10. Ground Conditions

Appendix 10.1

DESK STUDY REPORT – ES-BHE-ZA-LXX-RP-CG-0001

EXPLOSIVE ORDNANCE (EO) THREAT ASSESSMENT

BUROHAPPOLD ENGINEERING

The People's Project

Desk Study Report

0040026

23 December 2019

Revision P05

BMD01-BHE-ZX-XX-RP-CG-0001

Revision	Description	Issued by	Date	Checked
P01	RIBA Stage 1 + for information	JR	19/07/17	NP
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Author	**Nina Sopp**
Signature	
Date	**23/12/19**
Approved	**Jonathan Rowe**
Signature	
Date	**23/12/19**

Contents

1 Introduction

1.1 General

On instruction from Everton Stadium Development Limited, BuroHappold has carried out a geoenvironmental and geotechnical desk study at Bramley-Moore Dock (BMD) to inform a full planning application for a new stadium with associated facilities and infrastructure.

This Desk Study was originally published in July 2017 to support RIBA Stage 1+. It has since been updated to consider the finalised scheme for the proposed development but does not reflect that ground investigations and further surveys have been undertaken or include their results.

The study objective and information sources are summarised below.

1.2 Study Aim and Objectives

The aim of this Desk Study is to characterise the ground conditions at the application site in relation to geotechnical and geoenvironmental parameters that can be ascertained at this stage. The report has the following objectives:

- Determine the current and historical use of the site and its surroundings;
- Determine the nature of the ground conditions and the environmental sensitivity of the site;
- Assess the potential location, nature and extent of any ground and groundwater contamination;
- Assess the potential risks to people and the environment (natural and built) associated with ground contamination both in the existing site condition and for possible future use;
- Construct an Initial Conceptual Site Model and carry out a Preliminary Risk Assessment, in general accordance with the EA / DEFRA Model Procedures for the management of land contamination, 2004 (CLR11) [1];
- To prepare a report based upon all of the above suitable to support a full planning application in accordance with NPPF [2].
- To determine the status of the Site with respect to Part 2a of the Environmental Protection Act 1990 [3];
- Assess the geotechnical risks associated with the proposed development; and
- Where appropriate, suggest possible solutions to the identified potential geotechnical risks.

1.3 Information Sources

The principal sources of information for this Desk Study include:

- Historical and current topographic maps and reports;
- Public register information (in the form of a GroundSure report- Appendix A-C);
- BGS borehole/trial pit logs (Appendix D) and online Geology of Britain viewer [4];
- Geological maps [5] [6];
- Detailed UXO Desk top study (Appendix E);
- A feasibility report produced by BuroHappold, 2016 [7];

- Site walkovers conducted in 2016 and 2017 by BuroHappold (photographs in Appendix F) and interviews with site workers who provided anecdotal information; and
- Historical dock drawings held by Curtins Consultants.

This report is based upon information obtained from third party sources. The third party data has been accepted at face value and has not been independently verified. BuroHappold can therefore give no warranty, representation or assurance as to the accuracy or completeness of such information.

1.4 Planning Policy Framework / Statutory Legislation

Section 38(6) of the Planning and Compulsory Purchase Act 2004 and Section 70(2) of the Town & Country Planning Act 1990 requires planning applications should be determined in accordance with the statutory development plan, unless material considerations indicate otherwise.

The statutory development plan for the City of Liverpool currently comprises:

- Unitary Development Plan (adopted 2002); and
- Merseyside and Halton Joint Waste Local Plan (adopted July 2013).

A summary of the statutory development plan policies relevant to the application proposal and specifically matters relating to ground conditions are summarised below.

The following policies and guidance are material considerations which also inform the assessment:

- Liverpool Local Plan (Submission Draft, May 2018);
- National Planning Policy Framework (March 2012, updated in 2019); and
- Planning advice note for developers on developing on contaminated land.

1.4.1 Statutory Development Plan

1.4.1.1 Liverpool Unitary Development Plan (UDP)

The key policies within the adopted UDP are as follows:

- **Policy EP1 (Vacant, Derelict and Neglected Land)** promotes and encourages the reclamation of derelict land and the restoration of neglected land and encourages the development of these for other appropriate uses. In determining priorities for derelict land, particular attention will be given to:
    - The contribution the reclamation of the site would make to achieving the aims of urban regeneration and to aiding the implementation of policies in this Plan
    - The need to facilitate inward investment opportunities and create jobs
    - The degree of contamination, dereliction or danger posed by the site; and
    - The need to integrate with, and support, other regeneration initiatives and agencies in order to maximise the benefits of reclamation.

- **Policy EP2 (Contaminated Land)** before determining any application for planning consent on land which the City Council considers is seriously contaminated, the Council will require the applicant: to submit details of a site survey identifying the type, degree and extent of any contamination; and submit details to the City Council of specific remedial measures required to deal satisfactorily with any hazard, together with the proposed timescale for the implementation of the measures. Planning permission will only be granted prior to a full site investigation, where the Council considers that any known or suspected contamination is unlikely to adversely affect the proposed redevelopment. This permission may be subject to conditions requiring a site investigation together with the remediation of any contamination.
- **Policy EP3 (Landfill Gas)** planning permission will not be granted for development on former landfill sites, or within 250m of current or former landfill sites, unless the applicant can clearly demonstrate that there is no risk from the generation or migration of landfill gas, or that satisfactory measures can be taken to counter any possible hazard.
- **Policy EP12 (Protection of Water Resources)** planning permission will not be granted for development which, in the opinion of the City Council following consultation with the Environment Agency, would adversely affect the quality or supply of surface water or groundwater as a result of: the nature of the surface or waste water discharge; unsatisfactory arrangements for the disposal of foul sewage, trade effluent of surface water; the disturbance of contaminated land; or the spillage or leakage of stored oil or chemicals.

1.4.2 Material Considerations

1.4.2.1 Emerging Local Plan (Submission Draft May 2018)

A new local plan is presently awaiting formal public examination and when ultimately adopted will replace the Unitary Development Plan (UDP). In accordance with NPPF para. 48, the current submission draft has substantive but not full weight in decision-taking given that whilst it has been submitted for examination it is not clear at present as to the extent to which there are 'unresolved' objections to the overarching plan strategy or individual policies (whether allocations or development management policies).

The relevant policy for ground conditions is set out in part a of Policy STP2 -*Sustainable Growth Principles and Managing Environmental Impacts* which states that as a priority, new development should be located on previously developed land and/or re-use an existing building; seek to use secondary materials such as recycled aggregates; and where appropriate aim to secure the remediation of contaminated sites.

1.4.2.2 National Planning Policy Framework (NPPF, February 2019)

Paragraph 170 details that planning decisions should contribute to and enhance the natural and local environment by, amongst others:

- Clause E - prevent new development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil pollution or land instability; and
- Clause F - remediate degraded, derelict, contaminated and unstable land where appropriate.

Paragraph 178 thereafter details that in relation ground conditions and pollution, planning decisions should ensure that:

A. A site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation).
B. After remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990; and

C. Adequate site investigation information, prepared by a competent person, is available to inform these assessments.

Paragraph 179 ultimately draws the policy guidance together detailing that where a site is affected by contamination or land stability issues, responsibility for securing a safe development rests with the developer and/or landowner.

1.4.2.3 Planning advice note for developers on developing on contaminated land

The guide, produced by Liverpool City Council Environmental Protection Unit (EPU), comprises general advice to developers and requirements for planning application submissions on potentially-contaminated land. The note details that sufficient investigatory works should be undertaken for the purposes of assessing all 'site-specific' risks posed at, and from, a proposed development site.

2 The Site

2.1 Site Location

The application site which extends to 8.67 hectares, comprises BMD, on the River Mersey (centred on National Grid Reference (NGR) SJ3345292491).

A site location plan is shown in Figure 2-1. The application site redline boundary is shown in Figure 2-2.

To the north of BMD is Wellington Dock, which has been infilled and houses the United Utilities Wastewater Treatment Works (UU WwTW) (Planning Ref: 11F/1581, approved 12/01/2012), whilst to the northwest lies Sandon Half-Tide Dock, which remains connected to BMD via a pair of dock gates. Sandon Half-Tide Dock lies within the operational port.

Figure 2-1- Location of Bramley-Moore Dock. [8]

To the east of BMD, on the opposite side of Regent Road, lies a timber retailer, tyre retailer, and offices/residential uses. There is a public house, The Bramley Moore, across Regent Road from the southeast corner of the site.

To the south lies Nelson Dock, the connective dock gate to which is sealed with hydraulic connectivity maintained via pipe works/sluice gates. The dock comprises hard-standing to the perimeter of the dock water body and existing surface water drainage discharges into the River Mersey.

The western boundary of the site is the elevated River Mersey (sea / crown) wall, which forms a flood defence to the site.

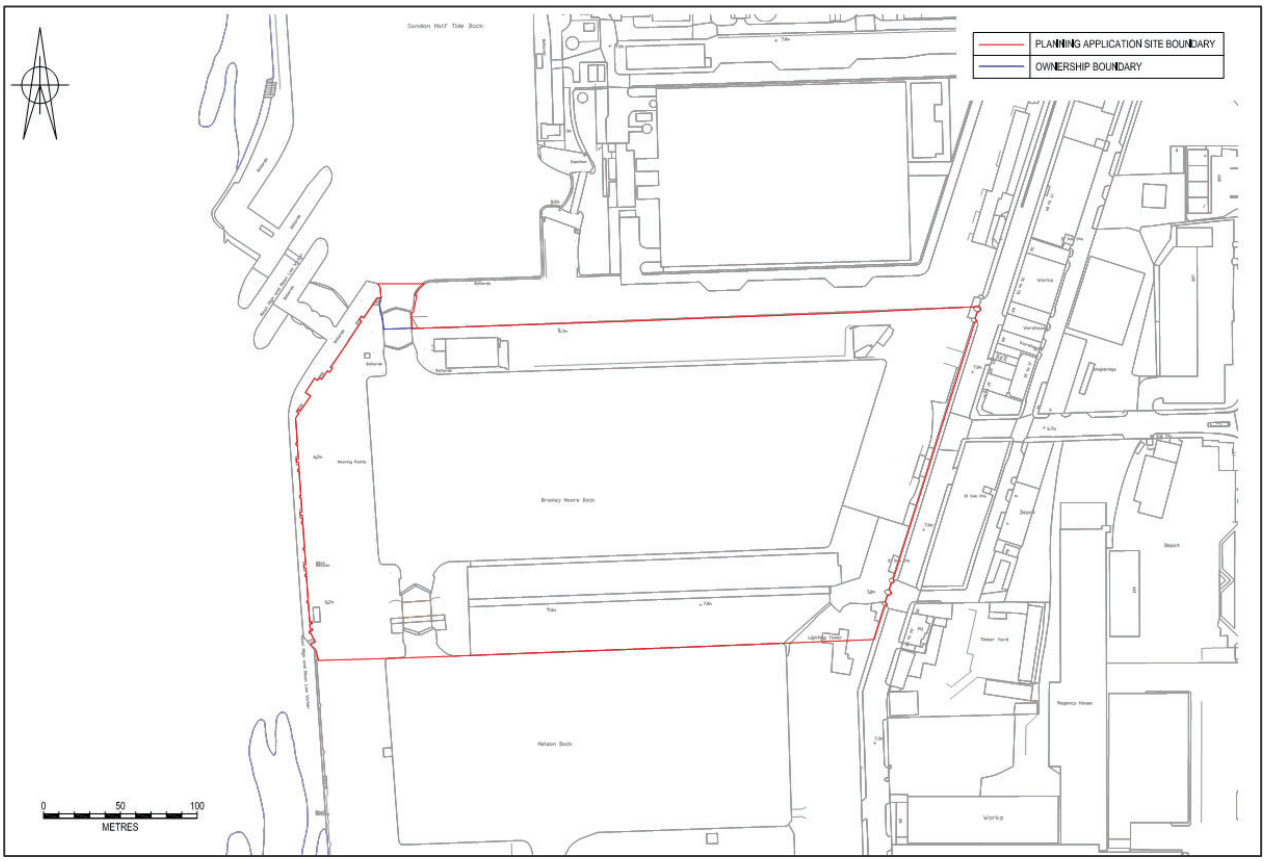

Figure 2-2 - Red line boundary of Bramley-Moore Dock

2.2 Current Site Condition and Current Site Activities

The site was previously used for aggregate storage and distribution (east and north wharves), operated by Mersey Sands. However, the lease for this use expired in August 2019. The site remains occupied by Svitzer, which operates their tug boat services and Cataclean (southern wharf), until the respective leases expire in December 2019. Aside from the ongoing operations a large part of the site is semi-derelict.

The western wharf is not occupied. Two historical outhouse structures are located on the wharf, one with a disused electricity substation inside.

Site walkover photos taken by BuroHappold in 2017 are included in Appendix F.

2.3 Proposed Development

A detailed description of development is provided in the wider planning application submission (Planning Statement, Environmental Statement etc.). However, in summary, the application proposes:

- Demolition of non-listed structures; part-demolition of listed structures (Regent Road wall); remediation; infill of BMD; engineering works; and alterations to the dock walls to accommodate the development of a 52,888 seated capacity stadium (Use Class D2) with vehicle parking (external at grade and multi-storey parking).
- Creation of a water channel (with hydraulic connectivity to Nelson Dock), new dock isolation structure at northern site boundary (to replicate existing structure at southern boundary), vehicular and pedestrian access, and hard / soft landscaping (including lighting, public art and boundary treatments).

- Proposed change of use of the Grade II listed Hydraulic Tower structure to an exhibition/cultural centre (Use Class D1) with ancillary cafe (works to the tower to be subject to separate listed building consent submissions).

The finishes of the proposed development are mostly hard landscaping with very limited areas of direct in-ground planting, see drawings BMD01-PLA-L1-00-DR-L-2000 and BMD01-PLA-L1-00-DR-L-0001 in Appendix G.

The proposed new water channel will provide hydraulic connectivity between Sandon Half-Tide Dock and Nelson Dock. This will be a non-navigable channel with isolation structures at its northern and southern ends. The isolation structure at the southern end is existing whilst the northern isolation structure is proposed to be constructed between BMD and Sandon Half-Tide Dock. Eight pipes will be cast in between the two sheet piles at identical levels to the existing southern isolation structure to enable the exchange of dock water to the north and south.

The water channel bed is designed to be 0.5m below the bottom of the pipes to ensure any silt build up does not restrict the flow of dock water through the pipes. A summary of the construction sequence is provided below for general information:

- Northern isolation structure constructed with culverts temporarily capped;
- BMD basin infilled followed by stadium construction;
- New retaining wall installed through dock infill to form the eastern edge of the new water channel;
- Infill material excavated to form the new water channel; and
- Northern isolation structure culverts opened to provide hydraulic connectively between north and south.

2.4 Site History

2.4.1 Historical maps

The history of the application site has been determined from available historic Ordnance Survey maps (Appendix A) from 1851 to 2014. The history is summarised in Table 2-1.

Table 2-1 - Summary of site history and of surrounding area from historic maps

Date	On Site History	History of the Surrounding Area
1851 (1:10,560)	Bramley-Moore Dock is present, with shed structures located on the north, south and west wharfs. Rail sidings are present on the eastern side.	Bramley-Moore Dock is part of the Port of Liverpool system. To the north is Wellington Dock and the Wellington Half Tide Dock, and to the south is Nelson Dock. Rail sidings lead from wider Liverpool to the various docks. Southeast of the site is North Shore Mill and North Docks Station, labelled as 'Goods'. To the east are numerous unlabelled buildings.
1890 (1:10,560)	One of the shed structures on the north wharf has been removed and is replaced by rail sidings	Expansion of shed structures on the north wharf of Wellington Dock. Minor changes to unlabelled buildings located to the east.
1893 (1:2500)	Rail sidings located on the north wharf and eastern perimeter are labelled as the 'High Level Coal Railway'. Two small unlabelled buildings are present in the northeast corner of the site, thought to comprise the Hydraulic Engine House.	Buildings to the east are labelled to be hotels, public houses, an engine works, a foundry and a cattle shed. No discernible changes to the surrounding docks.
1906-1907 (1:10,560)	Rail sidings have extended onto the south wharf.	The layout of Wellington Half Tide Dock has changed, and is renamed as Sandon Half-Tide Dock. A Goods Station is present to the northeast.
1908 (1:2500)	No discernible change.	Foundry to the east is no longer present.

Date	On Site History	History of the Surrounding Area
1909 (1:10,560)	No discernible change.	No discernible change.
1925-1927 (1:10,560)	Minor extension of rail sidings on north wharf.	No discernible change.
1927 (1:2500)	Cranes are labelled on the north wharf and east side.	Shed on north wharf of Wellington Dock is replaced with a larger structure.
1928 (1:10,560)	No discernible change.	No discernible change.
1938 (1:10,560)	No discernible change.	A Goods Station to the southeast has been removed and the land is unoccupied.
1954 (1:2500)	Rail sidings on the north wharf have been scaled back and two small buildings are in their place. Rail sidings on the eastern edge have also been scaled back and a small shed has been constructed in the available space.	North Docks Goods Yard to the southeast is replaced by a Construction Engineering Works. A number of buildings labelled on the 1927 map as the North Docks Cattle Station have been removed and the land is unoccupied.
1967 (1:2500)	The shed on the north wharf has been replaced by a larger structure. Two additional buildings are also present on the north wharf. The shed on the south wharf has been replaced by a larger structure.	The shed structure on the north and east sides of Nelson Dock have been removed, and two smaller buildings and two cranes are present in place. Castle Food Mill to southeast has been replaced by an oil refinery. A number of tanks are shown. A number of buildings to the east of site have been removed, others are now unlabelled and their uses unknown.
1973 (1:10,000)	Shed on north wharf possibly replaced by larger shed taking up the entire wharf length.	Additional shed added on north wharf of Nelson Dock.
1982 (1:10,000)	Large shed on north wharf removed and replaced by two smaller buildings. Other shed on north wharf removed.	Unlabelled buildings present on formerly unoccupied area of land to northeast.
1990 (1:10,000)	Rail sidings on north wharf and eastern perimeter removed, land remains unoccupied.	Sandon Dock has been infilled and a Waste Water Treatment Works constructed in its place. Rail sidings to the east have been removed.
2002 (1:10,000)	Three small buildings on north wharf removed.	All buildings present on perimeter of Nelson Dock have been removed. A pipeline is indicated in the southeast corner of Nelson Dock.
2010 (1:10,000)	No discernible change.	No discernible change.
2014 (1:10,000)	West wharf structure has been removed. Only shed on south wharf, hydraulic engine shed and one other building remain.	No discernible change.

2.4.2 Additional Historic Information

BMD was completed and opened in 1848 and was primarily used for exporting coal and storing coal for steamships. Since the earliest available map, the site has been in much the same configuration as exists today, except for sheds along the north and west wharves and rail tracks along the east wharf. In 1884, a Hydraulic Tower was added to the northeast corner of the dock; this was used for providing hydraulic power to operate the dock gates. By 1890, the northern shed had been replaced with further train tracks.

There was little change to the site until 1967, when the rail tracks on the north wharf were scaled back and a small structure was constructed in the northwest corner adjacent to the gate to the Sandon Half-Tide Dock to the north. By 1973, the tracks on the north wharf had been almost fully removed and another long structure put up in their place, the central portion of which had been demolished by 1982. The dock closed in 1988. The west wharf structure was removed by 2002 [7].

In recent years, the east and north wharf has been used by Mersey Sand Suppliers to stockpile material dredged from the River Mersey. BuroHappold observed these stockpiles in 2017 and 2018 to comprise medium sand, the nature of any washing or sorting of the dredged material on site is unknown. The sand has since been removed as of July / August 2019 following Mersey Sands vacating the site.

2.5 Regulatory Data

Regulatory data relating to potentially contaminative land uses on or adjacent to the site are summarised in Table 2-2. This information has been obtained from the GroundSure report (Appendix B). Other potentially contaminative uses identified in the GroundSure report are not considered to pose a risk to the site or current/future users.

Table 2-2 - Summary of Regulatory Data

Item	Approx. Location	Information	Potential to Affect Site
Railway Sidings	On Site	Records dated from 1851 to 1967.	Y
Railway Station (not shown on available maps)	On Site	Records dated from 1909 to 1938.	N
Goods Yard	Off-Site	Regulatory data indicate presence of various good yards, 57m off-site dated 1938 and 63m off-site dated from 1909 to 1938.	N
Tanks	On Site/ Off-Site	Unspecified tanks located on site, dated between 1969 and 1989. Numerous tanks located off-site, 1 within 50m dated 1927.	Y
Electricity Substation	On Site	Records dated from 1967 to 1998.	Y
Garage	Off-Site	Records dated 1953 and 1954, located 19m off-site.	N
Ship Repairing Engineering Works	Off-Site	Records dated 1953 and 1954, located 26m off-site	N
Part A(1) and IPPC Authorised Activities	Off-Site	Liverpool Waste Water Treatment Works, Sandon Dock, located 183 m off-site.	N
Red List Discharge Consents	Off-Site	Sewage discharge of final/treated effluent 83m off-site.	N
List 1 Dangerous Substance Inventory Sites	Off-Site	All Metal Plating located 83m off-site authorised to use cadmium. N & C Platers Ltd located 128m off-site.	N
Licensed Discharge Consents	Off-Site	Liverpool Waste Water Treatment Works, Sandon Dock, located 4m, 83m and 101m off-site.	N
Planning Hazardous Substance Consents	Off-Site	Warrant Distribution Ltd, located 115m off-site to store various hazardous substances.	N
Landfill Sites	Off-Site	Located at Sandon Dock, 180m off-site.	N
Waste Treatment, Transfer or Disposal Sites	Off-Site	Waste Transfer Unit, 42m off-site.	N
Current Industrial Data	On site	Electricity substation, marine equipment including boats and ships.	Y

2.6 UXO

BuroHappold commissioned a UXO assessment from PLANIT UXB (Appendix E). For the purpose of the assessment, it was assumed that works would include excavations beyond WW2 ground levels, including ground investigation, possible excavation and piled foundations. It is therefore possible that personnel or equipment could make physical contact with potential threat items during such operations.

The assessment found the following:

- The potential for larger items of explosive ordnance (British anti-aircraft artillery and German air-dropped munitions) to remain as Unexploded Bombs (UXBs) on areas around the wet docks is limited because the Site itself did not receive any direct bomb strikes. However, the same is not true for the wet docks, because bombs falling into water would have been extremely difficult to spot and may have gone unrecorded. In addition, the wet docks would have been impossible to search effectively at the time even if an UXB was suspected of landing within them. Therefore, the potential for these items to have landed within the wet docks and remain unexploded cannot be reasonably ignored.
- Recorded bomb impacts in the vicinity of Bramley-Moore Dock are shown in Figure 2-3.
- UXBs with shallow penetration depths are likely to have been previously discovered as a result of post-war redevelopment on the Site. It is therefore reasonable to discount these potential threat items. The same does not apply to the wet docks, unless dredging and/or maintenance operations have been conducted, which to date have not been made available to BuroHappold.
- It is considered that the facilities involved in the manufacture, storage, filling and testing of ordnance in Liverpool do not pose a potential threat to the Site, and the threat from WW1 unexploded ordnance is negligible.
- There is no evidence to indicate that the Site was ever used for military purposes.

PLANIT concluded that the Ordnance Threat Level varies across the Site:

- Volumes of ground within the Site that have already been subjected to extensive redevelopment involving the displacement of earth are considered to have a negligible ordnance threat level.
- Volumes of ground within the areas of the Site covered by hardstanding quays, roadways and trackways are considered to have a negligible ordnance threat level.
- The 'UXO Threat Zone' (i.e. the wet docks) is considered to have a medium ordnance threat level. The bomb penetration depth is estimated to be within a 1m safety margin of the dock's lining.

PLANIT concluded that a threat management strategy is required to be in place prior to intrusive engineering works within the UXO threat zone. Additionally, an explosive ordnance Safety Briefing should be included as part of routine site health and safety training and form a key element of the Site Health and Safety Plan.

Figure 2-3 - Excerpt from Liverpool Echo Bomb Map [9].

3 Environmental Setting

3.1 Topography

Existing ground levels within the application site typically range between 6.6m AOD (top of dock wall level) and 6.8m AOD. Along the eastern edge of the site ground levels rise gradually to meet the Regent Road level of 7.1m AOD to 7.2m AOD. The BMD walls surround the deep dock area expected to be approximately 9m deep. Recent bathymetric survey information has been made available by Peel Ports and this indicates the dock floor varies in elevation by approximately 3m. The thickness of silt and puddle clay is not known but variations in thickness of deposits in the dock probably result from ongoing usage including spills of aggregate materials during unloading operations and dock water circulation.

The bathymetric contour plot is included in Appendix H. An updated bathymetric survey is planned as part of the current design studies.

Existing water levels in the dock are understood to be in the range between 3.8m AOD and 4.6m AOD, with a mean level of 4.3m AOD. Tidal levels in the adjacent River Mersey vary from -2.0mOD to +5.5mOD.

3.2 Geology

Site geology has been determined from available British Geological Survey (BGS) maps and historic borehole records (Appendix D). BGS Sheet 96 [5] [6] and the BGS Geology of Britain viewer [4] indicate that the Site is underlain by:

- Tidal Flat Deposits over;
- Glacial Till over; and
- Sherwood Sandstone Group (Chester Formation).

Sheet 96 also indicates a nearby deposit of wind-blown sand which may be present on site. Nearby BGS archive borehole logs provide the following strata descriptions and thicknesses. Ground level has been estimated as +6.6m AOD.

Table 3-1 - Relevant BGS Borehole Detail

Stratum	Description	Thickness (m) (1)	Depth to Top (m bgl) (1)	Level of Top (m AOD) (1)
Made Ground (Demolition Rubble)	Dense to very dense, sandy (fine to coarse) angular fine to coarse GRAVEL. COBBLES of brick, concrete, pottery, ash and roof insulation.	2.4 to 3.4 (2.6)	0	+6.6
Glacial Till	Firm to stiff, brown sandy silty CLAY with a little gravel of fine and medium sandstone and siltstone.	9.2 to 9.7 (9.4)	3.3 to 4.3 (3.8)	+3.3 to +2.3 (2.8)
Chester Formation	Weak red-brown moderately-weathered fine- and medium-grained SANDSTONE	Not proven	11.5 to 13.0 (12.3)	-4.9 to -6.4 (-5.7)

(1) Values presented are the range for the strata. Average BGS borehole values shown in brackets.

The Tidal Flat Deposits indicated by BGS Sheet 96 are not indicated to be present in the available historic borehole records. It is possible that the Tidal Flat Deposits were removed when the dock was constructed. Anecdotal information from adjacent docks suggests that the docks would have been excavated to bedrock and lined with a layer of puddle clay. A layer of soft sediment is expected at the base of the dock, having settled out of the water over time. Exposed Tidal Flats of the River Mersey were observed off site (south of Nelson Dock) by BuroHappold during the 2016 and 2017 site walkover to comprise significant quantities of fine material, as expected given the depositional environment.

Demolition rubble is recorded in the BGS borehole logs and may originate from the construction of the dock area. The available borehole logs are located on the opposite side of Regent Road to Bramley-Moore Dock, however, given their proximity to the dock area, it is possible that this material is found behind part of the Bramley-Moore Dock walls.

3.3 Hydrogeology

The Tidal Flat Deposits are designated as an unproductive aquifer. The Glacial Till is a designated Secondary (undifferentiated) aquifer and the Chester Formation bedrock underlying the Site is a designated Principal aquifer [10]. These classifications can have a bearing on construction methods and the permanent structural configuration; design and construction will have to account for any existing on-site contamination and the possibility of introducing these contaminants to groundwater.

Groundwater level data is not available for the Site, however historic BuroHappold projects in central Liverpool have shown two distinct groundwater tables, one in the shallow Made Ground and one in the deep Sherwood Sandstone, both of which have been observed to be influenced by the tidal fluctuations of the River Mersey.

Figure 3-1 - River wall showing exposed Tidal Flat Deposits

Shallow groundwater conditions are likely to be complex at Bramley-Moore Dock. A seepage regime is likely to exist across the Site and will be dependent on the interactions of the River Mersey and the bodies of water held in the dock and behind the dock walls, the permeability of the dock and river walls, the permeability of backfill and the water tightness of the lock gates. Small variations in groundwater level will also be expected due to tidal variations in the level of the Mersey, but the magnitude of these changes cannot be known without monitoring data. The historic use of the Site as a dock clearly indicates that a relatively steady water level can be maintained, implying that the dock walls or more likely the surrounding geology provide a relatively impermeable barrier to changes in water level.

Available drawings do not indicate that the dock has been artificially lined to prevent egress of water, however it is understood that the adjacent Wellington Dock was lined with puddle clay.

3.4 Hydrology

The dock is situated on the east bank of the estuary of River Mersey, which flows from south to north into the Irish Sea. The Leeds and Liverpool Canal is situated approximately 500m east of the site, running approximately north-south, with an exit through Stanley, Collingwood and Salisbury Docks via a series of locks 150m to the south of the site.

From inspection of the Environment Agency's Flood Map data [11], the majority of the Site lies within Flood Zone 1, which is defined as having a low risk of flooding. The western edge of the Site is situated within a Zone 3 Floodplain, meaning this area is at a 1% or greater probability of flooding from rivers. The primary source of flooding is from the River Mersey, which is influenced by the tides, storm surges and the associated effects of sea level rise cause by climate change.

A separate Flood Risk Assessment has been undertaken and concludes a design flood level based on a 1 in 200yr event with allowance of climate change and freeboard of +7.3mOD should be adopted.

3.5 Ecology

The GroundSure report (Appendix B) does not indicate significant ecological constraints on the Site. The Mersey Narrows and North Wirral Foreshore areas are a designated SSSI, are listed under the RAMSAR Convention (protection of wetlands) and are designated Special Protection Area by Natural England. These areas are over 1km west of the Site and is not anticipated to have an impact on development.

3.6 Radon

The GroundSure report (Appendix B) indicates that the Site is not in a radon affected area as defined by the Health Protection Agency, as less than 1% of properties are above the Action Level. Therefore, no radon protection measures are considered necessary for the proposed development.

4 Preliminary Geotechnical Assessment

As outlined in Section 1.1, this Desk Study was originally published in July 2017 to support RIBA Stage 1+. It has since been updated to consider the finalised scheme for the proposed development but does not reflect that ground investigations and further surveys have been undertaken or include their results. As such, the following chapter will not take into account the results of the completed 2017, 2018 and 2019 site investigations.

4.1 Geology

At the time of writing, the results of the ground investigation have not been confirmed. The general geology profile across the site is broadly as expected:

- Made Ground/re-worked natural ground, over;
- Glacial Till (present on north, south and east docks), over;
- Sherwood Sandstone Group (Chester Formation).

4.2 Geotechnical Hazards

A number of ground related hazards have been identified. Investigations required to determine geotechnical hazards associated with the existing dock structure are summarised in Table 4-1.

Table 4-1 - Required investigations to determine geotechnical hazards

Survey/investigation	Why is this required?	Anticipated residual risk
Classification of fill behind the dock wall	Establish the suitability of shallow foundations for founding on the quay walkway	Made Ground is likely to be variable and further testing / investigation is likely to be required.
Buried extent of dock wall	Understand the proposed substructure constraints with positioning of piled foundations or ground improvement techniques. Inform superstructure and substructure design.	Extent of obstruction not fully defined if it proves to be variable across the site. Due to undocumented site constraints adjacent to the dock walls and the location of the existing structures on site, it is not possible to determine the buried extent of the dock wall on all four wharves within the Stage 1+ works.
Groundwater monitoring	Understanding the connectivity and relationship between the proposed development and the River Mersey, perched groundwater table and deep groundwater table.	Requirement to understand any seasonal variations in groundwater levels.
Thickness of silt on dock base	Determine the viability of leaving the silt in situ. Conclude if removal of the silt is necessary.	Need for intrusive investigation to confirm bathymetric / geophysics results.
Depth to base of dock	Inform volumes of fill required for the proposed development	-
Geotechnical classification of the silt	If silt remains in-situ, determine characteristics for ground bearing foundation, slabs and settlement criteria.	Need for dredging / removal of dock silt not cert
Visual condition survey of dock walls	Diver survey for visual inspection / condition survey.	Extent of any remedial works to dock walls not known.
Detailed ground investigation	Detailed investigation to provide confirmatory / detailed information following concept design development.	Local variations in ground conditions. Detailed geotechnical characteristics to be determined.

Survey/investigation	Why is this required?	Anticipated residual risk
Threat management strategy	Deal with potential explosive ordnance threats when conducting deep intrusive ground works.	Following the Explosive Ordnance Threat Assessment, the results indicated that a threat management strategy would be required.

4.3 Buried Obstructions

There is a very significant risk with respect to possible underground obstructions which may have an adverse impact on the proposed substructure works. These can be broadly categorised as either natural or manmade. Examples of the key obstructions that might be encountered during construction include:

- Manmade obstructions
    - Historic foundations, slabs, piles etc.;
    - Underground voids / in-filled voids (e.g. old cesspits, manholes, fuel tanks, etc. and / or buried live or abandoned services);
- Natural obstructions (e.g. boulders in Glacial Till)

Where obstructions or redundant services are encountered during construction, breaking out will likely be required. Risks associated with encountering manmade buried obstructions will need to be assessed further during detailed ground investigation. Owing to historical developments on the site, there will inevitably be buried obstructions not shown on historical plans. A ground investigation will not be able to truly characterise buried obstructions owing to the size and history of the site and it is anticipated that an enabling works contract will be required to undertake site clearance and obstruction removal works.

Historical photos [12] and drawings obtained from the Liverpool Museum showing different aspects of dock and wall construction are provided in Appendix I. The following site constraints plans are included in Appendix J and should be read alongside this Desk Study;

- ES-BHE-ZX-LXX-DR-CG-0002_Site Walkover Plan
- ES-BHE-ZX-LXX-DR-CG-0003_Constraints Plan - Historical Information
- ES-BHE-ZX-LXX-DR-CG-0004_Constraints Plan - Conjectural

Historic drawings indicate the presence of existing piles on both east and south sides of the dock. The form, depth and present condition of the piles is not known hence pile re-use is not considered to be a feasible option. Locations are shown indicatively and at this stage removal of the piles is not considered to be either feasible or necessarily required. Therefore, the proposed piling will need to be installed and work around these obstructions (the proposed South Stand of the stadium in particular).

The underlying bedrock is likely to prove a natural obstruction for any form of piling (e.g. sheet piling) that would require significant embedment. Further investigation is required to further define the bedrock level and rock strength characteristics.

4.3.1 BMD Walls

The available historic drawings (Appendix I) suggest that the BMD dock walls are gravity walls, near-vertical on the dock side with a stepped rear face and founded on bedrock approximately 9m below quay level (Figure I-5). However, the rock level shown in these drawings is several metres shallower than was observed in the nearest BGS borehole log, meaning the foundation of the walls is uncertain. No anchors or other stability measures are apparent on these drawings or from a visual inspection of the wall, however anecdotal evidence from Peel Holdings [13] as noted in the BuroHappold Feasibility Report [7] suggests the presence of reinforcement buried in the fill behind the wall. Available drawings give no indication of this reinforcement being present.

Ground investigation is required to validate the historical drawings and establish the dimensions and extent of the back of the listed dock walls to ensure the proposed foundation solution can be designed to completely avoid destructive penetration of the dock wall.

Proposed substructure works will be therefore be offset and span over the existing walls at a prescribed offset distance.

4.3.2 Northern wharf

Anecdotal evidence from a Liverpool dock worker of 35 years, who previously was based in the northwest warehouse structure on the north wharf, has indicated further buried obstructions not apparent on historical drawings:

- Steel girders previously used to support the high-level masonry railway line structure on the north wharf [12]. In recent years, an unknown number of the buried steel girders have been removed;
- Underlying the northwest warehouse structure on the north wharf, is a buried chamber. Described as very large, extending outside of the above ground extent of the building. The chamber has not been entered as part of this Desk Study;
- Historically, BMD and Wellington Dock were connected via an approximate 3m diameter tunnel, which was accessible via two timber 'trap doors' (Appendix F). The Liverpool dock worker confirmed that the water within the tunnel was displaced and the tunnel filled with sand during the filling works to Wellington Dock. The location of the 'trap doors' was identified during a further site walk over in June 2017. The results of the BMD dive survey were reviewed and there was no evidence of a tunnel / culvert being present which could suggest that it has been capped and that the vegetation and marine life has covered it completely;
- A buried chamber approximately 2m wide by 1m deep has been reported to run along the edge of the northern dock wall, constructed of masonry. The chamber is reportedly for pipes to connect the Hydraulic Engine House and the north west workshop structure; and
- Live service buried service running between the Hydraulic Engine House and workshop structure electricity substations along the northern wharf.

4.3.3 Southern wharf

Archive drawings obtained from the Liverpool Museum indicate that the warehouse located on the southern wharf is founded on piles (form and diameter unknown), which are anticipated to extend to rock head (Figure I-4). In addition, buried piles from a former structure remain beneath.

4.3.4 Western wharf

Archive drawings of the western wharf suggest that the former shed structure was founded on shallow footings. These probably remain in-situ following demolition of the shed. A disused substation is located on the western wharf which suggests abandoned services may be present.

4.3.5 Eastern wharf

Archive drawings of the eastern wharf indicate piled foundations beneath the rails of the dock cranes. However, the toe levels of the piles are not indicated on the available drawings and the form and diameter of the piles are also unknown.

4.4 Services

A combined existing utilities plan is provided in Appendix K.

4.5 Groundwater Level and Flow

4.5.1 Groundwater Level

Shallow groundwater conditions are expected to be variable with time and location and will depend on the permeability of the dock, river walls and lock gates. A permanent groundwater table is expected in the Sandstone underlying the site, and likely to be in hydraulic connectivity with the water level of the River Mersey.

It is proposed to infill the existing dock waterbody prior to construction of the proposed stadium. After infilling, groundwater levels within the fill material are likely to equilibrate to their former levels.

Due to the location of the application site adjacent to the River Mersey, the groundwater within the area of the docks is likely to respond to changes in water level within the dock and tidal variation within the river. When viewed in light of the local geology of the site, there is likely to be a perched groundwater table in the Made Ground that is hydraulically connected to the river/dock when this layer extends into the intertidal zone [7].

4.5.2 Flooding

The site is a low risk of flooding [7]. Where Glacial Till and puddle clay is present, the risk to groundwater flooding is comparatively reduced owing to the low permeability nature. Removal of the puddle clay within the dock area will increase the potential for hydraulic connectivity between the groundwater in the dock and external flood levels.

4.5.3 Uplift pressures and seepage flows

Any structure or part of a structure located below the groundwater table will be subjected to uplift pressures. These uplift pressures may be exacerbated during flood events as noted above, and seepage flows may also be generated within the underlying soil, depending upon the permeability characteristics of the soils. Should the self-weight of the structure be insufficient to resist the uplift pressures (either during a construction phase or in its finished condition) additional measures such as tension piles, a cut off wall or pumping will be required to resist or reduce the water pressure.

4.6 Buried Concrete Classification

A programme of controlled sampling and laboratory tests during the ground investigation will be required to determine the design class for buried concrete. None of the bedrock strata on site are principal sulphate and sulphide bearing strata as defined by BRE SD1 [14].

4.7 Foundation Options

Proposed structural loads will be concentrated in cores as well as areas of the stands. Significantly lower loads are to be applied to lower stand areas adjacent to the ground bearing pitch. Such variations in loads will mean that control of both total and differential settlement will be a major design consideration.

Piled foundations will be adopted to limit settlement to the acceptable tolerances. Piling is likely to be constructed using rotary bored cast in place or continuous flight auger piling techniques. Temporary casing may be needed to be used during boring, alternatively construction under support fluid may be an option. Penetration into the underlying Sandstone is required to achieve the proposed design capacity, in particular the requirement for achieving the required tension capacity.

Given the nature of infilling on the site, floor slabs for piled portions of the structure will need to be suspended slabs. External landscaping including Fan Zone will need to be detailed to accommodate differential settlement between infilled dock areas and existing quayside areas. The proposed car park within the Stadium Scheme will need to be piled.

The pitch will not be piled. The proposed methodology of filling the dock should ensure long term settlement is considered taking into account the thickness variation of current silt deposits and the compaction methodology of new fill material.

4.8 Earthworks

4.8.1 Dock Infilling

The Design Team have undertaken research to establish a dock filling strategy that removes the need to dredge the deposits that are present at the bottom of the dock basin.

In addition to programme savings, by not dredging, the dock deposits will not require off-site disposal (excluding pile spoil) which is evidently more sustainable. There are also subsequent reductions in the volume of imported material as Bramley-Moore Dock is effectively partially filled.

The proposed development at Bramley-Moore requires the dock to be infilled for the purposes of:

- Providing a construction working platform;
- Infilling the western water channel from the dock basin level (approximately -4.5mOD) to the top of the western water channel bed (+2.9mOD);
- Providing external zones including the western plaza and eastern fan zone.

The following bullet points outline the proposed methodology of infilling the dock (further details in BMD01-BHE-ZX-XX-RP-CG-0301 Dock Infill Methodology):

- Removal of marine life;
- Raking of the dock deposits;
- Undertaking a UXO risk mitigation survey;
- Dock wall remedial works;
- Installation of a membrane;
- Construction of dock isolation structure (north);
- Vibration and displacement monitoring of the dock walls;
- Dock infilling procedure; and
- Post filling compaction.

4.9 Ground Investigation

Two phases of ground investigation were undertaken at Bramley-Moore Dock during June 2017 and December 2017 to January 2018.

This Desk Study was originally published in July 2017 to support RIBA Stage 1+. It has since been updated to consider the finalised scheme for the proposed development but does not reflect that ground investigations and further surveys have been undertaken or include their results.

5 Preliminary Contaminated Land Risk Assessment

5.1 General Approach

In the UK, the assessment of risk from contamination follows the source-pathway-target approach. If one of these three elements are absent it is considered that there is no risk of harm. If, however, there is considered to be a linkage between any given source and any given target / receptor then a risk-based approach is used to assess the significance or impact of the potential linkage.

Risks are defined as the probability of an event occurring combined with the severity of the consequence should that event occur. To assess the risk to site end-user(s) posed by a given source, the sensitivity of each receptor is considered. For example, the concentration of contamination acceptable at a site to be developed as a residential property with a garden used to grow vegetables and accessible to young children is set lower than that for a commercial site where soil exposure is limited to areas of landscaping, and the only long-term users of the site are adults. Similarly, a site overlying an aquifer supplying potable water to a large population will be considered more stringently than a site overlying an impermeable geology with only minor seepages of groundwater.

5.2 Source-Pathway-Receptor Risk Assessment

Potential contamination sources from former uses of the Site and neighbouring area have been identified in Section 2 of this report. The potential contaminant source (Table 5-1) potential receptors (Table 5-2) and the plausible exposure pathways that could link them to the identified / potential sources are described below. The details of the Preliminary Risk Assessment are presented in Section 5.3.

The 'Contaminants of Concern' in this risk assessment are based primarily on information from the review of historical information, reference to DEFRA R&D Publication CLR 8 'Priority contaminants for the assessment of land' and relevant Industry Profile reports published by the Department of Environment [15].

Table 5-1- Summary of Potential Contamination Sources

Potential Source	Location	Likely Age	Potential Contaminants of Concern
Made Ground	On site	~170 years	Ground gas (methane, carbon dioxide, carbon monoxide), hydrocarbons, PCBs, PAHs, asbestos, phenol, paints, thinners, primers and varnishes.
Fill material (waste material from local industries; dock silts; marine dredgings)	On site	~170 years	Metals and metalloids, phenols, chlorides, sulphates, sulphides, PAHs, asbestos, cyanides.
Coal storage and spillage	Formerly on site	30-170 years	Metals and metalloids, sulphates, sulphides, cyanides.
Railway sidings	Formerly on site	~170 years	Hydrocarbons, PAHs, solvents, creosote, metals, asbestos, ash, sulphates.
Cargo handling plant and equipment (largely fuel and oil waste from hydraulic equipment, diesel and steam engines etc.)	Formerly on site	Up to 170 years	Diesel, petrol, mineral oils, phenols, aliphatic, alicyclic and aromatic hydrocarbons, dispersing agents
Ship maintenance operations	On site	Up to 170 years	Cleaning agents, paint residues, solvents (halogenated organics), metals and metalloids, hydraulic fluids, tributyltin.

Potential Source	Location	Likely Age	Potential Contaminants of Concern
Tanks	Formerly on site	Up to 50 years	Unspecified contents, likely fuels
Electricity Substation	Formerly and currently on site	Up to 50 years	Oils, PCBs

Table 5-2 - Summary of Receptors and Pathways

Receptor		Pathway
Human Health	Construction / Maintenance Workers	Direct contact and dermal uptake. Soil and dust ingestion and inhalation.
	Future Site Users	Migration via permeable strata, inhalation.
Controlled Waters	Secondary/Principal Aquifer	Leaching and migration of contamination via permeable strata and preferential pathways (i.e. structural failings in dock wall).
	River Mersey	
Built Environment	Buildings/services. Permeation of water supply pipework. Degradation of concrete.	Migration via permeable strata, accumulation in enclosed spaces, explosion, asphyxiation.
		Direct contact.

5.3 Results of Risk Assessment

The details of the Preliminary Risk Assessment are presented overleaf and the results discussed in Section 6.1.

Pollutant Linkage				Risk Assessment			Description of source
Source	Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Risk	
Made Ground Fill material	Hydrocarbons, PCBs, PAHs, asbestos, phenol, paints, thinners, primers and varnishes Metals and metalloids, phenols, chlorides, sulphates, sulphides, PAHs, asbestos, cyanides	**Made Ground and fill material are present on site as a result of dock construction. Predominant historical use of BMD was export and storage of coal, railway on site likely used for coal transport. Stockpiling and spillage of coal and other materials on site highly likely to have occurred. Other potential historical contamination sources arise from historical dock activities, including cargo handling equipment and maintenance operations. Regulatory data suggests tanks of unspecified contents have historically been present on site. Site currently used for stockpiling of dredged material from River Mersey. Possible that some maintenance operations are still ongoing. Electricity substations have been identified on site during site walkovers.**					
		Direct contact and dermal uptake Soil and dust ingestion and inhalation	Investigation, maintenance and construction workers	Medium	Unlikely	Low	Ground engineering aspects of construction will involve partial excavation and uncovering of Made Ground/fill material. Exposure time limited. Mitigation can be achieved by appropriate investigation and good construction practice. Possibility that mobile contamination may be present in voids or trapped by historic foundations within Made Ground. Standard Health and Safety Precautions likely to be used.
		Direct contact and dermal uptake Soil and dust ingestion and inhalation	Future site users	Medium	Low	Low	Proposed scheme envisages majority of on-shore areas of proposed development to be covered by hardstanding. Limited areas of direct in-ground planting proposed. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works.
		Leaching and migration of contamination via permeable strata and preferential pathways	Secondary /Principal Aquifer River Mersey	Medium	Low	Moderate /Low	Ground engineering aspects of construction will involve partial excavation and uncovering of Made Ground/fill material. Any mobile contamination likely to have migrated historically. Possibility that mobile contamination may be present in voids or trapped by historic foundations within Made Ground.
		Direct contact.	Buildings/services. Permeation of water supply pipework. Degradation of concrete.	Medium	Unlikely	Low	Any new services unlikely to be routed in areas where contamination that could affect pipework is found. Mitigation can be achieved by appropriate design and use of appropriate materials.
Made Ground	Ground gas (methane, carbon dioxide, carbon monoxide)	Migration via permeable strata, accumulation in enclosed spaces, explosion, asphyxiation	Investigation, maintenance and construction workers	Severe	Unlikely	Moderate /Low	Potential for gases to accumulate in excavations and enclosed spaces, though such spaces likely to be well ventilated during construction. Due to age of the material, any significant gassing likely to have occurred in the past with limited gas production now occurring. Ground gas regime to be characterised by investigation to determine the risk. Standard Health and Safety Precautions likely to be used.
		Migration via permeable strata, accumulation in enclosed spaces, explosion, asphyxiation	Future site users	Severe	Low	Moderate	Potential for gases to accumulate in enclosed spaces of final development. Due to age of the material, any significant gassing likely to have occurred in the past with limited gas production now occurring. Ground gas regime to be characterised by investigation to determine the risk.
		Migration via permeable strata, accumulation in enclosed spaces, explosion, asphyxiation	Buildings	Severe	Low	Moderate	Potential for gases to accumulate in enclosed spaces of final development. Due to age of the material, any significant gassing likely to have occurred in the past with limited gas production now occurring. Ground gas regime to be characterised by investigation to determine the risk.
Coal storage and spillage Cargo handling equipment	Metals and metalloids, sulphates, sulphides, cyanides Diesel, petrol, mineral oils, phenols, dispersing agents	Direct contact and dermal uptake Soil and dust ingestion and inhalation	Investigation, maintenance and construction workers	Medium	Unlikely	Low	Coal storage/export and cargo handling ceased some time prior to dock closure in 1988. Contamination from these sources likely to be limited. Exposure time limited. Mitigation can be achieved by appropriate investigation and good construction practice. Standard Health and Safety Precautions likely to be used.
		Direct contact and dermal uptake Soil and dust ingestion and inhalation	Future site users	Medium	Low	Low	Coal storage/export and cargo handling ceased some time prior to dock closure in 1988. Contamination from these sources likely to be limited. Proposed scheme envisages majority of on-shore areas of proposed development to be covered by hardstanding. Limited areas of direct in-ground planting proposed. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works.
		Leaching and migration of contamination via permeable strata and preferential pathways	Secondary/ Principal Aquifer River Mersey	Medium	Low	Low	Coal storage/export and cargo handling ceased some time prior to dock closure in 1988. Contamination from these sources likely to be limited. Any mobile contamination likely to have migrated historically.

Pollutant Linkage				Risk Assessment			Description of source
Source	Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Risk	
Ship Maintenance operations	Cleaning agents, paint residues, solvents (halogenated organics), metals and metalloids, hydraulic fluids, tributyltin	Direct contact and dermal uptake Soil and dust ingestion and inhalation	Investigation, maintenance and construction workers	Medium	Unlikely	Low	Most maintenance operations would have ceased by dock closure in 1988. Not clear if any significant maintenance occurred as there were maintenance facilities within the wider (offsite) dock area. Tug and dredging boats present within dock indicate that limited activities are ongoing. Contamination from these sources likely to be limited. Exposure time limited. Mitigation can be achieved by appropriate investigation and good construction practice.
		Direct contact and dermal uptake Soil and dust ingestion and inhalation	Future site users	Medium	Low	Low	Most maintenance operations would have ceased by dock closure in 1988. Not clear if any significant maintenance occurred as there were maintenance facilities within the wider (offsite) dock area. Tug and dredging boats present within dock indicate that limited activities are ongoing. Proposed scheme envisages majority of on-shore areas of proposed development to be covered by hardstanding. Limited areas of direct in-ground planting proposed. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works
		Leaching and migration of contamination via permeable strata and preferential pathways	Secondary /Principal Aquifer River Mersey	Medium	Unlikely	Low	Most maintenance operations would have ceased by dock closure in 1988. Not clear if any significant maintenance occurred as there were maintenance facilities within the wider (offsite) dock area. Tug and dredging boats present within dock indicate that limited activities are ongoing. Most mobile contamination likely to have migrated historically. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works
Railway sidings	Hydrocarbons, PAHs, solvents, creosote, metals, asbestos, ash, sulphates	Direct contact and dermal uptake Soil and dust ingestion and inhalation	Investigation, maintenance and construction workers	Medium	Unlikely	Low	Most rail tracks removed by 1973, subsequently covered by hardstanding. Possible some of the rail track bed could remain beneath the hardstanding though unproven. Ground engineering aspects of construction may involve partial excavation and uncovering of hardstanding. Contamination from these sources likely to be limited. Exposure time limited. Mitigation can be achieved by appropriate investigation and good construction practice.
		Direct contact and dermal uptake Soil and dust ingestion and inhalation	Future site users	Medium	Low	Low	Most rail tracks removed by 1973, subsequently covered by hardstanding. Possible some of the rail track bed could remain beneath the hardstanding though unproven. Proposed scheme envisages majority of on-shore areas of proposed development to be covered by hardstanding. Limited areas of direct in-ground planting proposed. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works.
		Leaching and migration of contamination via permeable strata and preferential pathways	Secondary /Principal Aquifer River Mersey	Medium	Unlikely	Low	Most rail tracks removed by 1973, subsequently covered by hardstanding. Possible some of the rail track bed could remain beneath the hardstanding though unproven. Ground engineering aspects of construction may involve partial excavation and uncovering of hardstanding. Exposed ground will be recovered as part of construction works. Any mobile contamination likely to have migrated historically.
Electricity substation	Oils, PCBs	Direct contact and dermal uptake Soil and dust ingestion and inhalation	Investigation, maintenance and construction workers	Medium	Unlikely	Low	Three substations on site stand on hardstanding and are housed within small brick buildings. Substation is likely to be of an age such that PCBs were used, PCB containing oils unlikely to be used currently. No evidence of contamination and limited potential for migration. Period of exposure likely to be limited. Only specialist contractor will decommission the substations and work in their immediate area. Standard Health and Safety precautions likely to be used.
		Direct contact and dermal uptake Soil and dust ingestion and inhalation	Future site users	Medium	Low	Low	Three substations on site stand on hardstanding and are housed within small brick buildings. Substation is likely to be of an age such that PCBs were used, PCB containing oils unlikely to be used currently. No evidence of contamination and limited potential for migration. Substation will be removed as part of redevelopment. Proposed scheme envisages majority of on-shore areas of proposed development to be covered by hardstanding. Limited areas of direct in-ground planting proposed. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works.

Pollutant Linkage				Risk Assessment			Description of source
Source	Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Risk	
		Leaching and migration of contamination via permeable strata and preferential pathways	Secondary /Principal Aquifer River Mersey	Medium	Unlikely	Low	Three substations on site stand on hardstanding and are housed within small brick buildings. Substation is likely to be of an age such that PCBs were used, PCB containing oils unlikely to be used currently. No evidence of contamination and limited potential for migration from the substations Substation will be removed as part of redevelopment. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works.
Tanks	Unspecified contents, likely fuels	Direct contact and dermal uptake Soil and dust ingestion and inhalation	Investigation, maintenance and construction workers	Medium	Low	Moderate /Low	Regulatory data suggests unspecified tanks previously present on site, no evidence on historical maps. No evidence of tanks or associated contamination observed during site walkover. Standard Health and Safety precautions likely to be used. Potential for contamination to remain present within old tanks if present which would require specialist removal, such contamination likely to be mobile if disturbed.
		Direct contact and dermal uptake Soil and dust ingestion and inhalation	Future site users	Medium	Low	Very low	Regulatory data suggests unspecified tanks previously present on site, no evidence on historical maps. No evidence of tanks or associated contamination observed during site walkover. Tanks would be removed as part of redevelopment works. Proposed scheme envisages majority of on-shore areas of proposed development to be covered by hardstanding. Limited areas of direct in-ground planting proposed. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works.
		Leaching and migration of contamination via permeable strata and preferential pathways	Secondary /Principal Aquifer River Mersey	Medium	Low	Moderate /Low	Regulatory data suggests unspecified tanks previously present on site, no evidence on historical maps. No evidence of tanks or associated contamination observed during site walkover. Any mobile contamination likely to have migrated historically. Potential for contamination to remain present within old tanks if present which would require specialist removal, such contamination likely to be mobile if disturbed. Tanks would be removed as part of redevelopment works. Some removal of Made Ground likely during development, any areas of encountered gross contamination likely to be removed during works.

6 Conclusions & Recommendations

6.1 Geoenvironmental Conclusion

An Initial Conceptual Site Model has been determined and a Preliminary Risk Assessment with respect to ground contamination has been carried out for the site on the basis of desk-based data and site walkover. The main sources of potential contamination have been identified and the potential risks have been qualitatively assessed. The assessment includes consideration of the potential risks associated with any below ground works (e.g. site investigation or enabling works etc.) and the proposed future use. A summary of the potentially significant risks (i.e. greater than Low) is presented below:

- Moderate / Low risk to controlled waters from Made Ground and fill due to the potential for mobile contamination to be trapped within foundations and in ground structures within the Made Ground which on disturbance due to development works could migrate to these receptors.
- Moderate / Low risk to construction workers and Moderate Risk to future site users and buildings from ground gas.
- Moderate / Low risk to construction workers and controlled waters from historic tanks which may still be present on site and could contain potentially contaminating liquids.

It is considered unlikely that the application site would be determined as Contaminated Land (under the provisions of Part 2A of the Environmental Protection Act 1990) in its current state or following the event of redevelopment. However, the above risks require quantification through ground investigation and monitoring in addition to below ground exploration to establish if any tanks are present or if trapped mobile contamination within structures / foundations is present. Once quantified it will be possible to mitigate these risks through enabling works / remedial design as part of the development.

6.2 Geotechnical Conclusion

Ground conditions at the site are expected to comprise:

- Onshore quay wall areas:
  - Made Ground up to 9.0m
  - Glacial Till – not present at all locations
  - Bedrock – Chester sandstone.
- Dock area:
  - Silt
  - Puddle clay layer
  - Bedrock – Chester sandstone
- Groundwater conditions are expected to be strongly influenced by the adjacent water bodies of the impounded dock and tidal fluctuations of the adjacent River Mersey. The presence of the existing quay walls and probable low permeability lining to the dock means that dock water levels are not strongly influenced by tidal fluctuations. Further monitoring is required to establish site groundwater levels.

The dock waterbody is proposed to be infilled using marine-won sand to create the development platform for the proposed new stadium. Dredging of the dock deposits is not required.

The main structural foundations will comprise piled foundations founded in the underlying Sandstone. Historical development of the site means that there are large number of potential ground obstructions that will affect the substructure works including:

- North wharf – steel girders, concrete slabs, chambers and tunnels
- East wharf – foundation piles
- South wharf – foundation piles
- West wharf – shallow foundations

The existing BMD dock walls are Grade II listed and will remain in situ for preservation. The proposed foundation solution should be designed to completely avoid destructive penetration of the dock wall.

A series of site plans have been prepared to highlight historical features and site constraints as shown in Appendix J – Drawings.

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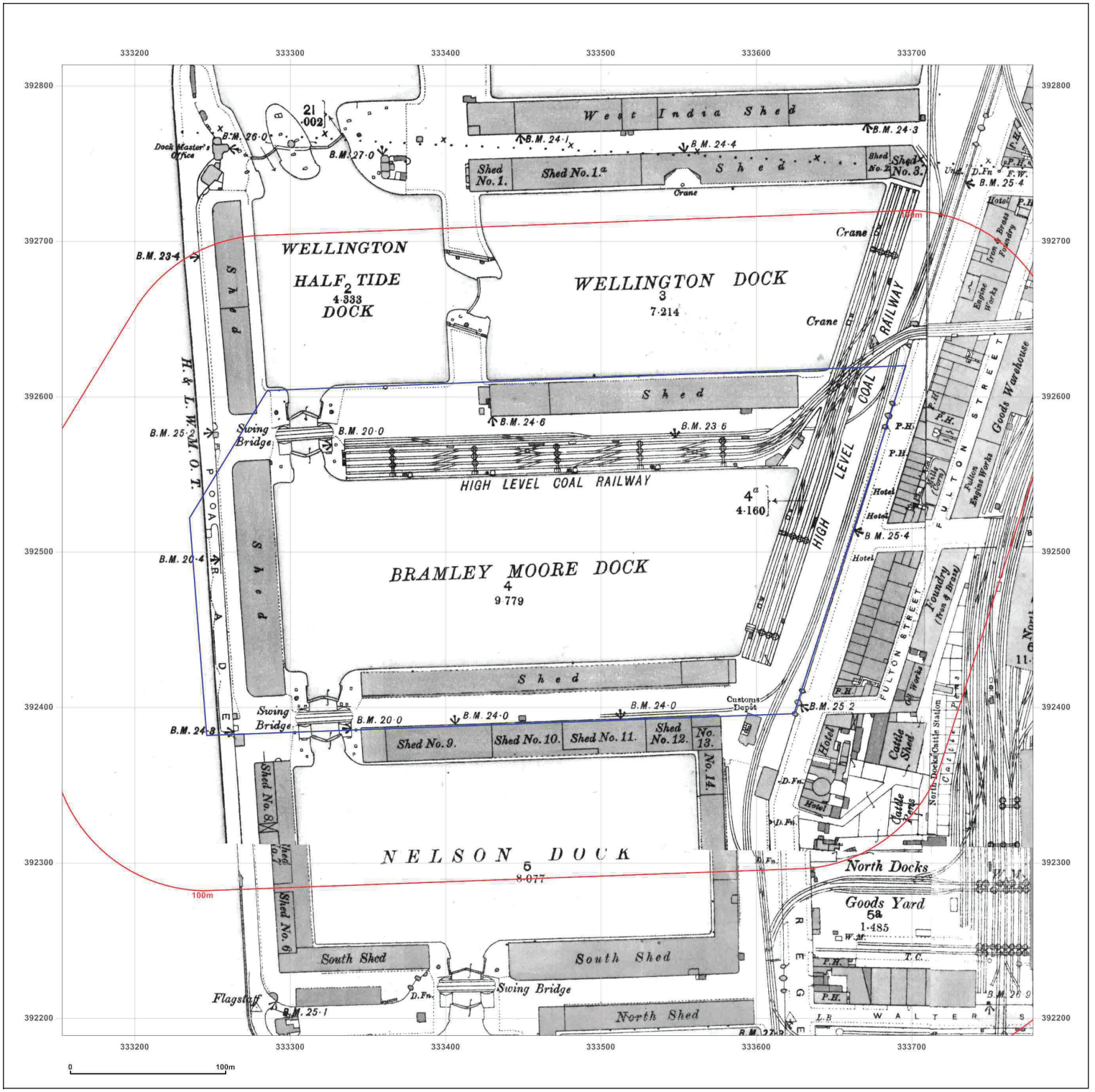
[15] Department of the Environment, "Industry Profile. Dockyards and dockland.," 1995.

Appendix A – GroundSure Historical Maps



Groundsure INSIGHTS

Site Details:

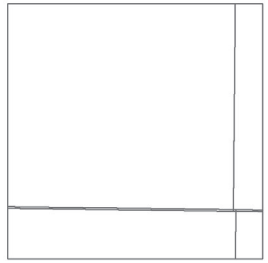
BRAMLEY-MOORE DOCK, L5 9SR

Client Ref: 035533
Report Ref: GS-3172488
Grid Ref: 333466, 392501

Map Name: County Series
Map date: 1893
Scale: 1:2,500
Printed at: 1:2,500

N W E S

Surveyed 1893
Revised 1893
Edition N/A
Copyright N/A
Levelled N/A



Surveyed 1893
Revised 1893
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1893
Revised 1893
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1893
Revised 1893
Edition N/A
Copyright N/A
Levelled N/A

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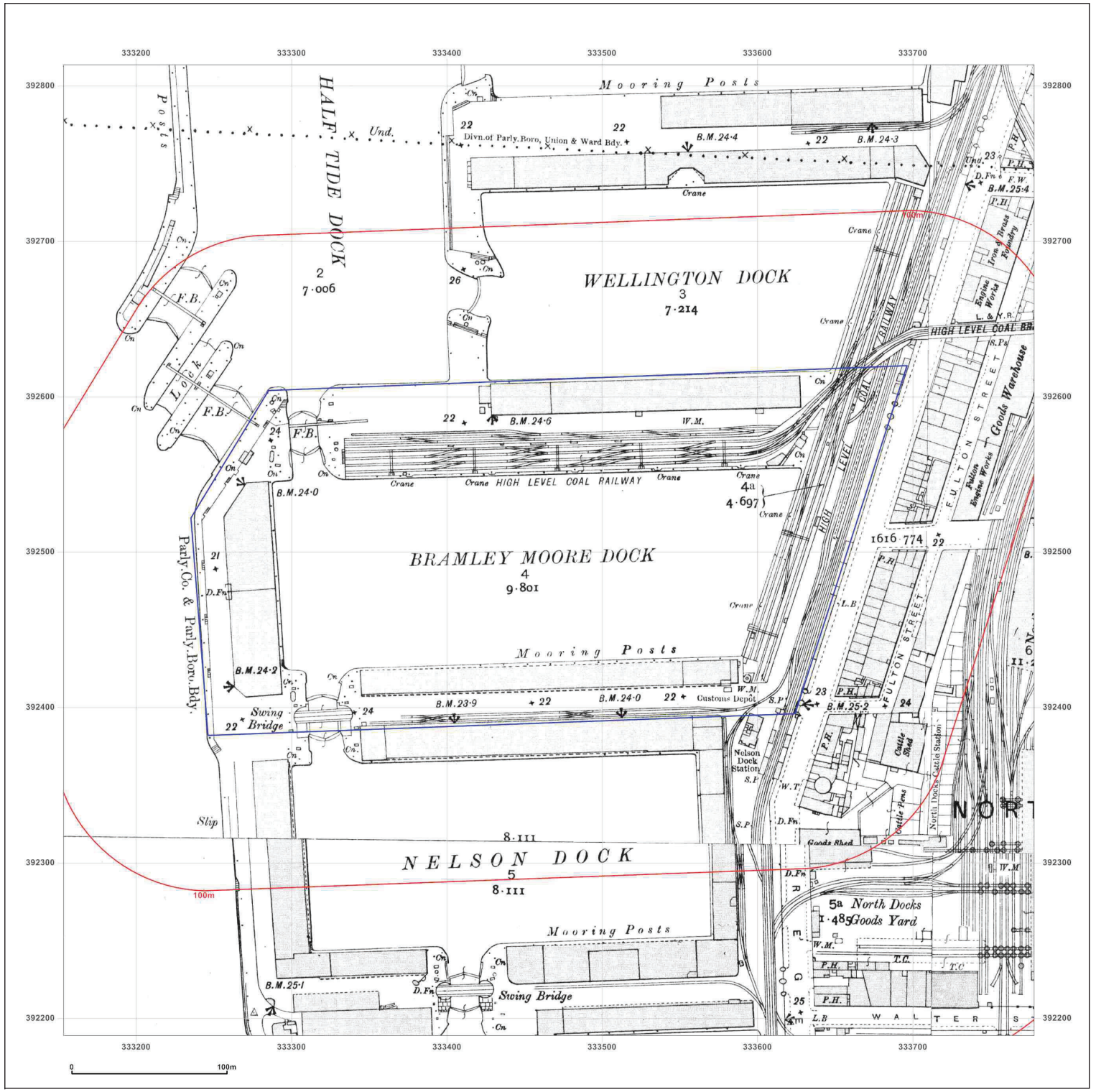


Groundsure INSIGHTS

Site Details:

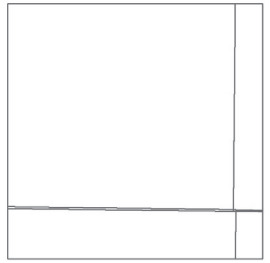
BRAMLEY-MOORE DOCK, L5 9SR

Client Ref: 035533
Report Ref: GS-3172488
Grid Ref: 333466, 392501

Map Name: County Series
Map date: 1908
Scale: 1:2,500
Printed at: 1:2,500

N
W E
S

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



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

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

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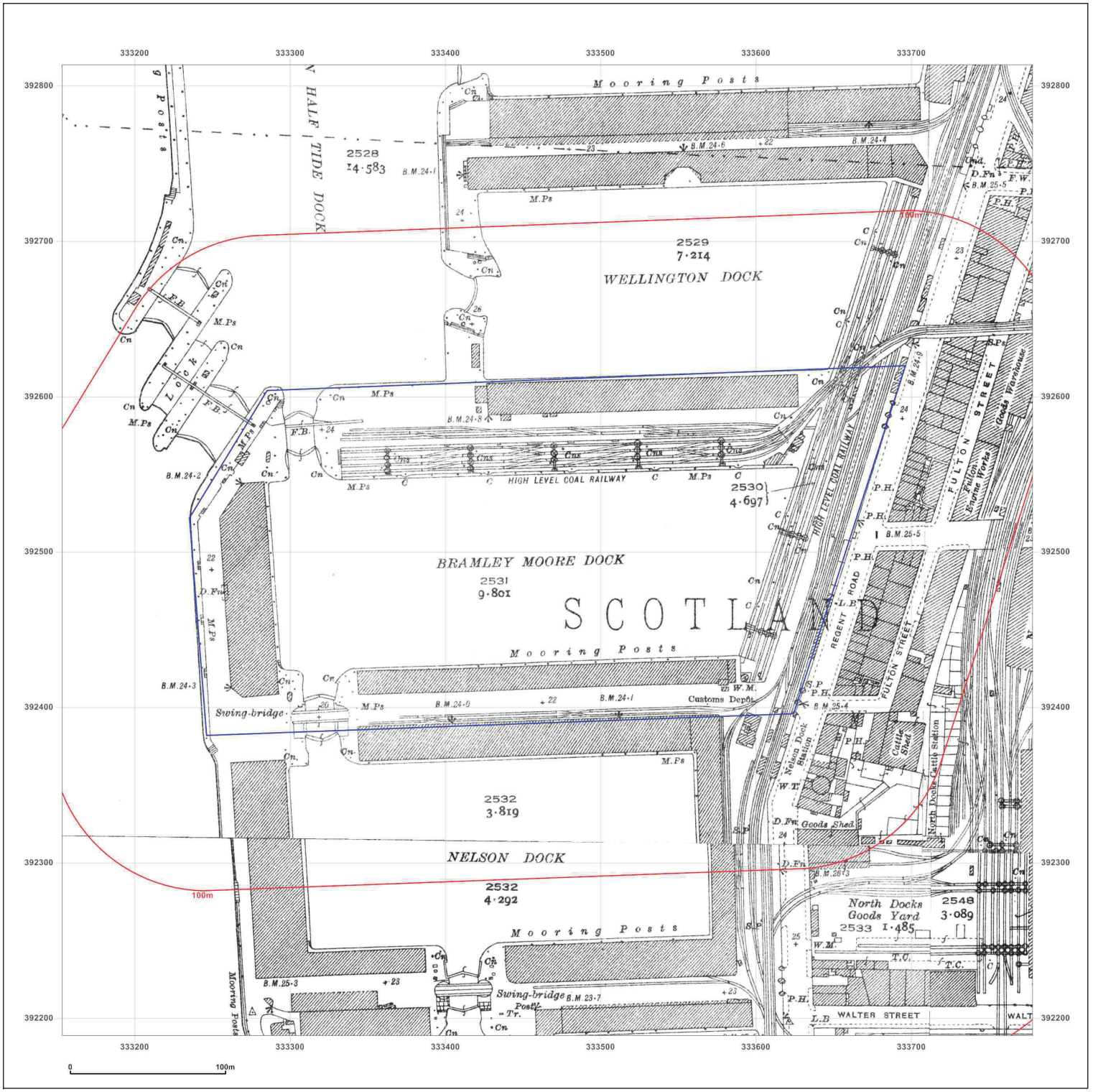

Groundsure INSIGHTS

Site Details:

BRAMLEY-MOORE DOCK, L5 9SR

Client Ref: 035533
Report Ref: GS-3172488
Grid Ref: 333466, 392501

Map Name: County Series
Map date: 1927
Scale: 1:2,500
Printed at: 1:2,500

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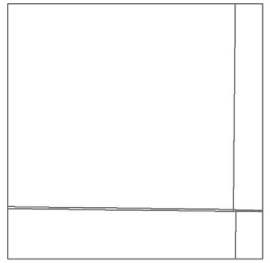
Surveyed 1927
Revised 1927
Edition N/A
Copyright N/A
Levelled N/A



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

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

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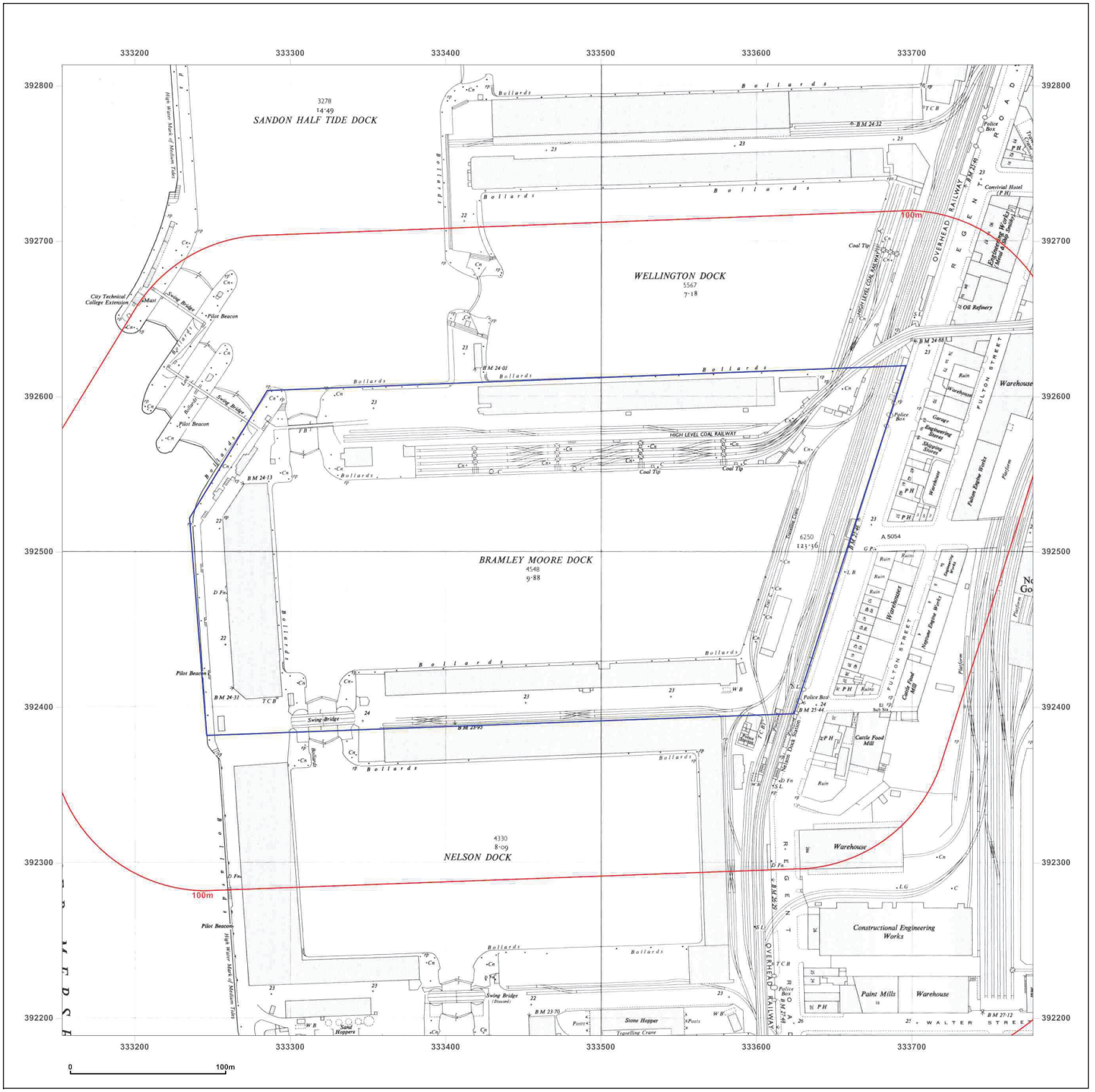

Groundsure INSIGHTS

Site Details:

BRAMLEY-MOORE DOCK, L5 9SR

Client Ref: 035533
Report Ref: GS-3172488
Grid Ref: 333466, 392501

Map Name: National Grid
Map date: **1954**
Scale: 1:2,500
Printed at: 1:2,500

N
W E
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Surveyed 1954
Revised 1954
Edition 1955
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Site Details:

BRAMLEY-MOORE DOCK, L5 9SR

Client Ref: 035533
Report Ref: GS-3172488
Grid Ref: 333466, 392501

Map Name: National Grid
Map date: **1967**
Scale: 1:2,500
Printed at: 1:2,500

N
W E
S

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