Appendix B. GRIP 4 GI Report

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Leeds Station Southern Entrance

Geotechnical and Geoenvironmental Desk Study and Preliminary Interpretative Report

Document No.: 60092600/IDAG

Network Rail

29/04/09

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Leeds City Station Southern Entrance Improvements – GRIP 4

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Executive Summary

Network Rail is assessing GRIP 4 development options for a new pedestrian entrance at Leeds City Station. The site is situated on the south side of Leeds City Station, adjacent to the existing bridge arches crossing the River Aire.

The new entrance will enable passengers to access Granary Wharf from Platforms 16 and 17. Pedestrian access is required from existing platform level down to a new bridge deck constructed over the River Aire. A new deck will also be constructed over the River Aire in the central arch of the viaduct and will provide access back to the location of the existing Granary Wharf Bridge, taking pedestrians into the Dark Arches and Dark Neville Street. A new deck is also required for Granary Wharf Bridge as the existing level of the bridge deck is too low and does not provide the flood level clearance required by the Environment Agency. The development includes link bridges from the new deck providing access to the east and west banks of the river immediately south of the viaduct.

Historical Ordnance Survey maps and Town Plans show a bridge crossing the River Aire to platforms in Wellington Station in 1850. New Station was constructed adjacent to Wellington Station in 1869 with rails carried almost entirely on viaducts and bridges, with the arches under the main station becoming known as 'the Dark Arches'. Rationalisation of these stations was completed in 1938 when they were combined to become Leeds City Station. The east and west banks of the River Aire at the site have a long history of industrial use. Land on the west bank was utilised as a boatbuilding yard prior to 1850 until the mid 1960's. On the east bank an Oil Works is recorded in 1850, and a travelling crane was historically placed along the line of the proposed bridge foundation. Recent development has seen construction of the Blue Apartments on the east bank and the ISIS Development on the west bank of the River Aire.

Published geological maps indicate the whole of the station area northwest of the site is an area of made ground. Superficial soils at the site comprise alluvium, described as clay, silt, sand and gravel, underlain by the Pennine Lower Coal Measures Formation comprising an interbedded sequence of sandstone, siltstone, mudstone, seatearth and coal. The Better Bed Coal is expected to underlie the site at shallow depth. A Coal Authority Mining Report indicates that the site is not within the zone of likely physical influence on the surface from known past or present underground workings.

Relevant borehole, in situ and laboratory testing from two previous ground investigations (by others) have been reviewed as part of this study. Data has been analysed to allow preliminary interpretation of anticipated ground conditions and to provide preliminary engineering recommendations for the development. Exploratory holes proved made ground comprising brown clayey sand and gravel of brick, concrete and ash from ground level to a maximum depth of 2.6m. The made ground is underlain by loose becoming medium dense slightly clayey alluvial sand or gravel to maximum depth of 7.1m. The superficial soils are underlain by an interbedded sequence of very weak and weak thinly laminated mudstone and very weak and weak siltstone. Intact coal is proved in a number of the exploratory holes and there is no evidence of unrecorded mining in the Better Bed seam.

Bathymetric survey data indicates the river channel is flat. Data suggests that only very thin deposits of river sediment would be anticipated and the existing concrete spillway probably rests directly on underlying weathered mudstone.

A preliminary site conceptual model and risk assessment has been developed. Examination of 'Source-Pathway-Receptor' linkages has been undertaken to define construction, human health and environmental risk associated with the existing and future condition. The principal receptors at risk from harm due to unexpected contamination and migration of dust (asbestos) and ground gasses and vapours (hydrocarbons) are ground workers. Environmental impact on surface water courses and groundwater requires consideration, particularly during construction. The risk to the groundwater aquifer (i.e. Lower Coal Measures) is considered negligible. It is considered unlikely that the development, once constructed, will significantly alter the existing condition for environmental or human health risks.

Piled foundations end bearing on rock are proposed for supports at extended pier positions in the River Aire and for supports on the east and west banks. Preliminary pile capacity assessments using the Beta method for a 600mm diameter rotary bored pile socketed into the underlying mudstone bedrock are provided.

A development specific ground investigation has not yet been carried out. Recommendations for further ground investigation are provided.

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Introduction

1 Introduction

1.1 Network Rail is assessing development options for a new pedestrian entrance at Leeds City Station.

1.2 The purpose of the study is to provide input to aid assessment of development options and GRIP 4 outline design for a new entrance to the south side of Leeds City Station. The new entrance will enable passengers to access Granary Wharf from Platforms 16 and 17. Pedestrian access is required from existing platform level (~41.6m OD) down to a new bridge deck (~29.0m OD) to be constructed over the River Aire. The site is situated on the south side of Leeds City Station at approximate National Grid Reference 429850 433120.

1.3 A new deck will be also constructed over the River Aire in the central arch of the viaduct and will provide access back to the location of the existing Granary Wharf Bridge, taking pedestrians into the Dark Arches and Dark Neville Street. A new deck is also required for Granary Wharf Bridge as the existing level of the bridge deck is too low and does not provide the flood level clearance required by the Environment Agency.

1.4 The development includes link bridges from the new deck providing access to the east and west banks of the river immediately to the south of the viaduct. These links will be in the open air and will only provide stepped access to the river banks.

1.5 As part of the desk study readily available information has been assessed in relation to the historical development of the site, the anticipated ground conditions and potential former impact of site use in light of development proposals.

1.6 Enquiries and consultations have been made to a number of organisations to obtain information concerning various aspects of the site; these are detailed in Appendix A.

1.7 Information obtained in the desk study has been used as a basis to design a development specific ground investigation. This report also contains a review of relevant historical ground investigation undertaken by Norwest Holst at Leeds Canal Basin, on land immediately west of the site, reference F14538, dated 2006[(3)]. This ground investigation was undertaken by others for the purposes of the ISIS Waterside Development.

1.8 This report contains an interpretation of the information received and an assessment of geotechnical and geoenvironmental factors that may influence development.

1.9 Geotechnical interpretation for preliminary design purposes has been undertaken based on existing information not specific to the proposed development.

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Limitations and Exceptions of the Report

2 Limitations and Exceptions of the Report

2.1 This report has been prepared for the sole internal use and reliance of Network Rail. This report shall not be relied upon or transferred to any other parties without the express written permission of Faber Maunsell. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

2.2 This report is not a comprehensive site characterisation and should not be construed as such.

2.3 Findings and opinions conveyed in this report are based on information obtained from third parties that Faber Maunsell believes are reliable. Nevertheless, Faber Maunsell cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

2.4 The report represents the findings and opinions of experienced geotechnical and geo-environmental consultants. Faber Maunsell Limited does not provide legal advice and the advice of lawyers may also be required.

2.5 Opinions presented in this report are based on findings derived from geological maps and memoirs, site photographs, a review of historical records and an Envirocheck Report dated January 2009 and previous ground investigation factual reports prepared and specified by others. Faber Maunsell has found conditions that suggest that hazardous substances exist at the site likely to warrant mitigation or consideration appropriate to the end use stated by Network Rail. Not finding other such indicators does not mean that other hazardous substances do not exist at the site.

2.6 It is possible that the research by Faber Maunsell, whilst fully appropriate for a geotechnical and geoenvironmental desk study and preliminary interpretative report, failed to indicate the existence of important information sources. Assuming such sources exist, the information could not have been considered in the formulation of the findings and opinions of Faber Maunsell.

2.7 Subsurface geological profiles and other plots are generalised by necessity and have been based on the information found at the locations of the exploratory holes and depths where samples have been collected and tested by others. Site specific ground investigation was not available for the preliminary interpretation made in this report.

2.8 Faber Maunsell believes that information about the limitations of the report is essential to help Network Rail identify and thereby manage risks. These risks can be mitigated, but cannot be eliminated through additional research.

2.9 Faber Maunsell will, on request, advise Network Rail of the additional research opportunities available, their impact on risk, and their cost.

2.10 In preparing this report it has been assumed that all past and present occupiers have provided all relevant information, especially relating to known or potential hazards. Authors of this report are not required to identify insufficiencies or mistakes in the information provided by the user or owner or from any other source, but have sought to compensate for these, where obvious in the light of other information.

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Site Description

3 Site Description

3.1 The site is situated the south side of Leeds City Station, adjacent to the existing bridge arches crossing the River Aire and includes land on the east and west banks of the river. Leeds City Station lies immediately south of Leeds City Centre. The site is situated at approximately National Grid Reference 429850 433130, as shown on Drawing 60092600/601.

3.2 A site inspection was undertaken during June 2008; photographs taken and observations are incorporated below.

3.3 The station is situated on a hillside falling from the south of the city down to the River Aire and the Leeds Canal Basin; much of it is supported on a number of Victorian brick vaulted arch viaducts, known as The Dark Arches. Situated just off Neville Street under the Dark Arches is Granary Wharf, comprising retail premises directly beneath the railway station. The station itself is constructed on barrel arch viaducts over two sub parallel roads which run along the length of the station.

3.4 The River Aire flows in a south west – north east direction parallel to the railway from Holbeck Triangle to the station. Beneath the station the river channel swings approximately 90 degrees to the south, passing beneath the station through a series of interconnected arches, see Plates 1 and 2. Within the arches is a 1.0 to 2.0m high weir. Approximately 150m south of the station the river again changes direction by some 90 degrees and flows to the east.

3.5 Immediately west of the site is Canal Wharf. At the time of the site visit, a multi storey building known as the ISIS Waterside Development building was still under construction, see Plate 2. There is little room available for access in front of the ISIS building. Immediately east of the site and River Aire is a multi storey building of residential apartments known as the Blue Apartments, as shown on Plate 3. Access between the arches and the ISIS Building and Blue Apartments is very restricted, see Plate 4.

3.6 Immediately south of the site is a new footbridge providing access over the River Aire, from the ISIS Building on the west bank and the promenade in front of the Blue Apartments on the east bank, see Plates 1 and 2.

3.7 As a result of the proximity of the adjacent buildings the favoured option under consideration is to take passengers from platform level at approximately 41.6 mOD, back under the railway and into the Dark Arches. Plate 5 is taken from platform level looking south down to the river level.

3.8 Plate 6 shows the existing Granary Wharf Bridge within the Dark Arches.

3.9 The Leeds and Liverpool canal runs between the river and the railway south of the site. It passes beneath the railway west of the station, joining the River Aire approximately 100m southeast of the site.

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Historical Development

4 Historical Development

4.1 Historical Ordnance Survey (OS) maps were obtained as part of the Envirocheck report. Maps at scales of 1:500, 1:2,500, 1:10,000 and 1:10,560 are included on the Data CD in Appendix B(1) covering the period between 1850 and 2008. Historical development of the site has been examined by studying these superseded and current ordnance survey maps.

4.2 Historical archive drawings showing 'As Built' construction for the existing arches and foundations were not available at the time of issue of this report.

General History

4.3 In the 16th century Leeds was a centre of manufacture, it was also the centre of a network of communications, especially by water. In 1699 the Aire and the Calder rivers were made navigable, linking Leeds with the Ouse, Humber and the sea. In 1816 the Leeds to Liverpool Canal, a coast to coast link passing through Leeds, was completed.

4.4 Leeds was ideally situated for the development of an engineering industry, making machinery for spinning, machine tools, steam engines and gears as well as other industries based on textiles, chemicals and leather and pottery. Coal was extracted on a large scale and the Middleton Railway, the first commercial railway in the world, transported coal into the centre of Leeds.

4.5 Leeds became a city in 1893 and became a centre of study and teaching by the end of the World War 1. Since the Second World War and more particularly since the fifties, significant transformation and rebuilding of the city has been undertaken and continues.

4.6 The railways first came to Leeds in 1834, when the Leeds and Selby Railway (which became part of the North Eastern Railway) opened its line. This had a terminus at Marsh Lane, to the east of the city centre.

Historical Maps

4.7 The first available plan received from Envirocheck is a Historic Town Plan dated 1850 (published at scale of 1:500). This shows approximately eight rail tracks passing over the River Aire to platforms in Wellington Station. Immediately south of the arches is a river ford crossing. Land east of the site has a very different layout at this time compared to later OS maps. Between the River Aire and Neville Street are a number of streets including Sandford Street, Little Neville Street and Mortimer Street. A number of industrial premises are identified in this general area (within 150m of the site) including a tanning pit, dye house, gasometer, cloth factory and tobacco house. However, only an unnamed building is shown adjacent to the proposed east structure support. Land to the west of the site comprises a boat building yard.

4.8 At this time the main railway station was known as Wellington Station, on Wellington Street, immediately north of the site. This station was constructed circa 1840. A further station identified as Leeds Central is situated approximately 450m north west of the site, which is reported to have been constructed around 1854 by the Manchester and Leeds Railway and the London and North Western Railway (LNWR).

4.9 The first available OS map dated 1854 shows the central area of Leeds is already well developed as Leeds expanded rapidly during the industrial revolution.

4.10 The 1891 Town Plan and 1894 OS map shows two station buildings in the current position of Leeds City Station. This additional station, identified as New Station, was built partially on a bridge over the River Aire and was situated adjacent to Wellington Station. New Station is reported to have been constructed in 1869. This was a joint enterprise by the LNWR and the North Eastern Railway. Construction of the station and associated line connected the former Leeds and Selby Railway line to the east with the LNWR lines to the west. A mile-long connection was built, carried entirely on viaducts and bridges, with the arches under the main station becoming known as 'the Dark Arches'. A number of railway lines associated with New

Station cross the River Aire immediately north of the site. Some railway sidings terminate immediately west of the River Aire.

4.11 Data held on the Leeds City Council Website http://www.leeds.gov.uk/discover/default.asp indicate '*Originally the arches were used for storage, some of them by Joseph Watson & Sons, soap manufacturers, to store resin, oil and tallow. In 1892 these caught fire, and the bridge and railway line over the canal basin were destroyed'*. It is reported that '*Platforms 1, 2 and 3 collapsed as their supports buckled in the heat'*.

4.12 Little Neville Street, a Wharf, Victoria Coal Wharf, and School Close Woollen Mill are identified on the east bank of the River Aire on the 1891 Town Plan and 1893 1:2,500 scale OS map. Neville Street passes beneath the rail tracks into New Station crossing the River Aire via Victoria Bridge, approximately 140m southeast of the site. A benchmark on the north east corner of Wellington Station is shown as 112 feet (34.1m OD), reducing to 99.1 feet (30.2 mOD) on Neville Street at New Station and 97.2 feet (29.6m OD) on the corner of Neville Street and Water Lane, just south of Victoria Bridge.

4.13 One of the buildings on the east river bank, approximately 15m north of the proposed structure support, is identified as an Oil Works on the 1891 Town Plan. The works is not further identified on any later OS maps.

4.14 Land upstream of the site, west of Wellington Station, is subject to residential, industrial and commercial uses which include a chemical warehouse, mills and coal wharfs.

4.15 By 1908 the rail sidings immediately west of the River Aire and the site have been extended across the river, suggesting that the viaduct arches were extended some time between 1893 and 1908. Upstream and northwest of the site the chemical warehouse is no longer shown and a large building identified as the Leeds Corporation Electric Lighting Works has been constructed. The buildings on the east bank of the River Aire are demolished and two structures are shown directly on the east bank.

4.16 The 1921 OS map identifies one of the structures on the east bank as a travelling crane. The proposed structure support on the east bank of the River Aire is over the position of the former travelling cane.

4.17 The first rationalisation & rebuilding of New and Wellington Stations occurred in 1938, when two stations were combined to form Leeds City Station. It is understood that the most westerly arches of the station were damaged during the Second World War by bombs. The 1953 OS map shows a single station at the site, identified as City Station. The buildings on the east bank of the River Aire are again changed, and the travelling crane is no longer shown. On the west bank at Canal Wharf within the Boatbuilding Yard individual buildings are labelled as a saw mill and two graving docks (dry docks).

4.18 On the 1964 OS map, School Close Woollen Mill is now shown as a car park. By 1978 this is identified as the Dragonara Hotel. On the west bank, a car park is now shown within the Boatbuilding Yard. The buildings associated with the yard are no longer shown although the docks remain.

4.19 In 1967 further remodelling of Leeds City Station took place, when all traffic using Central Station was diverted into the City Station. Central Station was subsequently demolished. As part of this work some bridges over the Leeds and Liverpool Canal were replaced and an overall roof was provided to City Station.

4.20 On the 1989 OS map there are no buildings identified on the east bank of the site. A car park is identified on the west bank at Canal Wharf.

4.21 It is reported that the station's capacity was exceeded in the 1990's and between 1999 and 2002, a major rebuilding project took place. This project saw the construction of additional approach tracks at the western end of the station. The station was expanded from 12 to 17 platforms. The most visible change to passengers was the replacement of the 1967 metal canopy with a new glass roof.

4.22 The Blue Apartments were constructed on the east bank of the River Aire some time prior to 2004. Major change has recently been seen on the west bank of the River Aire with the ongoing construction of the ISIS Waterside Development building. The hotel east of the site is now the Hilton Hotel.

4.23 In summary both the east and west banks of the River Aire at the site have a long history of industrial use. Infrastructure from the boat building yard on the west bank may still remain and may pose obstruction to foundations. On the east bank a travelling crane was positioned directly under the proposed structure support. An oil works was also present 15m north of this support.

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Envirocheck Environmental Database

5 Envirocheck Environmental Database

5.1 A search was commissioned from Envirocheck to cover an area within a 1km radius of the centre of the site. The search is carried out for any information relevant to a geotechnical or environmental study from a number of databases. Sources include the Environment Agency, British Geological Survey, Leeds City Council, The Coal Authority, The Countryside Agency, The Department for Environment, Food and Rural Affairs (DEFRA), Health Protection Agency (HPA) and the National Radiological Protection Board.

5.2 Results of the search are included in Appendix B(2) of this report and relevant points are discussed below.

5.3 The search has not indicated any Contaminated Land Register Entries and Notices, Enforcement of Prohibition Notices, Integrated or Local Authority Pollution Prevention and Control Sites, Registered Radioactive Substances, Water Abstraction Licences, Source Protection Zones, BGS Landfill Sites, Historical Landfill Sites, Local Authority Landfill Sites, Registered Landfill Sites, Registered Waste Treatment or Disposal / Transfer Sites or Waste Management Facilities / Waste Transfer Sites within 250m of the site.

5.4 There are no recorded discharge consents within 250m of the site, although there are a number of discharge consents recorded into the River Aire further upstream and downstream of the site.

5.5 There are 34 Pollution Incidents to Controlled Waters within 250m of the site, with only 4 of these upstream of the site. The majority of these are Category III – Minor Incidents relating to spillage of oils, diesel or sewage. There are 4 Category II Significant Pollution Incidents to Controlled Waters within 250m of the site, all of which are downstream of the site. These relate to spillage of chemicals & detergents, unknown sewerage, oils and cement/mortar. Given the localised nature of the proposed footbridge it is considered unlikely that these incidents will significantly impact the works.

5.6 The Envirocheck Report indicates that the site is within an area which may be affected by coal mining activity and it is recommended that a coal mining report is obtained from The Coal Authority. The report also indicates that the Ove Arup Mining Instability report indicates the site is in an area recorded as 'Inconclusive Coal Mining'.

5.7 The Envirocheck report has not highlighted any significant constraints to the proposed development.

Leeds City Council

5.8 As part of the desk study enquires were also made to Leeds City Council, a copy of the response is included in Appendix B(3).

5.9 Leeds City Council has confirmed the historical site uses identified by this independent study, including the boat building yards on the west bank from at least 1850 to 1970. They have confirmed the presence of buildings of unknown uses on the east bank, as well as a number of travelling cranes shown between 1850 and 1921. In addition the council has confirmed the presence of the oil works on the east bank on the 1891 map issue, they indicate that the works is no longer identified after 1891 but the building remained on site until at least 1970, and was used as a warehouse.

5.10 In summary the Council indicate:

- They have no reason to determine the site as Contaminated Land and the site is not listed on the Council's Part 2A Public Register.
- The Council do not hold any records to show that there has been any mining or minerals extracted at the site.
- The Council has confirmed the presence of one commercial borehole for private water supplies, located 1km east of the site.

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Geology and Hydrogeology

6 Geology and Hydrogeology

6.1 The following documents were examined during this study:

- 1:50,000 Geological Survey Sheet 70, Leeds, Solid Edition, British Geological Survey. Copyright NERC 1974.
- 1:50,000 Geological Survey Sheet 70, Leeds, Drift Edition, British Geological Survey. Copyright NERC 1974.
- 1:50,000 Geological Sheet 70, Leeds, Solid and Drift Geology, NERC, 2003.
- Cooper, A.H and Gibson, A, Geology of the Leeds district, A brief explanation of the geological map. Sheet Explanation of the British Geological Survey, 1:50,000 Sheet 70, Leeds, 2003
- 1:10,000 SE23SE, South West Leeds, British Geological Survey, NERC, 1991.
- 1:10,000 SE33SW, South East Leeds, British Geological Survey, NERC, 1991.
- Geology of the south-west Leeds district. Memoir of the British Geological Survey, Sheet 70 (England and Wales).
- Envirocheck Geology Report, January 2009.

6.2 The Envirocheck geology maps are included in Appendix B(4). These show that the whole of the station area northwest of the site is an area of made ground. Superficial soils at the site comprise alluvium, described as clay, silt, sand and gravel, underlain by the Pennine Lower Coal Measures Formation (PLCM), comprising an interbedded sequence of sandstone, siltstone, mudstone, seatearth and coal. Geological faults are noted north and south of the site, which down throw strata to the south east. The solid strata dip to the south east.

6.3 Published Geological Maps indicate that the site is underlain by superficial soils comprising river alluvium with river terrace gravels south of the site, predominantly on the west bank. Solid strata comprise the Westphalian Lower Coal Measures (now PLCM), which are regionally recognised as being worked. Geological faults are noted north and south of the site, and rock is dipping to the south east. The Better Bed Coal subcrops approximately 45m northwest of the site and is expected to underlie the site at shallow depth. The Better Bed Coal is underlain at depth by the 80 Yard Band and the 48 Yard Band Coals.

6.4 A borehole record (80a) is included on geological map sheet SE23SE. This borehole is approximately 40m north of the site. The borehole is identified as the 'Norwich Union Building' and proved made ground to 2.74m. The natural superficial soils are not described, however the Better Bed Coal (0.3m thick) was proved at 23.16m. The hole was extended to 30.48m and the solid strata are described as 'strata including Grenoside Sandstone to base of hole'.

British Geological Survey (BGS) Boreholes

6.5 Seven BGS borehole records whose to depths range between 9.3 and 25.0m have been purchased and are included in Appendix B(5). The location of the boreholes is shown on Drawing 60092600/602. These generally indicate areas of hand standing comprising concrete, tarmac, or stone flags underlain by made ground described as clay, ash, gravel and brick fragments to a maximum depth of 3.7m. The made ground is underlain by generally loose and medium dense alluvial sand and gravel to a maximum depth of 6.7m. Superficial soils are underlain by either completely weathered mudstone (described as firm and stiff clay) or highly weathered mudstone (recovered by cable percussive drilling techniques) to a maximum depth of 9.3m. In Norwest Holst BH01, rotary coring of the underlying solid strata proved an interbedded sequence of moderately weak mudstone and moderately strong siltstone and sandstone between 9.0 and 25.0m.

Previous Ground Investigation

6.6 Relevant boreholes from two previous ground investigations (by others) are available including Geotechnics Limited, Leeds Area Remodelling and Resignalling, Main Ground Investigation Report, Volumes 1 & 2, April 1999[(2)] and Norwest Holst Soil Engineering, Report on Ground Investigation at Leeds Canal Basin, Leeds, 2006[(3)] (ISIS Building). Ground conditions and

laboratory test data from these investigations are discussed in detail in Sections 11 and 12 of this report.

Hydrology and hydrogeology

6.7 The structure will span between the east and west banks of the River Aire. The River Aire and the Leeds and Liverpool Canal are listed as have a River General Quality Assessment (GQA) rating C – Fairly Good.

6.8 Groundwater levels within the superficial soils on the banks of the river are anticipated to be in hydraulic continuity with water levels within the River Aire.

6.9 The site is underlain by Pennine Lower Coal Measures Formation rocks which are classed as a minor aquifer of variable permeability. Minor aquifers can be fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. Although not producing large quantities of water for abstraction, they are important for local water supplies and in supplying base flow to rivers.

6.10 The soil has been classed by Envirocheck as High Leaching Potential (U), with the worst case vulnerability assumed and assigned to urban areas. There are no known groundwater abstractions within 250m of the site.

6.11 The Envirocheck report indicates the site is within a Zone 3 Flood Risk from a river without defences, See Appendix B(2).

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Mining and Mineral Extraction

7 Mining and Mineral Extraction

7.1 A Coal Authority Mining Report has been obtained as part of this study, reference 00001320-09, See Appendix B(6).

7.2 The Coal Authority Mining Report indicates that the site is not within the zone of likely physical influence on the surface from known past or present underground workings.

7.3 The site is not in an area for which the Coal Authority is determining whether to grant a licence/ or for which a licence has been granted to remove coal using underground methods.

7.4 The site is not in an area that is likely to be effected at the surface from any planned future workings, however the Coal Authority do indicate that reserves of coal exist in the local area which could be worked some time in the future, subject to appropriate licensing.

7.5 There are no known mine entries within 20m of the site or search area.

7.6 The site is not recorded to be within the geographical boundary of past, present or future opencast mining. It is also not within 800m of the boundary of an opencast site for which license to extract coal via opencast methods has been granted.

7.7 The Coal Authority has not received a damage notice or claim for the site since 1 January 1984 in respect of the property since the Coal Mining Subsidence Act 1991.

7.8 There is no record of a mine gas emission requiring action by the Coal Authority within the boundary of the site.

7.9 However, the geological map indicates the Better Bed Coal has been worked in the Leeds area. The geological map shows 'site of former pit' approximately 100m east of the site apparently sank to access the Better Bed Coal shown to subcrop to the north. In addition the map shows 'old bell pits' and 'coal debris in drift' on land west of the site. It is considered likely that possible workings in the Better Bed seam may pre-date available Coal Authority records.

7.10 Information contained within the BGS technical report WA/91/42[(1)], Geology of south-west Leeds district, 1:10,000 Sheet SE 23 SE indicates the Better Bed Coal is the stratigraphically lowest coal to have been worked in the district. The Technical Report indicates that the coal varies in thickness from 0.08m to 0.91m. The coal has a history of use in iron smelting and was later worked for the extraction of its seatearth which was a valuable fireclay of good quality but variable thickness. The report indicates that many old pits and adits exist in the Better Bed Coal which has been extensively worked in the general areas of Farnley, located north of Leeds City, as well as in (Lower) Wortley, approximately 350m southwest of the site.

7.11 An enquiry has been made to the Network Rail Mining Engineer for information they may have regarding potential unrecorded workings in the Better Bed seam. A response has not yet been received.

7.12 Previous ground investigation was undertaken by Geotechnics Limited in 1999 as part of the Leeds Remodelling and Resignalling contract. Two boreholes were undertaken adjacent to the Dark Arches, immediately east of the site (BH's 45 and 46). The boreholes were extended into rock by rotary coring. Core recovery from 15.0 mOD was 100% and no loss of drilling fluid was reported by the driller. No evidence of mine workings are reported on the exploratory hole logs. It was concluded by the design engineer (Bullen Consultants) that consolidation grouting of voids or disturbed ground was not required for the remedial works proposed at that time, which comprised extension of the existing concrete box subway over Dark Neville Street to accommodate construction of new platforms at station level.

7.13 Intact coal was proved in exploratory holes undertaken on the west bank of the River Aire, as part of the ISIS Ground Investigation (2006), as summarised below. The exploratory hole location plan for this investigation is provided in Appendix B(7).

Exploratory Hole	Depth from (m)	Depth to (m)	Level from (mOD)	Level to (mOD)
BH102	21.89	22.08	6.33	6.14
BH103	21.60	21.85	6.35	6.10
BH107	24.34	24.50	2.94	2.78

7.14 Ground conditions and rotary coring undertaken in previous ground investigations (by others) does not provide any evidence to suggest unrecorded workings are present in the Better Bed seam beneath the site.

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Potentially Contaminative Uses

8 Potentially Contaminative Uses

8.1 Contaminative uses are defined as "any use of land which may cause it to be contaminated with noxious substances" in Section 143 of the Environmental Protection Act (1990).

8.2 Contaminated land is "land which appears to the local authority [acting on Statutory Guidance] to be in such a condition, by reasons of substances in, on or under the land, that significant harm is being caused, there is significant possibility of such harm being caused or that pollution of controlled waters is being or is likely to be caused" according to Part IIA of the Environmental Protection Act.

8.3 Historical maps indicate that the west bank of the site was historically a Boatbuilding Yard prior to 1850 which remained in use until the mid 1960's. The east bank has been subject to a number of past potentially contaminative uses including an oil works (recorded only on 1850 town plan), tan pit (pre 1891), dye house (pre 1891), gasometer (pre 1891), woollen mill and a coal wharf (pre 1850 to ~1970). The oil works, tan pit, gasometer and dye house are all thought to have be demolished by 1891 as part of the construction of the extended arch viaducts and construction of New Station. The gasometer was situated north of the proposed footbridge but its operation may have resulted in some remnant contaminants typical of gas works in the general area. The woollen mill was historically to the east of the proposed entrance structure and the coal wharf was historically to the south, although all these industries were within 150m of the site.

8.4 It is not known what activities were undertaken at the oil works identified on the 1899 Town Plan. The Department for Environment Industry Profile for Oil refineries and bulk storage of crude oil and petroleum products(4) indicates that historically mineral oils derived from oil bearing shales were first exploited in the United Kingdom on a small scale for lamp oil (kerosene) in the early 19th Century and involved a process of distilling oil from bituminous shale and common coal. The low yields of oil from oil shale results in a considerable quantity of waste material per unit output of oil. It is reported that the quantity of spent shale amounted to almost the same as the volume of raw shale put through the retorts. However, the quantity of petroleum products produced from oil shale was low, and the volume of waste which was produced is not generally considered to be of significance. It is possible that some localised hydrocarbon contamination and spent shale may be encountered at the site.

8.5 The Department of Environment Industry Profile for shipbuilding, repair and ship breaking(5) indicates that contaminants associated with early shipbuilding (pre 1800) include wood preservatives such as tars and creosotes. Buried saw dust and wood shavings may be a source of gas generation and whilst organic solvents are used in paints, degassing thinning or cleaning may have caused contamination through spillage. At the start of the 19th Century, steel and iron replaced wood as the main materials in shipbuilding. Additional contaminants include fuel oils, lubricating oils and hydraulic fluid which may contaminate the ground through leakage or spillage. Asbestos was also extensively used as an insulation material and may be found in shipbuilding yards. Heavy metals and their oxides from welding, cutting and grinding and metal compounds used as pigment or corrosion inhibitors in paint may also be present.

8.6 The presence of the canal wharfs and dry docks may also be a source of potential contamination. Dock dredgings were often placed on surrounding land. Dock dredgings often concentrate certain contaminants. Heavy metal contamination in dredging spoil is common since metals, including zinc and cadmium may be largely insoluble within the aquatic environment. Spillages and leaks of cargo materials stored and transported is another common source of contamination. The major bulk commodities with the potential to cause contamination include petroleum products, coal, coke, metal ores and powders. Dredgings may also contain organic material which may potentially produce gas.

8.7 The Department of Environment Industry Profile for Gasometers and Gas Works, Coke Plants and other Coal Carbonisation Plants(6) indicates that heavy metals may be widely distributed on gas works sites. However, it is likely that higher heavy metal concentrations will be found

around old process areas, former coal storage sites and areas used for the disposal of spent oxide and/or other process residues. Former coke works sites are commonly also contaminated with arsenic, sulphur, sulphate, sulphide, asbestos, acidic and alkali chemicals, phenols, hydrocarbons, coal tars, cyanides, spent oxides and ammoniacal liquors. It is reported that lead was used in paintwork, as caulking for gas holders and in pipework.

8.8 It is possible that the historic use of the land south of the site as a coal wharf will result in some contamination by coal dust as a result of stockpiling of coal. It is likely to be concentrated in former coal storage/breaking areas.

8.9 The Department of Industry Profile Railway Land[(7)] indicates that fill material was often utilised during construction of railways where there was a shortfall of natural excavated soil. Fill and construction material often contains clinker and ash. Boiler ash generated by steam locomotives was also often used to form ballast along many railway lines. Ash is typically contaminated with heavy metals, polycyclic aromatic hydrocarbons (PAH's), phenols and sulphates. The made ground encountered at the site is noted to contain ash, brick and concrete and may in part be formed from dumped waste boiler ash.

8.10 Other potential sources of contaminants that may be encountered on railway land include herbicides, polychlorinated biphenyl (PCB's) utilised in electrical transformers, and general spills of materials used or transported, which may include fuel oils, lubricating oils, paraffin, solvents, creosote, paints etc. Metal fines, ash and asbestos are also frequently present on railway land. However, given that the site is at a lower elevation to the running lines and Leeds City Station the risk of contaminant pathway linkages is reduced.

8.11 It is considered possible that made ground on the site may contain material from any of these past potential contaminative uses.

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Public Utilities and Services

9 Public Utilities and Services

9.1 Faber Maunsell is undertaking a public utilities and services survey as part of the wider feasibility GRIP 4 assessment. Reference to the public utilities and services drawings must be undertaken prior to any future intrusive ground investigation works.

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Ground Investigation and Ground Conditions Encountered

10 Ground Investigation and Ground Conditions Encountered

10.1 Geological maps indicate drift cover at the site comprises alluvium, described as clay, silt, sand and gravel, underlain by the Pennine Lower Coal Measures Formation, an interbedded sequence of sandstone, siltstone, mudstone, seatearth and coal. Ground water levels are expected to be close to the river level and may vary seasonally and in response to weather conditions and rainfall events.

10.2 There have been several phases of historical ground investigation (by others) at or in the vicinity of the site. It is noted that no data is available at this stage specific to the development and proposed foundation support positions. Exploratory hole logs, in-situ testing and laboratory testing available for the following sources of information has been reviewed as part of this report.

- BGS Boreholes, Holst & Co., Cedro Holdings, June 1965
- BGS Boreholes, Norwest Holst Soil Engineering, Leeds Canal Basin, January 1988
- BGS Boreholes, Norwest Holst Soil Engineering, G.R.E properties, Neville Street Leeds, 1991
- Geotechnics Limited, Leeds Area Remodelling and Resignalling, Main Ground Investigation Report, Volumes 1 & 2, April 1999[(2)]
- Norwest Holst Soil Engineering, Report on Ground Investigation at Leeds Canal Basin, Leeds, 2006[(3)]

10.3 The location of the exploratory holes relative to the site is shown on Drawing 60092600/602. Anticipated ground conditions are shown on the geological cross section on Drawing 60092600/603. Note that the distance of the exploratory holes from the section line is identified on the geological section as [m]. The general soil succession encountered in the exploratory holes is summarised below:

Formation / Unit	Strata Code	Strata
Recent (Made ground)	c3	MADE GROUND – hard standing surfacing including tarmac, concrete, sandstone flags.
	c2	MADE GROUND - medium dense clayey sandy siliceous gravel.
	c1	MADE GROUND – clayey silty sandy gravel / sandy gravelly clay with gravel of concrete, ash ,brick, mortar, slate roof tiles.
Alluvium and River Terrace	b3	Firm, soft and stiff sandy gravelly CLAY.
	b2	Loose to medium dense SAND.
	b1	Loose to medium dense GRAVEL and SAND and GRAVEL.
Carboniferous Bedrock	a4	Thinly laminated very weak and weak MUDSTONE and SILTSTONE.
	a3	Moderately weathered very weak SILTSTONE.
	a5	COAL
	a2	Moderately weathered SANDSTONE, moderately weak.
	a1	Very weak and weak thinly laminated grey MUDSTONE.

10.4 Groundwater level monitoring (by others) is available for exploratory holes sunk for the adjacent ISIS Waterside Development building[(3)]. Groundwater level monitoring versus time profiles for BH-I106, I107 and I108 are included on Figure 11.1. Monitoring was undertaken on six occasions between 23rd August and 26th October 2006. Within the mudstone (a1) and siltstone (a3) standing water levels range between 23.7 and 25.5mOD. Standing water levels within the alluvial sands (b2) vary from 23.5 to 24.1mOD. A slow rise in water levels in the superficial deposits occurred over the monitoring period.

East Abutment - Geotechnics Limited 1999

10.5 Previous ground investigation was specified by Bullen Consultants as part of the Leeds Area Remodelling and Resignalling contract. Specialist ground investigation contractor Geotechnics Limited undertook the ground investigation in 1999, report reference, Main Ground Investigation Factual Report, 98-9861[(2)].

10.6 Relevant data includes two boreholes drilled within the Dark Arches, north of the site (BH's G45 and G46). The boreholes were extended into rock by rotary coring. Core recovery was 100% and no loss of drilling fluid was reported by the driller. No evidence of mine workings are reported on the exploratory hole logs. A copy of the exploratory hole logs and extract of the exploratory hole location plan are included in Appendix B(8).

10.7 BH-G45 was drilled 45m north of the site, at a ground level of 27.27 mOD. Tarmac and ash stone fill (c4) was proved to 0.4m, underlain by made ground comprising loose brown slightly clayey to clayey silty sandy gravel of sandstone, mudstone and red brick with pockets of soft gravelly clay (c1) to 3.3m (23.97 mOD). These soils are in turn underlain by medium dense siliceous gravel (b1) to 4.1m (23.17 mOD). These granular soils are interpreted as alluvial and river terrace soils associated with the River Aire. Firm and stiff grey clay with occasional mudstone lithorelicts (completely weathered mudstone a1w) was proved by cable percussive drilling techniques to 10.5m (16.77 mOD). Rotary core follow on proved an interbedded sequence of weak moderately weathered mudstone (a1), moderately weak sandstone (a2) and siltstone (a3) to the base of the hole at 21.2m (6.07 mOD).

10.8 In BH-G46 was drilled approximately 16m north of the site, at a ground level of 27.46 mOD. Underlying 0.4m of concrete and sandstone flags (c3), made ground comprising brown sandy slightly silty gravel of red brick, concrete and mudstone (c1) was proved to 2.2m (25.26 mOD), underlain by further made ground described as medium dense clayey sandy siliceous gravel or medium dense silty sandy siliceous gravel (c1) to 3.1m (23.96 mOD). These soils may have been mislogged and are actually alluvium and river terrace soils. Medium dense clayey siliceous gravel (b1) was proved to 4.2m (23.26 mOD). Very stiff grey silty clay (interpreted as completely weathered mudstone (c1w)) was encountered to 8.8m (18.66 mOD). Underlying the completely weathered mudstone, very weak mudstone (a1) was proved by cable percussive drilling to 10.0m (17.46 mOD). Rotary coring proved an interbedded sequence of weak and moderately weak mudstone (a1), moderately weak siltstone (a3) and moderately weak sandstone (a2) to the base of the hole at 20.8m (6.66m OD).

River Pier

10.9 There is no ground investigation available for the proposed extended arch piers and proposed structure foundation supports within the River Aire.

10.10 Bathymetric survey data has been overlain onto the geological cross section on Drawing 60092600/603. This show a river water level of 23.98 mOD. The river channel is very flat with levels of 21.96, 20.42 and 20.88 mOD at the west bank, centre of channel and east bank, respectively. Data suggest that only very thin deposits of river sediment would be anticipated and the existing spillway probably rests directly on underlying weathered mudstone.

West Abutment – Norwest Holst 2006 – ISIS Waterside Development [(3)]

10.11 Norwest Holst undertook ground investigation works for the adjacent Isis Water Development in 2003. A copy of the relevant exploratory hole logs and ground investigation location plan is included in Appendix B(8).

10.12 Trail pits 102 and 108 are shown on the exploratory hole plan but were not excavated due to proximity of buried services. Relevant exploratory holes include BH-I106, I108 and TP105 on the west bank, and TP113/113A on the east bank of the River Aire.

10.13 Cable percussive boreholes proved made ground comprising brown clayey sand and gravel of brick, concrete and ash (c1 & c2) from ground level to a maximum depth of 2.6m (24.79 mOD). The made ground is underlain by a loose becoming medium dense slightly clayey gravelly sand (b2) to maximum depth 7.1m (20.3 mOD). The superficial soils are underlain by an interbedded sequence of very weak and weak thinly laminated mudstone (a1) and very weak siltstone (a3). Holes were extended to depths of 23.3m (BH-I106) and 21.5m (BH-I108). In BH-I106 very weak mudstone is recorded from 10.8m (16.6mOD) to 12.6m (14.8mOD), in turn underlain by very weak siltstone to the base of the hole at 23.3m (4.1mOD).

10.14 As detailed in Section 9, intact coal was proved in exploratory holes undertaken as part of this investigation and there is no evidence to suggest that unrecorded workings are present at the site.

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Material Properties

11 Material Properties

11.1 No ground investigation data is available within the River Aire and all information described has been obtained from exploratory holes on the east and west river banks.

11.2 Figure 12.1 shows a Casagrande plasticity chart for the fine-grained soils encountered at the site. Atterberg limit data for cohesive soils plot above the A line as clays of low, intermediate and high plasticity.

11.3 The cohesive made ground (c1) plots as clay of low and intermediate plasticity. The completely weathered mudstone described as firm and stiff grey silty Clay (a1w) with occasional mudstone lithorelicts plots as clay of intermediate and high plasticity.

11.4 Variations of Atterberg Limits and moisture content with level are shown on Figure 12.2.

11.5 Moisture content of the cohesive made ground (c1) between 26.0 and 24.5 mOD range between 21 and 23%. Moisture contents are below the plastic limit and desiccated, probably friable cohesive material would be anticipated. In this zone, liquid limits are in the range 31 to 38%.

11.6 Values of moisture contents for the completely weathered mudstone (a1w) between 23.0 and 19.0 mOD are between 14 to 20%. The values are well below the plastic limits and suggest stiff and very stiff soils typical of weathered mudstone. Liquid limits are in the range 48 to 51%.

11.7 Standard penetration tests are plotted against level on Figure 12.3. N values obtained from the full 450mm test drive are shown together with values extrapolated from partially completed tests up to a maximum of 150 blows.

11.8 For cohesive soils an empirical correlation (cu = f*N (kPa) is commonly adopted, relating undrained shear strength of cohesive soils to SPT 'N' values, proposed by Stroud and Butler, 1975[10]. Values of 'f' are typically between 4 and 6 depending on the plasticity of the soil. Undrained shear strength has also been estimated using an empirical relationship with liquidity index proposed by Wroth and Wood, 1978 [11] modified to take account of research undertaken by Barnes and Staples, 1988[12].

11.9 SPT N values in the granular made ground (c1) between 26.8 and 24.7 mOD are generally in the range 3 to 21. The data is variable but generally indicates loose, medium dense and dense conditions. Extrapolated values range between 54 and to greater than 150 blows and may have been caused by possible cobble and boulder obstructions in the made ground.

11.10 SPT N values in the alluvial gravel (b1) and alluvial sand (b2) generally present between levels of 25.0 and 20.9 mOD range from 5 to 41. The data shows a trend of increasing N value with depth, with loose to medium dense soils above 23 mOD and medium dense and dense soils present below this level.

11.11 SPT N values in the weathered carboniferous mudstone (a1w) between 23.0 and 17.5 mOD range between 15 and 64, with extrapolated values exceeding 150 blows. The data suggests a variable weathered rock surface with stronger relatively intact rock present at levels below 19.0 mOD at the west support and 17.5 mOD at the east support.

11.12 Peak soil friction angles (ø') measured using small shearbox test method on alluvial sands (b2) samples from BH-I106 at 4.0m (23.4mOD) and BH-I108 at 5.0m (22.39mOD) gave peak values of 31 and 33º, respectively. Effective cohesion (*c'*) of 14 and 19 kPa are indicated, although these values are not considered representative of actual long term drained effective stress conditions.

11.13 Undrained shear strength data is plotted against level on Figure 12.4. Data plotted includes shear strengths calculated from correlation with liquidity indices and SPT N values. Given that most of the superficial deposits are granular (made ground and alluvial sand and gravel) only little data is available.

11.14 Undrained shear strengths derived from correlation with liquidity indices for two samples taken from cohesive pockets within the predominantly granular made ground (c1) indicate c_u values of 43 kPa and >250 kPa. The higher result is unlikely to be representative and is most likely implies desiccation of surface soils.

11.15 Undrained shear strengths within the completely weathered carboniferous mudstone extrapolated from liquidity indices gave one c_u value of 210 kPa, with all other results exceeding 250 kPa.

11.16 From correlation with SPT N values, undrained shear strengths within the completely weathered mudstone are generally above 125kPa, although values of 75 and 85 kPa are obtained at levels of 22.8 and 18.8 mOD, respectively. A number of results show truncated shear strengths exceeding 250 kPa.

11.17 Compression index (c_c) and swelling index (c_s) are plotted against level on Figure 12.5. Indices are determined from empirical correlation with index properties in accordance with the empirical relationship with liquid limit proposed by Skempton, 1944[13]. c_s data is limited to c_s values estimated as a proportion of the inferred c_c values in accordance with Sladen and Wrigley, 1983[14].

11.18 Values of c_c and c_s for made ground estimated using liquid limits range between 0.17 to 0.22 and 0.027 to 0.04, respectively. Values of c_c and c_s for firm and stiff grey clay (completely weathered carboniferous mudstone c1(w)) are consistent ranging from 0.29 to 0.30 and 0.050 to 0.052, respectively.

11.19 Axial and diametral point load testing was completed on lump samples of rock core recovered from the boreholes undertaken as part of the 2006 Norwest Holst ground investigation[3] . The point load strength test is frequently used to determine crushing strength through established empirical relationships like those proposed by Broch and Franklin, 1972[15]. Johnston, 1991[16] suggests that typical multiplication factors to convert from point load strength index to uniaxial compressive strength, typically values between 20 and 25 are applied are applied to diametral tests. CIRIA 181[17] states that the development of site specific or formation specific correlations based on UCS and Is(50) values are essential. This is not feasible at this site as only no uniaxial compressive strength tests are available for the mudstone in BH's I106 or I108.

11.20 Unconfined compressive strength (UCS) has been inferred from diametral point load results using a relationship of UCS = 20* Is(50). A wide variation of unconfined compressive strength values are obtained from the point load test data. Calculated values exceeding 15MPa in the weak mudstone are ignored. An average strength of 4.6MN/m^2 is calculated for the carboniferous mudstone from the results of point load testing on all samples.

11.21 The mudstone is described as very weak, weak and locally very weak in accordance with BS5930; 1999 (prior to Amendment No 1 December 2007). In accordance with BS5930 very weak rock has an unconfined compressive strength of <1.25MN/m^2 and weak rock has unconfined compressive strength in the range 1.25 to 5.0MN/m^2. Therefore, it is considered that the results from point load tests generally overestimate anticipated unconfined compressive strength.

11.22 Total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) values measured from the rock core recovered during rotary core drilling for BH's I106 and G46 are plotted against level in Figure 12.6. TCR within the bedrock is good with values generally ranging between 85 and 100%. SCR ranges from 6 to 100% and RQD varies between 0 and 72%, which indicates rock core quality to vary from very poor to good, Farmer 1983[18]. There is no pattern in the reduction of SCR and RQD recorded in the two holes.

11.23 It is noted that there is some discrepancy in the rock strength descriptions provided in the two available ground investigation reports. In the Geotechnics Limited, Leeds Area Remodelling and Resignalling, Main Ground Investigation Report (east bank) the mudstones are described as predominantly weak and moderately weak. In the Norwest Holst Soil Engineering report on Ground Investigation at Leeds Canal Basin, (ISIS development – west bank) the mudstones are described as predominantly very weak and weak.

11.24 Overall the results confirm the mudstone to contain moderately to highly weathered zones and it is anticipated these zones will exhibit lower compressive strength.

Chemical Conditions

11.25 Electrochemical testing results available for mudstone (c1) from the Norwest Holst Report on ground Investigation at Leeds Canal Basin are indicative of Design Sulphate Class 1 and an Aggressive Chemical Environment for concrete classification AC1 in accordance with BRE Special Digest 1 2005[19]. Mobile groundwater conditions are assumed at the site.

11.26 It is noted that there are no test results available for the surface made ground or alluvium and river terrace deposits and further testing is required. There is no test data for groundwater at the site.

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Site Conceptual Model & Preliminary Risk Assessment

12 Site Conceptual Model & Preliminary Risk Assessment

Environmental and Human Health

12.1 In order to make an assessment of the construction, environmental and human health risk a conceptual model needs to be developed for the site. This requires an examination of the 'Source-Pathway-Receptor' linkages to define construction, human health and environmental risk associated with existing and future conditions. The first step of the model development is to identify the contaminants of concern from possible sources and potential receptors on and around the site.

12.2 The risk assessment is based on guidance provided in CIRIA C552 - Contamination Land Risk Assessment, A Guide to Good Practice[8]. At this stage risk assessment is of a preliminary nature as site specific ground investigation and laboratory test results are not available. The risk assessment is based on information obtained in this geotechnical and geoenvironmental desk study and should be updated as further information becomes available.

12.3 The risk assessment is performed in accordance with the precautionary principle, in which a pathway is assumed to exist unless there is reasonable contrary evidence. The risk associated with each source-receptor linkage is a product of the probability that a significant pathway exists and the severity of the potential impact. For preliminary risk assessment the method for risk evaluation is a qualitative method and involves classification of :

- magnitude of the potential **consequence** (severity) of risk (Table 6.3 - CIRIA 552), classified as: Severe, Medium, Mild, Minor
- magnitude of the **probability** (likelihood) of risk occurring (Table 6.4 - CIRIA 552), classified as High Likelihood, Likely, Low Likelihood, Unlikely.

12.4 A comparison of consequence against probability is undertaken to indicate the risk presented by each pollutant linkage. This is calculated in accordance with Table 6.5 – CIRIA 552, reproduced below:

12.5

		CONSEQUENCE			
		Severe	**Medium**	**Mild**	**Minor**
PROBABILITY	**High Likelihood**	Very high risk	High risk	Moderate risk	Moderate / low risk
	Likely	High risk	Moderate risk	Moderate / low risk	Low risk
	Low Likelihood	Moderate risk	Moderate / low risk	Low risk	Very low risk
	Unlikely	Moderate / low risk	Low risk	Very low risk	Very low risk

12.6 Identified source-pathway-receptor linkages are summarised below, including assessment of consequence against probability.

Source	Pathways	Receptors	Consequence	Probability	Risk
MADE GROUND ASSOCIATED WITH PAST INDUSTRIAL USES **Oil Works** Spent shale & hydrocarbons, PAH's **Boatbuilding Yard & Dock dredgings** Wood preservatives, tars, creosotes, organic material. Organic solvents, fuel oils, lubricating oils, hydraulic fluid. Petroleum products, coal, coke, metal ores and powders. Heavy metals and their oxides. Asbestos TPH, PAH's, phenols. **Gasometers** Arsenic, sulphur, sulphate, sulphide, asbestos, acidic and alkali chemicals, phenols, hydrocarbons, coal tars, cyanides, spent oxides and ammoniacal liquors, lead. **Coal Wharf** Coal dust **Railway Land** Ash, heavy metals, TPH, PAH's, phenols and sulphates, PCB's	**1.** Dermal contact **2.** Inhalation of dust **3.** Ingestion of contaminated soils **4.** Ingestion of contaminated waters **5.** Migration of ground gasses / vapour inhalation **6.** Spontaneous combustion **7.** Leaching, migration, of contaminants to groundwater **8.** Leaching, runoff to surface water **9.** Plant uptake	General Public (1,2,3)	Medium	Unlikely	Low
		General Public (5)	Medium	Unlikely	Low
		Site Users (1,2,3)	Medium	Unlikely	Low
		Site Users (5)	Medium	Unlikely	Low
		Ground workers (1,2,3)	Medium	Likely	Moderate
		Ground workers (4)	Medium	Likely	Moderate
		Ground workers (5)	Medium	Likely	Moderate
		Ground-water (7)	Minor	Likely	Moderate / Low
		Surface Water (8)	Mild	Likely	Moderate / Low
		Fauna & Flora (9)	Minor	Low likelihood	Very Low

Magnitude of the potential **Consequence** (severity) of risk, Table 6.3, CIRIA C552.
Magnitude of the **Probability** (likelihood) of risk occurring, Table 6.4 - CIRIA C552.
Risk presented by each pollutant linkage, Table 6.5 – CIRIA C552

12.7 The principal receptors at risk from harm due to unexpected contamination and migration of dust (asbestos) and ground gasses and vapours (hydrocarbons) are ground workers. Risks to site uses are not significant as the entrance building will be constructed on pile supports above the River Aire and no pathway exists.

12.8 Environmental impact on surface water courses and groundwater may occur from mobilisation of contaminants as free-phase, dissolved phase or as suspended solids. Possible contaminants include toxic organic compounds and metals in fuels, lubrication oils that may be present within former dredgings and made ground at the site. The risk to surface water exists during construction if sediment is disturbed and moved downstream, causing pollution in the River Aire. Construction methods will need to be considered to minimise this risk and agreed with the Environment Agency. Piling through the made ground into the underlying mudstone is unlikely to create a significant new pathway for groundwater flow. Therefore, the risk to the groundwater aquifer (i.e. Lower Coal Measures) is considered negligible. It is considered unlikely that the development, once constructed, will significantly alter the existing condition, for environmental or human health risks.

12.9 Actions corresponding with the risk classification are calculated based on the requirements of Table 6.6 – CIRIA 552. The table indicates that any risk classified as moderate or higher will require further investigation or mitigation measures, as summarised below:

Source	Pathways	Receptors	Risk	Risk management
MADE GROUND ASSOCIATED WITH PAST INDUSTRIAL USES Oil Works Boatbuilding Yard & Dock dredgings Gasometers Coal Wharf Railway Land	1, 2, 3	Ground workers	Moderate	Ground Investigation – Chemical testing / quantitative risk assessment, CDM for construction Consideration of dust suppression during foundation construction.
	4	Ground workers	Moderate	Ground Investigation – Chemical testing / quantitative risk assessment, CDM for construction
	5	Ground workers	Moderate	Ground Investigation ,CDM for construction
	7	Ground-water	Moderate / Low	Adequate construction
	8	Surface Water	Moderate / Low	Adequate construction

12.10 Potentially contaminated soils have development implications which may include transport and disposal costs, regulatory implications, re-use of site won materials, importation of clean materials, planning restrictions and onerous construction procedures. In these cases there may be a requirement for pre treatment of soils. Ground investigation is therefore required to quantify hazardous properties and waste acceptance criteria for assessment of pre treatment options and disposal, for example from spoil arising from foundation construction.

Geotechnical and Construction Risks

12.11 Geotechnical and construction risks are evaluated using guidance recommended in the Highways Agency, Design Manual for Roads and Bridges, Volume 4, Section 1, Part 2, HD22/08, Managing Geotechnical Risk[(9)] . This requires the risks are identified, assessed and that the consequences of these risks to the project are determined. HD22/08 requires details of how the risks are to be managed. Geotechnical risks for the development and construction include:

Hazard / Risk	Cause	Consequence	Probability	Risk	Risk Management / Mitigation
Collapse of structures	Global failure Bearing capacity failure Depth of soils or bedrock variable. Unknown soils / rock strength	Severe	Low Likelihood	Moderate	Ground Investigation Adequate design Piled foundations
Structure settlement Differential settlement Deflection Deformation	Unknown soils strength Bearing capacity is lower than anticipated or different between supports. Depth of soils / rock or bedrock variable.	Medium	Likely	Moderate	Ground Investigation Adequate design Piled foundations Movement joints
Natural obstructions	Boulders within alluvial sand & gravels	Medium	Likely	Moderate	Ground Investigation Adequate design Suitable pile foundation technique
Man made obstructions,	Past site industrial uses. Buried foundations / structures / travelling cane	Medium	Likely	Moderate	Ground Investigation Adequate design Suitable pile foundation technique
Buried services	New construction damages utility services	Medium	Likely	Moderate	Adequate services survey
Aggressive ground conditions	Concrete attack Steel attack	Medium	Likely	Moderate	Ground Investigation Adequate design
Pollution of environment	Surface water runoff Dust	Severe	Unlikely	Moderate	Implement good construction / site management

12.12 It is considered that risks classified as moderate or higher should be further investigated. It is recommended that ground investigation is undertaken to aid the developer in assessment of estimates of overall development costs and aid in identifying value engineering opportunities and allow adequate design to accommodate or reduce potential geotechnical construction risks.

12.13 The proposed ground investigation is detailed in Section 14.

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Engineering Recommendations

13 Engineering Recommendations

13.1 It is proposed to construct a new southern entrance to Leeds City Station. An assessment of the effects of geotechnical and geoenvironmental characteristics of the site on feasibility of future development has been made. Comments are based on interpretation of the documents available at the time of writing and previous ground investigation data provided by others. This preliminary interpretation will need to be reviewed when ground investigation specific to the development and support positions is obtained.

13.2 Details of the proposed ground investigation are included within the next section of this report.

General Site Preparation Work

13.3 The banks of the River Aire at the site have been subject to a number of past contaminative uses. The Construction Design Management Coordinator should be informed of site conditions and risk assessment undertaken to comply with the Construction Design Management (CDM) regulations. Site personnel are to be made aware of site conditions.

13.4 Consideration of construction methods is required to ensure that sediment is not unnecessarily disturbed. Construction methods will need to be developed and agreed with the Environment Agency.

New Deck – Granary Wharf Bridge

13.5 A new deck is required over the River Aire in the central arch of the viaduct and for Granary Wharf Bridge, as the existing level of the bridge deck is too low and does not provide the flood level clearance required by the Environment Agency. The deck will be supported on the existing arches. It is not anticipated that existing loads will be significantly changed; therefore geotechnical assessment is not required.

Foundations

13.6 It is understood that one option under consideration is to construct the structure foundations in the River Aire from a floating barge.

13.7 Based on ground investigation available from the east and west bank of the River Aire and data obtained from the bathymetric survey, superficial soils and river sediment is anticipated to be thin and probably around only 0.5m thick. Any river sediment present will overly completely weathered mudstone, in turn underlain by very weak and weak thinly laminated mudstone.

13.8 It may be technically feasible to found the pier extension and structure on raft foundations bearing directly on weak mudstone. However, construction of this foundation option is likely to entail extensive temporary works, including river diversion and caisson construction at the support positions. It is also possible that the quality of the rock may be poorer than anticipated and fractures within the rock may make it difficult to effectively seal the caisson support. In this case there would be a requirement to construct the foundations below water. In view of the difficult temporary works constraints combined with the health and safety risks arising from potential flash fast water flows, which are typical along this section of the River Aire, it is likely that this option will be unfavourable.

13.9 For supports in the River Aire piled foundations end bearing on very weak or weak mudstone are recommended to carry structure loads. Following installation of the piled foundations a pre-cast reinforced concrete ‘pier’ would be placed over the piles and fixed.

13.10 Piles supports end bearing on rock are also proposed for the supports on the east and west banks of the River Aire. The pile foundations will carry the loads of the new structure to suitable bearing soils at depth and significant additional load will not be carried by the existing river edge retaining walls.

13.11 Driven piles provide a technically feasible alternative although within the River Aire it will be necessary to core through the existing concrete spillway prior to pile driving. At the river bank supports, made ground around 3.5m deep and cobble or boulder obstructions may be encountered. Small displacement piles such as steel open tubes or H section piles would be

preferable to large displacement piles for penetrating the made ground and weathered mudstone bedrock. However, noise and vibrations caused during pile driving will need to assessed, particularly given the close proximity of the adjacent Blue Apartment Buildings (east bank) and ISIS Waterside Development building (West Bank). Vibration effects on the existing river retaining walls and river pier foundations will need to be assessed. Consideration of these constraints may make the use of a driven pile foundation solution less favourable.

13.12 Significant access constraints are to be overcome at both the east and west bank pile foundation positions (See Plate 4). In order to access the proposed supports mini piling rigs will be required.

13.13 Continuous flight auger (CFA) displacement piles have the advantage that they induce less ground vibrations than driven piling techniques and do not create as much spoil at the ground surface. This may be advantageous for support positions on the east / west river bank supports. As mini rigs are required, significant dependence is placed on use of higher torque rigs capable of adequately socketing piles into bedrock to prevent unacceptable settlement.

13.14 If conventional bored piles are adopted at the east and west bank it should be noted that water bearing made ground and alluvial sand and gravel is present and pile bores would therefore need to be filled with water or drilling mud to balance external water pressures to avoid base disturbance during drilling.

13.15 Conventional bored piles cased through any sediment and existing concrete spillway curtain and socketed into the underlying bedrock are proposed for the extended pier support positions within the River Aire. Sacrificial casing would be required in order to form the pile from the barge platform level. Significant depth of river sediment is not anticipated and therefore the capacity of the pile is derived almost entirely from the rock socket formed in mudstone.

13.16 Piles to be formed at the extended pier positions in the River Aire are in close proximity to the existing arches / foundations. Archive drawings detailing the existing foundations for the arch supports were not available at the time of report issue and therefore the form of the foundations is unknown. It is recommended that archive drawings showing the form of the existing foundations for the arches within the River Aire are obtained if available.

13.17 Careful control of construction methods will be required to ensure that installation of new piles does not disturb soil around the existing arch foundations or river edge structures. Such disturbance may result in reduction of foundation capacity and induce settlement. Otherwise, no significant geotechnical problems are expected at the proposed structure support positions.

13.18 Further ground investigation is recommended to confirm anticipated ground conditions at the foundation support positions, particularly within the River Aire (Section 14).

13.19 An end product specification would be required for piling, stating the design axial and lateral loads and settlement criteria to be met. A specialist piling contractor will be responsible for the construction of the piles to support the loads indicated and achieve the settlement performance criteria specified by the Form B Detailed Designer.

13.20 Integrity problems can occur when CFA piles are installed through variable water bearing strata such as those found at the site. These are largely believed to have been addressed with the introduction of automated rig monitoring systems. For bored cast in situ concrete or CFA piles, small strain sonic velocity or resonant frequency measurements should be made to assess the integrity of pile concrete. Static load tests are generally recommended at support positions. However, access restrictions may preclude static load testing. Consideration may be given by the detailed designer to adopting higher factors of safety in lieu of static load testing. Pile test requirements are to be confirmed when the scheme design is finalised.

13.21 Preliminary pile capacity assessments using the Beta method have been carried out to determine the axial capacity for a 600mm diameter pile with an assumed rock socket into very weak and weak mudstone, deriving capacity from a combination of skin friction and end bearing using the following parameters:

Stratum	**Effective Friction Angle (degrees)**	**Unconfined compressive strength (MPa)**	**Bulk Unit Weight (kN/m^3)**	**Coefficient of Lateral Earth Pressure (K_o)**
Made ground - ash, brick, clay, gravel fill (c1)	28	NA	18.0	Varies
Loose / medium dense alluvial sand / gravel (b1/b2)	30	N/A	19.0	Varies
Completely weathered mudstone (a1w). Recovered as firm stiff and very stiff grey clay or de-structured clayey gravel.	28	N/A	21.0	Varies
Very Weak thinly laminated Mudstone (a1) or Siltstone (a3)	N/A	0.65	21.5	Varies
Weak thinly laminated Mudstone (a1)	N/A	2.00	21.5	Varies

13.52 To allow for the relief of lateral stress which occurs when boring through soils, the coefficient of in-situ earth pressure Ko is limited to 1.0. Accurate calculation of the ultimate skin friction around a bored pile into rock is not possible due to disruption of the structure of the bedrock by the drilling tools. The skin friction is limited to $0.2\sqrt{\sigma c}$ (MPa) in accordance with guidance provided in CIRIA Report 181 (1999)[17].

13.53 The structural engineer will need to verify working stresses and confirm that the proposed pile reinforcement will accommodate the proposed working stresses. Lateral load on the piles is not anticipated to be significant.

East / West Banks - Preliminary Pile Capacity (BH-I106)

13.54 Results of preliminary calculations on the geotechnical ultimate axial capacity of a 10.3m long, 600mm diameter concrete pile with 2.0m rock socket into weak mudstone is shown on Figure 13.1. This indicates an allowable bearing capacity in the order of 1230kN can be developed, adopting a global factor of safety of 2.5. It should be noted on the plot that axial capacity reduces to 880kN at 10.8m depth, as the strength of the mudstone is assumed to change from weak to very weak.

Extended Piers, River Aire - Preliminary Pile Capacity (BH-I106)

13.55 Results of preliminary calculations on the geotechnical ultimate axial capacity of a 3.0m long 600mm diameter concrete pile (with the whole of the axial capacity derived from a 3.0m rock socket into weak mudstone only - i.e. no sediment assumed) is shown on Figure 13.2. This indicates an allowable bearing capacity in the order of 900kN can be developed, adopting a global factor of safety of 2.5. Note that there is again a reduction in axial pile capacity to 750kN at 6.0m depth at the transition between weak and very weak mudstone.

13.56 It is noted that there is some discrepancy in the rock strength descriptions provided in the two available ground investigation reports. Where very weak bands of mudstone are encountered there is a risk of punching foundation failure at the toe of the pile. Ground investigation to verify conditions at the support positions is recommended.

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Proposed Ground Investigation

14 Proposed Ground Investigation

14.1 A development specific ground investigation for the proposed Leeds South Station Southern Entrance is not yet available.

14.2 BH-I106 is situated on the west bank and is in close proximity to the proposed foundation support. However, no data is available in close proximity to foundation supports within the River Aire or the east bank of the river.

14.3 In view of the interbedded sequence of weak and very weak mudstone and siltstone further information regarding the rock strength and quality at the pile foundation supports is required.

14.4 It is envisaged that additional ground investigation work will be undertaken at a later date to optimise detailed design, reduce risks and aid in refining construction proposals and costs.

14.5 The proposed ground investigation comprises 1 cable percussive borehole with 10.0m rotary core follow on the east bank and 2 over water rotary core boreholes to 10.0m depth at the pier support positions.

14.6 Ground investigation works are proposed to allow further assessment of the following:

- Prove the anticipated stratigraphy and provide geotechnical information to confirm the engineering properties of the soils and rock at the foundation support positions, in particular to provide confidence in the assumptions made regarding the level and strength of the mudstone bedrock.
- Confirm the groundwater level at the east bank.
- Undertake soil contamination testing for preliminary human health risk assessment (risk to ground workers as identified in Section 9).
- Electrochemical testing to determine the aggressiveness of soils and groundwater to buried steel and concrete.
- Determine the potential for buried obstructions / surface obstructions that may impede formation of the pile foundations (in particular the travelling crane base on the east bank).
- Chemical testing for classification of materials (pile bore spoil) for offsite disposal in accordance with the Environment Agency Waste Acceptance Criteria.
- If significant depth of river sediment is proved during the ground investigation, samples will be recovered from chemical and environmental testing.

14.7 A standpipe piezometer would be installed in the exploratory hole formed on the east bank and it is recommended that ground water levels are obtained over a minimum three month period.

14.8 Geotechnical testing would be undertaken on recovered samples of soil and rock to assess the engineering classification and properties of the soils for use in detailed design. In addition contamination testing would be undertaken to establish human health risk to construction workers.

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References

15 References

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3. Norwest Holst Soil Engineering, Report on Ground Investigation at Leeds Canal Basin, Leeds, 2006.

4. Department of the Environment Industry profile, (1995), Oil refineries and bulk storage of crude oil and petroleum products, Crown Copyright.

5. Department of the Environment Industry profile, (1995), Engineering works: shipbuilding, repair and shipbreaking (including naval shipyards), Crown Copyright.

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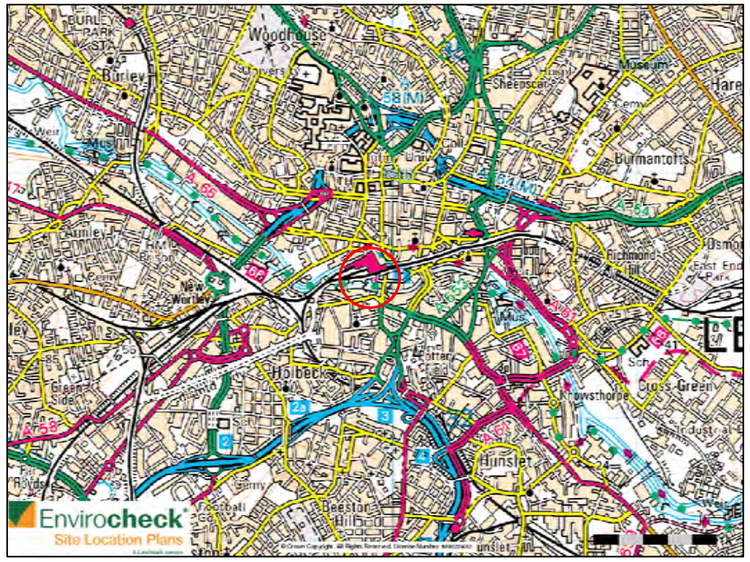
Drawings

Drawings

Drawing 60092600/601 - Site Location Plan

Drawing 60092600/602 - Previous Exploratory Hole & Geological Cross Section Location Plan

Drawing 60092600/603 - Geological Cross Section A-A'



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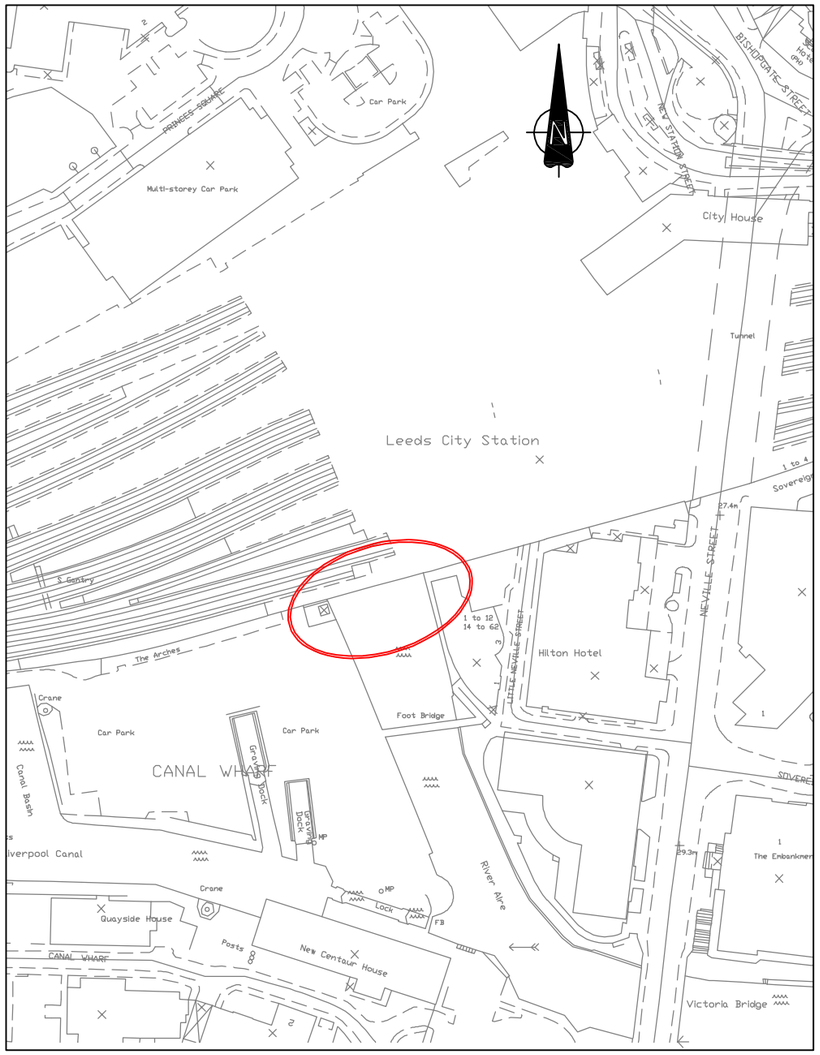

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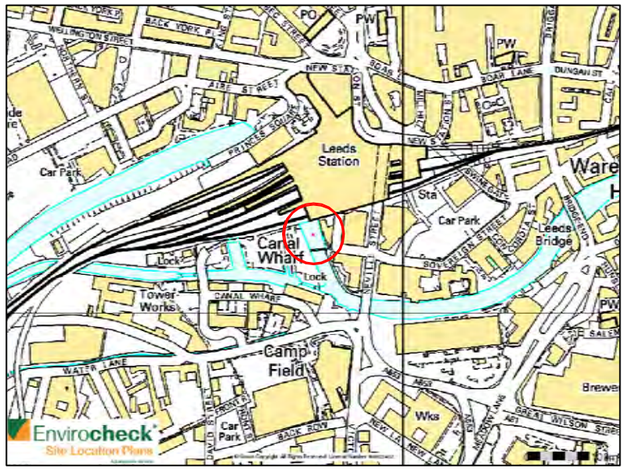

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NOTES

1. COLOUR RASTER IMAGES AND AERIAL PHOTOGRAPH OBTAINED AS PART OF ENVIROCHECK REPORT 27052630

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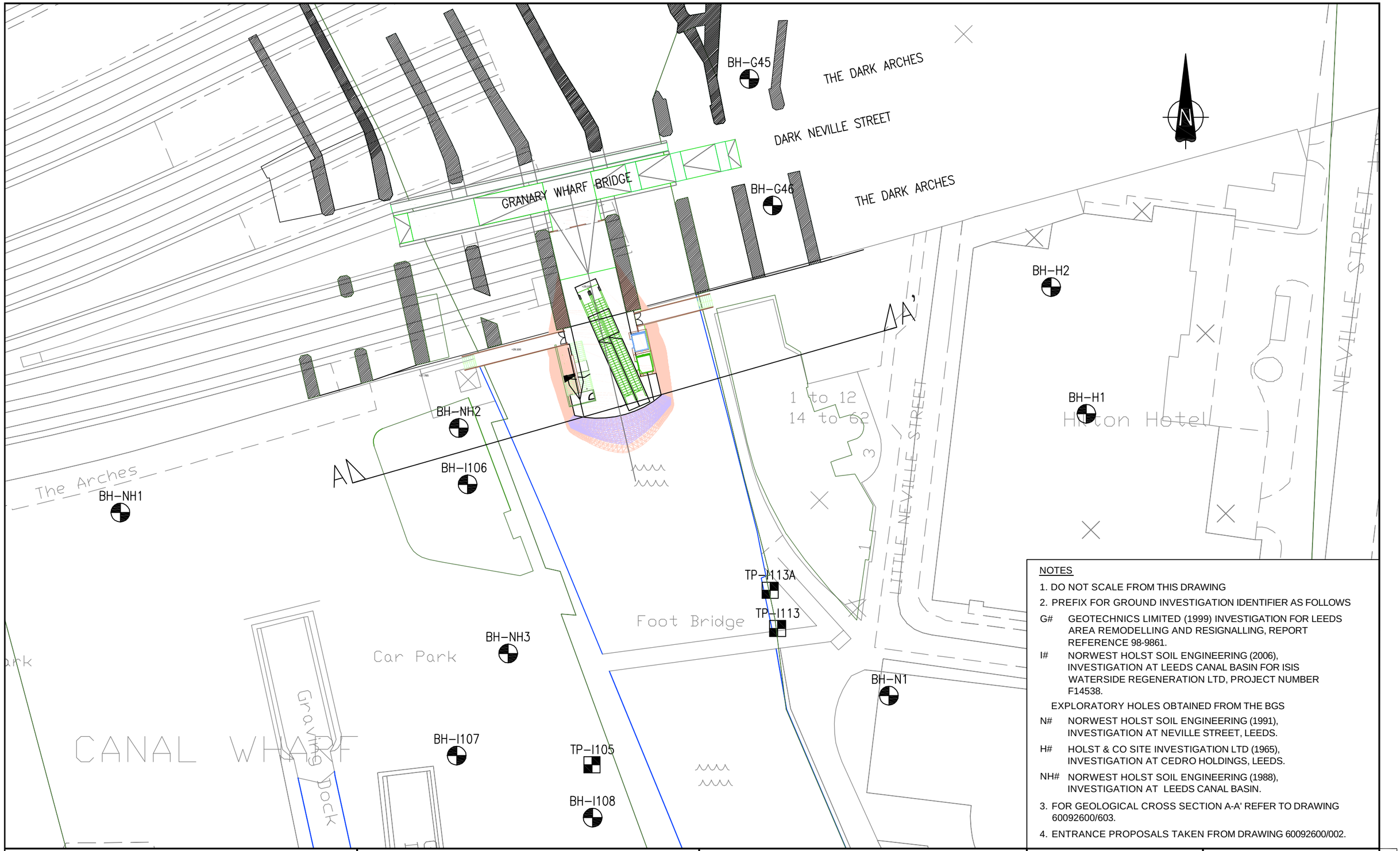
Project: LEEDS STATION SOUTHERN ENTRANCE			Chk'd: CMC / App'd: SDM
		First Floor, One Trinity Gardens, Quayside, NEWCASTLE UPON TYNE, NE1 2HF	Date: MARCH 2009 / Scale: AS SHOWN
		Tel: +44 (0) 191 224 6500 Fax: +44 (0) 191 224 6599 www.fabermaunsell.com	No. 60092600/601 / Rev: A

cm

P:\UKNCL2-TP\PROJECTS\Structures - Leeds Station Southern Entrance\06_Drawings\01_FM_Drawings\01_Environment\601 - Site Location Plan.dwg [AutoCAD Location]

cm A3



NOTES

1. DO NOT SCALE FROM THIS DRAWING
2. PREFIX FOR GROUND INVESTIGATION IDENTIFIER AS FOLLOWS

G# GEOTECHNICS LIMITED (1999) INVESTIGATION FOR LEEDS AREA REMODELLING AND RESIGNALLING, REPORT REFERENCE 98-9861.

I# NORWEST HOLST SOIL ENGINEERING (2006), INVESTIGATION AT LEEDS CANAL BASIN FOR ISIS WATERSIDE REGENERATION LTD, PROJECT NUMBER F14538.

EXPLORATORY HOLES OBTAINED FROM THE BGS

N# NORWEST HOLST SOIL ENGINEERING (1991), INVESTIGATION AT NEVILLE STREET, LEEDS.

H# HOLST & CO SITE INVESTIGATION LTD (1965), INVESTIGATION AT CEDRO HOLDINGS, LEEDS.

NH# NORWEST HOLST SOIL ENGINEERING (1988), INVESTIGATION AT LEEDS CANAL BASIN.

3. FOR GEOLOGICAL CROSS SECTION A-A' REFER TO DRAWING 60092600/603.
4. ENTRANCE PROPOSALS TAKEN FROM DRAWING 60092600/002.

ient: Network Rail

oject: LEEDS STATION SOUTHERN ENTRANCE

Title: PREVIOUS EXPLORATORY HOLE & GEOLOGICAL CROSS SECTION LOCATION PLAN

FABER MAUNSELL | AECOM

First Floor,
One Trinity Gardens, Quayside,
NEWCASTLE UPON TYNE, NE1 2HF

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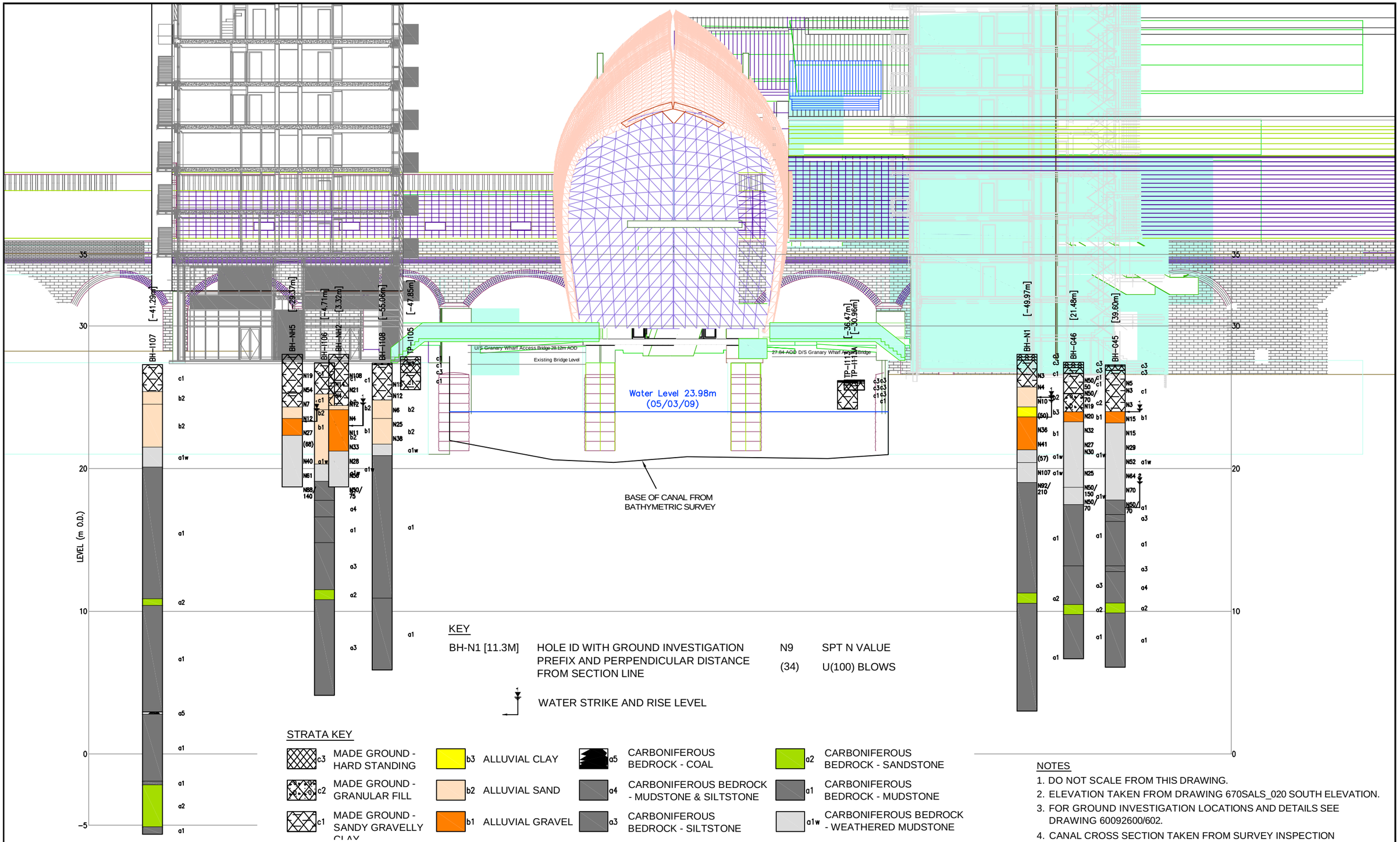
Fax: +44 (0) 191 224 6599
www.fabermaunsell.com

Design:	RPA	CAD:	RPA
Chk'd:	CMC	App'd:	SDM
Date:	MARCH 2009	Scale:	1:500

No. 60092600/602 Rev: A

cm



NOTES

1. DO NOT SCALE FROM THIS DRAWING.
2. ELEVATION TAKEN FROM DRAWING 670SALS_020 SOUTH ELEVATION.
3. FOR GROUND INVESTIGATION LOCATIONS AND DETAILS SEE DRAWING 60092600/602.
4. CANAL CROSS SECTION TAKEN FROM SURVEY INSPECTION SYSTEMS (SIS) LTD DRAWING 3127-LDS-004.

ient: Network Rail	Title: GEOLOGICAL CROSS SECTION A-A'	FABER MAUNSELL | AECOM	Design: RPA / CAD: RPA
oject: LEEDS STATION SOUTHERN ENTRANCE		First Floor, One Trinity Gardens, Quayside, NEWCASTLE UPON TYNE, NE1 2HF	Chk'd: CMC / App'd: SDM
		Tel: +44 (0) 191 224 6500 Fax: +44 (0) 191 224 6599 www.fabermaunsell.com	Date: MARCH 2009 / Scale: 1:500
			No. 60092600/603 / Rev: A

cm

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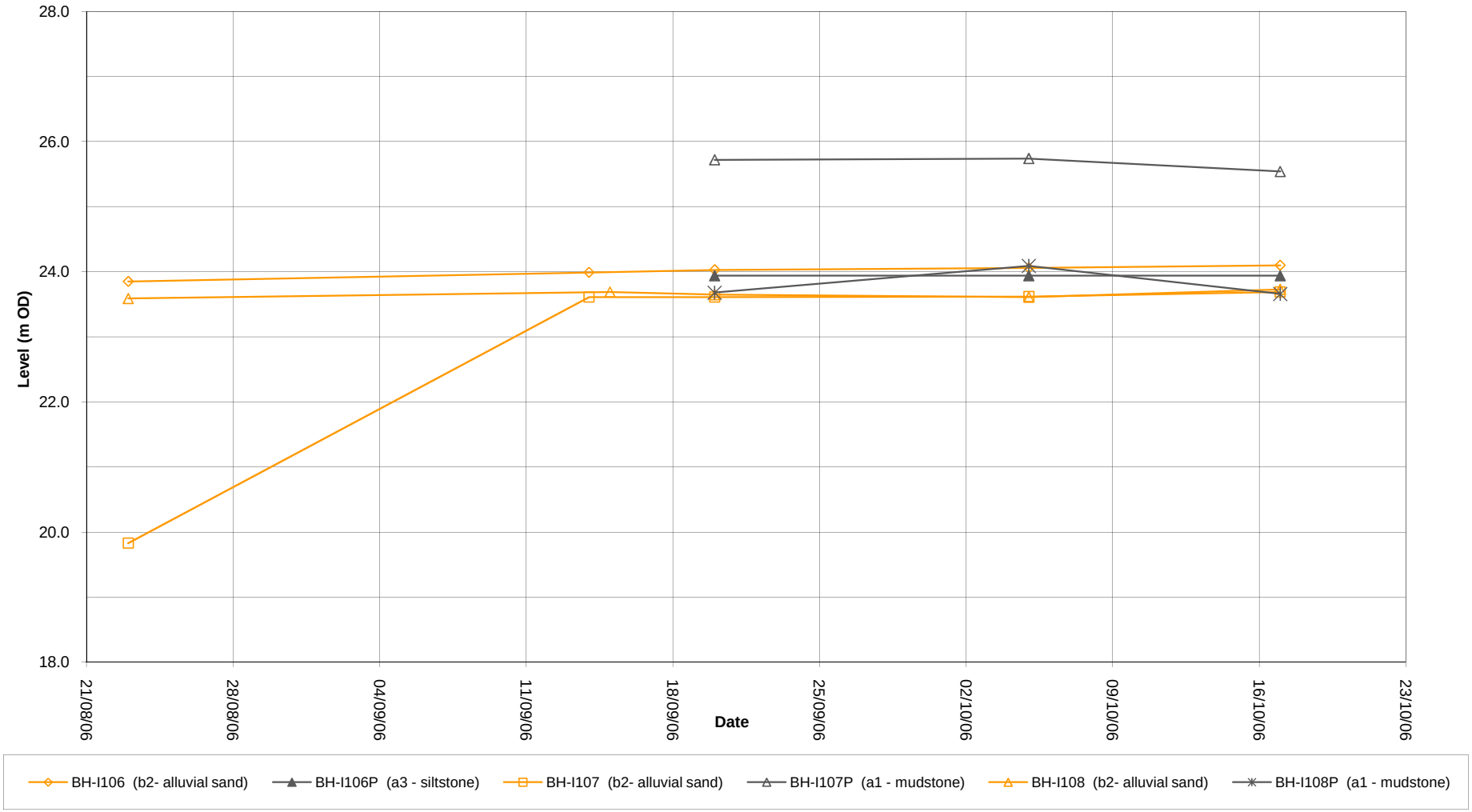
Figures

Figures



Network Rail

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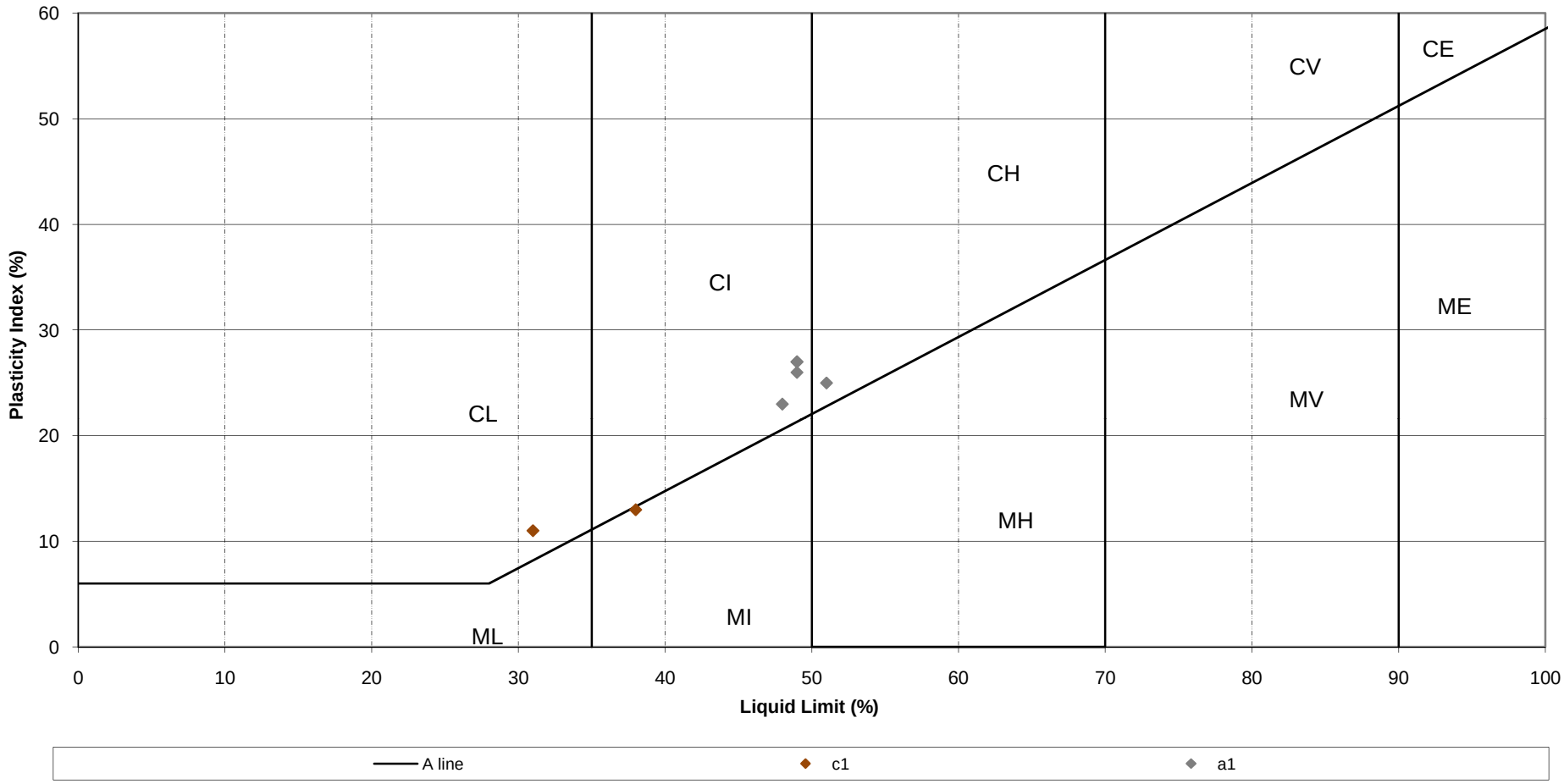
Leeds Station Southern Entrance, GRIP 4 Feasibility
Groundwater Level Monitoring - Norwest Holst Ground Investigation 2006, ISIS Building

Ref: 60092600
Date: March 2009

Figure 11.1



Network Rail

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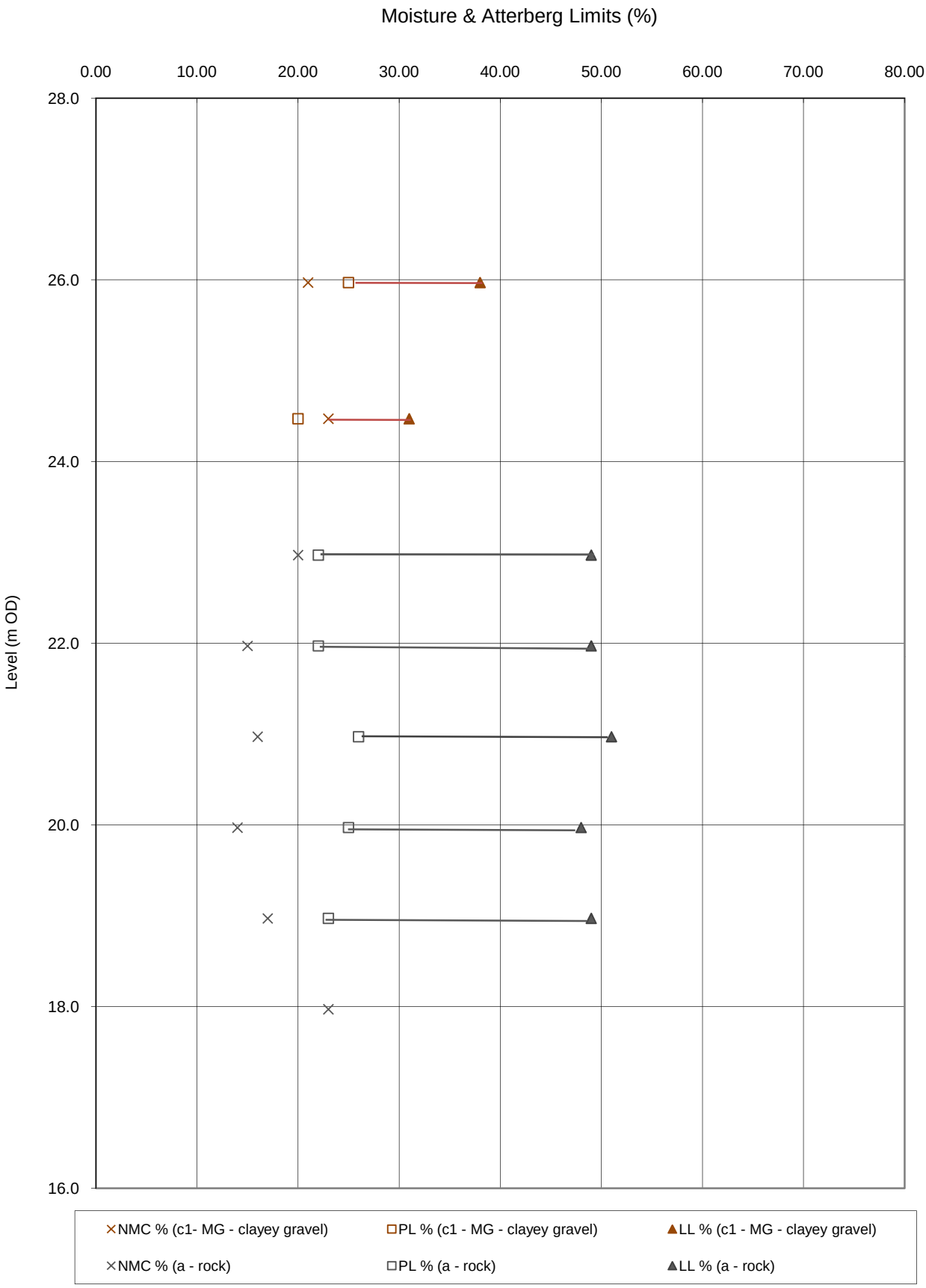
Leeds Station Southern Entrance, GRIP 4 Feasibility
Plasticity Chart - All Investigation Data

Ref: 60092600
Date: March 2009

Figure 12.1



Network Rail
Leeds Station Southern Entrance, GRIP 4 Feasibility

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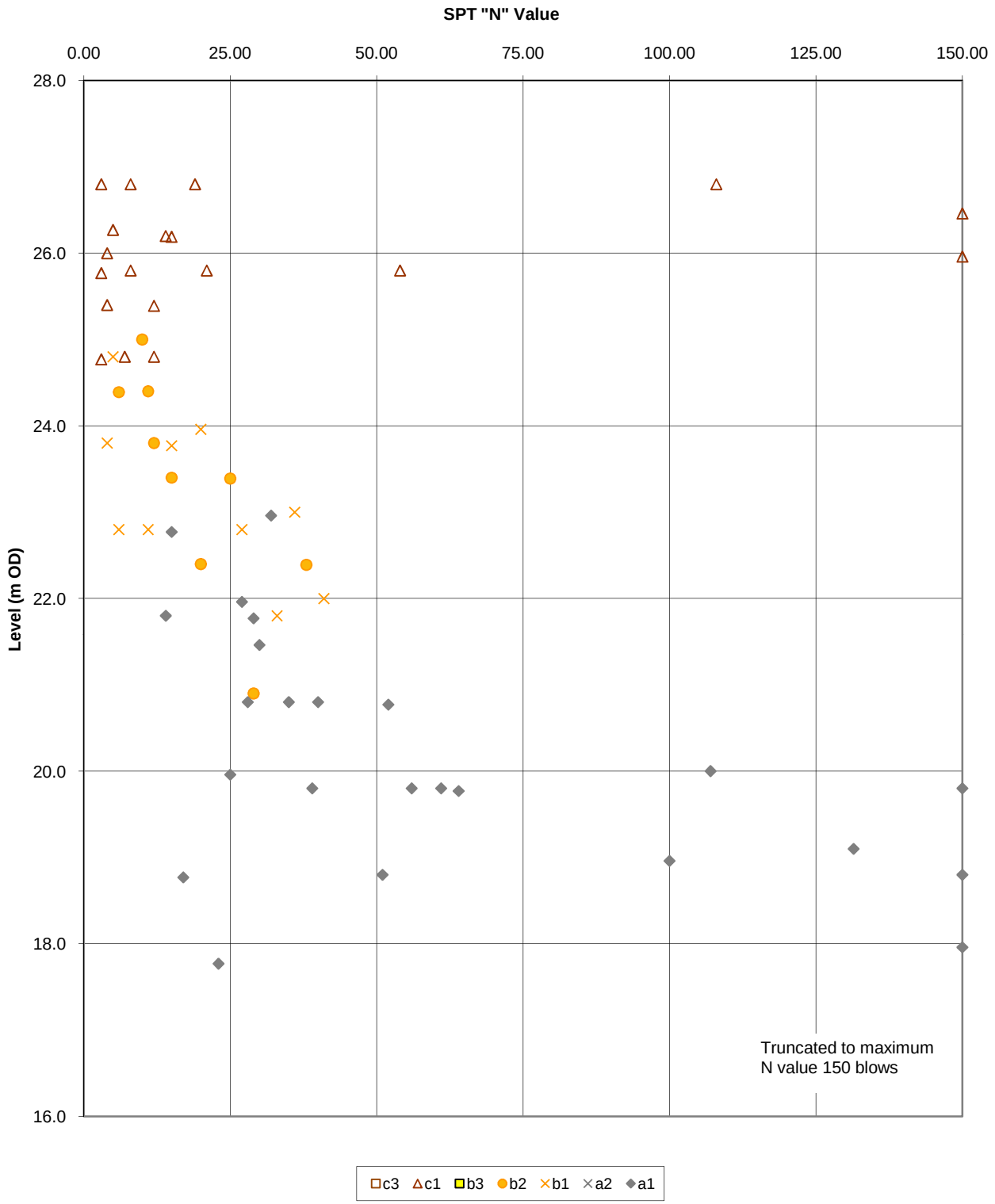
Moisture Content & Atterberg Limits vs. Level -
All Investigation Data

Ref: 60092600

Date: March 2009

Figure 12.2



Network Rail
Leeds Station Southern Entrance, GRIP 4 Feasibility

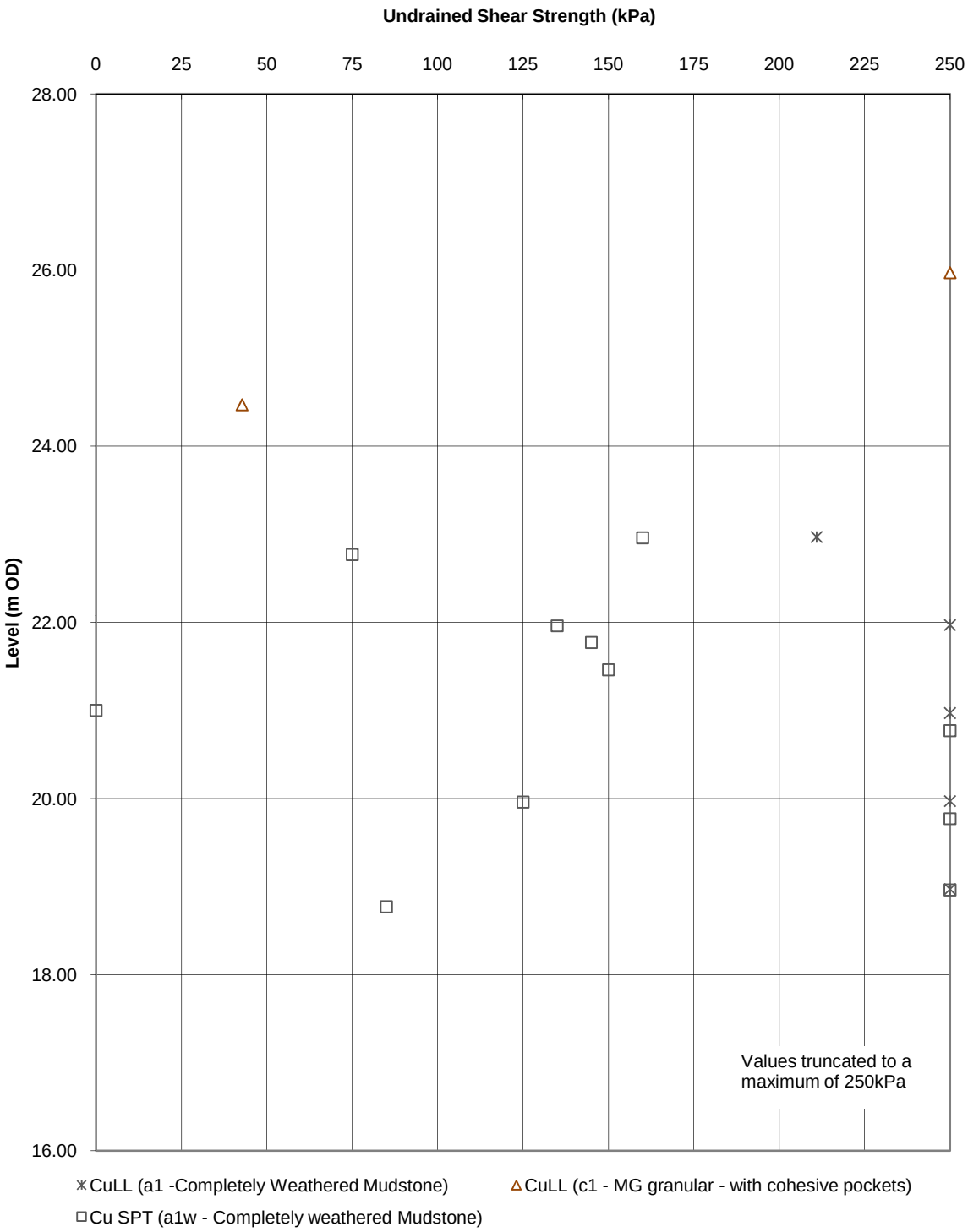
FABER MAUNSELL | AECOM

SPT N Value vs. Level -
All Investigation Data

Ref: 60092600

Date: March 2009

Figure 12.3



Network Rail
Leeds Station Southern Entrance, GRIP 4 Feasibility

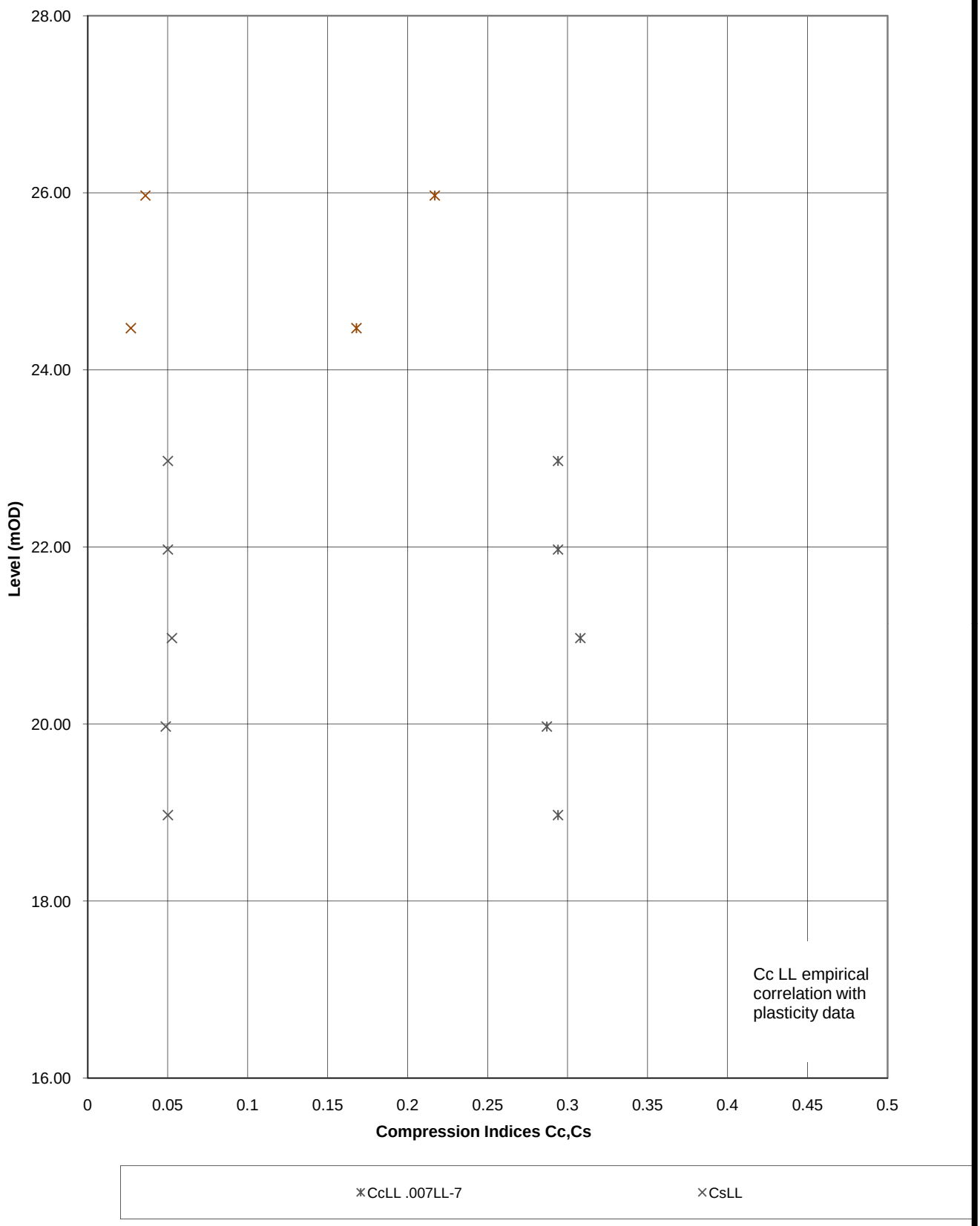
FABER MAUNSELL | AECOM

Ref: 60092600

Undrained Shear Strength vs. Level-
All Investigation Data

Date: March 2009

Figure 12.4



Network Rail

Leeds Station Southern Entrance, GRIP 4 Feasibility

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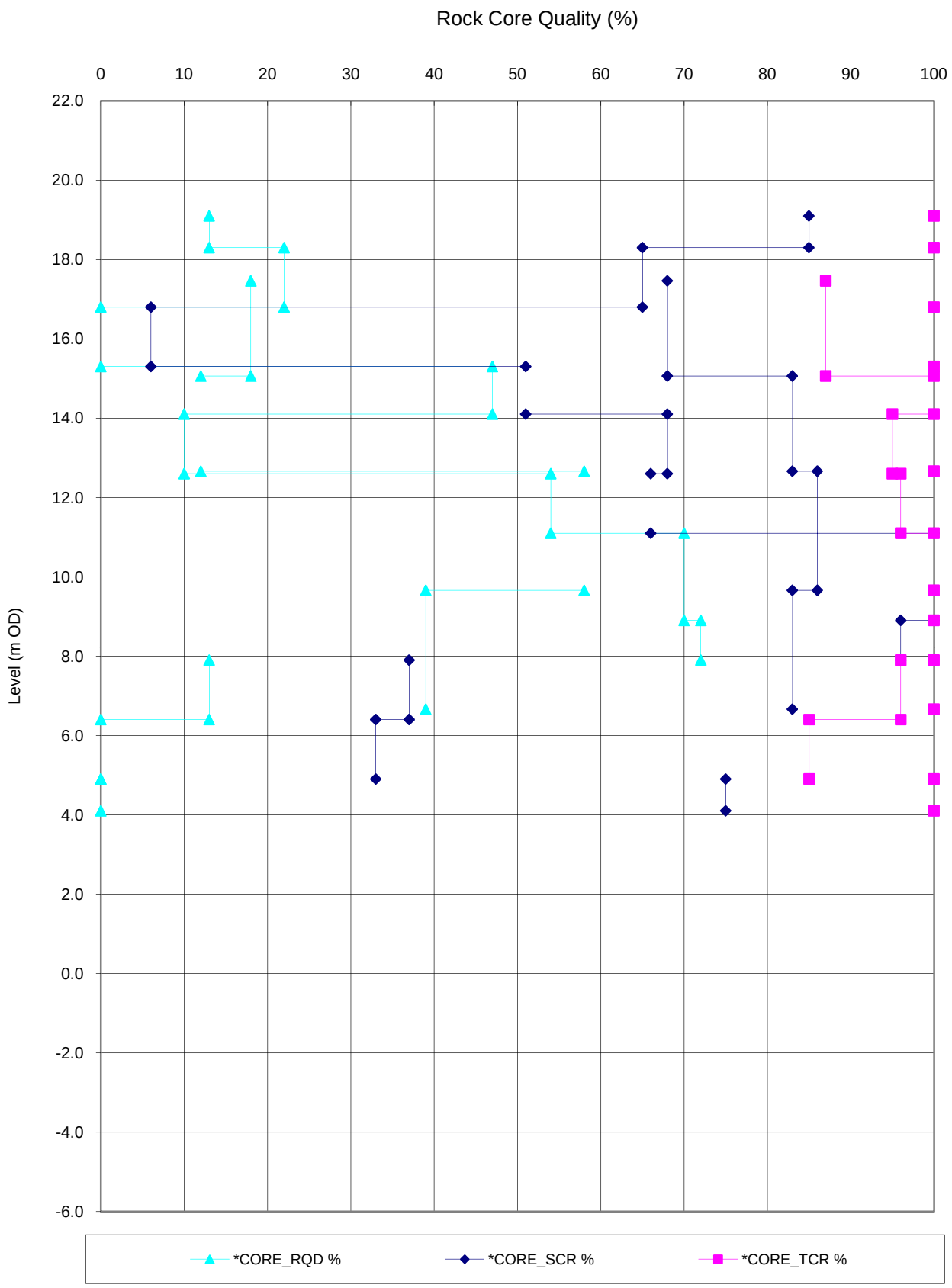
Ref: 60092600

Compression Indices vs. Level

All Investigation Data

Date: March 2009

Figure 12.5



Network Rail

Leeds Station Southern Entrance, GRIP 4 Feasibility

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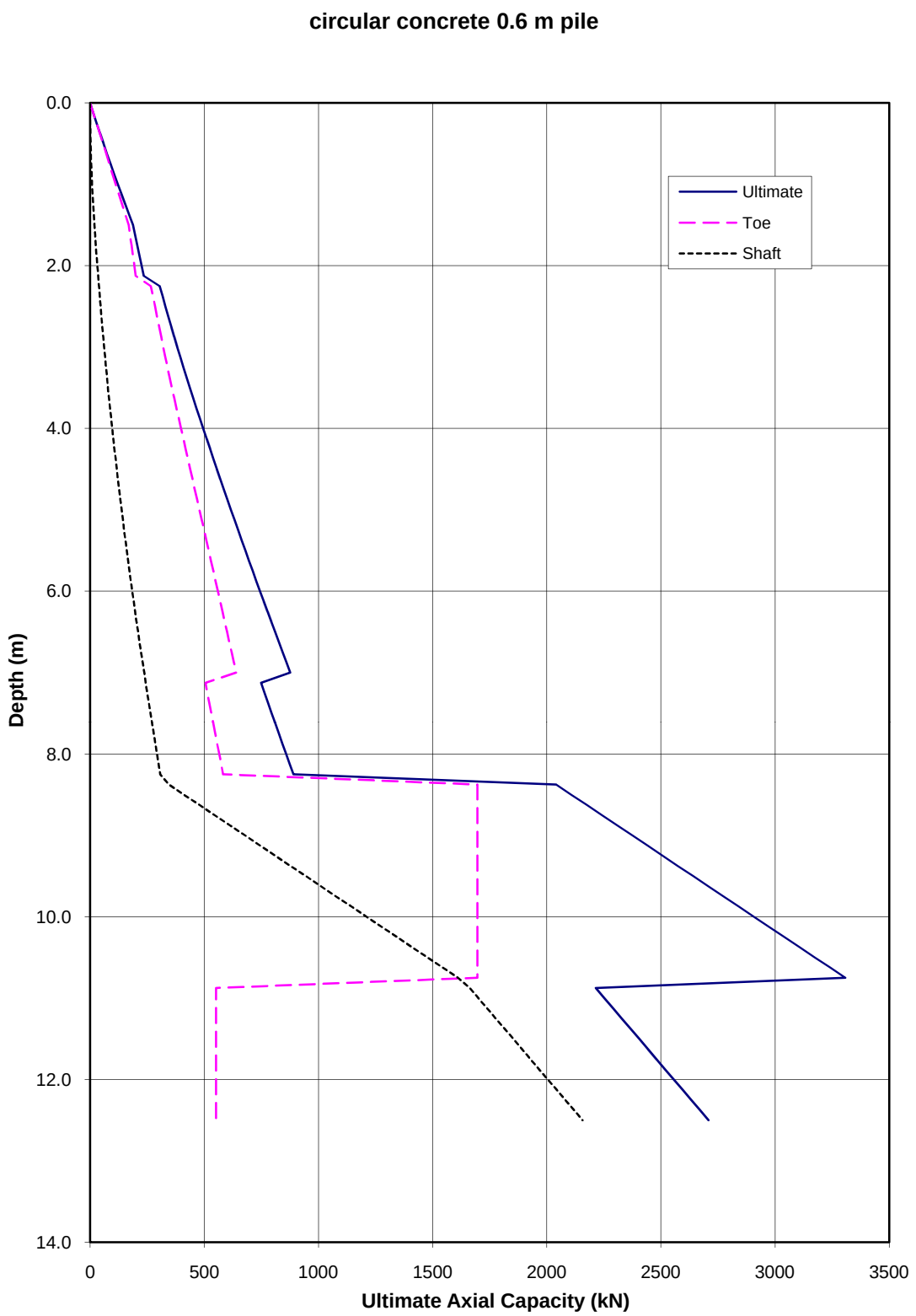
Rock Core Quality vs. Level -

BH-I106 & BH-G46

Ref: 60092600

Date: March 2009

Figure 12.6



CLIENT : **Network Rail**

PROJECT: **Leeds Station (east /west bank)**

FABER MAUNSELL | AECOM

FIGURE TITLE:-

Southern Entrance GRIP 4 (Isis BH106)

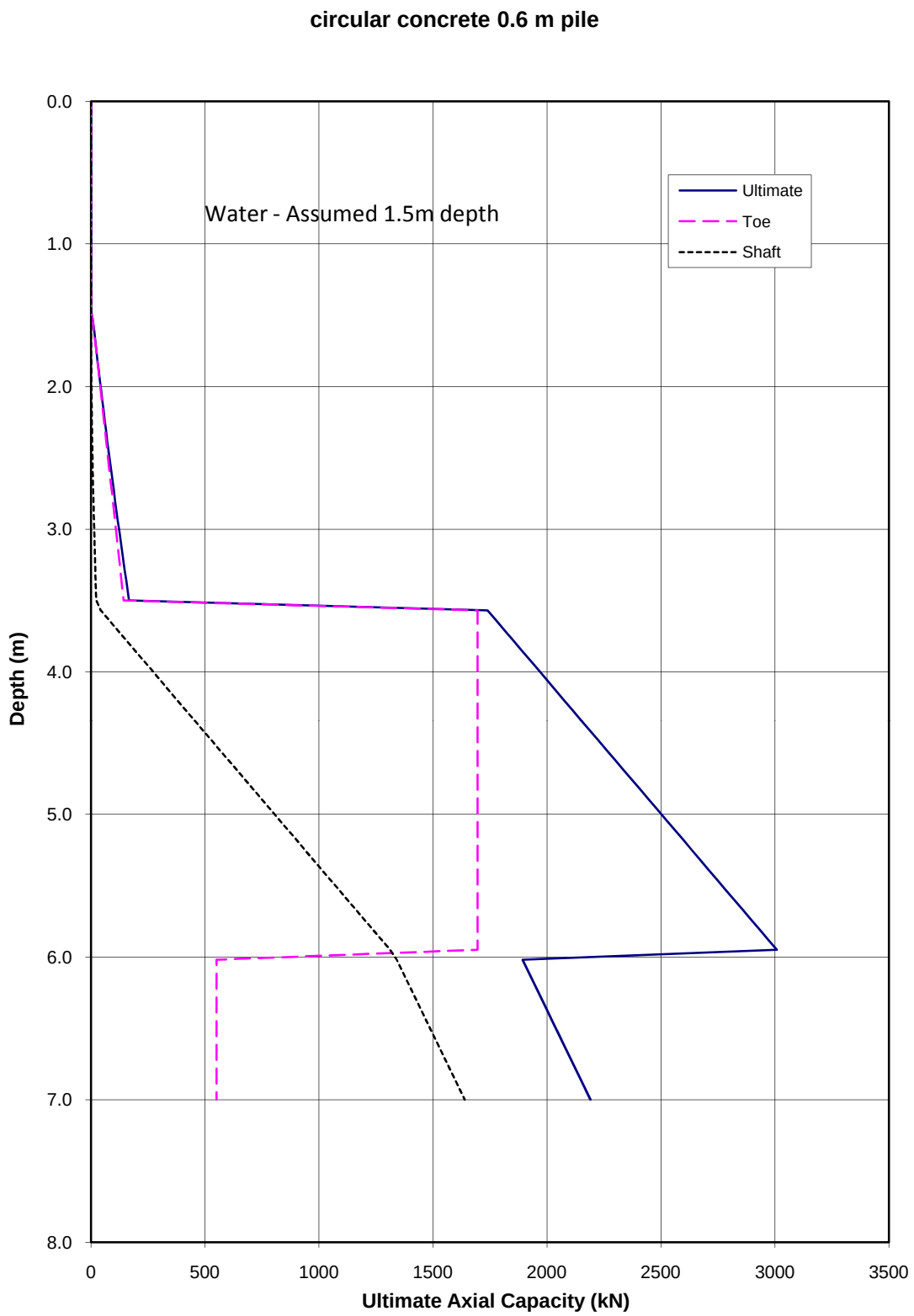
CALCULATION OF AXIAL PILE CAPACITY

Ultimate Axial Pile Capacity

REPORT No.: 60092600

DATE:- 11-Mar-09

FIGURE No. Figure 13.1



CLIENT : **Network Rail**

PROJECT: **Leeds Station (Extended piers)**

FABER MAUNSELL | AECOM

FIGURE TITLE:-

Southern Entrance GRIP 4 (Isis BH106)

CALCULATION OF AXIAL PILE CAPACITY

Ultimate Axial Pile Capacity

REPORT No.: 60092600

DATE:- 11-Mar-09

FIGURE No. Figure 13.2

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Plates

Plates

Plate 1: View looking north - Existing structure arch supports

Plate 2: View looking north - ISIS Water Development building under construction

Plate 3: View looking south – Blue Apartments

Plate 4: View looking west-southwest – access restrictions on east bank (foreground) and west bank (background)

Plate 5: View looking south / southwest from railway platform level

Plate 6: Granary Wharf Bridge within the Dark Arches

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Appendix A

Appendix A

Appendix A – Sources of Information Consulted

Enquiries for information of geotechnical, environmental and historical significance relevant to the site has been made of a number of organisations including the following: -

Site History
- Envirocheck Report
- Faber Maunsell Archive
- Network Rail Archives
- Leeds City Council

Geology and Hydrogeology
- British Geological Survey
- Envirocheck Environmental Database
- The Coal Authority – Mining reports Office
- Network Rail Mining Engineer

Potentially Contaminative Uses
- Envirocheck Environmental Database
- Leeds City Council

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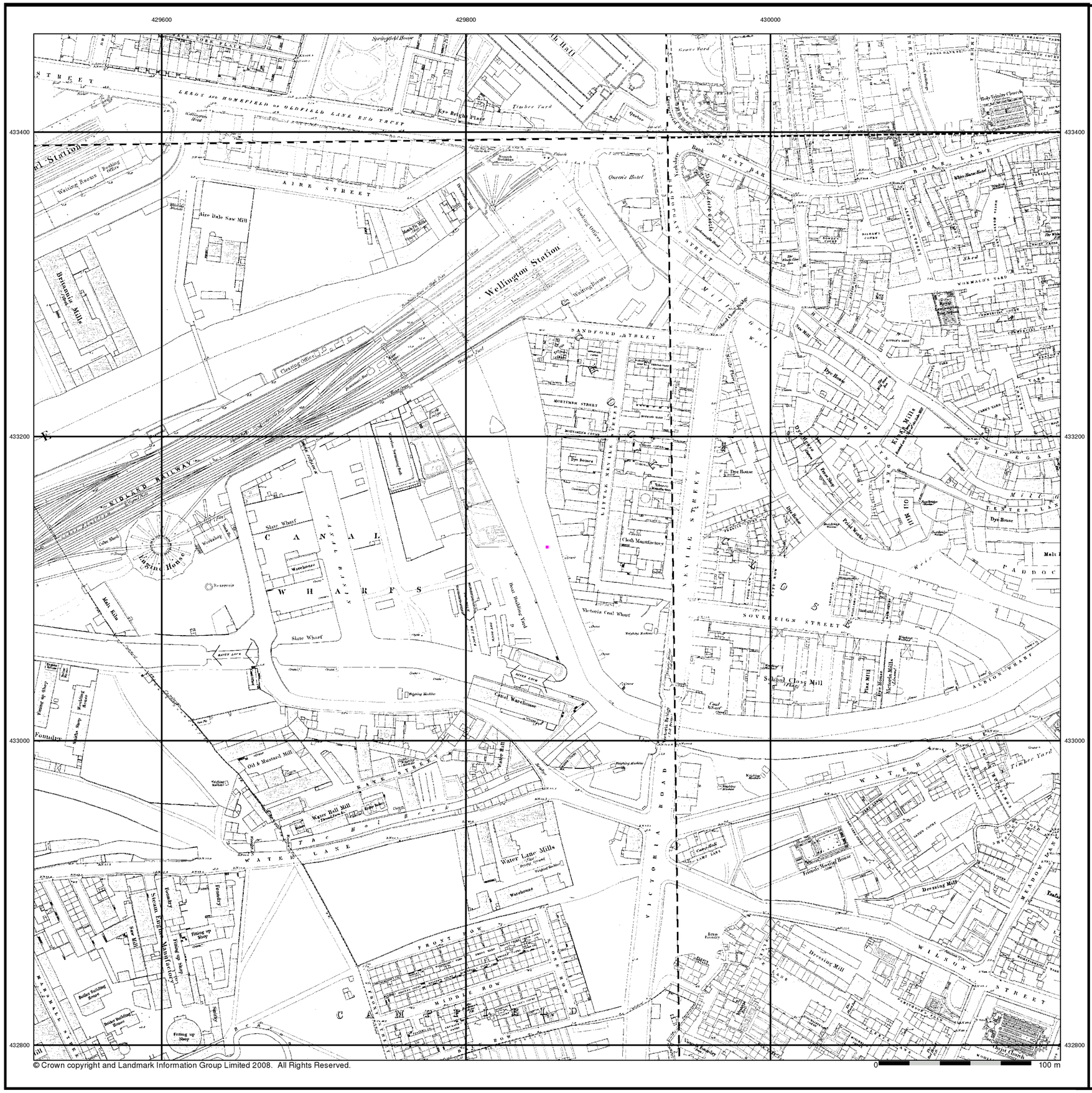
Appendix B

Appendix B – Data CD

Appendix B(1) - Historical Maps



0 100 m

Envirocheck® Historical Town Plans

A Landmark service

Yorkshire

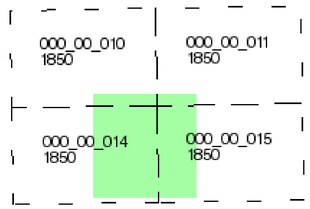
Published 1850

Source map scale - 1:1,056

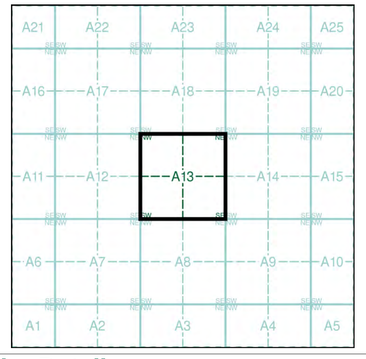
The 1:1056 scale of Ordnance Survey mapping was adopted from Ireland in 1848 and was used to survey towns with a population of over 4000, plus county towns of lesser population, in those counties mapped at the six-inch scale in 1841-55. The scale was the largest scale at which London was mapped by the Ordnance Survey and a 'skeleton' survey of the capital, showing little more than streets, street names, frontages and altitudes, was undertaken between 1848 and 1850. The majority of the 1:1056 surveys were later replaced by 1:500 surveys; although almost all the remainder were revised at this scale, sometimes more than once before 1895. The type of detail shown on the 1:1056 scale is broadly similar to that on 1:500; the apparent omission of minor details such as sewer access points and street lights may be as much a reflection of the generally earlier date of these plans, as of the specification of the map.

Please note: Due to the partial coverage of Historical Town Plans, it is possible that not all segments within an order will contain mapping. Only the segments that have Town Plan coverage will be generated.

Map Name(s) and Date(s)



Historical Town Plan - Segment A13



N

Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	0

Site Details

Site at 429850, 433120

LANDMARK Information Group

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk

Historical Mapping Legends

Ordnance Survey County Series and Ordnance Survey Plan 1:2,500

Quarry
Gravel Pit
Sand Pit
Clay Pit
Shingle
Refuse Heap
Sloping Masonry
Flat Rock
Marsh
Reeds
Osiers
Rough Pasture
Furze
Wood
Mixed Wood
Brushwood
Orchard
Fir
Ford
Stepping Stones
Ferry
Waterfall
Lock
Trig. Station
507 Altitude at Trig. Station
B.M.325·9 Bench Mark
342 Surface Level
Arrow denotes flow of water
Antiquities (site of)
Cutting
Embankment
Railway crossing Road
Level Crossing
Road crossing Railway
Railway crossing River or Canal
Road over single stream
Road over River or Canal
County Boundary (Geographical)
County & Civil Parish Boundary
Administrative County & Civil Parish Boundary
Co. Boro. Bdy. County Borough Boundary (England)
Co. Burgh Bdy. County Burgh Boundary (Scotland)

B P B S	Boundary Post or Stone	P.C.B	Police Call Box
B.R.	Bridle Road	P	Pump
E.P	Electricity Pylon	S.P	Signal Post
F.B.	Foot Bridge	St.	Sluice
F.P.	Foot Path	Sp.	Spring
G.P	Guide Post or Board	T.C.B	Telephone Call Box
M.S	Mile Stone	Tr.	Trough
M.P M.R	Mooring Post or Ring	W	Well

Ordnance Survey Plan, Additional SIMs and Supply of Unpublished Survey Information 1:2,500 and 1:1,250

Inactive Quarry, Chalk Pit or Clay Pit
Active Quarry, Chalk Pit or Clay Pit
Rock
Boulders
Cliff
Slopes
Top
Roofed Building
Glazed Roof Building
Sloping Masonry
Archway
Non-Coniferous Tree (surveyed)
Coniferous Tree (surveyed)
Non-Coniferous Trees (not surveyed)
Coniferous Trees (not surveyed)
Orchard Tree
Scrub
Bracken
Coppice, Osier
Reeds
Marsh, Saltings
Rough Grassland
Heath
Culvert
Direction of water flow
Bench Mark
Antiquity (site of)
Cave Entrance
Triangulation Station
Electricity Pylon
Electricity Transmission Line
County Boundary (Geographical)
County & Civil Parish Boundary
Civil Parish Boundary
Admin. County or County Bor. Boundary
L B Bdy London Borough Boundary
Symbol marking point where boundary mereing changes

BH	Beer House	P	Pillar, Pole or Post
BP, BS	Boundary Post or Stone	PO	Post Office
Cn, C	Capstan, Crane	PC	Public Convenience
Chy	Chimney	PH	Public House
D Fn	Drinking Fountain	Pp	Pump
El P	Electricity Pillar or Post	SB, S Br	Signal Box or Bridge
FAP	Fire Alarm Pillar	SP, SL	Signal Post or Light
FB	Foot Bridge	Spr	Spring
GP	Guide Post	Tk	Tank or Track
H	Hydrant or Hydraulic	TCB	Telephone Call Box
LC	Level Crossing	TCP	Telephone Call Post
MH	Manhole	Tr	Trough
MP	Mile Post or Mooring Post	Wr Pt, Wr T	Water Point, Water Tap
MS	Mile Stone	W	Well
NTL	Normal Tidal Limit	Wd Pp	Wind Pump

Large-Scale National Grid Data 1:2,500 and 1:1,250

Cliff
Slopes
Top
Rock
Rock (scattered)
Boulders
Boulders (scattered)
Positioned Boulder
Scree
Non-Coniferous Tree (surveyed)
Coniferous Tree (surveyed)
Non-Coniferous Trees (not surveyed)
Coniferous Trees (not surveyed)
Orchard Tree
Scrub
Bracken
Coppice, Osier
Reeds
Marsh, Saltings
Rough Grassland
Heath
Culvert
Direction of water flow
Triangulation Station
Antiquity (site of)
Electricity Transmission Line
Electricity Pylon
BM 291.60m Bench Mark
Buildings with Building Seed
Roofed Building
Glazed Roof Building
Civil parish/community boundary
District boundary
County boundary
Boundary post/stone
Boundary mereing symbol (note: these always appear in opposed pairs or groups of three)

Bks	Barracks	P	Pillar, Pole or Post
Bty	Battery	PO	Post Office
Cemy	Cemetery	PC	Public Convenience
Chy	Chimney	Pp	Pump
Cis	Cistern	Ppg Sta	Pumping Station
Dismtd Rly	Dismantled Railway	PW	Place of Worship
El Gen Sta	Electricity Generating Station	Sewage Ppg Sta	Sewage Pumping Station
El P	Electricity Pole, Pillar	SB, S Br	Signal Box or Bridge
El Sub Sta	Electricity Sub Station	SP, SL	Signal Post or Light
FB	Filter Bed	Spr	Spring
Fn / D Fn	Fountain / Drinking Ftn.	Tk	Tank or Track
Gas Gov	Gas Valve Compound	Tr	Trough
GVC	Gas Governer	Wd Pp	Wind Pump
GP	Guide Post	Wr Pt, Wr T	Water Point, Water Tap
MH	Manhole	Wks	Works (building or area)
MP, MS	Mile Post or Mile Stone	W	Well

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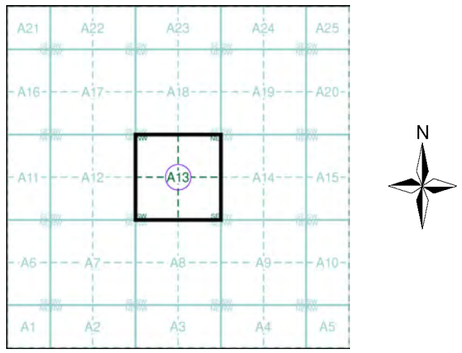
Historical Mapping & Photography included:

Mapping Type	Scale	Date	Pg
Yorkshire	1:2,500	1893	2
Yorkshire	1:2,500	1908	3
Yorkshire	1:2,500	1921	4
Ordnance Survey Plan	1:1,250	1953 - 1954	5
Ordnance Survey Plan	1:2,500	1954	6
Additional SIMs	1:2,500	1954	7
Ordnance Survey Plan	1:1,250	1962 - 1969	8
Ordnance Survey Plan	1:2,500	1964 - 1970	9
Ordnance Survey Plan	1:1,250	1970 - 1990	10
Supply of Unpublished Survey Information	1:1,250	1976	11
Additional SIMs	1:1,250	1978 - 1985	12
Ordnance Survey Plan	1:1,250	1979	13
Additional SIMs	1:1,250	1987 - 1990	14
Additional SIMs	1:1,250	1989 - 1990	15
Additional SIMs	1:1,250	1989 - 1990	16
Ordnance Survey Plan	1:1,250	1991	17
Large-Scale National Grid Data	1:1,250	1993	18
Large-Scale National Grid Data	1:1,250	1993 - 1994	19
Large-Scale National Grid Data	1:1,250	1995 - 1997	20

Historical Map - Segment A13



Order Details

Order Number: 27052630_1_1
Customer Ref: 60092600
National Grid Reference: 429850, 433130
Slice: A
Site Area (Ha): 0.01
Search Buffer (m): 100

Site Details

Site at 429850, 433120

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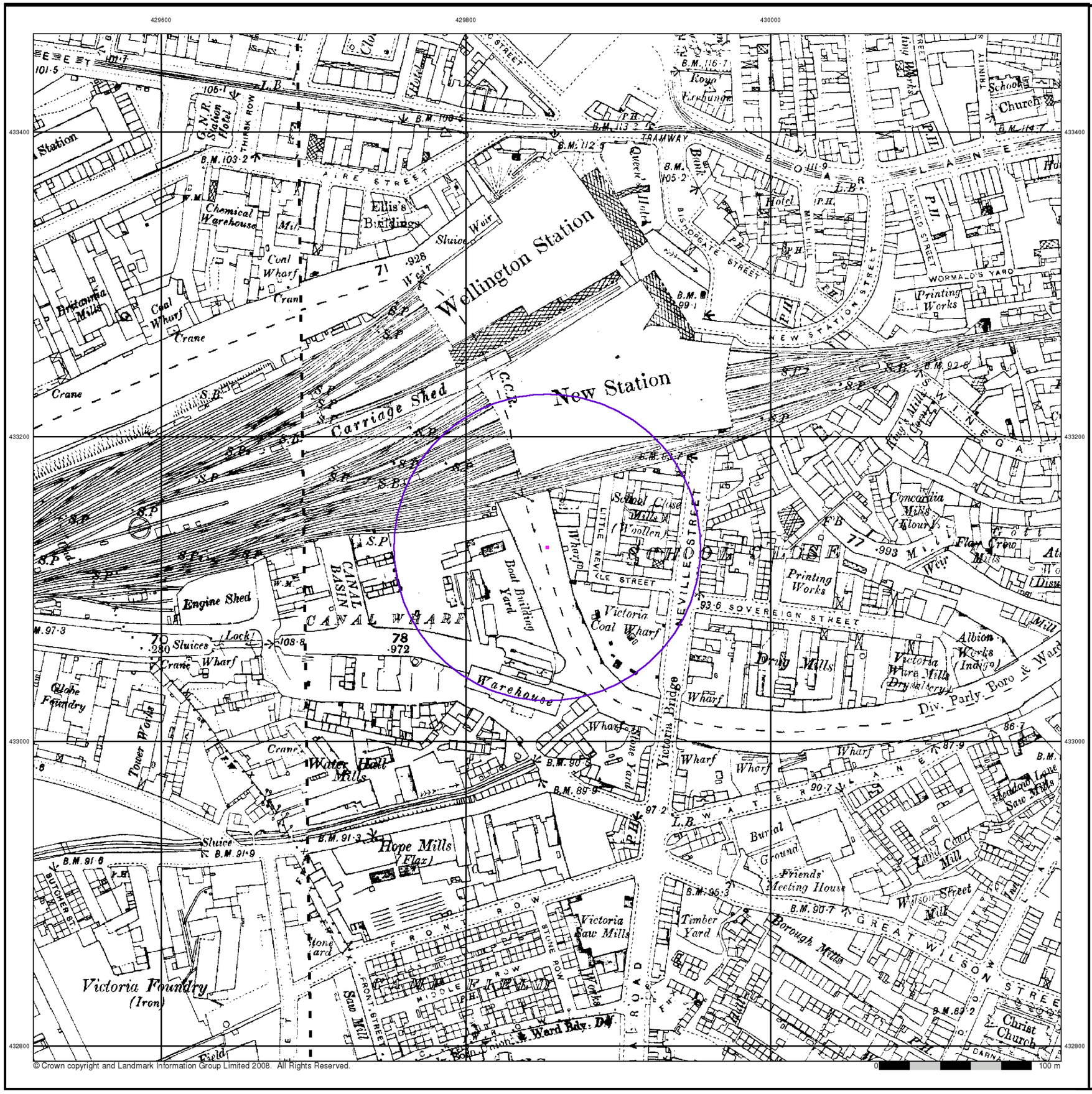
Web: www.envirocheck.co.uk



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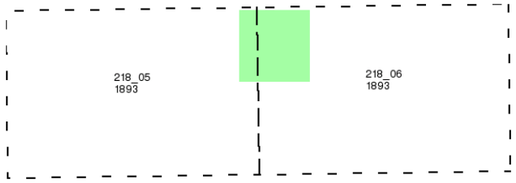
Yorkshire

Published 1893

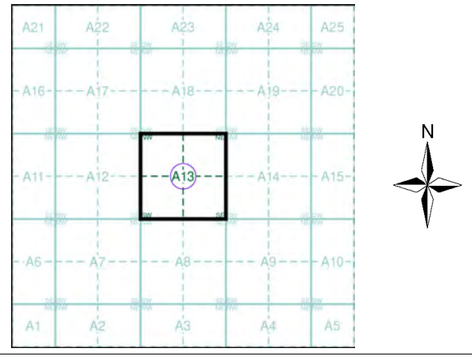
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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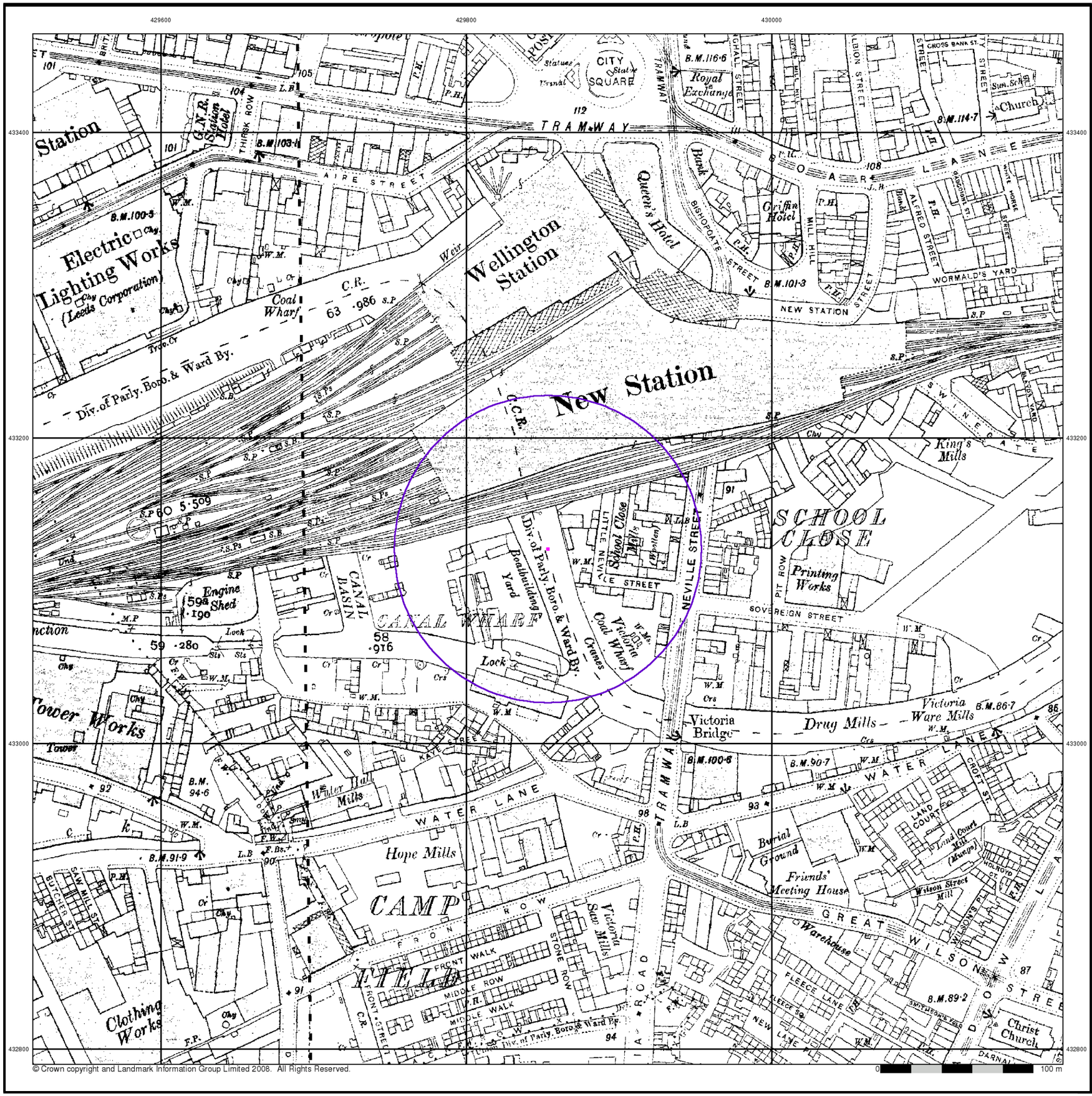

0 100 m

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Yorkshire

Published 1908

Source map scale - 1:2,500

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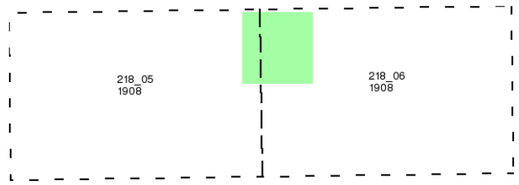
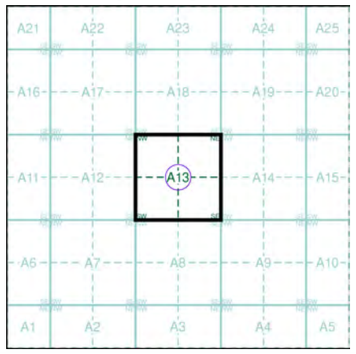
Map Name(s) and Date(s)



Historical Map - Segment A13



N

Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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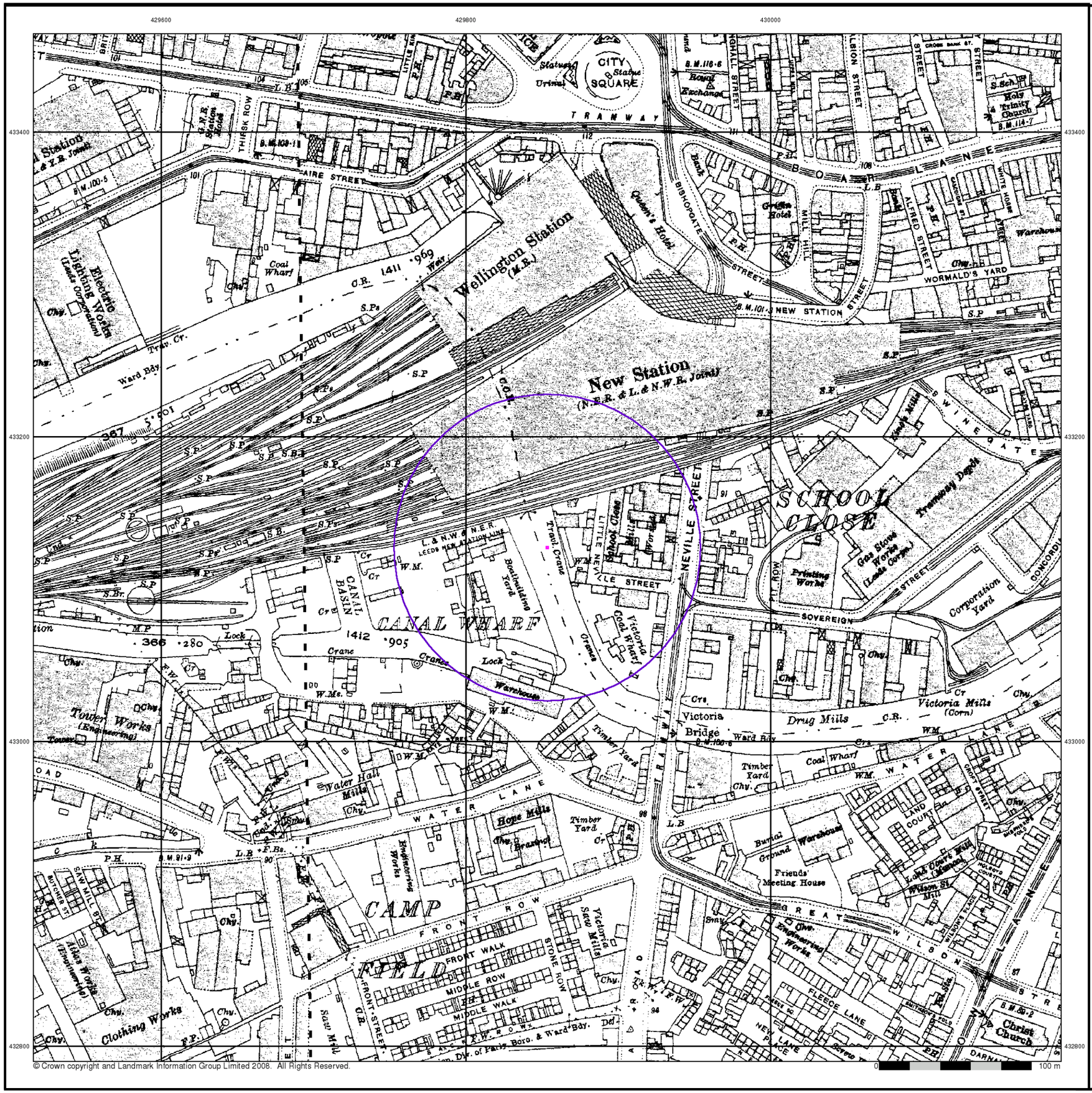

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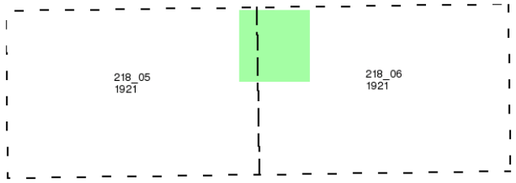
Yorkshire

Published 1921

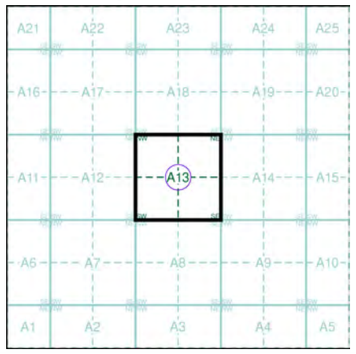
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



N

Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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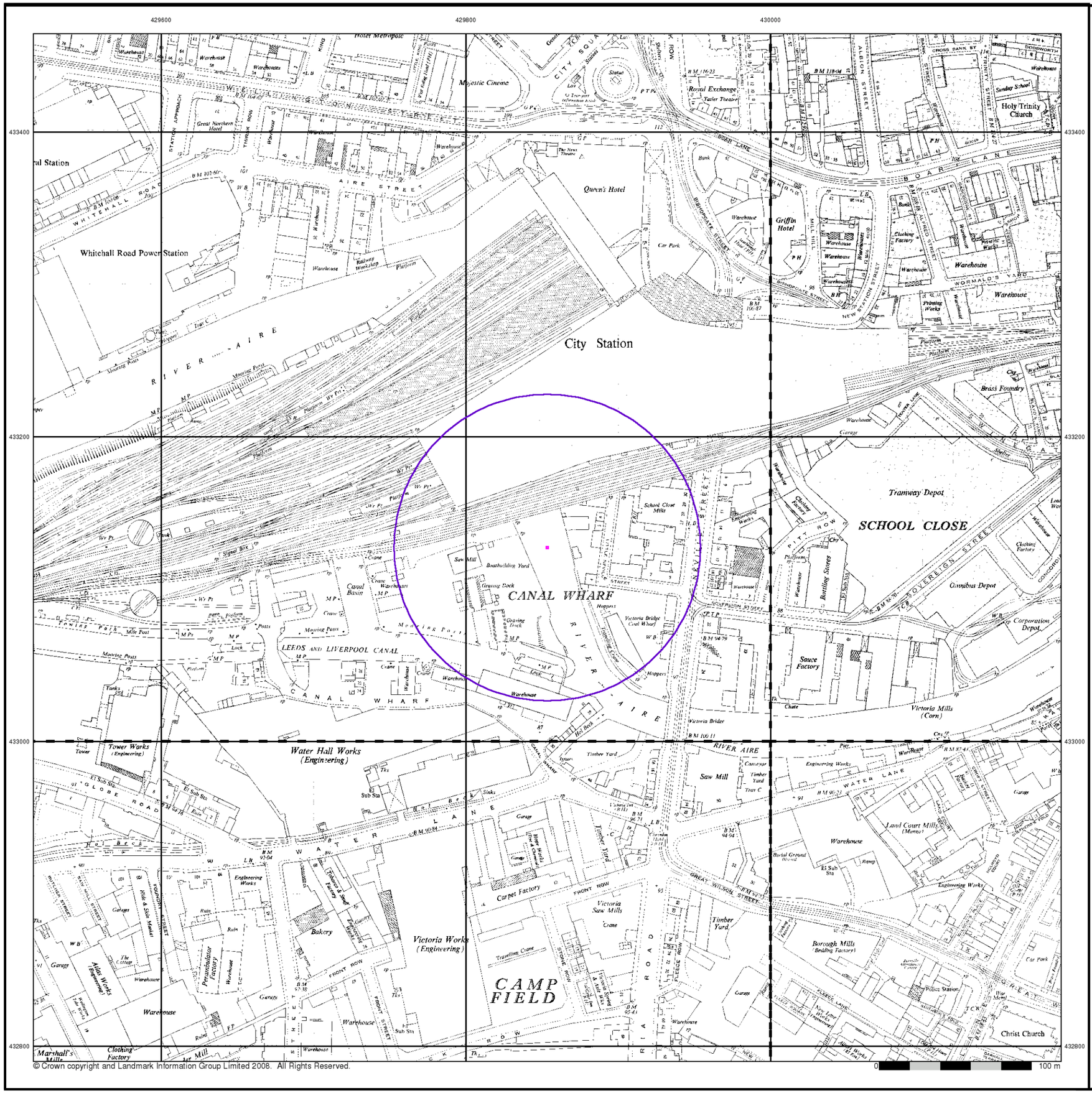

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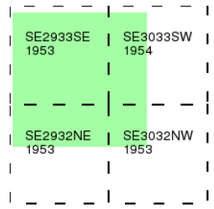
Ordnance Survey Plan

Published 1953 - 1954

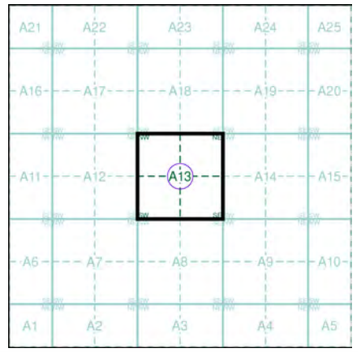
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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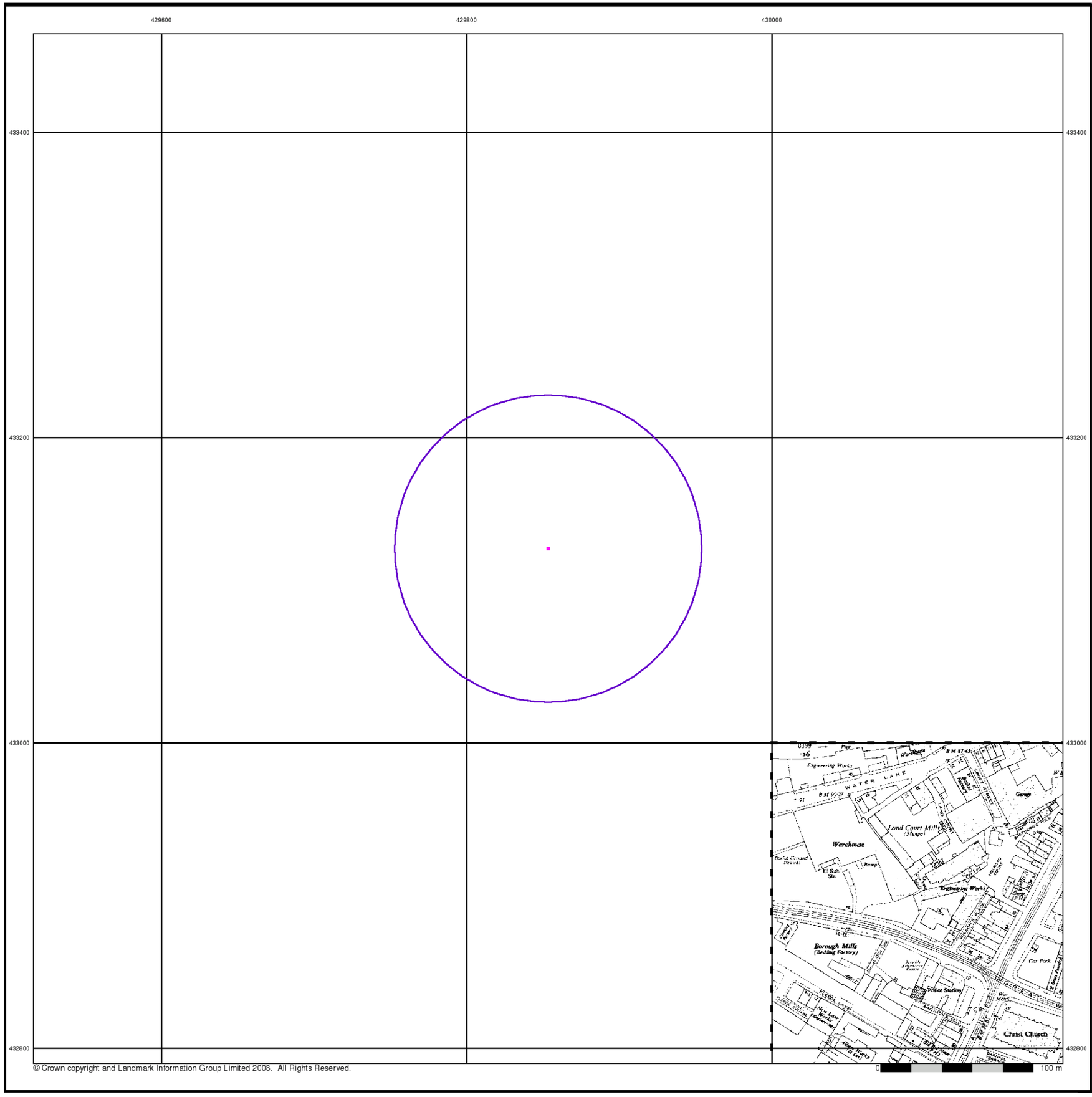

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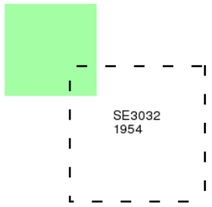
Ordnance Survey Plan

Published 1954

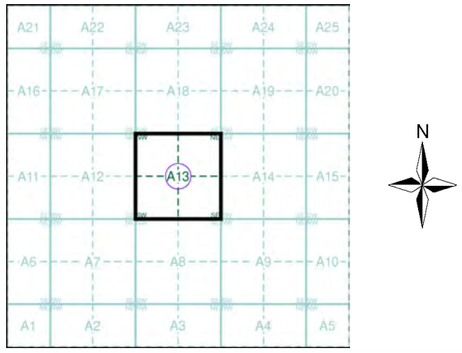
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

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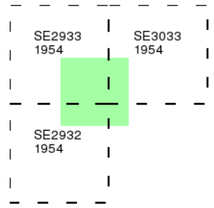
Additional SIMs

Published 1954

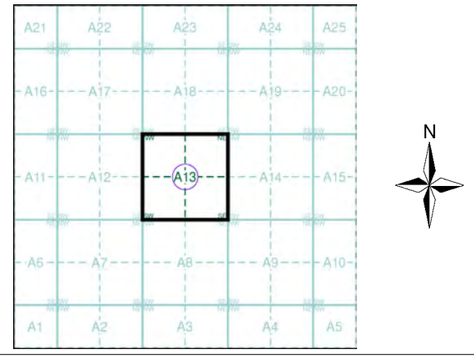
Source map scale - 1:2,500

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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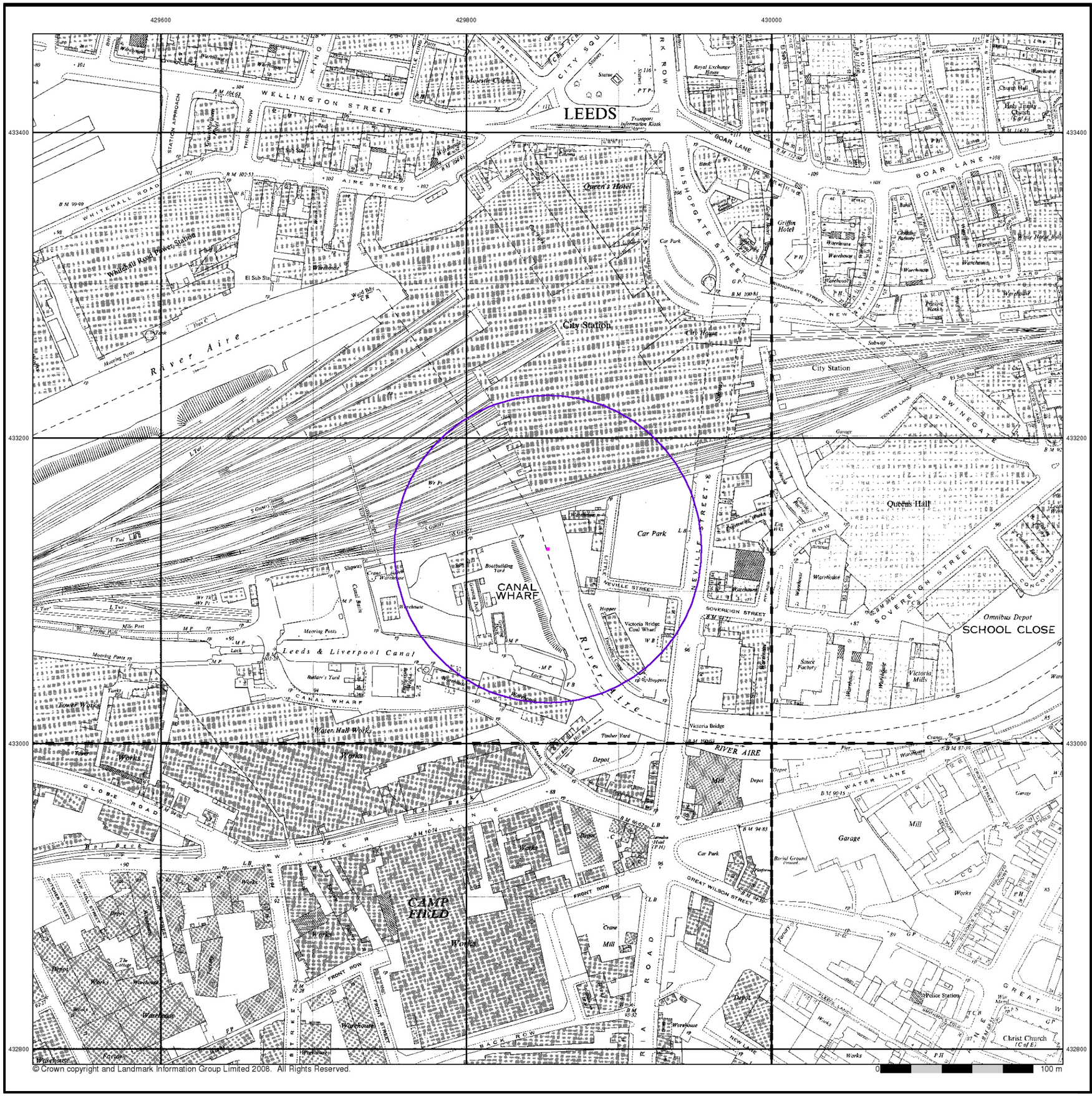

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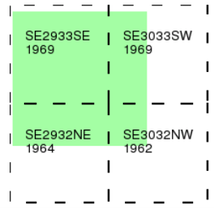
Ordnance Survey Plan

Published 1962 - 1969

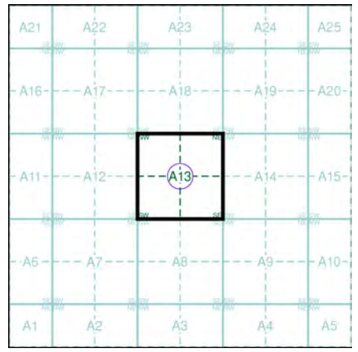
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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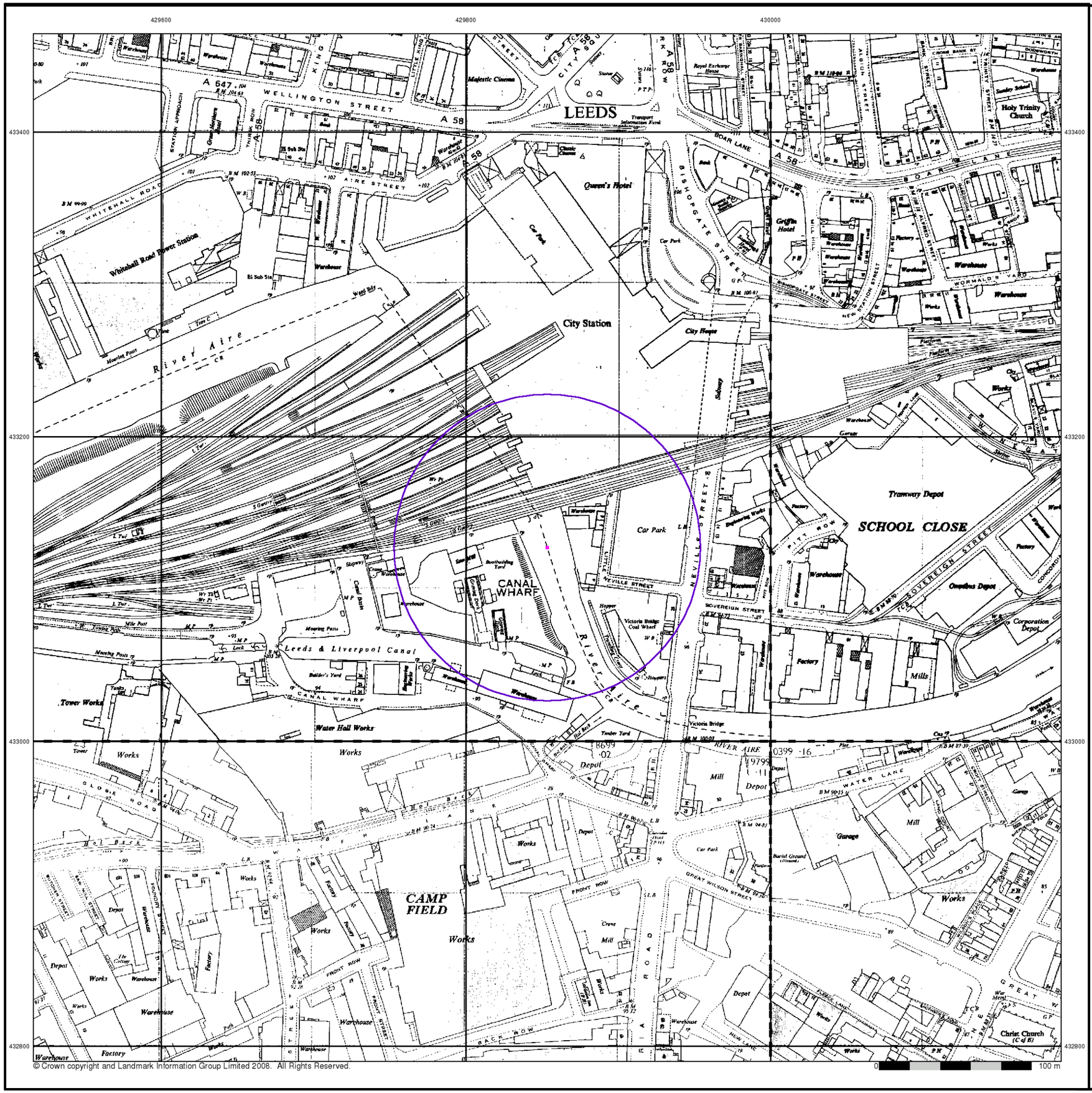

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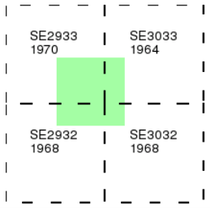
Ordnance Survey Plan

Published 1964 - 1970

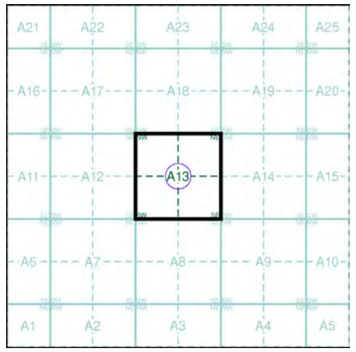
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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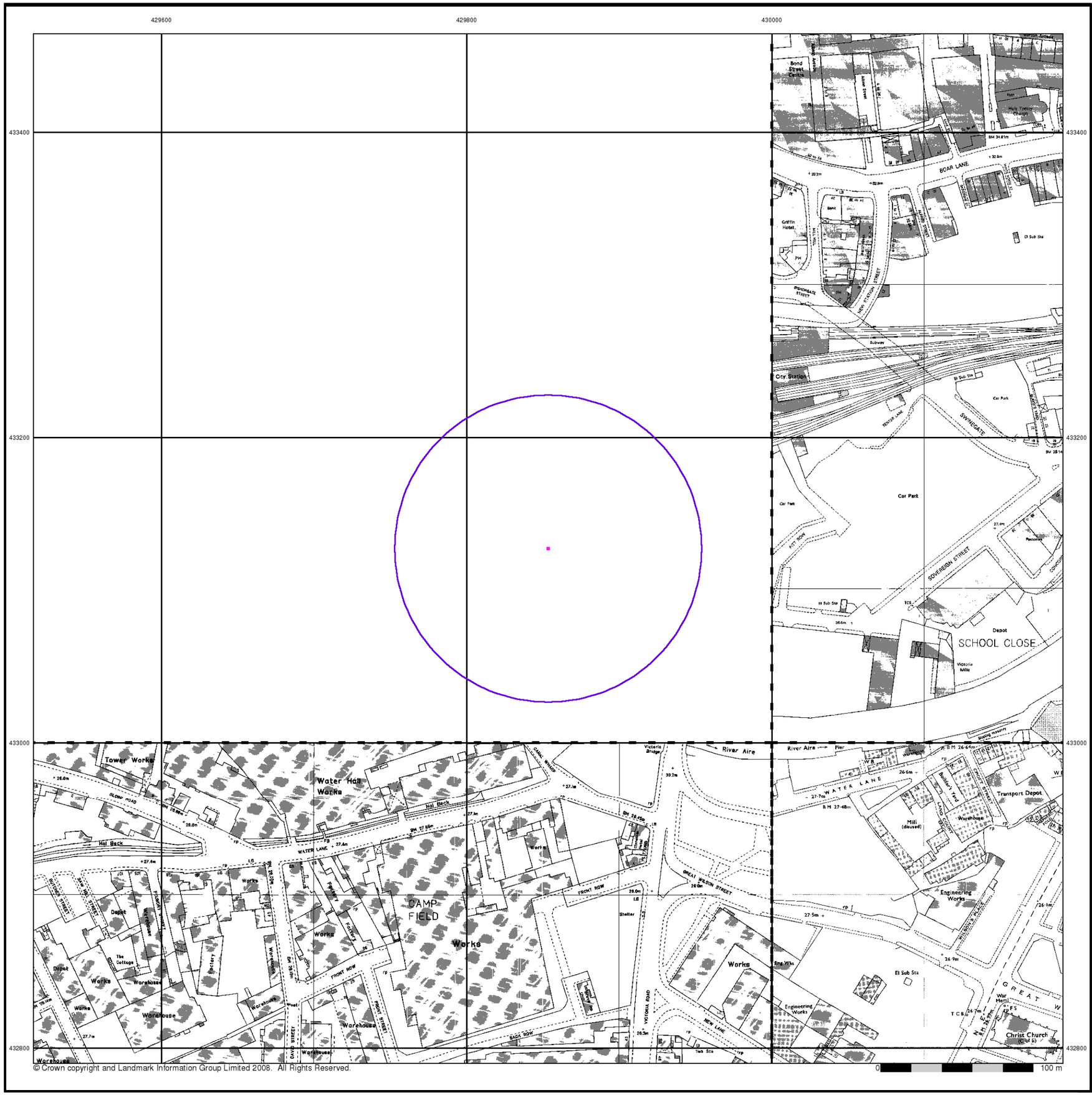

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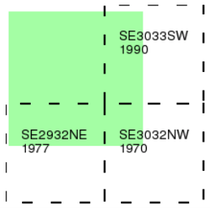
Ordnance Survey Plan

Published 1970 - 1990

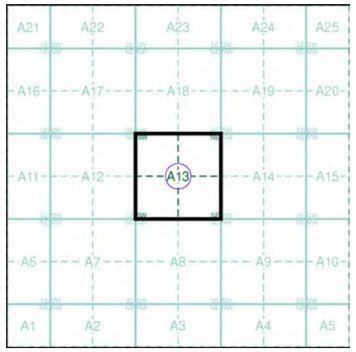
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



N

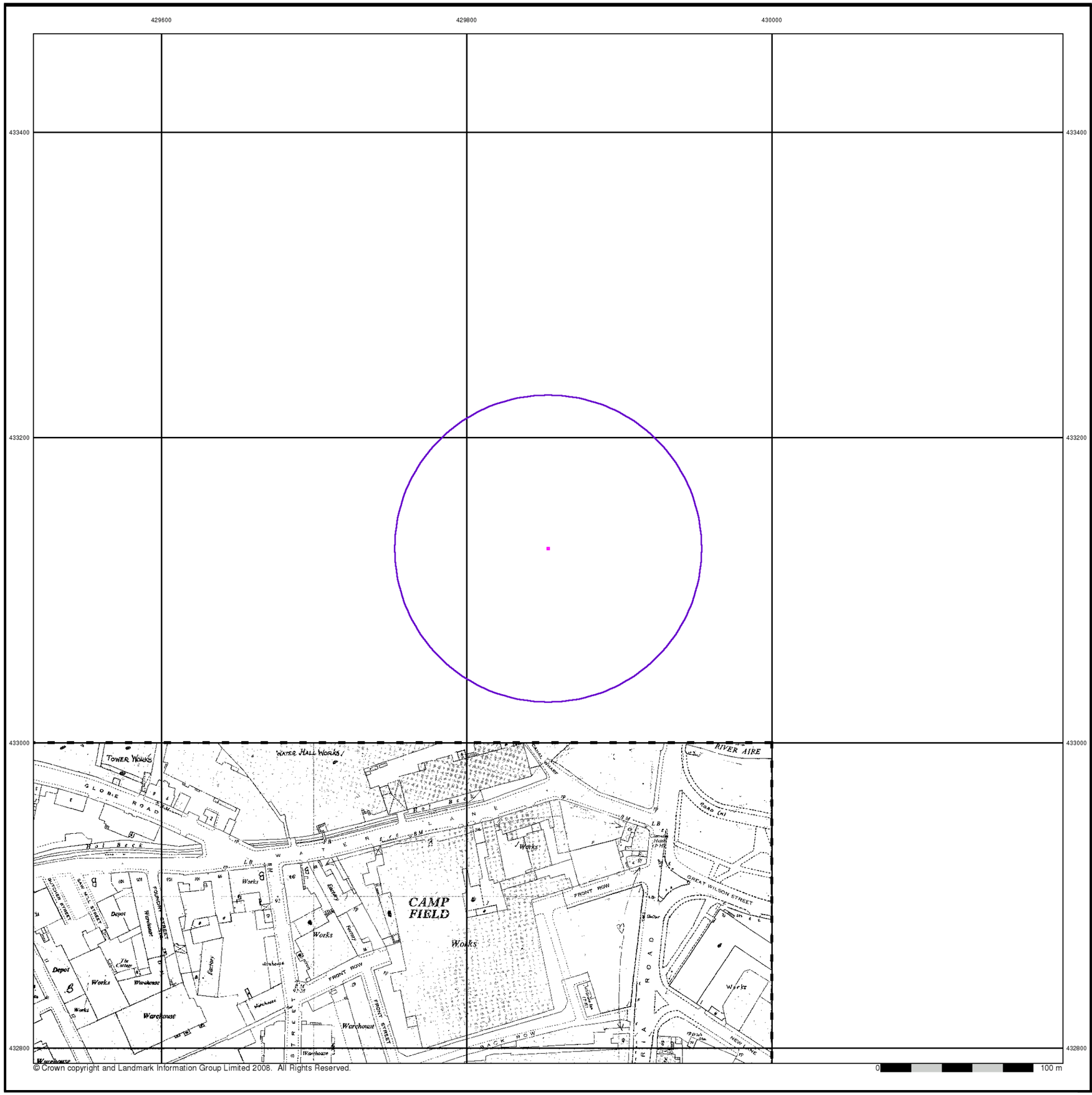
Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

LANDMARK Information Group
Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



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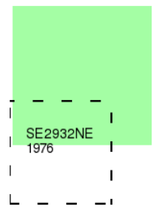
Supply of Unpublished Survey Information

Published 1976

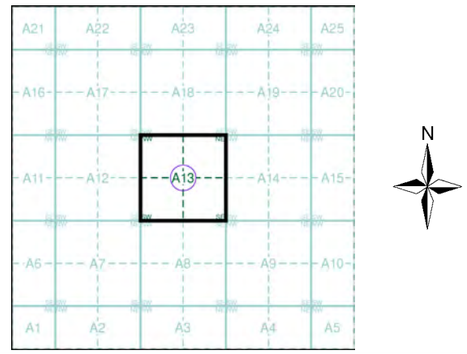
Source map scale - 1:1,250

SUSI maps (Supply of Unpublished Survey Information) were produced between 1972 and 1977, mainly for internal use at Ordnance Survey. These were more of a `work-in-progress' plan as they showed updates of individual areas on a map. These maps were unpublished, and they do not represent a single moment in time. They were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
Customer Ref:	60092600
National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
Search Buffer (m):	100

Site Details

Site at 429850, 433120

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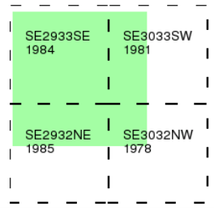
Additional SIMs

Published 1978 - 1985

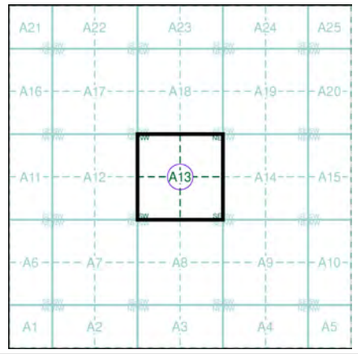
Source map scale - 1:1,250

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



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Order Details

Order Number:	27052630_1_1
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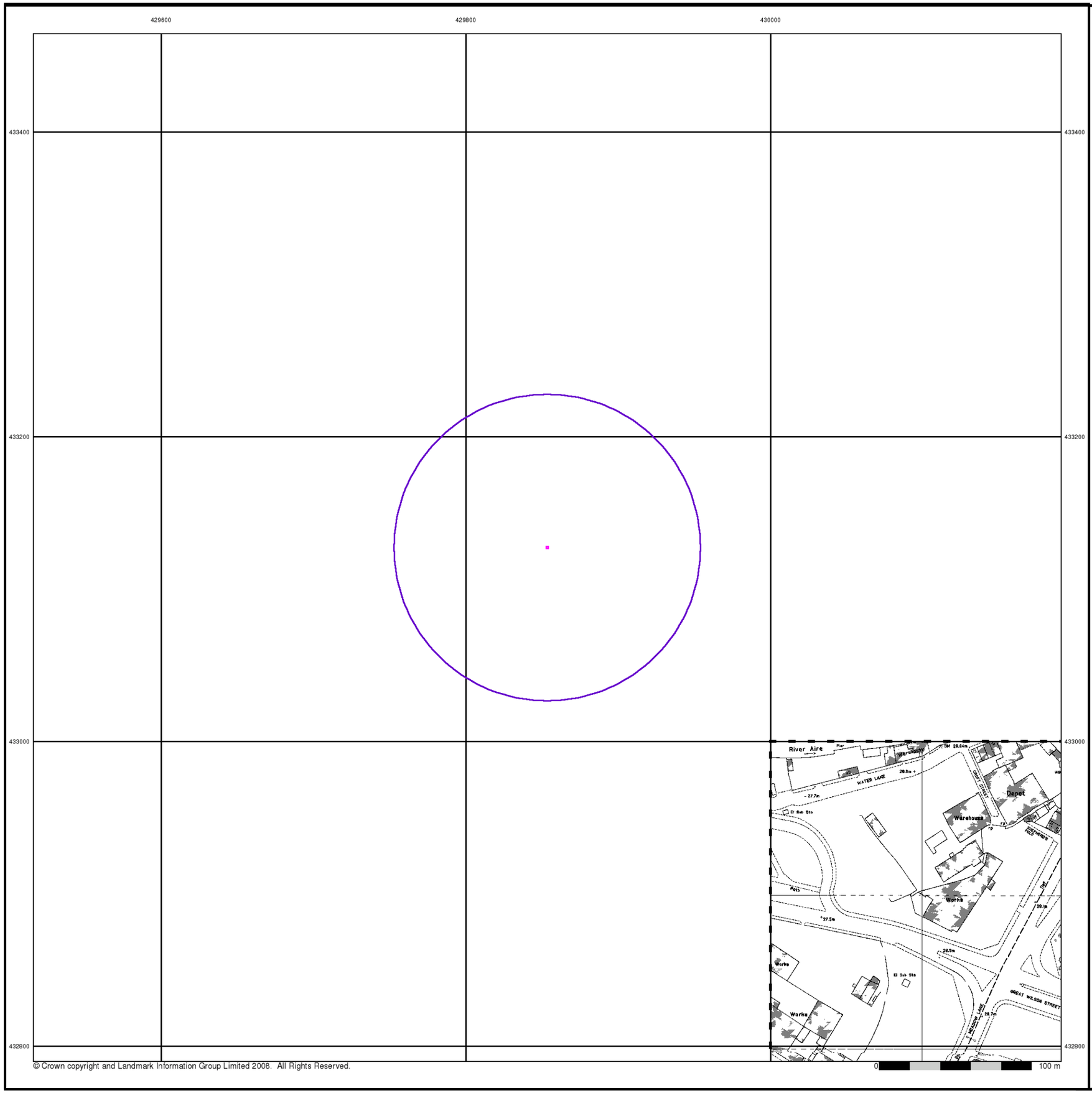

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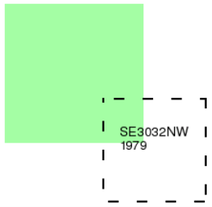
Ordnance Survey Plan

Published 1979

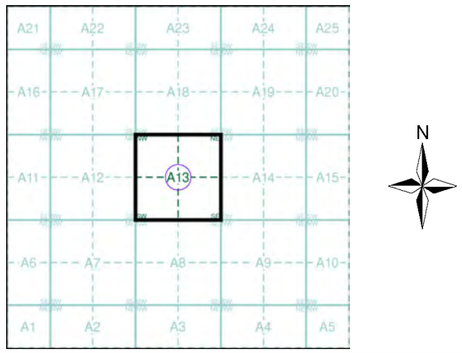
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



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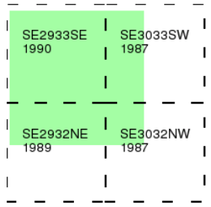
Additional SIMs

Published 1987 - 1990

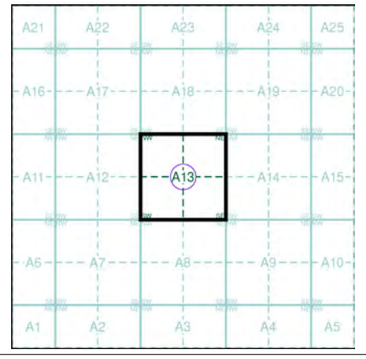
Source map scale - 1:1,250

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



N

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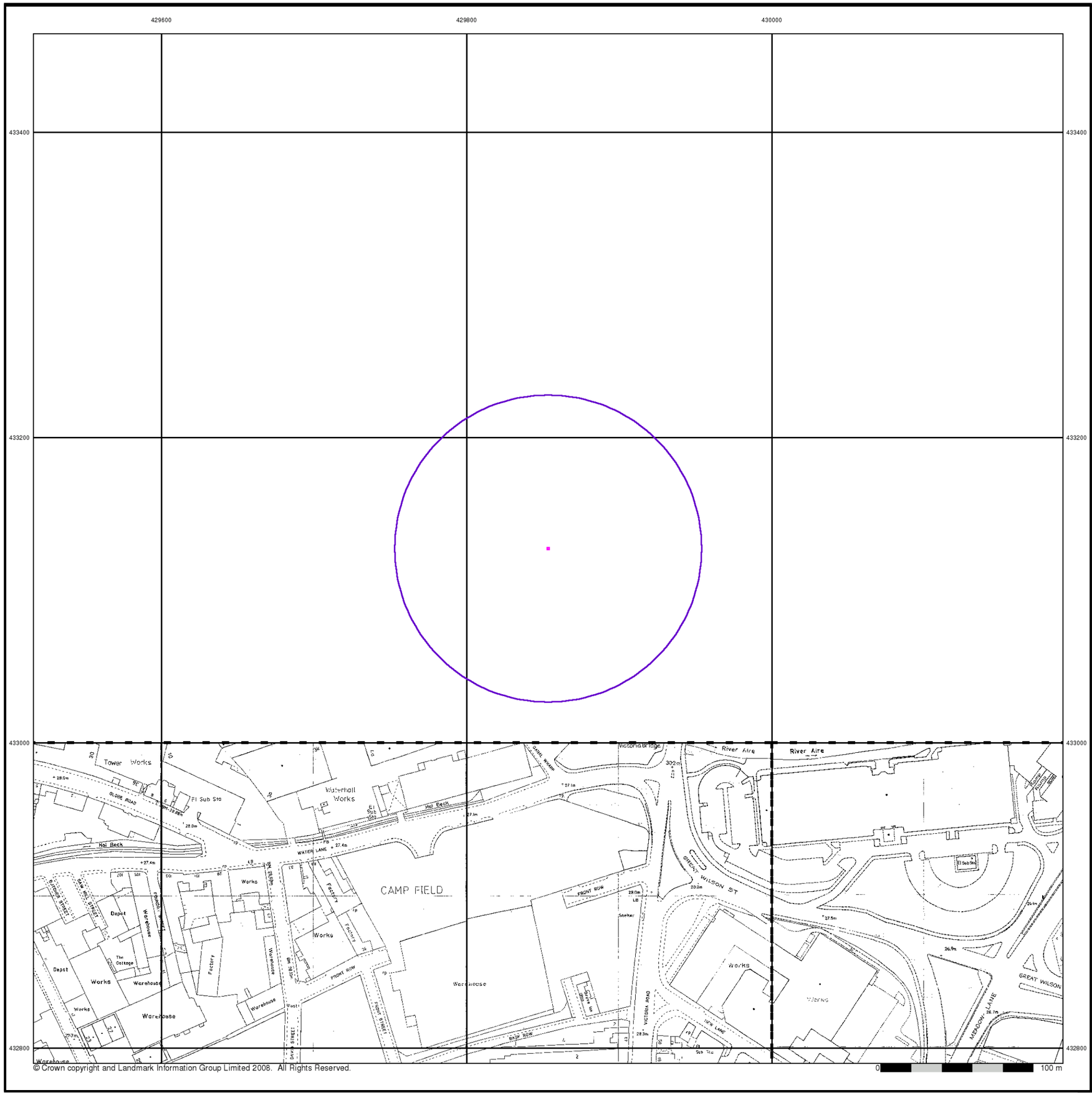

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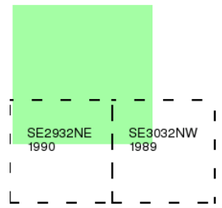
Additional SIMs

Published 1989 - 1990

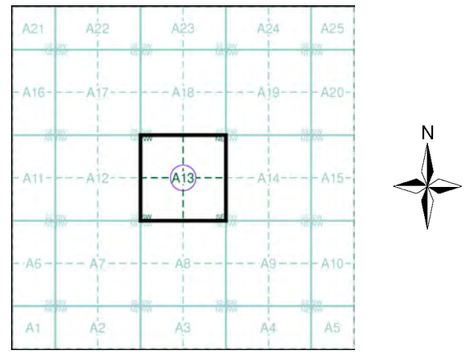
Source map scale - 1:1,250

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



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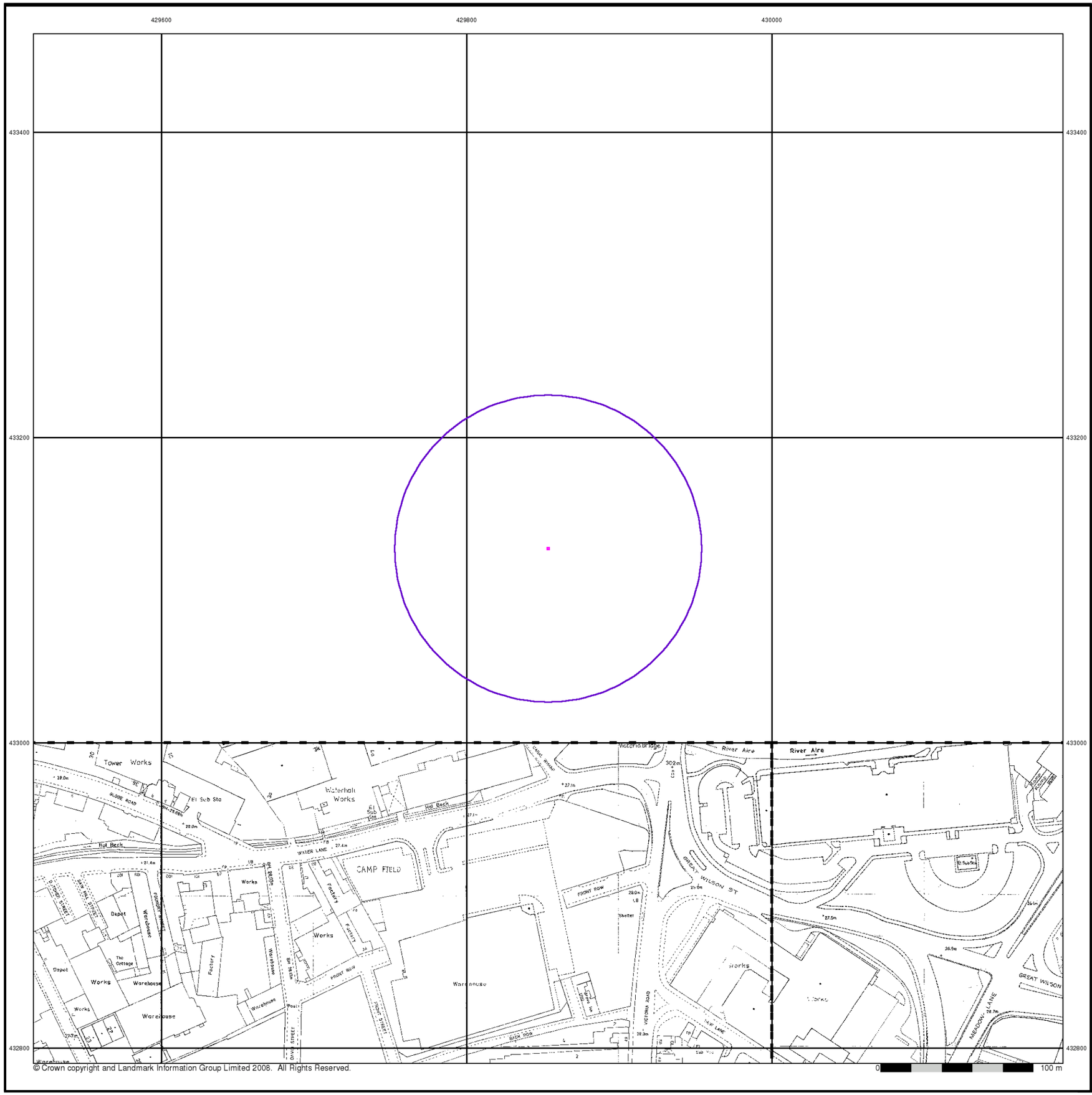

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Additional SIMs

Published 1989 - 1990

Source map scale - 1:1,250

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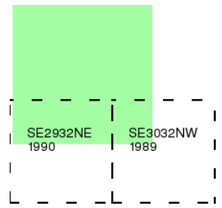
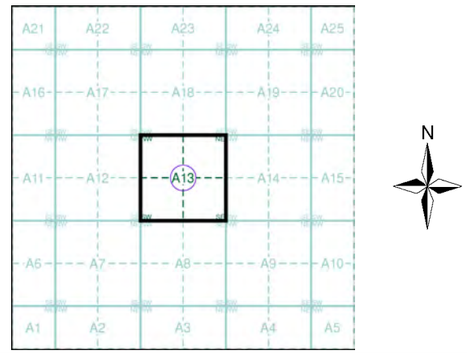


Historical Map - Segment A13



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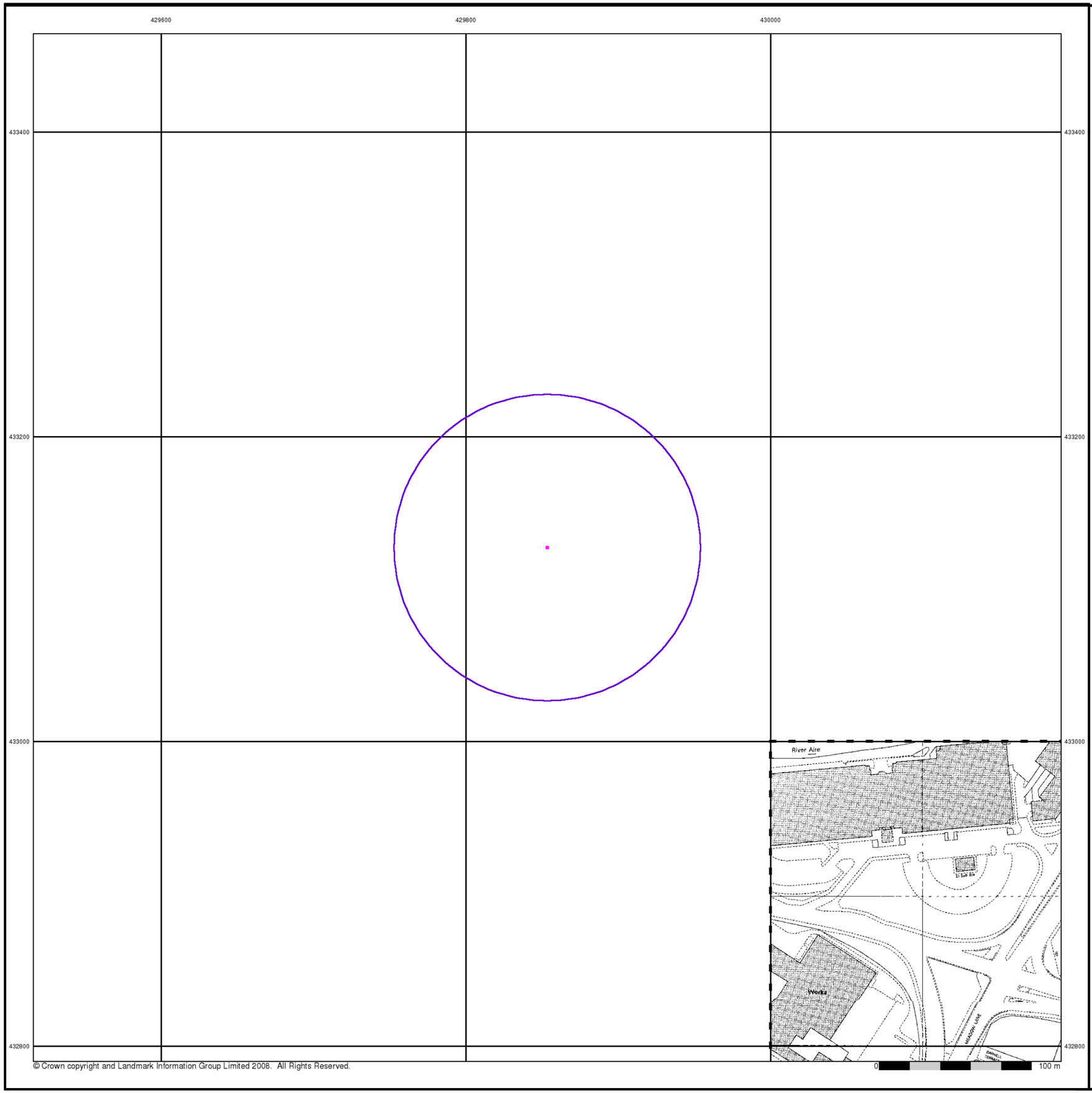

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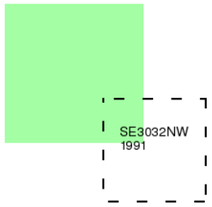
Ordnance Survey Plan

Published 1991

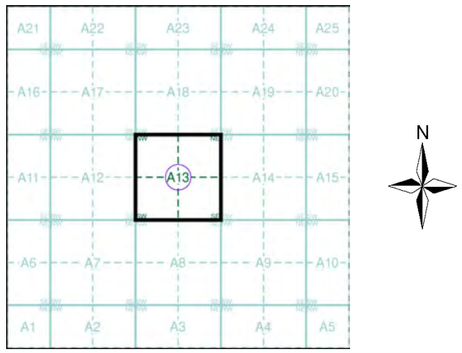
Source map scale - 1:1,250

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

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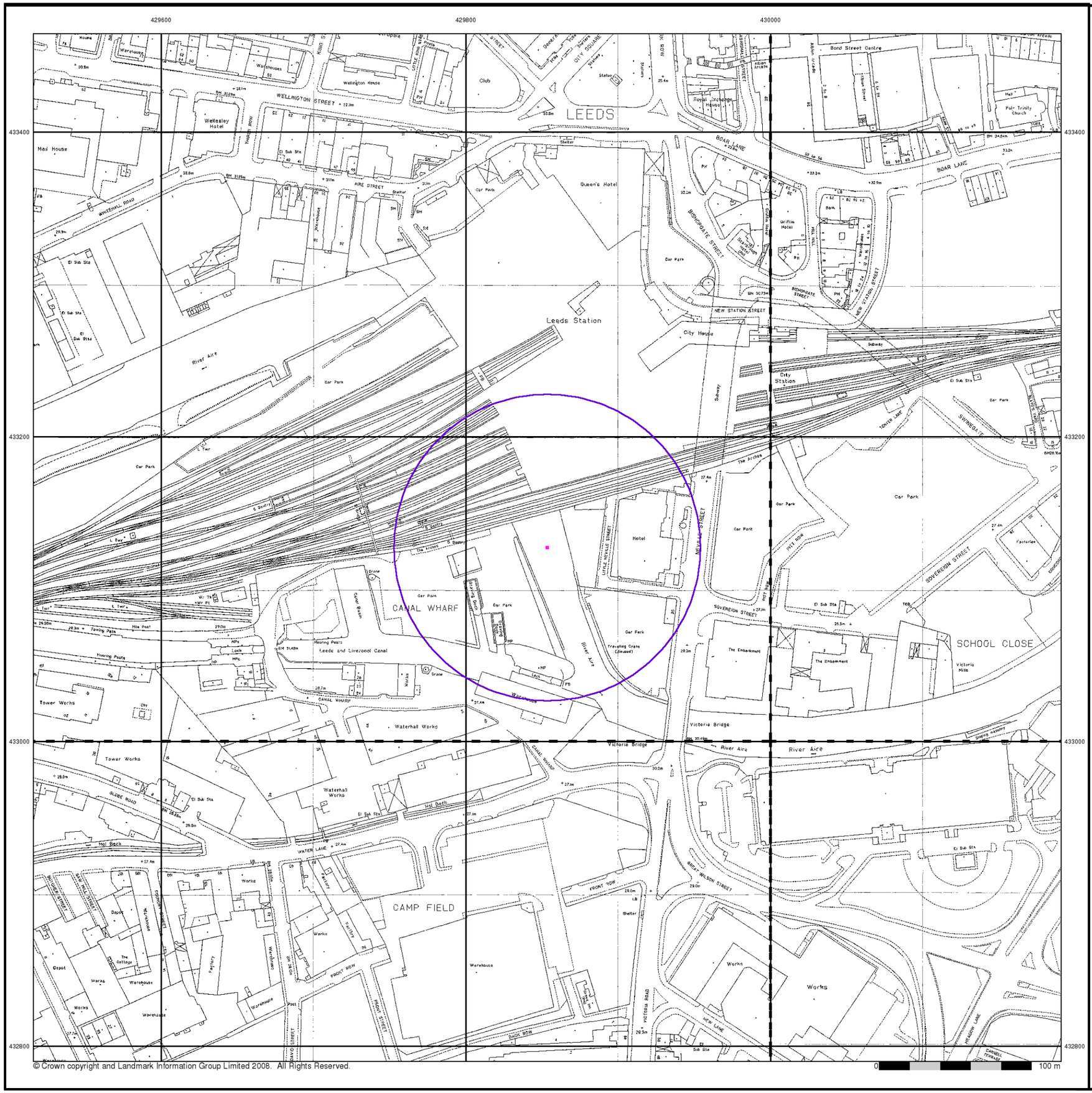

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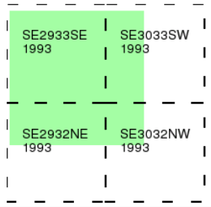
Large-Scale National Grid Data

Published 1993

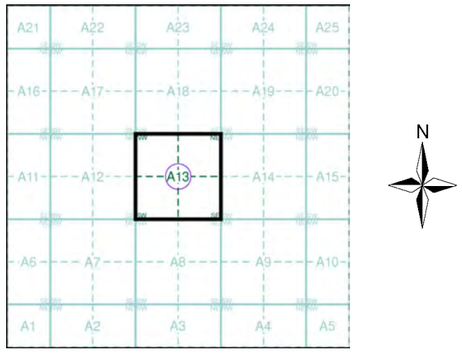
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	27052630_1_1
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National Grid Reference:	429850, 433130
Slice:	A
Site Area (Ha):	0.01
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Site Details

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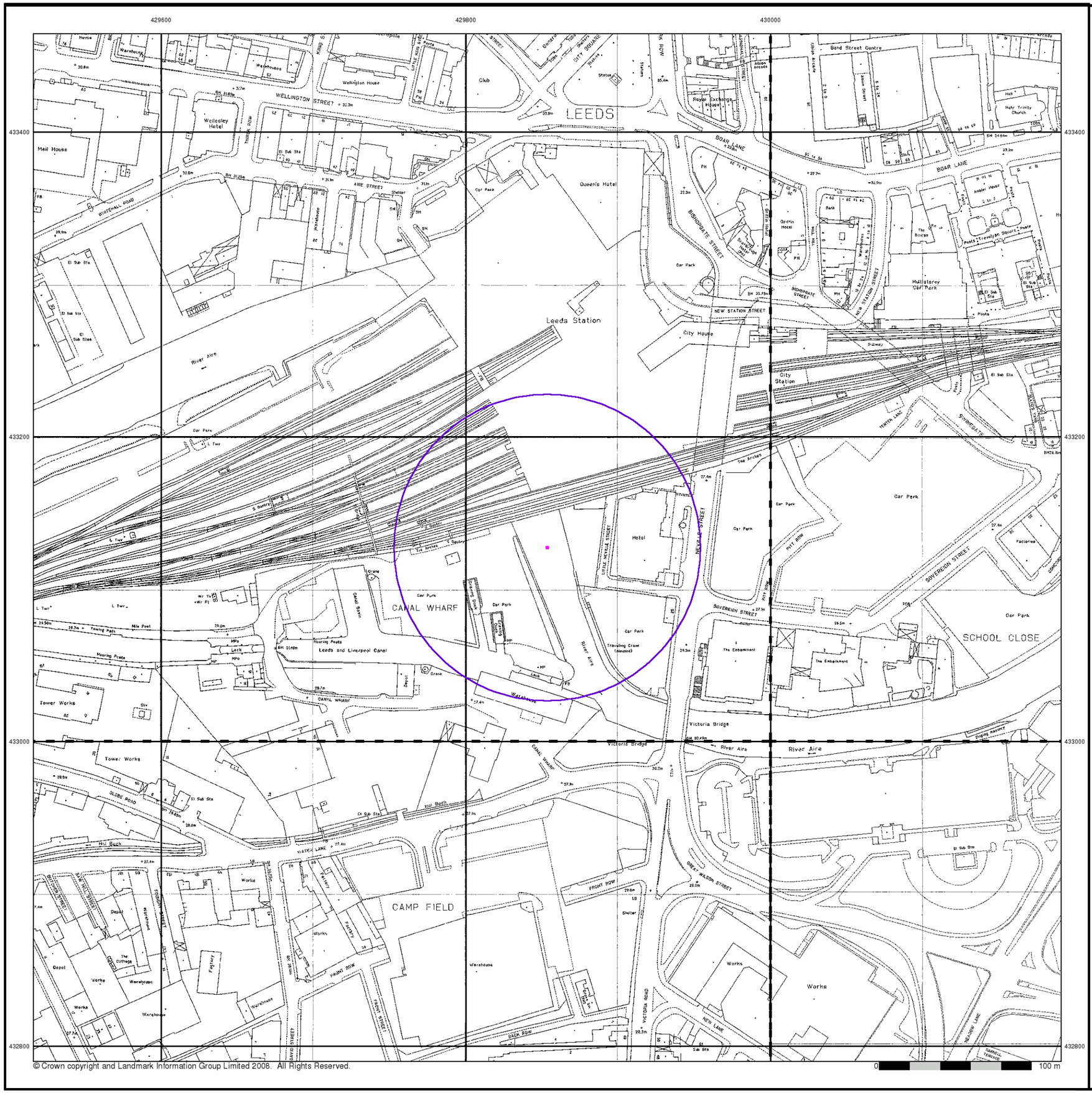

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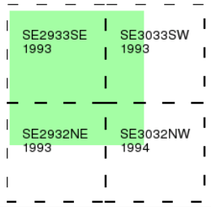
Large-Scale National Grid Data

Published 1993 - 1994

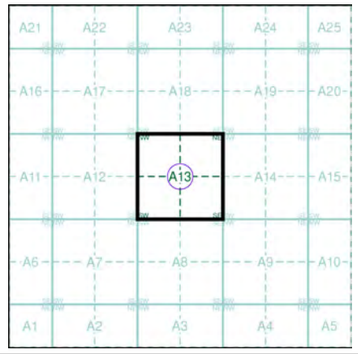
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



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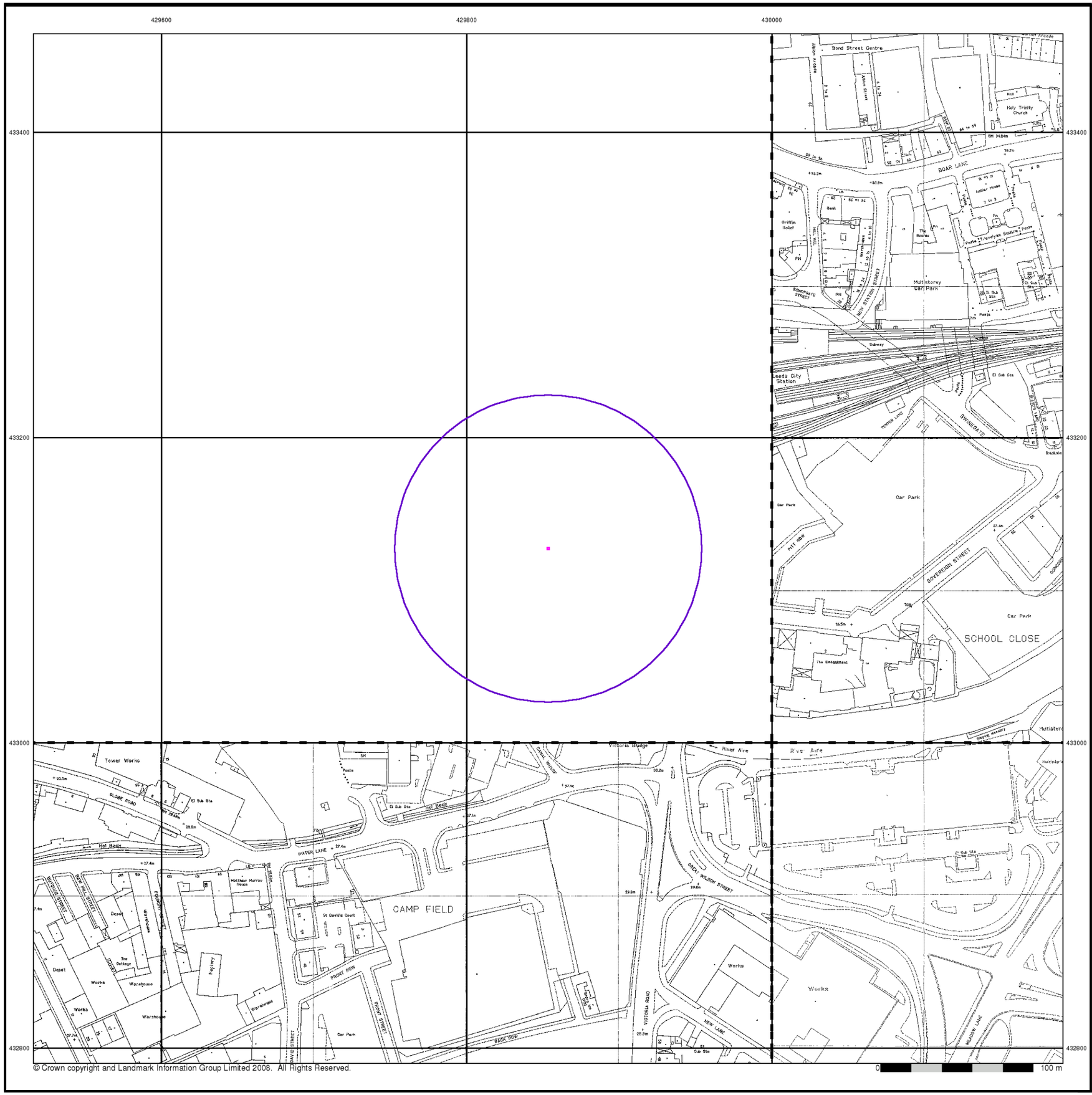

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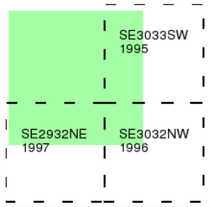
Large-Scale National Grid Data

Published 1995 - 1997

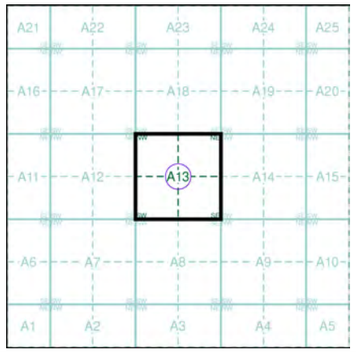
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



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