Appendix 10A: Phase 1 Desk Study

Humber Zero

Phase I Geo-Environmental and Geotechnical Desk Study

VPI Immingham LLP and Phillips 66 Ltd

Project number: 60668866

February 2023

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		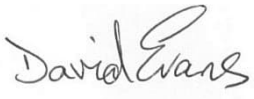	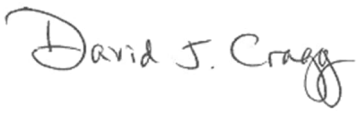
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The opinions expressed in this report and the comments and recommendations given are based on a desk assessment of readily available information and an initial site reconnaissance by an AECOM Engineer. At this stage intrusive investigations have yet to be undertaken at site to establish actual ground and groundwater conditions and to provide data for an assessment of the geo-environmental status of the site.

Reference to historical Ordnance Survey (OS) maps and/or data provides invaluable information regarding the land use history of a site. However, it should be noted that historical evidence will be incomplete for the period pre-dating the first edition and between the release of successive maps and/or data.

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10A.1. Introduction

10A1.1 Terms of Appointment

On the instruction of VPI Immingham LLP (hereafter referred to as 'VPI') and Phillips 66 Ltd (hereafter referred to as 'Phillips 66'), AECOM Limited (herein referred to as AECOM) has carried out a Phase 1 Geotechnical and Geo-environmental Desk Study of the VPI Site and Phillips 66 Site in South Killingholme, where two Post-Combustion Carbon Capture (PCC) developments and associated facilities located at VPI's Combined Heat and Power (CHP) Power Station and Phillips 66's Humber Refinery are proposed , which collectively form the Humber Zero Project (hereafter referred to as 'the Proposed Developments').

10A1.2 Background and Proposed Development Sites

This report has been produced on the assumption that the Proposed Developments will be developed for the purpose of decarbonisation. .The application site boundary for the Proposed VPI Development is presented as 'Humber Zero: VPI Immingham CHP Plant Post Combustion Carbon Capture Development Application Boundary' (ES Figure 1.3). The application site boundary for the Proposed Phillips 66 Development is presented as 'Humber Zero: Phillips 66 FCC Post Combustion Carbon Capture Development Application Boundary' (ES Figure 1.2).

The Proposed Development Sites ('the Sites') are part of the first phase of the Humber Zero Project which will consist of decarbonisation developments and blue hydrogen storage. The Proposed Developments will deliver up to 3.8 megatonnes per annum of abated carbon dioxide emissions. CO_2 pipelines will connect the developments to a CO_2 transportation network. The boundary of the Phillips 66 Site extends over the Network Rail lines and overlaps with areas of the VPI Site (as shown on ES Figure 1.2) to allow for this CO_2 pipeline connection.

10A1.2.1 VPI Site

The Proposed VPI Development on the VPI Site will comprise a Post-Combustion Carbon Capture (PCC) retrofit of two gas turbines (GT1 and GT2) and two auxiliary gas boilers at the VPI Immingham CHP Plant. A conceptual Site layout designed by Worley is provided as ES Volume III Figure 3.1. The development is anticipated to include the following components:

- ducting to connect GT1, GT2 and the auxiliary boilers to the PCC plant;
- two PCC units (or 'trains'), each with associated blower, direct contact cooler, absorber, stack, stripper/ regenerator, thermal reclaimer unit and air-cooled heat exchangers;
- a CO_2 vent stack for use during start up, shut down and emergencies only;
- low pressure CO_2 compression facility with associated air-cooled heat exchangers;
- oxygen removal and dehydration facilities;
- high pressure CO_2 compression facility;
- CO_2 metering and a pipeline connecting the PCC plant and compression facilities to the CO_2 gathering network interface;
- up to four on-site electrical substations;
- caustic, solvent and other chemical offloading and storage facilities;
- utilities (including chillers, steam generator, hydrogen package and air compressors)
- internal access roads;
- surface water drainage system
- realignment of the existing ditch (South Killingholme Drain) within the VPI Site;
- construction and maintenance laydown areas; and
- a new site access from Rosper Road.

10A1.2.2 Phillips 66 Site

The Proposed Phillips 66 Development at the Phillips 66 Site will comprise of Post-Combustion Carbon Capture (PCC) retrofit to the Fluid Catalytic Cracker (FCC) stack at the Humber Refinery within the Phillips 66 Site. An indicative layout plan of the Phillips 66 Site is provided as ES Volume III Figure 3.2. The development is anticipated to include the following components:

- FCC flue gas waste heat exchanger for steam raising;
- ducting over an existing internal access road to connect the FCC unit to the PCC plant;
- flue gas pre-treatment using Selective Catalytic Reduction (SCR), a wet gas scrubber and wet electrostatic precipitator with associated air-cooled heat exchangers;
- one PCC unit with associated absorber, stack, stripper/ regenerator, thermal reclaimer unit and air-cooled heat exchangers/ fin fans;
- low pressure and high pressure CO_2 vent stacks for use during start up, shut down and emergencies only;
- low pressure CO_2 compression facility with associated air-cooled heat exchangers/ fin fans;
- oxygen removal and dehydration facilities;
- high pressure CO_2 compression facility;
- CO_2 metering and a pipeline connecting the PCC plant and compression facilities to the CO_2 gathering network interface, including a pipeline crossing of the Phillips 66 railway sidings and Network Rail railway line;
- on-site electrical substation;
- caustic, solvent and other chemical offloading and storage facilities;
- utilities (including chillers, steam generator and air compressors)
- internal access roads;
- surface water and foul water drainage systems;
- construction and maintenance laydown areas; and
- a new site access from Eastfield Road.

10A1.3 Report Objectives

The primary objectives of this Phase 1 report are to:

- determine whether potentially contaminative uses have taken place within, or in close proximity to, the Sites which could have led to the contamination of underlying soils or groundwater; and
- to understand the effects of the geological conditions and Site activities on the geotechnical properties for Site redevelopment.

This Phase 1 report is prepared to support two planning applications under the requirements of Town and Country Planning Act 1990 (as amended) [(1)], the National Planning Policy Framework (2021) [(2)] and considers the potential implications of Part 2A of the Environmental Protection Act 1990 (Part 2A) [(3)] and the associated Contaminated Land (England) Regulations 2006 [(4)] and Contaminated Land Statutory Guidance (2012) [(5)].

This report has been prepared in general accordance with the technical guidance and procedures described in the UK Government guidance Land Contamination: Risk Management (2021) [(6)] and its predecessor, Model Procedures for the Management of Land Contamination, Contaminated Land Report (CLR) 11 (Department of Food and Rural Affairs (Defra)/ Environment Agency, 2004) [(7)], British Standard (BS) 5930:2015+A1:2020 Code of Practice for Site Investigations (BSI) [(8)], BS:EN 1997 Eurocode 7 – Geotechnical Design (BSI) [(9)] and BS 10175:2011+A2:2017 Investigation of Potentially Contaminated Sites – Code of Practice (BSI) [(10)], to:

- describe the geology, hydrogeology and shallow mining potential;

- describe the environmental setting/ sensitivity and current/ historical land use of the Sites and surrounding area;
- describe the findings of a site reconnaissance visit;
- summarise the history of the Sites;
- summarise the underlying geology and hydrogeology;
- summarise the findings of any historical ground investigation work;
- provide an initial Conceptual Site Model (CSM) for the prevailing ground conditions;
- using the source-pathway-receptor model present a preliminary qualitative risk assessment of potential land contamination risks to human (chronic), environmental, or controlled water receptors from contamination sources on or in the vicinity of the Sites, via transport pathways; and
- present a preliminary qualitative evaluation of potential geotechnical issues.

The report concludes with a series of recommendations for undertaking further investigative work. The purpose of such is to substantiate the findings of the preliminary risk assessment and thereby refine the CSM.

10A1.4 Information Sources

This report has been prepared using a combination of published records (e.g. British Geological Survey (BGS), Environment Agency, Defra). These include statutory records and historical mapping supplied within a Landmark Envirocheck Report (285387654_1_1 and 292199669_1_1), published geological and hydrogeological mapping, historical borehole records and observations made during the site reconnaissance. The information and documents reviewed for the purpose of this report are as follows:

- Google Maps (https://www.google.co.uk/maps) [(11)] (Accessed: January 2022);
- Envirocheck Report (Order No. 285387654_1_1) for the VPI Site (dated 24th September 2021) [(12)] (Presented in Annex A);
- Envirocheck Report (Order No. 292199669_1_1) for the Phillips 66 Site (dated 7th March 2022) [(13)] (Presented in Annex B) ;
- BGS GeoIndex Onshore Map Application (http://mapapps2.bgs.ac.uk/geoindex/home.html) [(14)] (Accessed: September 2022);
- BGS Lexicon of Named Rock Units (https://webapps.bgs.ac.uk/lexicon/) [(15)] (Accessed: January 2022);
- BGS Solid and Drift for Partington (Sheet 81 (and including parts of Sheet 82 and 90)) 1:50,000 Map [(16)];
- Geology of the Country around Grimsby and Partington: memoir for 1:50,000 Geological Sheets 90 and 91 and 81 and 82 (England & Wales) [(17)];
- Cranfield Soil and Agrifood Institute Soilscapes (http://www.landis.org.uk/soilscapes/) [(18)] (Accessed: September 2022);
- Natural England Agricultural Land Classification (https://naturalengland-defra.opendata.arcgis.com/datasets/provisional-agricultural-land-classification-alc-england/explore) [(19)] (Accessed: September 2022);
- The Coal Authority Online Interactive Map (http://mapapps2.bgs.ac.uk/coalauthority/home.html) [(20)] (Accessed: January 2022);
- Defra's MAGIC Map Application (https://magic.defra.gov.uk/MagicMap.aspx) [(21)](Accessed: September 2022);
- The Environment Agency Catchment Data Explorer (https://environment.data.gov.uk/catchment-planning) [(22)] (Accessed: September 2022);

- North East Lincolnshire Planning Application Portal (http://planninganddevelopment.nelincs.gov.uk/online-applications/) [23] (Accessed: January 2022);
- North Lincolnshire Planning Application Portal (https://apps.northlincs.gov.uk/) [24] (Accessed: January 2022);
- Ramboll Humber Refinery South Killingholme IPPC Permit UP3230LR Reporting of the Site Protection and Monitoring Programme Report (2020) [25];
- Ramboll Humber Refinery South Killingholme Interpretative Environmental Site Assessment Report (2020) [26]; and
- Zetica UXO Risk Maps (https://zeticauxo.com/downloads-and-resources/risk-maps/) [27] (Accessed: January 2022).

10A.2. Site and Surrounding Area

10A2.1 Site Location

The Sites (comprising the Phillips 66 Site and the VPI Site) are located in South Killingholme, Immingham. The Sites are centred on approximate National Grid Reference 516370, 416822. A Sites Location Plan is presented as ES Figure 1.1.

10A2.1.1 VPI Site

The VPI Site comprises the existing VPI Immingham CHP Plant in the north and an undeveloped area of land to the south and is centred on National Grid Reference 516823, 417027.

10A2.1.2 Phillips 66

The Phillips 66 Site comprises of the north-west corner, the northern boundary of the existing Humber Refinery site to the north of the A160 Humber Road, and an area of land crossing the Network Rail railway line and partly overlapping with the VPI Site. The Phillips 66 Site is centred on National Grid Reference 515828, 416959.

10A2.2 Site Description

10A2.2.1 VPI Site

OS mapping provided in the Envirocheck Report (285387654_1_1) [12] indicates the PCC plant and CO_2 compression station within the VPI Site is mostly covered in rough grassland, apart from an area immediately south of the existing VPI Immingham CHP Plant. Google Maps [11] satellite imagery indicates these areas may consist of hardstanding. Several pipelines are shown orientated north-west to south-east immediately adjacent to the southern VPI Site boundary. A drain is identified through the centre of the Proposed VPI Development area, orientated roughly east to west and some hardstanding is located immediately south, parallel to the drain which is associated with a track. A small patch of hardstanding is located to the south of the drain and track, on the eastern half of the VPI Site. The VPI Site appears to be relatively flat with elevations of approximately 4 mAOD.

The northern part of the VPI Site consists of the VPI Immingham CHP Plant. This comprises of hardstanding, and buildings and industrial infrastructure, including cooling towers, tanks, a chimney and electrical sub stations.

10A2.2.2 Phillips 66 Site

Google Maps satellite imagery [11] indicates most of the wider Phillips 66 Site is covered in hardstanding associated with the industrial land use of the refinery. The infrastructure on the Phillips 66 Site comprises pipelines, chimneys, buildings and surface water features. Railway lines are located on the eastern half of the Phillips 66 Site, adjacent to the northern boundary.

The north-west corner of the Phillips 66 Site currently comprises hardstanding, storage, and temporary usage, such as Phillips 66 Site cabins for maintenance contractors. There are existing buildings within this area and there is potential for some minor demolition works to be required.

Railway lines owned by Network Rail are partly located within the Phillips 66 Site boundary and to the north of the Phillips 66 Site. An embankment is depicted on mapping associated with the railway lines and a cutting associated with the railway lines is present towards the west. A row of vegetation is located either side of this railway line. A thin strip of land parallel to the railway lines within the VPI Site, and the existing track along the drain within the VPI Site is also included within the boundary of the Phillips 66 Site.

10A2.3 Surrounding Land Use

Table 10A2.1 summarises the key features and current land use of the surrounding area of the Sites. This is a review of desk-based sources including aerial photography.

Table 10A2.1 Summary of Current Surrounding Land Use of the Sites

Direction	Summary
North	There are fields and areas of hardstanding associated with car parks and large-scale warehouse type buildings within 500 m. A large-scale industrial site is located approximately 350 m north-west from the Sites which extends for over 1.5 km. Infrastructure associated with this include railway lines, pipelines and tanks. Land to the north-east of the Sites mostly consists of agricultural fields, a factory located 800 m from the Sites and areas of hardstanding located approximately 1.4 km north and north-east associated with vehicle storage facilities, car dealerships and car brokers. Several drains and small surface water features are identified on OS maps within 1 km.
West	Eastfield Road is located immediately to the west of the Sites and separates the main Phillips 66 Humber Refinery Site from a car park, buildings, access roads and open fields in the south-west. A large building assumed to be a warehouse, car parks and a building are located approximately 60 m west from the Phillips 66 Site. Google Maps satellite imagery indicates the area surrounding the warehouse consists of hardstanding and lorry trailer storage. A further lorry trailer storage site and associated buildings is located approximately 60 m west from the Phillips 66 Site, towards the south. A surface water feature is denoted approximately 220 m west, towards the south. Beyond this, the land use mostly consists of agricultural / open fields, until the village of South Killingholme which is located approximately 440 m west from the Phillips 66 Site. Land use beyond South Killingholme consists of agricultural / open fields. Several drains are identified on OS mapping within 1 km.
South	A dual carriageway road (A160 Humber Road) is located approximately 300 m south of the Phillips 66 Site and is orientated east to west parallel to the southern Phillips 66 Site boundary. This road adjoins to Manby Roundabout located approximately 100 m south-east from the Sites. Humber Road is located adjacent to Manby Roundabout and is orientated north-east to south-west. This adjoins to Rosper Road Immingham West Fire Station is located approximately 100 m south-east of the Sites. Roads to the east of Manby Roundabout adjoin to the ABP Immingham Dock West Gate. Further industrial infrastructure comprising tanks, drains and pipelines is located approximately 200 m south of the Sites. Large scale buildings associated with a depot are located approximately 143 m south-east from the southern Site boundary. Agricultural fields and open countryside are located beyond the industrial land use. The town of Immingham is located approximately 1.7 km south from the VPI Site. Drains are identified on OS mapping within 1 km.
East	Rosper Road is located immediately adjacent to the eastern VPI Site boundary orientated north-west to south-east. The road continues into Humber Road and separates into a branch of Humber Road, orientated north-east to south-west. Beyond this, land use mostly consists of agricultural fields. Several large-scale water features, assumed to be ponds, and a balancing pond are located within 500 m east from the VPI Site. Further drains are also shown within 1 km. Industrial land use is located approximately 600 m south-east of the VPI Site associated with coal storage, haulage, depots, warehouses and the Immingham Port Ferry Terminal located approximately 1.8 km east of the VPI Site. Beyond the terminal lies the Humber Estuary which flows north-west to south-east. Immingham Dock and infrastructure associated with tanks and oil refineries is located approximately 2.4 km south-east.

Source: Google Maps [11], Envirocheck Report (285387654_1_1) [12] and Envirocheck Report (292199669_1_1) [13]

10A.3. Geological and Environmental Setting

The environmental setting of the Sites is of importance because the topography, geology, hydrogeology and hydrology of the Sites and the surrounding land are the main factors that influence the way in which contaminants which may be in the soil or groundwater can be transported on or off site, potentially impacting on identified receptors. Information has been sourced from the Envirocheck Report (285387654_1_1 and 292199669_1_1) [12] [13] unless stated otherwise.

10A3.1 Published Geology & Exploratory Records

10A3.1.1 Published Geology

For the geological assessment of the Sites, the British Geological Survey (BGS) 1:50,000 Sheet 81 (and including parts of sheet 82 and 90) (Partington) [16], the BGS GeoIndex Onshore Map Application [14], BGS Geology of the Country around Grimsby and Partington Memoir [17], BGS Lexicon of Named Rock Units [15] and BGS Geology 1:10,000 maps included in the Envirocheck Report (285387654_1_1) [12] were reviewed. Table 10A3.1 outlines the published geology beneath the VPI Site.

Table 10A3.1 Published Geology at the VPI Site

Stratum	Expected Location	British Geological Survey (BGS) lithological description
Tidal Flat Deposits – Clay and Silt	The southern half of the VPI Site (undeveloped area of the VPI Site), apart from a small area in the south and a small area adjacent to the southern VPI Site boundary. The deposits are also anticipated in the north-east corner of the VPI Site. These deposits extend from the VPI Site over the railway lines.	The BGS Lexicon of Named Rock Units describes Tidal Flat deposits as "*unconsolidated sediment, mainly mud and/or sand. They may form the top surface of a deltaic deposit. Normally a consolidated soft silty clay, with layers of sand, gravel and peat. Characteristically low relief*".
Till, Devensian – Diamicton	The entire VPI Site underlying the Tidal Flat deposits.	No description given. Likely comprising a mixture of clay, sand, gravel, and boulders.
Bedrock: Burnham Chalk Formation	The entire VPI Site underlying the Devensian Till deposits.	The BGS Lexicon of Named Rock Units describes the Burnham Chalk Formation as "*White, thinly-bedded chalk with common tabular and discontinuous flint bands; sporadic marl seams*". The marl seams are of a volcanigenic nature, and often greenish grey in colour.

Source: BGS Sheet 81 (and including parts of sheet 82 and 90) (Partington) [16], BGS GeoIndex [14], BGS Geology of the Country around Grimsby and Partington Memoir [17], BGS Lexicon of Named Rock Units [15] and Envirocheck Report (285387654_1_1) [12]

Table 10A3.2 provides a summary of the published geology beneath the wider Phillips 66 Site.

Table 10A3.2 Published Geology at the Phillips 66 Site

Stratum	Expected Location	British Geological Survey (BGS) lithological description
Tidal Flat Deposits – Clay and Silt	A thin strip encroaching on the northern boundary in the east of the Sites underlying the railway lines and sidings. A small area of vegetated land that overlaps with the VPI Site and the existing track	The BGS Lexicon of Named Rock Units describes Tidal Flat deposits as "*unconsolidated sediment, mainly mud and/or sand. They may form the top surface of a deltaic deposit. Normally a consolidated soft silty clay, with layers of sand,*

Stratum	Expected Location	British Geological Survey (BGS) lithological description
	in the VPI Site are also underlain by Tidal Flat Deposits.	*gravel and peat. Characteristically low relief*".
Till, Devensian – Diamicton	The entire Phillips 66 Site, underlying the Tidal Flat deposits.	No description given. Likely comprising a mixture of clay, sand, gravel, and boulders.
Bedrock: Burnham Chalk Formation	The entire Phillips 66 Site, underlying the Devensian Till deposits.	The BGS Lexicon of Named Rock Units describes the Burnham Chalk Formation as "*White, thinly-bedded chalk with common tabular and discontinuous flint bands; sporadic marl seams*". The marl seams are of a volcanigenic nature, and often greenish grey in colour.

Source: BGS Sheet 81 (and including parts of sheet 82 and 90) (Partington) [16], BGS GeoIndex [14], BGS Geology of the Country around Grimsby and Partington Memoir [17], BGS Lexicon of Named Rock Units [15] and Envirocheck Report (285387654_1_1) [12].

10A3.1.2 Structural Geology

There are no recorded faults located at the Sites, or in the surrounding area. The nearest recorded fault is located approximately 11 km to the west of the Sites.

10A3.1.3 Historical Borehole Records on the VPI Site

The BGS GeoIndex (Onshore) Interactive Mapping Tool [14] indicates that there is one historic borehole located within the VPI Site boundary. A summary of the details of the onsite borehole is provided in Table 10A3.3.

Table 10A3.3 Historic Borehole Records on the VPI Site.

Geology	Typical Description	Depths to and from (m bgl)	Thickness Range (m)	Groundwater
Soil	-	0 – 0.3	0.3	-
Warp	Stiff brown Warp	0.3 – 3.96	0.91 – 2.44	Groundwater was encountered at 2.74m. The rest level of groundwater was recorded at 2.44m.
Sand and Gravel	-	2.74 – 3.05	0.31	-
Boulder Clay	-	3.96 – 11.89	7.93	-
Sand	-	11.89 – 12.95	0.15 – 0.45	Groundwater was encountered at 12.80m.
Clay	Occasionally with silt	12.04 – 18.90	0.46 – 5.95	-
Chalk	Chalk with flint beds	18.90 - 27.43*	8.53*	Groundwater was encountered at 18.90m.

*Source: BGS GeoIndex [14] *Depth to base not proven*

Warp was identified in historical borehole logs on the BGS GeoIndex [14] Interactive Mapping Tool. The BGS Lexicon of Named Rock Units [15] describe Warp as *"artificially induced alluvium"*.

10A3.1.4 Historic Borehole Records on the Phillips 66 Site

Data from the BGS GeoIndex indicates nine historic boreholes are located within the Philips 66 Site boundary and wider Phillips 66 Refinery Site. Six boreholes were drilled to depths in excess of 30 m and three were drilled to an unknown length. Accessible geological logs were only available for five boreholes on the Phillips 66 Site. Table 10A3.4 provides a summary of the onsite boreholes.

Table 10A3.4 Historic Borehole Records on the Phillips 66 Site.

Geology		Typical Description	Depths to and from (m bgl)	Thickness Range (m)	Groundwater	Borehole Reference
Made Ground	Made Ground	Backfill, red brown clay	0 – 0.25	0.25*	-	TA11NE110
Superficial Deposits	Boulder Clay	Occasional seams of silt.	0 – 19.81	5.18 – 14.5	Two boreholes recorded a rest level of groundwater at 7.01 m and 9.5 m below the top of the well.	TA11NE111 TA11NE328
	Clay	Brown, grey clay to silty clay with stones.	0 – 31.09	0.61 – 14.5	-	TA11NE111 TA11NE110 TA11NE108 TA11NE7
	Sand	Silty sand with flint, stones and chalk stones.	3.66 – 22.86	0.5 – 1.5	One borehole recorded the rest level of groundwater at 18m.	TA11NE111 TA11NE110 TA11NE108 TA11NE7
	Warp	-	4.57 – 5.79	1.22*	-	TA11NE7
	Gravel	-	5.18 – 6.1	0.92*	-	TA11NE328
	Marl Clay	-	5.79 – 13.72	7.93*	-	TA11NE7
	Sand and Silt	-	14.5 – 15	0.5*	-	TA11NE111
	Sand and Gravel	-	16.76 – 21.95	2.14 – 4.58	-	TA11NE328 TA11NE7
	Silt	-	22.86 – 24.99	2.13*	-	TA11NE7
Bedrock	Chalk	Chalk, flints and seams with increasing hardness with depth. Chalk and marl / marl seams described at depth. Occasional limestone at depth	18.5 - 180	11.5** – 151.5	-	TA11NE328 TA11NE7 TA11NE110 TA11NE111
	Marl	-	154 – 157.5	3.5*	-	TA11NE111
	Limestone	Pink, red chalk (limestone)	176 – 178.5	2.5*	-	TA11NE108
	Sandstone	Hard red / brown sandstone and gravel with some soft seams.	178.5 – 185	4 - 5	-	TA11NE108 TA11NE111
	Clay (denoted as part of the Upper	-	182.5 – 188**	3**	-	TA11NE108 TA11NE111

Geology	Typical Description	Depths to and from (m bgl)	Thickness Range (m)	Groundwater	Borehole Reference
	Jurassic Kimmeridge Clay)				

Source: BGS GeoIndex [14]

*The historical borehole logs only had limited descriptions, therefore, some of the geology observed does not have an associated description. *Only recorded in one borehole **base not proven*

10A3.2 Soils and Soil Chemistry

10A3.2.1 VPI Site

Information obtained from Soilscapes [18] describes the soils overlying the Tidal Flat Deposits (Clay and Silt) on the VPI Site as "*loamy and clayey soils of coastal flats with naturally high groundwater*". It is expected that the texture will be loamy and clayey with naturally wet drainage. As a result, the soils and water are described as pollution vulnerable due to the shallow groundwater and presence of ditches. The soils overlying the Till, Devensian (Diamicton) deposits on the VPI Site are described as "*slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils*". It is expected that the texture will be loamy and clayey with impeded drainage. Overland water flow is described as the main risk to this soil.

Natural England reports the Agricultural Land Use Classification (ALC) [19] to be Grade 3 across the majority of the VPI Site. The north-west corner of the VPI Site, where the existing VPI Immingham CHP Plant is located is designated as Grade Urban. The ALC divides land into Grades 1 to Grades 5, with Grade 3 separated into 3a and 3b. Grades 1-3a are described as the "*best and most versatile land*" [28].

The BGS estimated background soil chemistry concentrations (Envirocheck Report (285387654_1_1) [12] for the development area where the proposed VPI PCC plant and CO_2 compression station is located are as follows:

- arsenic: <15 mg/kg in the northern half of the VPI Site; a small area in the south; a small area adjacent to the southern VPI Site boundary This is associated with areas overlain by Tidal Flat Deposits (Clay and Silt)
- arsenic: 15-25 mg/kg within the centre of the southern half of the VPI Site that is associated with the Tidal Flat Deposits (Clay and Silt);
- cadmium: <1.8 mg/kg;
- chromium: 90 – 120 mg/kg;
- lead: <100 mg/kg; and
- nickel: 30 – 45 mg/kg.

It should be noted that the frequency of sampling and testing for the BGS Estimated Soil Chemistry resource is very low (approximately 1 sample per km^2).

10A3.2.2 Phillips 66 Site

Information obtained from Soilscapes [18] indicates the soils overlying the entire Phillips 66 Site are described as "*slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils*". It is expected that the texture will be loamy and clayey with impeded drainage. Overland water flow is described as the main risk to this soil. The soils may be present along the northern Phillips 66 Site boundary, the existing track within the VPI Site and the land parallel to the railway tracks in the VPI Site which are underlain by Tidal Flat Deposits (Clay and Silt). These soils are described as "l*oamy and clayey soils of coastal flats with naturally high groundwater"*. It is expected that the texture will be loamy and clayey with naturally wet drainage.

Natural England [19] reports the ALC to be Grade 3 across a thin strip of land parallel to the railway in the eastern half of the Phillips 66 Site and across the vegetated land parallel to the railway lines and the across the track (overlapping within the VPI Site). The remainder of Phillips 66 Site, including the sub areas of the Proposed Phillips 66 Development are classified as Grade Urban.

The BGS estimated background soil chemistry concentrations, provided in the Envirocheck Report (292199669_1_1) [13] for the Phillips 66 Site are as follows:

- arsenic: 15-25 mg/kg across areas of the Phillips 66 Site underlain by the Tidal Flat Deposits (Clay and Silt). This includes the north-eastern area of the Phillips 66 site, the railway and the land within the VPI Site (the land parallel to the railway and the existing track);
- arsenic: <15 mg/kg across most of the Phillips 66 Site. This is associated with areas that are not overlain by Devensian Till (Diamicton) only;
- cadmium: <1.8 mg/kg;
- chromium: 90 – 120 mg/kg;
- lead: <100 mg/kg; and
- nickel: 30 – 45 mg/kg.

10A3.3 Ground Subsidence and Stability

10A3.3.1 VPI Site

The following information on ground subsidence and stability identified for the entire VPI Site is provided in the Envirocheck Report (285387654_1_1) [12]:

- the hazards posed by collapsible ground are classified as *No Hazard* to *Very Low*;
- the potential for compressible ground hazards is classified as *No Hazard* to *Moderate*. The moderate hazard is associated with the areas of the VPI Site that are underlain by the Tidal Flat Deposits (Clay and Silt);
- the potential for ground dissolution hazards and landslide hazards is classified as *No Hazard* and *Very Low,* respectively;
- hazards associated with running sand are classified as *Very Low* to *Moderate*. The areas with a *Moderate* hazard correspond to the area of the VPI Site underlain by Tidal Flat Deposits (Clay and Silt); and
- shrinking or swelling clay ground stability hazards are classified as *Low* to *Very Low*.

10A3.3.2 Phillips 66 Site

The following information on ground subsidence and stability identified for the Phillips 66 Site and wider Phillips 66 Site is provided in the Envirocheck Report (292199669_1_1) [13]:

- the potential for compressible ground stability is considered to be *No Hazard* to *Moderate*;
- there is a *Very Low* to *Moderate* hazard associated with running sands ground stability;
- collapsible ground stability hazards over the Phillips 66 Site range between *No Hazard* and *Very Low*;
- the potential for landslide ground stability hazards is considered to be *Very Low* to *Low*; and
- thereare *No Hazards* for ground dissolution within the Phillips 66 Site.

Maps provided in the Envirocheck Report (285387654_1_1) [12] provide further information on the ground stability hazards:

- a *Moderate* risk for compressible ground stability and running sand ground stability hazards. The *Moderate* hazard is associated with areas of the Phillips 66 Site underlain by Tidal Flat Deposits. The remainder of the Phillips 66 Site underlain by Devensian Till is associated with a *Very Low* hazard;

- a *Very Low* risk of collapsible ground stability hazards; and
- a *Low* shrinking or swelling clay hazard over areas of the Phillips 66 Site underlain by Tidal Flat Deposits. The remainder of the Phillips 66 Site has a *Very Low* risk.

10A3.4 Mining and Mineral Extraction

The Coal Authority Interactive Map Viewer [20] indicates the Sites are not within a Coal Mining Reporting Area and it is not in a Development High Risk Area. Therefore, a Coal Mining Risk Assessment is not required.

10A3.4.1 VPI Site

No historical mineral extraction or non-coal mining records are present on VPI Site based on information provided in the Envirocheck Report (285387654_1_1) [12], although two records for extractive industries or potential excavations are noted for a railway embankment on the Network Rail land located 4 m south of the VPI Site and a dock located 94 m south-east of the VPI Site. However, the dock was only recorded on historical maps in 1964 and 1965.

10A3.4.2 Phillips 66 Site

There are not any historical mineral extraction or non-coal mining records present on the Phillips 66 Site based on information provided in the Envirocheck Report (292199669_1_1) [13]. The Envirocheck Report (285387654_1_1)[12] there is a record for extractive industries or potential excavations noted on the railway embankment.

10A3.5 Radon

10A3.5.1 VPI Site

Information from the BGS provided in the Envirocheck Report (285387654_1_1) [12] indicates the VPI Site is located within an area where less than 1% of homes are at or above the action level. Therefore, no radon protective measures are necessary. This information is only relevant if the use of the VPI Site were to change to residential use in the future.

It should be noted that this data is only available for the undeveloped area of the VPI Site, where the proposed VPI PCC plant and CO_2 compression station will be located.

10A3.5.2 Phillips 66 Site

Information from the BGS provided in the Envirocheck Report (292199669_1_1) [13] indicates the Phillips 66 Site is located within an area where less than 1% of homes are at or above the action level. Therefore, no radon protective measures are necessary. This information is only relevant of if the use of the site changes to residential use in the future.

10A3.6 Environmental Designations

10A3.6.1 VPI Site

Information on environmental designations were obtained from the Envirocheck Report (285387654_1_1) [12]. The VPI Site is located within a Nitrate Vulnerable Zone associated with Lincolnshire Chalk groundwater. This is limited to the northern half of the VPI Site, a small area in the south and a small area adjacent to the southern VPI Site boundary. This corresponds to the same area of the VPI Site with Devensian Till (Diamicton) superficial deposits only. A Nitrate Vulnerable Zone is also associated with the surface water North Beck Drain located 209 m south of the VPI Site.

10A3.6.2 Phillips 66 Site

According to MAGIC Map application (DEFRA) and the Envirocheck Report (292199669_1_1) [13], most of the Phillips 66 Site is located in a Nitrate Vulnerable Zone, apart from the small area that is underlain by Tidal Flat Deposits (Clay and Silt) in the eastern half of the Phillips 66 Site and the land within the VPI Site (parallel to the railway lines and along the existing track). This is associated with the North Beck Drain and the Lincolnshire Chalk groundwater.

10A3.7 Hydrogeology

10A3.7.1 Aquifer Classification

The superficial Tidal Flat Deposits (Clay and Silt) are classified as an Unproductive Aquifer [12]. The Environment Agency defines an Unproductive Aquifer as "*largely unable to provide usable water supplies and are unlikely to have surface water and wetland ecosystems dependent on them*" [29].

The superficial Devensian Till (Diamicton) deposits are classified as a Secondary Undifferentiated Aquifer [12]. The Environment Agency defines a Secondary Undifferentiated Aquifer as *"where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type. These have only a minor value"* [29].

The Burnham Chalk Formation underlying the Devensian Till (Diamicton) deposits is classified as a Principal Aquifer [12]. The Environment Agency defines a Principal Aquifer as an aquifer that can "*provide significant quantities of drinking water, and water for business needs. They may also support rivers, lakes and wetlands*" [29].

10A3.7.2 Chalk Aquifer Properties

A research report conducted by the British Geological Survey into the Chalk Aquifer System of Lincolnshire [30] provides information on the aquifer properties. A summary is provided in Table 10A3.5.

Table 10A3.5 Summary of Lincolnshire Chalk Aquifer Properties.

Property	Units	Maximum Value	
		Unconfined Aquifer	Confined Aquifer (beneath Devensian Glacial Till)
Temperature	°C	20.2	14.0
Dissolved Oxygen	mg/l	9.9	3.2
Redox Potential	mV	466	290
Conductivity	µg/l	961	4230
pH		7.5	7.82

Source: BGS Chalk Aquifer System of Lincolnshire Research Report [30]

A summary of the aquifer geochemistry is provided in Table 10A3.6. The report [30] notes the elevated levels of arsenic and iron within the aquifer.

Table 10A3.6 Summary of Aquifer Groundwater Composition

Determinand	Units	Maximum Value	
		Unconfined Aquifer	Confined Aquifer (beneath Devensian Glacial Till)
Arsenic	µg/l	10.7	62
Boron	µg/l	63	171
Cadmium	µg/l	0.4	0.06
Copper	µg/l	38	40
Chromium	µg/l	0.32	0.52
Iron	µg/l	760	6790
Lead	µg/l	1.4	0.96
Nickel	µg/l	5.2	4.3
Zinc	µg/l	359	140

Source: Smedley and Brewerton (1998) cited in the BGS Chalk Aquifer System of Lincolnshire [30]

The report [30] states that the potential for attenuation within the aquifer is low due to the speed of migration and limited dilution. Therefore, there is increased susceptibility to contamination. It is also noted that the concentrations of nitrate are particularly high due to the agricultural land use within the region. The report [30] also notes there is potential for saline intrusion, contamination generated from spillages / leakages of hydrocarbons and chlorinated solvents and waste disposal sites.

10A3.7.3 Groundwater Vulnerability

10A3.7.3.1 VPI Site

The Envirocheck Report (285387654_1_1) [12] indicates the Principal Bedrock Aquifer within the Burnham Chalk Formation has a combined vulnerability of *Low* in the centre of the southern half of the VPI Site. This is due to the combination of a productive bedrock aquifer and an unproductive superficial aquifer associated with the Tidal Flat Deposits (Clay and Silt). The Environment Agency describe *Low* vulnerability as "*areas that provide the greatest protection to groundwater from pollution. They are likely to be characterised by low leaching soils and/or the presence of low permeability superficial deposits*" [31]. The 1:100,000 Groundwater Vulnerability Map on Magic Maps also suggests this area has a *Low* vulnerability.

The Secondary Undifferentiated Aquifer within the Devensian Till (Diamicton) has a combined vulnerability of *Medium* in the northern half of the VPI Site and small areas in the south-west of the VPI Site [12]. This is due to the combination of a productive bedrock rock aquifer and a productive superficial aquifer. The Environment Agency describe *Medium* vulnerability as "*areas that offer some groundwater protection. Intermediate between high and low vulnerability*" [31].

The combined vulnerability in the south-east and a thin strip within the centre of the north-east boundary on the VPI Site, has a combined vulnerability of *High* due to the combination of the productive bedrock aquifer and a productive superficial aquifer. The Environment Agency describe *High* vulnerability as "*areas able to easily transmit pollution to groundwater. They are characterised by high leaching soils and the absence of low permeability superficial deposits*" [31]. The 1:100,000 Groundwater Vulnerability Map on Magic Maps [21] suggests this area has a *Medium – High Vulnerability*.

10A3.7.3.2 Phillips 66 Site

The majority of the Phillips 66 Site, apart from the areas which are overlain by Tidal Flat (Clay and Silt) deposits are designated as *Medium* vulnerability on the 1:100,000 Groundwater Vulnerability map available on Magic Maps [21] and on maps provided within the Envirocheck Report (292199669_1_1) [13]. This designation is a result of the combination of a productive bedrock aquifer and a productive superficial aquifer. The areas underlain by Tidal Flat (Clay and Silt) are designated as *Low* vulnerability due to the combination of an unproductive superficial aquifer and a productive bedrock aquifer.

10A3.7.4 Groundwater Flooding

10A3.7.4.1 VPI Site

The BGS Flood Data for groundwater flooding provided in the Envirocheck Report (285387654_1_1) [12] indicates that there is potential for groundwater flooding to occur in areas of the VPI Site that are not overlain by the superficial Tidal Flat Deposits (Clay and Silt). Therefore, it is interpreted that the Glacial Till is prone to groundwater flooding. There is potential for groundwater flooding at the surface in the northern half of the VPI Site, including a thin strip within the proposed area for the VPI PCC plant and CO_2 compression station. There is also potential for property that will be situated below ground level to be affected by groundwater flooding in the south, west, north-west and north-east within the VPI Site, adjacent to the VPI Site boundaries. Two small areas within the south-east and south-west of the VPI Site have been classified as limited potential regarding groundwater flooding.

10A3.7.4.2 Phillips 66 Site

The BGS Flood Data for groundwater flooding provided in the Envirocheck Report (292199669_1_1) [13] indicates that there is potential for groundwater flooding to occur in areas of the Phillips 66 Site that are not underlain by the superficial Tidal Flat Deposits (Clay and Silt). The majority of the Phillips 66 Site has potential for property below ground level to be affected by groundwater flooding. A small area in the north-west corner is designated as limited potential for groundwater flooding to occur and

a small area on the northern Phillips 66 Site boundary has potential for groundwater flooding to occur at the surface.

10A3.7.5 Groundwater Abstractions

10A3.7.5.1 VPI Site

The Envirocheck Report (285387654_1_ 1) [12] indicates there are no groundwater abstractions located within the VPI Site boundary. There are 19 groundwater abstractions within 1 km of the VPI Site which are listed below:

- Phillips 66 Limited hold two permits located 757 m east from the VPI Site and two permits 765m east of the VPI Site for '*other industrial / commercial / public services: general use (low loss)'* purposes. No end dates for the permits were supplied;
- a further seven permits are held by Phillips 66 Limited for '*petrochemicals: process water'* located 829 m west and 909 m west from the VPI Site. No end dates for the permits were supplied;
- Calor Gas Limited hold two permits for '*industrial / commercial / public services: general use'* purposes 757 m and 765 m east of the VPI Site. Chalk is referred to in the record, therefore, it is assumed the abstraction is located within the Burnham Chalk Formation. No end dates for the permit were supplied;
- Conocophillips Limited hold two permits for '*petrochemicals: process water*' located 829 m and 909 m west from the VPI Site. No end dates for the permits were supplied; and
- Conoco Limited hold five permits for '*petrochemicals: process water*' located 829 m west and 909 m west from the VPI Site. No end dates for the permits are provided. The records for two of the permits state that it is temporary and refer to 'Elsham Sst'. This may refer to the abstraction within the Elsham Sandstone Member of the Kimmeridge Clay Formation which underlies the Burnham Chalk Formation.

There are a further thirteen groundwater abstractions between 1 km and 2 km of the VPI Site.

10A3.7.5.2 Phillips 66 Site

The Envirocheck Report (292199669_1_1) [13] indicates there are 13 groundwater abstractions located within the Phillips 66 Site boundary and adjacent to the Phillips 66 Site boundary which are listed below:

- Three permits are held by Phillips 66 Limited for '*petrochemicals: process water* on the Phillips 66 Site'. No end dates for the permits were supplied;
- One permit is held by Conocophillips Limited for '*petrochemicals: process water* on the Phillips 66 Site'. No end dates for the permits were supplied;
- Four permits are held by Phillips 66 Limited for '*petrochemicals: process water'* for an abstraction located adjacent to the southern boundary. No end dates for the permits were supplied;
- Conoco Phillips Limited hold three permits for '*petrochemicals: process water'* for an abstraction located on the southern boundary. No end dates for the permits were supplied;
- Conoco Limited hold two permits for '*petrochemicals: process water* on the Phillips 66 Site'. End dates for the permits have not been provided. The records for two of the permits state that it is temporary and refer to 'Elsham Sst'. This may refer to the abstraction within the Elsham Sandstone Member of the Kimmeridge Clay Formation which underlies the Burnham Chalk Formation;
- Phillips 66 Limited hold two permits located 757 m east from the Phillips 66 Site and two permits 765 m east of the Phillips 66 Site for '*industrial / commercial / public services: general use*' purposes. No end dates for the permit were supplied;
- Calor Gas Limited hold two permits for '*other industrial / commercial / public services: general use (low loss)*' approximately 754 m east from the Phillips 66 Site. Chalk is referred to in the record, therefore, it is assumed the abstraction is located within the Burnham Chalk Formation. No end dates for the permit were supplied; and

- S. A. Davies holds a permit for 'agriculture (general)' located 824 m north-west from the Phillips 66 Site. Chalk is referred to in the record, therefore, it is assumed the abstraction is located within the Burnham Chalk Formation. No end dates for the permit were supplied.

Following discussions with Phillips 66, the number of groundwater abstractions has been confirmed. Phillips 66 currently hold one abstraction licence for the Refinery site (AN/029/0009/001/R01) for two boreholes. The abstraction licence was issued on 14th July 2017, with an effective date of 1st April 2018. The abstraction licence will expire on 31st March 2030. All records associated with Conocophillips Ltd and Conoco Ltd are historic.

There are a further thirteen permits for groundwater abstractions located between 1 km and 2 km from the Phillips 66 Site.

10A3.7.6 Source Protection Zones

10A3.7.6.1 VPI Site

The Envirocheck Report (285387654_1_1) [12] indicates the entire VPI Site is within an area classified as a Source Protection Zone (SPZ) SPZ3 (total catchment) and is associated with an SPZ1 located approximately 1.09 km south-east from the VPI Site and an SPZ1 located 3.5 km north-west from the VPI Site. The Environment Agency defines an SPZ3 as *"the area around a supply source within which all the groundwater ends up at the abstraction point. This is the point from where the water is taken. This could extend some distance from the source point"* [32]. This may be associated with extensive industrial, commercial and public services groundwater abstraction and private water undertaking (raw water supply) groundwater abstraction located between 1.3 km and 1.97 km south-east of the VPI Site. There are eight records for groundwater abstractions within this area. The records for one abstraction refer to chalk, therefore it is assumed that the abstractions are within the Principal Aquifer within the Burnham Chalk Formation.

10A3.7.6.2 Phillips 66 Site

Information in the Envirocheck Report (292199669_1_1) [13] indicates the entire Phillips 66 Site is within an area classified as a SPZ3 (total catchment) and is associated with an SPZ1 located approximately 1 km south-east and 2.52 km north-west. The SPZ1 located 1 km south-east is the same SPZ1 that is referred to in the VPI summary in Section 3.7.6.1. There is no information on the strata the abstraction is located within for the SPZ 1 located approximately 2.52 km north-west. However, based on the geology in the area it is assumed that the abstraction is located within the Principal Aquifer within the Burnham Chalk Formation.

10A3.8 Hydrology

10A3.8.1 Watercourses

10A3.8.1.1 VPI Site

The Environment Agency Catchment Data Explorer [22] indicates the VPI Site is located within the North Beck Drain Water Body catchment. It is assumed that the North Beck Drain is pumped. The current (2019) classification has a '*Moderate'* ecological status and a chemical status of '*Fail'* due to priority hazardous substances Mercury and its Compounds and Polybrominated Diphenyl Ethers (PBDE). This is also designated as a heavily modified water body.

The Envirocheck Report (285387654_1_1) [12] indicates there are eighteen OS Water Network Lines within the VPI Site boundary which all are designated as inland rivers. Of the eighteen inland rivers, fourteen are located on the ground surface and four are located underground. The watercourse lengths vary from 3.3 m to 261 m. There are a further twenty-seven OS Water Network Lines identified within 250 m of the VPI Site, of which twenty-five are inland rivers and two are designated as a lake. A further 233 OS Water Network Lines are identified within 1 km from the VPI Site.

The Humber Estuary is located approximately 1.7 km east of the VPI Site.

10A3.8.1.2 Phillips 66 Site

The Environment Agency Catchment Data Explorer [22] indicates the Phillips 66 Site is located within the North Beck Drain Water Body catchment. It is assumed that the North Beck Drain is pumped The current (2019) classification has a 'Moderate' ecological status and a chemical status of 'Fail' due to

priority hazardous substances mercury and its compounds and polybrominated diphenyl ethers (PBDE). This is also designated as a heavily modified water body.

The Envirocheck Report (292199669_1_1) indicates there are three OS Water Network Lines within the Phillips 66 Site boundary near the railway lines associated with the drain in the VPI site.

The Humber Estuary is located approximately 2.4 km east from the site.

10A3.8.2 Flooding Risk

10A3.8.2.1 VPI Site

Data provided in the Envirocheck Report (285387654_1_ 1) [12] suggests the entire VPI Site has the potential to be affected by river and coastal flooding that do not have defences. Areas in the east of the VPI Site have been identified as potential areas affected by extreme river or coastal flooding without defences.

The risk of surface water flooding identified within the Envirocheck Report (285387654_1_1) [12] suggests there is a *High Risk* (30-year return period) associated with the drain that is located within the centre of the VPI Site, orientated north-east to south-west, and a small area in the south-east near the VPI Site boundary. Areas within the centre and south of the eastern half of the VPI Site are at *Low Risk* (1000-year return period) of surface water flooding, although there are small areas in the south-east that are of *Medium Risk* (100-year return period). The north-east boundary within the existing VPI Immingham CHP Plant site in the north has a *Low Risk* (1000-year return period) and small patches within the existing VPI Site are designated as a combination of *Low Risk* (1000-year return period) and *Medium Risk* (100-year return period).

10A3.8.2.2 Phillips 66 Site

The Envirocheck Report (292199669_1_1) [13] has identified a risk of surface water flooding within the Phillip 66 Site. The risk of surface water flooding is within isolated patches across the northern boundary and southern half of the Phillip 66 Site, whereby the risk is mostly denoted as *Low* (1000-year return period). There is a *Low* risk (to a *High Risk* (30-year return period) associated with small patches in the south of the Phillip 66 Site. A small area parallel to the railway lines and along the drain (within the VPI Site) is designated as a *High* risk. The only area within the Phillip 66 Site that is affected by risks of both flooding and extreme flooding from rivers or sea without defences is within the eastern areas of the Phillip 66 Site.

10A3.8.3 Licenced Surface Water Abstractions

10A3.8.3.1 VPI Site

The Envirocheck Report (285387654_1_1) [12] suggests there are no surface water abstractions on the VPI Site. There are two surface water abstractions operated by Immingham Town Council 1.5 km south-east from the VPI Site and one surface water abstraction operated by Drax Biomass (Immingham) Limited 1.9 km north-east of the VPI Site.

10A3.8.3.2 Phillips 66 Site

The Envirocheck Report (292199669_1_1) [13] indicates there are no surface water abstractions within the Phillips 66 Site. There are two surface water abstractions operated by Immingham Town Council located approximately 1.45 km south-east from the Phillips 66 Site.

10A3.8.4 Artesian Aquifers across the Sites

A research report conducted by the British Geological Survey [30] has noted the potential for artesian aquifers within the Chalk system in Lincolnshire. This could lead to potential blow wells that have implications on boreholes, piling and aquifer protection measures. Blow wells occur in confined aquifers where there is a thin layer or a permeable layer of Glacial Till and there is an artesian aquifer. It is noted that groundwater abstraction in the region has caused most of the blow wells to dry up. However, it is noted within the report [30] that abstraction within the region has lowered the groundwater head and reduced the number of blow wells in artesian aquifers.

10A.4. Historical & Planned Development

10A4.1 Historical Development of the Site and Surroundings of the VPI Site

The historical development of the VPI Site and the immediate surroundings has been assessed using historical Ordnance Survey (OS) maps dating from 1887-2021 obtained as part of the Envirocheck Report (285387654_1_1) [12].

Table 10A4.1 presents a summary of the main features present on the VPI Site and within approximately 250 m of the VPI Site boundary which may represent potential sources of contamination, and surface water features within 1km. Where dates are stated, these refer to the published date and as such do not necessarily refer to the exact date of existence of a particular feature. Development that may have occurred between map editions is recorded as occurring on the latter published map.

Table 10A4.1 Summary of Historical Development of the VPI Site

Date	Scale	Onsite Features	Key Off-Site Features
1887	1:2,500 1:10,560	The VPI Site consists of agricultural fields and two linear features assumed to be footpaths orientated east to west and north-east to south-west. A '*Foot Bridge*' is identified adjacent to the VPI Site boundary in the north-east.	The surrounding area comprises agricultural fields, footpaths extending from the VPI Site and a road network ('*Humber Road*') orientated from east to west and '*Rosper Road'* orientated north-west to south-east. A '*Spring'* is denoted approximately 600 m north-east of the VPI Site at '*Marsh Farm'*.
1892	1:10,560	No significant changes.	No significant changes.
1907	1:2,500	No significant changes.	A '*Spring'* is denoted approximately 140 m north-east.
1908-1910	1:10,560	The *'Foot Bridge'* is no longer denoted.	A '*Well'* and several buildings are denoted approximately 50 m north-east from the VPI Site. A 'Spring' is denoted approximately 600 m and 900 m south-east from the VPI Site.
1910	1:10,560	No significant changes.	No significant changes.
1932	1:2,500 1:10,560	A building is shown in the centre of the eastern VPI Site boundary.	The '*L.N.E.R. Ulceby & Immingham Line'* railway line is denoted immediately to the south of the VPI Site. The railway line is orientated north-west to south-east. The railway line with embankments extends from the area of Network Rail land to the north-west and south-east. This branches into separate lines approximately 250 m south-east of the VPI Site. A *'Mile Post'*, *'Guide Post'* and several *'Signal Posts'* associated with the railway line are denoted immediately south of the VPI Site along the railway line. Buildings or structures denoted as '*Mission Room'* are located immediately adjacent to the eastern VPI Site boundary. A '*School'* is denoted approximately 100 m south-east of the VPI Site. The '*Spring'* is not denoted at '*Marsh Farm*'.
1938-1951	1:10,560	A small building is shown near the eastern Site boundary in the south-east of the VPI Site	No significant changes.
1956	1:10,000	No significant changes.	A '*Telephone Call Box'* is shown approximately 50 m east from the VPI Site.
1964-1965	1:2,500	The linear feature depicted through the centre of the VPI Site orientated east to west is now denoted as a '*Drain'*.	A network of interconnected '*Drains'* are denoted to the east of the VPI Site within 250 m. Buildings associated with '*Mission Room'* are also denoted '*Myrtle Villas, Westlea'* and a

Date	Scale	Onsite Features	Key Off-Site Features
			'*Drain'* which is adjacent to the eastern VPI Site boundary. The school is now denoted as '*Killingholme School*'.
1966	1:10,000	No significant changes.	No significant changes.
1968	1:10,000	The building is no longer denoted near the centre of the eastern VPI Site boundary. A '*Path'* is denoted parallel to the VPI Site boundary in the north-west of the site. A '*Drain'* is identified parallel to the eastern VPI Site boundary in the northern half of the VPI Site.	The buildings associated with the well 50 m north-east from the VPI Site are now labelled as '*Rosper Road Farm'*. A linear feature identified as '*Tk'*, assumed to be a track, is shown approximately 200 m east of the VPI Site near '*Killingholme School*'. A large number of '*Drains'* are identified within a 1 km radius surrounding the VPI Site, including a drain immediately parallel to the VPI Site boundary in the north. The '*Springs'* are no longer denoted 600 m and 900 m south-east from the VPI Site. Further linear '*Tk'* features assumed to be tracks are identified 530 m south, 750 m north and 900 m north-east from the VPI Site.
1971	1:2,500	No coverage.	Multiple railway lines are denoted located within 250 m north-west from the VPI Site. A '*Sluice'* is denoted associated with a '*Drain'* and an unknown feature approximately 20 m north-west.
1971-1973	1:2,500	Partial coverage, but no significant changes.	Partial coverage. Two '*Electrical Sub Stations'* are identified within 100 m south-east from the VPI Site associated with the railway line. The mapping symbols indicate that there is a clay pit approximately 250 m east from the VPI Site.
1973-1985	1:2,500	A '*Pipeline'* is denoted parallel to the western boundary in the south-east, and a second '*Pipeline'* intersects the western corner of the VPI Site, orientated north-east to south-west, and extends into the northern half of the VPI Site.	Further railway lines orientated north-west to south-east are denoted near the existing railway approximately 75 m south-west of the VPI Site. An '*Engine Shed'* is denoted approximately 150 m south-east from the VPI Site, associated with the railway lines. A '*Flare Stack'* is denoted approximately 250 m south-east from the VPI Site, and a further '*Pipeline'* orientated east to west is identified approximately 75 m west from the VPI Site. Four '*Tanks'* are denoted within 250 m south-east from the VPI Site.
1973-1988	1:2,500	Partial coverage. A '*Track'* is identified immediately adjacent, and parallel to, the '*Drain'*. A linear feature labelled '*Tk*', assumed to be a track, is identified within the centre of the site near the eastern site boundary.	Partial coverage. Several '*Warehouses'* are identified 50 m south of the VPI Site near the railway line.
1974	1:10,000	No significant changes.	The '*Warehouses'* are now denoted as a '*Depot'* and a roundabout is shown immediately south of the depot. The '*Clay Pit*' is not denoted on this map scale. '*Rosper Road Farm'* is no longer denoted.
1985	1:10,000	No significant changes.	Infrastructure associated with an '*Oil Refinery'* is shown approximately 250 m north-west from the VPI Site. The '*Pipeline'* that intersects the western corner of the VPI Site is now shown extending beyond 250 m from the northern VPI Site boundary.

Date	Scale	Onsite Features	Key Off-Site Features
1994	1:2,500	The building is no longer shown adjacent to the centre of the eastern VPI Site boundary.	The unknown feature associated with the '*Sluice'* and drain 20 m north-east from the VPI Site is now denoted as a '*Settling Tank'*. '*Killingholme School'* is no longer denoted, and some buildings associated with it are no longer shown. Several '*Ponds'* are denoted within 130 m of the southern VPI Site boundary. The '*Tanks'* in the south-east are now denoted as '*Silos'* associated with the '*Oil Refinery'*. The *'Clay Pit'* is no longer denoted and mapping indicating a slope is shown in the same location. Slopes are also shown parallel to '*Drains'* located within 250 m east from the VPI Site.
1999 (Aerial)		No significant changes.	The '*Clay Pit'* appears to be infilled. A large building is visible located approximately 110 m south-east from the VPI Site. Linear features, which may be pipelines, are shown within 250 m south-east from the VPI Site.
2000	1:10,000	No significant changes.	Roads on the roundabout are now denoted as the '*A160*'. Further ponds and '*Drains'* are denoted within 1 km from the VPI Site in the south-east and north. '*Mission Room'* is no longer denoted.
2006	1:10,000	Extensive industrial development is shown in the northern half of the VPI Site. A 'Chimney', several buildings and a surface water feature are denoted as part of this development. An extension of the 'Drain' in the centre and northern corner of the VPI Site is shown, with a pond. In the north-west of the VPI Site, 2 buildings are shown, and 9 buildings are denoted in the northern corner. The '*Pipeline'* through the western corner of the VPI Site is no longer denoted. However, it should be noted that Phillips 66 have confirmed that the industrial development occurred on the site in 2003. No mapping dated to 2003 is provided within the Envirocheck Report.	The building visible in aerial imagery located approximately 110 m south-east from the VPI Site is now denoted as a '*Fire Station'* on the raster map and an additional building is located nearby. 'Myrtle Villas' is no longer denoted, and it appears that the buildings associated with it have been demolished. The remaining building associated with *'Killingholme School'* appears to be demolished.
2021	1:10,000	The '*Chimney'* associated with the industrial development is no longer denoted, and '*Cooling Towers*' are identified in the northern half of the VPI Site. The extension of the '*Drain'* in the northern corner of the VPI Site with a pond is no longer shown, however, the rest of the drain is still present through the centre of the VPI Site. The buildings on VPI Site are no longer denoted. '*Rough Grassland'* covers most of the VPI Site, apart from an area immediately south of the VPI CHP Plant.	A '*Mast'* is denoted immediately adjacent to the southern VPI Site boundary. A '*Balancing Pond'* is shown approximately 10 m south-east from the VPI Site. A water surface feature is now associated with the '*Fire Station'*. A large water feature and 2 smaller water features, assumed to be ponds, are shown within 50 m of the eastern VPI Site boundary. Infrastructure associated with *'Oil Refinery'* is shown to extend within 200 m of the VPI Site boundary in the north-west.

Source: Envirocheck Report (285387654_1_1) [12] **Approximate distances only.*

10A4.2 Historical Development of the Site and Surroundings of the Phillips 66 Site

The historical development of the Phillips 66 Site and the immediate surroundings has been assessed using historical Ordnance Survey (OS) maps dating from 1887 to 2021 obtained as part of the Envirocheck Report (292199669_1_1) [13].

Table 10A4.2 presents a summary of the main features present onsite and within approximately 250 m of the Phillips 66 Site boundary which may represent potential sources of contamination. Where dates are stated, these refer to the published date and as such do not necessarily refer to the exact date of existence of a particular feature. Development that may have occurred between map editions is recorded as occurring on the latter published map.

Table 10A4.2 Summary of Historical Development of the Phillips 66 Site

Date	Scale	Onsite Features	Off-Site Features
1887	1:10,560 1:2,500	The site mostly comprises of agricultural fields and footpaths, which are orientated north-east to south-west and north to south through the site. A linear feature is denoted orientated east to west within the land of the VPI Site.	The surrounding area mostly comprises of agricultural fields. '*Eastfeld Road'* is denoted immediately parallel to the western Phillips 66 Site boundary. '*Stapple Road'* adjoins to '*Eastfield Road*', orientated east to west. *'Humber Road'* is denoted approximately 445 m south of the Phillips 66 Site. 'The village of '*South Killingholme'* is shown roughly 500 m south-west from the Phillips 66 Site. '*Houlton Farm'* and '*Cows Farm'* are shown approximately 800 m south-west from the Phillips 66 Site and several '*Pumps*' are shown associated with the farm. A '*Moat*' and '*Moat House'* are shown 600 m north-west from the site. A 'Pump' is shown approximately 435 m south from the Phillips 66 Site. Further '*Pumps*' are denoted between 500 m and 1 km from the Phillips 66 Site. A '*Spring*' is denoted approximately 640 m north-east of the Phillips 66 Site at 'Marsh Farm'. A 'Spring' is denoted approximately 140 m north-east.
1892	1:10,560	Very limited coverage to the north-west corner only.	Limited coverage of the area to the north of the Phillips 66 Site. No significant changes.
1907	1:2,500	No significant changes.	A '*Spring*' is denoted approximately 240 m north-west from the Phillips 66 Site. The '*Pump*' shown approximately 435 m south from the Phillips 66 Site is now denoted as a '*Well*'.
1908-1910	1:10,560	No significant changes.	A '*Well'* is denoted associated with 'Walmer House' approximately 590 m south of the Phillips 66 Site. Another '*Well*' is denoted approximately 500 m north-east from the Phillips 66 Site. A '*Spring*' is denoted approximately 655 m east from the Phillips 66 Site.
1931-1932	1:2,500	The '*L.N.E.R. Ulceby and Immingham Line'* railway is denoted orientated north-west to south-east. An embankment is shown either side of the railway	The railway line extends off site to the north-west and north-east. Towards the south-east, there are embankments either side of the railway and the railway tracks split into two directions. Towards the north-west, cuttings are denoted on either side of the railway which has been constructed underneath Eastfield Road. '*Signal Posts'* and '*Mile Posts'* are shown associated with

Date	Scale	Onsite Features	Off-Site Features
			the railway. The '*Well'* associated with '*Walmer House'* is no longer denoted. Several buildings are shown approximately 500 m south-west from the Phillips 66 Site. Buildings or structures denoted as '*Mission Room'* are located approximately 30 m north-east from the Phillips 66 Site. A '*School*' is denoted approximately 100 m south-east of the Phillips 66 Site. A building is denoted approximately 170 m north of the linear feature in the VPI Site. '*East Middle Mere Road'* is shown orientated north-east to south-west approximately 90 m north from the Phillips 66 Site. A small building is shown immediately south of '*East Middle Mere Road*'.
1932	1:10,560	No significant changes.	Slopes are denoted associated with a small unnamed road orientated north-east to south-west located approximately 25 m west from the Phillips 66 Site. A '*Pump*' is denoted approximately 840 m north-west from the Phillips 66 Site.
1938-1951	1:10,560	No significant changes.	A building is shown immediately south of the linear feature in the VPI Site.
1950-1951	1:10,560	No coverage.	Coverage of the area to the north of the Phillips 66 Site only. No significant changes.
1956	1:10,000	No significant changes.	A '*Telephone Call Box'* is shown approximately 170 m north from the linear feature in the VPI Site.
1964-1970 1964-1966	1:2,500	Another '*Drain'* is shown immediately north of the railway line orientated north-west to south-east. The linear feature is denoted within the land of the VPI Site is now identified as a 'Drain'.	Several '*Drains*' are denoted between 260 m and 335 m south-west from the site, and approximately 305 m south from the site. A network of interconnected 'Drains' are denoted to within 250 m east of the Drain within the VPI Site. immediately west of the area of the Phillips 66 Site to the west of '*Eastfield Road*'. Two '*Drains*' are shown approximately 330 m south of the Phillips 66 Site, orientated north to south. Further '*Drains*' are shown in all compass directions up to 1 km from the Phillips 66 Site boundary. '*Ponds*' are shown between 425 m and 680 m west and approximately 350 m and 800 m south-west. The buildings located approximately 500 m south of the Phillips 66 Site are now denoted as a '*Police Station'*, '*Stanwon*' and '*Anchorage*'. Two '*Refuse Heaps'* are denoted approximately 29 m and 98 m west of the Phillips 66 Site. '*Marsh'* land is denoted approximately 175 m west from the Phillips 66 Site. several buildings are shown associated with '*The Limits'* and '*The Gables'* located approximately 64 m north and 116 m north respectively. The '*Well*' located approximately 635 m north-east from the Phillips 66 Site is no longer denoted. The '*Springs*' located 655 m east and 975 m south-east from the Phillips 66 Site are no longer denoted. Buildings associated with '*Mission Room*' are also denoted '*Myrtle Villas, Westlea*'. The school is now denoted as '*Killingholme School*'.

Date	Scale	Onsite Features	Off-Site Features
1965-1968	1:10,000	No significant changes.	The '*Springs*' and '*Wells*' located around the Phillips 66 Site are shown again. The building located approximately 170 m north of the linear feature in the VPI Site is no longer denoted. A large number of 'Drains' are identified within a 1 km radius surrounding the Phillips 66 Site.
1970-1978	1:2,500 1:10,000	Small buildings are denoted in the south of the western areas of the Phillips 66 Site. '*Pipelines*' are denoted on the eastern Phillips 66 Site boundary. '*Drains*' are denoted orientated north to south and east to west near the railway lines. A slope towards the north is shown near the northern Phillips 66 Site boundary. Further railway lines are shown associated with the '*L.N.E.R. Ulceby and Immingham Line'* parallel to the northern Phillips 66 Site boundary.	Extensive industrial development is shown in the immediate surroundings of the Phillips 66 Site, including '*Tanks*', '*Chimneys*', '*Lighting Towers'*, a '*Flare Stack'*, '*Electric Sub Station*', and several unidentified buildings within 500 m south. A 'Depot' is located approximately 30 m south-east from the Phillips 66 Site. A *'Filling Station'*, '*Electric Sub Station'*, several '*Drains*' and a '*Warehouse*' are shown within 500 m south-west from the Phillips 66 Site. '*Tanks*' are shown within 520 m south of the site. One of the '*Refuse Heaps'* located to the north-west of the site now identified as a '*Refuse Tip'*. A '*Fire Station'* is denoted approximately 240 m north of the site. A '*Pipeline*' orientated east to west is located roughly 103 m north from the Phillips 66 Site. Further railway lines are shown that extend northwards. '*Drains*' and a '*Sluice*' are shown within approximately 260 m of the northern site boundary. A roundabout is shown associated with '*Humber Road'* immediately south of the Phillips 66 Site. A '*Depot*', '*Factory*' and '*Warehouses*' are shown approximately 300 m south-east from the Phillips 66 Site. Two '*Electric Sub Stations'* are denoted within 120 m east from the Phillips 66 Site. The '*Springs*' and '*Wells*' located around the site are no longer shown.
1973-1988	1:2,500	An '*Engine Shed*' is denoted associated with the railway lines in the north-east of the Phillips 66 Site. '*Pipelines*' are shown immediately north of the railway. The Phillips 66 Site is identified as an '*Oil Refinery*'.	'*Works*' and a '*Warehouse*' are denoted approximately 20 m and 60 m west of the Phillips 66 Site. '*Tanks'* are denoted associated with the '*Works*'. Further '*Tanks*' are denoted approximately 250 m north of the Phillips 66 Site. The '*Depot'* approximately 300 m south of the Phillips 66 Site is now identified as a '*Road Haul Depot*'. Further '*Drains*' are shown within 700 m south of the Phillips 66 Site. '*Pipelines'* extend from the northern Phillips 66 Site boundary to the north. A '*Garage*' is denoted approximately 350 m south-west of the Phillips 66 Site. The '*Police Station'* to the south-west of the Phillips 66 Site is no longer denoted. Additional railway tracks and a '*Level Crossing'* are shown orientated north to south approximately 150 m north from the Phillips 66 Site.
1985-1988	1:10,000	. No. significant changes.	The '*Refuse Heap'* is denoted over a wider area towards the west. An '*Electric Sub Station*' is shown approximately 225 m south-west and '*Works*' are denoted approximately 280 m south-west. The '*Depot*' to the south-east of the Phillips 66 Site is now identified as '*Warehouses*'.

Date	Scale	Onsite Features	Off-Site Features
1988	1:2,500	No significant changes.	Two '*Depots*' are shown approximately 30 m and 55 m west of the Phillips 66 Site. The '*Pond*' located 350 m south-west from the Phillips 66 Site is no longer denoted.
1994	1:2,500	A '*Chimney*' and a 'Tank' are shown in the western half of the Phillips 66 Site.	The building to the north of the drain in the VPI Site is no longer shown. '*The Limits'* and '*The Gables'* are no longer denoted, and a larger building is denoted in the same location to the north of the Phillips 66 Site. A '*Playing Field'* is denoted approximately 110 m north of the Phillips 66 Site. Further '*Tanks*' are shown within 250 m of the northern site boundary. The '*Depot*' to the south-east of the site is no longer identified as a '*Road Haul Depot'.* Several *'Ponds'* are denoted in approximately 10 m south.
1999 (Aerial Image)		Car parks are shown near the western Phillips 66 Site boundary. Industrial infrastructure is shown in the west of the site. Pipelines are shown over the railway sidings. A pipeline is shown adjacent to the northern site boundary in the VPI Site.	A car park is shown approximately 125 m north. A material stockpile is shown adjacent to the Phillips 66 Site boundary in the central area of the Phillips 66 Site.
2000	1:10,000	No significant changes.	Further '*Chimneys*' are denoted to the south of the Phillips 66 Site. Some of the tanks located 380 m south appear to be demolished and slopes are denoted around the tanks. A small building is shown within '*Refuse Tip'* and further buildings are shown 30 m west of the Phillips 66 Site. The '*Warehouse*' located roughly 60 m west of the Phillips 66 Site is now identified as a '*Depot*'. The '*Works*' and the '*Garage*' are no longer denoted to the west and south of the Phillips 66 Site respectively, however, the buildings are still shown. The '*Garage*' to the south of the Phillips 66 Site is no longer denoted. Some of the tanks located within 520 m of the southern Phillips 66 Site boundary appear to be demolished. Numerous '*Drains*' are shown within 1 km north and north-east. '*Mission Room'* is no longer denoted.
2006	1:10,000	Numerous small buildings have been constructed throughout the Phillips 66 Site.	The '*Refuse Tip'* is no longer denoted. The area to the south of the Phillips 66 Site is identified as an '*Oil Refinery'*. The '*Pipeline*' extending from the northern Phillips 66 Site boundary to the north is no longer shown. Industrial development has occurred within 70 m north-east in the area of the VPI Phillips 66 Site including '*Chimneys*', a '*Drain*' and ponds. However, it should be noted that Phillips 66 have confirmed that the industrial development occurred on the site in 2003. No mapping dated to 2003 is provided within the Envirocheck Report. A '*Fire Station'* is denoted approximately 100 m east. '*Myrtle Villas'* is no longer denoted, and it appears that the buildings associated with it have been demolished. The remaining building associated with '*Killingholme School'* appears to be demolished.

Date	Scale	Onsite Features	Off-Site Features
2021	1:10,000	Further small buildings are shown throughout the Phillips 66 Site. A '*Pipeline*' is identified near the northern site boundary.	'*Conveyors*' are denoted approximately 100 m south. Further '*Drains*' and '*Ponds*' are shown within 350 m south-west from the Phillips 66 Site. The '*Works*' located 20 m west from the Phillips 66 Site are now denoted as a '*Factory*' with a '*Conveyor*'. Further '*Pipelines*' are shown within 250 m north of the Phillips 66 Site. '*Cooling Towers'* are denoted approximately 180 m north-east from the Phillips 66 Site within the VPI Site. A '*Mast*' is shown roughly 38 m north of the Phillips 66 Site. A '*Balancing Pond'* is shown roughly 120 south from the site, and further surface water features, assumed to be ponds, are located roughly 150 m south-east from the drain in the VPI Site. The '*Warehouses*' to the east / south-east are now identified as a '*Depot*'. The '*Works*' in the south-west of the Phillips 66 Site are no longer denoted.

Source: Envirocheck Report (292199669_1_1) [13]

10A4.3 Planning Authority Records

10A4.3.1 VPI Site

The Planning Application Portals for North East Lincolnshire Council [23] and for North Lincolnshire Council [24] have been reviewed to provide information on historical planning applications submitted to the Local Authority. The historical planning applications for the VPI Site are summarised in Table 10A4.3.

Table 10A4.3 Summary of Planning Applications onsite

Date	Reference	Proposal	Decision
July 2017	PA/SCO/2017/3	Scoping opinion for VPI-Immingham Energy Park 'A' Power Station	Not yet determined
July 2022	PA/2022/1154	Application for a Lawful Development Certificate for a proposed installation of a battery storage facility, demolition of existing buildings and the redistribution of existing plant and storage within the existing operational area	Not yet determined

Source: North Lincolnshire Planning Application Portal [24] *and North East Lincolnshire Planning Application Portal* [23]

10A4.3.2 Phillips 66 Site

There are no historical planning applications for the Phillips 66 Site.

10A.5. Previous Ground Investigation Reports

This section presents a summary of the results of the existing ground investigation data available for areas within the Phillips 66 Site. There is no previous ground investigation data available for the VPI Site.

10A5.1 VPI Site

10A5.1.1 VPI Immingham Energy Park Phase 2 Geotechnical and Geoenvironmental Interpretative Report (AECOM, 2018)

A ground investigation was undertaken to the north of and adjacent to the northern VPI Site boundary in 2018 by SOCOTEC. A Ground Investigation Report was produced by AECOM dated to August 2018.

The ground investigation comprised of the following:

- three boreholes (BH1, BH2 and BH5) were drilled using cable percussion methods between 22.34 m bgl and 28.66 m bgl;
- three boreholes (BH3, BH4 and BH6) were drilled using cable percussion and extended by rotary core drilling / open hole drilling between 28.6 m bgl and 34.6 m bgl;
- three dynamic sampling holes were drilled between 3.75 m bgl and 5.45 m bgl;
- thirteen trial pits were excavated to depths between 2.5 m bgl and 4.60 m bgl;
- soil testing comprised of classification tests, consolidated and unconsolidated undrained triaxial tests, recompacted California Bearing Ratio (CBR) tests, consolidation tests, hydraulic cell tests and a soil chemical testing suite;
- soil and groundwater samples were analysed for chemical suite testing; and
- three rounds of groundwater and ground monitoring were undertaken between 11th May and 1st June 2018.

Key findings from the report are summarised as follows:

- the general sequence of strata comprised of:
    - Made Ground (ground level to 1.7 m bgl);
    - Glacial Till (ground level to 27.5 m bgl);
    - Glacial Sands and Gravels (12.9 m bgl to 16 m bgl);
    - Weathered Chalk (21.5 m bgl to 30.9 m bgl); and
    - Unweathered Chalk (26.1 m bgl to 30.9 m bgl, although the depth to base was not proven).
- one groundwater strike was recorded in granular Made Ground in TP7 at 0.7 m bgl;
- groundwater strikes were recorded in Glacial Till between 1 m bgl and 24 m bgl;
- groundwater strikes were recorded in Glacial Sands and Gravels between 3 m bgl and 13.5 m bgl;
- groundwater strikes were recorded in Chalk bedrock at 21.5 m bgl and 26.8 m bgl in two boreholes (BH3 and BH6);
- the groundwater levels encountered during the groundwater monitoring varied between 0.96 – 0.9 m bgl in WS04 to 3.7 – 3.97 m bgl in BH01;
- concrete aggressivity testing was undertaken on five samples of Made Ground and six samples of Glacial Deposits:

  - the classification for undisturbed ground in Made Ground was designated as DS-2, AC-2;
  - the classification for disturbed ground in Made Ground was designated as DS-2, AC-2;
  - the classification for undisturbed ground in Glacial Deposits was designated as DS-1, AC-1;
  - the classification for disturbed ground in Glacial Deposits was designated as DS-3, AC-3; and
  - the report notes that a high value of oxidisable sulphides (>0.3 %) was present in three out of four samples in Glacial Till which suggested pyritic ground was present.
- the report notes that visual and olfactory evidence of contamination was recorded (oily smell and black staining) within Made Ground in nine exploratory hole locations;
- asbestos was recorded in six out of twenty-five samples in the form of chrysotile fibre bundles at <0.001 w/w% between 0.3 m bgl and 1.25 m bgl;
- there were no exceedances of the human health GAC in soil and groundwater samples;
  - exceedances of the GAC criteria for groundwater were recorded as the following:
  - exceedance of Drinking Water Standards (DWS) for selenium (maximum concentration of 16 µg/l) in BH03;
  - exceedance of Environmental Quality Standards (EQS) for zinc (maximum concentration of 12 µg/l) in BH01, BH03 and WS05;
  - exceedance of EQS for sulphate (maximum concentration of 983,900 µg/l) in WS03 – WS06; and
  - exceedance of EQS for chloride (maximum concentration of 1,280,000 µg/l) in WS03 – WS05.
- the results of the ground gas monitoring indicated that the site would be classified as Characteristic Situation CS2. However, if all the Made Ground was removed during the construction works the site would be classified as CS1;
- the report notes that Made Ground cannot be relied on as a stable founding material due to the variable nature therefore shallow foundations should be placed in natural ground such as the firm to stiff clay in the Glacial Till
- the revised conceptual site model and environmental risk assessment indicated the potential residual risk to all receptors is considered Low.
- the residual risk associated with geotechnical risks is considered Low for variable Made Ground, limited information on the bedrock (Burnham Chalk Formation), unknown services and buried obstructions and high groundwater flow in granular soils and chalk.

10A5.1.2 Geotechnics Limited, November 2022. VPI Immingham Humber Zero PCC FEED Factual and Interpretative Report Draft (PY220483)

A GI was undertaken within the undeveloped land of the VPI Site by Geotechnics Limited between 5th and 12th September 2022.

Key findings within the report are summarised as follows:

- the GI comprised the following:
  - twenty inspection pits to 1.2 m bgl in the location of Cone Penetration Test (CPT) locations;
  - ten CPT's between 14.58 m bgl and 15.3 m bgl undertaken by Lankelma Limited;
  - four cable percussion boreholes (BH01, BH02, BH02A, BH05) to depths between 21.75 m bgl and 23.08 m bgl. However, the presence of a concrete obstruction resulted in the termination of BH02 at 0.9 m bgl. The report notes that an additional two boreholes (BH03 and BH04) will be completed during an additional phase of investigation; and

  - groundwater and ground gas monitoring in boreholes BH01 and BH02A between 9 m bgl to 10 m bgl and 18.4 m bgl and 19.4 m bgl respectively.

- the following strata was encountered:
  - topsoil between ground level and 0.3 m bgl;
  - Made Ground between ground level and 1.7 m bgl;
  - clay between 0.05 m bgl and 18 m bgl;
  - sand between 13 m bgl and 15.4 m bgl;
  - gravel between 15 m bgl and 18.2 m bgl; and
  - chalk at a minimum depth of 17.5 m bgl.
- groundwater strikes were encountered between 7 m bgl and 13 m bgl within clay. Groundwater strikes were recorded in sand and gravel at 14.9 m bgl and 15 m bgl respectively. One groundwater strike was recorded within chalk bedrock at 18.7 m bgl;
- the results of the human health risk assessment indicated that there were no exceedances of the human health GAC within seven soil samples analysed;
- no asbestos was detected in seven screened samples;
- the results of the controlled waters risk assessment indicated an EQS exceedances of zinc in BH01 (20 µg/l). EQS and DWS exceedances were also recorded for Aliphatics >C16-C21 (26 ug/l) and >C21-C34 (14 ug/l) and exceedances of EQS and DWS were also recorded for Aromatics >C16-C21 (19ug/l) in BH02A. However, Geotechnics consider this to be a minor exceedance and therefore not an indication of significant hydrocarbon contamination;
- the results indicated an exceedance of copper was recorded for EQS, however, a m-BAT tool was used resulting in a modified EQS which was greater than the recorded concentration of copper in BH01; and
- the results of the ground gas monitoring undertaken on four visits between 30th September 2022 and 31st October 2022 indicate that there is no significant source of ground gas at depth. Geotechnics note that the ground gas regime is designated as Gas Regime A and there are no ground gas protection measures required.

10A5.2 Phillips 66 Site

10A5.2.1 Ramboll, December 2020. Humber Refinery, South Killingholme, IPPC Permit UP3230LR: Reporting of the Site Protection and Monitoring Programme

A groundwater investigation and sampling programme was conducted by Ramboll between 20th and 23rd October 2020 on the wider Phillips 66 Refinery Site and a report on the programme was produced [25]. It should be noted that this includes areas of the Phillips 66 Humber Refinery Site to the south the A160 Humber Road that are not considered as part of this desk study. Monitoring was conducted in boreholes BH1 to BH34 (not including BH3 and BH5) and samples were obtained from 6 boreholes. It should be noted that this includes boreholes located in the Humber Refinery Site to the south of the A160 Humber Road. The depth to base in the boreholes was recorded between 2.15 m bgl and 15.29 m bgl.

10A5.2.2 Ramboll, 2020. Humber Refinery, South Killingholme: Interpretative Environmental Site Assessment.

An interpretative report [26] was compiled by Ramboll to assess possible contamination on the wider Phillips 66 Refinery Site and the risks to key receptors as part of a monitoring programme that is undertaken every three years. The boreholes on the wider Phillips 66 Humber Refinery Site were installed in 2008. It should be noted that this includes areas of the Phillips 66 Humber Refinery Site to the south the A160 Humber Road that are not considered as part of this desk study. The findings within the Ramboll report are summarised as follows:

- previous ground investigation (GI) data recorded Made Ground to <2 m depth and Glacial Till to the base of boreholes (15 m bgl);

- the Ramboll 2008 GI data did not record chalk deposits as the depth to the base of the Glacial Till was not proven. However, borehole logs were not provided in the report to confirm this;
- groundwater was mostly encountered between 0.6 m bgl and 2.4 m bgl, although the resting levels were between 0.00 m bgl and 4.91 m bgl;
- the response zone of boreholes which encountered groundwater were located within the Glacial Till;
- groundwater flow directions within the Glacial Till are described as inconsistent. Groundwater flow within the Glacial Till beneath the wider Phillips 66 Humber Refinery Site to the north of the A160 Humber Road is suggested to be from central areas to northern and southern directions. It is suggested by Ramboll that the Glacial Till may restrict (attenuate?) shallow groundwater flow;
- GAC exceedances were recorded in some metal, inorganic and organic determinands;
- Ramboll suggested there is not a significant contamination risk as there is not a spatial widespread pattern of contamination;
- groundwater flow is considered to be discontinuous due to the low permeability of clay (presumed to be Glacial Till); no further information or interpretation is provided;
- the risks were concluded to range between *Low* and *Low to Moderate* for human health and controlled waters in the conceptual site model;
- it is suggested that the clay deposits which are the predominant lithology in the Glacial Till with a thickness of at least 15 m bgl, provide good protection to the Chalk aquifer. However, it should be noted that no samples were obtained from the Chalk as the boreholes terminated in the Glacial Till deposits;
- most of the exceedances of GAC do not present a contamination risk in Ramboll's opinion as there are no sensitive water resources near the wider Phillips 66 Humber Refinery Site. However, further investigation is recommended by Ramboll for chlorinated Volatile Organic Compounds (VOCs) in BH29 and hydrocarbons in BH6A and BH29; and
- the groundwater quality is not considered by Ramboll to be deteriorating, although it is recommended by Ramboll that BH29 should be monitored regularly due to the increasing EPH and TCE concentrations. A further investigation and assessment of BH29 is also recommended for consideration by Phillips 66.

10A.6. Regulated Activities and Statutory Consultation

Regulated activities within 250 m of the Sites could, depending upon their nature, represent potential off-site sources of contamination. Whilst a 1 km search area was generally adopted; this section places emphasis on those activities within 250 m.

10A6.1 Regulated Processes

10A6.1.1 VPI Site

Table 10A6.1 summarises pertinent regulatory information obtained from the Envirocheck Report (285387654_1_1) [12] for records of regulated potentially contaminative industrial activities within 250 m of the VPI Site. Full details of all regulatory information are available within the Envirocheck Report (285387654_1_1) [12].

Table 10A6.1 Summary of Regulatory Information for the VPI from the Envirocheck Report (285387654_1_1) [12]

Subject	No. of Records Onsite	No. of Records 0-50 m	No. of Records 50-250 m	Description of Records Onsite
Waste				
Potentially Infilled Land (Water)	0	1	0	-
Hazardous Substances				
Control of Major Accidents Hazards Sites (COMAH)	4	0	0	• Conocophillips Power Operations Limited. Type: Lower Tier. Status: Active. • Humber Lpg Terminal Limited. Type: Upper Tier. Status: Active. • VPI Immingham Llp. Type: Lower Tier. Status: Active. • VPI Immingham Llp. Type: Lower Tier. Status: Active.
Planning Hazardous Substance Consents	1	0	1	• Immingham Chp Llp. Hazardous Substance: Automotive petrol and other petroleum spirits. Application Date: Not Supplied. Decision: Deemed consent granted.
Agency and Hydrological				
Discharge Consents	0	0	10	-
Integrated Pollution Prevention and Control	10	0	1	• Three records for Immingham Chp Llp. Effective Dates: 16th August 2001, 1st May 2003 and 28th October 2004. Status: Superseded By Variation. Activity Description: Combustion; Any Fuel Greater Or Equal To 50Mw. • Two records for Vpi Immingham Llp. Effective Dates: 1st January 2016 and 14th November 2019. Status: Superseded By Variation. Activity Description: Combustion; Any Fuel Greater Or Equal To 50Mw. • Four records for Vpi Immingham Llp. Effective Dates: 30th April 2007, 4th June 2009, 14th November 2014, 12th July 2018. Status: Superseded By

Subject	No. of Records Onsite	No. of Records 0-50 m	No. of Records 50-250 m	Description of Records Onsite
				Variation. Activity Description: Combustion; Any Fuel Greater Or Equal To 50Mw. • One record for VPI Immingham Llp. Effective Dates: 28th February 2020. Status: Effective. Activity Description: Combustion; Any Fuel Greater Or Equal To 50Mw. • VPI Immingham B Limited. Effective Date: 22nd November 2019. Status: Effective. Activity Description: Combustion; Any Fuel Greater Or Equal To 50Mw.
Local Authority Pollution Prevention and Controls	0	0	1	-
Pollution Incidents to Controlled Waters	1	2	3	• Onsite at a domestic/residential property type. Pollutant: Sewage – Septic Tank Effluent. Note: Tributary South Killingholme Main Drain. Incident Date: 1st June 1998. Cause: Wrong Connection. Incident Severity: Category 3 – Minor Incident.
Substantiated Pollution Incident Register	0	1	0	-
Industrial Land Use				
Contemporary Trade Directory Entries	0	0	1	-
Points of Interest – Commercial Services	0	0	1	-
Points of Interest – Manufacturing and Production	0	0	5	-

Source: Envirocheck Report (285387654_1_1) [12]

10A6.1.2 Phillips 66 Site

Table 10A6.2 summarises pertinent regulatory information obtained from the Envirocheck Report (292199669_1_1) [13] for records of regulated potentially contaminative industrial activities within 250 m of the Phillips 66 Site. Full details of all regulatory information are available within the Envirocheck Report (292199669_1_1) [13].

Table 10A6.2 Summary of Regulatory Information for the Phillips 66 site from the Envirocheck Report (292199669_1_1)

Subject	No. of Records Onsite	No. of Records 0-50 m	No. of Records 50-250 m	Description of Records Onsite
Waste				
Potentially Infilled Land (Water)	2	0	0	• Unknown Filled Ground (Pond, marsh, river, stream, dock etc) dated 1956.
Hazardous Substances				

Subject	No. of Records Onsite	No. of Records 0-50 m	No. of Records 50-250 m	Description of Records Onsite
Control of Major Accident Hazards Sites (COMAH)	0	0	2	• The wider Phillips 66 Refinery Site is classified as an active upper tier COMAH site.
Notification of Installations Handling Hazardous Substances (NIHHS)	0	0	1	-
Planning Hazardous Substance Consents	0	0	2	-
Agency and Hydrological				
Discharge Consents	2	4	6	• Conoco Ltd previously held 2 discharge consents for Trade Effluent into South Killingholme Main Drain and a Tributary of South Killingholme Main Drain. Revocation dates were 24th March 1994 and 7th May 1991 respectively.
Integrated Pollution Controls	0	0	14	-
Integrated Pollution Prevention and Controls	0	7	6	-
Local Authority Pollution Prevention and Controls	0	0	3	-
Pollution Incidents to Controlled Waters	4	2	3	• Property Type: Oil Industry (Not Garages). Pollutant: Oils - Other Oil. Note: South Killingholme Main Drain. Incident Date: 15th June 1997. Cause: Other Cause. Incident Severity: Category 2 - Significant Incident. • Property Type: Not Given. Incident Date: 2nd March 1993. Pollutant: Unknown. Note: Unnamed Stream. Cause: Unknown. Incident Severity: Category 3 - Minor Incident. • Onsite at a domestic/residential property type. Pollutant: Sewage – Septic Tank Effluent. Note: Tributary South Killingholme Main Drain. Incident Date: 1st June 1998. Cause: Wrong Connection. Incident Severity: Category 3 – Minor Incident.
Prosecutions Relating to Authorised Processes	0	0	1	-
Registered Radioactive Substances	0	0	6	-
Substantiated Pollution Incident Register	1	0	0	• Authority: Environment Agency - Anglian Region, Northern Area. Incident Date: 13th December 2004. Water Impact: Category 2 - Significant Incident. Air Impact: Category 3 - Minor Incident. Land Impact: Category 3 - Minor Incident. Pollutants: Oils – Crude. •
Industrial Land Use				

Subject	No. of Records Onsite	No. of Records 0-50 m	No. of Records 50-250 m	Description of Records Onsite
Contemporary Trade Directory Entries	0	0	18	-
Points of Interest – Commercial Services	0	0	4	-
Points of Interest – Manufacturing and Production	2	4	29	• 2 entries for Tanks. Category: Industrial Features. Class Code: Tanks (Generic). •
Points of Interest – Public Infrastructure	0	0	1	-

Source: Envirocheck Report (292199669_1_1) [13]

10A6.2 Licensed Waste Management Facilities

10A6.2.1 VPI Site

An attempt has been made to identify any landfilling operations, past and present that have taken place in the vicinity of the VPI Site. A summary is provided in Table 10A6.3.

Table 10A6.3 Waste Management Facilities (<1 km of the VPI Site)

National Grid Reference	Distance and Direction	Name	Operator	Dates	Permitted Wastes	Details
517324 416626	290 m SE	Historical Landfill Site: Landfill Site - South Killingholme	Landfill Site - South Killingholme	Not Supplied	Deposited Waste included Industrial Waste	-
516999 416356	381 m S	Historical Landfill Site: Conoco	Not Supplied	First Input Date: 31st July 1975 Last Input Date: Not Supplied	Deposited Waste included Industrial Waste and Liquid Sludge	-
516502 417339	130 m NW	Historical Landfill Site: Lindsey Oil Refinery	Not Supplied	First Input Date: 31st December 1986 Last Input Date: Not Supplied	Deposited Waste included Liquid Sludge	-
517086 416125	612 m S	Historical Landfill Site: Conoco	Not Supplied	First Input Date: 30th June 1975 Last Input Date: Not Supplied	Deposited Waste included Industrial Waste and Liquid Sludge	-
517737 417167	620 m S	Historical Landfill Site: Marsh Lane	Geostore Limited	First Input Date: 31st December 1985 Last Input Date: 31st December 1987	Deposited Waste included Inert Waste	-

National Grid Reference	Distance and Direction	Name	Operator	Dates	Permitted Wastes	Details
515815 416541	795 m W	Historical Landfill Site: South Killingholme Conoco	Not Supplied	Not Supplied	Not Supplied	-
516500 417500	250 m NW	Licenced Waste Management Facility	Lindsey Oil Refinery Ltd	Licence Issued: 6th November 1985 Surrendered: 18th October 2008.	Treatment: Biological	-
		Registered Waste Treatment or Disposal Site	Lindsey Oil Refinery Ltd	6th November 1985	Interceptor Pit Wastes Special Wastes (As In '96 Regs) Tank Cleaning Sludge Special Wastes (As In S17 1980)	Licence Status: Operational as far as is known. Max Input Rate: Very Small (Less than 10,000 tonnes per year)
517600 416500	584 m SE	Licenced Waste Management Facility	Tioxide Europe Ltd	Licence Issued: 8th October 1991 Surrendered: 6th November 2007.	Industrial Waste Landfill	-
		Registered Landfill Site	Tioxide UK Ltd	8th October 1991	Industrial Non-Hazardous. Waste Soil, Subsoil, Non-Hazardous Excavation Waste Washed Scrap Iron	Status: Site dormant Max Input Rate: Small (Equal to or greater than 10,000 and less than 25,000 tonnes per year)
516900 415800	945 m S	Licenced Waste Management Facility	Phillips 66 Limited	Licence Issued: 13th December 1987 Modified: 13th November 2014	Treatment: Biological	Licence Status: Closed
516950 416250	493 m S	Licenced Waste Management Facility	Conoco Ltd	1st April 1997	Sludge From Holding Ponds Special Wastes (As In '96 Regs)	Status: Site Closed Max Input Rate: Very Small (Less than 10,000 tonnes per year)
517736 417164	619 m E	Registered Landfill Site	Geostore Ltd	23rd October 1984	Excavated Natural Materials	Status: Licence lapsed / cancelled / defunct / not applicable / surrendered / cancelled

National Grid Reference	Distance and Direction	Name	Operator	Dates	Permitted Wastes	Details
517050 416050	685 m S	Registered Landfill Site	Conoco Ltd	6th August 1979	Sludge Ex Ponds At Killingholme	Status: Record Superseded Max Input Rate: Very Small (Less than 10,000 tonnes per year)
516340 416635	322 m SW	Registered Waste Treatment or Disposal Site	Conoco Ltd	23rd March 1991	Phosphoric Acid Spent Alumina Containing Aluminium Fluoride Spent Polymer'N Catalyst	Licence Status: Site Exempt Max Input Rate: Medium (Equal to or greater than 25,000 and less than 75,000 tonnes per year)
517324 416624	291 m SE	Licenced Waste Management Facility (Landfill Boundaries)	Tioxide Europe Ltd	8th October 1991	Industrial Waste	Max Input Rate: Not Supplied

Source: Envirocheck Report (285387654_1_1) [12]

10A6.2.2 Phillips 66 Site

An attempt has been made to identify any landfilling operations, past and present that have taken place in the vicinity of the Phillips 66 Site. A summary is provided in Table 10A6.4.

Table 10A6.4 Waste Management Facilities (<1 km of the Phillips 66 Site)

National Grid Reference	Distance and Direction	Name	Operator	Dates	Permitted Wastes	Details
515771 416518	140 m S	Historical Landfill Site: South Killingholme Conoco	Not Supplied	Not Supplied	Not Supplied	-
515145 416675	22 m NW	Historical Landfill Site: Eastfield Road Landfill Site	J W Stanley	First Input: 1st December 1975 Last Input: 1st March 1988	Deposited Waste included Inert, Industrial, Commercial, Household and Special Waste, and Liquid Sludge	-
516999 416356	488 m SW	Historical Landfill Site: Conoco	Not Supplied	First Input Date: 31st July 1975 Last Input: Not Supplied	Deposited Waste included Industrial Waste and Liquid Sludge	-
517324 416626	320 m SE	Historical Landfill Site: Landfill Site -	Landfill Site - South	Not Supplied	Deposited Waste included Industrial Waste	-

National Grid Reference	Distance and Direction	Name	Operator	Dates	Permitted Wastes	Details
		South Killingholme	Killingholme			
517086 416125	720 m S	Historical Landfill Site: Conoco	Not Supplied	First Input: 30th June 1975 Last Input: Not Supplied	Deposited Waste included Industrial Waste and Liquid Sludge	-
517807 417076	630 m E	Historical Landfill Site: Marsh Lane	Geostore Limited	First Input Date: 31st December 1985 Last Input Date: 31st December 1987	Deposited Waste included Inert Waste	-
516332 417773	430 m NE	Historical Landfill Site: Lindsey Oil Refinery	Not Supplied	First Input Date: 31st December 1986 Last Input Date: Not Supplied	Deposited Waste included Liquid Sludge	-
515759 417752	753 m NE	Historical Landfill Site: Lindsey Oils Site C	Not Supplied	Not Supplied	Not Supplied	-
515361 417898	828 m NW	Historical Landfill Site: Lindsey Oil Refinery Site A and C	Lindsey Oil Refinery Limited	First Input Date: 31st December 1960 Last Input: 31st December 1989	Deposited Waste included Inert, Industrial, Household and Special Waste, and Liquid Sludge	-
517324 416624	320 m SE	Licensed Waste Management Facilities (Landfill Boundaries)	Tioxide Europe Ltd	8th October 1991	Industrial Waste	Licence Status: Inactive
515488 418024	992 m N	Licensed Waste Management Facilities (Landfill Boundaries)	Prax Lindsey Oil Refinery Ltd	14th June 1977	Industrial Waste Landfills	Licence Status: Modified
515300 417000	91 m NW	Licensed Waste Management Facilities (Locations)	Wastewise Waste Management Services Ltd	Issued: 7th December 1992		Licence Status: Surrendered.

National Grid Reference	Distance and Direction	Name	Operator	Dates	Permitted Wastes	Details
		Registered Waste Transfer Sites	Humberside Wastewise W.M. Servs. Ltd	Licence Surrendered: 7th December 1992	Household / Civic Amenity Waste, Non-Hazardous. Industrial / Commercial Waste	Licence Status: Licence has completion certificate surrendered Max Input: Very Small (Less than 10,000 tonnes per year)
517600 416500	625 m SE	Licensed Waste Management Facilities (Locations)	Tioxide Europe Ltd	Licence Issued: 8th October 1991 Surrendered: 6th November 2007	Industrial Waste Landfill	-
		Registered Landfill Site	Tioxide Uk Ltd	8th October 1991	Industrial Non-Hazardous. Waste Soil, Subsoil, Non-Hazardous Excavation Waste Washed Scrap Iron	Status: Site dormant Max Input Rate: Small (Equal to or greater than 10,000 and less than 25,000 tonnes per year)
516900 415800	950 m SE	Licensed Waste Management Facilities (Locations)	Phillips 66 Limited	Licence Issued: 13th December 1987 Modified: 13th November 2014	Treatment: Biological	Licence Status: Closed
516500 417500	601 m E	Licensed Waste Management Facilities (Locations)	Lindsey Oil Refinery Ltd	Licence Issued: 6th November 1985 Licence Surrendered: 18th October 2006	Treatment - Biological	Status: Surrendered
		Registered Waste Treatment or Disposal Sites	Lindsey Oil Refinery Ltd	6th November 1985	Interceptor Pit Wastes Special Wastes (As In '96 Regs), Tank Cleaning Sludge	Licence Status: Operational as far as is known Max Input: Very Small (Less than 10,000 tonnes per year)
515500 418000	969 m N	Licensed Waste Management Facilities (Locations)	Lindsey Oil Refinery Ltd	Licence Issued: 14th June 1977 Licence Modified:	Industrial Waste Landfills	Licence Status: Modified

National Grid Reference	Distance and Direction	Name	Operator	Dates	Permitted Wastes	Details
				9th March 1977		
				14th June 1977	Household, Commercial And Industrial Waste Landfills	Licence Status: To PPC
515100 416900	314 m NW	Registered Landfill Sites	Humberside C.C.	1st December 1980	Cover Material, Household Waste	Status: Status: Licence lapsed / cancelled / defunct / not applicable / surrendered / cancelled
516950 416250	546 m SE	Registered Landfill Sites	Conoco Ltd	Site Closed: 1st April 1997	Sludge From Holding Ponds, Special Wastes (As In '96 Regs)	Max Input: Very Small (Less than 10,000 tonnes per year)
517050 416050	760 m SE	Registered Landfill Site	Conoco Ltd	6th August 1979	Sludge Ex Ponds At Killingholme Ref'Y	Status: Record superseded Max Input: Very Small (Less than 10,000 tonnes per year)
517801 417072	630 m NE	Registered Landfill Sites	Geostore Ltd	23rd October 1984	Excavated Natural Materials	Status: Licence lapsed / cancelled / defunct / not applicable / surrendered / cancelled
515300 417900	867 m NW	Registered Landfill Sites	Lindsey Oil Refinery Ltd	1st June 1977	Interceptor Pit Wastes, Tank Cleaning Sludge	Status: Licence lapsed / cancelled / defunct / not applicable / surrendered / cancelled Max Input: Very Small (Less than 10,000 tonnes per year)
516340 416635	135 m S	Registered Waste Treatment or Disposal Sites	Conoco Ltd	23rd March 1991. Phillips 66 have confirmed the site closed in October 2003.	Phosphoric Acid, Spent Alumina Containing Aluminium Fluoride, Spent Polymer'N Catalyst	Licence Status: Site Exempt Max Input Rate: Medium (Equal to or greater than 25,000 and less than 75,000 tonnes per year)
515435 417740	705 m NW	Registered Waste Treatment or Disposal Sites	Lindsey Oil Refinery Ltd	26th July 1991	Phosphoric Acid, Spent Polymer'N Catalyst	Licence Status: Site Exempt Max Input Rate: Small (Equal to or greater than 10,000 and less than 25,000 tonnes per year)

Source: Envirocheck Report (292199669_1_1) [13]

10A6.3 Unexploded Ordnance

10A6.3.1 VPI Site

According to the regional unexploded ordnance (UXO) risk maps published by Zetica [27], VPI Site lies within a zone that is classified as *Low Bomb Risk*. However, two Luftwaffe Targets are identified within Immingham Docks located approximately 2 km and 3 km south-east from the VPI Site.

10A6.3.2 Phillips 66 Site

The Zetica UXO risk maps [27] also indicate the Phillips 66 Site is designated as a *Low Bomb Risk*. Other strategic targets identified include Immingham Docks located approximately 1.7 km south-east and utilities located approximately 2.3 km north-west and 3.6 km south-east from the centre of the Phillips 66 Site.

10A.7. Site Reconnaissance

10A7.1 VPI Site

A Site walkover of the undeveloped land to the south of the existing VPI CHP Plant was undertaken by two AECOM engineers on 5th May 2022. A summary of the observations made during the visit is provided as follows and a photographic record is included in Annex B.

The VPI Site was accessed through a lay-by area located off Rosper Road to the east of the VPI Site (Photo 1). The eastern boundary of the VPI Site is fenced off using a combination of wooden fences and a gated entrance, leading to a track comprising of hardstanding through the site orientated east to west, parallel to a drain flowing through the VPI Site. Towards the west, the hardstanding of the track is covered by vegetation (Photo 2).

A drain (South Killingholme Drain) is located through the centre of the undeveloped land within the VPI Site, flowing west to east. Near the eastern VPI Site boundary, the drain splits into to culverted drains beneath Rosper Road (Photo 3). Two porthole-like features are visible within the concrete surrounding the drain and culverted drain which contained flowing water directed into the drain (Photo 4). The length of the drain through the VPI Site was observed during the walkover. The bank on the northern side of the drain comprises of dense and thick vegetation on a steep slope (Photo 5). On the southern side of the drain, the slope angle and density of vegetation is lower (Photo 6). Areas of the drain contains thick vegetation and silt deposits which increased upstream towards the west, as shown in Photos 8 to 9. Towards the western VPI Site boundary, the drain flows underground beneath the hardstanding track and returns to the ground surface at the western VPI Site boundary (Photo 10).

The hardstanding track and drain through the centre of the undeveloped land within the VPI Site lead to a series of interconnected above ground pipelines that are orientated north-west to south-east, parallel to the western VPI Site boundary (Photo 11). A structure containing overhead pipelines is located at the VPI Site boundary, which is directed off-site towards the railway, as shown in Photos 12 and 13. Traffic cones are positioned near the pipelines. A pipe and sheet of material are stored near the pipelines (Photos 14 and 15). The drain near the western VPI Site boundary, in close proximity to these pipelines, contains a thick material deposit. The colour of the deposit changes from white to dark brown downstream across a small section of the drain. This deposit is limited to a small area before the drain flows underneath the hardstanding track in the west of the VPI Site (Photo 16). A footpath was observed from the pipelines and drain in the west of the VPI Site which could not be accessed due to overgrown vegetation.

A rusty pipeline is located in the centre of the undeveloped land within the VPI Site, orientated east to west immediately south of the hardstanding track (Photos 17 and 18). The pipeline cannot be traced towards the western VPI Site boundary as the vegetation on the VPI Site is overgrown and conceals sections of the pipeline (Photo 19). It is unclear where the pipeline leads to, and it appears to be disused. Fly tipped waste comprising of a rusty refrigerator, rusty metal sheeting, fabric sheeting and a tyre is located in the centre of the undeveloped land within the VPI Site near the rusty pipeline (Photos 20 to 24).

The remainder of the undeveloped land within the VPI Site to the south of the drain comprises of vegetation that varies in both type and density. The land near the rusty pipeline mostly comprises of grassland (Photo 25), whereas the land near the fly tipped waste comprises of overgrown nettle like vegetation (Photo 26). A row of mature trees is located in the southern half of the VPI Site and along the western site boundary (Photos 27 and 28). Towards the south and south-east, the vegetation is approximately 1 m high (Photos 28 and 29). In the centre of the undeveloped land within the VPI Site, it was noted that the ground underfoot in grassland areas was spongy and uneven. Near the southern VPI Site boundary, the vegetation is less overgrown (Photos 30 to 33).

A vertical gas pipeline is located near the southern VPI Site boundary (Photo 34). The railway embankment to the south of the VPI Site is shown in Photo 35. A tall structure and small building are contained within a fenced off area between the southern VPI Site boundary and railway embankment (Photo 36). A gravelled track leads from Humber Road towards the railway embankment with gabion retaining structures located alongside the western edge of the gravel track (Photo 37).

The western VPI Site boundary comprises of a row of mature trees and overgrown vegetation with grassland towards the centre of the VPI Site (Photos 38). A traffic cone and concrete service posts are located near the western VPI Site boundary amongst overgrown vegetation.

The area to the east of the VPI Site, south of the drain, could not be accessed due to the overgrown nature of vegetation.

The northern area of undeveloped land to the north of the drain could not be accessed due to the density of vegetation and high fencing across the VPI Site. This area of the VPI Site was observed from a small lay-by off Rosper Road near the junction with Marsh Lane (Photo 39). The eastern VPI Site boundary is delineated by tall, wired fencing. A further drain is located offsite on the ground surface and underground beneath the lay-by, parallel to the site boundary (Photos 40 and 41). Waste and litter are located outside the VPI Site boundary near the lay-by area (Photos 41 and 42). A green telephone box is also located outside the VPI Site boundary in the northern area of the VPI Site (Photo 43). Intermediate Bulk Containers (IBCs) filled with gravel are located within the site boundary adjacent to the boundary fence (Photos 44 and 45). From the eastern VPI Site boundary, areas of hardstanding and vegetation was observed (Photo 46). Two floodlights are located in the eastern half of the VPI Site. Stockpiles of material of an unknown source are located near the northern site boundary, which separates the undeveloped land from the existing VPI Site (Photo 47).

10A7.2 Phillips 66 Site

A Site walkover of the Phillips 66 Site was undertaken by an AECOM engineer and an employee of Phillips 66 on 23rd November 2022. The following text provides an overview of the Phillips 66 Site using Google Earth imagery dated to June 2021 and a summary of the site from observations during the site walkover.

The western boundary of the Phillips 66 Site comprises hardstanding which is currently used as a car park. A thin row of vegetation separates the hardstanding used as a car park from a hardstanding area used for storage purposes. This area of the site was not visited during the site walkover.

The western extent of the Site comprises hardstanding construction laydown area that is currently used for storage of construction materials such as pipes and scaffolding. An office and warehouse building are located to the south of the construction laydown area. Several shipping containers, some of which were used as welfare cabins, and lighting towers are located throughout this area. At the time of the site visit, ponding of rainwater was visible throughout the construction laydown area. There is a pipeline in along the northern Phillips 66 Site boundary, through the centre of the hardstanding storage area for various materials including pipes and metal containers.. A surfaced road is located to the east of the construction laydown area, which is orientated north to south. The topography throughout this area is relatively flat, however, in the north-west corner of the site, there is an area of flat raised ground which is also used as a construction laydown area. This area is at an elevated height compared to the nearby areas of the Site and is accessed via a metal staircase over the pipeline running through the centre of the construction laydown area. At the time of the site visit, this area of the site had fewer construction materials stored compared to the laydown area further south and comprised hardstanding ground. The elevated laydown area is separated into two areas via mesh fencing in the centre orientated north to south. Multiple oil drum containers aligned in rows orientated north to south were located in the fenced area adjacent to the western site boundary at the time of the visit. Some small areas of litter were observed in this area.

The area of the Phillips 66 Site located adjacent to the hardstanding storage area to the east comprises further hardstanding and refinery infrastructure such as multiple ground level and overhead pipelines. The infrastructure is located at height, which is visible from a distance on nearby roads (A160) on the approach to the Phillips 66 Site. The area is separated into blocked structures via surfaced roads and pedestrian footpaths. A large flue-gas stack tower is located within the centre of the area. This area of the site is designated as the fluid catalytic convertor (FCC) processing unit and the crudes processing unit.

There is a surfaced road and several small buildings located along the northern boundary of the Phillips 66 Site, parallel to the railway sidings. At the time of the site visit, there was ponding on the northern side of the road. In the west of the site, there are minor vegetated cuttings either side of the railway sidings which separate the railway sidings from the railway line to the north and the Phillips 66

Proposed Development Boundary in the south. Towards the east, the cuttings reduce in gradient and are no longer present resulting in a relatively flat topography. Another pipeline is located along the northern Phillips 66 Site boundary, parallel to the railway sidings located off-site. This pipeline terminates in the centre of the northern Phillips 66 Site boundary. Shipping container style buildings containing electric sub stations are located adjacent to the surfaced road. Stockpiles of railway ballast were stored within the Phillips 66 Site boundary adjacent to the railway sidings. An area of waste material stockpiles to either be reused on site or disposed off-site are located off-site adjacent to the Phillips 66 Site boundary in the centre of the Site. The waste stockpiles are segregated using a walled concrete structure. At the time of the site visit, the material stockpiles may have contained Made Ground, sand and sandbags. A large walled concrete structure separates the southern site boundary from the surfaced road adjacent to the railway lines. Multiple petroleum coke stockpiles are stored within the confines of the walled structure. The stockpile height extended above the walled structurewith a mixture of finer material and larger boulders. There are waste disposal areas located immediately to the south of the Phillips 66 Site boundary which contained separate waste bins for general waste, scrap waste and oil waste.

The triangular area in the eastern half of the Phillips 66 Site comprises of hardstanding, with multiple pipelines orientated east to west along the southern boundary. A railway track is located within the Phillips 66 Site orientated north-east to south-west, leading to a small building. The track crosses the surfaced road and leads towards a building within the wider refinery site. Instrument houses and small buildings are also located within this area of the Phillips 66 Site. The pipelines at the southern boundary extend across the railway sidings and railway lines via a pipeline overbridge towards the VPI Site. A smaller pipeline bridge is located to the west, which extends over the railway sidings to fill railway tank wagons. At the time of the site visit, there were multiple tank wagons on the railway sidings. Vegetation is located either side of the railway lines. There are no cuttings either side of the railway. There is an area of hardstanding between the railway sidings and vegetation which separates the sidings from the railway lines. Holding ponds are located to the south, which are fenced off with concrete walls and metal structures.

The eastern extent of the Phillips 66 Site comprises of vegetated land and a hardstanding track which overlaps with the VPI Site. This area of the Phillips 66 Site was visited as part of the site walkover for the VPI Site. As discussed in Section 7.1, this area of the VPI Site is bounded by a row of mature trees and overgrown vegetation and grassland. Interconnected above ground pipelines were observed parallel to the Phillips 66 Site boundary. A drain (South Killingholme Drain) encroaches onto the application site boundary of the Phillips 66 Site. In the area of the pipelines, the drain contained a thick material deposit that varied in colour from white to dark brown downstream of the drain. A pipe and sheet of material were stored near to the pipelines. A footpath is located parallel to the pipelines which could not be accessed at the time of the site walkover due to vegetation growth. A vertical gas pipeline was observed on the eastern boundary of the Phillips 66 Site, near to the tall structure and small building within a fenced off area discussed in Section 7.1.

10A.8. Initial Conceptual Site Model (iCSM)

10A8.1 Introduction

This section is aimed at identifying possible risks, if any, arising from substances used or deposited onsite, or from other sources of land contamination. Both past and current potentially contaminative land uses have been considered

10A8.2 Assessment Framework

Current legislation relating to contaminated land in the UK is contained within Part 2A of the Environmental Protection Act 1990 [3], which was inserted by Section 57 of the Environment Act 1995 [33] and by Section 86 of the Water Act 2003 [34], and elaborated within the Contaminated Land (England) Regulations 2006 [S.I. 2006/1380] [35] (amended 2012 [S.I. 2012/263]) [36].

The “suitable for use” approach is adopted for the assessment of contaminated land. Remedial measures are only undertaken where unacceptable risks to human health or the environment are realised, taking into account the use (or proposed use) of the land in question and the environmental setting.

Current best practice recommends that the determination of health hazards due to contaminated land is based on the principle of risk assessment, as outlined in Part 2A of the Environmental Protection Act 1990 [3].

The risk assessment process for the environmental contaminants is based on a source-pathway-receptor analysis. These terms can be defined as follows:

- Source: Hazardous substance that has the potential to cause adverse impacts;
- Pathway: Route whereby a hazardous substance may come into contact with the receptor. Examples include ingestion of contaminated soil and leaching of contaminants from soil into watercourses; and
- Receptor: Target that may be affected by contamination. Examples include human occupants/users of Sites, water resources (surface waters or groundwater), or structures.

For a risk to be present, there must be a viable contaminant linkage; i.e. a mechanism whereby a source impacts on a sensitive receptor via a pathway.

The following sections detail the conceptual site model, which has been developed for the Sites with the view to assessing the potential risks during construction and upon completion of the proposed new development. The potential sources of contamination, potential receptors and potential pollutant pathways are identified and presented in Tables 10A8.1 to 10A8.6. Figure 10A8.1 and Figure 10A8.2 present graphical iCSMs.

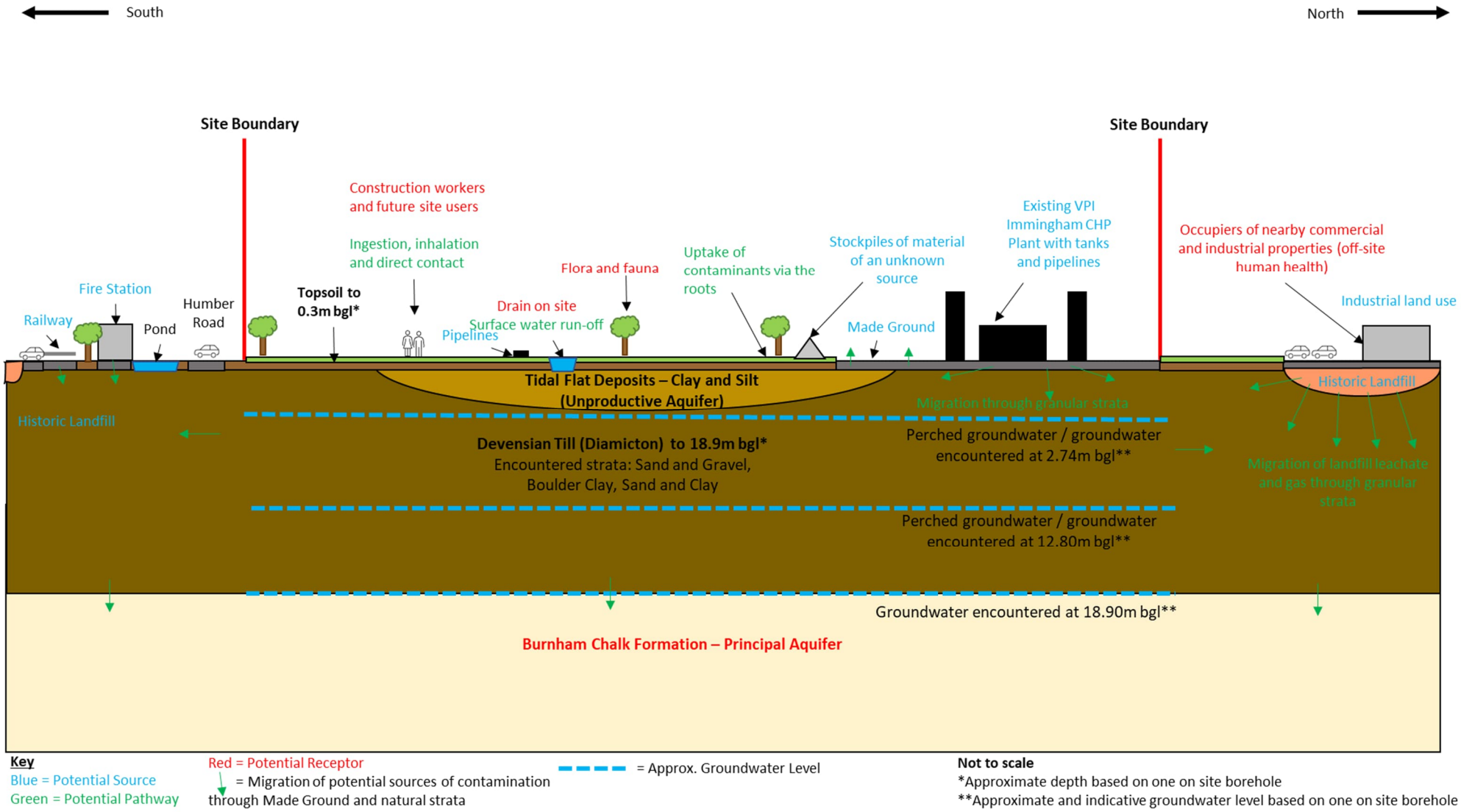

Figure 10A8.1 iCSM of VPI Site

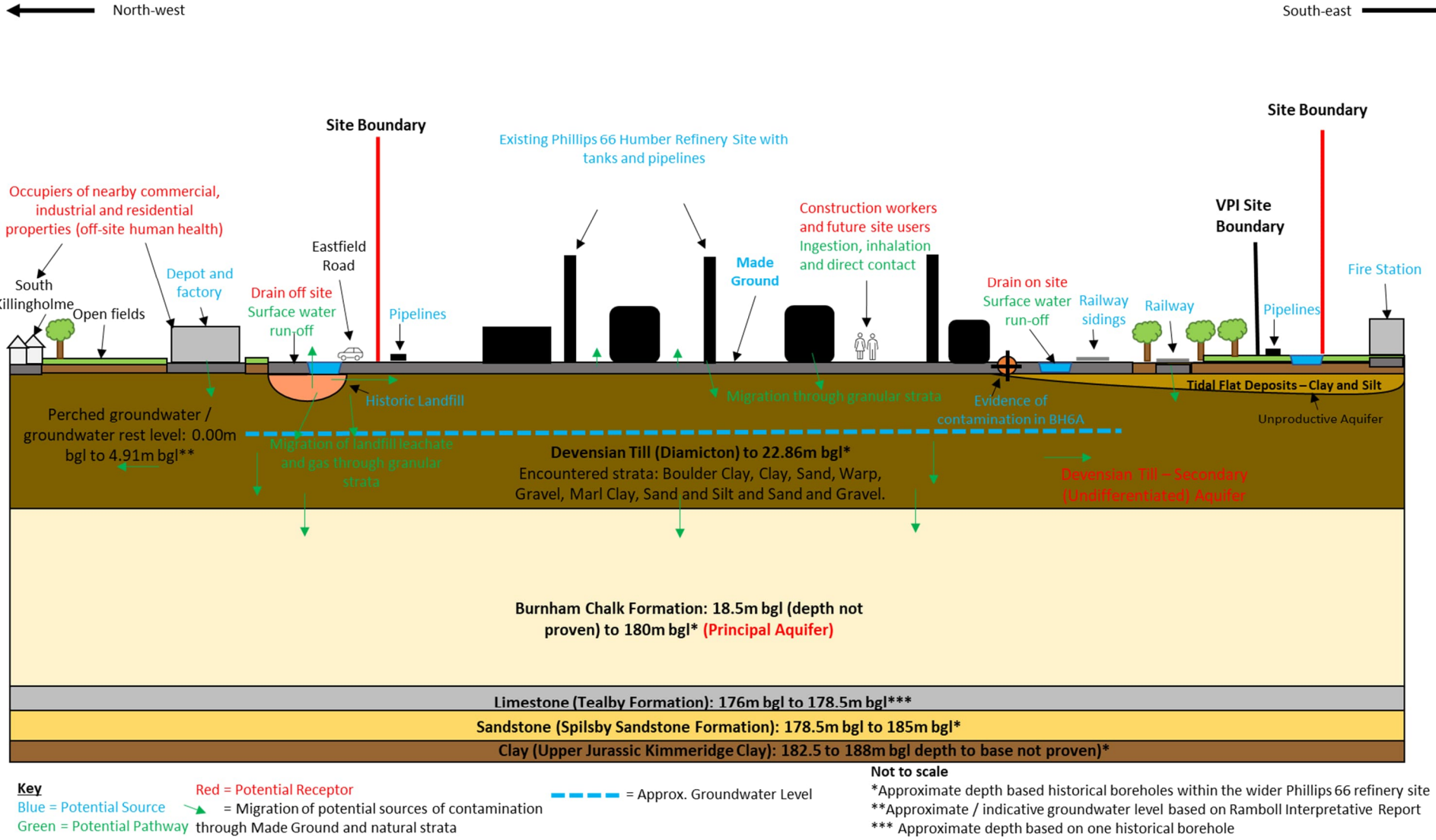

Figure 10A8.2 iCSM of Phillips 66 Site

10A8.3 Potential Sources

This section highlights those former/current onsite and off-site activities that have been identified as potential sources of contamination. These activities may have in turn impacted on soil, soil leachate, and groundwater. A buffer of 1 km has been considered for potential sources beyond the VPI and Phillips 66 Site boundary. However, only sources within 250 m realistically pose the highest potential for any contamination to impact the site area.

Table 10A8.1 Potential Sources (VPI Site)

Potential Source	Description
Made Ground	Made Ground is expected to be present where hardstanding is located to the north-east of the VPI Site and along the eastern VPI Site boundary. Made Ground may also be located to the south of the drain, adjacent to the eastern VPI Site boundary, where a building was previously located. The drain located on the VPI Site and the track parallel to this may contain Made Ground. The tanks and pipeline on the VPI Site are a potential source of contamination from potential leaks into Made Ground. This may contain asbestos containing materials, metal, inorganic and organic contaminants. During the site walkover, spoil and aggregate material stockpiles of an unknown source were observed in the northern area of undeveloped land.
Natural Strata	The underlying strata was identified as Tidal Flat Deposits (Clay and Silt), Devensian Till (Diamicton) and the Burnham Chalk Formation. These strata may contain contaminants that have migrated from the Made Ground or may have been contaminated by potential herbicides, insecticides and pesticides from previous land use. The tanks and pipeline on the VPI Site are a potential source of contamination from potential leaks into the natural strata.
Soil Leachate	Potential contaminants leached from Made Ground, usage of agricultural chemicals and possible leaks from the tanks and pipeline on the VPI Site may be a source of contamination in soil leachate.
Groundwater	Shallow perched groundwater may be present in Made Ground and superficial deposits could contain potential contaminants from the VPI Site history and potential leakage from the onsite pipeline and tanks.
Ground Gases	Ground gases (methane, carbon dioxide, hydrogen sulfide and Volatile Organic Compounds (VOCs)) could be generated in Made Ground and through organic content within the underlying superficial deposits, which could be migrating through the strata. Carbon dioxide has the potential to be generated within the underlying Chalk deposits.
Off-Site Sources	Possible migration of potential contaminants is associated with the adjacent land use. This includes Made Ground associated with the existing railway and surrounding industrial land use. The industries surrounding the VPI Site contain tanks, silos and pipelines which may be a potential source of contamination associated with potential leakages into Made Ground, natural strata, soil leachate and groundwater. Nearby haulage and transport services may be a potential source associated with leakages into Made Ground. The Fire Station to the south of the VPI Site may also be a source of contamination as a result of potential spillages or leakages. If fires have occurred at the VPI Site, there may be potential contaminants such as per- and polyfluroakyl substances (PFAS) and Perfluorooctanesulfonic acid (PFOS). Other potential contaminants from off-site sources may include asbestos containing materials, metals and organics. Historical landfills and registered disposal sites are located within 1 km from the VPI Site which may, if not managed correctly at the source site, produce and allow contaminated soil leachate to migrate through natural strata. Ground gases could be generated in Made Ground and the offsite historical and current landfills which may, if not managed correctly at the source site, be migrating through the strata. Undeveloped land nearby may contain potential contaminants such as herbicides due to the potential historical land use as agricultural land. However, it is anticipated at low levels.

Table 10A8.2 Potential Sources (Phillips 66 Site)

Potential Source	Description
Made Ground	Made Ground is expected to be present across the entire Phillips 66 Site. The industrial infrastructure on the Phillips 66 Site, such as tanks and pipelines a may be a potential source of contamination from potential leaks / spillages into Made

Potential Source	Description
	Ground.. The Made Ground may contain asbestos containing materials, metal, inorganic and organic contaminants.
Natural Strata	The underlying strata was identified as Tidal Flat Deposits (Clay and Silt), Devensian Till (Diamicton) and the Burnham Chalk Formation. Potential for contamination in Made Ground to have migrated into the natural strata. Tanks and pipelines are a potential source of contamination from leaks and/or spillages.
Soil Leachate	Potential contaminants may be leached from Made Ground and/or other potential sources of contamination at the Phillips 66 Site.
Groundwater	Shallow perched groundwater may be present and groundwater within the underlying strata could contain potential contaminants due to potential leakage / spillage from the onsite pipeline and tanks, and from historical industrial uses of the Phillips 66 Site.
Ground Gases	Ground gases (methane, carbon dioxide and volatile gases) could be generated in Made Ground and through organic content within the underlying deposits, which could be migrating through the strata. Carbon dioxide has the potential to be generated within the underlying Chalk deposits.
Off-Site Sources	Possible migration of potential contaminants is associated with the adjacent land use. Hazardous substance consents and registered radioactive substances are also near the Phillips 66 Site which may be a potential source of contamination. However, it is assumed the use of the substances complies with the requirements of consents /permits / licences. The industries surrounding the Phillips 66 Site contain tanks, silos and pipelines which may be a potential source of contamination associated with potential leakages into Made Ground, natural strata, soil leachate and groundwater. Nearby haulage and transport services, and the fire station located approximately 250 m east, may be a potential source associated with leakages into Made Ground. If fires have occurred at the Phillips 66 Site, there may be potential contaminants such as per- and polyfluroakyl substances (PFAS) and Perfluorooctanesulfonic acid (PFOS). Other potentially contaminative land uses include railways, oil refineries, a filling station, garages and works. Numerous historical landfills and registered landfill sites are located within a 1 km radius from the Phillips 66 Site which may have contaminated soil leachate and landfill gas. Ground gases (carbon dioxide and volatile gases) could be generated in Made Ground in the surrounding area. Undeveloped land nearby may contain potential contaminants such as herbicides, however, this is anticipated to be at a low level.

10A8.4 Contaminants of Potential Concern (CoPC)

The Contaminants of Potential Concern for the VPI Site and the Phillips 66 Site are summarised in Table 10A8.3 and Table 10A8.4, respectively.

Table 10A8.3 Contaminants of Potential Concern Associated with the Sources for the VPI Site

Location	Potential Source	Potential Contaminants of Concern
Onsite	Made Ground and stockpiles of an unknown source	Metals, PCBs, PAHs, oils, inorganics, sulphuric acid, hydrochloric acid, sodium hydroxide, hydrocarbons, and asbestos. Ground gases such as carbon dioxide and methane.
Onsite	Tanks (existing VPI site only), electrical sub stations (existing VPI site only) and pipelines (disused and active)	Metals, PCBs, PAHs, oils, inorganics, sulphuric acid, hydrochloric acid, sodium hydroxide, hydrocarbons and asbestos.
Onsite	Grassland	Herbicides,
Immediately south-east from the VPI Site	Railways	PCBs, PAHs, herbicides, metals, sulphates, asbestos.
Approximately 100 m south-east	Electrical sub stations	PCBs
Approximately 50 m south	Unspecified warehouses	Heavy metals, asbestos, sulphate (water soluble), sulphate (acid soluble), easily liberated sulphide, sulphur, pH, TPH, SVOCs including PAHs and VOCs.

Location	Potential Source	Potential Contaminants of Concern
Within a 1 km radius	Landfills	Organics such as phenols and polyaromatic hydrocarbons, inorganics, metals. Gases including methane, carbon dioxide, hydrogen and hydrogen sulfide.
Approximately 100 m south-east	Fire station	Heavy metals, PAH, TPH. PFOS, PFAS
Immediately north-west and within approximately 100 m south-west.	Tanks, pipelines, silos and other infrastructure associated with the nearby industrial land use and oil refineries.	Metals, hydrocarbons, organic compounds (e.g., MTBE, PCBs, TAME) and asbestos

Source: D of E Industry Profiles for: Power Stations (excluding nuclear power stations)[37], Railway Land[38], Landfills[39] and Oil Refineries[40]

PAH: Polycyclic Aromatic Hydrocarbons

PCBs: Polychlorinated Biphenyls

MTBE: Methyl Tertiary Butyl Ether

TAME: Tertiary Amyl Methyl Ether

PFOS: Perfluorooctanesulfonic Acid

PFAS: Per- and Polyfluroakyl Substances

Table 10A8.4 Contaminants of Potential Concern Associated with the Sources for the Phillips 66 Site

Location	Potential Source	Potential Contaminants of Concern
Onsite	Made Ground	Metals, PCBs, PAHs, TAME, MTBE, oils, inorganics, sulphuric acid, hydrochloric acid, sodium hydroxide, hydrocarbons, and asbestos. Ground gases such as carbon dioxide and methane.
Onsite	Tanksand pipelines	Metals, PCBs, PAHs, oils, inorganics, sulphuric acid, hydrochloric acid, sodium hydroxide, hydrocarbons and asbestos.
Onsite and immediately north of the Phillips 66 Site	Railways	PCBs, PAHs, herbicides, metals, sulphates, asbestos.
Within 100 m south and 120 m east and 225 m south-east	Electrical sub stations	PCBs
Within a 1 km radius	Landfills	Organics such as phenols and polyaromatic hydrocarbons, inorganics, metals. Gases including methane, carbon dioxide, hydrogen and hydrogen sulphide.
Off-site within a 250 m radius	Previous and current industrial land use (garages, filling station, warehouses, works, depots, oil refinery)	Heavy metals, organics, inorganics, solvents, oils, acids, alkalis, PCBs, PAHs, MTBE, TAME, asbestos, pesticides, VOCs. Potential radioactive contaminants associated with the use of registered radioactive substances.
Approximately 100 m south-east	Fire station	Heavy metals, PAH, TPH, PFOS, PFAS
Onsite within the VPI Site	Grassland	Herbicides

Source: D of E Industry Profiles for: Railway Land[38], Landfills[39], Oil Refineries[40], Industrial Activities which may have used Materials containing Radioactivity and Garages[41] and Filling Stations[42]

10A8.5 Potential Receptors

Table 10A8.5 lists the potential receptors at the Sites.

Table 10A8.5 Summary of Potential Receptors

Potential Receptors	Description
Construction Workers	Exposures experienced by construction workers are much less than for future site users due to the limited period of exposure. However, construction workers are more likely to encounter potential contaminants during the construction works.
Future Site Users	Users of the Sites may be affected by the presence of elevated concentrations of certain determinands. These workers will have a longer-term exposure to potential contaminants at the Sites which may lead to chronic health conditions.
Controlled Waters	The Tidal Flat Deposits (Clay and Silt) are classified as an Unproductive Aquifer and is therefore unlikely to be a receptor. However, the superficial Devensian Till (Diamicton) deposits are designated as a Secondary Undifferentiated Aquifer and the Burnham Chalk Formation is designated as a Principal Aquifer. These aquifers could be affected by potential contaminants. The drains which flow through the VPI Site and the Phillips 66 Site may also be affected by potential contaminants. A brown to white thick deposit / film was observed in the drain of the VPI Site near pipelines.
Development Infrastructure	Development infrastructure may be affected by chemical aggressivity and ground gases within Made Ground and Natural Strata. Concrete is a receptor of chemical aggressivity in contaminated soils with a low pH and high sulphate concentrations. Plastic piped services and concrete foundations can be adversely affected by the presence of hydrocarbons, including phenolic compounds, where the integrity of the pipes can be compromised. This can lead to penetration of the pipes by mobile contaminants.
Flora and Fauna	Flora and fauna on the southern undeveloped half of the VPI Site, which includes land within the Phillips 66 Site, could be affected by the presence of elevated concentrations of certain determinands. Flora and fauna within the western and northern Phillips 66 Site boundary, and between the railway lines in the Phillips 66 Site could be affected by the presence of elevated concentrations of certain determinands.
Off-site Receptors	Potential receptors off site comprise of the human health of workers and occupiers of nearby commercial and industrial buildings and properties. The nearest commercial and industrial buildings to the VPI Site are located 60 m north-west. The nearest commercial and industrial buildings to the Phillips 66 Site are located 40 m south-east. Residential properties are located 600 m west from the Phillips 66 Site and 1.55 km west from the VPI Site.

10A8.6 Potential Pathways

This section provides a summary of the potential pathways by which the identified sources may come into contact with receptors. A summary of the potential pathways is provided in Table 10A8.6.

Table 10A8.6 Potential Pollutant Linkages

Source	Pathway	Receptor
Soil Source Pathways Including the following sources: • Made Ground on the VPI and Phillips 66 Sites and off-site; • Contaminants associated with potential agricultural land usage on the VPI Site and potential leakages generated from the	Dermal Contact	Dermal contact with contaminated soils, soil derived dust, soil leachate and perched groundwater.
	Direct Contact	Direct contact of building materials with contaminated soils, soil leachate and perched groundwater.
	Ingestion	Direct or indirect ingestion of soil and soil derived dust.

Source	Pathway	Receptor
onsite pipeline and tanks on the VPI and Phillips 66 Sites; and • Soil derived leachate from Made Ground, off site landfills and potential spillages associated with the pipeline and tanks on the VPI and Phillips 66 Sites and off-site industry.	Inhalation	Inhalation of soil derived dust, organic vapours or ground generated gas.
	Plant Uptake	Uptake of contaminants via the roots.
Groundwater Source Pathways Including the following sources: • Soil derived leachate from Made Ground, off-site landfills and potential spillages associated with the pipeline and tanks on the VPI and Phillips 66 Site, and off-site industry; • Perched groundwater in Made Ground or superficial deposits underlying the VPI and Phillips 66 Sites; and • Deep groundwater underlying the VPI and Phillips 66 Sites.	Rainfall Infiltration & Vertical / Lateral migration via permeable strata and drainage networks	Rainfall infiltration can generate and mobilise soil derived leachate impacting on surface water and groundwater. If perched groundwater is present, there may also be vertical migration into deeper pathways.
	Lateral Migration through Aquifer	As well as being a receptor, aquifers allow transportation of contaminants through the permeable strata.
Surface Water Pathways Includes the following sources: • Made Ground	Surface Run-off and Surface Water Drainage	Surface spills could migrate via surface run off to drainage onsite and off-site.
Gas Pathways Including the following sources: • Ground gas generation in Made Ground, natural strata and the off-site landfills.	Vertical / Lateral Migration via permeable strata	Permeable strata and areas of Made Ground may allow transportation of ground gases.

10A8.7 Potential Pollutant Linkages

Table 10A8.7 and Table 10A8.8 provides a summary of the potential pollutant linkages associated with identified sources, pathways and receptors considered most appropriate to the VPI and Phillips 66 Sites respectively.

Table 10A8.7 Potential Pollutant Linkages at the VPI Site

Source	Pathway	Receptor
Diffuse metal, inorganic and organic contamination within Made Ground or the natural strata	• Ingestion of contaminated soil • Inhalation/ingestion of soil derived dust • Inhalation of organic vapours • Direct contact with soil/dust • Plant uptake	• Future Site Users • Construction Workers • Off-site Receptors • Development Infrastructure • Flora and Fauna
Generated leachate from Made Ground / natural ground	• Rainfall infiltration and vertical / lateral migration via permeable strata	• Controlled Waters • Future Site Users • Construction Workers • Flora and Fauna • Off-site Receptors

Source	Pathway	Receptor
Contaminants in groundwater (perched or otherwise)	• Migration and diffusion	• Controlled Waters • Construction Workers • Future Site Users • Off-site Receptors
Ground gases	• Vertical and lateral migration of gas through permeable strata	• Future Site Users • Off-site Receptors • Construction Workers • Development Infrastructure
Off-site sources	• Rainfall infiltration and vertical / lateral migration of contamination through permeable strata • Vertical and lateral migration of gas through permeable strata • Migration of gases in the dissolved phase (within the groundwater)	• Future Site Users • Construction Workers • Development Infrastructure • Controlled Waters • Off-site Receptors

Table 10A8.8 Potential Pollutant Linkages at the Phillips 66 Site

Source	Pathway	Receptor
Diffuse metal, inorganic and organic contamination within Made Ground or the natural strata	• Ingestion of contaminated soil • Inhalation/ingestion of soil derived dust • Inhalation of organic vapours • Direct contact with soil/dust	• Future Site Users • Construction Workers • Off-site Receptors • Development Infrastructure • Flora and Fauna
Generated leachate from Made Ground / natural ground	• Rainfall infiltration and vertical / lateral migration via permeable strata	• Controlled Waters • Future Site Users • Construction Workers • Off-site Receptors • Flora and Fauna
Contaminants in groundwater (perched or otherwise)	• Migration and diffusion	• Controlled Waters • Construction Workers • Future Site Users • Off-site Receptors • Flora and Fauna
Ground gases	• Vertical and lateral migration of gas through permeable strata	• Future Site Users • Off-site Receptors • Construction Workers • Development Infrastructure
Off-site sources	• Rainfall infiltration and vertical / lateral migration of contamination through permeable strata • Vertical and lateral migration of gas through permeable strata • Migration of gases in the dissolved phase (within the groundwater)	• Future site users • Construction workers • Development Infrastructure • Controlled Waters • Off-site Receptors • Flora and Fauna

10A.9. Environmental Risk Assessment

10A9.1 Risk Assessment Principles and Framework

Current best practice recommends that the determination of hazards due to contaminated land is based on the principle of risk assessment, as outlined in the Environment Agency guidance on Land Contamination Risk Management (LCRM), April 2021 [6].

For a risk to be present, there must be a viable contaminant linkage; i.e. a mechanism whereby a source impacts on a sensitive receptor via a pathway. The potential contaminant linkages that have been identified for the Sites are presented in Section 8.

Assessments of risks associated with each of these contaminant linkages, following review of available information for the Sites are discussed in the following sections.

Using criteria broadly based on those presented in the Construction Industry Research and Information Association publication Research & Development (R&D) Publication 66, National House Building Council (NHBC)/Environment Agency/Chartered Institute of Environmental Health (CIEH) 2008 [43], the magnitude of the risk associated with potential contamination at the Sites has been assessed. To do this an estimate is made of:

- The potential severity of the risk; and
- The likelihood of the risk occurring.

The severity of the risk is classified according to the criteria in Table 10A9.1.

Table 10A9.1 Severity of Risk

Severity	Description
High	• Acute risks to human health likely to result in "significant harm" (e.g. very high concentrations of contaminants/ground gases); • Catastrophic damage to buildings/property (e.g. by explosion, sites with high gassing potential, extensive VOC contamination); • Major pollution of controlled waters (e.g. surface watercourses or Principal Aquifers / Source Protection Zones); and • Short term risk to a particular ecosystem.
Medium	• Chronic (long-term) risk to human health likely to result in "significant harm" (e.g. elevated concentration of contaminants/ground gases); • Pollution of sensitive controlled waters (e.g. surface watercourses or principal/secondary A aquifers); and • Significant effects on sensitive ecosystems or species.
Mild	• Pollution of non-sensitive waters (e.g. smaller surface watercourses or secondary B aquifers or unproductive strata); and • Significant damage to crops, buildings, structures or services (e.g. by explosion, sites with medium gassing potential, elevated concentrations of contaminants).
Minor	• Non-permanent human health effects (requirement for protective equipment during site works to mitigate health effects); • Damage to non-sensitive ecosystems or species; and • Minor (easily repairable) damage to buildings, structures or services (e.g. by explosion, sites with low gassing potential).

The probability of the risk occurring is classified according to the criteria given in Table 10A9.2.

Table 10A9.2 Probability of Risk Occurring

Probability	Explanation
High likelihood	Contaminant linkage may be present that appears very likely in the short term and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.

Probability	Explanation
Likely	Contaminant linkage may be present, and it is probable that the risk will occur over the long term.
Low Likelihood	Contaminant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Unlikely	Contaminant linkage may be present but the circumstances under which harm would occur even in the long term are improbable.

An overall evaluation of the level of risk is gained from a comparison of the severity and probability, as shown in Table 10A9.3.

Table 10A9.3 Level of Risk

Probability	Severity: Severe	Medium	Mild	Minor
High Likelihood	Very High	High	Moderate	Moderate / Low
Likely	High	Moderate	Moderate / Low	Low
Low Likelihood	Moderate	Moderate / Low	Low	Very Low
Unlikely	Moderate / Low	Low	Very Low	Very low

10A9.2 LCRM Assessment of Risk

In October 2020 (updated April 2021), the UK government issued new guidance on the evaluation and management of contaminated land; LCRM [6]. Current contaminated land guidance LCRM (Environment Agency, 2021) [6] categorises risk at Stage 1 Tier 1 as follows:

- Acceptable; and
- Unacceptable.

However, no framework for assessing the risk has been published to accompany the guidance, so the CIEH & NHBC R&D Publication 66 [43] assessment framework constitutes best practice in this regard. To align the risk rankings in Section 9.1 with the LCRM rankings and with the Part 2A definitions [3], the following matrix has been utilised. This conversion is presented in Table 10A9.4.

Table 10A9.4 Conversion of LCRM Risk Categories

	Acceptable	Unacceptable
Very Low		
Low		
Moderate/Low		
Moderate*		
High		
Very High		

**This risk category spans both acceptable and unacceptable. This is intentional as it is this risk band that tends to have the greatest level of uncertainty associated with it. Acceptability will be dependent on site-specific circumstances and level of confidence in the available evidence.*

For a risk to be unacceptable, the contaminant linkage should be associated with at least a "medium" severity as defined in Table A4.3 in Annex 4 of R&D66 [43] and the probability should (in the majority of cases) be at least "likely" as defined in Table A4.4 of R&D66 [43].

These risk categories represent the level of risk as it is currently understood from the information available at this time.

10A9.3 Preliminary Risk Assessment

An evaluation of the potential risks associated with the identified sources at the location of the Proposed VPI Development to the various receptors is discussed and presented in Table 10A9.5 and Section 10A9.4. The potential risks associated with the Proposed Phillips 66 Development is presented in Table 10A9.6 and discussed in Section 10A9.4. The level of risk is determined based on the current condition of the Sites, i.e., the effects of mitigation measures such as soil or groundwater treatment are not included but the level of risk takes into account the nature of the Proposed Development.

Table 10A9.5 Risk Evaluation of Potential Contaminant Linkages for the VPI Site

Source	Pathway	Receptor		Potential Contaminant Linkage	Severity	Probability	Risk	Potential Risk LC:RM
Contaminants of potential concern within soil in Made Ground and natural strata	Direct Contact / Ingestion / Inhalation of vapours & dust	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptan;e
	Direct Contact / Ingestion / Inhalation of vapours & dust	Human Health	Construction Workers	Y	Mild	Likely	Moderate / Low	Acceptable
	Surface run-off / Migration via Site drainage	Controlled Waters	Surface Water: Drains onsite	Y	Mild	Likely	Moderate / Low	Acceptable
	Infiltration / Vertical Migration	Controlled Waters	Groundwater: Superficial Secondary Undifferentiated Aquifer (Devensian Till – Diamicton)	Y	Mild	Likely	Moderate / Low	Acceptable
		Controlled Waters	Groundwater: Principal bedrock aquifer of the Burnham Formation	Y	Medium	Low Likelihood	Moderate / Low	Acceptable
	Direct Contact	Development Infrastructure	Buildings to be constructed on VPI Site and associated foundations and infrastructure	Y	Minor	Likely	Low	Acceptable
	Inhalation of vapours / dusts	Off-Site Receptors	Human Health: Occupiers of nearby properties / workers	Y	Minor	Low Likelihood	Very Low	Acceptable
	Direct Contact / Uptake	Flora and Fauna	Onsite flora and fauna	Y	Minor	Likely	Low	Acceptable
Leachate and Groundwater contaminants from Made Ground and Natural Strata	Direct Contact / Ingestion / Inhalation of vapours	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptable
		Human Health	Construction Workers	Y	Mild	Likely	Moderate / Low	Acceptable
	Lateral Migration	Controlled Waters	Surface Water: Drains on the VPI Site	Y	Mild	Likely	Moderate / Low	Acceptable
	Preferential Migration Through Surface Water Drainage	Controlled Waters		Y	Mild	Likely	Moderate / Low	Acceptable

Source	Pathway	Receptor		Potential Contaminant Linkage	Severity	Probability	Risk	Potential Risk LC:RM
	Vertical Migration		Groundwater: Superficial Secondary Undifferentiated Aquifer (Devensian Till – Diamicton	Y	Mild	Likely	Moderate / Low	Acceptable
	Vertical Migration		Groundwater: Principal bedrock aquifer of the Burnham Formation	Y	Medium	Low Likelihood	Moderate / Low	Acceptable
	Direct Contact	Development Infrastructure	Buildings to be constructed on the VPI Site and associated foundations and infrastructure	Y	Minor	Likely	Low	Acceptable
	Infiltration / Off-site Migration	Off Site Receptors	Human Health: Occupiers of nearby properties / workers		Minor	Low Likelihood	Very Low	Acceptable
	Direct Contact / Uptake	Flora & Fauna	Any onsite flora and fauna	Y	Minor	Low Likelihood	Very Low	Acceptable
Ground Gas potentially produced by Made Ground and naturally from organic content within the underlying deposits	Inhalation	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptable
	Inhalation / Migration & Explosion		Construction Workers	Y	Mild	Low Likelihood	Low	Acceptable
	Migration & Explosion	Development Infrastructure	Buildings to be constructed on VPI Site and associated foundations and infrastructure	Y	Minor	Likely	Low	Acceptable
	Inhalation / Migration & Explosion	Off-Site Receptors	Human Health: Occupiers of nearby properties / workers	Y	Minor	Low Likelihood	Very Low	Acceptable
Off Site Sources	Rainfall infiltration / migration of contaminants via permeable strata / surface water / groundwater and / or migration of gases leading to direct contact / ingestion / inhalation / explosion	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptable
			Construction Workers	Y	Medium	Likely	Moderate	Acceptable
	Rainfall Infiltration & Vertical / Lateral Migration	Controlled Waters	Surface Waters: Drains on the VPI Site	Y	Mild	Likely	Moderate / Low	Acceptable

Source	Pathway	Receptor		Potential Contaminant Linkage	Severity	Probability	Risk	Potential Risk LC:RM
	of Contaminants via permeable strata		Groundwater: Groundwater: Superficial Secondary Undifferentiated Aquifer (Devensian Till – Diamicton)	Y	Mild	Likely	Moderate / Low	Acceptable
			Groundwater: Principal bedrock aquifer of the Burnham Formation	Y	Medium	Likely	Moderate / Low	Acceptable
	Rainfall infiltration/migration of contaminants via permeable strata / surface water / groundwater and / or migration of gases leading to direct contact / Explosion	Development Infrastructure	Buildings to be constructed on the VPI Site and associated foundations and infrastructure	Y	Minor	Likely	Low	Acceptable
		Off-Site Receptors	Human Health: Occupiers of nearby properties / workers	Y	Minor	Likely	Low	Acceptable
		Flora and Fauna	Any onsite flora and fauna	Y	Minor	Likely	Low	Acceptable

Table 10A9.6 Risk Evaluation of Potential Contaminant Linkages for the Phillips 66 Site

Source	Pathway	Receptor		Potential Contaminant Linkage	Severity	Probability	Risk	Potential Risk LC:RM
Contaminants of potential concern within soil in Made Ground and natural strata	Direct Contact / Ingestion / Inhalation of vapours & dust	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptable
	Direct Contact / Ingestion / Inhalation of vapours & dust	Human Health	Construction Workers	Y	Medium	Likely	Moderate	Acceptable
	Surface run-off / Migration via site drainage	Controlled Waters	Surface Water: Drains on the Phillips 66 Site	Y	Mild	Likely	Moderate / Low	Acceptable
	Infiltration / Vertical Migration	Controlled Waters	Groundwater: Superficial Secondary Undifferentiated Aquifer (Devensian Till – Diamicton)	Y	Mild	Likely	Moderate / Low	Acceptable
		Controlled Waters	Groundwater: Principal bedrock aquifer of the Burnham Formation	Y	Medium	Likely	Moderate	Acceptable
	Direct Contact	Development Infrastructure	Buildings to be constructed on the Phillips 66 Site and associated foundations and infrastructure	Y	Mild	Likely	Moderate / Low	Acceptable
	Inhalation of vapours / dusts	Off-Site Receptors	Human Health: Occupiers of nearby properties / workers	Y	Minor	Low Likelihood	Very Low	Acceptable
	Direct Contact / Uptake	Flora and Fauna	Onsite flora and fauna	Y	Minor	Likely	Low	Acceptable
Leachate and Groundwater contaminants from Made Ground and Natural Strata	Direct Contact / Ingestion / Inhalation of vapours	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptable
		Human Health	Construction Workers	Y	Medium	Likely	Moderate	Acceptable
	Lateral Migration	Controlled Waters	Surface Water: Drains on the Phillips 66 Site	Y	Mild	Likely	Moderate / Low	Acceptable
	Preferential Migration Through Surface Water Drainage	Controlled Waters						

Source	Pathway	Receptor		Potential Contaminant Linkage	Severity	Probability	Risk	Potential Risk LC:RM
	Vertical Migration		Groundwater: Superficial Secondary Undifferentiated Aquifer (Devensian Till – Diamicton	Y	Mild	Likely	Moderate / Low	Acceptable
	Vertical Migration		Groundwater: Principal bedrock aquifer of the Burnham Formation	Y	Medium	Likely	Moderate	Acceptable
	Direct Contact	Development Infrastructure	Buildings to be constructed on site and associated foundations and infrastructure	Y	Mild	Likely	Moderate / Low	Acceptable
	Infiltration / Off-site Migration	Off-Site Receptors	Human Health: Occupiers of nearby properties / workers		Minor	Low Likelihood	Very Low	Acceptable
	Direct Contact / Uptake	Flora & Fauna	Any onsite flora and fauna	Y	Minor	Low Likelihood	Very Low	Acceptable
Ground Gas potentially produced by Made Ground, on site landfills and naturally from organic content within the underlying deposits	Inhalation	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptable
	Inhalation / Migration & Explosion		Construction Workers	Y	Medium	Likely	Moderate	Acceptable
	Migration & Explosion	Development Infrastructure	Buildings to be constructed on the Phillips 66 Site and associated foundations and infrastructure	Y	Medium	Likely	Moderate	Acceptable
	Inhalation / Migration & Explosion	Off-Site Receptors	Workers in adjacent buildings located to the north, south and south-west of the Phillips 66 Site	Y	Minor	Low Likelihood	Very Low	Acceptable
Off Site Sources	Rainfall infiltration / migration of contaminants via permeable strata / surface water / groundwater and / or migration of gases leading to direct contact / ingestion / inhalation / explosion	Human Health	Future Site Users	Y	Minor	Low Likelihood	Very Low	Acceptable
			Construction Workers	Y	Medium	Likely	Moderate	Acceptable

Source	Pathway	Receptor		Potential Contaminant Linkage	Severity	Probability	Risk	Potential Risk LC:RM
	Rainfall Infiltration & Vertical / Lateral Migration of Contaminants via permeable strata	Controlled Waters	Surface Waters: Drains on the Phillips 66 Site	Y	Mild	Likely	Moderate / Low	Acceptable
			Groundwater: Groundwater: Superficial Secondary Undifferentiated Aquifer (Devensian Till – Diamicton)	Y	Mild	Likely	Moderate / Low	Acceptable
			Groundwater: Principal bedrock aquifer of the Burnham Formation	Y	Medium	Likely	Moderate	Acceptable
	Rainfall infiltration/migration of contaminants via permeable strata / surface water / groundwater and / or migration of gases leading to direct contact / Explosion	Development Infrastructure	Buildings to be constructed on the Phillips 66 Site and associated foundations and infrastructure	Y	Mild	Likely	Moderate / Low	Acceptable
		Off-Site Receptors	Human Health: Occupiers of nearby properties / workers	Y	Mild	Likely	Low	Acceptable
		Flora and Fauna	Any onsite flora and fauna	Y	Minor	Likely	Low	Acceptable

10A9.4 Discussion of Risk to Receptors

10A9.4.1 Risk to Construction Workers

10A9.4.1.1 VPI Site

The risk to construction workers onsite from direct contact, ingestion and inhalation of potential contaminants is considered to be *Low* to *Moderate / Low* based on the contaminant linkages identified in Table 10A9.5. Construction and maintenance workers would be expected to spend longer durations on the VPI Site and are likely to come into contact with soil, soil derived leachate or groundwater due to the minimal hardstanding ground present on the VPI Site and the potential excavations that may be required for the Proposed VPI Development. Material stockpiles of an unknown source were observed during the site walkover which may pose an additional risk to construction workers. There is potential for shallow groundwater onsite or perched groundwater within the Made Ground, which construction workers may come into contact with, therefore the probability is considered *Likely*.

There is potential for ground gas generation at the VPI Site due to the Made Ground present and the anticipated organic content within the underlying deposits. The severity of ground gas risk at the VPI Site to construction / maintenance workers is considered *Mild* as the Burnham Chalk Formation has the potential to generate gas, and the foundation depths and extent of excavation required for the development is unknown. However, there is minimal Made Ground within the proposed area for the VPI PCC plant and CO_2 compression station which reduces the risk associated with gas generation from Made Ground. Due to the presence of lower permeability superficial deposits overlying the chalk, the probability is considered *Low Likelihood*. Therefore, the risk to construction workers from inhalation of ground gas and risk of explosion due to the build-up of ground gas in enclosed spaces is considered to be *Acceptable*. However, it is recommended that entry into excavations or any other enclosed space on a construction site should comply with confined space legislation and be assessed prior to entry.

Construction workers may also be considered a receptor to off-site sources of potential contamination that could migrate to the VPI Site. The severity of off-site sources is considered to be *Medium* due to the extensive development surrounding the VPI Site comprising of warehouses, oil refineries and associated infrastructure such as tanks and pipelines and a large number of landfills within a 1 km radius from the VPI Site. The likelihood is considered to be *Likely* and the overall rating is *Moderate*.

However, a site-specific risk assessment and the use of personal protective equipment should be a pre-requisite for workers coming onto VPI Site and should therefore be protected from any potential contaminants. If construction workers were to come into contact with potential contaminants on the VPI Site, it is expected that they would experience limited periods of exposure. Therefore, the risks to construction workers are considered to be *Acceptable* using the LC:RM risk rating.

Before construction works start, a health and safety risk assessment should be carried out in accordance with current health and safety regulations. This assessment should cover potential risks to both construction staff and the local population. Based on the findings of this risk assessment, appropriate mitigation measures should be implemented during the course of the earthworks.

10A9.4.1.2 Phillips 66 Site

The risk to construction workers onsite from direct contact, ingestion and inhalation of potential contaminants is considered to be *Moderate* based on the contaminant linkages identified in Table 10A9.6. Construction and maintenance workers would be expected to spend longer durations on the Phillips 66 Site and are likely to come into contact with soil, soil derived leachate or groundwater due to the minimal hardstanding ground present on the Phillips 66 Site and the potential excavations that may be required for the Proposed Phillips 66 Development. There is potential for shallow groundwater onsite or perched groundwater within the Made Ground, which construction workers may come into contact with, therefore the probability is considered *Likely*.

There is a *Moderate* risk associated with potential contaminants in groundwater and soil leachate as the previous ground investigation Ramboll reports for the wider refinery site identified exceedances of

the GAC criteria for several determinands in the controlled waters assessment. The report recommended further investigation for TCE risks and elevated hydrocarbons in two boreholes, including one borehole within the Phillips 66 Site boundary. Therefore, it is considered *Likely* that the contaminant linkage is present and a *Medium* risk.

As exceedances of GAC criteria were identified in groundwater samples in the Ramboll reports, it is considered *Likely* that there is contamination in the soil and the severity is considered to be *Medium*. Therefore, the risk from soils to construction workers is considered to be *Moderate*.

There is potential for ground gas generation at the Phillips 66 Site due to the Made Ground present and organic content within the underlying deposits. The Ramboll interpretative report also identified an exceedance of the GAC criteria for the human health groundwater volatilisation pathway for TCE and recommended further investigation for VOCs associated with the results from one borehole. Therefore, the likelihood of ground gas risk at the Phillips 66 Site to construction / maintenance workers is considered *Likely* The Burnham Chalk Formation also has the potential to generate ground gas, however, this is considered to be a lower likelihood due to the depth and thickness of superficial deposits. However, it is recommended that entry into excavations or any other enclosed space on a construction site should comply with confined space legislation and be assessed prior to entry.

Construction workers may also be considered a receptor to off-site sources of contamination that could migrate to the Phillips 66 Site. The severity of off-site sources is considered to be *Medium* due to the extensive development surrounding the Phillips 66 Site comprising of the remainder of the oil refinery site, warehouses, oil refineries and associated infrastructure such as tanks and pipelines and a large number of landfills within a 1 km radius from the Phillips 66 Site including registered waste treatment / disposal site located 135 m south with phosphoric acid, alumina and aluminium fluoride. The likelihood is considered to be *Likely* and the overall rating is *Moderate.*

However, a site-specific risk assessment and the use of personal protective equipment should be a pre-requisite for workers coming onto Phillips 66 Site and should therefore be protected from any potential contaminants. If construction workers were to come into contact with potential contaminants on the Phillips 66 Site, it is expected that they would experience limited periods of exposure. Therefore, the risks to construction workers are considered to be *Acceptable* using the LC:RM risk rating.

Before construction works start, a health and safety risk assessment should be carried out in accordance with current health and safety regulations. This assessment should cover potential risks to both construction staff and the local population. Based on the findings of this risk assessment, appropriate mitigation measures should be implemented during the course of the earthworks.

10A9.4.2 Risk to Future Site Visitors

10A9.4.2.1 VPI Site

The risk to future site visitors is considered to be *Very Low* for all contaminant linkages identified in Table 10A8.5, and these risks are considered as *Acceptable* using the LC:RM risk rating.

Future site users are unlikely to come into direct contact with the underlying soils as the majority of the VPI Site will likely be covered in hardstanding, and there is already existing hardstanding in the northern half of the VPI Site where the VPI Immingham CHP Plant is located. This will act as a barrier to the VPI Site and break the contaminant linkage by removing the pathway.

10A9.4.2.2 Phillips 66 site

The risk to future site visitors is considered to be *Very Low* for all contaminant linkages identified in Table 10A9.6, and these risks are considered as *Acceptable* using the LC:RM risk rating.

All of the existing Phillips 66 Site is covered in hardstanding which will act as a barrier and break the contaminant linkage through the removal of a potential pathway. Therefore, future site visitors are unlikely to come into contact with underlying soils.

Pathways for ground gas sourced from Made Ground, underlying strata and off-site landfills may be present, however, low permeability strata and the presence of hardstanding reduce the potential for migration and hence the likelihood of affecting future site visitors.

10A9.4.3 Risk to Controlled Waters: Surface Water

10A9.4.3.1 VPI Site

The risk from potential contaminants in Made Ground, natural soils, groundwater and leachate at the VPI Site to surface waters is considered to be *Moderate / Low*. The severity is considered to be *Mild* as the drains onsite are small surface watercourses which fall within the catchment of the North Beck Drain. However, this is considered *Likely* as the existing and potential hardstanding associated with the Proposed VPI Development will result in increased surface run off into the drain networks. During the site walkover, it was noted that the drain flows underneath pipelines, and the water within this area was affected by a brown to white film / deposit. Surface run-off near the stockpiled material observed during the site walkover may contaminant water on the VPI Site. Some areas of soft ground may remain in the southern areas of the VPI Site which may allow infiltration of rainwater and thus the generation of soil leachate. Various potential pathways exist to surface water drains, including surface water (overland) run-off, run-off into surface water drains and lateral migration of shallow or perched groundwater. Low permeability strata may hinder lateral migration of shallow or perched groundwater. There is also potential for off-site sources of contamination to affect the drains onsite as there are a large number of interconnected drains within the area. Overall, the LC:RM risk rating to surface waters is considered to be *Acceptable*.

10A9.4.3.2 Phillips 66 site

The risk from potential contaminants in Made Ground, natural soils, groundwater and leachate at the Phillips 66 Site to surface waters is considered to be *Moderate / Low*. The severity is considered to be *Mild* as the drains onsite are small surface watercourses which fall within the catchment of the North Beck Drain. However, this is considered *Likely* as the majority of the Phillips 66 Site comprise of hardstanding which will result in increased surface run off into the drain networks. Some areas of soft ground may remain on the area of land within the VPI Site which may produce soil leachate if rainfall can infiltrate through. Various potential pathways exist to surface water drains, including surface water (overland) run-off, run-off into surface water drains and lateral migration of shallow or perched groundwater. However, the presence low permeability strata and the thickness of strata may hinder the lateral migration of groundwater into surface waters. Therefore, the risk is considered to be *Acceptable* using the LC:RM risk ratings.

10A9.4.4 Risk to Controlled Waters: Groundwater

10A9.4.4.1 VPI site

The risk from potential contaminants in Made Ground, natural soils, groundwater and leachate at the VPI Site to groundwater is considered to be *Moderate / Low* to *Moderate*.

Although the Tidal Flat Deposits (Clay and Silt) which underlie part of the VPI Site are designated as an Unproductive Aquifer, the Devensian Till (Diamicton) is designated as a Secondary Undifferentiated Aquifer and therefore has a *Mild* severity to contamination. The Tidal Flat Deposits (Clay and Silt) may afford some protection to vertical migration. However, this is not present across the whole VPI Site and there may be lenses of granular material within this. As there is shallow groundwater within the VPI Site, there is potential for contaminants within the soil to be mobilised within the groundwater. Therefore, it is considered *Likely* that potential contamination could reach the Secondary Aquifer via vertical migration, particularly in areas that are not overlain by Tidal Flat Deposits.

The Burnham Chalk Formation is designated a Principal Aquifer, therefore the severity is considered to be *Medium*. The thick low permeability clay deposits on the VPI Site may reduce and atttenuate vertical migration within the clay deposits onsite. It should be noted that there may be lenses of granular material that can support groundwater., There is uncertainty regarding the foundation design of the Proposed VPI Development and the extent of excavation that may be required. Removal of clay layers has the potential to increase vertical migration into the Principal Aquifer, although there is a

significant thickness of clay material overlying the bedrock. There is the potential for future construction involving piling. This may create preferential pathways for migration of impacted groundwater into the Principal Aquifer. However, the potential risks associated with piling would be considered within a piling risk assessment with the appropriate mitigation implemented. Therefore, the likelihood is considered to be *Low Likelihood* and the risk is considered to be *Moderate / Low* for the Principal Aquifer onsite.

There is also potential for lateral migration of contaminants from off-site sources such as potential spillages or leakages associated with the surrounding industrial land use and leachate associated with the off-site landfills. This may affect both the superficial and bedrock aquifers on the VPI Site. However, the low permeability clay deposits may provide a barrier to vertical migration and therefore protect the Principal Aquifer. Therefore, this is considered to be *Acceptable* using the LC:RM risk ratings.

Overall, the LC:RM risk rating to groundwater is considered to be *Acceptable* as there is potential for low permeability layers within the Tidal Flat Deposits (Clay and Silt) and the Devensian Till (Diamicton) to protect the underlying aquifers.

10A9.4.4.2 Phillips 66 Site

The risk from potential contaminants in Made Ground, natural soils, groundwater and leachate at the Phillips 66 Site to groundwater is considered to be *Moderate / Low* to *Moderate.*

There is only a small area of Tidal Flat Deposits (Clay and Silt) in the north-west of the Phillips 66 Site which is classified as an Unproductive Aquifer. These deposits will afford some protection to the underlying Secondary Undifferentiated Aquifer associated with the Devensian Till (Diamicton) deposits, however, the majority of the Phillips 66 Site is not protected by the Unproductive Aquifer. Therefore, the superficial deposits have a *Mild* severity to contamination. Although there are low permeability strata in the superficial deposits, data provided in the Ramboll 2020 Interpretative Report indicates there is shallow discontinuous groundwater bodies on the Phillips 66 Site. Therefore, potential contaminants in the soil could be mobilised into groundwater which may flow into nearby surface water bodies. The Ramboll 2020 report also noted exceedances of GAC criteria for controlled water and surface waters within groundwater samples obtained from onsite boreholes. There is also potential for leachate from the onsite landfill to affect shallow groundwater within the superficial deposits. Therefore, it is considered *Likely* for the superficial aquifer to be affected by contamination.

As the Burnham Chalk Formation is designated a Principal Aquifer, the severity is considered to be *Medium*, particularly as exceedances of GAC criteria in groundwater samples collected from the Glacial Till were noted in the Ramboll 2020 report. However, it should be noted that the boreholes terminated within the Glacial Till and no groundwater samples were collected from the Burnham Chalk Formation. There are also numerous groundwater abstractions on the Phillips 66 Site, which are likely within the Burnham Chalk Formation. Although there is potential for low permeability and reduced vertical migration and flow within the clay deposits of the superficial deposits, there may be lenses of granular material that can support groundwater which may migrate laterally and vertically. Furthermore, there is uncertainty regarding the foundation design of the Proposed Phillips 66 Development and the extent of excavation that may be required. Removal of clay layers has the potential to increase the potential for vertical migration into the Principal Aquifer. Therefore, the risk to the Principal Aquifer is considered to be *Moderate*, particularly as contamination has been identified within the groundwater of onsite boreholes.

There is the potential for future construction involving piling. This may create preferential pathways for migration of impacted groundwater deeper into the Secondary (Undifferentiated) Aquifer and the Principal Aquifer. The potential risks associated with piling would be considered within a piling risk assessment with the appropriate mitigation implemented. If a piling risk assessment and mitigation measures are not undertaken, this will increase the likelihood of contamination affecting both the Secondary (Undifferentiated) Aquifers and the Principal Aquifer to be a *High Likelihood*.

There is also potential for lateral migration of contaminants from off-site sources such as potential spillages or leakages associated with the surrounding industrial land use and leachate associated

with the off-site landfills. This may affect both the superficial and bedrock aquifers on the Phillips 66 Site.

Overall, the LC:RM risk rating to groundwater is considered to be *Acceptable*. However, the Ramboll Report suggested that the exceedances of GAC do not indicate a widespread spatial pattern of contamination and therefore, it is unlikely for there to be a significant contamination risk. Ramboll also suggest that the historic activities on the site are likely associated with the contamination and that exceedances are also within localised areas. Therefore, it is considered that the risk is Acceptable. Furthermore, the thickness of the attenuation capacity of the Glacial Till may further reduce the potential risk to the Principal Aquifer. Risk to Development Infrastructure

10A9.4.4.3 VPI Site

The risk to development infrastructure for the three potential contaminant linkages identified in Table 10A9.5 are considered to be */Low* These risks are considered as *Acceptable* using the LC:RM risk rating. There is potential for gas generation arising from the underlying chalk and the migration of potential contaminants from the surrounding industrial land use may increase the risk to development infrastructure. However, the significant thickness of lower permeability superficial deposits may afford some protection against gas migration from bedrock towards the surface.

It is assumed that potential risks would be mitigated by using concrete and service pipes appropriate for any aggressive ground conditions identified at the VPI Site.

It is anticipated that appropriate gas protection measures, where ground gas monitoring results indicate that protection is necessary, will be sufficient to mitigate the potential risk from ground gas. Therefore, the LC:RM risk rating is *Acceptable*.

10A9.4.4.4 Phillips 66 Site

The risk to development infrastructure for the three potential contaminant linkages identified in Table 10A8.5 are *Moderate / Low* to *Moderate*. There is potential for gas generation arising from the underlying chalk, potential landfill gas generation from the landfills onsite and the migration of potential contaminants from the surrounding industrial land use may increase the risk to development infrastructure. Furthermore, the Ramboll GI report noted elevated concentrations of VOC's. Therefore, the severity is considered to be Severe for the ground gas pollutant linkage.

It is assumed that potential risks would be mitigated by using concrete and service pipes appropriate for any aggressive ground conditions identified at the Phillips 66 Site. Therefore, this is considered to be *Acceptable* using the LC:RM risk ratings.

It is anticipated that appropriate gas protection measures, where ground gas monitoring results indicate that protection is necessary, will be sufficient to mitigate the potential risk from ground gas.

10A9.4.5 Risk to Flora and Fauna

10A9.4.5.1 VPI Site

The risks to flora and fauna on the VPI Site have been classified as *Very Low* to *Low* for the potential contamination linkages identified in Table 10A9.5. This assessment is made on the basis that there are no environmental protection or designations for the VPI Site and the Proposed VPI Development will introduce hardstanding ground. Therefore, the LC:RM risk is considered *Acceptable*.

10A9.4.5.2 Risk to Flora and Fauna at the Phillips 66 Site

The risks to flora and fauna on the Phillips 66 Site have been classified as *Very Low* to *Low* for the potential contamination linkages identified in Table 10A9.6. This assessment is made on the basis that there are no environmental protection or designations for the Phillips 66 Site. The majority of the Phillips 66 Site currently comprises of hardstanding ground. The only area of the Phillips 66 Site that comprises of undeveloped land is within the VPI Site. Therefore, the LC:RM risk is considered *Acceptable*.

10A9.4.6 Risk to Off Site Receptors

10A9.4.6.1 VPI Site

The risk to offsite receptors from direct contact, ingestion or inhalation of potential contaminants in Made Ground, natural soils, groundwater, leachate and gas generation at the VPI Site is considered to be *Very Low* to *Low*.

The risk posed by ground gas and contaminants in Made Ground and Natural Stata is considered *Very Low* to *Low* as any risks to local off-site receptors would be associated with off-site migration of contamination, for instance, in the form of wind-blown dust and organic vapours. Exposure via inhalation of dust is considered to be negligible for off-site receptors following development works, and as such there is not considered to be plausible contaminant linkage. The greatest potential for generation will be during the construction phase. Dust generation should be kept to a minimum in accordance with general best practice, as outlined in, for example, “Environmental Good Practice on Site”, 3rd Edition, CIRIA Publication C762 [44]. Overall, the risks to off-site receptors from on-site soil derived dusts are considered to be *Low*, which is *Acceptable* under the LC:RM risk rating.

10A9.4.7 Phillips 66 Site

The risk to offsite receptors from direct contact, ingestion or inhalation of potential contaminants in Made Ground, natural soils, groundwater, leachate and gas generation at the site is considered to be *Very Low* to *Low.* There is a potential pathway associated with inhalation of dust which can affect off-site human health receptors. However, this is considered to be negligible after development works, therefore the risk is considered to be *Very Low* to *Low*. Dust generation should be kept to a minimum in accordance with general best practice, as outlined in, for example, “Environmental Good Practice on Site”, 3rd Edition, CIRIA Publication C762 [44]. Therefore, this is considered to *be Acceptable* under the LC:RM risk rating.

The risks associated with ground gas are considered to be *Very Low* as it is unlikely that the Proposed Phillips 66 Development will change the existing ground conditions and cause ground gas migration to these receptors.

Overall, the LC:RM risk rating to offsite receptors is considered to be *Acceptable.*

10A.10. Preliminary Geotechnical Appraisal

10A10.1 Preliminary Engineering Assessment of the VPI Site and the Phillips 66 Site

10A10.1.1 Weak and Compressible Ground

The potential for collapsible, compressible, landslide, running sand and shrinking or swelling clay ground stability hazards onsite has been considered based upon data from Envirocheck Report (285387654_1_1) for the VPI Site [12]. The hazards associated with compressible ground are considered to be *No Hazard* to *Moderate*, which corresponds to areas of the site that are underlain by the Tidal Flat Deposits (Clay and Silt). Areas of the Sites with a *Moderate* hazard of running sand also correspond to areas underlain by the Tidal Flat Deposits (Clay and Silt). The potential for shrinking and swelling clay ground instability is considered to be *Low* to *Very Low*, and hazards associated with collapsible ground, landslides and ground dissolution have hazard ratings of *Very Low* or below.

The Envirocheck Report (292199669_1_1) [13] provides information on ground stability hazards at the Phillips 66 Site. Similar ground stability hazards are anticipated at the Phillips 66 Site compared to the VPI Site. The small area of the Sites in the north-east where Tidal Flat Deposits (Clay and Silt) underlie the site is associated with the greatest risks. This area has a *Moderate* risk for compressible ground and running sand a Low risk for shrinking and swelling clay and a very low risk of collapsible ground.

Across the entire Phillips 66 Site, the hazard associated with shrinking and swelling clay and landslides are Very Low to Low. There are no hazards associated with ground dissolution. Running sand and collapsible ground hazards are rated as Very Low to Moderate and No Hazard to Very Low respectively. Compressible ground hazards range between No Hazard and Moderate.

10A10.1.2 Foundations

Areas of Warp are known to be present between 0.3 m bgl and 3.96 m bgl at thicknesses between 0.91 m and 2.44 m at the VPI Site and will require further detailed investigation.

Made Ground at the wider Phillips 66 Refinery Site was only encountered in one borehole to a depth of 0.25 m bgl. However, it is anticipated that Made Ground is present across the entire Phillips 66 Site, apart from a small area within the undeveloped land within the VPI Site. Warp was recorded, 1.22 m thick, in one historical borehole, out of nine boreholes reviewed for this desk study within the wider Phillips 66 Refinery Site. Warp was encountered between 4.57 m bgl and 5.79 m bgl at the wider Phillips 66 Refinery Site. This will require further investigation. In general, foundations should be located within natural ground beneath any fill, Warp, Made Ground, soft highly compressible soil, and below the depth of effect of variations due to vegetation, seasonal and climatic change. Remedial measures in these areas may be required.

Subject to detailed design, for lightly loaded structures with no concern for excessive total and differential settlement, the underlying Glacial Till deposits may be suitable for the use of traditional spread foundations founded within the formation. This is subject to assessment of ground conditions following a ground investigation. However, bearing resistance of foundation stratum of the proposed structures will need to be considered for suitability of any spread foundations. Foundation design will consider both total and differential settlement. Shallow foundations will also consider the shrinking and swelling potential of the strata present.

Similarly, footings should be taken deeper than the minimum depth specified, where structures are located within influencing distance of any existing or future trees. In these circumstances reference should be made to Chapter 4.2 of NHBCs Standards (2011) [45].

The construction of both bored and driven piles would be technically feasible at both the VPI Site and the Phillips 66 Site. However, the suitability of driven piles should be considered from an environmental/nuisance issue. Piles may encounter a variety of obstructions including boulders within the Glacial Till, obstructions from existing or historical underground structures and foundations, variable rock head level and into variable properties of rock. All of these potential features should be taken into consideration.

If contamination is identified or suspected on both or either of the Phillips 66 and VPI Sites, a piling risk assessment should be carried out during the detailed design stage in accordance with the Environment Agency Guidance, "Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention" [46] and "Piling in Layered Ground: risks to groundwater and archaeology – Since Report SC0200074/SR" [47].

There is also potential for buried foundations to be encountered in the southern half of the VPI site, where the proposed VPI PCC plant and CO_2 compression station will be located. Due to the extensive industrial development of the Phillips 66 Site, there may also be buried foundations and structures within the Phillips 66 Site. This can cause delays where they are encountered, unforeseen, in initial foundation ground works as they need to be broken out. When left in place, buried foundations can also promote differential settlement in new structures, leading to cracking and damage to the new construction.

10A10.1.3 Excavations

Where excavations for foundations, earthworks, and drainage are required, stability of excavated areas should be considered. Close or continuous support will be required for any manned entry to excavations.

Shallow groundwater was encountered, at the Phillips 66 Refinery Site, between ground level and 4.91 m bgl in the Ramboll 2020 groundwater investigation. Therefore, this will require control during excavation. Although there are no GI data on the groundwater regime at the VPI Site, it should be assumed that shallow groundwater is likely to be encountered and may require groundwater control during excavation. This assumption is made on the basis that groundwater was encountered at 2.74 m bgl in the historical borehole drilled within the VPI Site and encountered at greater depths of 12.8 m bgl and 18.9 m bgl. There is also potential for groundwater to be encountered within isolated lenses of granular material at both the VPI and Phillips 66 Sites which may be under excess pressure. Detailed information regarding the groundwater regime will be available following a ground investigation and subsequent monitoring.

10A10.1.4 Soakaways

The ground conditions may be unsuitable for the use of soakaway pits due to the general presence of cohesive, low permeability strata with limited infiltration and shallow groundwater levels. Intrusive ground investigation should include for permeability testing to determine the suitability of the ground for infiltration-based drainage solutions and SUDS, if required in the Proposed Development Sites. If unsuitable, surface water run-off should be directed to the main drainage subject to appropriate consent to discharge.

10A10.1.5 Aggressive Ground Conditions

Aggressive ground conditions may be present at the Sites. However, it is anticipated that the risk will be mitigated by using concrete and service pipes appropriate for any aggressive ground conditions identified at the Sites.

10A10.2 Geotechnical Risk Assessment

A number of geotechnical hazards have been identified for the Sites. In order to quantify the risks associated with the proposed works, a preliminary geotechnical risk assessment has been conducted. To do this, an estimate is made of:

- the potential severity of the risk (consequence); and
- the likelihood of the risk occurring.

The likelihood and consequence of the risk are classified according to the criteria in Table 10A10.1.

Table 10A10.1 Scoring rationale describing likelihood and consequences of geohazards

Likelihood			Consequence	
1	Improbable	Extremely unlikely to occur in relevant period	1	Unlikely to have impact on works
2	Remote	Unlikely to occur in relevant period	2	Minor first aid incident or requiring routine maintenance repair.
3	Occasional	Likely to occur in relevant period	3	Lost time, injury or illness; minor damage to property/ infrastructure or significant environmental effect.
4	Probable	Likely to occur several times in relevant period	4	Major injury, major damage to property/infrastructure, or major environmental effect.
5	Frequent	Likely regular occurrence in relevant period	5	Death or major loss; total systems failure

An overall evaluation of the level of risk is gained from a comparison of the severity and probability, as shown in Table 10A10.2.

Table 10A10.2 Geohazard index ranges

Index = Likelihood (L) x Consequence (C) (See also CIRIA SP125)		
16-25	Very High Risk	Unacceptable. Re-examine activities to provide lower risk.
9-15	High risk	Further mitigation measures required and/or alter method of work. Seek approval from all stakeholders if risk cannot be reduced.
6-8	Medium Risk	Tolerable only if further mitigation is not reasonably practical and there is need to continue activity with identified controls.
1-5	Low Risk	Broadly acceptable if all reasonably practicable control measures in place.

A geotechnical risk register for the proposed works has been developed; identifying the risks associated with the current condition of the Sites and typical construction risks relating to the proposed improvement options. The geotechnical risk register is a live document and will need to be updated as risks are identified in subsequent stages of the scheme.

The geotechnical risks associated with the proposed works for the VPI Site, and the Phillips 66 Site are summarised in Table 10A10.3 and 10A10.4, respectively.

Table 10A10.3 Geotechnical Risk Register for the VPI Site

Number	Hazard	Risk	Risk before Mitigation			Mitigation	Risk after Mitigation		
			L	C	I		L	C	I
VPI 001	Unidentified services	Delays or changes to proposed works. Injury or death of site operatives. Damage as a result of works which results in commercial compensation and delays. Increased cost and delay to divert or lower services.	3	5	15	Obtain up to date service plans and records. Service providers contacted before mobilisation and known services marked out. VPI Site to be scanned using Cable Avoidance Tool (CAT) and Ground Penetrating Radar (GPR) before ground works, and hand dug investigation where necessary. Design proposed scheme to minimise impact on existing services. Continued vigilance during work.	1	5	5
VPI 002	Slope instability along drainage ditches	Potential instability in close proximity to onsite drains.	2	3	6	Avoid works undercutting slopes. Where unavoidable, use temporary stabilising structures and provide continuous slope monitoring for signs of instability. Suitable ground investigation and geotechnical analysis prior to works. Earth retaining structures to be considered as necessary.	1	3	3
VPI 003	Unexploded ordnance	Potential UXO related to historical military activity. Injury or death of site operatives. Delays to works.	2	5	10	Continued vigilance during and excavation works. Use of CAT and GPR scanning.	1	5	5
VPI 004	Made Ground, Warp and Tidal Flat Deposits (Clay and Silt)	Any existing artificial and superficial deposit in its current state is unlikely to provide a suitable founding stratum for structural foundations and potentially unsuitable for pavement. Made Ground is anticipated in the northern areas of the undeveloped part of the VPI Site. Tidal Flat Deposits (Clay and Silt) are anticipated in the southern half of the undeveloped area of the VPI Site, apart from small areas in the south and west of the VPI Site, adjacent to the southern VPI Site boundary.	3	3	9	The extent of and potentially highly variable thickness of existing weak and compressible materials or soils, should be assessed during a ground investigation and foundations should be placed on a suitable bearing stratum below any weak and compressible soil. It may require excavation and replacement, or treatment for new hardstanding areas. Deep foundations may be required.	1	3	3
VPI 005	Hard rock / boulders / buried structures	Delays or changes to proposed works / scheme. Piling obstruction.	3	3	9	Suitable ground investigation.	1	3	3

Table 10A10.3 Geotechnical Risk Register for the VPI Site

Number	Hazard	Risk	Risk before Mitigation L	C	I	Mitigation	Risk after Mitigation L	C	I
		Scheme design alterations to avoid underground structures.				Live assessment of ground excavatability. Provision for a pneumatic breaker /suitable plant onsite during excavation. Obtain drawings and information related to current and previous structures for consideration in permanent and temporary works design. Design proposed scheme to minimise impact from existing obstructions and/or break out and remove.			
VPI 006	Unforeseen ground conditions	Inadequate or uneconomic design. Delays or changes to proposed temporary & permanent works. Failure of works. Excessive cost of works.	3	4	12	Suitable ground investigation. Inspection of ground and material during construction to ensure conditions are the same or better than expected. Redesign of temporary and permanent works where necessary.	1	3	3
VPI 007	Differential Settlement of weak compressible soils (Made Ground, clay, Tidal Flat Deposits)	Differential settlement leading to damage to buildings and/or foundations.	3	3	9	Ground investigation to identify underlying ground conditions and design appropriate foundation solutions.	1	3	3
VPI 008	Groundwater Flooding due to shallow groundwater	Additional costs and delays to site works. Flooding of excavations during construction or ground investigation. Flooding of unprotected basements.	4	3	12	An investigation into the groundwater levels including tidal and seasonal variation is recommended prior to commencement of any detailed earthworks or foundation design. Appropriate dewatering equipment onsite. Consideration in permanent and temporary works design.	1	3	3
VPI 009	Groundwater Flooding due to blow wells from Chalk Artesian Aquifers; groundwater in the Till and / or Chalk	Additional costs and delays to site works. Flooding of excavations during construction or ground investigation. Flooding of unprotected basements. Instability of excavations and pile bores as a result of groundwater pressure	3	3	9	Suitable ground investigation. An investigation into the groundwater levels including tidal and seasonal variation is recommended prior to commencement of any detailed earthworks or foundation design. Appropriate dewatering equipment to be deployed to dewater excavations in advance	1	3	3

Table 10A10.3 Geotechnical Risk Register for the VPI Site

Number	Hazard	Risk	Risk before Mitigation			Mitigation	Risk after Mitigation		
			L	C	I		L	C	I
	under excess pressure					Consideration of groundwater pressures in permanent and temporary works design.			
VPI 010	Shrink and Swell associated with tree removal	Increase or decrease in soil water pressure caused by removal or presence of trees causes change in soil volume. This could lead to differential settlement or subsidence of shallow foundations and pavement construction.	2	3	6	Consideration of retention of trees, where present, and impact on shallow foundations or the reverse. Consider deeper foundations to impact mitigation. Root confining planters may be prudent near areas of new landscaping and pavement construction. Where trees are to be removed, retained or planted as part of the Proposed VPI Development assessment should be undertaken to determine the risk they may cause via shrink/heave of soils as a result of their presence/absence. This should be informed by intrusive ground investigation to determine the characteristics of the VPI Site soils and how susceptible they are to changes in pore water pressure.	1	3	3
VPI 011	Acid or sulphate bearing soil & groundwater.	Chemical attack on buried concrete, steel or geosynthetic. The presence of clays onsite within the superficial strata may result in aggressive ground conditions on the VPI Site.	2	3	6	Geochemical laboratory testing on samples taken during ground investigation and analysis of results. Suitable specification of permanent works undertaken.	1	3	3

Table 10A10.4 Geotechnical Risk Register for the Phillips 66 Site

Risk Number	Hazard	Risk	Risk before Mitigation			Mitigation	Risk after Mitigation		
			L	C	I		L	C	I
Phillips 66 001	Unidentified services	The entire Phillips 66 Site is an active oil refinery. Therefore, extensive underground service networks are anticipated. Delays or changes to proposed works. Injury or death of site operatives. Damage as a result of works which results in commercial compensation and delays. Increased cost and delay to divert or lower services.	3	5	15	Obtain up to date service plans and records. Service providers contacted before mobilisation and known services marked out. Site to be scanned using Cable Avoidance Tool (CAT) and Ground Penetrating Radar (GPR) before ground works, and hand dug investigation where necessary. Design proposed scheme to minimise impact on existing services. Continued vigilance during work.	1	5	5
Phillips 66 002	Slope instability along drainage ditches and slopes near the north of the Phillips 66 Site. The Phillips 66 Site is relatively flat, however, there are slopes along the northern Phillips 66 Site boundary and adjacent to drainage ditches.	Potential instability in close proximity to onsite drains, the northern Phillips 66 Site boundary and slopes around industrial infrastructure. Propagation of slope failure into third party land, resulting in cost to client for compensation for damages.	2	4	8	Avoid works undercutting slopes. Where unavoidable, use temporary stabilising structures and provide continuous slope monitoring for signs of instability. Suitable ground investigation and geotechnical analysis prior to works. Earth retaining structures to be considered as necessary.	1	3	3
Phillips 66 003	Unexploded ordnance	Potential UXO related to historical military activity. Injury or death of site operatives. Delays to works.	2	5	10	Continued vigilance during and excavation works. Use of CAT and GPR scanning.	1	5	5
Phillips 66 004	Made Ground, Warp and Tidal Flat Deposits (Clay and Silt)	Any existing artificial and superficial deposit in its current state is unlikely to provide a suitable founding stratum for structural foundations and potentially unsuitable for pavement. Made Ground is anticipated across the entire Phillips 66 Site, apart from the area of undeveloped land to the west of	3	3	9	The extent of and potentially highly variable thickness of existing weak and compressible materials or soils, should be assessed during a ground investigation and foundations should be placed on a suitable bearing stratum below any weak and compressible soil.	1	3	3

Risk Number	Hazard	Risk	Risk before Mitigation			Mitigation	Risk after Mitigation		
			L	C	I		L	C	I
		Eastifled Road. Tidal Flat Deposits (Clay and Silt) along a thin strip encroaching onto the Phillips 66 Site in the north-east area only.				It may require excavation and replacement, or treatment for new hardstanding areas. Deep foundations may be required.			
Phillips 66 005	Hard rock / boulders / buried structures	Delays or changes to proposed works / scheme. Piling obstruction. Scheme design alterations to avoid underground structures.	3	3	9	Suitable ground investigation. Live assessment of ground excavatability. Provision for a pneumatic breaker /suitable plant onsite during excavation. Obtain drawings and information related to current and previous structures for consideration in permanent and temporary works design. Design proposed scheme to minimise impact from existing obstructions and/or break out and remove.	1	3	3
Phillips 66 006	Unforeseen ground conditions	Inadequate or uneconomic design. Delays or changes to proposed temporary & permanent works. Failure of works. Excessive cost of works.	3	4	12	Suitable ground investigation. Inspection of ground and material during construction to ensure conditions are the same or better than expected. Redesign of temporary and permanent works where necessary.	1	3	3
Phillips 66 007	Differential Settlement of weak compressible soils (Made Ground, clay, Tidal Flat Deposits)	Differential settlement leading to damage to buildings and/or foundations.	3	3	9	Ground investigation to identify underlying ground conditions and design appropriate foundation solutions.	1	3	3
Phillips 66 008	Groundwater Flooding due to shallow groundwater	Additional costs and delays to site works. Flooding of excavations during construction or ground investigation. Flooding of unprotected basements.	4	3	12	An investigation into the groundwater levels including tidal and seasonal variation is recommended prior to commencement of any detailed earthworks or foundation design. Appropriate dewatering equipment onsite. Consideration in permanent and temporary works design.	1	3	3
Phillips 66 009	Groundwater Flooding due to blow wells from Chalk Artesian Aquifers; groundwater in the	Additional costs and delays to site works. Flooding of excavations during construction or ground investigation. Flooding of unprotected basements.	3	3	9	Suitable ground investigation. An investigation into the groundwater levels including tidal and seasonal variation is recommended prior to commencement of any detailed earthworks or foundation design.	1	3	3

Risk Number	Hazard	Risk	Risk before Mitigation			Mitigation	Risk after Mitigation		
			L	C	I		L	C	I
	Till and / or Chalk under excess pressure	Instability of excavations and pile bores as a result of groundwater pressure				Appropriate dewatering equipment to be deployed to dewater excavations in advance Consideration of groundwater pressures in permanent and temporary works design.			
Phillips 66 010	Shrink and Swell associated with tree removal	Increase or decrease in soil water pressure caused by removal or presence of trees causes change in soil volume. This could lead to differential settlement or subsidence of shallow foundations and pavement construction.	2	3	6	Consideration of retention of trees and impact on shallow foundations or the reverse. Consider deeper foundations to impact mitigation. Root confining planters may be prudent near areas of new landscaping and pavement construction. Where trees are to be removed, retained or planted as part of the Proposed Phillips 66 Development assessment should be undertaken to determine the risk they may cause via shrink/heave of soils as a result of their presence/absence. This should be informed by intrusive ground investigation to determine the characteristics of the Phillips 66 Site site soils and how susceptible they are to changes in pore water pressure.	1	3	3
Phillips 66 011	Acid or sulphate bearing soil & groundwater.	Chemical attack on buried concrete, steel or geosynthetic. The presence of clays onsite within the superficial strata may result in aggressive ground conditions on the Phillips 66 Site.	2	3	6	Geochemical laboratory testing on samples taken during ground investigation and analysis of results. Suitable specification of permanent works undertaken.	1	3	3

10A.11. Conclusions

10A11.1 VPI Site

VPI Immingham LLP propose to develop a PCC plant and CO_2 compression station to the south of the existing VPI Immingham CHP Plant as part of the Humber Zero project.

The anticipated geology at the VPI Site consists of Tidal Flat Deposits (Clay and Silt) over the southern half of the VPI Site, mostly within the area of undeveloped land. The remainder of the VPI Site, and the Tidal Flat Deposits, are underlain by Devensian Till (Diamicton). Historical boreholes indicate this consists of boulder clay, clay, sand and sand and gravel. The bedrock geology consists of the Burnham Chalk Formation.

Based on a review of historical maps, the entire VPI Site was mostly undeveloped until 2006 when the VPI Immingham CHP Plant was built in the northern area of the VPI Site. The remaining southern area of the VPI Site has been mostly undeveloped, with minimal pipeline infrastructure located in the south-west. A railway line has been present to the south-west of the VPI Site from 1932 onwards. The surrounding area of the VPI Site has been extensively developed from the 1970s onwards for industrial land use purposes.

10A11.1.1 Geo-environmental

It is considered, based on the information obtained, that geo-environmental risks range between *Very Low* and *Moderate*. Potential sources of contamination relating to both onsite, off-site, historical and current land uses have been identified and potential linkages to human health (construction workers and future site users), controlled waters, development infrastructure and flora and fauna may be present.

Made Ground, pipeline networks on the VPI Site, the off-site landfills and surrounding industrial land use are considered to be sources of potential contamination on the VPI Site. Ground gas may also be generated within Made Ground and natural strata located both on and off site, as well as within landfills located off site.

All levels of risk in respect to the LC:RM classifications are considered to be *Acceptable* for all of the pollutant linkages.

10A11.1.2 Geotechnical

Key geotechnical findings as part of this desk study include:

- Made Ground is anticipated in the northern areas of the undeveloped VPI Site. Warp has also been observed in historical boreholes at depths between 0.3 m bgl and 3.96 m bgl.
- Superficial deposits are anticipated across the VPI Site, including Tidal Flat Deposits within the majority of the undeveloped areas of the VPI Site which may have potential compressibility and running sands hazards. This overlies the Devensian Till (Diamicton) deposits across the entire site.
- The bedrock is designated as the Burnham Chalk Formation which is present across the whole VPI Site.

The key geotechnical hazards identified include:

- The VPI Site is potentially underlain by significant depths of soft/compressible cohesive deposits which are likely to comprise of the Tidal Flat Deposits (Clay and Silt), which pose a risk of total or differential settlement of foundations.
- The groundwater is likely to be at shallow levels-based borehole records and Soilscapes [18] data for the VPI Site. This may affect temporary and permanent works.

- There may be utilities and underground services across the VPI Site, therefore, this needs to be considered during the ground investigation.
- The Made Ground, Warp and Tidal Flat Deposits are unlikely to be suitable strata for foundations.
- There is also potential for boulders and cobbles to be encountered within the Devensian Till (Diamicton) superficial deposits.

The risks may be mitigated by further assessment through a supplementary intrusive ground investigation and risk assessment at the detailed design stage, and if necessary, the inclusion of routine construction measures. Therefore, the potential risks identified are not considered to pose a significant risk to the Proposed VPI Development.

10A11.2 Phillips 66 Site

Phillips 66 Limited propose to develop a PCC plant and CO_2 compression station as part of the Humber Zero project. A CO_2 pipeline will connect the Phillips 66 Site to the VPI Site located to the north.

The anticipated geology consists of Tidal Flat Deposits (Clay and Silt) over a thin strip in the north-east area of the Phillips 66 Site. These deposits extend across the railway to the VPI Site in the north. The remaining area of the Phillips 66 Site and the Tidal Flat Deposits (Clay and Silt) are underlain by Devensian Till (Diamicton). Historical boreholes indicate this consists of boulder clay, clay, sand, silt, marl clay and sand and gravel. The bedrock geology consists of the Burnham Chalk Formation with thicknesses up to approximately 150 m recorded in historical boreholes onsite.

Based on a review of historical maps, the Phillips 66 Site e was mostly undeveloped until the 1970s when the industrial infrastructure for the oil refinery was constructed. Since the 1970s, further infrastructure has been constructed on the Phillips 66 Site such as tanks, railway lines and chimneys. The L.N.E.R. Ulceby and Immingham railway line has been present to the north of the Phillips 66 Site since 1932. Extensive industrial development occurred from the 1970s in the surrounding area, including further oil refinery sites to the north and south.

10A11.2.1 Geo-environmental

It is considered, based on the information obtained, that geo-environmental risks range between *Very Low* and *Moderate*. Potential sources of contamination relating to both onsite, off-site, historical and current land uses have been identified and potential linkages to human health (construction workers and future site users), controlled waters, development infrastructure and flora and fauna may be present.

Made Ground, infrastructure associated with the oil refinery onsite (pipelines, tanks and silos), the landfills located onsite and offsite and surrounding industrial land use are considered to be sources of potential contamination on the site. Ground gas may also be generated within Made Ground, natural strata and landfills located both on and off-site. Data from the Ramboll 2020 report indicates there are currently exceedances of GAC criteria within the groundwater on the wider Phillips 66 Refinery Site which Ramboll recommended requires further investigation. However, Ramboll suggest that there is no significant contamination risk on the Phillips 66 Site and indicate that the GAC exceedances may be associated with historic activities on the Phillips 66 Site.

All levels of risk in respect to the LC:RM classifications are considered *Acceptable.*

10A11.2.2 Geotechnical

Key geotechnical findings as part of this desk study include:

- Although Made Ground was only encountered to 0.25 m bgl in one borehole within the wider refinery site; Made Ground is anticipated across the entire Phillips 66 Site, apart from the undeveloped land within the VPI Site. Warp has also been observed in one historical borehole within the wider refinery site at 4.57 m bgl and 5.79 m bgl, with a thickness of 1.22 m.
- Superficial deposits are anticipated across the Phillips 66 Site. A thin band of Tidal Flat Deposits encroaches on the Phillips 66 Site from the north-east which is associated with *Moderate*

compressibility and running sands hazards. Devensian Till (Diamicton) deposits are present across the entire Phillips 66 Site.

- The bedrock is designated as the Burnham Chalk Formation which is present across the whole Phillips 66 Site.

The key geotechnical hazards identified include:

- The Phillips 66 Site is potentially underlain by significant depths of soft/compressible cohesive deposits which are likely to comprise of the Devensian Till (Diamicton) deposits which pose a risk of total or differential settlement of foundations.
- The groundwater is likely to be at shallow levels based on the monitoring data provided in the Ramboll 2020 Interpretative Report. This may affect temporary and permanent works.
- There is a high likelihood that utilities and underground services are located across the site as it is an active oil refinery. Therefore, this needs to be considered during the ground investigation.
- The Made Ground, Warp and Tidal Flat Deposits are unlikely to be suitable strata for foundations.
- There is also potential for boulders and cobbles to be encountered within the Devensian Till (Diamicton) superficial deposits. There may be potential slope stability hazards associated with slopes near the northern Phillips 66 Site boundary.

The risks may be mitigated by further assessment through a supplementary intrusive ground investigation and risk assessment at the detailed design stage, and if necessary, the inclusion of routine construction measures. Therefore, the potential risks identified are not considered to pose a significant risk to the Proposed Phillips 66 Development.

10A.12. Recommendations

10A12.1 VPI site

It is recommended that ground investigation works are undertaken across the footprint of the Proposed VPI Development. The ground investigation would be required to determine the presence of any geo-environmental and/or geotechnical issues that require mitigation. A ground investigation is proposed to be undertaken by Worley following the end of the bird nesting season in 2022. AECOM have reviewed the scope of works for the ground investigation and provided additional recommendations for the investigation.

Prior to the ground investigation, service providers should be contacted before mobilisation and known services marked out. The VPI Site should also be scanned using Cable Avoidance Tool (CAT) and Ground Penetrating Radar (GPR) before ground works, and hand dug investigation where necessary. In addition to this, drawings and information related to current and previous structures should be obtained.Worley have provided a scope of works for an Underground Facilities Detection Survey to identify detectable underground features up to 4 m bgl which will be marked on survey drawings and the properties of the feature will be specified, such as the depth, type and size of the utility.

The investigation is proposed to include the following:

- Investigation of the soil profile and properties using cable percussion boreholes and trial pits (to 2 m bgl);
- Investigation of chalk bedrock depth using boreholes to 25 m bgl;
- Cone Penetration Tests, Seismic Cone Penetration Tests, Vane Shear Tests (if saturated clay or silty soil is encunteted) and Soil Thermal Resistivity / Earth Resistivity Test
- Potential use of Multi-channel Analysis of Surface Waves to investigate boulders and inclusions in Glacial Till;
- Geotechnical sample collection and laboratory testing for the following:
    - Moisture content;
    - Attererg limits;
    - Bulk and dry density;
    - Specific gravity;
    - Particle size distribution;
    - Compaction properties;
    - Compressibility / permeability properties;
    - Shear strength;
    - Unconfined compression tests;
    - CBR tests;
    - Maximum and minimum density / relative density; and
    - Dynamic Modulus of Elasticity, Shear Modulus and Poisson’s Ratio.
- Geoenvironmental sampling and laboratory testing, including the following:
    - Carbonate content;
    - Chloride content;
    - Ammonia;
    - Magnesium;

  - pH;
  - Sulphate;
  - Water sulphate;
  - Water chloride;
  - Water pH;
  - Water carbonate content; and
  - Geoenvironmental testing for contamination and Waste Acceptance Criteria.
- Investigation of groundwater and ground gas using monitoring standpipes within the boreholes; and
- Post-works monitoring of groundwater and ground gas for a minimum of one return visit one week after completion of site works

Following the ground investigation, Worley will provide borehole logs, a factual report, engineering calculation and an interpretative report.

10A12.2 Phillips 66 Site

It is recommended that ground investigation works are undertaken across the footprint of the Proposed Phillips 66 Development. The ground investigation would be required to determine the presence of any geo-environmental and/or geotechnical issues that require mitigation.

Prior to the ground investigation, service providers should be contacted before mobilisation and known services marked out. The Phillip 66 Site should also be scanned using Cable Avoidance Tool (CAT) and Ground Penetrating Radar (GPR) before ground works, and hand dug investigation where necessary. In addition to this, drawings and information related to current and previous structures should be obtained.

It is recommended that the ground investigation should include the following:

- Investigate the nature and extent of Made Ground across the Site;
- Investigate the nature of the underlying natural superficial deposits, where present, including determination of in-situ soil properties;
- Investigate depths to the weathered and competent bedrock (Burnham Chalk Formation);
- Investigate bedrock materials (dependent on proposed structure loadings) to determine an adequate founding stratum;
- Obtain soil and groundwater samples for chemical testing and geotechnical testing. Particular attention should be focused on the borehole locations where GAC exceedances were recorded in the Ramboll 2020 Interpretative Report;
- Install gas and groundwater monitoring wells and undertake monitoring of ground gas concentrations, groundwater levels and determinand concentrations within boreholes, particularly around the area of BH29 described in the Ramboll 2020 Interpretative Report; and
- Undertake a range of suitable soil, leachate, and groundwater chemical tests, including BRE sulfate tests.

Following the ground investigation, an interpretative report comprising human health, controlled waters, ground gas and geotechnical risk assessments should be undertaken to fully assess the levels of contamination and geotechnical constraints across the Phillips 66 Site, to identify mitigation measures where required and make recommendations to allow the redevelopment of the Phillips 66 Site. This report would also review the related geotechnical issues based on the ground investigation results and provide outline guidance on the need for ground improvement and feasible foundation types that may be appropriate at the Phillips 66 Site.

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Drawings (Replicated from ES Volume III)

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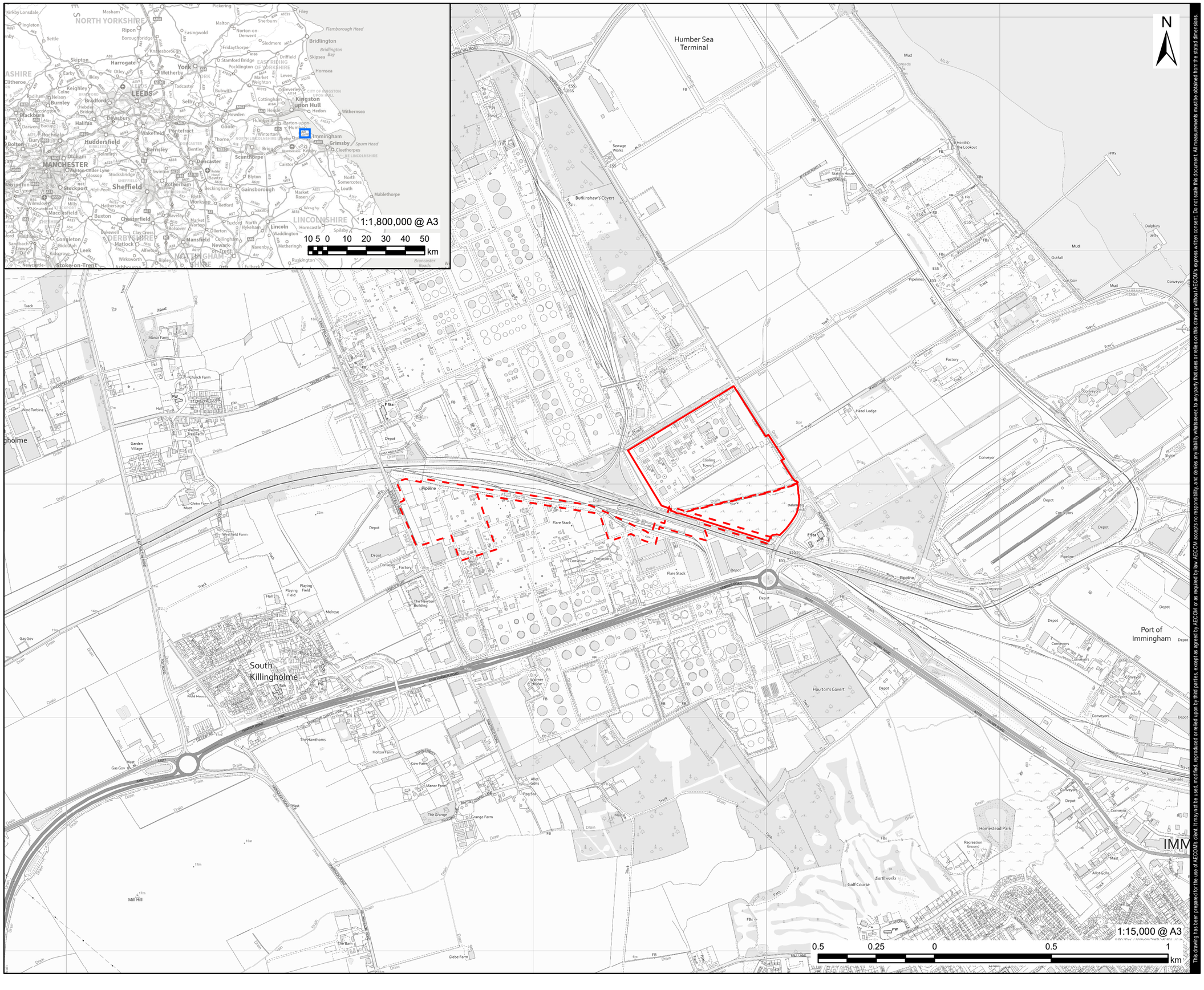

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LEGEND

- Proposed Phillips 66 Development Application Boundary (the Phillips 66 Site)
- Proposed VPI Immingham Development Application Boundary (the VPI Site)

NOTES

The boundaries of the Phillips 66 Site and the VPI Site are shown separately on Figures 1.2 and 1.3

ISSUE PURPOSE

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PROJECT NUMBER

60668866

FIGURE TITLE

Sites Location Plan

FIGURE NUMBER

Figure 1.1

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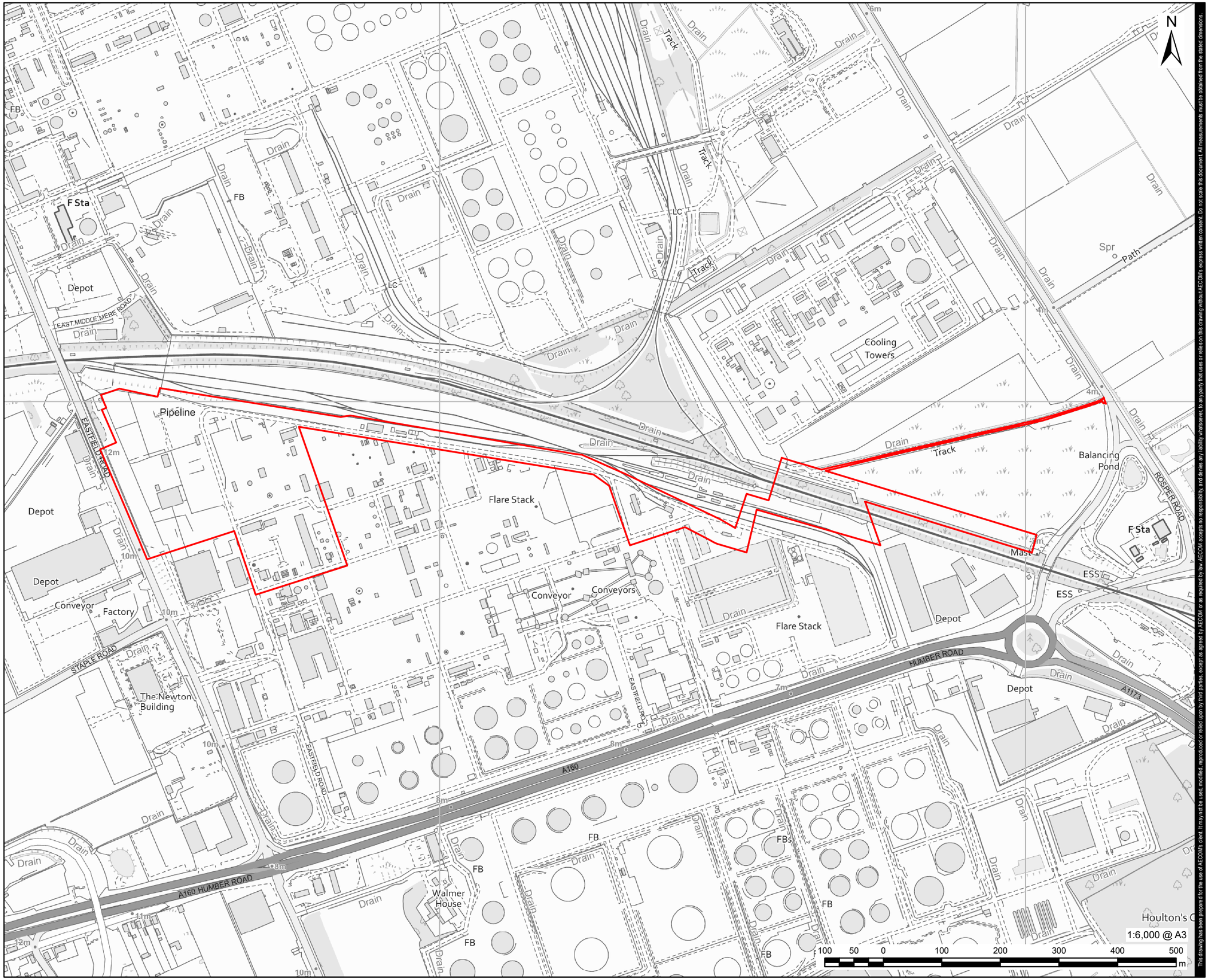

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Proposed Phillips 66 Development Application Boundary (the Phillips 66 Site)

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FIGURE TITLE

Proposed Phillips 66 Development Application Boundary (the Phillips 66 Site)

FIGURE NUMBER

Figure 1.2

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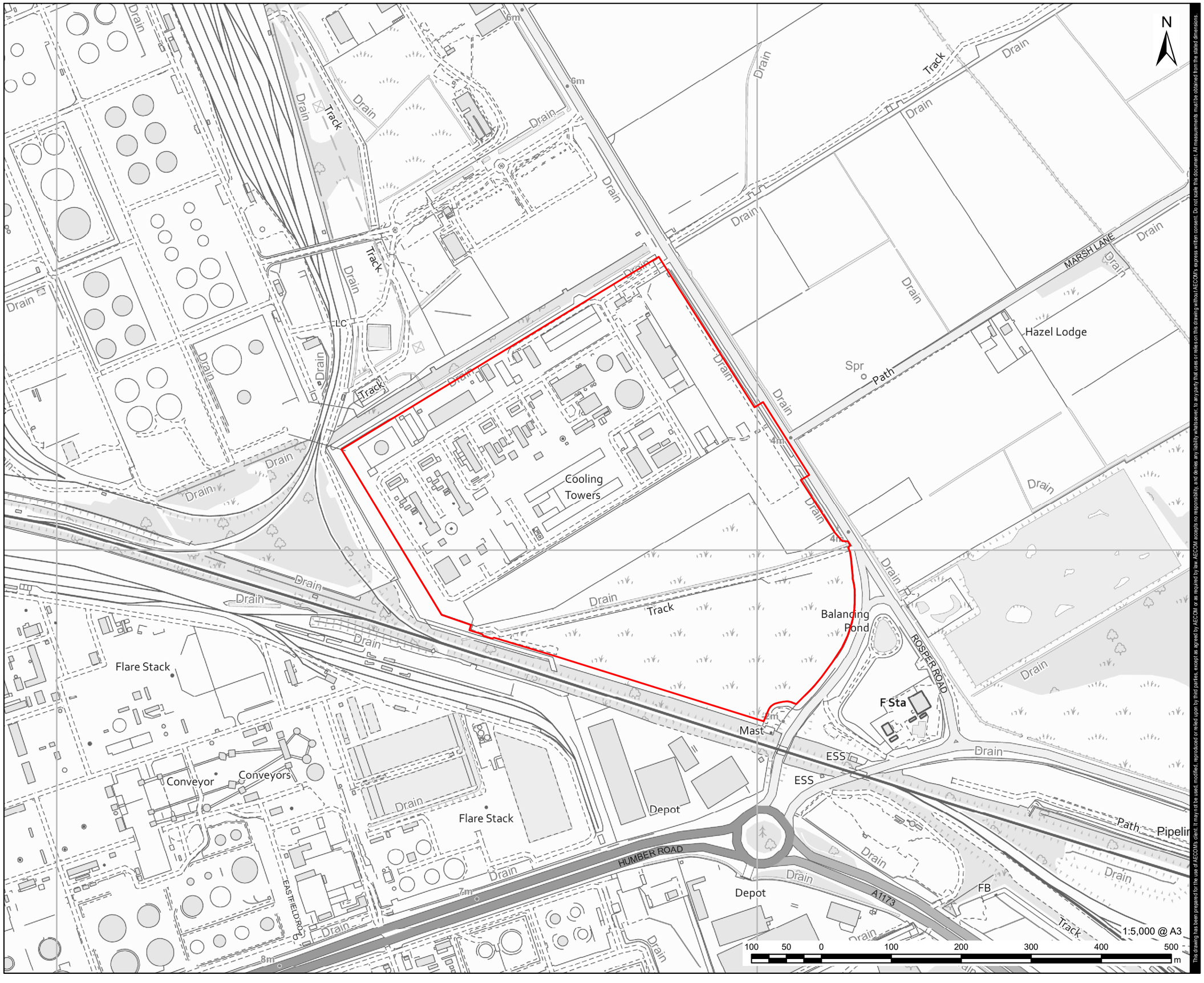

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Proposed VPI Development Application Boundary (the VPI Site)

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FIGURE TITLE

Proposed VPI Development Application Boundary (the VPI Site)

FIGURE NUMBER

Figure 1.3

Annex A Envirocheck Report for the VPI Site

Refer to separate document

Annex B Envirocheck Report for the Phillips 66 Site

Refer to separate document

Annex C AECOM Engineer Site Walkover Photographs

Refer to separate document

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