



Dock Infill Methodology

Revision 3

Liverpool Waters
Plot CO2
East Waterloo Dock

24th October 2019

Ref: 4/6679/DIM/2

Prepared on Behalf of:

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Date originated: 28th November 2018

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Appendix C -	CCGeotechnical Ground Investigation Report (October 2018)

1.0 INTRODUCTION

1.1 General

- 1.1.1 This report has been prepared on instructions received from Romal Capital Group Ltd and relates to the proposed development works at West Waterloo Dock as part of Liverpool Waters Project. The development is currently referred to as Plot CO2.
- 1.1.2 CC Geotechnical Ltd (CCG) were commissioned to undertake a combined Phase 1 Desk Study / Phase 2 Ground Investigation Report providing 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.
- 1.1.3 A copy of the Ground Investigation can be found in Appendix C.
- 1.1.4 This report outlines the findings of this report and the initial methodology philosophy for the infill of the dock and the piling operations for the proposed development.
- 1.1.5 This report is prepared solely for the benefit of the Client. This report may not be assigned without prior written permission from Clancy Consulting (CC).
- 1.1.6 This report is based upon existing and proposed plans for the development as well as data obtained from site investigations undertaken by CCG.

2.0 SITE CHARACTERISTICS

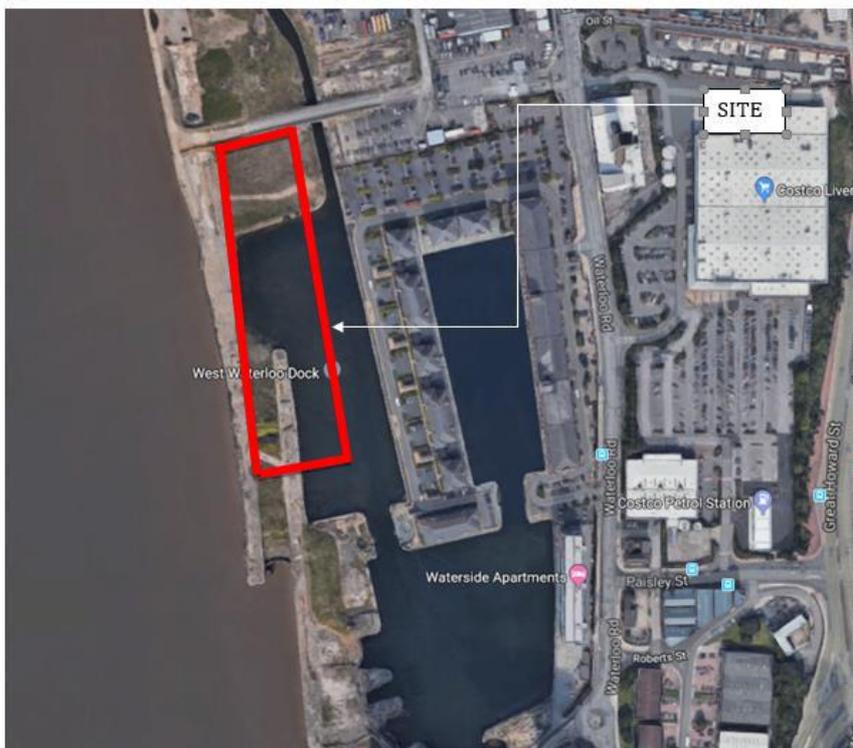
2.1 Existing Site Characteristics

- 2.1.1 The site is situated on West Waterloo Dock and the adjacent infilled Waterloo Lock as shown Figure 1.0.
- 2.1.2 The quaysides within the site stand at an elevation of around 8m AOD.

Table 1 - Site Location References (streetmap.co.uk)

OS X (Eastings)	333455
OS Y (Northings)	391242
Nearest Post Code	L3 0BT
Lat (WGS84)	N53:24:50 (53.413770)
Long (WGS84)	W3:00:09 (-3.002624)
LR	SJ334912
mX	-334250
mY	7025569

Figure 1 - Site Location Map (streetmap.co.uk)



2.2 Site Description

- 2.2.1 The development is located North of Liverpool City Centre within West Waterloo Dock on the waterfront. The development is bordered by the Liverpool Canal Link to the West, Princes Half Tide Dock to the South, The River Mersey (and river wall) to the East and undeveloped land to the North.
- 2.2.2 The area proposed for development was historically West Waterloo Docks and warehouses. Over time, the warehouses have been demolished and the dock itself has been partially infilled along with Waterloo Lock system, whilst other areas remain as the dock.
- 2.2.3 The development contains the 'quayside/ dockside' formed when Waterloo Lock was introduced. Waterloo Lock has been infilled to match current site levels and it is understood that the three lock gates and their manoeuvring mechanisms remain in place with the gates in the 'closed' position.
- 2.2.4 The North end of the development contains an area of infill sloping down to the canal level.
- 2.2.5 The development falls within the wider Liverpool Waters masterplan – covering the re-development of up to 60 hectares of former dock land along Liverpool Waterfront providing mixed use developments and an extension from Liverpool City Centre northwards.
- 2.2.6 Outline planning was granted by Liverpool City Council in June 2013 (Application no. 100/2424).
- 2.2.7 The overall area proposed for re-development within this application is approximately 1.12 hectares
- 2.2.8 Site ground levels along the dock sides are generally flat at a level of approximately 8.000m AOD. The canal level is generally kept at approximately 4.770m AOD.

2.3 Site Proposals

- 2.3.1 The development comprises initially of land reclamation from the dock by installing a new dock wall within West Waterloo Dock to provide a separation between the Leeds-Liverpool canal and the development.
- 2.3.2 Once the new dock wall has been installed, the area behind the wall will be infilled with imported materials to raise existing levels to proposed before piling operations can then commence for the foundations for the four new mixed-use blocks (A-D). These blocks are 10 storeys and provide a total of 538 apartments (one – three bedrooms), along with associated commercial space, car parking, landscaping, servicing and access.
- 2.3.3 Three of the four blocks (A-C) will sit within the infilled dock with the remaining block (D) straddling over the quayside and partially within Waterloo Lock.
- 2.3.4 The development will also include a canal-side walkway along the canal perimeter of the development to provide access between the blocks and the canal itself.

- 2.3.5 Along this walkway, Blocks A and B will extend over the dock to create a colonnade with the ends of the buildings constructed within Waterloo Dock itself off a piled solution.
- 2.3.6 To the North of the blocks, this will be developed into car parking, access and communal spaces to provide access between the blocks.

3.0 SITE INVESTIGATION REPORT SUMMARY

3.1 Site History

- 3.1.1 CCG's report established Waterloo Dock opened in 1834 and by 1868 was separated into two distinct basins – West Waterloo Dock and East Waterloo Dock.
- 3.1.2 Waterloo Lock was constructed with the three lock gates by 1949 with the dock closed to shipping in 1988 and by 1993, maps show that the dock has partially infilled with the lock disused and infilled by 2010.
- 3.1.3 The report draws attention to the fact that modifications to the dock infrastructure have the potential to have left structures/ foundations in place which are now covered but may be obstructive to piling operations.

3.2 Credible Potential Sources of Contamination

- 3.2.1 CCG's report highlights four potential sources of contamination with the current site arrangement;
 - 1. The infill within Waterloo Lock
 - 2. The deposits making up the infill within West Waterloo Dock.
 - 3. Water entrapped within Waterloo Lock
 - 4. Water within West Waterloo Dock.

3.3 Phase II Intrusive Investigations

- 3.3.1 The Phase II Intrusive Investigation involved sinking/taking a series of boreholes 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. These were undertaken between September and October 2018.
- 3.3.2 Trial pits were undertaken and gas/ groundwater pipes installed and monitored
- 3.3.3 In all instances, subsampling of borehole recovery for soil contamination and soil classification testing was also completed.

3.4 Observations

- 3.4.1 The investigations found West Waterloo Dock is infilled to an average depth of about 3m below standing dock water level (understood to be generally kept at 4.77m AOD). The infill is classified as 'Made Ground' and consists of a mixture of brick, concrete and stone, etc. with occasional glass, wood, ceramics. This is classified as very loose to medium dense.
- 3.4.2 Natural sandstone bedrock was found to be between 8m below ground level (-0.6m AOD) within the dock extending to a maximum depth of 26.6m below ground level (-18.6m AOD) within Waterloo Lock.
- 3.4.3 Groundwater in each of the boreholes and is consistent with the dock water level.
- 3.4.4 Details of the testing and the results can be found within CCGeotechnical's Ground Investigation report.

3.5 Chemical Testing

- 3.5.1 Samples have been assessed for a range of contaminants with all contaminants below their respective threshold values and therefore no potential risk to human health is identified.
- 3.5.2 Details of the testing and the results can be found within CCGeotechnical's Ground Investigation report (Appendix C).

3.6 Waste Classification

- 3.6.1 If existing materials are removed as part of the construction, all soil analyses conform to a Non-Hazardous waste classification. If destined for landfill, it is recommended that consultation with landfill operators be undertaken during the development of the waste management plan.

4.0 INFILL METHODOLOGY

4.1 Cut-off Wall Construction

- 4.1.1 A new dock wall is to be constructed within West Waterloo Dock to form the separation between the development and the existing Leeds-Liverpool Canal.
- 4.1.2 This wall will follow a line that will encapsulate the existing Waterloo Lock and the quayside, running parallel with the opposite dock wall to create a channel for continued and uninterrupted vessel navigation along the Leeds – Liverpool Canal.
- 4.1.3 The line of the new wall is highlighted in Appendix B.
- 4.1.4 It is expected that the new dock wall will be coordinated with the new dock wall proposed at the neighbouring development – The Isle of Man Ferry Terminal. During detailed design, it will be imperative that both developments liaise with one another to ensure dock wall construction does not hinder each other's development.
- 4.1.5 At this stage, it is anticipated that the cut-off wall between the development and the dock will be constructed using a 'Combi-wall' piling solution or a similar type of arrangement.
- 4.1.6 This type of construction typically consists of tubular steel piles taken into the underlying sandstone bedrock in rock sockets at consistent centres along the length of the wall line with sheet piles installed between the tubular piles and taken down to the surface of the bedrock
- 4.1.7 The design of this type of arrangement considers the tubular piles acting as cantilever posts fixed into the sandstone bedrock, supporting the applied loading from the retained backfill to new site levels and the surcharges from, initially, the construction activities and then the car parking in the permanent condition. The sheet piles span between the tubular piles supporting the aforementioned backfill and surcharges which are then transferred into the tubular piles.
- 4.1.8 To ensure that the tubular piles are capable of supporting all relevant applied loads, the piles are likely to be secured into the bedrock by installing them with deep sockets which would then need to be grouted up.
- 4.1.9 It is likely, as CCG's report suggests, that the pile installation for the wall will use floating rigs loaded onto pontoons/ barges as opposed to undertaking these works from piling rigs running across the existing dock infill material and imported fill to raise it above existing water levels. This is for predominantly practicality reasons and are explored within CCG's report.
- 4.1.10 In terms of finalising the technical aspects of the design, some further investigation may be required to confirm the position of existing structures in relation the proposed line of the wall. For example, at the North end of the development, initial overlays of proposed with historical drawings suggest there is the potential for the wall to run across the buried abutments of an old swing bridge.

4.2 Dock Infilling and Settlement Potential

- 4.2.1 On completion of the dock wall installation, land reclamation works behind the new dock wall line can commence. This is likely to involve the introduction of approximately 6m in depth of imported fill to raise levels (within the existing dock/infilled lock) to proposed finished ground levels.
- 4.2.2 Initial proposed site levels can be found on the Site Plan within Appendix A.
- 4.2.3 Due to the known nature of the existing fill within the dock (worst case results are consistent with very loose made ground), filling the site with approximately 6m of imported material will impose loadings onto the existing fill which will settle/depress under these conditions.
- 4.2.4 It is imperative that the imported fill is placed under controlled conditions – with attention drawn to the depth at which new layers of the imported fill are introduced and how each of these layers is compacted before the next layer can be introduced. A full a detailed method statement would be produced to demonstrate this.
- 4.2.5 Details of these conditions, along with an outline material specification and suggested testing regime are included in the outline specification which is as follows;

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	<ul style="list-style-type: none"> • Particle size analysis – 1 test for 200m³ • Plate load tests at 2 per layer with max settlement of 2mm under 450mm dia plate loaded to 20kN/m² • Broad spectrum soil contamination analyses for compliance with LQM/CIEH criteria for Residential without Plant Uptake – 1 analysis per 250m³ - 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 250m³ – 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

Table 2 – Dock Infilling Specification (Source: CC Geotechnical Ground Investigation Report)

- 4.2.6 The method of achieving the required density of the imported fill to be used as a platform may be achieved in a number of ways, including but not restricted to;
- Reducing the water level within the ‘dock’ which is now enclosed within this development to a level below the top of the existing fill to allow compaction of the upper levels of the existing fill.

- Raise the existing fill levels beyond the existing dock water level within the area now enclosed on the development with self-compacting rock fill typically graded to between 250mm down to 100mm.
 - Introduction of hydraulically placed dredged sand to raise fill levels above the existing levels within the dock.
- 4.2.7 The options noted above each have their own advantages and disadvantages – with each discussed briefly within CCG’s report and subject to further deliberation and investigation during the detailed design phase of the development.
- 4.2.8 It is estimated approximately 55,500m³ of imported fill will be required for this development.
- 4.2.9 Following review of the ground conditions encountered, a potential settlement of 200mm is estimated at the surface of the existing submerged fill across the development once the 6m of imported fill has been installed in accordance with the suggested specification.
- 4.2.10 The neighbouring development for the new Isle of Man Ferry Terminal also involves land reclamation as a result there will be an interface between the two developments.
- 4.2.11 During detailed design, it will be imperative that both developments liaise with one another to ensure the infill works do not hinder each other’s development.

4.3 Individual Block Foundations

- 4.3.1 The potential for high levels of settlement to the existing infill material within the dock make the use of conventional concrete foundations bearing onto the fill implausible.
- 4.3.2 Therefore, the individual buildings are likely to utilise piled foundation solutions and this section will discuss the suggested design concepts to overcome the known obstructions and ground conditions of the development.
- 4.3.3 Blocks A, B and C will be sited within the West Waterloo Dock. Based on overlays of current with proposed, a small percentage of Block C overlays with the quayside.
- 4.3.4 As Blocks A, B and C sit within the newly infilled dock, it is likely Continuous Flight Augured (CFA) piles will be taken down to and socketed into the sandstone bedrock.
- 4.3.5 Block D sits across a number of ground conditions and existing structures – in particular over the existing quayside and into the infilled Waterloo Lock.
- 4.3.6 Similarly to the other blocks where these sit within the infilled dock, Block D will likely use CFA piles taken down to and socketed into the sandstone bedrock.
- 4.3.7 Where Block D spans across the existing quayside and the potential chambers, voids and mechanisms for the gates hidden within this quayside, there are a number of potential solutions to be considered for the foundation solution here. These include, but are not limited to;
- Bridging over the quayside with CFA piles likely to the West Waterloo Dock side and rotary piles likely to be installed within Waterloo Lock.

- Piling through the quayside structure into the underlying sandstone bedrock using rotary percussive methods (ODEX or similar).
 - Removing the soil infill and mass filling with concrete to provide a large spread foundation to support the superstructure above.
- 4.3.8 Each of the above options have their advantages and disadvantages in providing a suitable foundation structure over the quayside, with each proposal discussed within CCG's report. These will be subject to further deliberation and investigation during the detailed design phase of the development.
- 4.3.9 It is likely that within Waterloo Lock, the depth to the natural sandstone bedrock (approximately 21m below ground level) will make the use of CFA piling unlikely as there is a 3m thick concrete slab at the base of the lock.
- 4.3.10 It is anticipated rotary piling methods will be required and due to the depth of loose materials around the piles, there may be a requirement for permanent casings around the piles to be used.
- 4.3.11 Existing structures may result in offset bases/ cantilever ground beams in order to avoid said structures. This will need to be established with a detailed overlay of the proposed footprint on site with digs undertaken on site to identify any potential clashes.
- 4.3.12 CCGeotechnical Limited within their report discuss in detail the implications of piling in the vicinity of Merseytravel asset The Kingsway road tunnel, setting out some initial calculations and advising of vibration limits.
- 4.3.13 Outside of the superstructure and their foundations, the levels of potential settlement will necessitate that items such as drainage access chambers will need to be supported off piles to minimise the differential settlement between the neighbouring ground and the cover levels.

4.4 Quality Assurance, Method Statements, Risk Assessments

- 4.4.1 A stringent regime of material selection, compaction control, monitoring and validation testing will be employed for the dock infilling and the piling methods used on this development to ensure accountability can be identified at any point along the design and construction process.
- 4.4.2 This will not only support the integrity of the design solutions chosen for the dock infill and piling solution but ensure the wider environmental risks have been considered.
- 4.4.3 It is anticipated the information required to demonstrate compliance with the regulations and conditions in place for the works will include (but not be limited to) the type and source of imported fill and test reports to demonstrate acceptability of the fill materials, along the lines of the specification previously referred to within this report.
- 4.4.4 All documentation presented should be accompanied by relevant certification
- 4.4.5 Method Statements will be presented to show the safe method of works to be used and that those undertaking the works have the competency and relevant experience to achieve this.

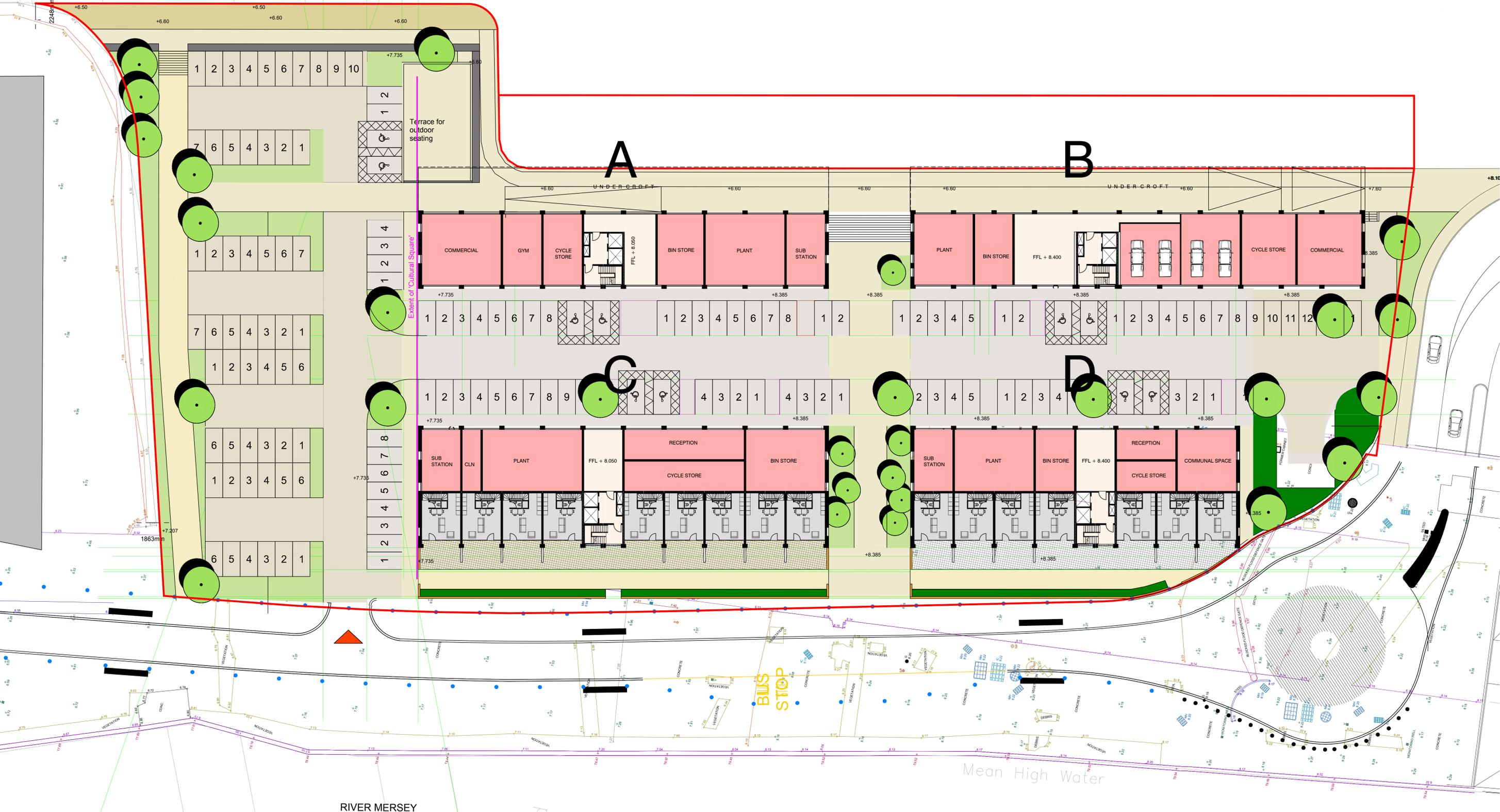
- 4.4.6 Risk Assessments will be presented in accompaniment to the Method Statements and reflect the proposed works – to cover not just the health and safety of those undertaking the works, but the surrounding environment effecting a number of receptors.
- 4.4.7 This can be undertaken and included within the preparation of a Construction Environmental Management Plan (CEMP). The CEMP will be implemented and adhered to throughout the Works.
- 4.4.8 The details of the CEMP will be agreed with LCC and the Marine Management Organisation (MMO) prior to the commencement of the Works and would comprise, in effect, an operational manual detailing the management, monitoring, auditing and training procedures to be followed during the Works to ensure compliance with relevant legislation, planning policy, regulations and best practice. It would also set out the specific roles and responsibilities of on-site personnel.
- 4.4.9 The CEMP includes but is not limited to:
- Details of the operations and phasing of the proposed dock infill and piling works.
 - Prohibited or restricted operations;
 - A framework for compliance with relevant legislation and guidance;
 - Proposed Plant to be used;
 - Details of proposed routes for vehicles travelling to and from the site;
 - Roles and responsibilities of key staff including training of staff, liaison with stakeholders and management of enquiries and complaints;
 - Details of emergency procedures which would be implemented;
 - Details of general site management practices, including working hours, hoarding, access, lighting, site facilities, energy and water use, waste, materials procurement and storage;
 - Details of environmental management and control procedures, covering issues such as traffic and access, noise and vibration, dust, archaeology, contamination, hazardous materials, drainage and pollution control;
 - Requirements for auditing, monitoring and record-keeping;
 - Mechanisms for third parties to register complaints and the procedures for responding to complaints; and
 - Provisions for reporting, public liaison and prior notification, especially where dispensations would be required.
- 4.4.10 During the consideration of piling options, a piling risk assessment will be undertaken in accordance with the Environment Agency 2001 report – Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention.
- 4.4.11 The Piling Risk Assessment will identify any potentially unacceptable risks from the proposed piling works (i.e. creation of pathways for contamination to become a risk to a variety of receptors).

5.0 SUMMARY

- 5.1 The development of Plot CO2 will consist of the construction of a new dock wall within West Waterloo Dock and the subsequent infilling of this dock to provide a platform to construct seven new residential blocks with additional areas for commercial use.
- 5.2 The desktop study and intrusive site investigations undertaken by CC Geotechnical and presented in their Ground Investigation Report (October 2018), established West Waterloo Dock has an extensive history and has undergone significant alterations since its opening in 1834.
- 5.3 The report indicates the dock has previously been backfilled with loose granular material classified as 'Made Ground' with the water at a consistent depth of approximately 3m and the fill ranging in depth between 2.5 – 15m before the natural sandstone bedrock is encountered.
- 5.4 It is anticipated that the dock wall between the development and the dock will be constructed using a 'Combi-wall' piling solution or a similar type of arrangement.
- 5.5 It is estimated in the region of 6m depth of imported fill will be required to increase existing levels to the proposed development levels.
- 5.6 An outline specification has been provided for the imported fill, laying and testing procedures to be followed.
- 5.7 The introduction of the imported fill will result in settlement of the existing loose fill within the dock and this has been estimated to be in the region of 200mm.
- 5.8 A variety of piling techniques are suggested to support the superstructures of the proposed blocks due to the range of ground conditions and obstructions (dock walls, gate mechanisms, etc) likely to be encountered.
- 5.9 Some of the piling operations are likely to be over or in the vicinity of the existing Kingsway Road Tunnel with some initial recommendations noted with the Ground Investigation Report.
- 5.10 The proposed works will require stringent regime of material selection, compaction control, monitoring and validation testing will be employed for the dock infilling and the piling methods used on this development along with all relevant certification.
- 5.11 A Construction Environmental Management Plan (CEMP) will be necessary to ensure compliance with legislation, regulations, planning policy and best practice.
- 5.12 A Piling Risk Assessment will be required to show consideration of potential contamination, pathways and receptors.
 - 5.12.1 The neighbouring development for the new Isle of Man Ferry Terminal also involves land reclamation and piling works and as a result there will be an interface between the two developments. During detailed design, it will be imperative that both developments liaise with one another to ensure the works do not hinder each other's development.

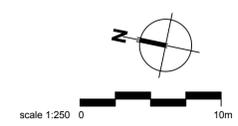
APPENDIX A
Proposed Site Plan

Cont. edge of batter



- cores/ reception/ circulation
- one bed - 38sqm
- two bed - 57sqm
- three bed - 97sqm
- penthouse - varies
- duplex - 79sqm
- ancillary

C02 SITE GROUND FLOOR PLAN



NOTES
1. This drawing is copyright of Ollier Smurthwaite Architects Ltd

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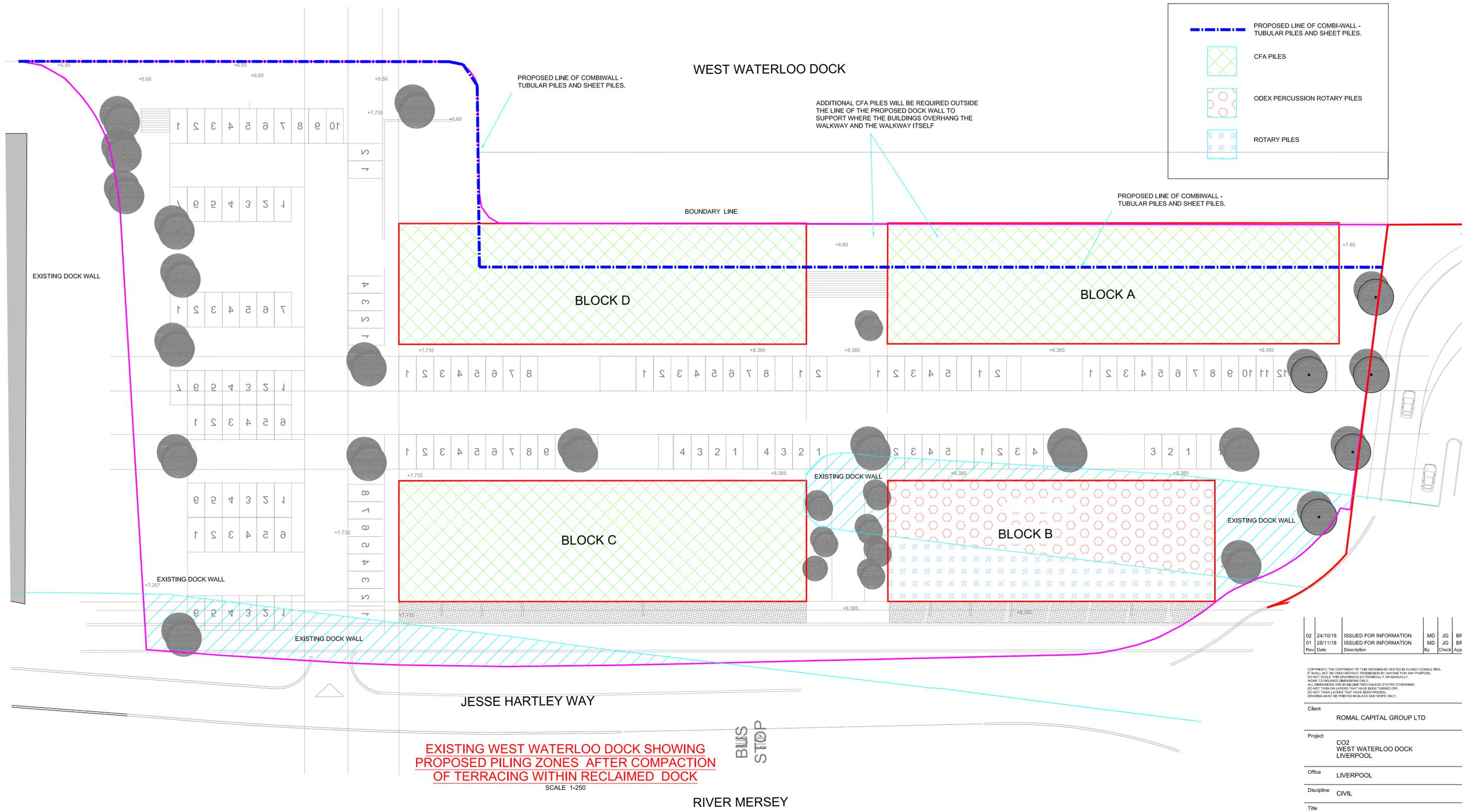
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OLLIER SMURTHWAITE ARCHITECTS

Client	ROMAL CAPITAL	Scale	1:500@A3	Drawn	VM	Checked	DM	Date	20.08.19
Job title	LOTS C02 CENTRAL DOCKS, LIVERPOOL	Job number	A476	Drawn number	A476_P_101				
Drawing title	PROPOSED GROUND FLOOR PLAN								

APPENDIX B

Concept Piling Solutions General Arrangement Drawing



PROPOSED LINE OF COMBIWALL - TUBULAR PILES AND SHEET PILES.

CFA PILES

ODEX PERCUSSION ROTARY PILES

ROTARY PILES

ADDITIONAL CFA PILES WILL BE REQUIRED OUTSIDE THE LINE OF THE PROPOSED DOCK WALL TO SUPPORT WHERE THE BUILDINGS OVERHANG THE WALKWAY AND THE WALKWAY ITSELF

EXISTING WEST WATERLOO DOCK SHOWING PROPOSED PILING ZONES AFTER COMPACTION OF TERRACING WITHIN RECLAIMED DOCK
SCALE 1-250

AREAS OUTSIDE OF THE AREAS DENOTED FOR PILING (I.E. BETWEEN BLOCKS, CAR PARKING, ETC) WILL BE SUBJECT TO BACKFILLING WITH ENGINEERING FILL IN ACCORDANCE WITH SPECIFICATIONS TO PROVIDE A PLATFORM SUITABLE FOR LOADING TO VEHICULAR/ FOOT TRAFFIC.

NOTES

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ENGINEERS AND ARCHITECTS DRAWINGS AND SPECIFICATION.

DO NOT SCALE OFF THIS DRAWING

REFER TO EXISTING SITE INVESTIGATION REPORTS FOR GROUND CONDITIONS.

ANGLE OF CUT ASSUMED 45 DEGREES .

02	24/10/19	ISSUED FOR INFORMATION	MD	JG	BRH
01	28/11/18	ISSUED FOR INFORMATION	MD	JG	BRH
Rev	Date	Description	By	Check	App.

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Client	ROMAL CAPITAL GROUP LTD				
Project	CO2 WEST WATERLOO DOCK LIVERPOOL				
Office	LIVERPOOL				
Discipline	CIVIL				
Title	CONCEPT PILING SOLUTIONS GENERAL ARRANGEMENT				
Scale @ A1	AS STATED	Status	INFORMATION		



Job Number	Originator	Building/Zone	Level
4_6679	CCL	CO2	EXT
Type	Discipline	Drawing No.	Revision
GA	C	SK02	01

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APPENDIX C**CCGeotechnical Ground Investigation Report
(October 2018)**