APPENDIX C
SUMMARY OF LEGISLATION AND POLICY RELATING TO CONTAMINATED LAND

Part IIA of the Environmental Protection Act 1990

Part IIA of the Environmental Protection Act 1990 (Part IIA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, formed the basis for the current regulatory framework and the statutory regime for the identification and remediation of contaminated land. Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters are considered to include all groundwater, inland waters and estuaries.

In August 2006, the Contaminated Land (England) Regulations 2006 (SI 2006/1380) were implemented, which extended the statutory regime to include Part IIA of the EPA as originally introduced on 1 April 2000, together with changes intended chiefly to address land that is contaminated by virtue of radioactivity. These have been replaced subsequently by the Contaminated Land (England) (Amendment) Regulations 2012, which now exclude land that is contaminated by virtue of radioactivity.

The intention of Part IIA is to deal with contaminated land issues that are considered to cause significant harm on land that is not undergoing development (see Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, April 2012). This document replaces Annex III of Defra Circular 01/2006, published in September 2006 (the remainder of this document is now obsolete).

Planning Policy

Contaminated land is often dealt with through planning because of land redevelopment. This approach was documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use. PPS23 was withdrawn early in 2012 and has been replaced by much reduced guidance within the National Planning Policy Framework (NPPF), reference ISBN: 978-1-4098-5302-2, July 2018.

The new framework has only limited guidance on contaminated land, as follows:

- *"planning policies and decisions should also ensure that:*
    - *the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation;*
    - *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*

- *adequate site investigation information, prepared by a competent person, is presented".*

Water Resources Act (WRA)

The Water Resources Act 1991 (Amendment) (England and Wales) Regulations 2009 updated the Water Resources Act 1991, which introduced the offence of causing or knowingly permitting pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so.

Water Framework Directive (WFD)

The Water Framework Directive 2000/60/EC is designed to:

- enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands that depend on the aquatic ecosystems
- promote the sustainable use of water
- reduce pollution of water, especially by 'priority' and 'priority hazardous' substances
- ensure progressive reduction of groundwater pollution.

The WFD requires a management plan for each river basin be developed every six years.

Groundwater Directive (GWD)

The 1980 Groundwater Directive 80/68/EEC and the 2006 Groundwater Daughter Directive 2006/118/EC of the WFD are the main European legislation in place to protect groundwater. The 1980 Directive is due to be repealed in December 2013. The European legislation has been transposed into national legislation by regulations and directions to the Environment Agency.

Priority Substances Directive (PSD)

The Priority Substances Directive 2008/105/EC is a 'Daughter' Directive of the WFD, which sets out a priority list of substances posing a threat to or via the aquatic environment. The PSD establishes environmental quality standards for priority substances, which have been set at concentrations that are safe for the aquatic environment and for human health. In addition, there is a further aim of reducing (or eliminating) pollution of surface water (rivers, lakes, estuaries and coastal waters) by pollutants on the list. The WFD requires that countries establish a list of dangerous substances that are being discharged and EQS for them. In England and Wales, this list is provided in the River Basin Districts Typology, Standards and Groundwater threshold values (Water Framework Directive) (England and Wales) Directions 2010. In order to achieve the objectives of the WFD, classification schemes are used to describe where the water environment is of good quality and where it may require improvement.

Environmental Permitting Regulations (EPR)

The Environmental Permitting (England and Wales) Regulations 2010 provide a single regulatory framework that streamlines and integrates waste management licensing, pollution prevention and control, water discharge consenting, groundwater authorisations, and radioactive substances regulation. Schedule 22, paragraph 6 of EPR 2010 states: 'the regulator must, in exercising its relevant functions, take all necessary measures - (a) to prevent the input of any hazardous substance to groundwater; and (b) to limit the input of non-hazardous pollutants to groundwater so as to ensure that such inputs do not cause pollution of groundwater.'

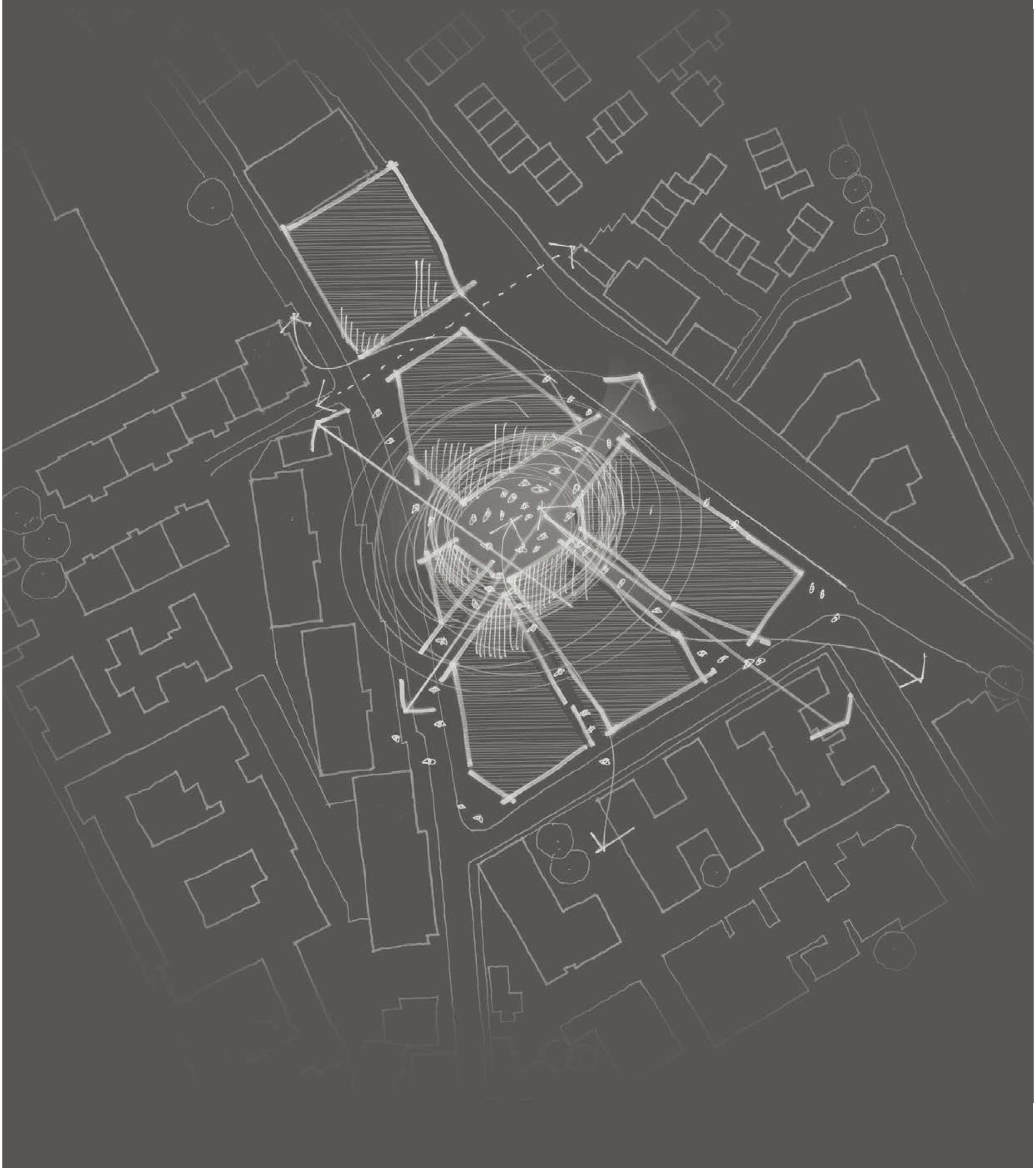
APPENDIX D
ENVIRONMENTAL DATABASE REPORT

Transformation of the Ugly Brown Building

DTS Raeburn

Preliminary Risk Assessment

June 2017



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PRELIMINARY RISK ASSESSMENT REPORT FOR UGLY BROWN BUILDING, 2-6 ST PANCRAS WAY LONDON NW1 0TB

Prepared by
DTS Raeburn Limited

Client: GD Partnership Ltd

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Generic List of Acronyms and Abbreviations

µg/kg	micrograms per kilogram
µg/l	micrograms per litre
ACEC	aggressive chemical environment for concrete
ACM	asbestos containing material
AOD	above Ordnance datum
bgl	below ground level
BGS	British Geological Survey
BH	borehole
BTEX	benzene, toluene, ethylbenzene and xylene compounds
CBR	California bearing ratio
CH_4	methane
CIRIA	Construction Industry Research and Information Association
CLR	Contaminated Land Report
CO	carbon monoxide
CO_2	carbon dioxide
COMAH	control of major accident hazards
CPT	cone penetration test
CSM	conceptual site model
DEFRA	Department of Environment, Food and Rural Affairs
DoE	Department of Environment (now part of DEFRA)
DP	dynamic probe
DPSH	dynamic probe super heavy
DQRA	detailed quantitative risk assessment
DS	design sulphate class
DWS	drinking water standard
EA	Environment Agency
EHO	Environmental Health Officer
EQS	environmental quality standard
FRA	flood risk assessment
GAC	generic assessment criteria
GPR	ground penetrating radar
GPS	global positioning systems
GQRA	generic quantitative risk assessment
GW-TV	groundwater threshold value
ha	hectare
H_2S	hydrogen sulphide
HPA	Health Protection Agency
HSE	Health and Safety Executive
IPPC	Integrated Pollution Prevention and Control
LAPPC	Local Authority Pollution Prevention and Control
LNR	Local Nature Reserve
mb	millibar
MCERTS	Monitoring Certification Scheme
mg/kg	milligrams per kilogram
mg/l	milligrams per litre
NIEA	Northern Ireland Environment Agency
NGR	National Grid Reference
O_2	oxygen
OS	Ordnance Survey
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PFS	petrol filling station
PPE	personal protective equipment
PRA	preliminary risk assessment
SAC	Special Area of Conservation
SEPA	Scottish Environment Protection Agency
SGV	soil guideline value
SOM	soil organic matter
SPA	Special Protection Area
SPT	standard penetration test
SPZ	Source Protection Zone
SSSI	Site of Special Scientific Interest
SVOCs	semi-volatile organic compounds
TOC	total organic carbon
TP	trial pit
TPH	total petroleum hydrocarbons
TPO	Tree Preservation Order
UKAS	United Kingdom Accreditation Service
UXO	unexploded ordnance
VOCs	volatile organic compounds
WAC	Waste Acceptance Criteria
WFD	Water Framework Directive
WHO	World Health Organisation
WS	window sampling borehole

PRELIMINARY RISK ASSESSMENT REPORT FOR UGLY BROWN BUILDING, 2-6 ST PANCRAS WAY, LONDON NW1 0TB

Executive Summary

Objectives and Scope of Report	To carry out a PRA of the site in accordance with the risk assessment framework presented in CLR11 in order to assess the potential geo-environmental risks for proposed redevelopment at the site. It is understood that the existing building on the site will be redeveloped in phases and will involve construction of additional floors, extensions, partial demolition and refurbishment.
Site Description	The site is roughly triangular and covers approximately 1.14ha. The site is accessed from St. Pancras road to the west and is currently occupied by office accommodation within a five storey portal frame structure. There is also car parking, a plant room and a fuel tank located on the ground floor; no evidence of spillage or leakage was noted on the hardstanding.
Geology	The site is indicated to be directly underlain by bedrock of the *Palaeogene* London Clay Formation. An intrusive site investigation was undertaken prior to the construction of the existing building which was previously used as a postal sorting office. It was indicated that the site was underlain by up to 2.5m bgl of made ground, overlying approximately 20m thickness of London Clay. This was underlain by the Woolwich and Reading Beds (clay).
Hydrology	The nearest surface water is the Grand Union Canal located adjacent the north east boundary of the site.
Hydrogeology	The London Clay is classified as unproductive strata. The site does not lie within a Source Protection Zone (SPZ) and there are no abstractions for potable supplies within 1km of the site.
Ecological Receptors	There is a local nature reserve located 500m to the southeast of the site. There are no other major ecological receptors located within 1km of the site.
Flood Risk	The site lies within a Flood Zone 1 (lowest risk).
Key Historical Developments	The historical maps and planning records consulted indicate that the site was used for the storage of ale from at least 1875 with additional granary storage from the early 1950s. There was a small unidentified building and railway sidings located in the north of the site up until the late 1960s. By 1985 the site had been redeveloped into a postal sorting office that covered the entire site. The building has remained largely unchanged up until the present day and is now occupied by office accommodation.
Mineral Extraction	It is considered unlikely that subsidence due to mineral extraction will affect the site.
Ground Contamination Risk/Liability Assessment	Residual contamination associated with the historical use of the site and its locality may present a risk of pollution to human health and end development. It is recommended that an exploratory intrusive investigation be undertaken to assess the extent of residual ground contamination beneath the site and the associated risk. It is also recommended that gas / vapour monitoring be included as part of the scope of the intrusive investigation.
Other Considerations	• Geotechnical ground investigation is recommended prior to the proposed development in order to provide quantitative data for foundation design. • It is recommended that a preliminary UXO desk study is undertaken prior to any intrusive investigation. • An asbestos survey should be undertaken prior to any redevelopment and any known ACM should be removed by a licensed asbestos removal contractor.
Summary of main risks	A summary of the main risks to the proposed development at the site are tabulated in Section 8.6. This list is not exhaustive and should be read in conjunction with the main text of the report.
Limitations	The limitations of this report are highlighted in Section 9.0.

1.0 INTRODUCTION

DTS RAEBURN Limited were commissioned by GD Partnership Ltd to carry out a preliminary risk assessment (PRA) of a site located on St Pancras Way, Camden, London. It is understood that the site is to be redeveloped in three phases.

The principal objective of the PRA was to assess whether the land is potentially contaminated or whether there are other potential geo-environmental liabilities. These could include, but are not limited to, subsidence hazards due to shallow mining, the generation or migration of soil gas to beneath the site and other geotechnical abnormalities.

The environmental aspects of the PRA have been prepared utilising a risk-based approach and incorporating the accepted 'pollutant linkage' approach to contaminated land hazard identification (i.e. contaminant–pathway–receptor linkage). This approach is consistent with methodologies contained in both CLR11 'Model Procedures for the Management of Land Contamination' (DEFRA and EA, 2004) and Part IIA of the Environmental Protection Act 1990. The latter was introduced by Section 57 of the Environment Act 1995, which came into force in England and Wales in April 2000.

The scope of the PRA included a desk study and site reconnaissance, which comprise the minimum information required for sites where contamination is either known or suspected. The PRA has also been designed to fulfil the objectives of a 'preliminary investigation' as defined by British Standard BS10175:2011 'Investigation of Potentially Contaminated Sites – Code of Practice'.

The following information has been used to formulate the PRA report:

- Site walkover survey on 31st March 2016
- Historical OS maps supplied by Landmark
- BGS Sheet 256 of North London (1:63,360 Solid and Drift Edition)
- Environmental database information prepared by Landmark
- Correspondence with local authorities and other statutory agencies
- The Structural Engineer, Volume 63A, Paper No.4 (April 1985) 'The Granary Site – design and construction of a mechanised letter-sorting office'

2.0 SITE AND SURROUNDING AREA

2.1 Site Location

The site is located on St Pancras Way, Camden, London as shown in Figures 1 and 2. The site is centred on NGR 529630, 183749. Vehicular access to the site is gained from St Pancras Way to the west.

2.2 Site Description

A photographic record taken during the site walkover undertaken in March 2016 is presented as Plates 1-4, located after the report figures. A plan showing the layout of the site and the immediate surrounding area is included as Figure 3.

The site is roughly triangular and covers approximately 1.14ha. The site is accessed from St Pancras Way to the west and is currently occupied by both office accommodation and a data centre.

The current site comprises of a five storey portal frame structure with a car parking, a fuel tank and a plant room located on the ground floor. The ground floor has a concrete floor slab and no evidence of spillage or leakage was noted during the site visit.

2.3 Ecology/Invasive & Injurious Plant Species

Detailed ecological and agricultural surveys were outside the scope of this report. However, no Japanese Knotweed or other injurious or invasive weeds were observed within or immediately adjacent to the site at the time of the reconnaissance.

2.4 Surrounding Area

The area surrounding the site comprises the following:

- Grand Union Canal to the northeast with residential units beyond.
- Commercial units to the northwest
- St Pancras Way to the southwest with parking, commercial and residential units beyond
- Granary Street to the southeast with St Pancras Hospital beyond

3.0 GEO-ENVIRONMENTAL SETTING

3.1 Topography

No topographical survey data for the site had been supplied to DTS at the time of writing. However, a recent digital map of the area supplied by Landmark Information Group Limited identifies the site to lie about 25m Above Ordnance Datum (AOD). Site observations suggest that the footprint of the building is flat however the site generally slopes downwards from east to west with a drop of around 2m noted along Granary Street.

3.2 Geological Setting

3.2.1 Geological Map Information

The geology of the site has been determined by reference to BGS Sheet 256 of North London (1:63,360 Solid and Drift Edition), from which Figure 4 has been extracted. Reference has also been made to online BGS geological mapping and the Lexicon of Named Rock Units.

The referenced information indicates the site to be directly underlain by bedrock of the London Clay Formation consisting of clay, silt and sand of the *Palaeogene Period*. There are no recorded superficial deposits at the site.

3.2.1 The Structural Engineer – Volume 63A

In April 1985 The Structural Engineer produced a paper entitled ‘The Granary Site – design and construction of a mechanised sorting office’, as presented in enclosure A. This paper included a summary of an intrusive site investigation that was undertaken prior to construction of the sorting office. It was indicated that the former granary building had been founded upon a concrete raft foundation that had been placed by excavating down approximately 6m below the water level of the adjacent canal, above which 225mm thick sandstone blocks had been placed on a 4.2m grid to form bases to cast iron columns. According to the paper the concrete raft had been placed directly upon London Clay and infilling above the concrete raft and around the sandstone blocks had been carried out with approximately 1.2m of reworked clay upon which the floor had been constructed. This was confirmed within nine borehole records that indicated that the hardstanding of the former granary building was underlain by approximately 20m of London Clay that was in turn underlain by clay of the 'Woolwich and Reading Beds'. It is reported that triaxial tests were undertaken on the clay indicating cohesion values ranging from 50 to 400kN/m^2 and increasing with depth (firm to hard clay).

3.2.2 BGS Borehole Information

Reference has been made to the records of two boreholes located approximately within a 100m radius of the site, that were obtained from the BGS database. A summary of the ground conditions reported is presented in Table 3.1 below and a copy of the corresponding exploratory hole records are presented in Enclosure B.

Table 3.1 Summary of BGS Borehole Records

BGS Reference	Depth (m bgl)	Discription	Groundwater
TQ28SE314 (40m W)	0.00-0.60 0.60-7.10	MADE GROUND: Tarmac over made ground Brown CLAY	Not encountered
TQ28SE1564 (70m S)	0.00-1.2 1.2-6.0 6.0-15.0 15.0-25.0 25.0-92.0	MADE GROUND Brown CLAY ('Drift') Blue CLAY (London Clay) Woolwich and Reading Beds and the Thanet Sands Upper Chalk	About 64m bgl to 77m bgl

3.3 Hydrology

The nearest surface water is the Grand Union Canal located adjacent the north east boundary of the site. It was indicated in The Structural Engineer paper that the construction of the canal wall was found to be suspect during the intrusive site investigation undertaken prior to construction of the existing building in 1985. Following approval from the canal authority a new permanent sheet steel wall was constructed in the canal over the whole length of the site and sealed back into the existing wall at each end.

Given that the adjacent canal is known to be lined with a sheet steel wall and the low permeability of the underlying London Clay, the site is not considered sensitive with respect to surface water.

3.4 Hydrogeology

The maps included in Enclosure C and information from the Environment Agency indicates that the underlying London Clay is classified as unproductive strata.

The site does not lie within a Source Protection Zone (SPZ) and there are no abstractions for potable supplies within 1km of the site.

In view of the foregoing information, the site is not considered sensitive with respect to groundwater resources.

3.5 Major Ecological Receptors

There is a local nature reserve located 500m to the southeast of the site (Camley Street Nature Park), however this is considered to be too far away to be affected by the site. There are no other major ecological receptors located within 1km of the site.

3.6 Flood Risk

The flood map (also presented in Enclosure C) and further information from the EA indicates that the site lies within a Flood Zone 1 (lowest risk).

3.7 Summary

The site is not considered sensitive with respect to controlled waters, ecological receptors or flooding.

4.0 SITE HISTORY

The site history has been deduced primarily from a review of historical OS maps provided by Landmark and complemented by information supplied by the Local Planning Authority. Where necessary, additional enquires were made in the site locality.

4.1 Historical maps

Table 4.1 summarises the previous uses of the site and surrounding area as identified in maps dated between 1850 and 2015. Copies of the maps referenced in the table are included in Enclosure D. Any identified uses of the site and the surrounding area that are considered potentially contaminative are shown in ***bold italics***. The distances and directions from the site stated in the table below are approximate.

Table 4.1 Review of Historical Maps

On-site	Surrounding area
1875 (1:2,500)	
The majority of the site is used as an ale store; there is also an unmarked building and ***railway sidings*** in the northwest.	There is a canal adjacent the northeast of the site with a ***goods depot*** and shed beyond. ***Railway sidings*** extend to the northeast of the site. The ***railway*** is located 100m to the east of the site with a number of ***engine sheds*** beyond. There is a road adjacent the southwest of the site with stables and ***veterinary*** college beyond (within 50m). There are residential developments within 100m to the west and northwest and a ***hospital*** located beyond a road to the southeast.
1896 (1:2,500)	
The ale store now appears to be under cover and is main building on the site.	There is a mineral water ***manufacturer*** located 100m to the northwest.
1916 (1:2,500)	
No significant developments are indicated.	The mineral water ***manufacturer*** is now marked as Idris ***Factories*** and Camden ***Works*** is located 70m to the west.
1953 (1:2,500)	
The main building is now marked as granary warehouse and ale store.	St Pancras ***generating station*** is located 200m to the northwest. Camden ***Works*** are now marked as Britannia ***Works***.
1968 (1:2,500)	
The building in the north is no longer shown but there is evidence of some earthworks present, possibly related to its ***demolition.***	There is an ***engineering works*** located 20m to the west.
1988 (1:2,500)	
The ***railway sidings*** have been removed from the north of the site. The site has been redeveloped into a sorting office and the building covers the entire site.	The ***goods depot*** and associated buildings and ***sidings*** are no longer present to the northeast of the site and have been replaced with warehouses. There are also warehouses 80m to the west and the ***engineering works*** is now used for commercial units. The Idris ***Factories*** have been replaced with ***garages and workshops***.

On-site	Surrounding area
1991 (1:10,000)	
No significant developments are indicated.	No significant developments are indicated.
2016 (1:10,000)	
No significant developments are indicated.	No significant developments are indicated.

4.2 Planning History

Information held by the Planning Department of Camden Council includes seventeen separate planning applications for development within the site boundary that have been submitted since 1st January 1926. Approval was granted for the erection of a new postal sorting office with ancillary administration, welfare, workshop and car parking accommodation on 18th January 1980 (application number 29863). The other sixteen applications referred to minor extensions and/or alterations to the existing development and are not considered significant.

4.3 UXO

Given the development history of the site and the nearby canal and railway lines (likely targets), the possibility of unexploded ordnance (UXO) being present beneath or adjacent the site cannot be discounted. Furthermore, available online information indicates that high explosive bombs were dropped in the vicinity of the site during World War II. On this basis, it is recommended that a preliminary UXO desk study is undertaken.

4.4 Summary

The historical maps and planning records consulted indicate that the site was used for the storage of ale from at least 1875 with additional granary storage from the early 1950s. There was also a small unidentified building and railway sidings located in the northwest of the site up until the late 1960s. By 1985 the site had been redeveloped into a postal sorting office that covered the entire site. The building has remained largely unchanged up until the present day and is now occupied by office accommodation. There have been a number of industrial uses in the site locality since the late nineteenth century.

The possibility of ground contamination having occurred at the site as a result of its current and historical use is discussed further in Section 7.0 (Initial Conceptual Site Model).

5.0 MINERAL EXTRACTION

Reference to the Coal Authority website indicates that the site is not located within a coal mining area. Additionally, the historical maps reviewed in Section 4.0 show no evidence of mineral extraction within the site vicinity.

On the basis of the above, it is therefore considered that the proposed development is unlikely to be affected by subsidence due to mineral extraction activities.

6.0 ENVIRONMENTAL DATABASE INFORMATION

Enclosure C contains a database of environmental information supplied by Landmark Information Group. The main points of note within this database are tabulated below:

Table 6.1 Summary of Environmental Database Information

	No. of incidents		Details of notable database entries	
	0-250m	251-500m	Distance & Direction from site	Additional Information
Discharge Consents	0	0	-	There are 5no. within 1km of the site which all relate to trade discharge – cooling water
LAPPC	1	3	197m SW 258m NE 292m NW 408m NE	Dry Cleaning Blending, packing, loading, and use of bulk cement Blending, packing, loading, and use of bulk cement Blending, packing, loading, and use of bulk cement
Pollution Incidents	1	2	167m SE 308m SE 405m SE	All of the incidents were classified as Category 3 (minor) and related to miscellaneous and oil pollutants.
Water Abstractions	1	1	140m SE 327m NE	Non-remedial river /wetland support Mineral products: General use
Registered radioactive substances	14	1	Various	Related to the use, storage and disposal of radioactive material by the veterinary college and hospital located 70m SW and 100m SE respectively.
Landfill sites	0	0	-	-
Licensed Waste Management Facilities	2	5	71m S 208m E	Metal recycling sites Household, commercial and industrial transfer centre
COMAH sites	0	0	-	-
Fuel Station Entries	0	0	-	There are 11 fuel station entries within 1km
Potentially contaminative land uses	40	80	Various	The database indicates that there are 40 potentially contaminative land uses within 250m of the site including mechanical engineers, clothing and textile manufacturers, laboratories, building merchants, garage services, scrap metal merchants, photographic processors, printers, a hospital, commercial and domestic cleaning services, food and confectionary manufacturers, and pharmaceutical manufacturers and distributors.

The database entries have identified the presence of various industrial activities in the vicinity of the site. The possibility of ground contamination having been caused at the site as a result of these activities is discussed further in Section 7.0.

Table 6.2 Geological Conditions

Hazard	Risk On-site
Shrinking or swelling clay	Moderate
Collapsible ground	Very Low
Compressible ground	No Hazard
Ground dissolution	No Hazard
Landslide Ground stability	Very low
Running sand ground stability	No Hazard

7.0 INITIAL CONCEPTUAL SITE MODEL (CSM)

A qualitative risk assessment of the site was undertaken utilising the information obtained in the preceding desk study section of the report in order to facilitate the development of an initial CSM. This was based on a risk-based approach and incorporated the accepted contaminant–pathway–receptor linkage approach ('pollutant linkage') outlined in Part IIa of the Environmental Protection Act 1990. This approach also follows the risk assessment framework included in CLR11 (DEFRA and EA, 2004) in which three essential elements to any risk are considered:

- A **contaminant** – a substance that is in, on or under the land and has the potential to cause harm or to cause pollution of controlled waters;
- A **receptor** – in simple terms, something that may be adversely affected by a contaminant
- A **pathway** – a route or means by which a receptor can be exposed to, or affected by, a contaminant.

A risk is created only where the above three elements are linked together, and must first be established for a contaminated land hazard to exist and before any other secondary considerations are given to the effects and the need/requirement for remediation.

Table 7.1 below summarises the potential contaminants, receptors and pathways identified. Contaminants arising from the current and historical uses of both the site and surrounding area have been considered. For the purpose of this assessment the contaminants have been separated according to whether they are likely to have originated from on-site or off-site sources.

Table 7.1 Initial CSM

Potential sources (Associated Contaminants)
On-site sources: • Current use of site and associated car park (generally considered to present a low likelihood of ground contamination, however, the possibility of hydrocarbon contamination as a result of localised oil or fuel leakages from vehicles has been considered) • Former railway sidings (*heavy metals, TPH, PAH, glycols and acids/alkalis (low/high soil pH*). • Demolition of former buildings (*asbestos and heavy metals associated with pipework and/or paint*).
Off-site sources: • Current and former industrial activities undertaken within 250m of the site (*heavy metals, inorganic ions, TPH, PAH, phenols, dyes/solvents, sulphates and acid/alkalis (low/high soil pH)*). • Existing and former railway lines / sidings located within 250m of the site (*heavy metals, TPH, PAH, glycols and acids/alkalis (low/high soil pH*). • Demolition of former works within 250m of the site *(asbestos and heavy metals associated with pipework and/or paint*).
Potential Receptors
• Humans: Construction workers, future maintenance workers, site end users, off-site residents. • Development end use: buildings, hardstandings, services, utilities and limited landscaped areas.
Potential pathways
• Humans: Ingestion, skin contact, inhalation of dust and indoor and outdoor air • Development end use: Contact

The CSM summarises the identified potential sources of ground contamination, potential exposure/migratory pathways and potential receptors, and indicates that it is possible for the accepted contaminated land hazard identification convention (contaminant–pathway receptor linkage) to be completed for this site with respect to human receptors and the development end use as a result of both on-site and off-site sources of contamination.

Section 8 below provides a prioritisation of risk.

8.0 PRELIMINARY RISK ASSESSMENT

8.1 Ground Contamination Risk Prioritisation

Tables 8.1(a) and 8.1(b) summarises each of the potential 'pollutant linkages' identified in the initial CSM and classifies the associated risk based on a comparison of the 'pollutant linkage' occurring against the severity of the consequence. This approach is based on that presented in CIRIA Guidance document C552 (2001). The comparison and definitions of the classified risks are provided in Tables 6.5 and 6.6 of that document, copies of which are presented in Enclosure E.

Table 8.1(a) Risk Evaluation of Potential Pollutant Linkages (on-site sources)

On-site Sources	Pathway	Receptor	Consequence	Probability	Risk Classification
Ground contamination from recent site activities (storage of fuel / chemicals and possible leakage from parked vehicles)	Direct contact with or ingestion of impacted soils. Inhalation of volatile vapours	Humans Health: existing and future site occupiers and end development	Medium	Unlikely	Low
Contamination from demolition of former buildings and potentially conatminated made ground	Direct contact with or ingestion of impacted soils Inhalation of volatile vapours and asbestos fibres Migration of volatile vapours into buildings Penetration of services by contaminants	Humans Health: existing and future site occupiers and end development	Severe	Unlikely	Moderate/ Low

Table 8.1(b) Risk Evaluation of Potential Pollutant Linkages (Off-site sources)

Off-site Sources	Pathway	Receptor	Consequence	Probability	Risk Classification
Contamination from industrial activities within a 250m radius of the site (inclusive of demolition of former buildings)	Lateral migration of gases to beneath site. Subsequent inhalation of volatile vapours by humans	Humans Health: existing and future site occupiers and end development	Severe	Unlikely	Moderate/ Low

The assessment in Table 8.1 indicates a low risk to site occupiers and the existing development from ground contamination caused by existing site activities. However, a potentially moderate / low risk is indicated with respect to residual contamination from demolition of former buildings, made ground and other industrial activities within the site locality.

8.2 Preliminary Geotechnical Assessment

BGS and site specific information suggests that the site is underlain by a variable thickness of made ground underlain by bedrock geology of the London Clay Formation up to about 20m bgl. This is underlain by Woolwich and Reading Beds.

An intrusive investigation at the site is recommended to provide quantitative data for foundation and pavement design. The potential for shrinkage / swelling of the clay should also be investigated.

8.3 Asbestos Survey

Reference should be made to the Asbestos Register for the premises, and where appropriate an asbestos survey should be undertaken to identify all ACMs that will require removal by a suitably licensed specialist contractor, prior to any demolition / redevelopment at the site.

8.4 Soil Gas Hazards

The site is underlain by London Clay which is unlikely to constitute a potential natural source of ground gases including methane and carbon dioxide. There is however a potential risk of gas/vapour ingress into any future development from the historic industrial land uses in the locality of the site.

It is recommended that a gas monitoring regime should be incorporated into any future intrusive investigation works in order to assess the requirement and extent of any gas protection measures required at the site.

The site is in a low probability radon area, as less than 1% of homes are above the action level. However, Public Health England guidance also recommends that basic radon protection measures should be included in all new buildings regardless of their location. Basic radon protection measures comprise a radon barrier, which would also act as the damp-proof membrane and afford some protection from ingress of other soil gases.

8.5 UXO Survey Recommendations

It is recommended that a preliminary UXO desk study is undertaken (see Section 4.3).

8.6 Summary of Main Risks

Table 8.6 summarises the main risks to the proposed redevelopment identified by the PRA as perceived by DTS Raeburn. A risk classification has not been included, as this would need to include a likely cost-benefit analysis, which is outside the scope of this report. The list of hazard/risks tabulated is not exhaustive and should be read in conjunction with the main text of the report.

Table 8.6 Summary of main identified risks

Hazard/Risk	Cause	Possible Impact/ Consequence	Recommendations
Potential inhalation of gas/volatile vapours by future site occupiers	Release of gas/vapours from affected soils/groundwater beneath the site and its locality	Possible migration into buildings/services	Undertake gas monitoring in existing building and shallow boreholes, recommended as part of any future site investigation works.
Potential ground contamination	Nature of made ground and underlying soils	Damage to end development	Protection of underground services and substructures
Geotechnical considerations	Possible soft ground conditions. Potential for shrinking or swelling clay	Need for piled foundations or ground improvement if ground conditions unsuitable for shallow foundations. Cost and programming implications	Geotechnical investigation recommended as part of any future site investigation works to provide quantitative data for foundation design

9.0 LIMITATIONS AND USE OF THIS REPORT

IMPORTANT: This section should be read before reliance is placed on any of the opinions, advice, recommendations and conclusions contained in this report.

a) This report has been prepared on behalf of GD Partnership Ltd ('the Client') pursuant to their appointment of DTS Raeburn Limited in connection with the PRA;

b) Except for GD Partnership Ltd, no duty is undertaken or warranty or representation made to any party in respect of the opinions, advice, recommendations or conclusions contained in this report;

c) All work carried out in preparing this report has used, and is based upon DTS Raeburn's professional knowledge and understanding of the current (March 2016) relevant standards, codes, technology and legislation. Changes in the above may cause the opinion, advice, recommendations or conclusions set out in this report to become inappropriate or incorrect. Following delivery of this report, DTS Raeburn will have no obligation to advise the Clients of any such changes or of their effects. It may therefore be necessary to review the opinions, advice, recommendations and conclusions of this report following future changes to legislation;

d) Some of the information referenced and included in the PRA has been provided by third parties and whilst DTS Raeburn has no reason to doubt the accuracy, these items have not been verified. DTS Raeburn accepts no responsibility for errors within third party materials referenced and presented in this report;

e) The content of this report represents the professional opinion of experienced geotechnical and environmental specialists/consultants. DTS Raeburn does not provide associated legal advice and appropriate legal advice should be sought if required;

f) The lack of evidence of the presence of hazardous materials, voids or obstructive features at the subject property does not guarantee the absence of such materials, rather it indicates only that none was found as a result of the services provided.

DTS RAEBURN LTD
E12897/1 –April 2016

References

i) British Standards Institution
Investigation of Potentially Contaminated Sites - Code of Practice
BS10175: 2011

ii) Department for Environment, Food and Rural Affairs and the Environment Agency
R&D Publication CLR11: Model procedures for the management of land contamination
2004

iii) CIRIA Guidance (C552)
Contaminated Land Risk Assessment
2001

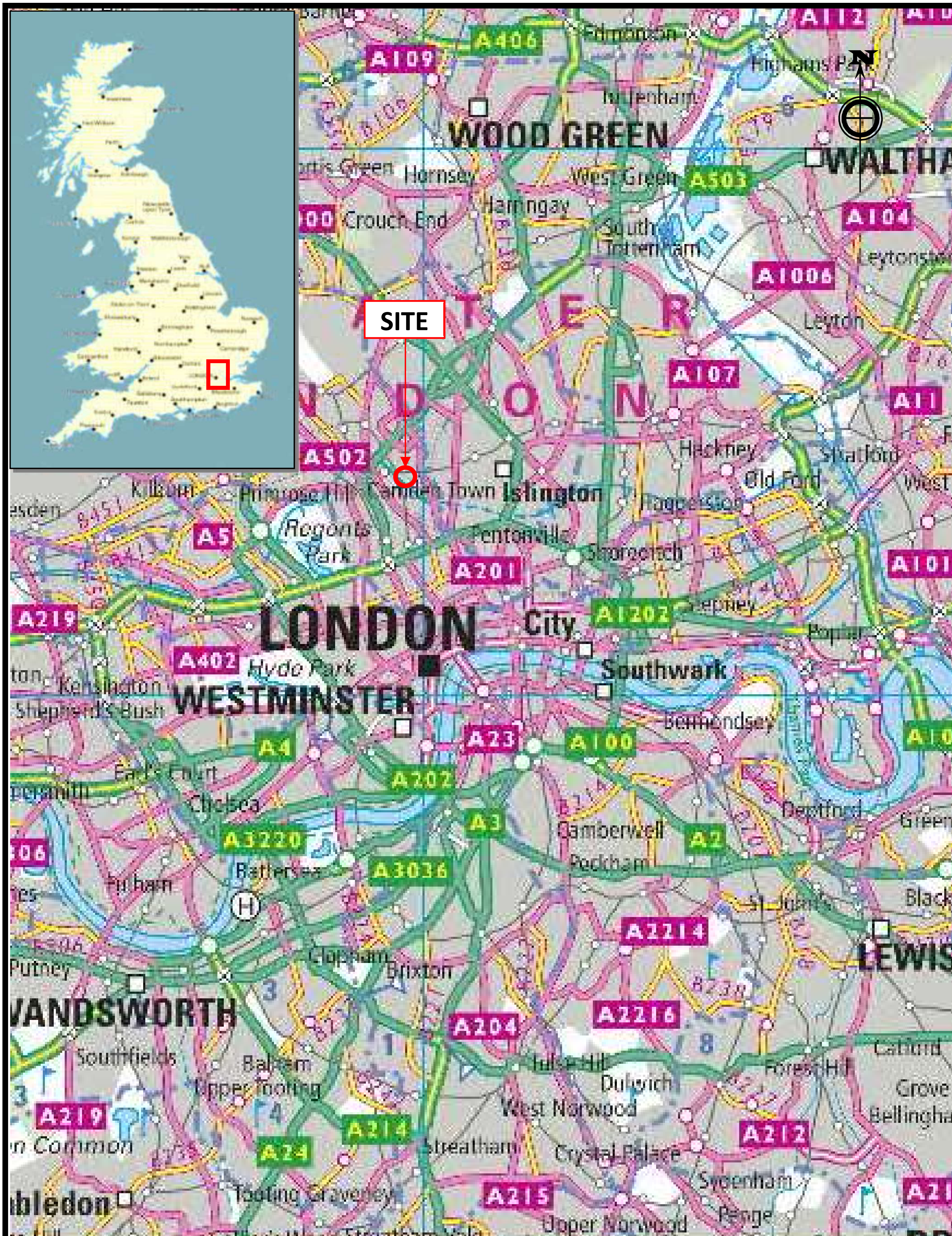

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FIGURE 1

Site Location Plan
Scale 1:200,000

E12897/1: St Pancras Way
Prepared for: GD Partnership Ltd

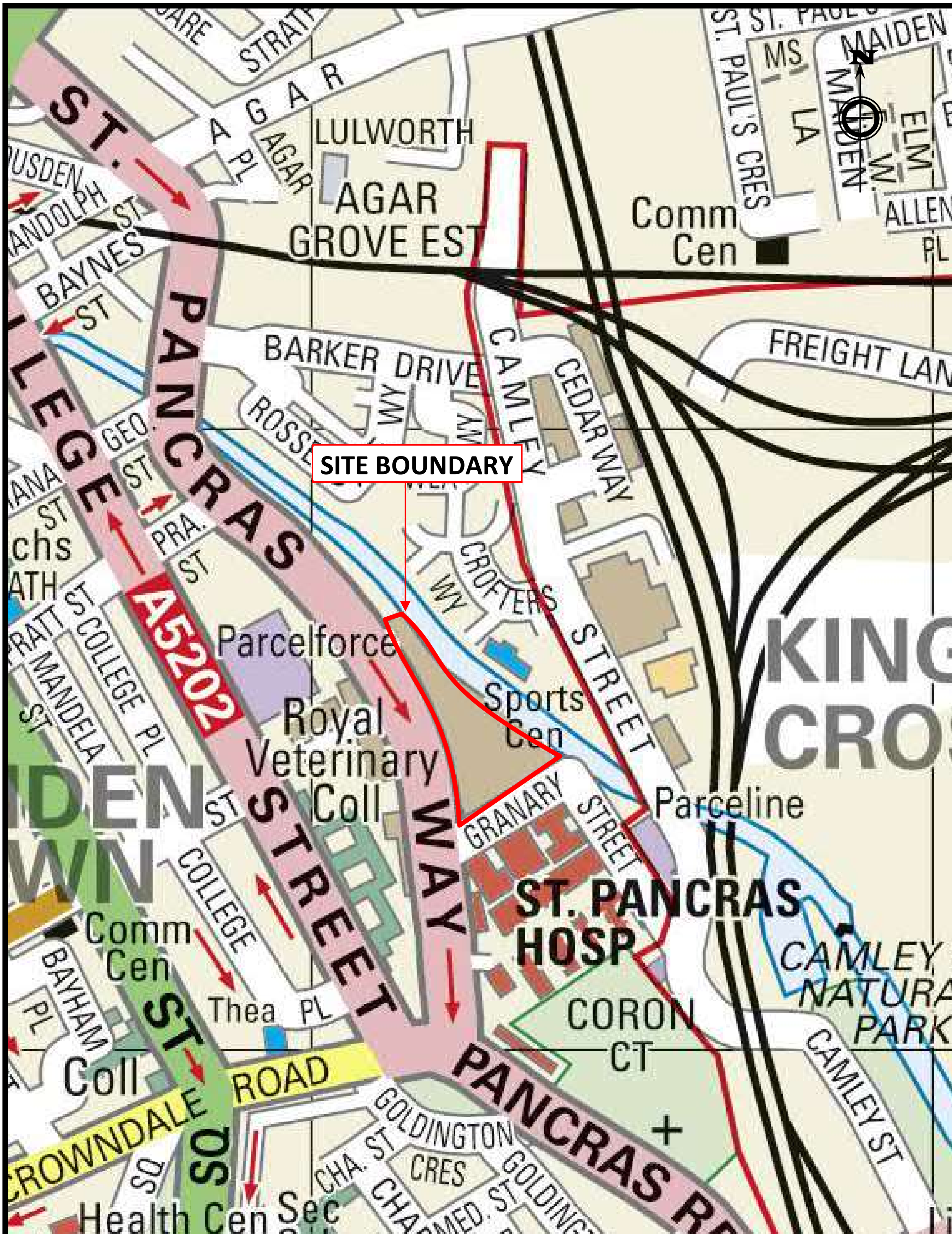

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FIGURE 2

Street Plan

Scale 1:2,500

E12897/1: St Pancras Way

Prepared for: GD Partnership Ltd

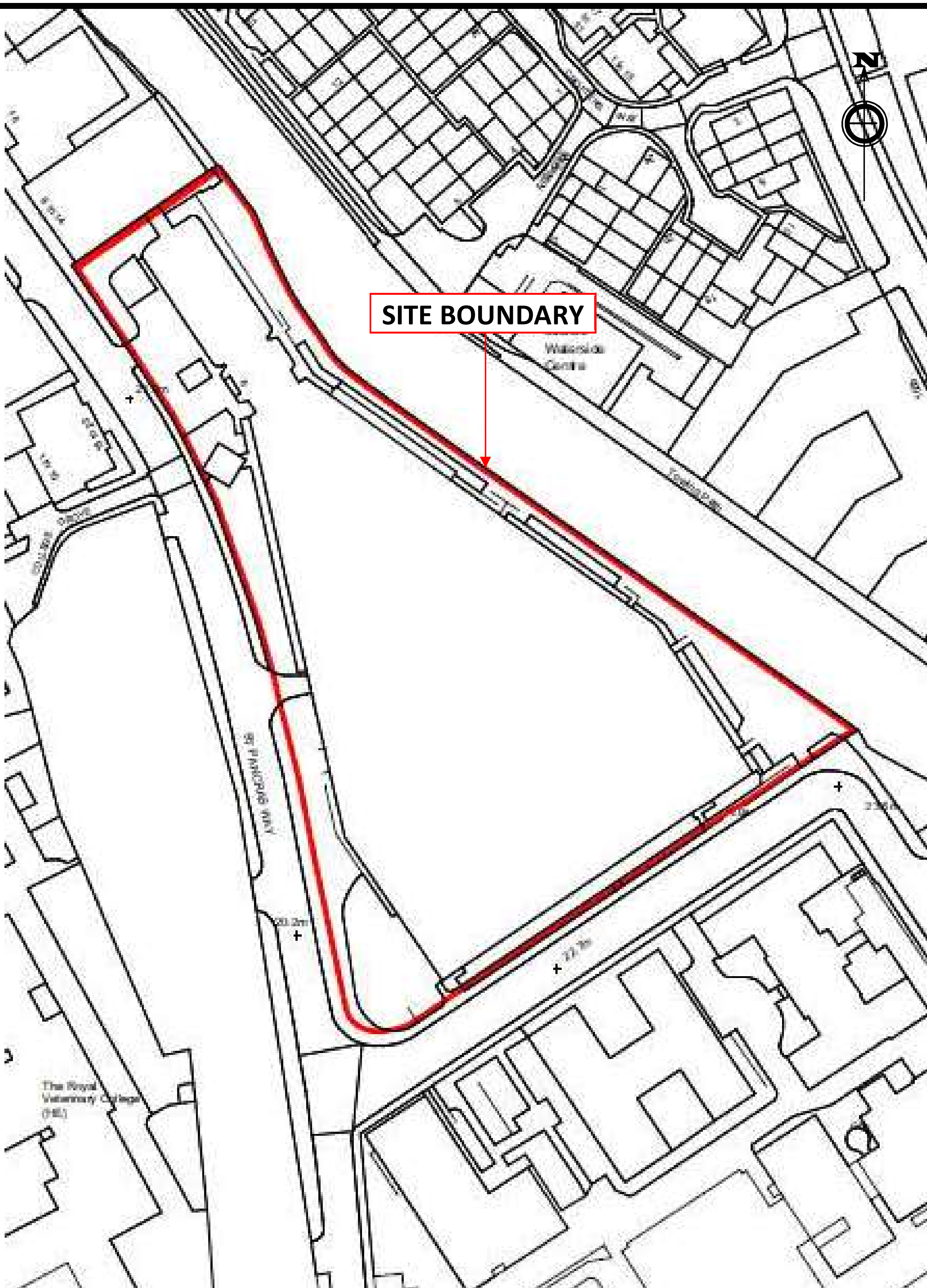

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FIGURE 3

Existing Site Plan
Scale 1:1,000

E12897/1: St Pancras Way
Prepared for: GD Partnership Ltd

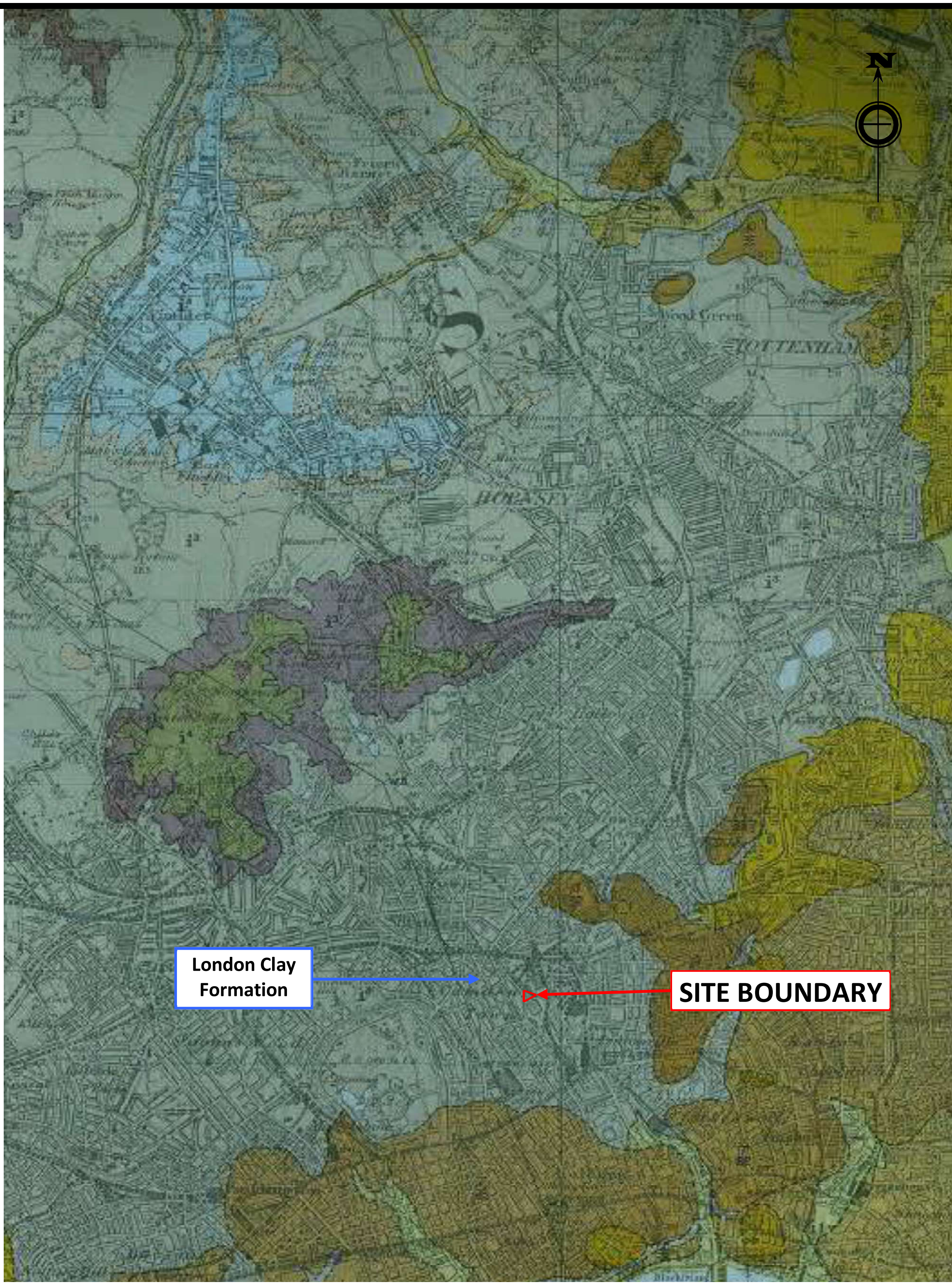

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FIGURE 4

Extract from BGS Sheet 256
Drift Edition; Scale 1:63,360

E12897/1: St Pancras Way
Prepared for: GD Partnership Ltd

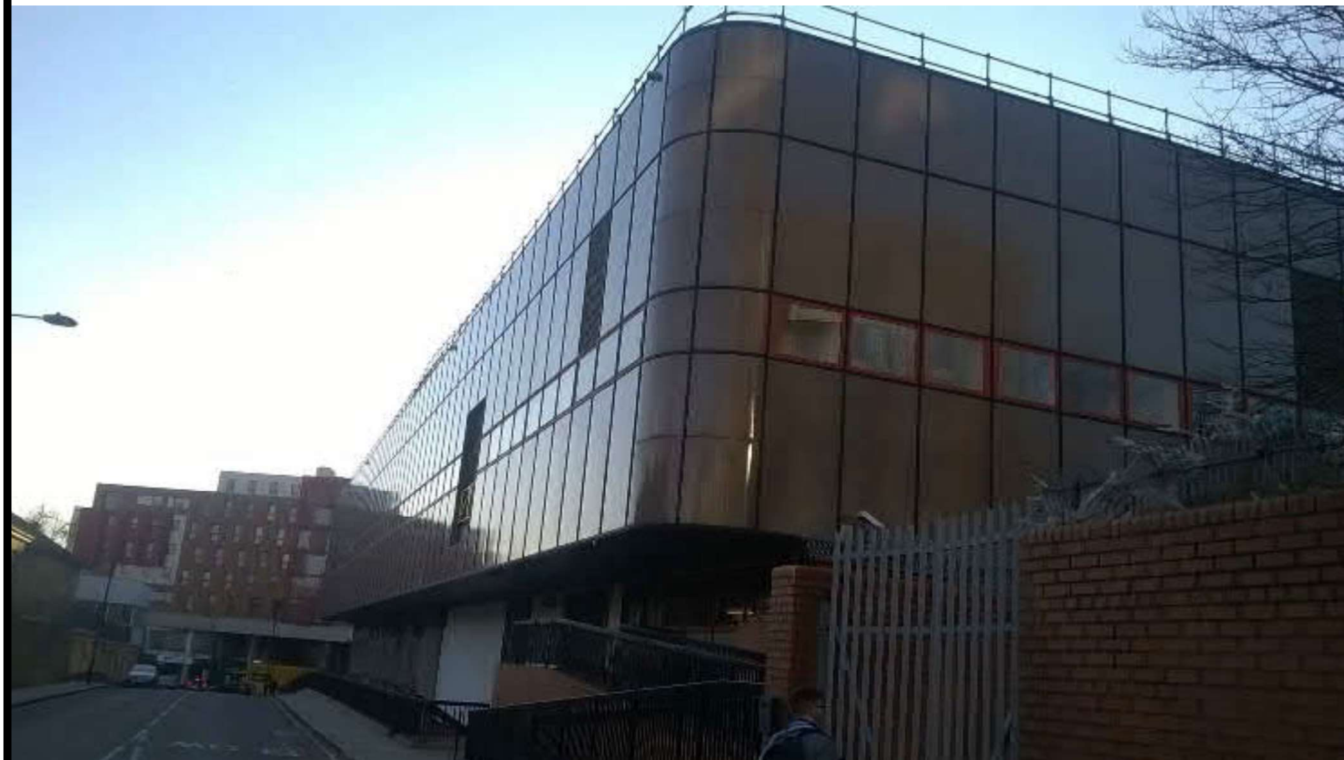

Plate 1: View West Along Granary Street

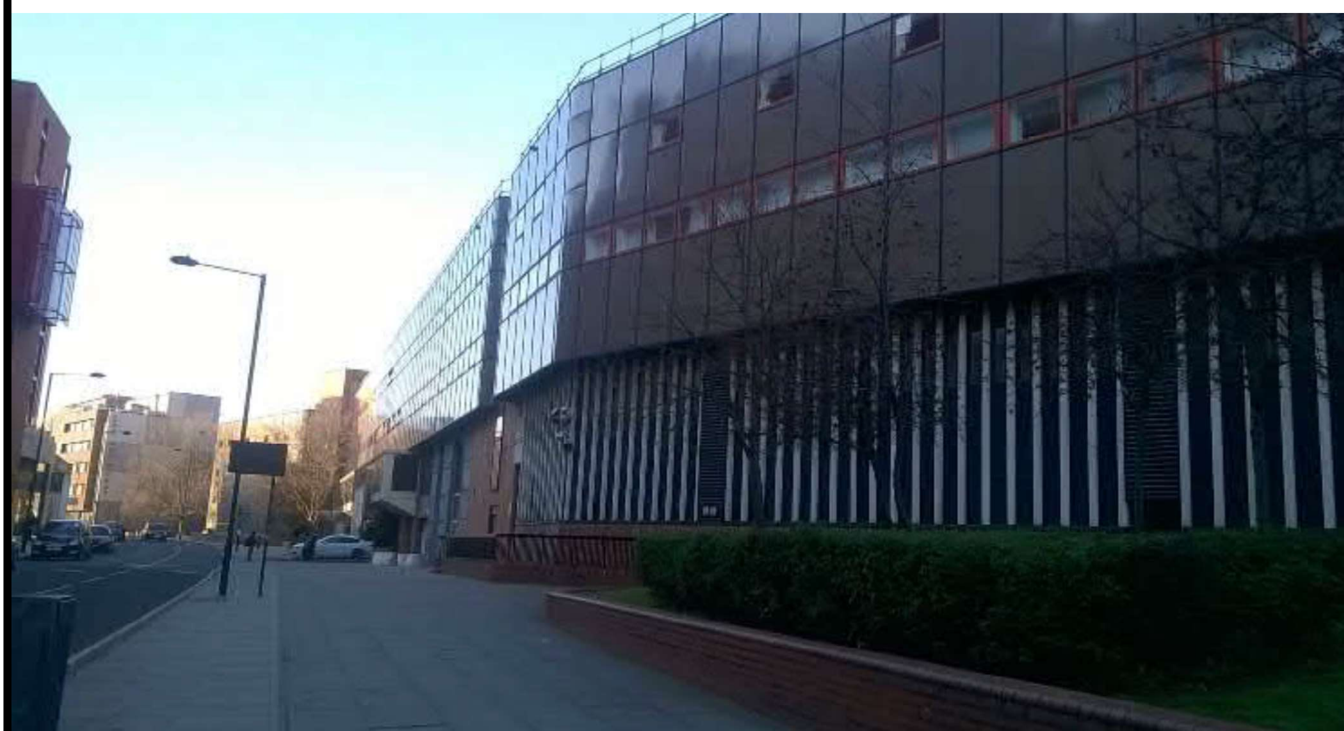

Plate 2: View North Along St Pancras Way

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PLATES 1 & 2

Photographic Record of Site Reconnaissance

E12897/1: St Pancras Way
Prepared for: GD Partnership Ltd

Plate 3: Eastern Boundary with Canal

Plate 4: Inside Plant Room

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PLATES 3 & 4

Photographic Record of Site Reconnaissance

E12897/1: St Pancras Way
Prepared for: GD Partnership Ltd

Enclosure A

The Structural Engineer,
Volume 63A, Paper No.4
(April 1985)

8 Pages

UDC 725.16: 69.054

ORDINARY MEETING

A paper to be presented and discussed at a meeting of the Institution of Structural Engineers, 11 Upper Belgrave Street, London SW1X 8BH, on Thursday 18 April 1985, at 6.00 pm.

The Granary site—

design and construction of a mechanised letter-sorting office

K. C. White, BSc(Eng), CEng, FIStructE, MICE, FIHT
Travers Morgan & Partners
A. P. Myers, BSc(Eng), ACGI, CEng, MICE
Travers Morgan & Partners
A. H. Dutton, MA(Cantab), CEng, MIStructE, MICE
Travers Morgan & Partners

Keith White graduated through part-time study at Northampton Polytechnic, London. After National Service in the Royal Engineers, he spent 2 years as an Assistant Resident Engineer on a roads and bridgeworks contract. He then returned to the design office of Travers Morgan where he was continuously engaged as a Project Engineer for structural works until being taken into Partnership in 1973. As a Partner he has had particular responsibility for the firm's structural engineering work both in the UK and overseas.

He was first elected to the Institution's Council in 1973 and has been Chairman of both the Education & Examinations and Associate-Membership Committees. He has been a Vice-President since 1983.

Alan Myers joined the structural group of Travers Morgan & Partners on graduation from Imperial College. He has had extensive responsibility for the design and supervision of construction of many types of new building structure, upgrading and alteration schemes, and the rehabilitation of old buildings. He also has considerable experience in structural investigation work, appraisals, and certification. Other interests include the fire resistance of concrete structures, with membership of the appropriate Concrete Society committee, and computer aided drafting.

He was Project Engineer for the Granary site development from its inception early in 1980. He became an Associate of Travers Morgan in that year and a salaried Partner of the practice in 1984.

Andrew Dutton graduated from Trinity College, Cambridge, in 1973 and spent the next 6 years with Sir Bruce White, Wolfe Barry & Partners, initially involved with the design of ports for the Far East and later as principal designer for the Dartford Creek Barrier. From 1979 to 1981 he worked overseas in Mauritius as Deputy Engineer for a major water supply project. On his return to the UK he joined the structural group of Travers Morgan & Partners and has been concerned with the design of a wide range of projects in the UK and abroad. He has particular experience of buildings with difficult foundations and undertook much of the substructure design for the Granary site development.

Synopsis

This paper describes the design and construction of a district postal sorting office in North West London. The earlier use of the site and its location in relation to the Regent's Canal gave rise to the need for special consideration of the substructure. Particular reference is made to the problems arising from the removal of a former railway embankment and the soil movements likely to result. The way in which the design was developed in stages from feasibility to construction is described.

The development

The Post Office's new building complex in St. Pancras Way, London NW1, will form one of the last links in the programme for the mechanisation of letter sorting in the London postal region. Currently, the NW districts are run from three buildings, only one of which is in Post Office ownership and that is on a restricted site with little opportunity for expansion either within the site or on adjacent properties. The introduction of letter-sorting machinery would have required significant structural strengthening of that building, while the site itself would have been unable to cope with the associated increase in vehicle traffic.

In recognition of these facts the Post Office adopted a 'new build' strategy, seeking to create on one site mechanised letter-sorting facilities for the whole NW postal district. With their appointed architects they considered several alternative locations in the Camden area, together with various schemes for each, and eventually decided to proceed with the

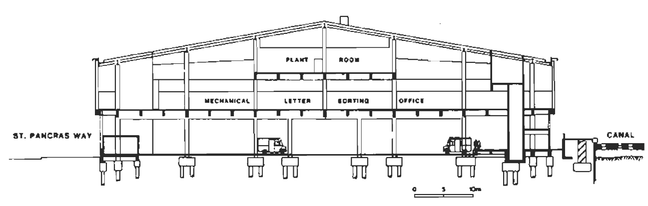

Fig 1. Cross-section through sorting office block

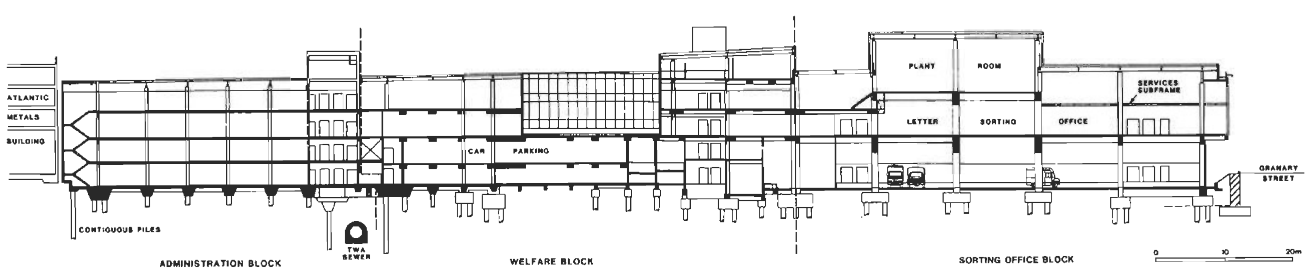

Fig 2. Longitudinal section through development

Granary site. Even that choice was less than ideal, since its limited area meant that the brief, which required all the components of the development to be located at ground level, could not be met. The necessary planning compromise was to stack some of the components so that, in the sorting office block, the mechanised letter-sorting office is at first floor above the yard for postal vehicle loading and unloading and the motor transport workshop (see Fig 1), while in the adjoining welfare block the facilities are located above a twin-level staff carpark. The development is completed by the administration block, which stands at the north end of the site (see Fig 2).

The site lies within a conservation area alongside the Regent's Canal and planning restrictions affected the height of the development.

History of the site

The Granary site is a 1·1 ha wedge-shaped piece of land between St. Pancras Way and the Regent's Canal (see Fig 3) and lies just to the north of St. Pancras Hospital. Historically, the ground sloped from east to west with a fall of about 3 m towards the River Fleet which is now culverted and lies to the west of St. Pancras Way.

In about 1817 part of the Regent's Canal construction passed along the eastern boundary where it was cut into the locally outcropping London clay. Two access bridges crossed the canal with roads running across the site. Following the advent of the railways, a brick barrel sewer was constructed beneath the canal, on the line of one of the access roads, to provide a foul drain to a goods yard on the east side of the canal.

Then, in 1864, the London and Midland Railway Company proposed the construction of the St. Pancras Ale & Corn Store, to be serviced by a branch line from the main St. Pancras railway lying to the east of the canal. The Ale & Corn Store, covering some 0·8 ha, later became known as the Granary, and was a structure with massive masonry walls and five floors supported by cast-iron columns. The railway access to the site had three tracks and crossed the canal on a two-span plate girder bridge. As the railway was elevated about 4 m above the canal, the whole of the north end of the site was raised to this level by backfilling between massive brick retaining walls up to 8 m high. Along the canal frontage a covered loading wharf was constructed by widening the canal up to the main external wall of the Granary; the wharf and roof were supported on cast-iron columns founded in the canal bed.

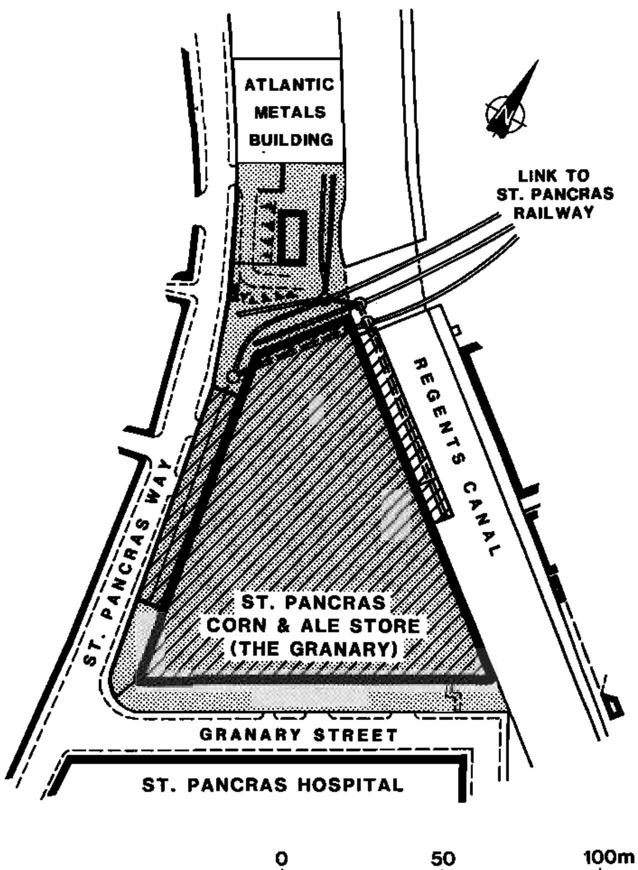

Fig 3. Site plan showing former Granary

In 1907, as part of the trunk sewer scheme for London originally conceived by Bazalgette, the middle level sewer no. 2, now part of the Thames Water Authority's system, was constructed by tunnelling under the northern part of the site. The sewer is approximately 2 m in diameter and is brick lined throughout, with its crown about 4·5 m below the bed of the canal.

No further construction took place on the site, but in the mid 1960s a five-storey office building with a two-storey warehouse was constructed on adjoining land against the northern boundary. Known as the Atlantic Metals building, it is of reinforced concrete framed construction, with concrete block infill panels, and is founded at a relatively high level in the brown London clay.

In 1978, after several years of disuse and much debate about its future, the Granary burnt down in dramatic fashion. The ruins were considered dangerous and were demolished, measures being taken to stabilise the now free-standing canal wall and other perimeter and internal retaining walls. Some while later, the railway bridge across the canal was also demolished, thus leaving the site in the condition faced by the design team for the Post Office development.

Structural feasibility study

A feasibility study was among the first tasks undertaken, its purpose being to determine the most appropriate structural response to the proposed development. While prime cost was a significant criterion in choosing the form of the structure, considerable attention was also paid to the need to provide an expeditious resolution, in construction terms, to the problems arising from the nature of the site. The principal areas of the study are now discussed.

Superstructure options

As has been described earlier, the development is formed in three sections, the sorting office block, the welfare block, and the administration block (see Fig 4). Alternative structural solutions were considered for each section, both in steelwork and in reinforced concrete. The schemes for steelwork were discarded when they failed to show economy compared with reinforced concrete—that in part being a reflection of the complexity of some sections of the development, e.g. in the shape of the welfare block and in the shallow depth of the structural floor zone available in the administration block. The final selection was to use reinforced concrete throughout, except for the roofs which were in structural steelwork.

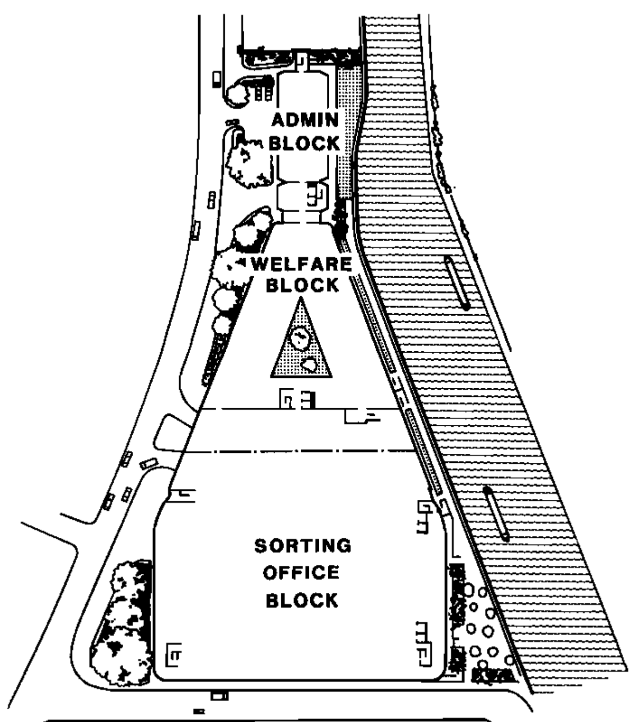

Fig 4. Plan of development

Sorting office block. In the sorting office block a column grid of 12 m × 12 m was adopted above first floor to accommodate the positioning of the mechanised letter-sorting equipment. Generally, that grid was carried down to ground floor but, to allow for vehicle movements, one row of columns was displaced. The resulting arrangement was less than ideal but to permit the optimum arrangement for vehicle movement would have made the first-floor construction excessively heavy.

The ground-floor slab in the vehicle movement areas was regarded as an external ground bearing pavement, and this resulted in the need to place 1·75 m of fill material to achieve the correct levels. Other areas at ground level, e.g. the receipt and dispatch platform, were all to be designed as fully suspended construction.

Welfare block. The welfare block, filling the triangular space between the administration block and the sorting office, was to be mainly four storeys high. The lower two storeys were to form a carpark, while the upper two were to provide welfare facilities and some offices. The brief required clear spans of 12 m in the carpark, but the height restrictions on the building meant that a structural zone for the floor construction of only 750 mm was available, resulting in a grillage of relatively shallow beams being provided.

Administration block. The administration block was also to be of four storeys but again, because of the planning restrictions, the structural zone was limited, this time to 350 mm. No drops were permissible beneath that zone and the structural options were therefore confined to some form of flat slab construction. The solution adopted was a traditional flush soffit slab spanning transversely onto longitudinal beam strips. The external column grid emerged, from architectural considerations, at 6 m, while, to allow for a central corridor, the internal column line was placed asymmetrically, giving 7·5 m and 6 m bays across the building.

So different are the three blocks in terms of mass, number of storeys, internal configuration, and grid arrangement, that they have been separated structurally by movement joints.

Substructure options

Usually it is possible to obtain some information about existing construction from records held by the original designers, the local authorities or the building owner. In this instance a few drawings were located in the Public Records Office and the London Borough of Camden's archives, but they related mainly to alterations to the superstructure and gave few details of the original construction. Similarly, the minutes of the Canal Company were most interesting to read but gave no details of the canal construction.

Clearly, for a building as massive as the Granary, there was every likelihood that there would be substantial foundations. As the building had covered the majority of the site up to the embankments at the north end, and seemingly had stood successfully for some 120 years, one of the first questions to be answered was whether it would be possible to reuse those foundations for the new development.

Characteristic of the period when developments such as the Granary were built was the practice of excavating the site to a common level and then covering the excavation with a substantial bed of concrete. From that excellent working platform the new building would be raised with the walls and columns being founded on some form of spread footings. However, the arrangement of internal columns for the Granary at 4·2 m square was a total mismatch with that for the new sorting office which produced much higher column loads on the 12 m square grid. Hence the best that could be looked for was to design pad foundations using the concrete raft, if it existed, as the equivalent of a generous layer of blinding concrete. However, calculations showed that pad footings would need to be very large and from costing exercises were shown to be uneconomical compared with bored pile foundations. Hence the latter were adopted, with the pile caps located above the existing foundation level.

At the north end of the site in the embankment area, the requirement was to level the site by removing some 8 m of fill material and the associated massive retaining walls. Further excavation would follow as necessary for the foundations to the administration block and part of the adjoining welfare block. It was recognised that heave would result in the London clays, and early calculations indicated that, in the worst case, this could be as much as 150 mm. Obviously, normal pad footings, which otherwise could have been used, would have been quite inappropriate in such conditions and some form of special foundation would be required. The decision was taken to use piling with the piles sleeved over their upper lengths, and to protect the pile caps, ground beams, and suspended ground-slabs, by the extensive use of Clayboard.

There remained the problems of how to deal with the boundaries of the site. Clearly, it was necessary to have regard to the damage that might occur to the Atlantic Metals building on the northern boundary as a result of ground heave, and it was decided that measures would be taken to isolate, as far as practicable, the ground beneath this building from that on the Granary site.

Although the highest level of protection would have been achieved by the use of a tied back diaphragm wall, this proposal was abandoned as it would have involved works outside the site boundary. Further options were considered and the choice eventually lay between a freestanding diaphragm wall and a contiguous piled wall; costing of alternative schemes led to the selection of the latter. In providing the contiguous piled wall with piles embedded some 25 m deep, it was intended that they would act not as a retaining wall but would provide pinning down action, holding down the upper heave zone to reduce the vertical movement on the area of the Atlantic Metals site.

Alongside the canal the problem was different in that the development of the site required the material against the canal wall to be excavated, effectively undermining it so that permanent support would be required from the new works. It was also recognised, ahead of the site investigation, that the construction of the wall was in some places less than robust, its watertightness somewhat doubtful, and that great care would be necessary during construction to avoid causing further distress. To overcome these problems the decision was taken to provide a line of support inside the site positioned as close to the canal wall as practicable.

Various options were considered, including a diaphragm wall, a contiguous piled wall, and a sheet piled wall. The diaphragm wall was discounted as, for the majority of the length of the canal, it would have had to be constructed through approximately 3 m of rubble fill. Guide walls to clear these obstructions would have had to be over 4 m deep and their construction would have endangered the stability of the canal wall. Sheet steel piling was rejected, as it was considered that the heavy driving likely to be necessary would in all probability further weaken the canal wall and in any case there were noise restrictions on the site inhibiting the use of normal pile driving equipment. The chosen solution was to employ contiguous bored piling inside the full length of the canal wall, even though there would be practical difficulties in clearing the brick rubble fill.

The site investigation

The site investigation was designed to achieve two principal objectives. The first was to determine the nature and characteristics of the underlying soils, while the second was to discover, as far as practicable, the details of the exisiting foundations and boundary construction. It was also intended to determine whether there was leakage through the canal wall and standing or moving water on the site.

Existing foundations and boundary wall construction

A trial pit investigation was carried out, comprising some 22 pits (see Fig 5). Most pits were machine dug but, because of the depth of fill materials, exploratory timbered shafts up to 8 m in depth were sunk at the north end of the site, particularly to determine the construction of the canal wall. Even though the locations of the pits and shafts were chosen to reveal all likely forms of boundary wall construction, it was not possible to explore every detail of the existing structures on such a large site, and in one area in particular this led to complications during the building works.

The trial pits revealed that the foundations to the Granary building had indeed been made by excavating to a common level, approximately 6 m below canal water level. A hydraulic lime concrete raft, some 750 mm thick, had then been placed over the whole 0·8 ha building area, above which bases to the cast-iron columns had been formed by positioning several layers of 225 mm-thick massive sandstone blocks on a 4·2 m grid. Infilling above the concrete raft and around the sandstone blocks had been carried out with approximately 1·2 m of clay on which a brick sett floor had been constructed. Standing water was encountered on the brown London clay at the underside of the concrete raft.

The trial pits also revealed the construction of the canal wall. Over the length of the Granary building the wall was 1·6 m thick, supported on mass concrete footings. It obtained lateral support from a second inner wall through a slab forming a gallery at an intermediate level. To the north of the railway bridge the wall showed evidence of several generations of construction with relatively shallow foundations and considerable repair work. The abutments to the railway bridge were formed in massive brick piers, in turn supported on sandstone blocks. No water penetration of the canal wall was observed in the trial holes adjacent to the southern section. However, those along the northern section revealed that water was leaking through the wall in several locations.

On the southern boundary another brick retaining wall some 5 m high supported the recently renamed Granary Street and made possible a lower cartway.

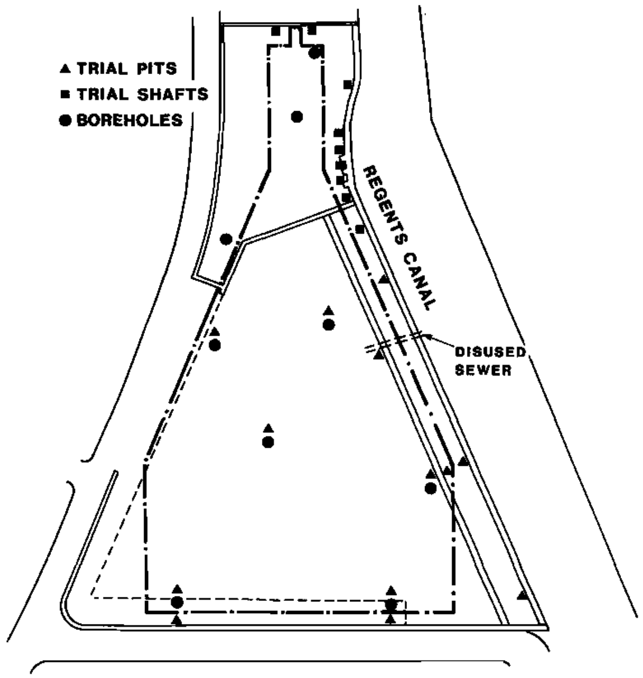

Fig 5. Site investigation

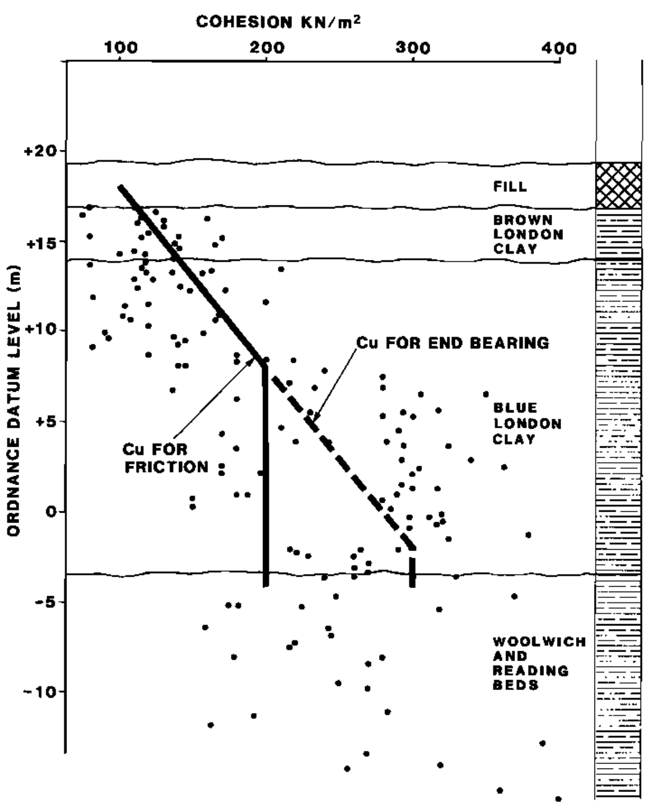

Fig 6. Cohesion values determined by site investigation

Calculations showed that many of the retaining walls had relied on the dead weight of the structure above to give them stability. This had been appreciated during demolition of the Granary as a large rubble berm had been left against the canal wall and temporary steel propping had been inserted to support the Granary Street and railway embankment retaining walls.

Borehole investigations

Nine boreholes were drilled (see Fig 5). Undisturbed soil samples were taken for laboratory testing from each borehole at intervals of 1·5 m depth. As anticipated from reference to the records of other nearby developments, brown London clay was found immediately beneath the oversite concrete of the former Granary building. That overlaid blue London clay, approximately 20 m thick, which in turn overlaid the Woolwich and Reading beds, these being clay in this area. Triaxial tests on the clays indicated cohesion values ranging from 50 to 400 kN/m^2 increasing in strength with depth but with a wide scatter (see Fig 6). The clay had few sand lenses and the bores were dry, except for one or two small incursions. Consolidation and expansion tests were carried out on selected borehole samples to determine the coefficients of compressibility and expansion of the clay from which an assessment could be made of the likely amount of heave.

Foundation design

Ground movements

During the feasibility study it had been recognised that removal of the railway embankment at the north end of the site would give rise to ground heave and that the design of piled foundations in that area would need to take account of such movement. At that time the principal concern was for vertical movement, but during the design stage it was further recognised that the removal of such a major surcharge load would also result in the ground recovering from its horizontal displacement. Despite an extensive literature search, very little information on the subject was located, probably attributable to the fact that ground heave is more normally encountered in deep basements and relates to the floor only. However, unlike basement construction where retaining walls are provided with effective restraint by the slab, in this project minimal restraint would be provided by the proposed piled foundations. Thus movement in the soils would continue until equilibrium conditions were reached, by which time structural failure of the piles would probably have occurred.

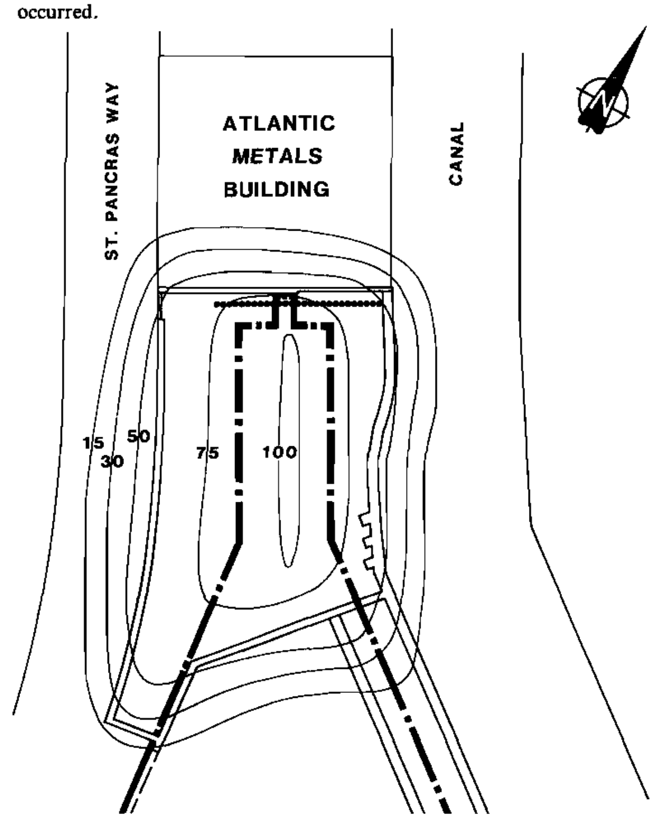

Fig 7. Anticipated unrestrained ground movement—vertical

Analyses were undertaken to determine the likely magnitude of both vertical and horizontal soil movements with regard to their time dependency. These movements were considered independently, using consolidation theory to assess the vertical heave, while an estimate of the horizontal movement was made by considering a simple stress path analysis.

Unrestricted heave was shown to be in the order of 100 mm at the centre of the area from which the embankment had been removed, reducing to about 50 mm at the boundaries of the site (see Fig 7). However, the restraining action of the piles for the new building would significantly reduce these figures by about half.

The horizontal component of the ground movement was estimated to be in the order of 20 mm at the perimeter of the administration block at surface level, reducing to virtually no movement at 20 m depth (see Fig 8). It was estimated that between one-third and one-half of this movement would occur within the first few months following removal of the surcharge, so clearly it would be advantageous to delay the construction of the foundations in this area for as long as possible.

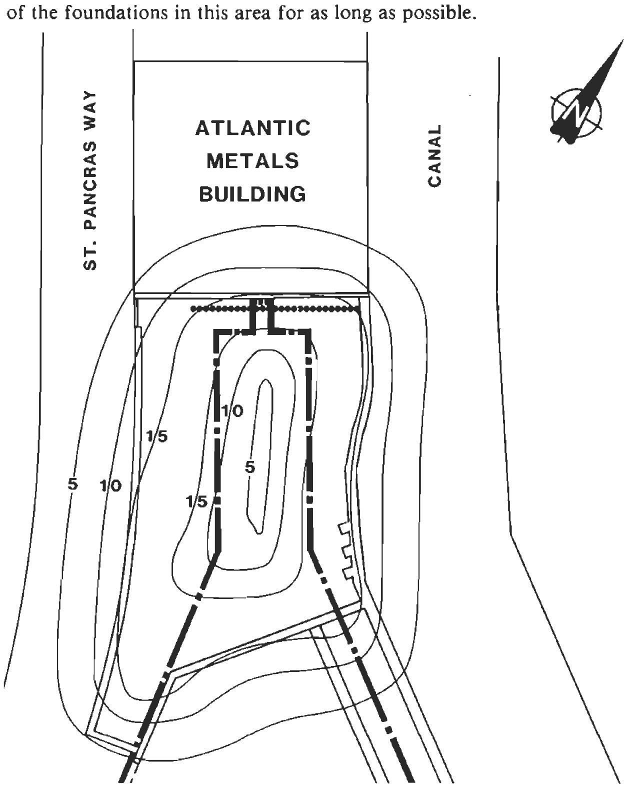

Fig 8. Anticipated unrestrained ground movement—horizontal

Design of foundations in ground movement areas

An analysis of the ability of the clay to flow horizontally around the piles indicated that this would be of low order and that the induced shear forces and bending moments at the top of the piles could become critical, leading to shear failure in them at the undersides of the pile caps. The literature search had revealed no reports of structures where measures had been taken to overcome this problem, except perhaps in the case of houses with deep strip footings in desiccated clay soils, where it is common to provide cross trenches internally to relieve horizontal swelling pressures. Such measures would have been unsuitable in this instance as the depth of trenches required would have been excessive and their presence in the vicinity of the canal wall would have seriously endangered its stability.

Clearly, the proposal for sleeved piles arising from the feasibility study, and conceived to cater for vertical ground heave only, was now inadequate and a different approach to protecting the piles was required.

The solution adopted was to create a zone immediately around each pile and of sufficient depth that the horizontal ground movement could take place in an unrestrained fashion without imposing excessive lateral loading on the piles. Calculations showed that this latter condition would be met if the annular space extended over the first 4 m of the piles and was bored some 100 mm oversize on the pile diameter. It was decided that the resulting void should be filled with bentonite both to prevent the clay surface from softening and also to inhibit construction material falling back into it. The design of the piles could now be completed making due provision for the effects of heave until such time as the loads from the new construction produced a compensating effect.

The piles supported caps which in turn received ground beams carrying the suspended ground-floor slab, the whole construction being protected against heave by 100 mm thickness of Clayboard (see Fig 9). The pile caps and ground beams were designed to resist the bending moments and shear forces induced in them by the lateral deflection of the piles. As the horizontal ground movement along the centreline of the administration block would be negligible, it was decided not to sleeve the piles adjacent to this line and to take the wind forces through them to the ground.

Foundations around the TWA sewer

The sewer is also located in the area likely to be affected by ground movement. Consideration was therefore given to the order and rate of change of vertical displacement which might occur along its length, but the view was reached that it could accept the calculated distortions without distress and accordingly no special protective measures were adopted. Its alignment also coincided with the stair and lift core at the south end of the administration block. There, at foundation level, beams positioned to allow the formation of the lift pits were designed to bridge the sewer spanning onto pile caps running along each side. Their supporting piles lay within the defined zone of significant vertical and horizontal ground movement, and also had to meet the TWA requirement that no load from the new construction be imposed on the sewer. Accordingly, they were designed to be friction-free down to invert level,

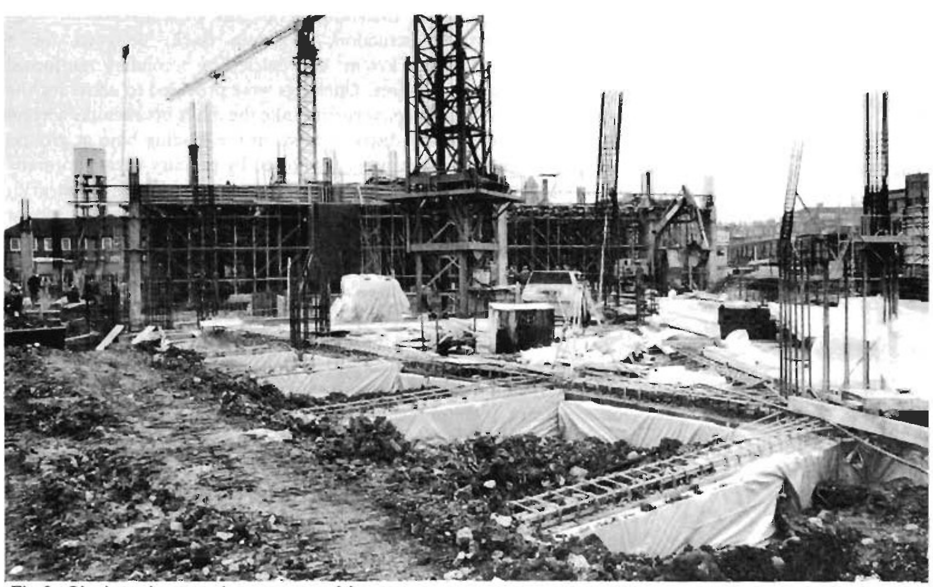

Fig 9. Clayboard protection to ground beams