CCG-C-18-10350

PRELIMINARY

GROUND INVESTIGATION REPORT FOR SITE AT

CO2, WEST WATERLOO DOCK, LIVERPOOL

OCTOBER 2018

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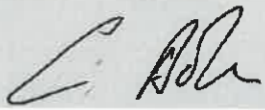
Signature:	
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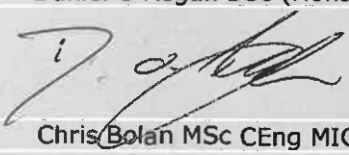
Signature:	
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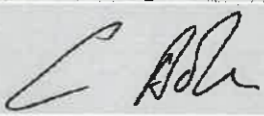
Signature	
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1.0 INTRODUCTION

CC GEOTECHNICAL LTD (CCG) is providing ground investigation and consultancy services to *ROMAL CAPITAL*, in connection with the proposed redevelopment of the disused West Waterloo Dock and adjoining Waterloo Lock, where it is proposed that a number of high-rise buildings be constructed.

The proposed development comprises the construction of 4nr mixed use blocks providing both commercial and residential accommodation. The development is identified as CO2 in the Liverpool Waters Masterplan approved by Liverpool City Council under planning reference 10O/2424: June 2013. The development will require land reclamation works by the construction of a cut off wall within the West Waterloo Dock providing a physical delineation between the reclaimed land and the Leeds-Liverpool canal alignment which presently traverses a strip bound by floating buoys along the eastern boundary of the dock. It is proposed that buildings will be sited wholly within the infilled dock.

A combined Phase 1 Desk Study / Phase 2 Ground Investigation Report was required to provide information relevant to the detailed design and construction of foundations and infrastructure elements of the proposed development, and to secure discharge of relevant pre-commencement planning conditions.

2.0 PURPOSE & AIMS OF THE STUDY & INVESTIGATION

The primary aim of the Phase I Desk Study was to assess whether the site is likely to be affected by contamination, to an extent that it may pose a risk to human health and/or the built environment and/or the natural environment and/or is affected by any other natural or man-made feature which may impact on the proposed development. Specific tasks undertaken to achieve this were as follows:

- A review of available information including historical mapping, commercial environmental databases and Environment Agency Data
- The undertaking of a site walkover
- The development of a Preliminary Conceptual Model

The main purpose of the Phase II Intrusive Investigation was to confirm the conclusions of the desk study, with particular reference to:

- The assessment of the nature and extent of contamination in relation to potential risks to human health for end users, construction workers, and worker occupants of adjacent properties
- The assessment of the nature and extent of contamination in relation to potential risks to controlled waters
- The assessment of the nature and extent of contamination in relation to potential risks to the fabric of

buildings and services

- The refinement of the Preliminary Conceptual Model confirming pollution linkages that have been demonstrated to be actually present
- The identification of feasible remediation measures to remove or break the identified pollution linkages
- The provision of factual information and interpretative comment on ground conditions in relation to foundation selection, design and construction

3.0 SITE DATA

3.1 Site Location

The site is situated on West Waterloo Dock and the adjacent infilled Waterloo Lock as shown on the Drawings provided in Appendix A. The Ordnance Survey coordinates for the approximate site centre are 333452E, 391297N. The quaysides within the site stand at an elevation of around 8mAOD.

3.2 Site Description & Walkover Observations

The site was visited during August 2018 on completion of a review of relevant historical and environmental mapping data (provided in Appendices C and P). Photographs taken at the time of the visit are presented in Appendix B.

It was observed that the site is situated within a marine context. The proposed development area comprises part of a redundant dock and part of the adjoining redundant lock, extending to the approximate overall dimensions of 170m x 70m. It was evident from visual inspection that the dock was partially infilled, with a depth of free water of around 3m above fill level. The eastern side of the dock is adjoined by a modern residential apartment development, sited on the historic quayside which separated West Waterloo and East Waterloo Docks. The western side is formed by a quayside. At the western side of this quay is the River Mersey river wall, the eastern side forming the western wall of the Waterloo Lock. Adjacent to the western quayside is a parallel “promontory” quay which forms the eastern wall of the Waterloo Lock and which historically provided an operational dock quayside on its eastern side against which vessels berthed.

Within the Waterloo Lock there are 3 sets of lock gates – one at the lock entrance from the river (outside of the subject site), one at the mid-point of the lock alignment (just infringing into the site), and one at the northern end of the lock alignment, this being within the site. All 3 sets of gates are intact and in the `closed` position. The lock has been infilled roughly to quayside level.

At the northern end of the site is an earth bank sloping down into the dock. This bank was formed when new bridge works and canal alignment improvements were carried out in the past 10 years or so.

South of the site, the West Waterloo Dock adjoins the open stretch of water forming the Princes Half Tide dock. It is understood that development of a new terminal for the Isle of Man ferry service is to proceed at the junction of West Waterloo dock and Princes Half Tide dock.

The surface topography across the quaysides is essentially flat, standing at a level of about 8mAOD. Surface cover on the quaysides comprises largely of concrete paving, with extensive broken ground and weed growth. Numerous

large steel hatches and openings are present within the quaysides enclosing the Waterloo Lock consistent with the heavy mechanical plant that would have been installed to operate the massive lock gates.

4.0 SITE HISTORY

The history of the site and its immediate surrounds was investigated by consultation with a range of archive resources. Historical mapping was procured for the site and is provided in Appendix C. Geographical information, and environmental data were primarily obtained via the GroundSure Geo Insight and Enviro-Insight Reports (CMAPS-AAG-747728-4165-091018, dated October 2018) presented in Appendix P. An aerial photograph of the site circa 1937 is shown hereunder:

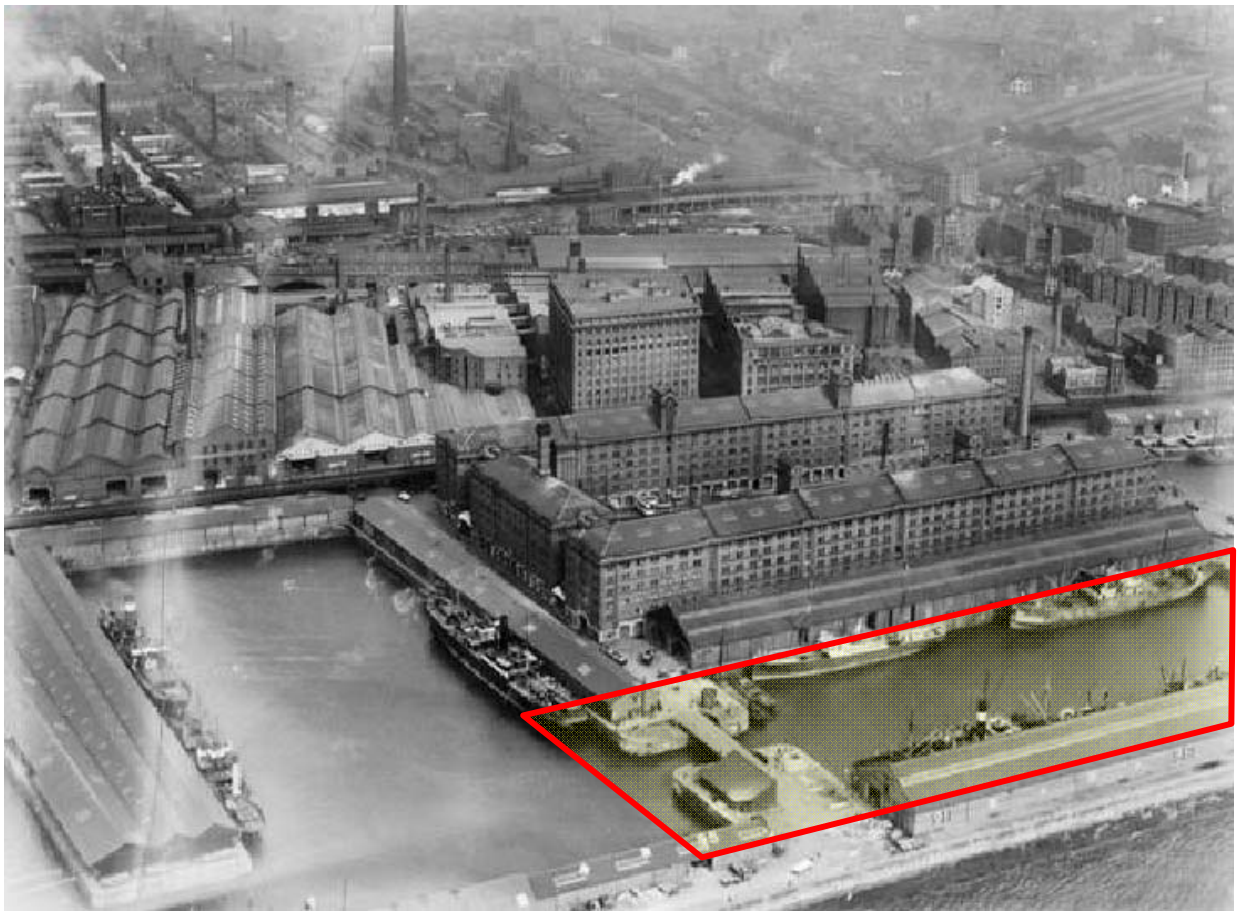


Plate 1: Site Configuration circa 1937

A summary of the historical mapping data is given hereunder:

Table 1: Historical Map Review

YEAR	SCALE	ON SITE	ADJACENT TO SITE	<250M
1848 1850 1851	1:1,056 1:1,056 1:10,560	Site is within Waterloo Dock which is constructed as a single dock (before its later division into East & West sections)	Waterloo Dock Lock to the SE of the site N: Swing bridge entrance to Victoria Dock E: Expanse of Waterloo Dock S: A `Wrecked Goods` Depot is situated in the located to the S of the site, with Liverpool Observatory further to the S. W: Quayside adjoining River Mersey	[Mapping unclear] c.85m N: Trafalgar Dock c.170m E: Dock Road, with Railway established c.200m E: Waterloo Station (Goods)
1890 1893 1898-99 1899 1906-07 1908 1911 1926 1925-27 1927 1928 1935 1938 1938	1:10,560 1:2,500 1:10,560 1:2,500 1:10,560 1:2,500 1:2,500 1:2,500 1:10,560 1:2,500 1:10,560 1:2,500 1:10,560 1:10,560	Layout changes made to the docks – Waterloo dock now divided East and West - Site now wholly within West Waterloo Dock	N: Swing bridge entrance to Victoria Dock E: East Shed [of Waterloo Dock] W: West Dock Shed S: Swing bridge beyond which is Prince's Half Tide Dock [former Prince's Dock Basin]	c.50m E: East Waterloo Dock, adjacent Warehouse to the N and Grain Warehouses to the W/E. c.210m E: Paint Works, in close proximity to Crane to the E c.210m E: Saw Mill, in close proximity to Brass Foundry to the N c.240mm SE: Tobacco Warehouse, in close proximity to Lead Works to the N Much of the above recognised as "Warehouses" in later mapping
1953 1954 1953-55 1958-62 1962 1964 1966-67 1967-69	1:1,250 1:1,250 1:2,500 1:1,250 1:2,500 1:2,500 1:10,560 1:1,250	West Shed [of West Waterloo Dock] no longer present – Waterloo Lock now constructed incorporating 3 lock gates one of which carries a swing bridge. The lock has required the construction of a new quayside incorporating the eastern wall of the lock	No significant change Swing bridge no longer present at north end of the site	No significant change
1973 1974-75 1982 1982-84 1983-84 1990	1:10,000 1:1,250 1:10,000 1:1,250 1:1,250 1:10,000	Kingsway Tunnel transects the site in the N portion on an approximate W-E alignment	W/E: Kingsway Tunnel E: Travelling Crane recognised	c.20m NE: Container Depot c.40m E: Container Depot [former West Warehouse of East Waterloo Dock] c.200m E: Waterloo Station no longer recognised
1993 1993 1993 2002 2010 2014	1:1,250 1:1,250 1:1,250 1:10,000 1:10,000 1:10,000	No significant change in layout but it is known that the dock has now been partially infilled. Waterloo Lock now disused and infilled by 2010	E: Scrap Yard [former Travelling Crane / Container Depot]	No significant change

The most significant events in the history of the site are the construction of the Waterloo Lock and its later abandonment followed by its infilling, and the partial infilling of the adjoining dock. Various other modifications to dock infrastructure layout have occurred. These modifications may have left remnants foundation structures in the ground.

5.0 ENVIRONMENTAL SETTING

5.1 Natural Geology

The natural geology of the site was researched by reference to Sheet 96, Liverpool, 1:50000 scale British Geological Survey Solid and Drift Geology (1997).

The BGS map documents the site to be directly underlain by Tidal Flat Deposits of post-glacial origin, possibly overlying Diamicton of Glacial origin. The documented solid geology comprises of Chester Pebble Beds.

Geological Information obtained from the GroundSure Environmental Report is presented in Appendix P, and summarised hereunder:

Table 2: Summary of Geological Data from GroundSure Report

GEOLOGY		
Data	**Distance**	**Comments**
Artificial Ground	On Site	Artificial made ground of unknown composition and thickness underlies the site within the infilled Waterloo Lock and within the partially infilled West Waterloo Lock
Superficial Deposits / Drift Geology	On Site	Tidal Flat Deposits of post-glacial origin overlying Diamicton of Gacial origins
Permeability of Drift Deposits	>200m	Low Permeability
Landslip	On Site	None found
Bedrock and Solid Geology	On Site	Chester Pebble Beds
Permeability of Bedrock	On Site	Maximum Permeability – High
	On Site	Minimum Permeability – Moderate
Faults	On Site	N/A
	<500m	461m E: Fault, inferred, displacement unknown
Radon Affected Area	On Site	Less than 1% of properties are above the action level
Radon Protection	On Site	No radon protective measures are necessary
HISTORIC AND CURRENT GROUNDWORKINGS		
Data	**Distance**	**Comments**
Historical Surface Ground Workings	On site	Docks [1890-1990]
	<50m	No records
	<250m	No records
Historical Underground Workings	<500m	On Site: Tunnel [1973-90] 395m E: Tunnel [1973] 482m E: Tunnel [1906] 485m E: Tunnel [1938] 496m E: Tunnel [1909-73]
Current Ground Workings	<500m	No records
Historical Mining	<500m	No records
Are there any coal mining areas within 1km of the study site?	<1000m	No records
Non-Coal Mining Activities	<500m	No records
Non-Coal Mining Cavities	<1000m	No records
Natural Cavities	<1000m	No records
Brine Extraction Activities	<1000m	No records
Gypsum Extraction	<1000m	No records
Tin Mining	<1000m	No records
Clay Mining	<1000m	No records

Table 2: Summary of Geological Data from GroundSure Report (continued)

HAZARDS		
Data	**Distance**	**Comments**
Maximum Shrink-Swell hazard rating	On site	Very Low
Maximum Landslide hazard rating	On site	Very Low
Maximum Soluble Rocks hazard rating	On site	Negligible
Maximum Compressible Deposits hazard rating	On site	Very Low / Moderate
Maximum Collapsible Deposits hazard rating	On site	Negligible / Very Low

5.2 Hydrology and Hydrogeology

Information on hydrology and hydrogeology obtained from a GroundSure Environmental Report is presented in Appendix P, and summarised hereunder:

Table 3: Summary of Hydrology and Hydrogeological Data

UNIT	PROPERTIES		HYDROGEOLOGICAL DESIGNATION
Made ground deposited in dock and adjoining lock	Generally granular with high permeability.		Unproductive
Chester Pebble Beds Formation	Geology of high inter-granular and fracture permeability, usually providing a high level of water storage any may support water supply /river base flow on a strategic scale.		Principal
Tidal Flat Deposits	These are drift deposits with low permeability that have negligible significance for water supply or river base flow		Unproductive
Groundwater Abstraction licenses		<1000m	515m SE: Point: BH(B) at St. Paul's Square off Old Hall Street. Licence No: 2569030066 519m SE: Point: BH(B) at St. Paul's Square off Old Hall Street. Licence No: 2569030066/R01 523m SE: Point: BH(C) at St. Paul's Square off Old Hall Street. Licence No: 2569030066/R01 524m SE: Point: BH(C) at Paul's Square off Old Hall Street. Licence No: 2569030066 556m SE: Point: Pipeline at George's Dock Pumping Station. Licence No: 2569030065 559m SE: Point: Pipeline at George's Dock Pumping Station. Licence No: 2569030065R01 890m E: Point: Borehole at 23 Blackstock Street. Licence No: 2569030057
Surface water abstraction licenses		<1000m	None
Potable Water Abstraction Licences		<1000m	None
Source Protection Zone		<500m	None
Environment Agency information on groundwater vulnerability and soil leaching potential within 500m of the study site		<500m	On Site: Major Aquifer / High Leaching Potential (HU) 462m NE: Minor Aquifer / High Leaching Potential (HU)
Nearest surface water body		<250m	On Site 10m N 214m S
Is there any EA information on river quality within 500m of study site?		<500m	No
Are there any Detailed River Networks within 250m of Site?		<250m	No

Table 3: Summary of Hydrology and Hydrogeological Data (continued)

FLOODING		
Is the site within 250m of an Environment Agency Zone 2 floodplain?	<250m	On Site: Zone 2 (Fluvial / Tidal Models)
Is the site within 250m of an Environment Agency Zone 3 floodplain?	<250m	On Site: Zone 3 (Fluvial Models)
What is the highest risk of flooding onsite?	On Site	High
Are there any Flood Defences within 250m of the study site?	<250m	No
Are there any areas benefiting from Flood Defences within 250m of the study site?	<250m	No
Are there any areas used for Flood Storage?	<250m	No
Are there any BGS groundwater flooding susceptibility flood areas within 50m of study site?		None identified
What is the BGS Flood Risk Susceptibility Rating?		Not Prone

For simplified interpretation, the geological succession underlying the site may be regarded as a series of discrete units in terms of their hydrogeological significance, as illustrated hereunder:

Table 4: Hydrogeological Interpretation

UNIT	PROPERTIES	HYDROGEOLOGICAL DESIGNATION
Made ground infill	Granular deposits of high permeability	Unproductive
Tidal Flat Deposits	These are drift deposits with low permeability that have negligible significance for water supply or river base flow	Unproductive
Chester Pebble Beds Formation	Geology of high inter-granular and fracture permeability, usually providing a high level of water storage any may support water supply /river base flow on a strategic scale.	Principal

5.3 Radon

The site is not in a Radon Affected Area, as less than 1% of properties are above the Action Level, and therefore radon protective measures are not required.

5.4 Mining

Geological mapping together with the appended Groundsure Report confirmed that there are no coal mining areas within 1000m of the study site, no non-coal mining areas within 1000m of the study site boundary, and no brine affected areas within 1000m of the study site, and therefore a Coal Authority Coal and Brine Report was not procured.

5.5 UXO Risk

A UXO Risk assessment was procured from a specialist consultancy and is contained herein in Appendix N. The report concluded that `considering the findings of the assessment, a UXO Threat Mitigation Strategy is not required to be in place prior to intrusive engineering works at this site of concern`.

6.0 FURTHER ENVIRONMENTAL DATA

Environmental data was researched using several sources including Environment Agency Maps and GroundSure Envirosight Report presented in Appendix D and is summarised hereunder in Table 5.

Table 5: Further Environmental Data

Records of Potentially Contaminative Land Uses		
Data	Distance	Comments
Current Land Uses within 250m of study site	<250m	On Site: West Waterloo Dock [Marine Equipment including Boats and Ships] 5m S: Electric Sub-Station [Electrical Features] 17m E: Electric Sub-Station [Electrical Features] 18m E: Electric Sub-Station [Electrical Features] 37m E: Electric Sub-Station [Electrical Features] 59m N: Trafalgar Dock [Marine Equipment including Boats and Ships] 81m S: Tank [Tanks (Generic)] 82m E: East Waterloo Dock [Marine Equipment including Boats and Ships] 85m E: Waterloo Quay [Moorings and Unloading Facilities]
Petrol & Fuel Sites	<250m	No records
Records of National Grid high voltage underground electricity transmission cables within 500m of the study site:	<500m	No records
Records of National Grid high pressure gas transmission pipelines within 500m of the study site	<500m	No records
Records of historical tanks within 250m of the study site	<250m	On Site: Unspecified Tank [1927] 11m S: Unspecified Tank [1927] 51m E: Unspecified Tank [1927] 80m S: Tanks [1975] 81-82m S: Unspecified Tank [1975-96] 91-92m E: Unspecified Tank [1975-83] 92-93m E: Tanks [1953-69] 106m E: Tanks / Unspecified Tanks [1975-83] 119-20m E: Tanks [1969-83] 153m E: Unspecified Tank [1982-83] 156m E: Unspecified Tank [1982-83] 167m SE: Unspecified Tank [1982-83] 171m SE: Unspecified Tank [1982-83] 172m N: Tanks [1962] 173-74m N: Tanks / Unspecified Tank [1908-62] 192m N: Tanks [1962] 233m NE: Tanks [1893] 235m E: Unspecified Tank [1996] 240m E: Unspecified Tank [1996] 242m NE: Tanks [1908-27]
Records of historical garage and motor vehicle repair sites within 250m of the site	<250m	229m NE: Garage [1967]
Records of historical energy features within 250m of the site	<250m	58m N: Disused Power Station [1993] 135m E: Electric Sub-Station [1993-96] 193m E: Electric Sub-Station [1969] 209m N: Power Station / Disused Power Station [1967-84]
Records of Potentially Infilled Features from 1:10,000 scale mapping within 250m of the site	<250m	On Site: Tunnel [1973-90] On Site: Dock / Docks [1851-1990] 10m N: Dock [1851] 30m N: Dock [1851] 53m E: Dock [1851] 90m S: Dock [1851] 106m E: Dock [1927] 165m N: Dock [1851] 172m SE: Dock [1928] 199m S: Dock [1927]

Table 5: Further Environmental Data (continued)

Records of Potentially Contaminative Land Uses		
Data	Distance	Comments
Records of historical petrol stations and fuel sites within 500m of the site	<500m	No records
Records of sites with a potentially contaminative past land use within 250m of the site	<250m	On Site: Railway Sidings [1906-90] On Site: Tunnel [1973-90] On Site: Dock / Docks [1851-1990] 1m E: Unspecified Warehouse [1967] 1m SW: Unspecified Tank [1928] 9m SE: Railway Sidings [1890] 10m N: Dock [1851] 15m NE: Unspecified Depot [1982-90] 26m S: Unspecified Tank [1906] 30m N: Dock [1851] 53m E: Dock [1851] 90m S: Dock [1851] 90m E: Unspecified Tank [1967] 95m E: Unspecified Tanks [1982-90]

STATUTORY AUTHORISATIONS		
Data	Distance	Comments
Records of Historical IPC Authorisations within 500m of study site	<500m	456m N: North Western Ship Repairers and Shipbuilders Ltd. Process: Coating Processes and Printing [Status: Revoked]
Records of Part 1(A) & IPPC Authorised Activities within 500m of study site	<500m	No records
Records of Water Industry Referrals (potentially harmful discharges to public sewer) within 500m of study site	<500m	No records
Records of Red List Discharge Consents (potentially harmful discharge to controlled waters) within 500m of study site	<500m	No records
Records of List 1 Dangerous Substance Inventory sites within 500m of study site	<500m	472m SW: Scottsfield Screening Plant, Wallasey. Authorised Substances: Cadmium [Not Active]
Records of List 2 Dangerous Substance Inventory sites within 500m of study site	<500m	No records
Records of Part A(2) & Part B Activities & Enforcements within 200m of study site	<200m	No records
Records of Category 3 or 4 Radioactive Substance Licences within 500m of study site	<500m	No records
Records of Planning Hazardous Substance Consents & Enforcements within 500m of study site	<500m	No records
Records of COMAH & NIHHS sites within 500m of study site	<500m	No records
Records of National Incidents Recording System, List 2 within 200m of study site	<200m	83m E: 3/7/2001. ID: 13303. Pollutant: Other Pollutant – Other 108m E: 10/7/2002. ID: 90449. Pollutant: Oils and Fuel – Diesel
Records of National Incidents Recording System, List 1 within 200m of study site	<200m	175m SE: 25/7/1999. ID: 30597. Catchment Name: River Mersey (Etherow). Water Description: Estuary. Water Course: Coastline Trib for 68/69

Table 5: Further Environmental Data (continued)

STATUTORY AUTHORISATIONS		
Data	Distance	Comments
Records of Licenced Discharge Consents within 100m of study site	<100m	47m SW: Mersey Docks & Harbour Co. Effluent Type: Sewage Discharges – Unspecified – Not Water Company. Permit No: 016990737 47m SW: Mersey Docks & Harbour Co. Effluent Type: Sewage Discharges – Final/Treated Effluent – Not Water Company. Permit No: 01699036 87m E: Mersey Docks & Harbour Co. Effluent Type: Sewage Discharges – Unspecified – Not Water Company. Permit No: 016990726 87m E: Mersey Docks & Harbour Co. Effluent Type: Miscellaneous Discharges – Surface Water. Permit No: 016990725 87m E: Mersey Docks & Harbour Co. Effluent Type: Sewage Discharges – Unspecified – Not Water Company. Permit No: 016990728 87m E: Mersey Docks & Harbour Co. Effluent Type: Sewage Discharges – Unspecified – Not Water Company. Permit No: 016990724 87m E: Mersey Docks & Harbour Co. Effluent Type: Sewage Discharges – Unspecified – Not Water Company. Permit No: 016990727
Records of sites determined as Contaminated Land under Section 78R of the Environmental Protection Act 1990 are there within 200m of the study site	<200m	No records
LANDFILL & OTHER WASTE SITES		
Data	Distance	Comments
Records of Environmental Agency historical Landfill data within 500m of study site	<500m	On Site: Waterloo Dock River. Site Reference: GDO M178 2m E: Victoria Branch Dock. Site Reference: GDO M177 57m N: Trafalgar Branch Dock. Site Reference: GDO M176
Records of Operational Landfill Sites Sourced from Landmark within 500m of study site	<500m	No records
Records of Operational Waste Treatment, Transfer or Disposal sites within 500m of study site	<500m	On Site: Scrap Yard 22m N: Waste Transfer Station 289m E: Scrap Metal Yard 338m E: Scrap Merchants 341m E: Scrap Merchants
Records of Environmental Agency Waste sites within 500m of study site	<500m	No records
Records of Local Authority landfill sites within 500m of the study site	<500m	No records
Records of EA Licenced Waste sites within 500m of study site	<500m	226m E: 25 Vandries Street. Metal Recycling Site (Vehicle Dismantler). Waste Management Licence No: 53667 374m NE: Unit 1, 8 Regent Road. 75kte Vehicle Depollution Facility. Waste Management Licence No: 401259 446m E: 76/2 Sprainger Street. ELV Facility. Waste Management Licence No: 50386
Records of Registered Waste Transfer or Disposal sites within 500m of study site	<500m	No records
Records of Non-operational Landfill sites sourced from Landmark within 500m of study site	<500m	No records
Records of BGS/DoE non-operational Landfill sites within 500m of study site	<500m	No records
DESIGNATED ENVIRONMENTALLY SENSITIVE SITES		
Data	Distance	Comments
Records of SSSI within 500m of site	<500m	None
Records of National Parks (NP) within 500m of the study site	<500m	None
Records of NNR within 500m of site	<500m	None
Records of SAC's within 500m of site	<500m	None

Table 5: Further Environmental Data (continued)

DESIGNATED ENVIRONMENTALLY SENSITIVE SITES		
Data	Distance	Comments
Records of SPA's within 500m of site	<500m	None
Records of Ramsar sites within 500m of site	<500m	None
Records of LNR sites within 500m of site	<500m	None
Records of ESA within 500m of site	<500m	None
Records of AONB within 500m of site	<500m	None
Records of Nitrate Sensitive Areas within 500m of site	<500m	None
Records of Nitrate Vulnerable Zones within 500m of site	<500m	None
Records of Ancient Woodlands within 500m of site	<500m	None
Records of World Heritage Sites within 500m of site	<500m	On Site: Liverpool – Maritime Mercantile City [Historic England] On Site: Liverpool – Maritime Mercantile City Buffer Zone [Historic England]

7.0 ARCHAEOLOGICAL DATA

A full discussion on the archaeology of the dock system is contained in Appendix O. Of specific interest on this site are the lock gates of the Waterloo Lock. There are 3 sets of gates – the most southerly of which form the entrance to the Lock. These are just outside the site and are intact and clearly visible. The middle set of gates is exposed at its upper levels, the lock being infilled on each side of the gates. The most northerly set is completely covered by the infill to the Lock. The proposed construction works may require piling through the quayside forming the eastern boundary of Waterloo Lock, since two of the buildings span this structure. Subject to final decision on foundation construction, It may also be that much of the subterranean mechanisms within this quay are exposed and these features will be of significant archaeological interest, and it is recommended that the Liverpool City Council archaeologist is notified of the groundworks programme in order that an observational record may be made.

8.0 PREVIOUS SITE INVESTIGATIONS / REPORTS

Searches and consultations have not established evidence of previous site investigations having been undertaken on the subject site.

9.0 PRELIMINARY QUALITATIVE RISK ASSESSMENT (TIER 1)

9.1 Introduction

The risk assessment methodologies adopted by *CCG* are based on current available guidance and best practice and are included in Appendix K.

The Tier 1 Risk Assessment and Preliminary Conceptual Model (PCM) were formulated using the information discussed above and taking account of likely construction processes and associated potential risks to construction workers, and potential risks to end users of the development.

9.2 Credible Potential Sources of Contamination

Considering the evidence of the desk study, site inspections, review of historical mapping and published environmental data, the potentially contaminative features warranting further assessment are as summarised hereunder:

- The nature of the infill placed in the redundant Waterloo Lock
- Recent deposits partially infilling the West Waterloo Dock
- Waters entrapped within the Waterloo Lock
- Water forming the expanse of West Waterloo Dock

The contaminants of concern associated with the soil infill materials were assumed to be potentially of a broad-spectrum nature. Water quality was considered against EQS guidance for saltwater bodies. On this basis, contaminants of concern are as summarised hereunder:

Table 6: Summary of Contaminants of Concern

SOURCE	METALS	NON-METALS	ORGANICS	GASES	OTHERS
Made Ground / Imported made ground associated with the infilling of the former Waterloo Lock and with the partial infilling of West Waterloo Dock	Cd, Cr (total and VI), Ni, Cu, Pb, Hg, Se, Zn	As, sulphates, Cyanides, boron	PAH's, TPH's	-	pH Asbestos
Ground gases generated by made ground soils within Waterloo Lock infill	-	-	-	CH_4, CO_2, H_2S	-
Water entrapped within the former Waterloo Lock and forming the expanse of the West Waterloo Dock	Cd, Cr (total and VI), Ni, Cu, Pb, Hg, Se, Zn	As, sulphates, Cyanides, boron	PAH's, TPH's		pH

9.3 Potential Receptors

Credible potential receptors of contamination on this site may be evaluated as hereunder:

Table 7: Potential Receptors

RECEPTOR	IS RECEPTOR PRESENT?
Human beings (construction workers)	Yes – Construction workers will be exposed during any future redevelopment of the site
Human beings (future occupants)	Yes - The site is to be redeveloped for residential land use. Future occupants may include both male & females [adults & infants]
Designated ecological systems	Yes – The adjacent canal system and River Mersey are sensitive ecological systems which may be impacted by the proposed works
Property in the form of buildings (on site)	Yes – Site to be redeveloped for residential land use
Property in the form of buildings (adjacent)	Yes- Adjoining land developed for residential land use
Property in the form of crops/livestock (on site)	No – There are no forms of crops/livestock adjoining the site
Property in the form of crops/livestock (adjacent)	No - The are no crops or livestock adjacent to the site
Potable water mains (on site)	Yes – Development will be served by water mains
Potable water mains (off site)	No – Services for adjacent properties should not run through the site
Entrapped soil water (within Waterloo Lock)	Yes – There is a potential for a discrete body of water to be entrapped within the Waterloo Lock infill
Groundwater (underlying aquifer)	Yes – The underlying bedrock is a Principal Aquifer
Groundwater abstractions	Yes - There are a number of active licensed groundwater abstractions within 1km of the site – all being for industrial / process waters
Surface water bodies	Yes – The River Mersey, Leeds-Liverpool canal, and Princes half Tide Dock all adjoin the site
Local flora and fauna during and post construction	Yes – There is significant bird life active on the dock and quaysides Marine life within the dock waters has not been researched by this investigation

9.4 Pollutant Linkages / Preliminary Conceptual Model

Pollutant linkages potentially exist between each identified contamination source and each identified receptor as illustrated in the Preliminary Conceptual Model summarised hereunder:

Table 8: Summary of Potential Pollutant Linkages / Preliminary Conceptual Model

SOURCE	RECEPTOR	PATHWAY
Potential soil contaminants as listed in Table 6	Construction workers	Dermal contact
		Ingestion of soil/soil dust (outdoors)
		Inhalation of soil/soil dust (outdoors)
		Inhalation of vapours from soil (outdoors)
	Future worker/resident occupants	Dermal contact
		Ingestion of soil/soil dust (indoors & outdoors)
		Inhalation of soil/soil dust (indoors & outdoors)
		Inhalation of vapours from soil (indoors & outdoors)
	Building fabric	Direct contact with aggressive soils
	Potable water supply for human consumption	Direct contact of water mains with contaminated soils and/or groundwater
Migrating ground gases arising from made ground soils	Future occupants	Inhalation of asphyxiant gases Accumulation of explosive gas / air mixtures
Fabric of buildings and services	In ground construction such as piles, pads and ground beams, manholes and services	Direct contact with aggressive ground
Contaminated groundwater	Controlled waters in the Leeds – Liverpool canal and River Mersey	Contaminated water discharges to these receptors arising from the displacement of waters during the pumping out and infilling of the West Waterloo Dock. Suspended solids in water discharges

10.0 SCOPE OF PHASE II INTRUSIVE INVESTIGATION

Based on the findings of the Phase I desk study, and taking account of the potential presence of pollution linkages an intrusive investigation was planned. The Phase II Intrusive Investigation provided for exploratory holes to be sunk through the made ground deposits within the dock and the made ground deposits in the infilled lock, into the underlying natural drift strata, and into the bedrock strata. The primary objectives of the investigation were to obtain enough soil and groundwater contamination data to reliably assess risks to human and environmental receptors, and sufficient data on the engineering properties of the soils and bedrock in relation to the design and construction of suitable foundations for the proposed buildings.

11.0 FIELDWORK

11.1 Introduction

The programme of fieldwork investigation was undertaken in September / October 2018. The intrusive works were carried out at overwater and land locations as follows:

<u>West Waterloo Dock (Overwater):</u>

- The sinking of 3nr cable percussion boreholes to bedrock level, with associated sampling and in-situ testing from a pontoon (BH1 - BH3).
- The further advancement of each of the 3nr cable percussion boreholes into the bedrock by rotary coring (BH1 - BH3) recovering 6m of core at each location.
- The subsampling of borehole recovery for soil contamination and soil classification testing
- The recovery of random grab samples of the dock infill
- The recording of the levels at the surface of the infill across the dock (m AOD)

Waterloo Lock, Quay and surrounding area (Land based):

- The sinking of 4nr cable percussion boreholes to bedrock level, with associated sampling and in-situ testing (BH4 – BH7)
- The advancement of each of the 4nr cable percussion boreholes into the bedrock by rotary coring (BH4 – BH7)
- The mechanical excavation of 6nr trial pits using a 13-tonne tracked excavator
- The subsampling of borehole recovery for soil contamination and soil classification testing
- The installation of gas/groundwater monitoring standpipes within each of the 4 boreholes
- The undertaking of a programme of standpipe monitoring for ground gas composition and flow rate, and standing water levels

The fieldwork was planned in accordance with BS10175: 2013 and was carried out in accordance with BS10175: 2013 and BS5930: 2015, insofar as they related to the scope of the investigation.

Sampling and monitoring methodologies employed by *CCG* are as presented in Appendix D.

The locations of the boreholes, trial pits, and spot level measurements are as annotated on the plan in Appendix A.

11.2 Overwater Boreholes

Each of the 3nr overwater boreholes were sunk from a pontoon incorporating a `moon-hole` and anchored at borehole positions by spud legs driven into the dock bed. All relevant boring plant was craned on at the quayside. Boring tools were decontaminated prior to commencement and between positional moves.

Casings were lowered through the pontoon deck moon-hole and through the dock water to commence boring in the dock infill using Dando 2000 light cable percussion boring rigs, deploying 200mm and 150mm diameter tools and casings. Each borehole was advanced through the full depth of the infill to “refusal” on bedrock, typically encountered at around -5m AOD.

Standard Penetration Tests were carried out at regular depth increments throughout the cable percussion boring. SPT hammer energy ratio test certificates are also provided in Appendix E.

Small disturbed and bulk disturbed samples were also recovered at regular incremental depths.

Each borehole was then further advanced into the bedrock formation by rotary coring methods using an Apageo-Apafor rotary coring rig, deploying 90mm diameter equipment and air mist flush.

Approximately 6m of rock core was recovered from each borehole.

The cores were recovered in Perspex liners, and transferred to core boxes for transportation to the laboratory for logging and photographing. Cores were logged in the laboratory according to the guidance contained in BS5930: 2015.

Logs of the boreholes annotated with SPT`N` values, and Total Core Recovery, Solid Core Recovery, Rock Quality Designation, and Fracture Index properties are contained in Appendix E.

Photographs of rock cores are given in Appendix G.

11.3 Land Based Boreholes

The land-based boreholes were positioned within the infilled Waterloo Lock and the quayside forming its eastern boundary. As with the overwater boreholes each borehole was advanced through the full depth of the infill to "refusal". At BH5 and BH6 `refusal` was reached on the concrete base slab of the Waterloo Lock. At B7, `refusal` was reached either on the concrete base or concrete stepped foundation of the quay walls

Standard Penetration Tests were carried out at regular depth increments throughout the cable percussion boring. SPT hammer energy ratio test certificates are also provided in Appendix E.

Small disturbed and bulk disturbed samples were also recovered at regular incremental depths.

Each borehole was then further advanced into the bedrock formation by rotary coring methods using an Apageo-Apafor rotary coring rig, deploying 90mm diameter equipment and air mist flush.

Approximately 6m of core was recovered from each borehole.

The cores were recovered in Perspex liner, and transferred to core boxes for transportation to the laboratory for logging and photographing. Cores were logged in the laboratory according to the guidance contained in BS5930: 2015.

Logs of the boreholes annotated with SPT`N` values, and Total Core Recovery, Solid Core Recovery, Rock Quality Designation, and Fracture Index properties are contained in Appendix E.

Photographs of rock cores are given in Appendix G.

11.4 Monitoring Installations

Standpipes comprising 50mm diameter HDPE plain and slotted welltube set in bentonite and non-limestone pea gravel surround were installed in each of the 4nr land-based cable percussion/rotary boreholes. Each standpipe was fitted with a gas valve and was protected by a flush cover set in concrete. Details of standpipe installations are provided on the relevant borehole logs in Appendix E and summarised in the tabulation hereunder:

Table 9: Borehole Installation Details

BOREHOLE	Top of borehole (mAOD)	Base of borehole (mAOD)	Depth of borehole from GL (mbgl)	Length of standpipe (m)	RESPONSE ZONE			
					From (mAOD)	To (mAOD)	From (mbgl)	To (mbgl)
BH4	7.70	-6.10	13.8	7.0	6.70	0.7	1.0	7.0
BH5	8.15	-18.15	26.3	7.0	7.15	1.15	1.0	7.0
BH6	8.01	-18.59	26.6	7.0	7.01	0.01	1.0	7.0
BH7	8.12	-13.48	21.6	7.0	7.12	1.12	1.0	7.0

The standpipe installations were periodically monitored for flow rate and composition of ground gas using a Geotechnical Instruments GA 2000 infra-red analyser. The installations were also monitored for standing water levels with an electronic dipmeter.

The results of the gas and groundwater monitoring, together with calibration certificates of the instruments used are given in Appendix H.

12.0 OBSERVED GROUND CONDITIONS

12.1 Observed Stratigraphy in Overwater Boreholes

The West Waterloo Dock has been infilled to an average depth of about 3m below standing dock water level (dock water level stands at about 4.9mAOD). In some locations, the depth of water is less than the notional 3m mean, with levels at the infill surface recorded as high as 3.1mAOD i.e. about 1.8m below water level. Similarly, infill surface levels were recorded to be as low as 1.1mAOD at the north eastern corner of the site i.e. about 3.8m below water level.

The dock infill extends to the natural sandstone bedrock forming the original base level of the dock. Rock levels were observed to be at -5.5mAOD, - 3.2mAOD and – 3.5mAOD at BH1, BH2 and BH3 respectively.

The made ground infill was observed to comprise a heterogenous mixture of silt and sand with much cobbles and gravels of brick, concrete, sandstone, limestone, granite, and occasional inclusions of slag, shell, wood, glass, ceramics etc. The infill deposits vary from `very loose` to `medium dense` with occasional SPT `refusals` (SPT`N`>50) recorded in dense layers / obstructions.

The bedrock was encountered as a slightly weathered reddish brown occasionally grey fine to medium grained thickly laminated sandstone.

12.2 Observed Stratigraphy in Land Based Boreholes

Ground conditions are highly variable under the quayside and infilled Waterloo Lock as described in the table hereunder.

Table 10: Observed Succession at land Based Boreholes

BH	Location	Co-ordinates	Ground level mAOD	Description
BH4	Quayside between River Mersey and Waterloo Dock	333409E 391287N	7.70	The borehole commenced on concrete (0.2m), overlying MADE GROUND deposits comprising brown silty sandy with much gravel of brick and sandstone extending to around 5.0mbgl, Further MADE GROUND comprising a clay matrix with much gravel of brick and sandstone extends to 8.3mbgl. At 8.3mbgl (-0.6mAOD) sandstone masonry construction (around 3.0m thick) was encountered as evidenced by mortar beds within. It was concluded that this was a section of the stepped formation of the old Mersey wall as shown on the archive drawings herein. The borehole terminated in sandstone gravels and cobbles at -6.1m AOD (13.8mbgl)
BH5	Within Waterloo Lock (North)	333433E 391268N	8.15	The borehole commenced and continued in MADE GROUND deposits comprising brown silty sand and gravel, with much brick, concrete, metal, timber and sandstone extending to around 18.3mbgl, at which depth the 3m thick base slab of the lock basin was encountered. Rockhead was encountered beneath the base at around -13.1m AOD (21.3mbgl) and comprised weak red fine to medium grained SANDSTONE, proven to -18.1m AOD (26.3mbgl).
BH6	Within Waterloo lock (South)	333444E 391196N	8.01	The borehole commenced and continued in MADE GROUND deposits comprising brown silty sand and gravel, with much brick, ash, concrete, and sandstone extending to around 18.5mbgl at which depth the 2m thick base slab of the lock basin was encountered. Rockhead was encountered beneath the base at around -12.6m AOD (20.6mbgl) and comprised weak red fine to medium grained SANDSTONE, proven to -18.6m AOD (26.6mbgl).
BH7	"Promontory" quay which forms the eastern wall of the Waterloo Lock	333448E 391245N	8.12	The borehole commenced on concrete (0.3m), overlying MADE GROUND deposits comprising brown silty sand and gravel, with much brick and concrete extending to around 12mbgl and resting on a concrete base / foundation of 3.3m thickness. Rockhead was encountered beneath the concrete base at around -7.5m AOD (15.5mbgl) and comprised weak red fine to medium grained SANDSTONE, proven to -13.5mAOD (26.6mbgl)

12.3 Groundwater Regime

Groundwater was encountered in each of the boreholes and was recorded to standing at around 4.9mAOD during the standpipe monitoring programme, consistent with the dock water level.

13.0 LABORATORY TESTING

13.1 Engineering Testing

Soil, rock and concrete engineering testing was undertaken at the *CCG* UKAS accredited laboratory. The testing comprised:

- Determination of Particle Size Distribution in accordance with BS1377: Part 2: 1990
- Determination of Uniaxial Compressive Strength in accordance with I.S.R.M. Suggested Methods 1981
- Determination of Point Load Strength in accordance with ISRM Suggested Method: Int. J. Rock Mech. Sci. Geomech. Abstr. Vol.22, No.2, pp. 51 - 60, 1985
- Determination of Concrete core compressive strength in accordance with BS 12504-1: 2009

The engineering test results are presented in Appendix I.

13.2 Chemical Laboratory Testing

A programme of soil and water chemical analyses were undertaken at a UKAS / MCERTS accredited laboratory:

- 5nr subsamples of made ground soils from the dock infill were analysed for a broad range of contaminants including pH, Metals, Non-Metals, Free cyanide, Total and Water-Soluble Sulphates, Sulphides, speciated PAH's, TPHCWG and BTEX compounds, Asbestos Containing Materials (ACM)
- 5nr subsamples of the Waterloo Lock infill were analysed for a broad range of contaminants including pH, Metals, Non-Metals, Free cyanide, Total and Water-Soluble Sulphates, Sulphides, speciated PAH's, TPHCWG and BTEX compounds, Asbestos Containing Materials (ACM)
- 2nr subsamples of the infill within the Waterloo Lock east quayside were analysed for a broad range of contaminants including pH, Metals, Non-Metals, Free cyanide, Total and Water-Soluble Sulphates, Sulphides, speciated PAH's, TPHCWG and BTEX compounds, Asbestos Containing Materials (ACM)
- 2nr groundwater samples from the entrapped body within the Waterloo Lock were analysed for a broad range of contaminants including pH, Metals, Non-Metals, Hardness, Cyanides, Sulphates, Sulphides, Total Organic Carbon, speciated PAH's, TPHCWG and BTEX compounds
- For the purposes of comparison of quality, water samples from the Waterloo Dock and River Mersey were analysed for a broad range of contaminants including pH, Metals, Non-Metals, Hardness, Cyanides, Sulphates, Sulphides, Total Organic Carbon, speciated PAH's, TPHCWG and BTEX compounds

The soil, groundwater and surface water contamination test results and certificates are presented in Appendix J.

14.0 RISK ASSESSMENT FOR THE PROTECTION OF HUMAN HEALTH

14.1 Generic Quantitative Risk Assessment (Tier 2 / GQRA)

An assessment of the soil analysis data was carried out in accordance with the guidance presented in CLR11 and in accordance with current guidance and legislation.

The Human Health Risk Assessment was carried out in accordance with the *CCG* methodology for assessing soil contamination data as contained in Appendix K, and since it is proposed that the site be redeveloped for

residential/commercial land use, the assessment was based on Generic Assessment Criteria (GAC) contained in publication LQM/CIEH S4UL`s for Human Health Risk Assessment (2015) (*CCG* Licence No. S4UL3233), applicable to the "Commercial / Industrial" land use scenario. This document does not provide criteria for Lead, for which the results were compared to the C4SL published by DEFRA SP1010 Development of Category 4 Screening Levels.

14.2 Assessment of Contamination Data

Based on a Soil Organic Matter content of average 1.0%, the human health risk assessment of soil data is summarised in the tabulations hereunder, and presented on the worksheets in Appendix K.

14.2.1 Assessment of Metal Data

The assessment of the metal data is presented hereunder:

Table 11: Assessment of Metal Data

Contaminant	LQM / CIEH S4UL / C4SL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Cadmium	190	0.6	-	-
Chromium	8,600	56.6	-	-
Chromium (hexavalent)	6	<0.8	-	-
Copper	68,000	104	-	-
Lead*	310	222	-	-
Mercury	25.8	0.5	-	-
Nickel	980	47	-	-
Zinc	730,000	194	-	-

* C4SL published value

The above assessment concludes that none of the results exceeded their respective threshold value and therefore no risk to human health is indicated.

14.2.2 Assessment of Non-Metal Data

The assessment of the non-metal data is presented hereunder:

Table 12: Assessment of Non-Metal Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Arsenic	640	40.5	-	-
Selenium	12,000	<1.0	-	-
Free Cyanide	22	<1.0	-	-

The above assessment concludes that none of the results exceeded their respective threshold value and therefore no risk to human health is indicated.

14.2.3 Assessment of Polycyclic Aromatic Hydrocarbon [PAH's] Data

The assessment of the Polycyclic Aromatic Hydrocarbon (PAH's) data is presented hereunder:

Table 13: Assessment of PAH Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Naphthalene	76.4	0.7	-	-
Acenaphthylene	83,000	0.2	-	-
Acenaphthene	84,000	1.1	-	-
Fluorene	63,000	0.7		
Phenanthrene	22,000	4.6		
Anthracene	520,000	1.0	-	-
Fluoranthene	23,000	5.7	-	-
Pyrene	54,000	5.2	-	-
Benz(a)anthracene	170	2.7	-	-
Chrysene	350	3.1	-	-
Benzo(b)fluoranthene	44	2.6	-	-
Benzo(k)fluoranthene	1,200	2.4	-	-
Benzo(a)pyrene	35	2.6	-	-
Indeno(123-cd)pyrene	500	1.7	-	-
Dibenz(ah)anthracene	3.5	0.5	-	-
Benzo(ghi)perylene	3,900	2.1	-	-

The above assessment concludes that none of the results exceeded their respective threshold value and therefore no risk to human health is indicated.

14.2.4 Assessment of Total Petroleum Hydrocarbon [TPH's] Data

The assessment of TPH data is presented hereunder:

Table 14: Assessment of Hydrocarbon Data

Contaminant	LQM / CIEH S4UL (mg/kg)	Maximum (mg/kg)	Exceedances	
			(mg/kg)	Location
Aromatic EC5-EC7	26,000	<0.01	-	-
Aromatic EC7-EC8	56,000	<0.01	-	-
Aromatic EC8-EC10	35,000	<1.0	-	-
Aromatic EC10-EC12	16,000	<1.0	-	-
Aromatic EC12-EC16	36,000	8.9	-	-
Aromatic EC16-EC21	28,000	22.1	-	-
Aromatic EC21-EC35	28,000	279	-	-
Aromatic EC35-EC44	28,000	121	-	-
Aliphatic EC5-EC6	3,200	<0.01	-	-
Aliphatic EC6-EC8	7,800	<0.01	-	-
Aliphatic EC8-EC10	2,000	<1.0	-	-
Aliphatic EC10-EC12	9,700	<1.0	-	-
Aliphatic EC12-EC16	59,000	4.6	-	-
Aliphatic EC16-EC21	1,600,000	12.7	-	-
Aliphatic EC21-EC35	1,600,000	192	-	-
Aliphatic EC35-EC44	1,600,000	79.1	-	-

The above assessment concludes that none of the results exceeded their respective threshold value and therefore no risk to human health is indicated.

14.2.5 Assessment of BTEX Data

BTEX compounds were not detected within any of the 12nr soil samples analysed and therefore no risk to human health is indicated.

14.2.6 Assessment of Asbestos Data

Asbestos containing material was not detected within any of the 12nr soil samples analysed and therefore no risk to human health is indicated.

14.2.7 Summary of Human Health Risk Assessment

A total of 12nr samples were assessed for a broad range of contaminants with all contaminants below their respective threshold values and therefore no potential risk to human health is identified.

15.0 CONTROLLED WATERS RISK ASSESSMENT

15.1 Water Quality in Waterloo Lock

Groundwater samples recovered from standpipes installed in BH5 and BH6 were analysed for a broad range of contaminants including PAH's and hydrocarbons to the TPHCWG methodology. The results were assessed against EA published criteria for Saltwater environments as summarised hereunder. The assessment is presented hereunder:

Table 15: Assessment of Groundwater Data

Contaminant	BH5 Result (µg/l)	BH6 Result (µg/l)	EQS Saltwater (ug/l)
Arsenic			
Cadmium			
Lead			
Nickel			
Chromium			
Chromium(hexavalent)			
Copper			
Mercury			
Selenium			
Boron			
Zinc			
pH			
Sulphate			
Cyanide			
Naphthalene			
Acenaphthylene			
Fluorene			
Phenanthrene			
Anthracene			
Fluoranthene			
Pyrene			
Benzo[a]anthracene			
Chrysene			
Benzo[b]fluouranthene			
Benzo[k]flouranthene			
Benzo[a]pyrene			
Ideno(123-cd)pyrene			
Benzo(ghi)perylene			

Table 15: Assessment of Groundwater Data (continued)

Contaminant	BH5 Result (µg/l)	BH6 Result (µg/l)	EQS Saltwater (ug/l)
Aromatic EC5-EC7 (benzene)			
Aromatic EC7-EC8 (toluene)			
Aromatic EC8-EC10 (ethyl benzene)			
Aromatic EC10-EC12			
Aromatic EC12-EC16			
Aromatic EC16-EC21			
Aromatic EC21-EC35			
Aliphatic EC5-EC6			
Aliphatic EC6-EC8			
Aliphatic EC8-EC10			
Aliphatic EC10-EC12			
Aliphatic EC12-EC16			
Aliphatic EC16-EC21			
Aliphatic EC21-EC35			

Discussion to follow.

15.2 Water Quality in Waterloo Dock and River Mersey

For the purpose of comparison of water quality, samples from the supernatent water in the partially infilled dock and the River Mersey were analysed. The results are tabulated hereunder:

Table 16: Dock and River Water Quality

Contaminant	River Mersey (µg/l)	Waterloo Dock (µg/l)
Arsenic	6	<5
Cadmium	<1	<1
Lead	<1	<1
Nickel	<5	<5
Chromium	<5	<5
Copper	<5	<5
Mercury	<0.1	<0.1
Selenium	88	77
Boron	3950	3380
Zinc	16	11
pH	7.6	7.7
Sulphate	1950	1660
Cyanide	<5	<5

Table 16: Dock and River Water Quality (continued)

Contaminant	River Mersey (µg/l)	Waterloo Dock (µg/l)
Naphthalene	0.02	0.02
Acenaphthylene	<0.01	<0.01
Fluorene	0.01	<0.01
Phenanthrene	0.08	0.04
Anthracene	0.01	<0.01
Fluoranthene	0.09	0.04
Pyrene	0.07	0.03
Benzo[a]anthracene	0.04	0.01
Chrysene	0.04	0.02
Benzo[b]fluouranthene	0.04	0.02
Benzo[k]flouranthene	0.03	0.02
Benzo[a]pyrene	0.03	0.02
Ideno(123-cd)pyrene	0.02	0.01
Benzo(ghi)perylene	0.03	0.01
Aromatic EC5-EC7 (benzene)	<1.0	<1.0
Aromatic EC7-EC8 (toluene)	<1.0	<1.0
Aromatic EC8-EC10 (ethyl benzene)	<5.0	<5.0
Aromatic EC10-EC12	<5.0	<5.0
Aromatic EC12-EC16	<5.0	<5.0
Aromatic EC16-EC21	<5.0	<5.0
Aromatic EC21-EC35	<5.0	<5.0
Aliphatic EC5-EC6	<1.0	<1.0
Aliphatic EC6-EC8	<1.0	<1.0
Aliphatic EC8-EC10	<5.0	<5.0
Aliphatic EC10-EC12	<5.0	<5.0
Aliphatic EC12-EC16	<5.0	6.7
Aliphatic EC16-EC21	<5.0	<5.0
Aliphatic EC21-EC35	<5.0	<5.0

It can be seen that there are no significant differences between the water analyses and therefore no risk to water quality in the River Mersey will arise from natural or pumped discharges from the site, subject to suspended solids management

15.3 Summary of Controlled Waters Risk Assessment

DISCUSSION TO FOLLOW

16.0 SPECIFICATION OF BURIED CONCRETE

The soil data obtained in the investigation was assessed against the guidance given in BRE Special Digest 1: 2005, as summarised hereunder:

Table 17: Design Chemical Class Based on Soil Data

CONCRETE SPECIFICATION DATA SHEET		
Is the site Brownfield or Greenfield?	Brownfield	
Is the water table static or mobile?	Mobile	
Highest water-soluble Sulphate result mg/l	480	Design Sulphate Class of DS-1 ACEC Class AC-1
Lowest pH result	8.0	
Intended Working Life	100 years	Adopt Design Chemical Classification of DC-1

Table 18: Design Chemical Class Based on Groundwater Data

CONCRETE SPECIFICATION DATA SHEET		
Is the site Brownfield or Greenfield?	Brownfield	
Is the water table static or mobile?	Mobile	
Highest Sulphate result mg/l	1950	Design Sulphate Class of DS-3 ACEC Class AC-3
Lowest pH result	7.6	
Intended Working Life	100 years	Adopt Design Chemical Classification of DC-3

On the basis of the foregoing assessments, concrete in the ground should be specified to conform to the compositional requirements of Design Chemical Class DC-3, as defined in BRE Special Digest 1: 2005. For a design life of 100 years a Design Chemical Class of DC-3 + one Additional Protective Measure (APM – Table D4 of the digest) should be adopted.

17.0 GAS RISK ASSESSMENT

Data gathered in the monitoring programme was assessed in accordance with guidelines set out in CIRCA C665 2007 "Assessing Risk Posed by Hazardous Gases to Buildings". The CIRIA risk assessment methodology uses typical maximum soil gas concentrations and worse case borehole flow rates to define a "Characteristic Situation" for the gas regime.

The volumetric gas flow rate used by the risk assessment is termed "Gas Screening Value (GSV)" in the guidance, and is defined below.

GSV (litres/hr) = borehole flow rate (litres/hr) x gas concentration.

There are also two stages to the assessment method proposed in CIRIA C665; compliance with a GSV Threshold Value and secondly, compliance with additional factors such as maximum permissible gas concentration. A summary of the gas monitoring data is presented hereunder and presented in Appendix H.

Table 19: Summary of Gas Monitoring Data

Position	BH4	BH5	BH6	BH7
No Monitoring Visits	3	3	2	2
Max CH_4 (%)	0.0	0.0	0.0	0.0
Max CO_2 (%)	0.1	0.0	0.1	0.1
Min O_2 (%)	19.9	20.0	20.0	20.1
Max H_2S (ppm)	0.0	0.0	0.0	0.0
Max CO (ppm)	0.0	0.0	0.0	0.0
Max Flow (l/hr)	<0.1	<0.1	<0.1	<0.1
Max PID response	nil	nil	nil	nil
Pressure Range (mb)	1015 - 1031			

Based on these results, a Gas Screening Value (GSV) of 0.0001l/hr is calculated for CO_2.

Using this GSV value, the risk to the proposed development was assessed in line with Situation A as defined in CIRIA C665, and on this basis the site complies with Characteristic Situation 1. It should be borne in mind that further monitoring is in hand and the final classification is to be confirmed.

Notwithstanding the above, existing monitoring wells within the surrounding area were also monitored. Installation details of these wells were not available but are assumed to have response zones within the infill. The monitored levels in one of these installations within the Waterloo Lock (at about 30m south of the southern boundary of the site) exhibited high gassing levels, with methane levels >80% and elevated CO_2, levels that warrant remedial/protective actions. The significance of these observations is discussed in the post investigation conceptual model hereunder.

18.0 NEW WATER MAINS SUPPLY

The specification for new water mains at this site was assessed against the criteria specified in Paper 10/WM/03/21 'Guidance for the selection of Water Supply Pipes to be used in Brownfield Sites' published by UK Water Industry Research (UKWIR) January 2011, and the supplementary guidance UUENG/RL/V2/September 2012, published by United Utilities Water (UUW).

The findings indicate that the soil concentrations of hydrocarbons are below the threshold concentrations permitted under the UKWIR and UUW guidance for normal PE water mains. On this basis, new water mains may be specified as normal PE.

Pipes should be laid in accordance with BS EN 12201-2 'Plastic piping systems for water supply, and for drainage and sewerage under pressure as stated in UKWIR guidance.

Notwithstanding the above preliminary assessment, the developer should contact the relevant water supply company (United Utilities) to obtain concurrence with the recommendations given above, and may be required to return a completed UUW Risk Assessment.

19.0 POST INVESTIGATION CONCEPTUAL MODEL & OPTIONS APPRAISAL

Based on the findings of the investigation, a conceptual model may be constructed illustrating proven pollution linkages and summarising the conceptual remediation recommendations discussed above, as tabulated hereunder:

Table 20: Post Investigation Conceptual Model

SOURCE	POTENTIAL RECEPTORS	PATHWAY(S) OF EXPOSURE	REMEDIAL RECOMMENDATIONS
High methane concentrations in ground gas in Waterloo Lock	Construction workers Future	Explosive air/gas mixtures accumulating in buildings and excavations	The gassing regime may be significantly disturbed by the construction works on this and the adjacent Isle of Man Ferry terminal. The liberation of the high methane concentrations generated in Waterloo Lock infill south of the site may be substantially hampered and the migratory regime altered. Furthermore, biodegradation of plant and aquatic life in the infilled dock may give rise to gassing. In this circumstance, it is strongly recommended that as a minimum all buildings be protected by installation of proprietary gas proof membranes (i.e Visqueen low permeability Gas Barrier or similar) within the ground floor slabs, and that subfloor venting be incorporated.
Elevated water-soluble sulphates in soils	Concrete in the ground	Direct contact	For a design life of 100 years, specify concrete to conform to the compositional requirements of Design Chemical Class DC-3, as defined in BRE Special Digest 1: 2005. For a design life of 100 years a Design Chemical Class of DC-3 + one Additional Protective Measure (APM – Table D4 of the digest) should be adopted.

20.0 PRELIMINARY WASTE CLASSIFICATION

Whilst it is unlikely that any arisings from piling or excavations will be disposed of offsite, a preliminary waste classification exercise was undertaken based on soil contamination data. The assessment entailed the assessment of the basic soil contamination data via the ***HAZWASTE*** program. The output data from this basic assessment is provided in Appendix L. This program generates the baseline Hazardous / Non-Hazardous classification of soils. The assessment demonstrated that all soil analyses conform to a Non-Hazardous waste classification.

Should any material be destined for landfill, the contractor may wish to carry out Waste Acceptance Criteria (WAC) analyses on the waste to determine if it may be downgraded from 'Non-Hazardous' classification to 'Inert' waste.

It should be noted that the final decision on waste classification is at the discretion of the accepting landfill, and it is recommended that consultation with landfill operators be undertaken during the development of the waste management plan.

21.0 GEOTECHNICAL ASSESSMENT

21.1 Introduction

A considerable volume of information is available on archive drawings of the River Mersey wall and Waterloo Lock construction as made available by Peel Ports. These are contained in Appendix A. Given the complexity of the subterranean and marine conditions prevailing on the site, specific consideration has been given to each of the principal elements of ground engineering works relevant to the development as discussed hereunder.

21.2 Cut-Off Wall Construction

In the observed conditions it is considered that the only realistic method of cut-off wall construction is to form a combi-wall structure by the installation of steel tubular piles in rock sockets at suitable centres, with sheet piles installed between the steel tubes and seated into the surface of the bedrock. In this form of construction, the cut-off is acting as a cantilevered retaining wall with the steel tubular piles taking all of the bending and overturning forces to be imposed by the backfill to site design levels, and the surcharges from construction plant and future traffic etc. Hence these piles will need to be installed in deep sockets within the bedrock probably by drilling out rock sockets within a cased borehole before inserting and grouting the tubular piles in position

For the purposes of design, the following parameters are recommended:

Table 21: Cut-off (Retaining) Wall Design Parameters

Density/phi of insitu submerged fill (+4mAOD to -3.2mAOD)	18kN/m^3 / 30^0
Density/phi of engineered submerged fill – following dock draw down placement and compaction of fill, and restoration of dock water levels (+4mAOD to +6.5mAOD)	20kN/m^3 / 35^0
Density/phi of engineered fill above dock water level (+6.5mAOD to +8.1mAOD)	20kN/m^3 / 35^0
Water table	4.9mAOD

With regard to construction methodology, the installation of the piles using plant standing on dock infill raised above existing dock water levels were considered but discounted as not practicable, as this suffers from a number of shortcomings including:

- the need to deposit imported fill into standing water with the inherent aggravation of the high settlement potential latent in the existing submerged infill
- the potential for high suspended solids entering the canal and adjoining docks resulting from the tipping into standing water
- the need to fill beyond the cut-off line and cut back to existing levels by backhoe thereby working beyond site boundaries

Taking account of these limitations, it is concluded that the cut-off wall must be installed off jack-up barges or possibly floating spud leg pontoons. The advice of specialist marine piling contractors should be obtained in relation to the design and construction methodology.

It should be borne in mind that there is a possibility that the cut-off wall may traverse a section of the buried abutments of the old swing bridge at the northern end of the site which divided the West Waterloo and Victoria Docks, since there is no record that these abutments were broken out when the swing bridge was abandoned and the new bridge constructed at its present position north of the original position. This possibility requires further investigation as it may require particular consideration in the design of the cut off wall.

21.3 Dock Infilling and Settlement Potential

Following installation of the cut-off wall, approximately 6m of fill will be required to raise the existing dock infill levels to proposed finished ground levels. This fill must be placed under controlled conditions if settlement of the surface infrastructure is to be kept to acceptable limits. Deep fills such as are proposed at this site are often surcharged by placement of an additional height of fill to accelerate settlement, but it is understood that the delivery programme precludes this. Nevertheless, a phased approach to the development may allow some parts of the site to be surcharged, and where possible and economic this should be considered. The various developments proposed in adjacent docks may offer economic disposal options for surcharge materials.

The achievement of sufficient density of the fill will probably require the dock water levels to be drawn down to below the top of existing fill, and preferably to a level significantly below the top of existing fill, thus allowing some compaction to be applied to the upper levels of the insitu material. The practicality of drawing down the water levels by around 4m may need to be proven since based on particle size analyses the existing infill is highly permeable, and the hydraulic conductivity of the sandstone bedrock may induce rapid upward inflow. Water pumped out of the dock will probably require a Discharge Consent limiting the suspended solids permissible in the discharge. The evidence of the analyses of dock water and River Mersey water samples contained herein, is that there is no significant difference in their chemistry and hence subject to suspended solids control it should be acceptable to pump to the river.

As an alternative to drawing down the dock water, the fill levels may be raised above existing dock water levels by the placement into standing water of durable rock fill of such grading that it is self-compacting. It is envisaged that suitable rock fill would be notionally graded 250mm – 100mm. Such material would probably be a quarried product. The material would be tipped directly into the dock water, until a platform is created above standing dock water level. The remaining fill from rock fill platform level to finished level may be obtained from other suitable local sources. One possible shortcoming in this alternative is the subsequent installation of piles through the 3m layer of rock fill, since it is envisaged that CFA piling will be the preferred solution in the infilled dock part of the development site. If this filling alternative is to be considered further, then specialist piling contractors should be consulted regarding this potential problem.

As a further alternative to drawing down the dock water levels, the fill levels may be raised above existing dock water levels by hydraulically placed dredged sand, which may be available from River Mersey channel dredging operations. However, the method suffers the shortcoming that the density of the fill placed into existing standing water cannot be controlled and hence the potential high settlement of the completed infill may be aggravated. Once raised above standing water levels, alternative land-based sources of fill may be utilised with conventional compacted layer construction. Notwithstanding the inability to control density when placed in the dock water, the method is environmentally preferable insofar as it eliminates road traffic, and if applied in conjunction with settlement monitoring may offer an alternative to drawing down the dock levels.

On the premise that the most likely solution is to draw down the dock water levels, and the fill be sourced locally, then it is recommended that the following material / construction parameters be adopted:

Table 22: Dock Infilling Specification

Acceptable materials	Virgin or recycled aggregates containing not more than 10% bituminous planings and excluding materials containing tar and tar-bitumen binders, chalk, unburnt colliery spoil
Grading limits	Conforming to Table 6/1 of DTp Specification for Highway Works – 6F2 material. Max particle size 125mm. Max passing 63um 12%
Acceptable moisture content	OMC +/- 3% as determined by BS1377: 1990: Part 4: Cl3.6
Compacted layer thickness	250mm
Compactive effort	In accordance with Table 6/4 of DTp Specification for Highway Works using vibratory roller of minimum mass per unit width of 2900kg and minimum 10 passes per layer
Acceptance testing	• Particle size analysis – 1 test for 200m^3 • Plate load tests at 2 per layer with max settlement of 2mm under 450mm dia plate loaded to 20kN/m^2 • Broad spectrum soil contamination analyses for compliance with LQM/CIEH criteria for Residential without Plant Uptake – 1 analysis per 250m^3 - see Table A in Appendix M for acceptance criteria • Broad spectrum soil leachate analyses for compliance with EQS criteria for Estuarine Waters – 1 analysis per 250m^3 – see Table B in Appendix M for acceptance criteria
Monitoring	Installation of rod and plate settlement gauges at surface of insitu soil at say 6 locations prior to commencement of filling and monitoring settlement at monthly intervals

Settlement of the dock infill will result from loading of the insitu submerged fill and settlement of the 6m of fill to be constructed, compounded by inundation of 3m of the placed fill as the water table re-establishes to its normal dock level. It is assumed that there is no feasible method of density improvement of the insitu material other than surface compaction to provide a working base for the imported filling. Assuming this to be the case an estimate of the worst-case potential magnitude of settlement of the insitu fill was obtained by application of the method proposed by Burland & Burbidge (ref 2) taking a notional width of 15m (approx. spacing between buildings), an average SPT`N` of 2 (BH1 on cut-off alignment), and an imposed stress of 90kN/m^2 imposed by the imported fill. By application of these parameters, a potential settlement in the order of 200mm is estimated at the surface of the submerged fill. The submerged materials are essentially granular and hence this settlement should occur rapidly as the placement of engineered fill proceeds, but It is strongly recommended that rod and plate settlement gauges are installed at the surface of the insitu material allowing the rate and magnitude of settlement to be monitored during the earthworks.

Taking account of potential settlement in the fill, it is strongly recommended that consideration be given to piling of key drainage elements such as manholes.

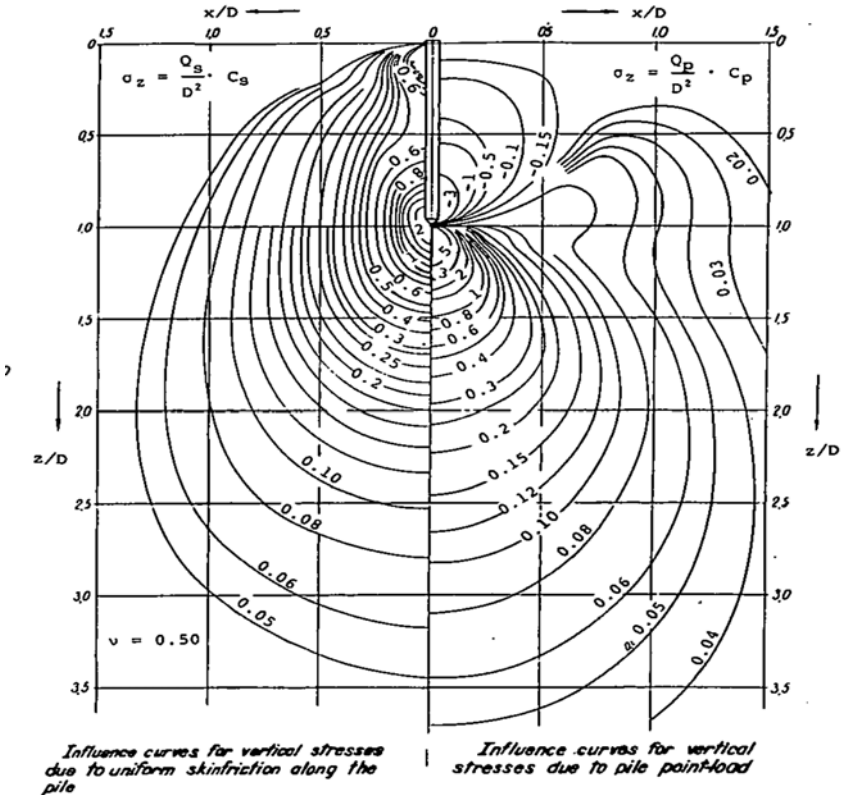


Fig 1: Stress Distribution around a Pile in an Elastic Solid

21.5 Piling Vibrations in Relation to Kingsway Road Tunnel

Actual vibrational effects of groundworks will be a function of the type of piling plant, the construction method, the ground conditions and the structural characteristics of the receptor – in this case the Kingsway Road Tunnel. Piling at this site will not involve dynamic methods and hence is likely to generate relatively low vibrational effects. However, prospective piling contractors must be required to prepare a risk assessment to address this matter. It may also be appropriate to monitor ground borne vibrations in boreholes set adjacent to a remote pile at a distance equal to the distance between the tunnel and the closest pile. Measured peak particle velocities (PPV) may then be assessed against the guidance contained in BS7385: Part 2: 1993. The recommendations given by Hiller 2011 in the paper `The Prediction and Mitigation of Vibration Impacts of Tunnelling`, which contains recommendations on acceptability criteria for intermittent vibrations induced by construction works taking place adjacent to existing railway tunnels, may be appropriate for adoption in this context. These are reproduced hereunder:

Table 24: Proposed Acceptance Criteria for Vibrational Effects at Road Tunnel

Action required	PPV criteria* for cast iron, steel, concrete segmental linings, mm/s
Proceed using only the construction methods for which calculations have been approved by the tunnel operator. In-tunnel monitoring not required – at tunnel operator`s discretion	<7.5
Works may proceed. Continuous alarmed monitoring in tunnel will be required	7.5 - 15
Alternative pile construction method required	>15

*For continuous vibration the PPV criteria should be halved.

21.6 Ground Gas Protection

The gassing regime may be significantly disturbed by the construction works on this and the adjacent Isle of Man Ferry terminal. The liberation of the high methane concentrations generated in Waterloo Lock infill south of the site may be substantially hampered and the migratory regime altered. Furthermore, biodegradation of plant and aquatic life in the infilled dock may give rise to gassing. In this circumstance, it is strongly recommended that as a minimum all buildings be protected by installation of proprietary gas proof membranes (i.e Visqueen low permeability Gas Barrier or similar) within the ground floor slabs, and that subfloor venting be incorporated.

22.0 PAVEMENT DESIGN

Taking account of the depth of made ground and the inherent risk of significant variations in density, it is recommended that roads and pavements be designed on a CBR of 2%, and hence a capping layer (preferably reinforced with geogrids) will be required.

23.0 CONCLUSIONS & RECOMMENDATIONS

The conclusions and recommendations hereunder are based on the salient sections of the report and should not be referred to in isolation of the relevant sections of the text. All recommendations are subject to Regulatory Authority review.

Table 25: Conclusions & Recommendations

Soil Contamination & Mitigation Measures	Based on the results obtained, all contaminants were below their respective threshold values and therefore no potential risk to human health is identified. As a result, no mitigation measures are required.
Disposal of dock water to River Mersey	There are no significant differences between the dock and river water analyses and therefore no risk to water quality in the River Mersey will arise from natural or pumped discharges from the site, subject to suspended solids management
Settlement of existing infill to dock	A potential settlement in the order of 200mm is estimated at the surface of the submerged fill. The submerged materials are essentially granular and hence this settlement should occur rapidly as the placement of engineered fill proceeds, but It is strongly recommended that rod and plate settlement gauges are installed at the surface of the insitu material allowing the rate and magnitude of settlement to be monitored during the earthworks. Taking account of potential settlement in the fill, it is strongly recommended that consideration be given to piling of key drainage elements such as manholes.
Controlled filling of West Waterloo Dock	A stringent regime of material selection, compaction control, monitoring and validation testing will be required for the dock infilling. See Section 21.2 for full discussion
Controlled Waters Risk Assessment	DISCUSSION TO FOLLOW
Concrete Specification	On the basis of the soil and groundwater assessments, concrete in the ground should be specified to conform to the compositional requirements of Design Chemical Class DC-3, as defined in BRE Special Digest 1: 2005. For a design life of 100 years a Design Chemical Class of DC-3 + one Additional Protective Measure (APM – Table D4 of the digest) should be adopted.

Table 25: Conclusions & Recommendations (Continued)

Water Mains	The findings indicate that the soil concentrations of hydrocarbons are below the threshold concentrations permitted under the UKWIR and UUW guidance for normal PE water mains. On this basis, new water mains may be specified as normal PE. Pipes should be laid in accordance with BS EN 12201-2 'Plastic piping systems for water supply, and for drainage and sewerage under pressure as stated in UKWIR guidance. Notwithstanding the above preliminary assessment, the developer should contact the relevant water supply company (United Utilities) to obtain concurrence with the recommendations given above, and may be required to return a completed UUW Risk Assessment
Gas Risk Assessment	Given that the site will be significantly disturbed by the construction works on this and the adjacent Isle of Man Ferry terminal, the liberation of gas generated in Waterloo Lock infill may be substantially hampered. Hard cover may induce with significant quantities of clean imported fill material, it is advised that the building design incorporates a proprietary gas proof membrane (i.e Visqueen low permeability Gas Barrier or similar) within a suspended floor slab, to mitigate any potential risks from "off-site" sources.
Waste Classification	The assessment demonstrated that all soil analyses conform to a Non-Hazardous waste classification. Should any material be destined for landfill, the contractor may wish to carry out Waste Acceptance Criteria (WAC) analyses on the waste to determine if it may be downgraded from 'Non-Hazardous' classification to 'Inert' waste. It should be noted that the final decision on waste classification is at the discretion of the accepting landfill, and it is recommended that consultation with landfill operators be undertaken during the development of the waste management plan.
Foundations Piling Stress Effects on Road Tunnel Ground borne vibrations	See Section 21.0 for full discussion
UXO risk	A UXO Risk assessment was procured from a specialist consultancy. The report concluded that `considering the findings of the assessment, a UXO Threat Mitigation Strategy is not required to be in place prior to intrusive engineering works at this site of concern`.
Further Work	• Undertake further geotechnical investigation adjacent to northern elevations of Blocks • Prepare testing and monitoring plan for dock infilling • Undertake vibration monitoring during piling • Prepare completion report including gas protection validation

References:

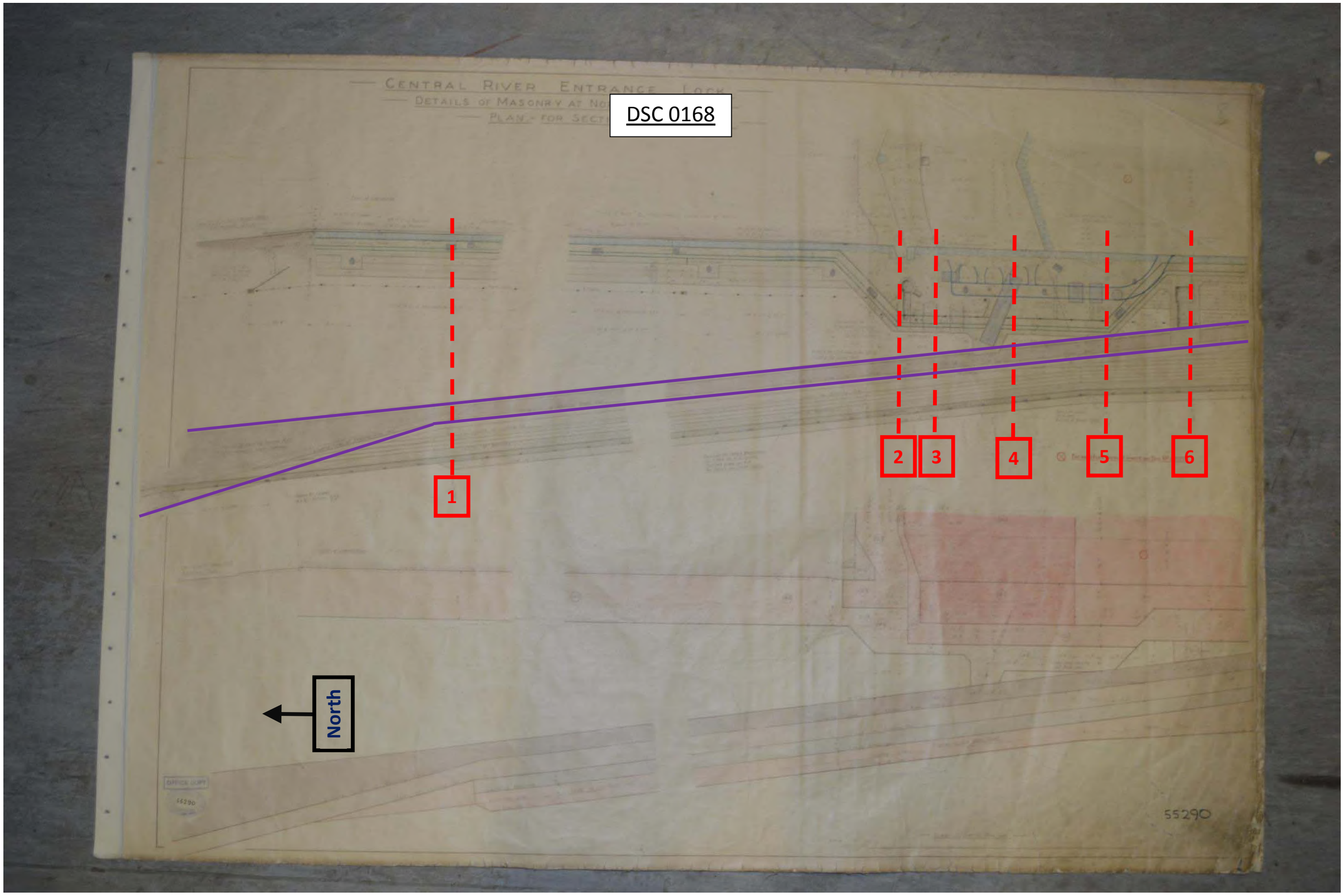
1. Burland & Burbidge `Settlement of foundations on sand and gravel`; Proc Instn Civil Engineers: Part 1 : 1985, 78, 1325-1381
2. GRILLO, O., `Influence Scale and Influence Chart for Computation of Stresses Due, Respectively, to Surface Point Load and Pile Loads` *Proc 2nd Int Conf.Soil Mech. Found. Engrg. Rotterdam (1948) pp. 70-3*

APPENDIX A

DRAWINGS

Chainages only approximate for illustration. See drawings for accurate chainages.

DSC 0168


CENTRAL RIVER ENTRANCE LOCK
DETAILS OF MASONRY AT NO
PLAN - FOR SECT
1
2
3
4
5
6
North
55290

DSC 0171

CENTRAL [illegible] ENTRANCE LOCK.
DETAILS O[illegible] ORTHWEST SIDE.
[illegible] PLAN. SEE D[illegible] 55290.

Section No. 1

Section No. 2

Section No. 3

Section No. 4

Section No. 5

Section No. 6

For modified form of invert see Dwg. No. 62007

55291

DSC 0158

CENTRAL RIVER ENTRANCE LOCK WALL - Details of Masonry at North End.

Section No. A-A

Section No. B-B

Section No. C-C

Section No. D-D

Section No. E-E

Elevation of East Wall

General Plan

Excavation Plan

A

B

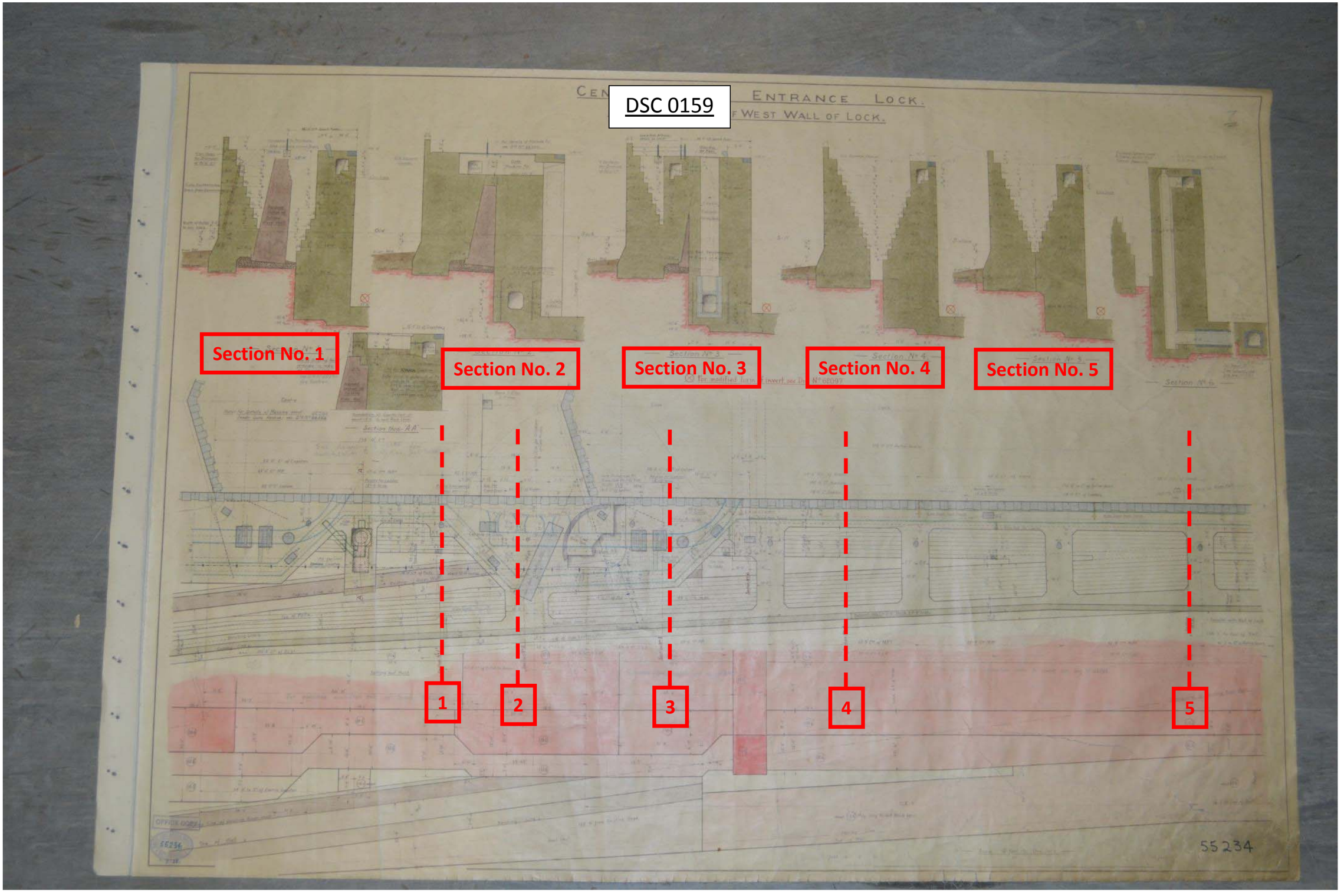
C

D

E

55191

DSC 0159


Section No. 1
Section No. 2
Section No. 3
Section No. 4
Section No. 5
1
2
3
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5
55234

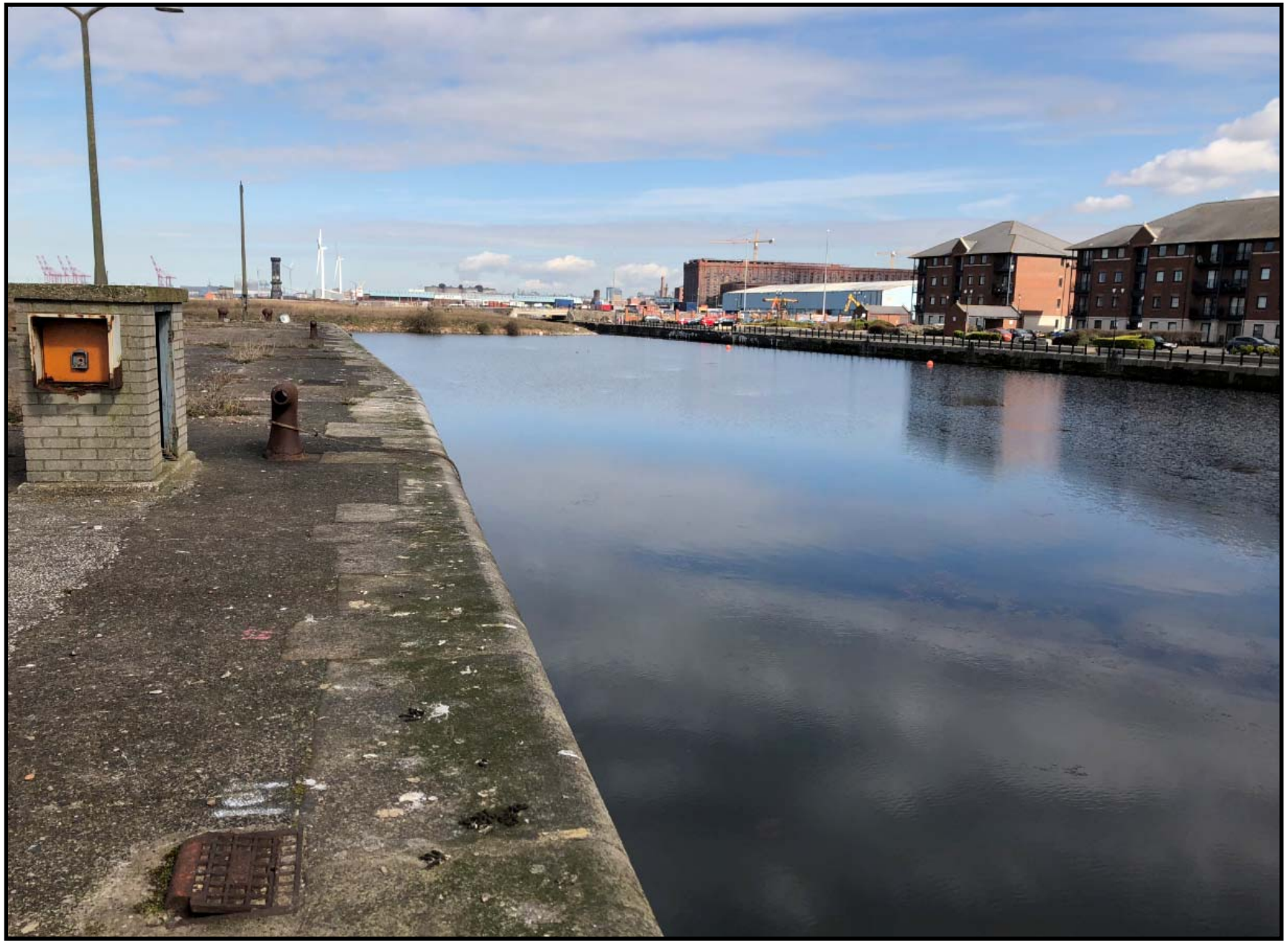
APPENDIX B

SITE PHOTOGRAPHS

CC GEOTECHNICAL LTD

Unit 1
Deltic Way
Knowsley Industrial Estate
Merseyside
L33 7BA
e: enquiries@ccgeotechnical.co.uk
w: www.ccgeotechnical.co.uk

Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Photograph Number:	1



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Photograph Number:	2

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Job Number:	CCG-C-18-10350
Photograph Number:	3

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Photograph Number:	4

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Job Number:	CCG-C-18-10350
Photograph Number:	5

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Job Number:	CCG-C-18-10350
Photograph Number:	6

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Job Number:	CCG-C-18-10350
Photograph Number:	7

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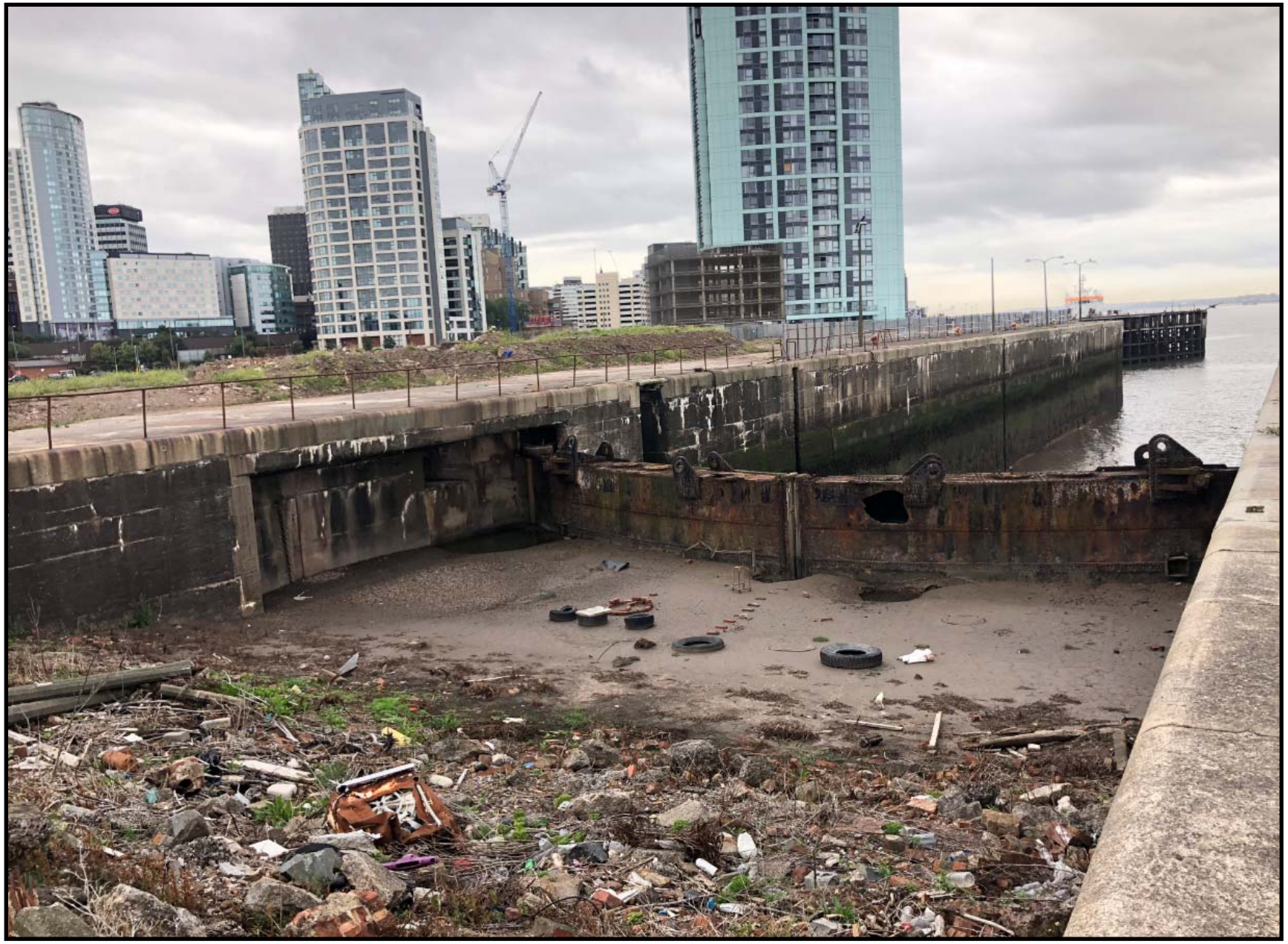
Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Photograph Number:	8



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Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Photograph Number:	9

APPENDIX C

HISTORICAL MAPS

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: 1056 Scale Town Plan

Map date: **1848**

Scale: 1:1,056

Printed at: 1:1,056

N
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Surveyed 1848
Revised N/A
Edition 1850
Copyright N/A
Levelled N/A

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www.centremapslive.com
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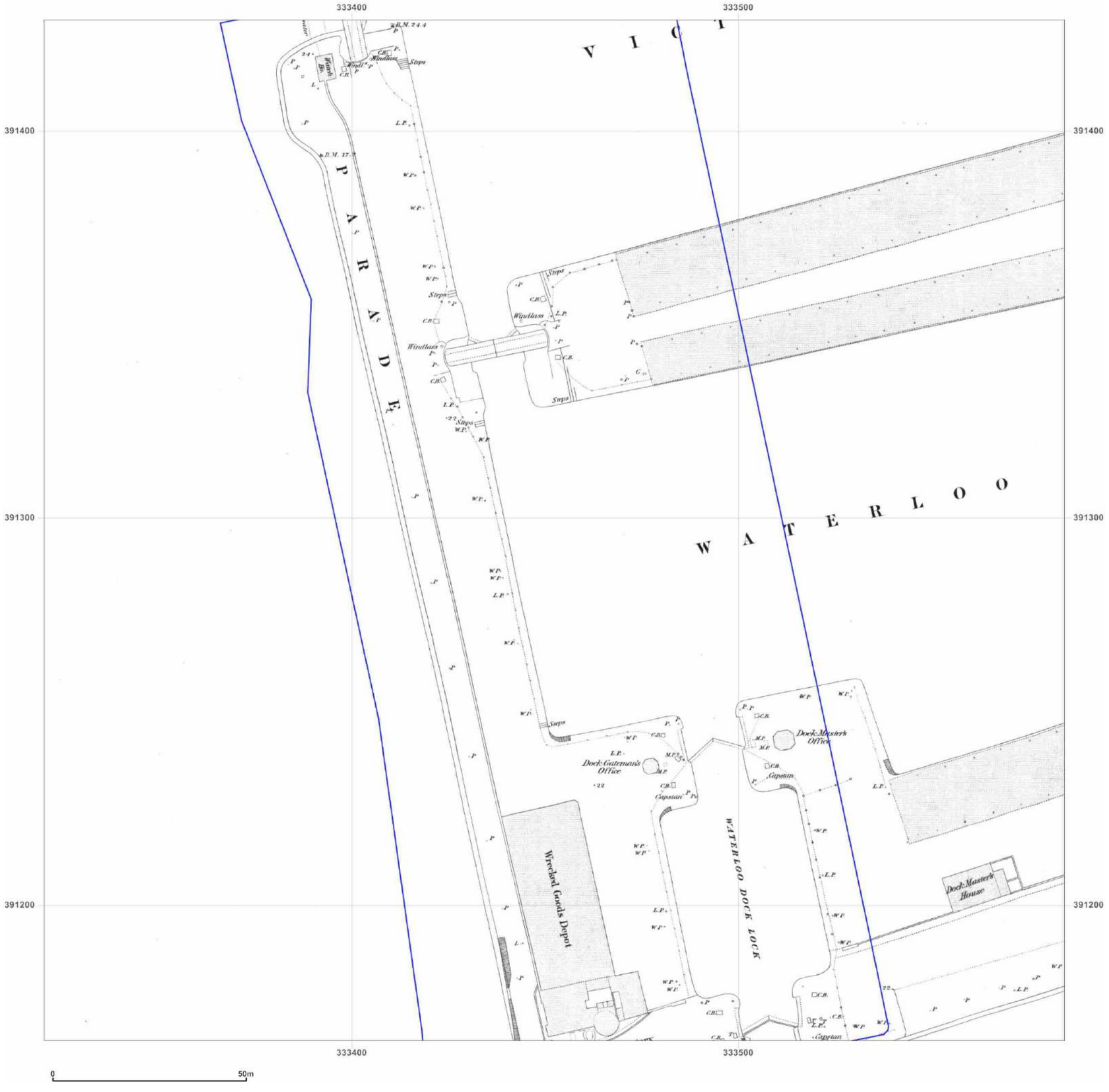
Production date: 09 October 2018

Map legend available at:
www.groundsure.com/sites/default/files/groundsure_legend.pdf



Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

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Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: 1056 Scale Town Plan

Map date: **1850**

Scale: 1:1,056

Printed at: 1:1,056

N
W E
S

Surveyed 1848
Revised N/A
Edition 1850
Copyright N/A
Levelled N/A

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Production date: 09 October 2018

Map legend available at:
www.groundsure.com/sites/default/files/groundsure_legend.pdf

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: County Series

Map date: **1893**

Scale: 1:2,500

Printed at: 1:2,500

N
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Surveyed 1893
Revised 1893
Edition N/A
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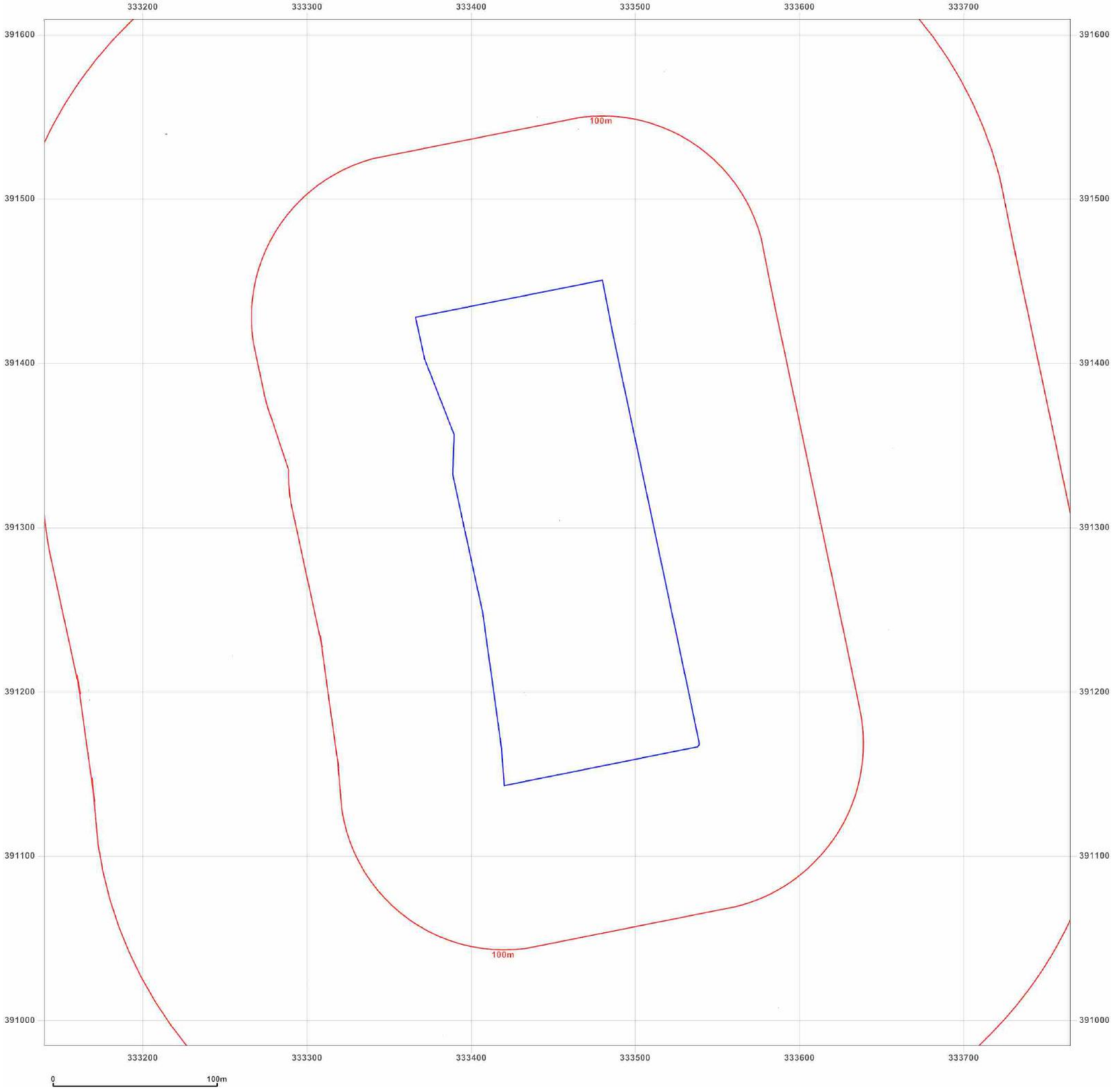

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: County Series

Map date: **1899**

Scale: 1:2,500

Printed at: 1:2,500

N
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Surveyed 1899
Revised 1899
Edition N/A
Copyright N/A
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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: County Series

Map date: **1908**

Scale: 1:2,500

Printed at: 1:2,500

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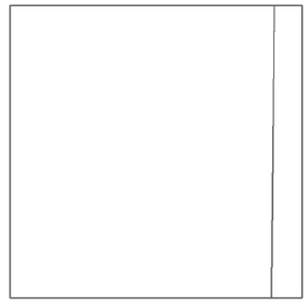
Surveyed 1908
Revised 1908
Edition N/A
Copyright N/A
Levelled N/A



Surveyed 1908
Revised 1908
Edition N/A
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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: County Series

Map date: **1911**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1911
Revised 1911
Edition N/A
Copyright N/A
Levelled N/A

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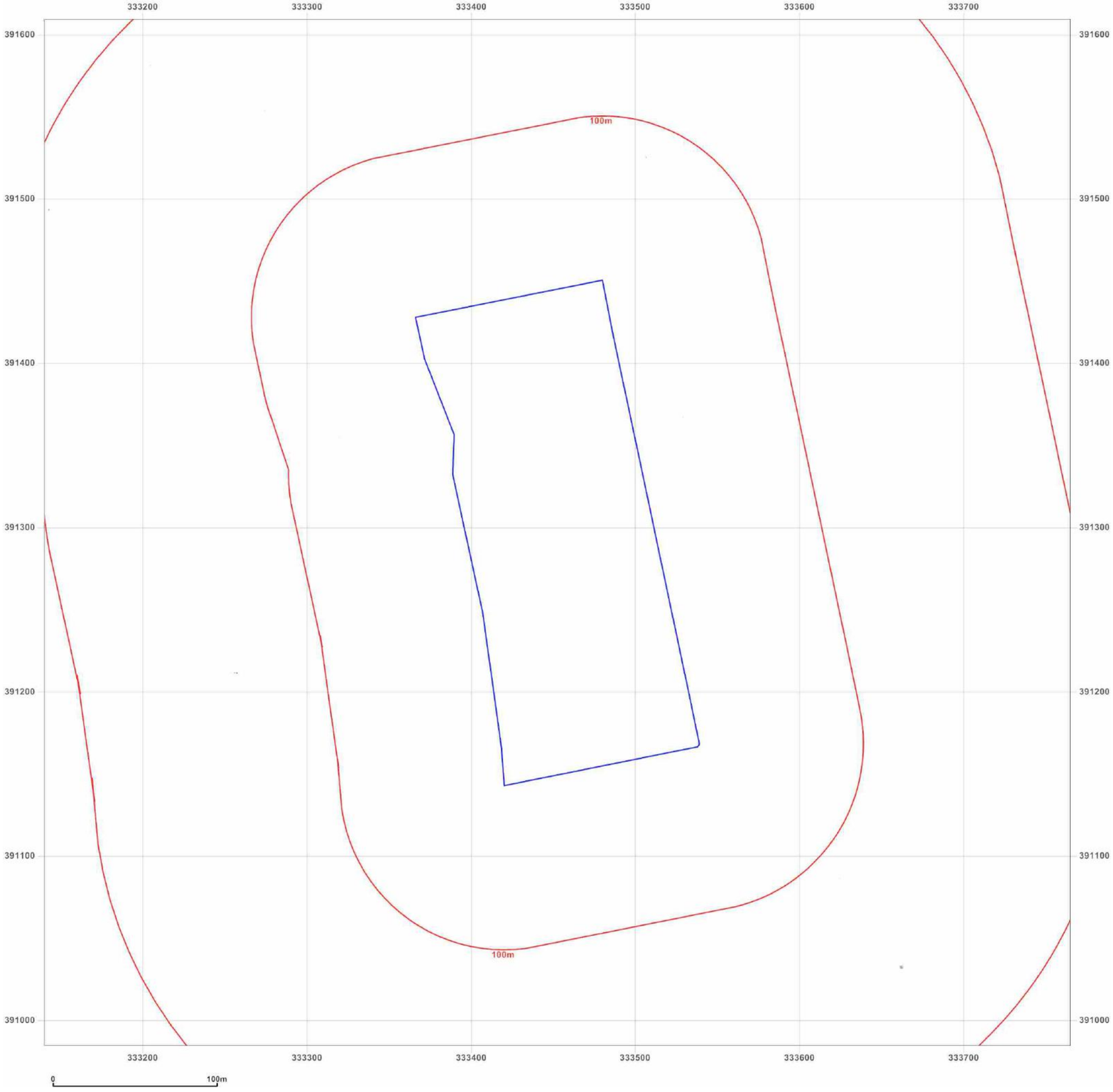

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: County Series

Map date: **1926**

Scale: 1:2,500

Printed at: 1:2,500

N
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Surveyed 1926
Revised 1926
Edition N/A
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Site Details:

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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: County Series

Map date: **1927**

Scale: 1:2,500

Printed at: 1:2,500

N
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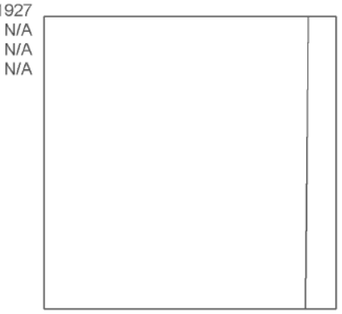
Surveyed 1927
Revised 1927
Edition N/A
Copyright N/A
Levelled N/A



Surveyed 1927
Revised 1927
Edition N/A
Copyright N/A
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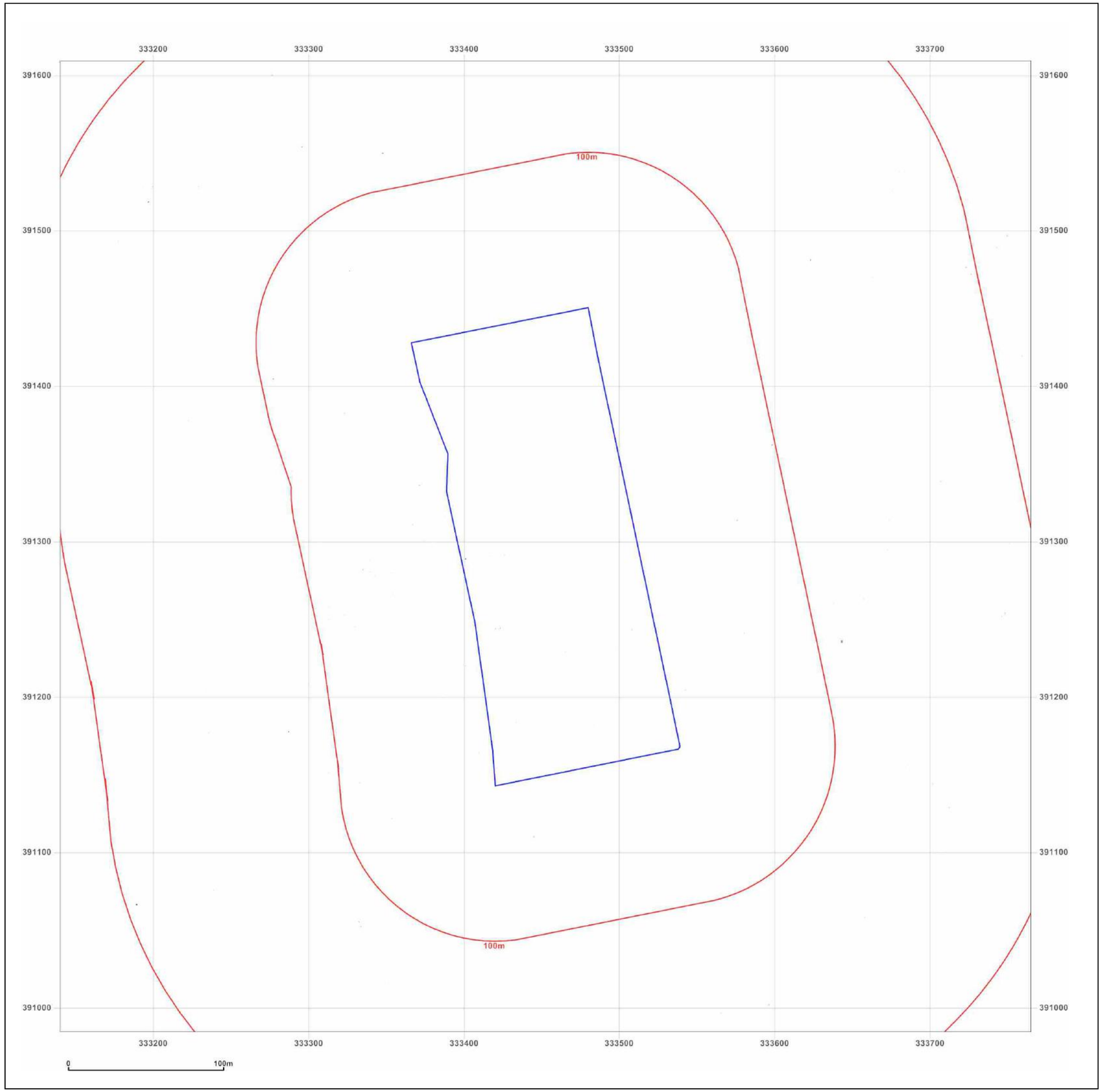

Site Details:

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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: County Series

Map date: **1935**

Scale: 1:2,500

Printed at: 1:2,500

N
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Surveyed 1935
Revised 1935
Edition N/A
Copyright N/A
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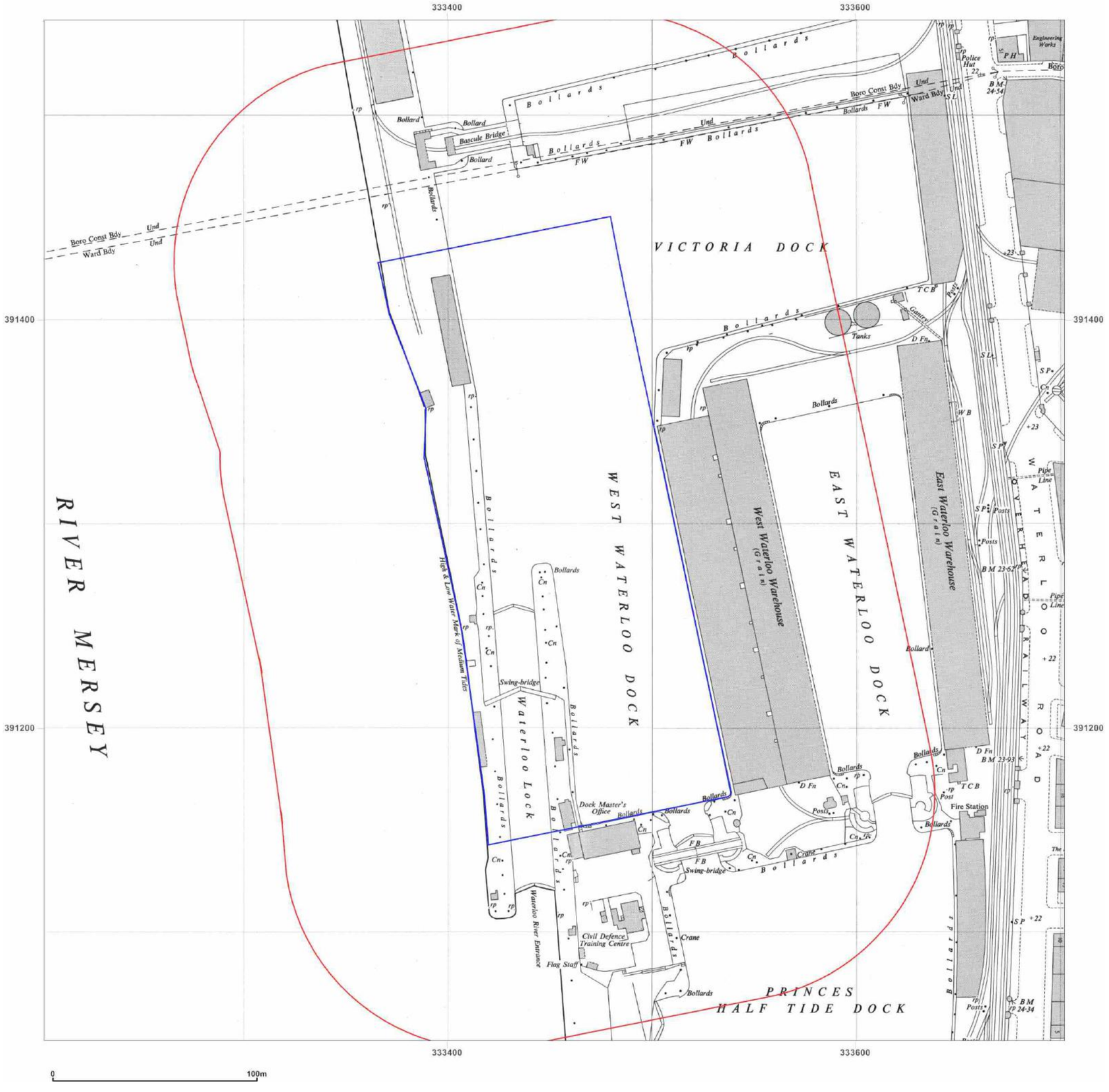

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid
Map date: **1953**
Scale: 1:1,250
Printed at: 1:2,000

N
W E
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Surveyed 1953
Revised 1953
Edition N/A
Copyright N/A
Levelled 1947

Surveyed 1953
Revised 1953
Edition N/A
Copyright N/A
Levelled 1947

Surveyed 1953
Revised 1953
Edition N/A
Copyright N/A
Levelled 1947

Surveyed 1953
Revised 1953
Edition N/A
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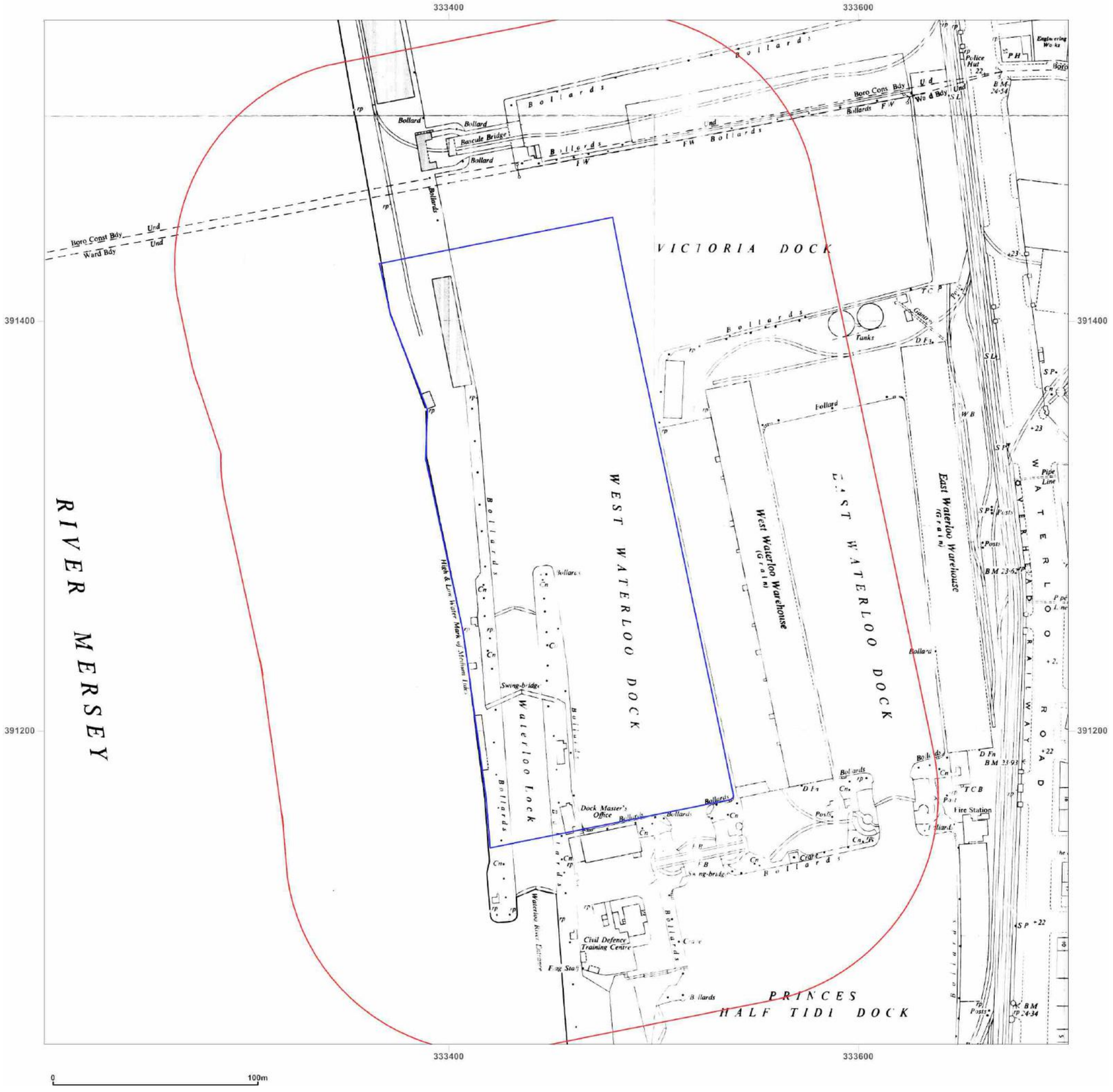

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid
Map date: **1954**
Scale: 1:1,250
Printed at: 1:2,000

N
W E
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Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

Surveyed N/A
Revised N/A
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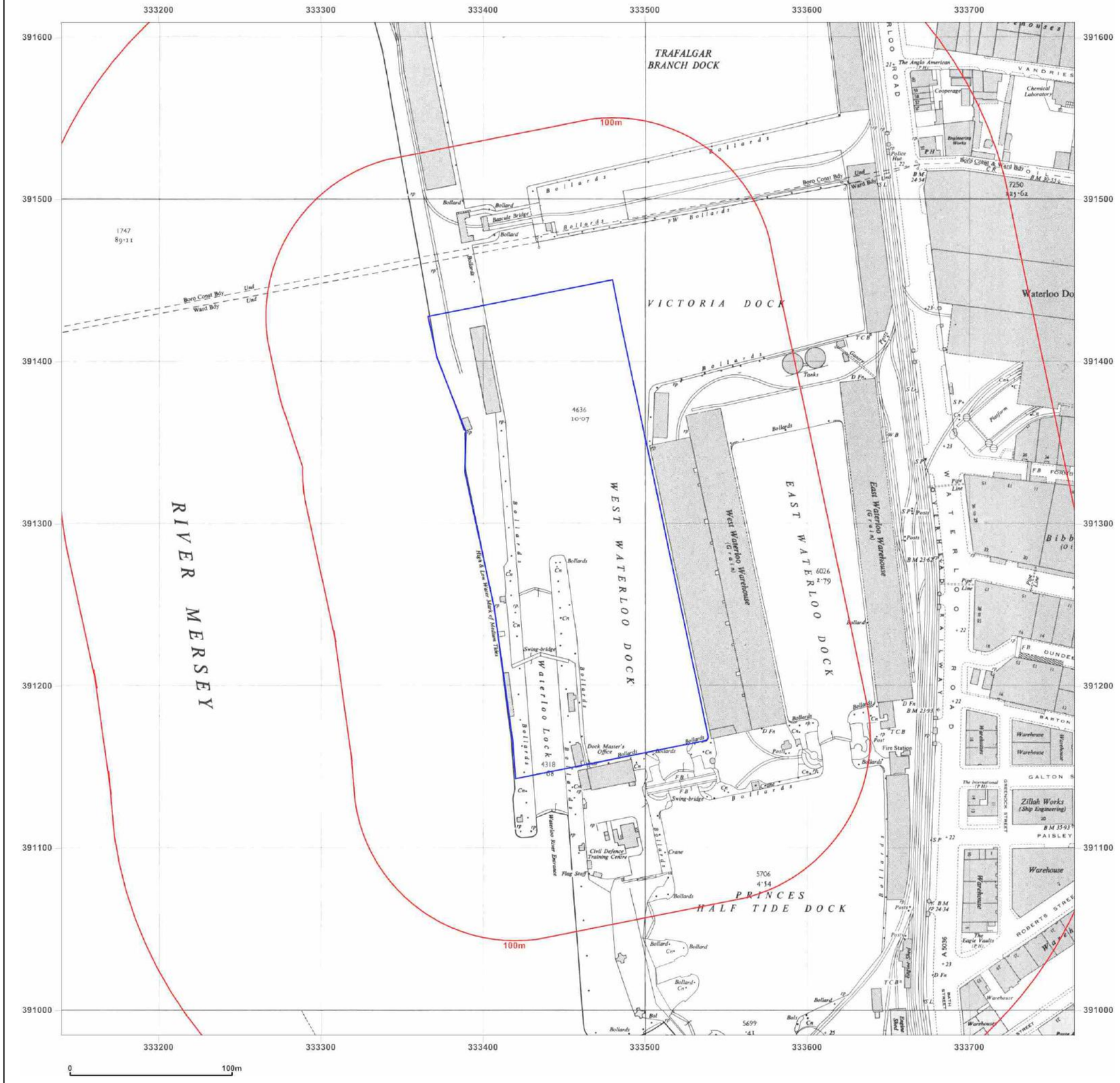

CCG

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1953-1955**

Scale: 1:2,500

Printed at: 1:2,500

N
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Surveyed 1953
~~Revised 1953~~
Edition 1955
Copyright N/A
Levelled 1947

Surveyed 1954
Revised 1954
~~Edition 1955~~
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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1958-1962**

Scale: 1:1,250

Printed at: 1:2,000

N
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Surveyed 1953
Revised 1962
Edition N/A
Copyright 1962
Levelled 1960

Surveyed 1953
Revised 1958
Edition N/A
Copyright N/A
Levelled 1947

Surveyed 1953
Revised 1962
Edition N/A
Copyright 1962
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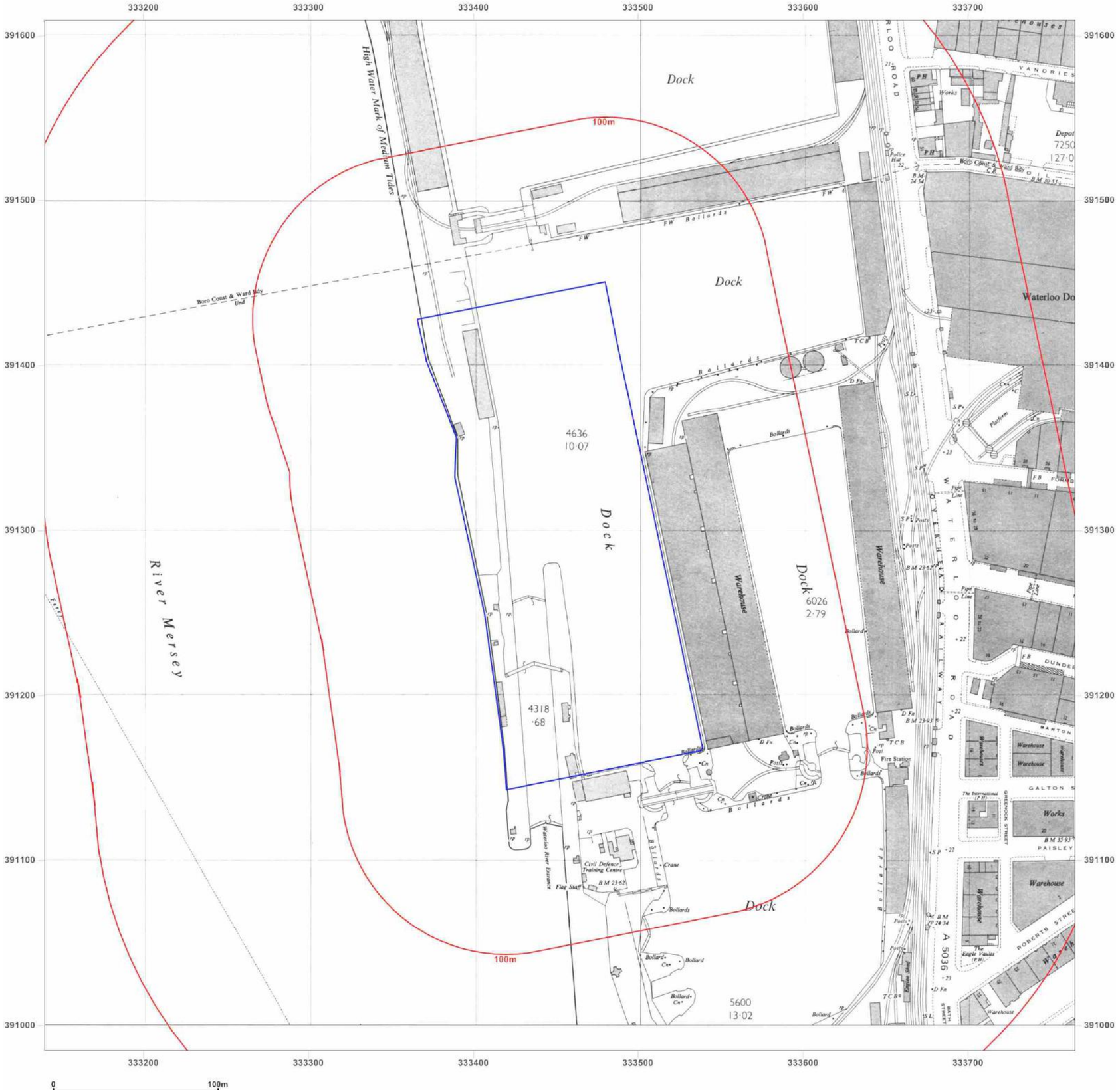

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1962**

Scale: 1:2,500

Printed at: 1:2,500

N
W E
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Surveyed 1962
Revised 1962
Edition 1964
Copyright 1964
Levelled 1960

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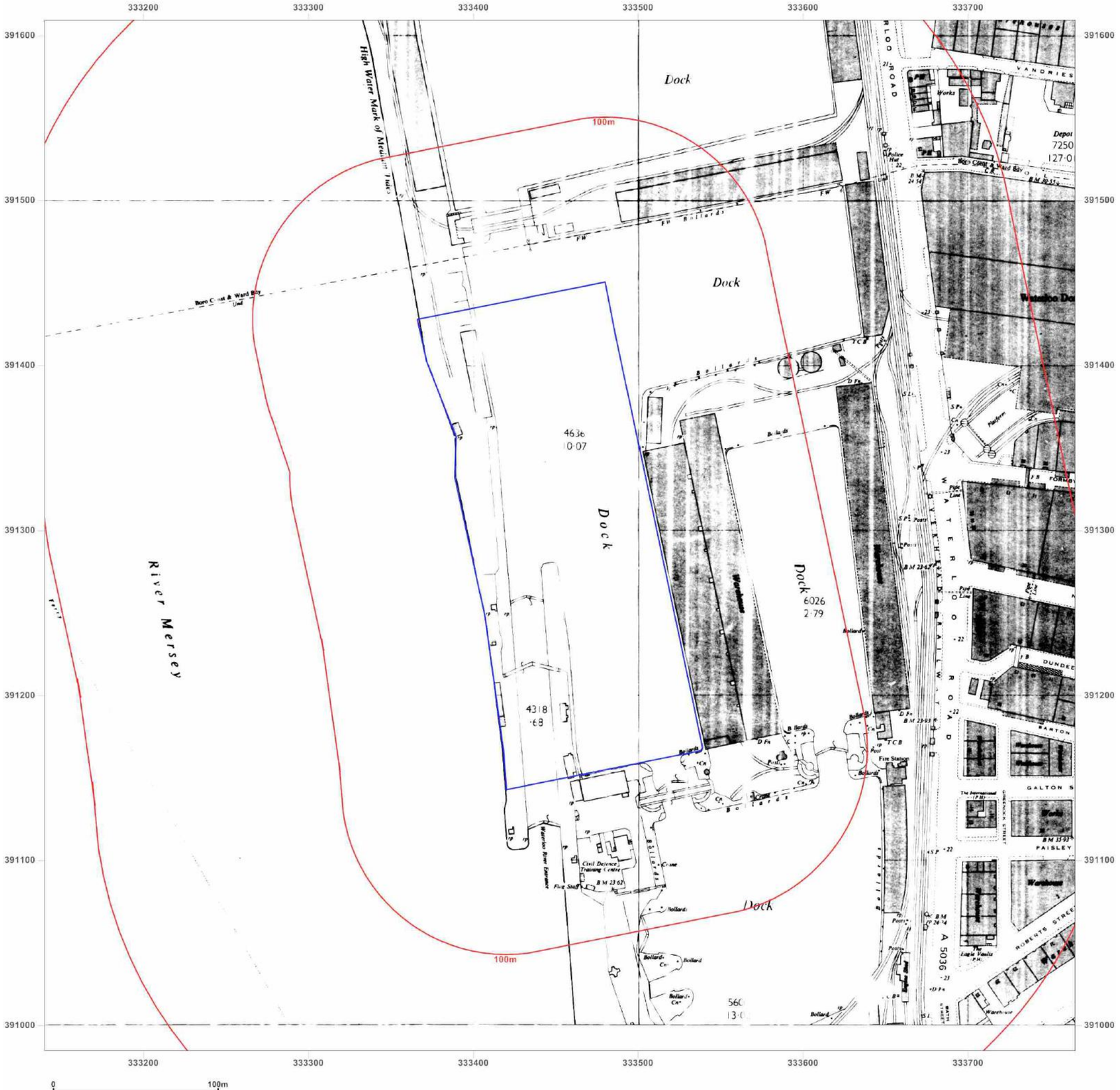

Site Details:

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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1964**

Scale: 1:2,500

Printed at: 1:2,500

N
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Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
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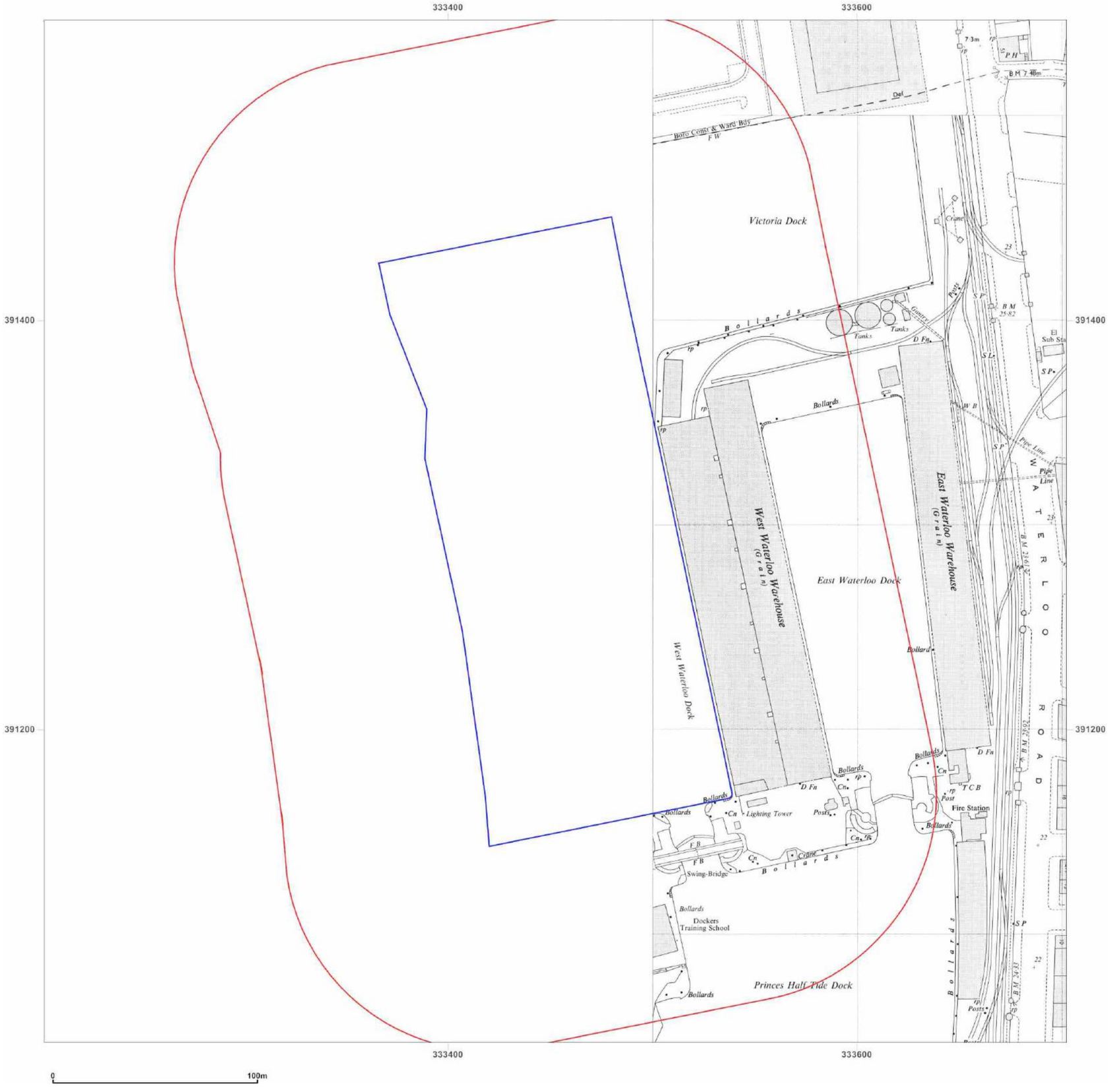

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1967-1969**

Scale: 1:1,250

Printed at: 1:2,000

N
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Surveyed 1953
Revised 1967
Edition N/A
Copyright 1967
Levelled 1960

Surveyed 1953
Revised 1968
Edition N/A
Copyright 1969
Levelled 1960

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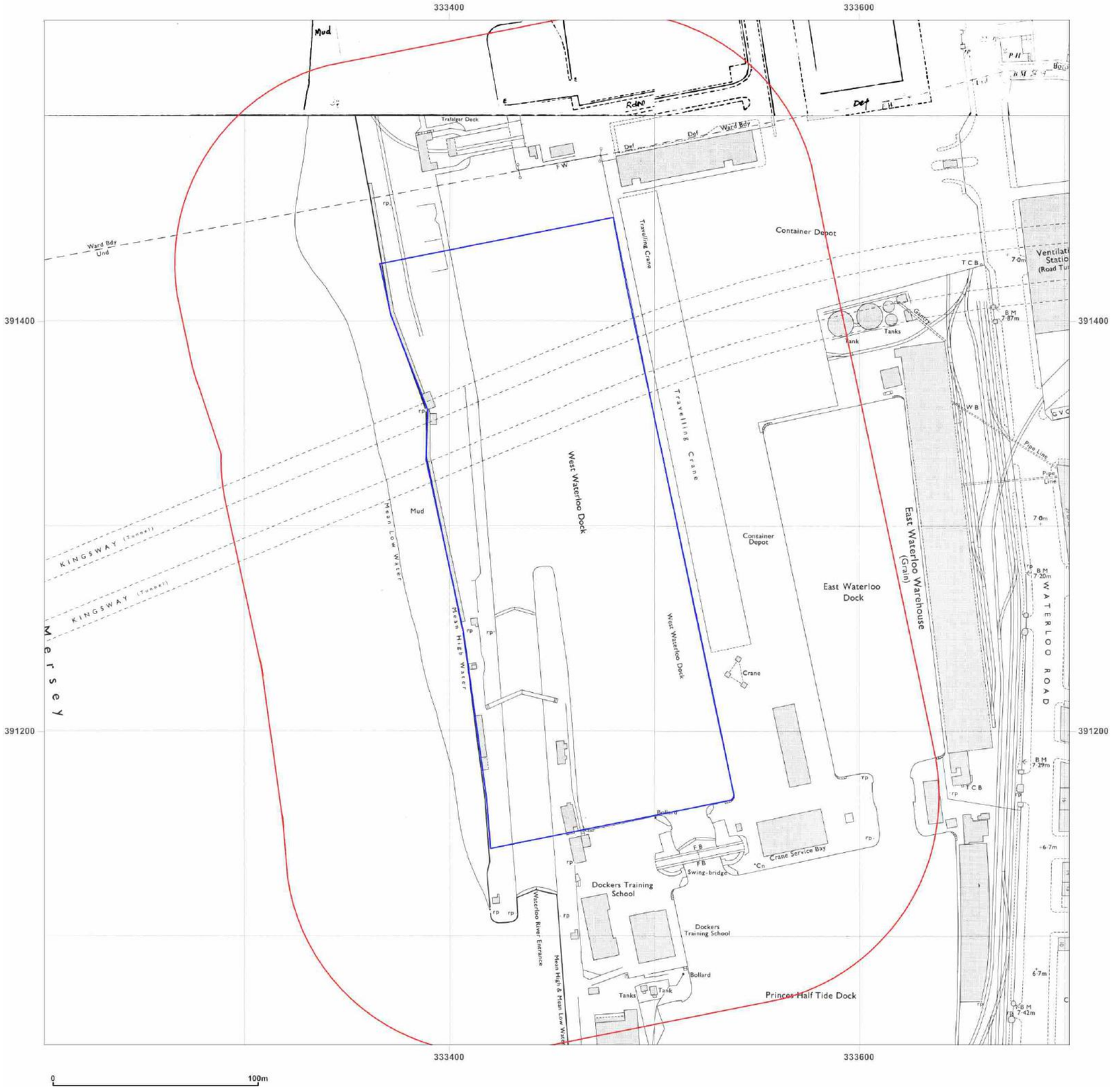

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1974-1975**

Scale: 1:1,250

Printed at: 1:2,000

N
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Surveyed N/A
Revised N/A
Edition N/A
Copyright 1974
Levelled N/A

Surveyed N/A
Revised N/A
Edition N/A
Copyright 1974
Levelled N/A

Surveyed 1953
Revised 1974
Edition N/A
Copyright 1975
Levelled 1960

Surveyed 1953
Revised 1974
Edition N/A
Copyright 1975
Levelled 1960

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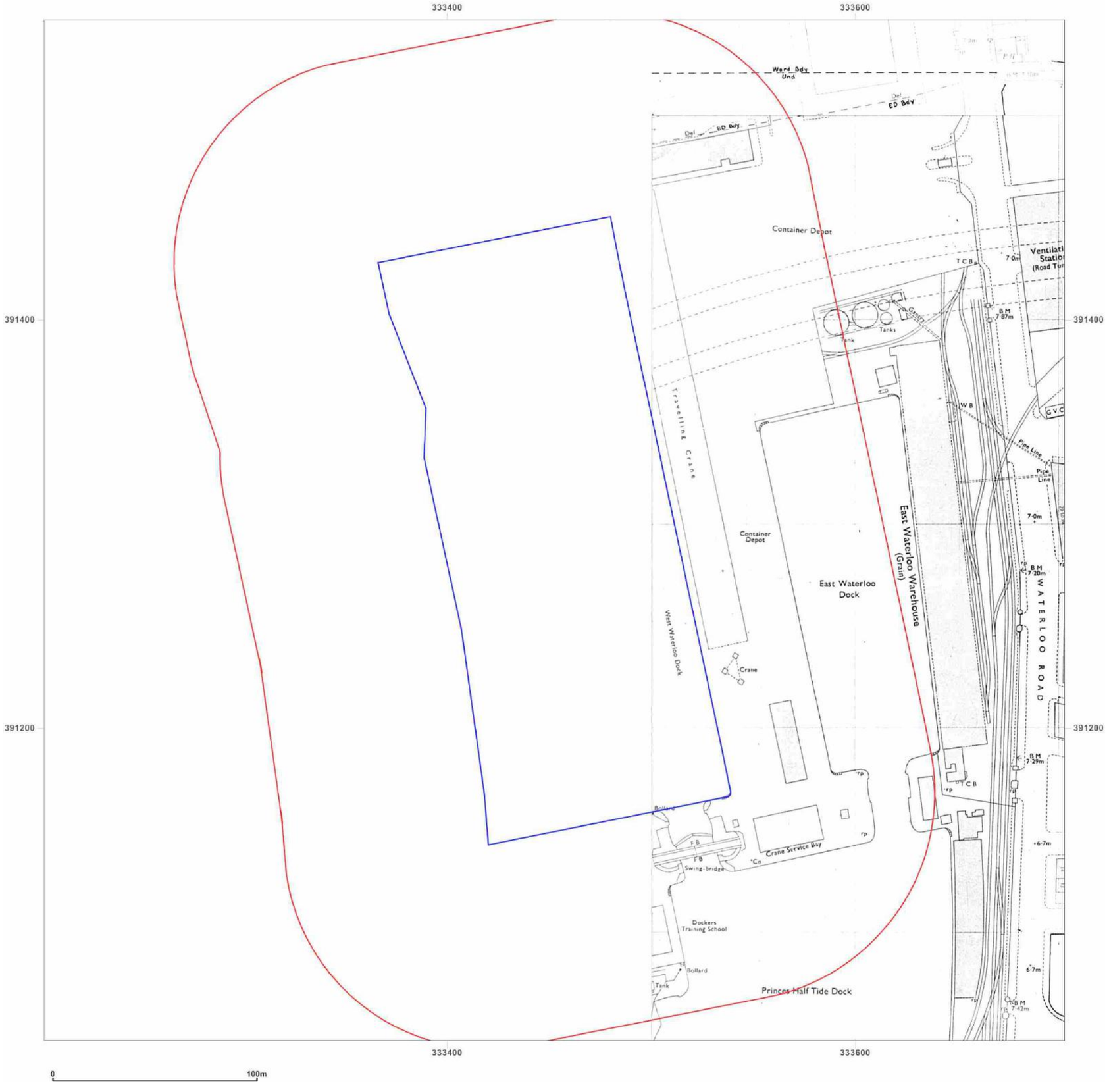

Site Details:

A5036 Waterloo Road (Vauxhall, Liverpool)

Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1982-1984**

Scale: 1:1,250

Printed at: 1:2,000

N
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Surveyed 1960
Revised 1984
Edition N/A
Copyright 1984
Levelled 1960

Surveyed N/A
Revised N/A
Edition N/A
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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1983-1984**

Scale: 1:1,250

Printed at: 1:2,000

N
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Surveyed 1960
Revised 1984
Edition N/A
Copyright 1984
Levelled 1960

Surveyed N/A
Revised N/A
Edition N/A
Copyright 1983
Levelled 1960

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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1993**

Scale: 1:1,250

Printed at: 1:2,000

N
W E
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Surveyed N/A
Revised N/A
Edition N/A
Copyright 1993
Levelled N/A

Surveyed N/A
Revised N/A
Edition N/A
Copyright 1993
Levelled N/A

Surveyed N/A
Revised N/A
Edition N/A
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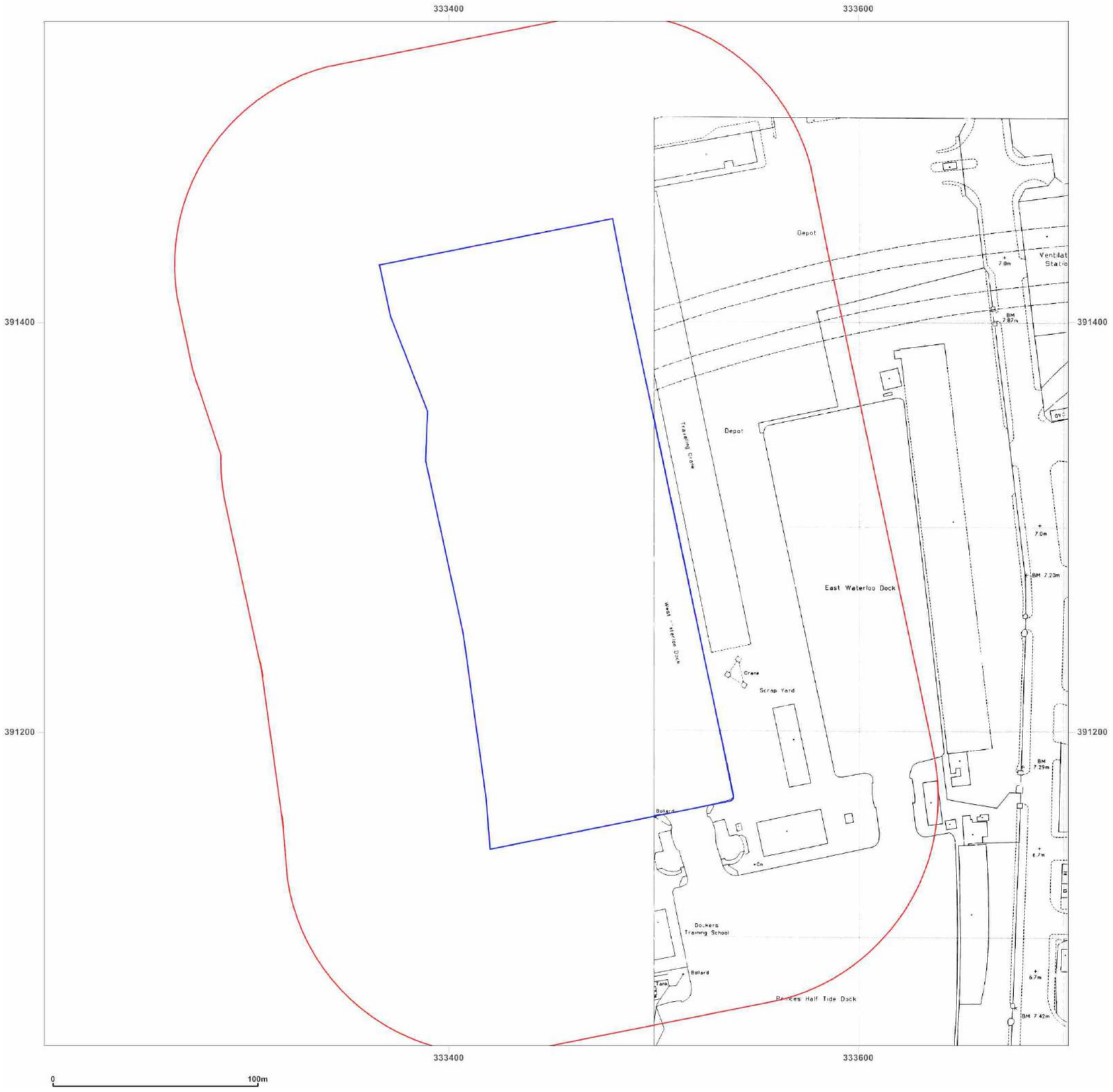

Site Details:

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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1993**

Scale: 1:1,250

Printed at: 1:2,000

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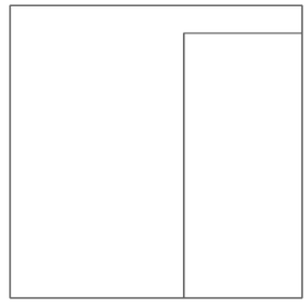

Surveyed N/A
Revised N/A
Edition N/A
Copyright 1993
Levelled N/A

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Site Details:

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Client Ref: 4165
Report Ref: CMAPS-AAG-747728-4165-091018HIS
Grid Ref: 333452, 391297

Map Name: National Grid

Map date: **1993**

Scale: 1:1,250

Printed at: 1:2,000

N
W E
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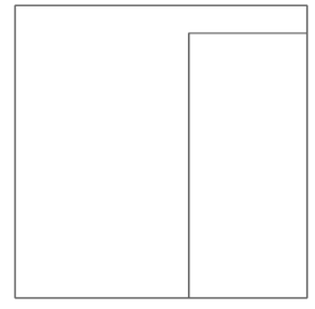

Surveyed 1993
Revised 1993
Edition N/A
Copyright 1993
Levelled N/A

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APPENDIX D

SAMPLING METHODOLOGY

SAMPLING, SAMPLE TRANSPORTATION, AND FIELD MONITORING PROTOCOLS

Soil, water and gas sampling and monitoring methodologies employed by ***CC GEOTECHNICAL LTD*** are presented hereunder.

SAMPLING OF SOIL FOR CHEMICAL ANALYSIS

Soil samples may be recovered from a variety of intrusive investigation methods including *inter alia* dynamic sampling boreholes, cable percussion boreholes, machine or manual excavation of trial pits.

All equipment which has the potential to introduce extraneous materials into soils – borehole casings, sampling drilling rods, borehole sampling tools, hand tools such as trowels and spades etc. – must be cleaned by jet washing before initial use and between sampling positions.

Cable Percussion Boreholes

In this method of investigation disturbed bulk and small disturbed samples are recovered at regular depth increments throughout the length of the borehole. Each bulk/small disturbed sample is uniquely labelled with the Project Name / Project No / Borehole No / Depth / Date. Where possible, samples are immediately scanned by PID.

Light Dynamic Sampling Boreholes

In this method of investigation samples are recovered in relatively undisturbed 1m long Perspex liners. Each liner is uniquely labelled with the Project Name / Project No / Borehole No / Depth / Date. The liner tubes are sealed by air tight caps fitted at each end, and are temporarily stored out of sunlight. Where possible, samples are immediately split, scanned by PID, logged and subsampled. In the event that splitting and logging on site is not practicable, then the liners are immediately transported to the laboratory where they are immediately split, scanned by PID, logged and subsampled

Trial Pits

Samples are to be taken from the bucket of an excavator and placed in appropriate airtight containers. Each container is uniquely labelled with the Project No / Trial Pit No / Depth / Date. The samples are then immediately placed in a cool box chilled by ice packs, and the boxes are sealed for transportation to the chemical laboratory.

Sampling Containers

Containers used to store soil samples are selected dependant on the required analysis. The testing laboratory will be consulted should there be any doubt as to the correct sampling container. Typically, a minimum of 1nr 1kg plastic tub, 1nr 500g plastic tub, 1nr 250g amber glass jar and 2nr glass vials are taken at each sample depth. Samples held on site awaiting same day courier collection are stored at $4^{O}C$ in a cool box. Only in circumstances where same day collection cannot be arranged are samples held overnight, and in this event all samples are refrigerated at $4\ ^{O}C$ either on site (if a refrigerator is available) or at CC GEOTECHNICAL soil laboratory. Courier collection is then arranged for immediate pick up the following day.

Chain of Custody records

A Chain of Custody Record (CoC) is to be sent with each batch of samples submitted to the testing laboratory. A copy of the CoC will be made available for inspection by the client, their agents, or any requesting regulatory authority.

HEADSPACE ANALYSES

Duplicate subsamples of all soil samples selected for laboratory analysis may be taken for headspace analyses.

Headspace analysis is undertaken using a MiniRae 2000 Photo Ionisation Detector (PID). In the test method, an amber glass jar is half filled with soil, and the lid is sealed with aluminium foil secured by an elastic band. The jar and contents are agitated for 30 seconds and left for a minimum of 30 minutes out of direct sunlight for the headspace to achieve equilibrium. The PID then pierces the seal and the maximum reading is recorded. Prevailing weather conditions and ambient air temperature are also recorded.

The PID headspace results are recorded on the exploratory borehole or trial pit logs.

PID headspace data is then used to inform the chemical testing schedule for volatile organic compounds analyses.

SAMPLING OF GROUNDWATER FOR CHEMICAL ANALYSIS

Groundwater is sampled from standpipes or piezometers installed during borehole drilling. On completion of the construction of the standpipe, the installation is initially developed by removing up to 10 x the internal volume of the installation. The volume of water purged is recorded. The installation is then typically left for a week for hydraulic equilibrium to be restored.

Prior to sampling the standpipe, the depth to the water table, and the depth to the base of the installation are monitored using an electronic dipmeter. In circumstances where free phase product is suspected to be present, then an 'Interface Meter' is used to determine the free phase film thickness.

A minimum of 3 x the installation volume is then removed. The pH of the water is then monitored and the sample is taken when the change in pH between any two consecutive extracts is less than 10%. The volume of water removed is recorded.

A sample comprises of a minimum of 3 litres. Two litres are taken in amber glass bottles, and one litre in a plastic bottle.

To avoid cross-contamination one bailer is used per position.

The samples are uniquely labelled with Project Name / Project No / Borehole No / Depth / Date Sampled. They are placed in a cool box chilled by ice packs, and the containers are sealed for transportation to the laboratory.

Once the samples are received in the ***CC GEOTECHNICAL LTD*** laboratory, the samples are stored in a refrigerator and returned to the cool boxes once collected.

Water taken from the installations are taken back to the ***CC GEOTECHNICAL LTD*** laboratory and disposed.

Other data recorded in the sampling comprises:

- Volume of water removed during development of well
- Volume of water removed during purging of the well
- Results of on-site pH analyses
- Sample appearance – colour, suspended solids

MONITORING OF GAS

Prior to embarking on a gas-monitoring round, all equipment is checked for functionality and the calibration status is confirmed.

At the commencement of the monitoring round, the prevailing weather conditions, air temperature, barometric pressure and direction of movement of barometric pressure are recorded.

The flow meter is first attached to the standpipe valve, and the flow rate is measured (peak and steady flow) for 1 minute. The results are recorded in $l.hr^{-1}$. The flow meter tube is protected from the effects of wind by aligning the exhaust downwind.

Following measurement of borehole flow rate, the installation is left for a minimum of 10 minutes for the headspace to restore equilibrium.

Once the gas in the installation has regained equilibrium, the gas analyser is connected and monitoring commences. The peak and steady state readings for CH_4, CO_2, CO, H_2S and CO are recorded. The steady state is monitored for a minimum of one minute, and possibly up to a maximum of 10 minutes where fluctuations continue.

When the monitoring is complete, the depth to the water table, and the depth to the base of the well are monitored using an electronic dipmeter. In circumstances where free phase product is suspected to be present, then an 'Interface Meter' is used to determine the free phase film thickness.

APPENDIX E

BOREHOLE LOGS

	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH1**
	Contract Number: CCG-C-18-10350	Date Started: 18-09-2018	Logged By: DO	Checked By: CB	Status: FINAL
Cable Percussion Borehole Log	Easting: 333483.0	Northing: 391321.0	Ground Level: 1.20mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: CB/KM
					Sheet 1 of 2
					Scale: 1:50

Weather: | Termination: | SPT Hammer: N/R, Energy Ratio: N/R

Samples & In Situ Testing							Strata Details					Groundwater	
Depth	Sample ID	Test Result	TCR	SCR	RQD	Fracture	Water	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
0.50	B										Dark grey silty sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded brick, concrete, slag, cinders, limestone, ceramic, glass, sandstone, granite and coal with inclusions of metal fragments (MADE GROUND)		
		SPT(S)N=6 (2,1/2,1,1,2)											
1.50	B												
		SPT(S)N=5 (1,0/1,2,1,1)											
2.50	B												
		SPT(S)N=2 (1,0/1,0,1,0)											
3.50	B								(6.70)				
		SPT(S)N=3 (1,0/1,0,1,1)											
4.50	B												
		SPT(S)N=3 (1,0/1,0,1,1)											
6.50	B												
						15		-5.50	6.70		Weak reddish brown occasionally brown and grey fine to medium grained thickly laminated SANDSTONE. Slightly weathered. Discontinuities are extremely close to medium spaced, horizontal, clean, rough and tight to open with occasional drilling-induced sub-vertical fractures		
6.70 - 8.20	97	57	7								*COMPLETELY WEATHERED. RECOVERED AS SLIGHTLY SANDY FINE TO COARSE ANGULAR TO SUB-ROUNDED GRAVELS OF SANDSTONE - 6.70-6.88mbgl* *COMPLETELY WEATHERED. RECOVERED AS SLIGHTLY SANDY FINE TO COARSE ANGULAR TO SUB-ROUNDED GRAVELS OF SANDSTONE - 7.05-7.07mbgl*		
											WEAK - PL = 12.24mPa - 8.00mbgl		
8.20 - 9.70	96	77	31			10 70 170			(6.00)		*WEAK - PL = 20.45mPa - 9.10mbgl*		
											Continued next sheet		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Chiselling			
From (m)	To (m)	Duration	Remarks
6.60	6.70	00:30	Rockhead

Installation			
Top (m)	Base (m)	Type	Dia (mm)

Remarks:
Over water borehole. Depth to bed - 3.70m below water
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH1**
	Contract Number: CCG-C-18-10350	Date Started: 18-09-2018	Loggged By: DO	Checked By: CB	Status: FINAL
Rotary Core Drilling Log	Easting: 333483.0	Northing: 391321.0	Ground Level: 1.20mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: CB/KM
					Sheet 2 of 2
					Scale: 1:50
Weather:		Termination:		SPT Hammer: N/R, Energy Ratio: N/R	

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	TCR	SCR	RQD	Fracture Spacing	Water Added	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
9.70 - 11.20	60	91	52	45 186 290					WEAK - UCS = 8.00mPa - 10.40mbgl		
11.20 - 12.70	97	95	82						MEDIUM STRONG - PL = 30.26mPa - 11.50mbgl WEAK - UCS = 7.40mPa - 11.70mbgl WEAK - PL = 12.77mPa - 12.40mbgl		
						-11.50	12.70		End of Borehole at 12.70m		

10 11 12 13 14 15 16 17 18 19

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Flush Information					Installation			
Top (m)	Base (m)	Flush Type	Return	Flush Colour	Top (m)	Base (m)	Type	Dia (mm)

Remarks:

Over water borehole. Depth to bed - 3.70m below water
PL = Point Load

Water Strikes					
Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

Fracture spacing reported in mm as min, Average and Max values. TCR, SCR and RQD reported in %

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH2**
Contract Number: CCG-C-18-10350	Date Started: 16-09-2018	Logged By: DO	Checked By: CB	Status: FINAL
Cable Percussion Borehole Log	Easting: 333490.0	Northing: 391268.0	Ground Level: 4.00mAOD	Plant Used: Dando 150 S/A Rig
Rig Crew: KM/PC CB/KM	Scale: 1:50			Sheet 1 of 2
Weather:	Termination:	SPT Hammer: N/R, Energy Ratio: N/R		

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	Sample ID	Test Result	TCR	SCR	RQD	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
0.50	B								Dark grey silty very sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded cinders, sandstone, concrete, limestone, glass, shell, brick, wood, slag and granite (MADE GROUND)		
1.00	B	SPT(S)N=4 (1,0/0,1,2,1)									
1.50	B										
		SPT(S)N=6 (2,2/2,1,1,2)									
2.50	B										
		SPT(S)50 (25 for 30mm/50 for 60mm)									
3.50	B						(7.20)				
		SPT(S)N=10 (3,3/2,2,3,3)									
4.50	B										
		SPT(S)N=2 (1,0/1,0,1,0)									
6.00	B										
6.50	B										
		SPT(S)50 (25 for 20mm/50 for 40mm)				-3.20	7.20				
7.20 - 8.70	99		87	36	70 / 20				Weak reddish brown occasionally brown and grey fine to medium grained SAND. Slightly weathered. Discontinuities are extremely close to medium spaced, horizontal, clean, rough and tight to open. Rare occurrences of clay on fracture faces *COMPLETELY WEATHERED. RECOVERED AS SLIGHTLY SANDY FINE TO COARSE ANGULAR TO SUB-ANGULAR GRAVELS OF SANDSTONE - 7.49-7.54mbgl* *COMPLETELY WEATHERED. RECOVERED AS SLIGHTLY SANDY FINE TO COARSE ANGULAR TO SUB-ANGULAR GRAVELS OF SANDSTONE - 7.66-7.69mbgl*		
8.70 - 10.20	95		90	84					*WEAK - UCS = 5.70mPa - 9.20mbgl*		
			TCR	SCR	RQD				Continued next sheet		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Chiselling			
From (m)	To (m)	Duration	Remarks
7.10	7.20	00:30	Rockhead

Installation			
Top (m)	Base (m)	Type	Dia (mm)

Remarks:

Over water borehole. Depth to bed - 0.90m below water
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH2**
	Contract Number: CCG-C-18-10350	Date Started: 16-09-2018	Loggged By: DO	Checked By: CB	Status: FINAL
Rotary Core Drilling Log	Easting: 333490.0	Northing: 391268.0	Ground Level: 4.00mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/PC CB/KM
					Sheet 2 of 2
					Scale: 1:50
Weather:		Termination:		SPT Hammer: N/R, Energy Ratio: N/R	

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	TCR	SCR	RQD	Fracture Spacing	Water Added	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
10.20 - 11.70	98	89	57	19 74 350			(6.00)		WEAK - PL = 15.86mPa - 10.40mbgl		
11.70 - 13.20	97	89	80						WEAK - UCS = 9.00mPa - 12.20mbgl WEAK - PL = 15.19mPa - 12.80mbgl		
						-9.20	13.20		NO RECOVERY - 13.15-13.20mbgl End of Borehole at 13.20m		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Flush Information					Installation			
Top (m)	Base (m)	Flush Type	Return	Flush Colour	Top (m)	Base (m)	Type	Dia (mm)

Remarks:

Over water borehole. Depth to bed - 0.90m below water
PL = Point Load

Water Strikes					
Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

Fracture spacing reported in mm as min, Average and Max values. TCR, SCR and RQD reported in %

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital			Borehole ID: **BH3**
Contract Number: CCG-C-18-10350	Date Started: 11-09-2018	Logged By: DO	Checked By: CB	Status: FINAL	Sheet 1 of 2
Cable Percussion Borehole Log	Easting: 333496.0	Northing: 391219.0	Ground Level: 4.00mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD SB/IO	Scale: 1:50
Weather:	Termination:	SPT Hammer: N/R, Energy Ratio: N/R			

Samples & In Situ Testing							Strata Details				Groundwater	
Depth	Sample ID	Test Result	TCR	SCR	RQD	Fracture	Water	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
								4.00	(0.00)		Brown becoming dark brown silty very sandy GRAVEL. Gravel is fine to coarse sub-angular to sub-rounded concrete, sandstone, brick, limestone, wood, granite, glass, cinders and ceramic (MADE GROUND)		
1.00	B												
		SPT(S)N=5 (1,1/1,1,2,1)											
1.50	B												
		SPT(S)N=7 (1,2/2,2,1,2)											
2.50	B												
		SPT(S)N=9 (2,3/2,2,2,3)											
3.50	B												
		SPT(S)N=25 (1,4/5,6,6,8)							(7.50)				
4.50	B												
		SPT(S)50 (25 for 30mm/50 for 40mm)											
6.00	B												
		SPT(S)N=6 (1,1/1,2,1,2)											
7.50	B	SPT(S)50 (25 for 5mm/50 for 0mm)						-3.50	7.50		Weak reddish brown occasionally grey fine to medium grained thickly laminated SANDSTONE. Slightly weathered. Discontinuities are extremely close to medium spaced, horizontal, clean, rough and tight to open		
7.50 - 9.00	57		45	37		15 120 361					NO RECOVERY - 7.50-8.15mbgl WEAK - PL = 13.27mPa - 8.40mbgl NON-INTACT. RECOVERED AS GRAVEL - 8.87-8.95mbgl		
9.00 - 10.50	100		100	79							WEAK - UCS = 8.60mPa - 9.40mbgl		
											Continued next sheet		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)
11-09-2018	16:00	3.50	3.50	2.50				
12-09-2018	08:00	3.50	3.50	2.50				

Chiselling			
From (m)	To (m)	Duration	Remarks
5.00	5.50	00:30	Brick/Concrete
7.40	7.50	00:45	Rockhead

Installation			
Top (m)	Base (m)	Type	Dia (mm)

Remarks:

Over water borehole. Depth to bed - 0.90m below water
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital			Borehole ID: **BH3**
Contract Number: CCG-C-18-10350	Date Started: 11-09-2018	Loggged By: DO	Checked By: CB	Status: FINAL	Sheet 2 of 2
Rotary Core Drilling Log	Easting: 333496.0	Northing: 391219.0	Ground Level: 4.00mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD SB/IO	Scale: 1:50
Weather:	Termination:	SPT Hammer: N/R, Energy Ratio: N/R			

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	TCR	SCR	RQD	Fracture Spacing	Water Added	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
									WEAK - PL = 16.56mPa - 10.40mbgl		
10.50 - 12.00	100	100	89	50 147 388			(6.00)		WEAK - UCS = 9.0mPa - 11.40mbgl		
12.00 - 13.50	100	89	70	38 132 180					NON-INTACT. RECOVERED AS GRAVEL - 12.78-12.94mbgl WEAK - PL = 19.19mPa - 12.80mbgl		
						-9.50	13.50		End of Borehole at 13.50m		

10 11 12 13 14 15 16 17 18 19

Start & End of Shift Observations				
Date	Time	Depth (m)	Casing (m)	Water (m)
11-09-2018	16:00	3.50	3.50	2.50
12-09-2018	08:00	3.50	3.50	2.50

Borehole Diameter		Casing Diameter	
Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Flush Information				
Top (m)	Base (m)	Flush Type	Return	Flush Colour

Installation			
Top (m)	Base (m)	Type	Dia (mm)

Remarks:

Over water borehole. Depth to bed - 0.90m below water
PL = Point Load

Water Strikes					
Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

Fracture spacing reported in mm as min, Average and Max values. TCR, SCR and RQD reported in %

CCG	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH4**
	Contract Number: CCG-C-18-10350	Date Started:	Logged By: CB	Checked By: CB	Status: FINAL
Cable Percussion Borehole Log	Easting: 333409.0	Northing: 391287.0	Ground Level: 7.70mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD
					Sheet 1 of 2
					Scale: 1:50
Weather:		Termination:		SPT Hammer: N/R, Energy Ratio: N/R	

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
			7.50	0.20		CONCRETE		
0.50	B					Red/brown slightly silty sandy GRAVEL. Gravel is fine to coarse angular brick and sandstone (MADE GROUND)		
1.00	B	SPT(S)N=10 (2,3/3,2,2,3)						
1.50	B							
		SPT(S)50 (1,1/50 for 85mm)						
2.50	B			(4.80)				
		SPT(S)N=33 (2,4/6,9,8,10)						
		SPT(S)N=15 (2,3/3,4,4,4)						
4.50	B							
		SPT(S)N=11 (1,1/2,3,3,3)	2.70	5.00		Grey slightly sandy gravelly silty CLAY. Gravel is fine to coarse angular brick and sandstone (MADE GROUND)		
6.00	B							
		SPT(S)N=13 (1,2/3,3,3,4)		(3.30)				
7.50	B							
		SPT(S)50 (1,3/50 for 160mm)						
8.50	B		-0.60	8.30		SANDSTONE MASONRY CONSTRUCTION		
		SPT(S)50 (25 for 15mm/50 for 15mm)		(1.50)				
			-2.10	9.80				

TCR | SCR | RQD | Fracture | Water

Continued next sheet

Start & End of Shift Observations

Date	Time	Depth (m)	Casing (m)	Water (m)
06-09-2018	16:00	3.00	3.00	
07-09-2018	08:00	3.00	3.00	
07-09-2018	16:00	8.70	8.70	5.50

Borehole Diameter

Depth (m)	Dia (mm)

Casing Diameter

Depth (m)	Dia (mm)

Chiselling

From (m)	To (m)	Duration	Remarks
8.30	8.70	01:00	Sandstone

Installation

Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
6.49			0		Monitored water level on 19/10/2018

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital			Borehole ID: **BH4**
Contract Number: CCG-C-18-10350	Date Started:	Loggged By: CB	Checked By: CB	Status: FINAL	Sheet 2 of 2
Rotary Core Drilling Log	Easting: 333409.0	Northing: 391287.0	Ground Level: 7.70mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD	Scale: 1:50
Weather:	Termination:	SPT Hammer: N/R, Energy Ratio: N/R			

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	TCR	SCR	RQD	Fracture Spacing	Water Added	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
9.80 - 10.80	85								Reddish brown fine to medium grained SANDSTONE with rare inclusions of mortar		
10.80 - 12.30	94						(3.20)		MORTAR - 11.20mbgl MORTAR - 11.80mbgl		
12.30 - 13.80	67					-5.30	13.00		Red/grey SANDSTONE gravels and cobbles		
							(0.80)				
						-6.10	13.80		End of Borehole at 13.80m		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)
06-09-2018	16:00	3.00	3.00					
07-09-2018	08:00	3.00	3.00					
07-09-2018	16:00	8.70	8.70	5.50				

Flush Information					Installation			
Top (m)	Base (m)	Flush Type	Return	Flush Colour	Top (m)	Base (m)	Type	Dia (mm)
					0.00	1.00	PLAIN	
					1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
6.49			0		Monitored water level on 19/10/2018

Fracture spacing reported in mm as min, Average and Max values. TCR, SCR and RQD reported in %

	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH5**
	Contract Number: CCG-C-18-10350	Date Started: 29-08-2018	Logged By: DO	Checked By: CB	Status: FINAL
Cable Percussion Borehole Log	Easting: 333433.0	Northing: 391268.0	Ground Level: 8.15mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD
					Sheet 1 of 3
					Scale: 1:50

Weather: | Termination: | SPT Hammer: N/R, Energy Ratio: N/R

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
						Brown slightly silty sandy GRAVEL. High cobble and boulder content. Gravel is fine to coarse angular brick and concrete with inclusions of metal and timber (MADE GROUND)		
0.50	B							
1.00	B	SPT(S)N=18 (1,3/3,4,5,6)						
1.50	B							
		SPT(S)N=28 (2,5/7,8,7,6)		(4.00)				
2.50	B							
		SPT(S)50 (25 for 70mm/50 for 40mm)					▼	
3.50	B							
		SPT(S)N=8 (1,0/1,2,2,3)	4.15	4.00		Brown slightly silty SAND and GRAVEL. Gravel is fine to coarse angular brick, concrete and wood (MADE GROUND)		
5.00	B	SPT(S)50 (25 for 45mm/50 for 30mm)						
6.00	B							
		SPT(S)50 (25 for 60mm/50 for 40mm)						
				(8.50)				
7.50	B							
		SPT(S)N=20 (2,4/4,5,6,5)						
9.00	B							
		SPT(S)N=31 (1,4/5,8,9,9)						
						Continued next sheet		

Start & End of Shift Observations

Date	Time	Depth (m)	Casing (m)	Water (m)
29-08-2018	16:00	5.00	5.00	4.70
31-08-2018	08:00	5.00	5.00	4.70
31-08-2018	16:00	11.00	11.00	9.50
03-09-2018	08:00	11.00	11.00	4.50
03-09-2018	16:00	17.00	17.00	10.00

Chiselling

From (m)	To (m)	Duration	Remarks
5.00	6.50	01:30	
15.00	17.00	02:00	
18.30	18.80	01:30	

Borehole Diameter

Depth (m)	Dia (mm)

Casing Diameter

Depth (m)	Dia (mm)

Installation

Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
3.20			0		Monitored water level on 19/10/2018

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH5**
Contract Number: CCG-C-18-10350	Date Started: 29-08-2018	Logged By: DO	Checked By: CB	Status: FINAL
Cable Percussion Borehole Log	Easting: 333433.0	Northing: 391268.0	Ground Level: 8.15mAOD	Plant Used: Dando 150 S/A Rig
Rig Crew: KM/JD	Scale: 1:50	Sheet 2 of 3		
Weather:	Termination:	SPT Hammer: N/R, Energy Ratio: N/R		

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
						Brown slightly silty SAND and GRAVEL. Gravel is fine to coarse angular brick, concrete and wood (MADE GROUND)		
10.50	B							
		SPT(S)50 (3,5/50 for 140mm)						
12.00	B							
		SPT(S)N=23 (2,4/4,5,7,7)	-4.35	12.50		Brown slightly silty SAND and GRAVEL with frequent pockets of clay. Gravel is fine to coarse angular brick, concrete and wood (MADE GROUND)		
13.50	B							
		SPT(S)N=50 (3,10/50 for 245mm)						
15.00	B			(5.80)				
		SPT(S)50 (25 for 30mm/50 for 20mm)						
16.50	B							
		SPT(S)50 (1,4/50 for 160mm)						
18.00	B							
			-10.15	18.30		Grey CONCRETE. Aggregate: 2-70mm (rounded gravels of granite and limestone). No rebar. Voidage: 13%		
18.30 - 19.80	91			(3.00)		*CONCRETE COMPRESSIVE STRENGTH TEST = 29.90mPa - 19.00mbgl*		
	TCR	SCR	RQD	Fracture	Water			
						Continued next sheet		

Start & End of Shift Observations

Date	Time	Depth (m)	Casing (m)	Water (m)
29-08-2018	16:00	5.00	5.00	4.70
31-08-2018	08:00	5.00	5.00	4.70
31-08-2018	16:00	11.00	11.00	9.50
03-09-2018	08:00	11.00	11.00	4.50
03-09-2018	16:00	17.00	17.00	10.00

Borehole Diameter

Depth (m)	Dia (mm)

Casing Diameter

Depth (m)	Dia (mm)

Chiselling

From (m)	To (m)	Duration	Remarks
5.00	6.50	01:30	
15.00	17.00	02:00	
18.30	18.80	01:30	

Installation

Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
3.20			0		Monitored water level on 19/10/2018

Contract Name: West Waterloo Dock, Liverpool			Client: Romal Capital		Borehole ID: **BH5**
Contract Number: CCG-C-18-10350	Date Started: 29-08-2018	Loggged By: DO	Checked By: CB	Status: FINAL	Sheet 3 of 3
Rotary Core Drilling Log	Easting: 333433.0	Northing: 391268.0	Ground Level: 8.15mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD	Scale: 1:50
Weather:	Termination:		SPT Hammer: N/R, Energy Ratio: N/R		

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	TCR	SCR	RQD	Fracture Spacing	Water Added	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
19.80 - 21.30	93								Grey CONCRETE. Aggregate: 2-70mm (rounded gravels of granite and limestone). No rebar. Voidage: 13%		
						-13.15	21.30				
21.30 - 23.30	95	76	50	20 114 75					Weak reddish brown occasionally grey fine to medium grained thickly laminated SANDSTONE. Slightly weathered. Discontinuities are very close to medium spaced, horizontal, clean, rough and tight to open with occasional drilling-induced sub-vertical fractures *WEAK - PL = 14.08mPa - 21.60mbgl*		
									NON-INTACT. RECOVERED AS SLIGHTLY SANDY GRAVEL - 22.90-23.18mbgl		
23.30 - 26.30	100	95	68	11 119 560			(5.00)		*WEAK - UCS = 9.70mPa - 23.60mbgl* *WEAK - PL = 17.11mPa - 25.65mbgl*		
						-18.15	26.30		End of Borehole at 26.30m		

Start & End of Shift Observations				
Date	Time	Depth (m)	Casing (m)	Water (m)
29-08-2018	16:00	5.00	5.00	4.70
31-08-2018	08:00	5.00	5.00	4.70
31-08-2018	16:00	11.00	11.00	9.50
03-09-2018	08:00	11.00	11.00	4.50
03-09-2018	16:00	17.00	17.00	10.00

Borehole Diameter		Casing Diameter	
Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Flush Information				
Top (m)	Base (m)	Flush Type	Return	Flush Colour

Installation			
Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
3.20			0		Monitored water level on 19/10/2018

Fracture spacing reported in mm as min, Average and Max values. TCR, SCR and RQD reported in %

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital			Borehole ID: **BH6**
Contract Number: CCG-C-18-10350	Date Started: 04-09-2018	Logged By: DO	Checked By: CB	Status: FINAL	Sheet 1 of 3
Cable Percussion Borehole Log	Easting: 333444.0	Northing: 391196.0	Ground Level: 8.01mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD	Scale: 1:50
Weather:	Termination:	SPT Hammer: N/R, Energy Ratio: N/R			

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
			7.91	0.10		CONCRETE		
			7.81	0.20		Brown slightly silty sandy GRAVEL (MADE GROUND)		
0.50	B					Brown slightly silty sandy GRAVEL. Gravel is fine to coarse angular brick and ash (MADE GROUND)		
1.00	B							
		SPT(S)N=17 (1,2/2,3,5,7)		(1.80)				
1.50	B							
		SPT(S)N=11 (2,2/3,3,3,2)	6.01	2.00		Brown/black slightly sandy slightly gravelly silty CLAY (MADE GROUND)		
2.50	B							
		SPT(S)N=13 (1,2/3,3,3,4)		(2.00)				
3.50	B							
		SPT(S)N=31 (2,5/6,6,9,10)	4.01	4.00		Brown slightly silty SAND and GRAVEL. Gravel is fine to coarse angular brick and concrete (MADE GROUND)		
4.50	B							
		SPT(S)50 (25 for 45mm/50 for 30mm)						
6.00	B							
		SPT(S)N=28 (2,4/7,8,7,6)						
7.50	B							
		SPT(S)N=16 (1,2/2,3,5,6)						
9.00	B							
		SPT(S)N=13 (2,3/4,3,3,3)						
						Continued next sheet		

Start & End of Shift Observations

Date	Time	Depth (m)	Casing (m)	Water (m)
04-09-2018	16:00	3.00	3.00	
05-09-2018	08:00	3.00	3.00	
05-09-2018	16:00	12.50	12.50	7.00
06-09-2018	16:00	18.50	18.50	8.00

Borehole Diameter

Depth (m)	Dia (mm)

Casing Diameter

Depth (m)	Dia (mm)

Chiselling

From (m)	To (m)	Duration	Remarks
18.50	18.55	01:00	

Installation

Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
3.08			0		Monitored water level on 19/10/2018

CCG	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH6**
	Contract Number: CCG-C-18-10350	Date Started: 04-09-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 2 of 3
Cable Percussion Borehole Log	Easting: 333444.0	Northing: 391196.0	Ground Level: 8.01mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD
					Scale: 1:50

Weather: | Termination: | SPT Hammer: N/R, Energy Ratio: N/R

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
						CONTINUED BORING IN SAME STRATUM		
10.50	B	SPT(S)50 (3,9/50 for 115mm)						
12.00	B	SPT(S)50 (2,4/50 for 160mm)						
13.50	B	SPT(S)50 (7,9/50 for 75mm)		(14.50)				
15.00	B	SPT(S)N=18 (1,0/1,2,4,11)						
16.50	B	SPT(S)N=15 (2,4/4,5,3,3)						
17.50	B	SPT(S)50 (25 for 10mm/50 for 0mm)						
			-10.49	18.50				
18.50 - 19.10			-10.56	18.57 (0.44)		BRICK CONCRETE. AGGREGATE = 2-30mm. NO REBAR		
			-11.00	19.01		CONCRETE WITH METAL INCLUSIONS (ROTARY OPEN HOLE DRILLING)		
	TCR	SCR RQD Fracture Water				Continued next sheet		

10 11 12 13 14 15 16 17 18 19

Start & End of Shift Observations

Date	Time	Depth (m)	Casing (m)	Water (m)
04-09-2018	16:00	3.00	3.00	
05-09-2018	08:00	3.00	3.00	
05-09-2018	16:00	12.50	12.50	7.00
06-09-2018	16:00	18.50	18.50	8.00

Borehole Diameter

Depth (m)	Dia (mm)

Casing Diameter

Depth (m)	Dia (mm)

Chiselling

From (m)	To (m)	Duration	Remarks
18.50	18.55	01:00	

Installation

Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
3.08			0		Monitored water level on 19/10/2018

Contract Name: West Waterloo Dock, Liverpool			Client: Romal Capital		Borehole ID: **BH6**
Contract Number: CCG-C-18-10350	Date Started: 04-09-2018	Loggged By: DO	Checked By: CB	Status: FINAL	Sheet 3 of 3
Rotary Core Drilling Log	Easting: 333444.0	Northing: 391196.0	Ground Level: 8.01mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: KM/JD	Scale: 1:50
Weather:		Termination:		SPT Hammer: N/R, Energy Ratio: N/R	

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	TCR	SCR	RQD	Fracture Spacing	Water Added	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
							(1.59)		CONCRETE WITH METAL INCLUSIONS (ROTARY OPEN HOLE DRILLING)		
20.60 - 22.10	96	83	73	53 117 231		-12.59	20.60		Weak reddish brown occasionally brown fine to medium grained occasionally thinly laminated SANDSTONE. Moderately weathered. Recovered locally as gravel. Discontinuities are very close to medium spaced, horizontal, clean, rough and tight to open with occasional drilling-induced vertical fractures *WEAK - UCS = 11.40mPa - 21.30mbgl* *NO RECOVERY - 22.04-22.10mbgl* *WEAK - PL = 13.44mPa - 22.40mbgl*		
22.10 - 23.60	92	88	66	90 173 390					*NO RECOVERY - 23.48-23.60mbgl*		
23.60 - 25.10	100	33	20	30 110 152 198			(6.00)		*NON-INTACT. RECOVERED AS GRAVEL - 23.60-23.92mbgl* *NON-INTACT. RECOVERED AS GRAVEL - 24.16-24.78mbgl* *WEAK - PL = 7.02mPa - 24.90mbgl*		
25.10 - 26.60	100	45	45	40					*NON-INTACT. RECOVERED AS SLIGHTLY SANDY GRAVEL - 25.69-26.35mbgl* *WEAK - PL = 10.71mPa - 26.30mbgl*		
						-18.59	26.60		End of Borehole at 26.60m		

Start & End of Shift Observations				
Date	Time	Depth (m)	Casing (m)	Water (m)
04-09-2018	16:00	3.00	3.00	
05-09-2018	08:00	3.00	3.00	
05-09-2018	16:00	12.50	12.50	7.00
06-09-2018	16:00	18.50	18.50	8.00

Borehole Diameter		Casing Diameter	
Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Flush Information				
Top (m)	Base (m)	Flush Type	Return	Flush Colour

Installation			
Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
3.08			0		Monitored water level on 19/10/2018

Fracture spacing reported in mm as min, Average and Max values. TCR, SCR and RQD reported in %

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH7**
Contract Number: CCG-C-18-10350	Date Started: 15-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
Cable Percussion Borehole Log	Easting: 333448.6	Northing: 391245.2	Ground Level: 8.12mAOD	Plant Used: Dando 150 S/A Rig
Rig Crew: SG/GM CB/IO	Scale: 1:50	Sheet 1 of 3		
Weather:	Termination:			

Samples & In Situ Testing			Strata Details				Groundwater	
Depth	Sample ID	Test Result	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
			7.82	(0.30) 0.30		CONCRETE		
				(2.50)		Brown slightly silty SAND and GRAVEL. Gravel is fine to coarse angular brick and concrete with inclusions of wood (MADE GROUND)		
2.80	B		5.32	2.80		Black slightly silty SAND and GRAVEL (MADE GROUND)		
6.00	B			(9.50)				
9.00	B							
						Continued next sheet		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Chiselling			
From (m)	To (m)	Duration	Remarks

Installation			
Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
2.65			0		Monitored water level on 19/10/2018
3.00			0		Seepage

	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH7**
	Contract Number: CCG-C-18-10350	Date Started: 15-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
Cable Percussion Borehole Log	Easting: 333448.6	Northing: 391245.2	Ground Level: 8.12mAOD	Plant Used: Dando 150 S/A Rig	Rig Crew: SG/GM CB/IO
					Sheet 2 of 3
					Scale: 1:50
Weather:		Termination:			

Samples & In Situ Testing							Strata Details				Groundwater	
Depth	Sample ID	Test Result	TCR	SCR	RQD	Fracture	Water	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
											Black slightly silty SAND and GRAVEL (MADE GROUND)		
12.00	B							-4.18	12.30				
											CONCRETE		
									(3.30)				
								-7.48	15.60				
15.60 - 17.10	99	81	55	60 113 140							Reddish brown occasionally grey fine to medium grained occasionally thinly laminated SANDSTONE. Slightly weathered. Discontinuities are extremely close to medium spaced, horizontal, clean, rough and tight to open WEAK - PL = 8.63mPa - 15.80mbgl NON-INTACT. RECOVERED AS GRAVEL - 16.62-16.88mbgl		
17.10 - 18.60	86	54	12	38 12 51 181 31					(6.00)		NON-INTACT. RECOVERED AS GRAVEL - 17.26-17.54mbgl WEAK - PL = 6.34mPa - 17.30mbgl NON-INTACT. RECOVERED AS GRAVEL - 18.05-18.18mbgl NO RECOVERY - 18.39-18.60mbgl		
18.60 - 20.10	95	91	86										
											Continued next sheet		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Chiselling			
From (m)	To (m)	Duration	Remarks

Installation			
Top (m)	Base (m)	Type	Dia (mm)
0.00	1.00	PLAIN	
1.00	7.00	SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
2.65			0		Monitored water level on 19/10/2018
3.00			0		Seepage

Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Borehole ID: **BH7**
Contract Number: CCG-C-18-10350	Date Started: 15-10-2018	Loggged By: DO	Checked By: CB	Status: FINAL
Rotary Core Drilling Log	Easting: 333448.6	Northing: 391245.2	Ground Level: 8.12mAOD	Plant Used: Dando 150 S/A Rig
Rig Crew: SG/GM CB/IO	Scale: 1:50	Sheet 3 of 3		
Weather:	Termination:			

Samples & In Situ Testing						Strata Details				Groundwater	
Depth	TCR	SCR	RQD	Fracture Spacing	Water Added	Level (mAOD)	Depth (m) (Thickness)	Legend	Strata Description	Water Strike	Backfill/ Installation
20.10 - 21.60	99	99	44	40 136 251					WEAK - UCS = 10.10mPa - 19.80mbgl WEAK - PL = 18..50mPa - 21.50mbgl		
						-13.48	21.60		End of Borehole at 21.60m		

Start & End of Shift Observations					Borehole Diameter		Casing Diameter	
Date	Time	Depth (m)	Casing (m)	Water (m)	Depth (m)	Dia (mm)	Depth (m)	Dia (mm)

Flush Information					Installation			
Top (m)	Base (m)	Flush Type	Return	Flush Colour	Top (m)	Base (m)	Type	Dia (mm)
					0.00 1.00	1.00 7.00	PLAIN SLOTTED	

Remarks:

1 hour hand excavating 1.20mbgl service avoidance pit
PL = Point Load

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
2.65			0		Monitored water level on 19/10/2018
3.00			0		Seepage

Fracture spacing reported in mm as min, Average and Max values. TCR, SCR and RQD reported in %

APPENDIX F

TRIAL PIT LOGS & PHOTOGRAPHS

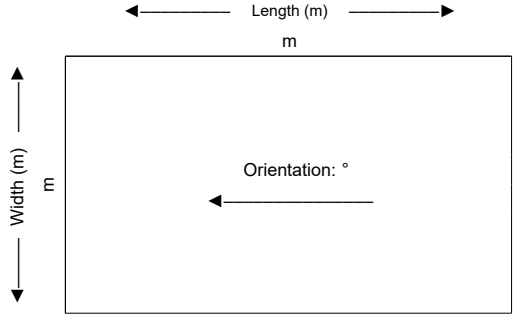
	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP1
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 1 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
0.50	B					Brown slightly silty sandy GRAVEL. High cobble and boulder content. Gravel is fine to coarse angular brick and concrete with inclusions of metal and timber (MADE GROUND)		
1.50	B							
2.50	B							
3.50	B							
						Continued in same stratum		

1
2
3

Dimensions:

Final Depth: 5.20m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

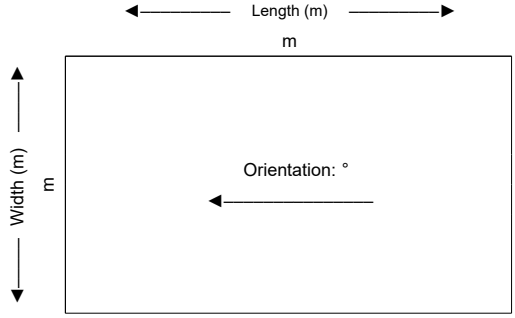
	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP1
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 2 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
4.50	B			5.20		End of Trial Pit at 5.20m		

4
5
6
7

Dimensions:

Final Depth: 5.20m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

CC GEOTECHNICAL LTD

Unit 1
Deltic Way
Knowsley Industrial Estate
Merseyside
L33 7BA
e: enquiries@ccgeotechnical.co.uk
w: www.ccgeotechnical.co.uk

Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Trial Pit Number:	TP1
Plate Number:	1

CC GEOTECHNICAL LTD

Unit 1
Deltic Way
Knowsley Industrial Estate
Merseyside
L33 7BA
e: enquiries@ccgeotechnical.co.uk
w: www.ccgeotechnical.co.uk

Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Trial Pit Number:	TP1
Plate Number:	2

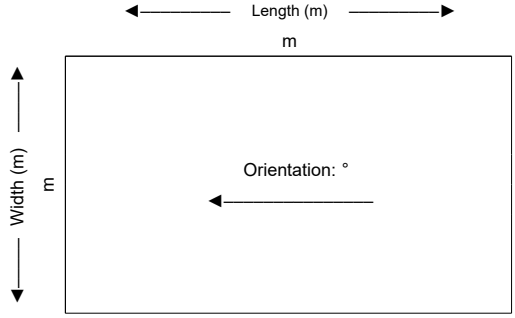
	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP2
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 1 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details					
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description	Water	Backfill
0.50	B			(1.20)		Brown silty clayey gravelly cobbly SAND. Gravel is fine to coarse angular brick and concrete with inclusions of plastic (MADE GROUND)		
				1.20		Brown silty sandy gravelly CLAY. Gravel is fine to coarse angular brick (MADE GROUND)		
1.50	B			(0.80)				
				2.00		Black organic silty sandy gravelly CLAY with inclusions of plastic, bags and metal pipes Medium cobble content (MADE GROUND)		
2.50	B							
3.50	B							
						Continued in same stratum		

1 2 3

Dimensions:

Final Depth: 4.80m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
4.00			0		Water entry

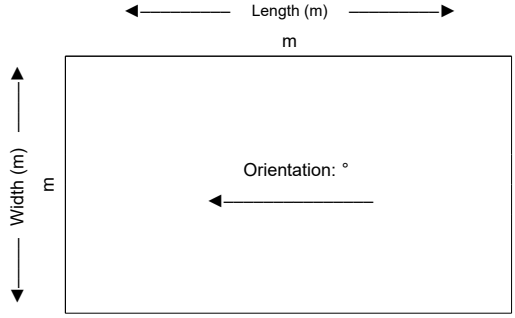
Contract Name: West Waterloo Dock, Liverpool			Client: Romal Capital		Trial Pit ID: TP2
Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL	Sheet 2 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018	Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
4.50	B			4.80		CONCRETE BOULDERS End of Trial Pit at 4.80m		

4
5
6
7

Dimensions:

Final Depth: 4.80m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

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Job Number:	CCG-C-18-10350
Trial Pit Number:	TP2
Plate Number:	1

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Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Trial Pit Number:	TP2
Plate Number:	2

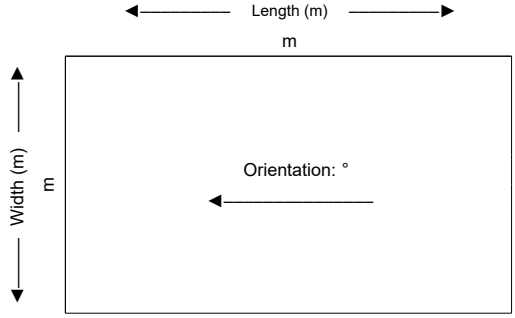
	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP3
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 1 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
0.50	B			(1.30)		Dark brown silty gravelly cobbly SAND. Low boulder content. Gravel is fine to coarse angular brick and concrete (MADE GROUND)		
				1.30		Light brown silty gravelly CLAY (MADE GROUND)		
1.50	B			(1.20)				
2.50	B			2.50		Black silty slightly clayey gravelly cobbly SAND. Gravel is fine to coarse angular brick with inclusions of bags and metal pipes (MADE GROUND)		
3.50	B							
						Continued in same stratum		

1 2 3

Dimensions:

Final Depth: 4.50m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks
3.00			0		Water entry

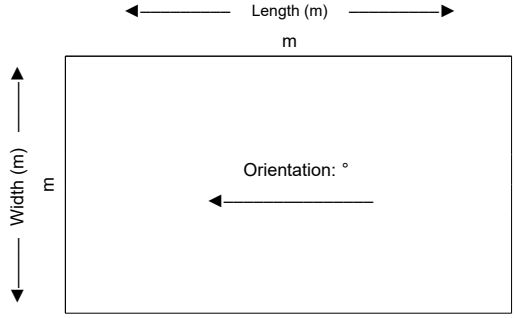
	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP3
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 2 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
4.50	B			4.50		End of Trial Pit at 4.50m		

4
5
6
7

Dimensions:

Final Depth: 4.50m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

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Trial Pit Number:	TP3
Plate Number:	1

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Job Number:	CCG-C-18-10350
Trial Pit Number:	TP3
Plate Number:	2

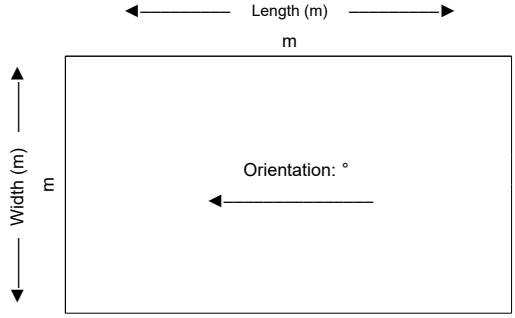
	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP4
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 1 of 1
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
1.00	B			(2.80)		Brown slightly silty sandy GRAVELS and COBBLES. Gravel is fine to coarse angular brick, sandstone and concrete (MADE GROUND)		
2.00	B							
				2.80		CONCRETE		
				2.85		End of Trial Pit at 2.85m		

1
2
3

Dimensions:

Final Depth: 2.85m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

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Job Number:	CCG-C-18-10350
Trial Pit Number:	TP4
Plate Number:	1

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Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Trial Pit Number:	TP4
Plate Number:	2

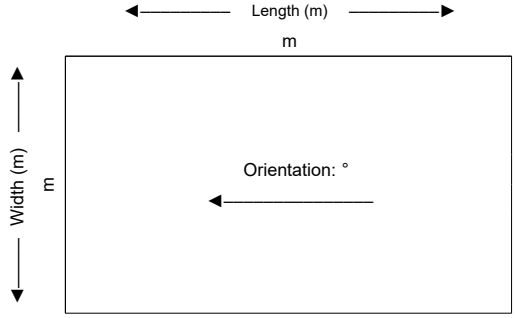
	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP5
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 1 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
				0.10		CONCRETE		
						Brown slightly silty sandy GRAVELS and COBBLES. Gravel is fine to coarse angular brick, sandstone and concrete (MADE GROUND)		
1.50	B							
2.50	B							
						Continued in same stratum		

1 2 3

Dimensions:

Final Depth: 4.00m



Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

	Contract Name: West Waterloo Dock, Liverpool		Client: Romal Capital		Trial Pit ID: TP5
	Contract Number: CCG-C-18-10350	Date Started: 12-10-2018	Logged By: DO	Checked By: CB	Status: FINAL
					Sheet 2 of 2
Trial Pit Log	Easting:	Northing:	Ground Level:	Plant Used: 13T Excavator	Date Printed: 31-10-2018
					Scale: 1:25
Weather:		Hole Termination:		Stability:	

Samples & In Situ Testing			Strata Details				Water	Backfill
Depths	Sample ID	Test Result	Reduced Level	Depth (m) (Thickness)	Legend	Strata Description		
				4.00		End of Trial Pit at 4.00m		

4
5
6
7

Dimensions:

Final Depth: 4.00m

Length (m)

m

Width (m)

m

Orientation: °

Inclination: °

General Remarks:

Water Strikes

Strike (m)	Casing (m)	Sealed (m)	Time (mins)	Rose to (m)	Remarks

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Trial Pit Number:	TP5
Plate Number:	1

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Site	CO2, West Waterloo Dock, Liverpool
Job Number:	CCG-C-18-10350
Trial Pit Number:	TP5
Plate Number:	2