Archaeology South-East

ASE

LEVEN ROAD GASHOLDER STATION, POPLAR, LONDON, E14 0LL

HISTORIC BUILDINGS RECORD (HISTORIC ENGLAND LEVEL 2)

NGR: 538672 181472

Commissioned by
Montagu Evans

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SUMMARY

In October 2015 Archaeology South-East (a division of the Centre for Applied Archaeology, University College London) carried out a programme of historic building recording of the three gasholders at Leven Road Gasholder Station, Leven Road, Poplar, London, E14 0LL (hereafter 'the site'; centred NGR: 538672 181472). The work was commissioned by Montagu Evans LLP on behalf of National Grid, in advance of the demolition of the structures on the site as part of a scheme to remediate the site ahead of redevelopment.

The former gasworks contains three gasholders of the water-sealed type. Gasholder No. 1 was built as part of the gasworks initial phase of works in 1876-8. The gasholder is one of the earliest examples of the use of wrought-iron lattice guide standards and is a particularly early example of the use of lattice box-section middle girders, based on designs by Robert and Henry Jones. In addition, the holder utilises an early example of an entirely concrete tank without the use of puddled clay (English Heritage 2002, 91). Gasholder No. 2 constructed in 1974, represents a typical late 20th century spiral-guided design, based on a developed design by Gadd & Mason of Manchester (1887). Gasholder No. 2 is representative of a typical trend occurring from the 1950s onwards in which a new gasholder was constructed as a replacement of a former holder of a lesser capacity, utilising the original in-ground tank. In this case a typical 1970s spiral-guided gasholder replaced a former column-guided holder dated to 1882. Gasholder No. 3 has a construction date of 1928 and was designed by Samuel Cutler & Sons. The structure represents a typical early 20th century column-guided gasholder design. Its 'Type 37' lattice guide frame and above-ground steel tank, reflect the advancements in gasholder design throughout the 20th century. This gasholder forms the last phase of major development of the late 19th century gasworks.

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1.0 INTRODUCTION

1.1 In October 2015 Archaeology South-East (a division of the Centre for Applied Archaeology, University College London) carried out a programme of historic building recording of the three gasholders at Leven Road Gasholder Station, Leven Road, Poplar, London, E14 0LL (hereafter 'the site'; centred NGR: 538672 181472; Figure 1). The work was commissioned by Montagu Evans LLP on behalf of National Grid, in advance of the demolition of the structures on the site as part of a scheme to remediate the site ahead of redevelopment.

1.2 National Grid requested that the structures on the site were subject to historic building recording prior to their dismantlement. The recording was undertaken by National Grid as a voluntary exercise as part of a broader commitment to the stewardship of the heritage assets within their property portfolio.

1.3 The Leven Road Gasholder Station is a non-designated site. No designated heritage assets (e.g. scheduled monuments or listed buildings) are located within the site and the land does not lie within a conservation area or archaeological priority area.

2.0 SCOPE & METHODOLOGY

2.1 The scope of work and methodology for the building recording is detailed in a brief produced for the work by Montagu Evans LLP, dated August 2015. The work was also carried out in accordance with the relevant CIfA standards and guidance and the Greater London Archaeology Advisory Service's Archaeological Guidance Papers Nos. 3-5.

2.2 Gasholders No. 1 and No. 3 were subject to an enhanced Level 2 record and Gasholder No. 2 was subject to a basic Level 2. The recording levels are defined in Historic England guidance (Historic England 2016) and a brief produced for the work (Montagu Evans August 2015). A Level 2 record is essentially a descriptive record.

2.3 The descriptive section of this report uses the gasholder terminology provided in the *London Gasholders Survey* (English Heritage 2000, 7-8). Definitions for the main structural components have been summarised in a separate appendix at the back of this report (see Appendix 1).

2.4 The site was visited by Hannah Samuels and Seth Price on the 25th September and 6th October 2015 to carry out the initial record, and again by Hannah Samuels on the 12th July 2017 and 19th October 2017 to make additions to the record during the demolition of the gasholders. The recording of the site entailed the compilation of written notes, the verification of existing measured survey drawings, and the production of a photographic record.

2.5 A brick-built meter house of late 19th century origin is located along the site's western boundary but does not form part of this record; a basic photographic survey has been included of this building for contextual purposes. This building would have housed the station meter, which measured the volume of purified gas on its way to the gasholders.

2.7 A digital photographic record was made during the site visit. Selected photographs include a 0.5m scale, to provide appropriate reference to detailed shots. Within the report selected digital images have been reproduced as plates to supplement the descriptive text, together with a full index of the digital photography and location plots (Appendix 4). A full catalogue of all photographs is included in the archive.

2.8 The drawn record comprises plans of the gasholders as existing to illustrate their layout. These plans were provided by Montagu Evans and have been verified for their accuracy and amended, where necessary, during the recording exercise. The measured survey drawings are included within the report as Figures 2, 19 & 20.

2.9 In drawing up this report, a variety of cartographic and documentary sources were consulted. Relevant sources were obtained/sought from the National Gas Archive (NGA, Warrington), Historic England Archive (Swindon), the National Archives (NA, Kew) and the Tower Hamlets Local History Library and Archives. Additional sources held within the Archaeology South-East library were utilised, and appropriate on-line databases interrogated. These included: Heritage Gateway, National Heritage List for England, and the Magic website, which holds government digital data on designated sites in GIS map form. A search was made of the aerial photographs held by the Historic England Archive, as well as on Google Earth and on the Britain from Above website (2015). Material has been referenced separately within the text where necessary. A full list of the cartographic sources used during this assessment can be seen at the end of this report (Section 7.0); where possible, the pictorial sources referred to within the text are reproduced as figures.

2.10 In connection with the redevelopment of the site National Grid have commissioned a full photographic record of the site, to be undertaken by industrial photographer Ben Murphy.

3.0 SITE LOCATION

3.1 The former gasworks occupies a roughly rectangular area of land measuring approximately 8.1ha. The gasholder station itself occupies an area of land measuring *c.*2.3ha (Figure 1). The site is located to the north-west of the Leamouth Peninsula towards the eastern edge of the London Borough of Tower Hamlets. The site itself is bound to the north and west by the River Lea / Bow Creek. To the south-west corner lies Leven Wharf, which is currently in industrial use. The Blackwell Trading Estate borders the site's north-eastern corner and is in use as a storage facility and car compound. Properties along Oban Street create the eastern boundary. Leven Road is situated to the south of the site, comprising residential units of two and three storey terraces. Site boundaries are defined by mixed metal fencing around its perimeter, which is fronted by an original 3m brick-built boundary wall along its northern side.

3.2 The site is accessed on its southern side via Leven Road, the ground level rising gradually *c.*2m towards the northern side. Internal circulation is defined by a tarmacked road which is roughly 'T' shaped, bearing north – south from the principal entrance, and branching east – west along the northern boundary. The gasholder compound comprises three water-sealed decommissioned gasholders; Nos. 1 and 3 are of the guide-frame type with No. 2 comprising a spiral-guided design. All three gasholders are situated to the southern boundary of the former gasworks compound. Gasholders No. 1 and No. 3 occupy the site's western side with Gasholder No. 2 situated to the eastern boundary. Areas of concrete hardstanding and grassland separate each of the gasholders. The site has been largely cleared, with a high proportion of ancillary buildings and associated gas infrastructure dismantled. The principal remaining structures on the site comprise the three gasholders, a small quantity of modern gas distribution pipework, a dry well with valve and two brick-built buildings comprising a Booster House and Electricity Sub-Station.

4.0 HISTORIC BACKGROUND

4.1 The background of the site and its environs has been prepared in consultation with a variety of documentary, online and archive resources and is duly referenced where necessary.

General

4.2 A general overview of the gas industry in Britain is presented in Appendix 1. The use of gas for street lighting originated during the late 18th century in London and was established by Frederic Windsor. By 1823 London had three gas works, supporting 40,000 street lamps in 213 streets, demonstrating gas as a viable industry and an effective form of lighting. By 1830 gas street lighting had spread with the erection of 200 gas companies operating throughout England (English Heritage 2000, 5).

The Site

4.3 In 1824, local residents urged the Poplar Vestry to invest in gas street lighting for the area, resulting in the Poplar Gasworks, operated by the Poplar Gas Company (Montagu Evans 2015). The area's first gasworks were built adjacent to the West India Dock wall by 1829. After the Poplar Gas Company fell into financial difficulties, the works were bought out by the Commercial Gas Company.

4.4 The Commercial Gas Company (CGC) was established in 1837 at Stepney and became a statutory gas undertaking in 1847. Ordnance Survey mapping of the Leven Road site between 1850-51 and 1869, illustrates the gasholders had not been built by this date. In 1875 the CGC merged with the Ratcliff Gas Company, so that its area of supply then covered most of the present borough of Tower Hamlets (English Heritage 2002, 91).

4.5 Land for the Leven Road Gasworks next to the River Lea was purchased in November 1873 and March 1876. The new works were intended to supplement the company's existing works at Stepney and rival the Imperial Gas Company's Bromley works on the opposite side of the creek. Previous to the construction of the gasworks, the land comprised marshland which was later used as farmland (Montagu Evans 2015).

4.6 Following the Company's Act of 1875, Robert Jones, engineer of the CGC, who had overseen reconstruction works at the Stepney site, proposed plans for Gasholder No. 1 in January 1876 (English Heritage, 2002, 92). By this date Robert's son Henry had begun working on the site to aid the completion of the first phase of works in April 1879 (English Heritage 2002, 92). Contracts for the gasholder and a single tar tank were sealed on 5th May and 22nd April 1876, by a Mr W Webster for £25,000. A separate contract covered the gasworks buildings. Payments for the construction of the column guided two-lift holder were made to the constructional engineering firm of Samuel Cutler and Sons of Millwall, which specialised in the erection of gasholders all over the country. Payments were made in May and July 1877, and 18th January 1878, the final completion payment was given in July 1878. Gas first passed through the station meters on 28th November 1878 (English Heritage 2002, 92). These payment dates coincide with the historic mapping of the area: Stanford's 6-inch map of 1877 shows the gasworks were not present by this date but the site, complete with a single gasholder appears on the Kelly's Directory street plan for 1882 (Montagu Evans 2015).

4.7 The contract for the original column-guided Gasholder No. 2 was given in 1880 and construction works were completed by 1882 for a total cost of £33,290. A site plan

dated *c.*1890 (Figure 3), shows the site for the first time with detailed annotation, comprising Gasholders No. 1 and No. 2, retort houses and purifiers, among other associated infrastructure on the site (Montagu Evans 2015). Gasholder No. 1 is identified as having a nominal capacity of *c.*1.5million cubic feet, whereas Gasholder No. 2 was constructed to hold 3.3 million cubic feet of gas per day and comprises 22 guide frame standards (English Heritage 2002, 93).

4.8 By 1895 the site constituted two gasholders and five ancillary buildings. The site continued to expand, and in 1928-9 Gasholder No. 3 had been constructed, by Cutler's, with a capacity of 4 million cubic feet (Montagu Evans, 2015). A number of ancillary buildings and structures were situated in the northern part of the site by this date and can be viewed on the aerial photography of 1931 (Figure 4). During this same phase of works, the bell of Gasholder No. 1 was re-sheeted using Armco iron (English Heritage 2002, 93). The configuration of the gasholders on both the photography and the Ordnance Survey map of 1938 (not reproduced) reflect that of the site today.

4.9 The CGC maintained independence from the ever increasing Gas Light and Coke Company, and in 1930 the South Metropolitan Gas Company took a significant shareholding. However, in 1949 during the nationalisation of the gas industry, the undertaking passed to the North Thames Gas Board (English Heritage 2002, 93). During this transition the site continued to expand as can be seen on aerial photography of the site taken between July 1946 (Figure 5) and May 1949 (Figure 6). As part of these expansion works, Gasholder No. 2 was replaced and is identified for demolition on the site plan of c.1950 (Figure 7) and 1957 (Figure 8), with a four-lift spiral guided design, utilising the original in-ground tank. Site plans and aerial photography of the site produced between September 1960 and August 1973 (Figures 9 – 13) show the former guide frame removed, with only the tank and dumpling in-situ. The gasworks' site plans, dated to 1966 (Figure 10) and 1972 (Figure 12) identified Gasholder No. 2 as 'Tank Only', highlighting the demolition of the original guide frame in preparation for the construction works. The replacement holder was completed by 1974, and can be seen on the site plan produced in October 1976 (Figure 14).

4.10 Following the discovery of North Sea natural gas reserves the requirement for the site's production plant went into decline. Clearance works of the plant began in 1976 and are clearly visible on the site plan dated to the same year (Figure 14); they were completed by 1982-4 (Figure 15). Despite the closure of the plant, the gasholders remained in use and continued to operate into the early 21st century. Following these clearance works the northern extent of the site became used as a car storage compound by September 1991 (Figure 16 & 17). The new residential development along Leven Road can be seen on aerial photography taken in September 2006. All three gasholders are presently redundant, isolated from the network and purged of gas.

5.0 DESCRIPTION OF THE GASHOLDERS

5.1 Overview

The Site

5.1.1 Following the decommissioning of the gasholders, the surrounding area has been well secured by perimeter fencing. The gasworks is fronted along its southern boundary by an original boundary wall, measuring *c.*3m in height. The wall is constructed using London stock bricks with recessed panels and Staffordshire blue coping blocks. The

main gated entrance to the east of Gasholder No. 3 has Portland stone capitals that support cast-iron gas lamp standards (Plate 1).

5.1.2 Although the site has been largely cleared, a modern small brick built electrical sub-station remains to the south and a booster house survives *in-situ* to the north of Gasholder No. 1. Alongside these simple structures are associated services and redundant gas pipelines connecting the eastern and western extents of the site along the northern boundary. Gasholders No. 1 and No. 3 occupy the western area of the site, while Gasholder No. 2 is located a short distance to the eastern extent, divided by an area of made gravel ground that formerly held associated plant for the gasworks. All three gasholder have been purged of gas and their bells in a deflated position inside their tanks providing clear visibility of the guide-frame structures.

Tabulated information of the Poplar Gasholders

Table 1 presents a summary of the generalised data corresponding to each of the Gasholders at Leven Road, Poplar:

	Gasholder 1	**Gasholder 2**	**Gasholder 3**
Construction Date	1876-8	1881-2 (original) 1974 (current)	1928-9
Holder Capacity	1.525,000*m.c.ft.*	3.300,000*m.c.ft* (original) 6,000,000*m.c.ft* (current)	3,750,000*m.c.ft.*
Tank Diameter/Depth	52.4*m (diameter)* 10.9*m (depth)*	67*m (diameter)*	*57.8m (diameter)*
Tank Construction	Concrete (below)	Concrete (below)	Steel (above)
Number of Lifts	2	4 (current)	4
Overall Height	22*m*	42*m* (original) Not Known (current)	55*m*
Guide Frame Type	Column-Type 30	Column-Type 36 (original) Spiral guided (current)	Column-Type 37

Table 1: Dimensional and Constructional Data for Gasholder Nos. 1 to 3

5.2 Gasholder No. 1

The General Design

5.2.1 Gasholder No. 1 was built in 1876-8 (Figure 19), based on designs devised by Robert and Henry Jones. The gasholder is of two lifts and was designed to enable a storage capacity of 1.5 million cubic feet (Plate 2). The guide frame corresponds to a 'Type 30', in the typology devised by English Heritage (English Heritage 2002, 35) and measures 52.5m in diameter, with a height of 22m. The gasholder is one of the earliest examples of the use of wrought-iron lattice guide standards and is a particularly early example of the use of lattice box-section middle girders. In addition, the holder utilises an early example of an entirely concrete tank without the use of puddled clay (English Heritage 2002, 91). The design resulted in a particularly robust structure of superior strength, resistant to buckling, with increased lateral support to balance opposing tension on the radial standards. The design of the lattice guide frame standards was based on the

first of the type, erected at Hove in October 1876 by John Paddon (now demolished), although the guide frame design at Poplar was the first to use curved and tapering box-lattice girders. The use of radially-placed standards in place of cylindrical columns (which were commonly used at this date), was revived by George Anderson in 1868 and later greatly supported by Henry Jones, on the basis that the columns commonly sported 'inadequate bases…for resisting lateral rather than vertical loads' (English Heritage 2002, 95). The design utilises careful component integration and clean lines to create an elegant structure dominated by notably slender 'T' section standards with pronounced tapering towards their crown, and middle girders that taper considerably at their midspan, creating a distinctive innovative design (English Heritage 2002, 91). The majority of the frame is constructed using riveted wrought iron with cast iron components.

The Principal Elements

5.2.2 The guide frame structure of Gasholder No. 1 consists of 19 equally-spaced wrought iron lattice standards, with two tiers of girders and diagonal bracing (Plate 3). The flat-plated, 'T' section vertical standards taper from bottom to top, measuring 1.37 x 0.91m at the base and 0.2m across the top and rise to a height of 22m. Each standard has internal rolled-tees at the front and back, with each standard comprising rhomboidal sections that diminish in height towards the top (Plate 4). The panels measure 1.25 times as tall as they are wide, their overall ratio of diameter to height is just under 2.5 (English Heritage 2002, 94). The standards comprise a radial web of flat-bar lattice-bracing at a 45 degree configuration, with solid plate lateral webbing (Plate 5). As the standards taper, the crosses become smaller with closer spacing, with the size of the bars remaining constant. The top panels comprise solid plates in place of lattice work due to the pronounced taper. The bracing is riveted at each cross intersection, in addition to each terminating end, both the radial and lateral webbing have rolled-tee flanges. Five additional horizontal diaphragms are secured at wide intervals along the length of the standards for increased structural stiffness. A rolled 'I' section guide rail is riveted to the inner face of each standard (Plate 6), which is where the guide rollers connect from the individual bell lifts. A flange plate is present towards the base of each standard.

5.2.3 The wrought iron intermediate girders (Plate 7) are of box-lattice construction, measure *c.*9m in length, and taper in plan and elevation towards a narrower section at their midspan. They are unique in design to this gasholder (English Heritage 2002, 91). The girder forms a lattice set at 45 degree crosses in a box configuration, each cross placed at decreasingly-spaced intervals towards their central point. Each girder houses 12 crosses to each face, separated by a gently curved solid-plate box construction at its midspan. The riveted lattice work is made of flat bars, so as to minimise the surface area exposed to corrosion and to reduce paint renewal. Each girder is fixed to their corresponding standard by a rolled-iron gusset plate to the front and by four substantial bolts to the rear (Plate 8). The use of intermediate girders between each standard increased horizontal stiffness to protect the outer leg of the standard from lateral buckling (English Heritage 2002, 96). It was first done by Joseph Clark of the Imperial Company at Bethnal Green in 1858 (English Heritage 2000, 47). Lattice work was first used in structural wrought iron for bridge girders in the 1840s, becoming widespread by the 1870s (English Heritage 2000, 47).

5.2.4 The crown girder (top) is comprised of shallow rolled 'I' sections, secured to the standards by horizontal gusset plates on the top flanges (Plate 9). Their arrangement and identification as 'Frodingham Iron & (Steel)', indicates the present girders are not original. The original girders are likely to have borne a close resemblance to those of the original Gasholder No. 2 design, comprising a lattice construction with a single

lattice web. The original crown girder presumably followed the lower girder arrangement comprising a distinct taper towards the midspan. Despite their replacement, Tucker (English Heritage 2002, 94) notes the current crown girder is 'by no means out of keeping and they match the slim lines of the other members'.

5.2.5 To ensure an increased resistance to overturning of the relatively narrow standards at their base, Jones combined the use of an intermediate and crown girder, with additional diagonal bracing rods. The bracing provided additional support to either side of each standard, giving overall improved stability against sidesway (English Heritage 2002, 96). Each rod is tensioned using central rings and each has forged clevis ends.

5.2.6 Each of the 19 standards is erected on a wrought iron base plate measuring a depth of 60mm. Each base is trapezoidal in plan, measuring a width of 1.25m along its inner edge and 0.89m across its outer face, with an overall central length of 1.83m. The standards are secured to the base by two substantial holding down bolts at their inner edge, set within a flanged housing either side of the rear rolled 'I' section guide rail (Plate 10). An additional set of bolt fastenings are placed at regular intervals around the base perimeter, securing it to a concrete pad. A series of low-lying intermediate iron supports are located around the perimeter of the tank.

5.2.7 At ground level, to the northern edge, a modern metal sign identifies the gasholder as 'No. 1' (Plate 11). The in-ground tank is constructed of mass concrete with a diameter of 52.4m with a depth of 10.9m (English Heritage 2002, 93). The tank has concrete coping and is made watertight using cement render, a method pioneered by George Livesey at Old Kent Road No. 12 in 1874-5 (English Heritage 2002, 96).

5.2.8 The tank perimeter is framed by an outer course of blue engineering brickwork, measuring 0.92m in width, with an additional course of brickwork set within a herringbone arrangement around the circumference, adding an extra 0.57m in width. A low brick curb of a single brick's width is located around the brickwork (approximately 240mm high) (Plate 12). Between Standards 10 and 11, on the western edge, the brickwork is reduced in width to a measurement of 220mm (Plate 13); the function of this is no longer clear following site clearance works. There is no guard rail present around the external edge of the tank. The tank base (Plate 14), which was revealed following the removal of the bell, contains a large dumpling, covered in concrete, whose function was to support the crown structure when empty of gas. The dumpling has steep sides which finish at a flat central circular platform. The outer edge of the dumpling contains a series of regularly spaced projecting platforms with central square mortices (Plates 15 and 16), measuring between a height of 0.70/0.75m and a width of *c.*1.15m. Each platform served as base for the timber members of the crown framework. The inner face of the tank contains a series of shallow I-section uprights (Plate 17), which are riveted to the concrete perimeter. Each is situated in line with, and directly between, the guide-frame stanchions and would have acted as guides for the corresponding outer lift rollers.

5.2.9 Situated towards the north-eastern side of the holder is a dry well with blue brick coping, measuring a width of 4.5m (Plate 18). Located over the centre of the well on a modern metal grid are two large hand wheels. Tucker (English Heritage 2002, 93) notes their function accordingly, 'the one mounted on a cast-iron A-frame … work(s) a sump pump, via a crank and a parallel-motion linkage, and the other on a cast-iron pillar work(s) the inlet stop valve via a bevel reduction gear and a vertical spindle'. Additionally, a large manual wheel is mounted to a semi-circular base (Plate 19), with inscriptions 'Robt Cort & Son Ltd, Reading Bridge Ironworks, Reading' is situated a short distance to the north of the well. All equipment related to the well is thought to be contemporaneous with the gasholder.

5.2.10 To the east of the well is a single iron pipe (Plate 20) located adjacent the 19th century meter house. The relatively substantial pipe rests on a short brick pier and is marked with the initials 'Stanton 1965', its most likely function being a syphon for the regulation of gas inlet and outlet supplied to the gasholder when operational.

5.2.11 The crown of the bell has a convex shape (Plate 21). It is made up of nine rings of staggered single-riveted steel sheets, laid vertically from the centre outwards with the two outer rings of the curb set horizontally, providing additional tensile strength. The bell formation comprises the use of a light, untrussed crown, supported by heavy rivets around the top curb. The generous crown-rise reduced the pressure and weight on the bell and provided additional robustness. The crown occupies a surface area of c.2094.82 sq. m, has an outer diameter of 51.8m, with a rise of 2.7m. The present bell was re-sheeted in the 1920s using corrosion-resistant Armco iron, presumably due to a difficultly in sourcing wrought iron during the period. A single rectangular inspection access hatch protrudes from the centre of the crown's top curb, accompanied by a flush circular hatch situated within the 5th tier of sheeting on the south-western edge (bell sheeting has been assigned from the outer edge inwards) (Plate 22). The removal of the crown's steel sheets during demolition revealed the crown to be supported internally by a framework comprising square section posts (360mm x 360mm; Plate 23), which rest within the concrete bases located on the outer edge of the dumpling and upon integral concrete plinths situated over the dumpling platform. The top of each post contains a tongue-and-groove mortice (measuring 250mm x 70mm) to secure four radiating board-like beams (Plate 24), which form a frame to support the underside of the crown. Each post is fixed to the next by a board-like timber strut, identical in nature the board-like beams which bridge the gaps between the posts. The outer circuit of posts (Plate 25) which correspond with the perimeter of the inner lift, are connected to each other by a mid-level girder and raking struts, together forming a star-like configuration. The posts are additionally supported by a lateral beam connected to the base of each adjacent inner post (Plate 26). A number of the timber posts have been etched with merchant marks and constructional carpentry marks (Plate 27).

5.2.12 Two lifts are present, the outer lift wall measuring 200mm in width (Plate 28). Each lift is separated by a water-sealed channel (lute); the widest channel, which separates the first lift from the tank edge measures 330mm, with the inner channel measuring 110mm. Tucker (English Heritage 2002, 95) notes that the cups and grips of the lifts are of a traditional, riveted rectangular construction. Each lift is 10.7m deep, enabling a nominal capacity of 1.5 million cubic feet. The inner face of each lift wall comprises horizontal steel sheets, supported vertically by a series of regularly spaced I-section steel uprights (Plate 29). The inner lift wall is constructed using 11 horizontal sheets. The base of each lift wall rests of a series of paired rectangular concrete plinths set around the tank base (Plate 30).

5.2.13 The top of each lift is mounted by a rounded L-shaped housing for its respective radial guide roller, which is secured with bolts to the outer edge of each lift and engages with the rolled 'I' sections riveted to the rear of each standard (Plate 31). The double-flanged roller carriages are of solid plate and appear to date from the bell re-sheeting (English Heritage 2002, 94). The rollers increase from the outer lift inwards, so that the guide roller of the inner lift is significantly larger than that serving the outer lift.

5.2.14 The gasholder's lift water seals are fitted with modern continuous cup-level monitoring equipment, that, when operational, provide warning for high or low water levels. Accompanying this equipment to the north-eastern edge of the holder is a self-monitoring electrical modular heating pump system (Plate 32), whose aim is to prevent cup water from freezing between the individual lifts and the tank which would inhibit

the holder from rising. An electrical anti-freeze system works in conjunction with water circulating pumps to regulate the water temperature between 0.6 degrees Celsius and 1.1 degrees Celsius. Cables associated with the monitoring systems are guided to each lift by a cable guide panel located on the northern edge (Plate 33). The panels, fitted with alarms, are part of a graduated pressure warning and venting system to prevent over pressurisation of the tank. The pressure alarm panels are mounted on steel stanchions surmounted by 45 degree angle irons. The panels themselves are simple square shaped steel panels with attached switches facing towards the centre of the gasholder. The panels are labelled 'LO' (low-pressure alarm), 'LOLO' (low-pressure alarm and shutdown), 'HI' (high-pressure alarm) and 'HIHI' (high-pressure alarm and shutdown) in turn. Cables likely related to the antifreeze system are guided to the two lifts by shepherd's-crook shaped guides that are bolted to the inner edge of the standards at regular intervals (Plate 34). The associated switch boxes are located at ground level to the west of the well.

5.2.15 Each lift it served by a bolted steel guard rail around its perimeter, comprising angle-iron uprights with combined mid and top tier tubular rail; standing *c.* 1.5m tall and rails measuring 25mm in diameter with an additional flat steel plate measuring 150mm, secured around the base of rail's inner edge. Due to the change in construction material, it is likely to be a later addition presumably reflecting changing safety recognition.

5.2.16 When extended, each lift would have been accessed via a caged ladder shaft fitted to the north-eastern edge of the guide frame (Plate 35). The access ladders are arranged over two tiers, both set at an angle to the north, with each tier comprising 13 slender rungs. The ladders are securely bolted to the concrete tank surround, in addition to both the intermediate and crown girders. The ladder height extends above the working rise of the bell. A circular guard cage serves the outer edge of both ladders. The bottom and top tier are connected via a guarded (as elsewhere) half-landing which is bolted to the mid girder using paired flat-plate brackets at either end (Plate 36).

5.3 Gasholder No. 2

The General Design

5.3.1 Gasholder No. 2 (Plate 37) (Figure 20) had been constructed by 1974 (Figure 14) to replace the former column-guided holder. The latter had a 'Type 36' guide frame, designed by Henry Jones and was completed in 1882 (Figure 6). The present gasholder was built in the same location and utilised the original in-ground tank. This phase of redevelopment is shown on Ordnance Survey mapping during the *c.*1950s, when it was marked with a corresponding 'Demolition' reference (Figure 7) and is identified as an empty tank with dumpling construction between September 1960 and August 1973 (Figures 9 - 13). The holder was built by with a nominal capacity of 6 million cubic feet (English Heritage 2000, 35) of gas per day compared to its predecessor with a capacity of 3.3 cubic feet. Despite this the holder's former capacity was one of the largest capacities operating in the late 19th century, second only to the gasholder at Old Kent Road No. 13 (English Heritage 2002, 93).

5.3.2 The extant gasholder represents a typical late example of a four lift, water-sealed spiral-guided holder with below-ground concrete tank, set to a developed design first patented in 1887 by Gadd & Mason of Manchester (Appendix 3). The spiral-guided design features a series of rails arranged in a helical pattern set at 45 degrees around the entire circumference of the bell. This design produces a self-supporting structure eliminating the need for an external guide frame and resulting in a significant reduction in construction materials required. The economic design and easily maintainable

construction increased its popularity, such that by the 1930s the design was commonly used for replacement holders of earlier designs of less capacity, reusing the old tanks, as can be seen at Poplar (English Heritage 2000, 42). The gasholder is predominantly constructed using welded steel with cast components.

Operation

5.3.3 The design of a spiral-guided gasholder ensures the structure is self-supporting during operation. As the gasholder is filled, the inner lift is raised vertically and automatically engages the annulus ring of the second lift. This process is known as cupping. As the gasholder contents are further increased, the second lift engages the third lift, and the process is repeated until the gasholder is full. When gas is extracted, the process works in reverse with the outermost lift descending until it automatically disengages or 'uncups' from the next inner lift (National Grid, 1999, 7-8).

The Principal Elements

5.3.4 The former guide frame of the 1882 holder bore many developed principles seen on Gasholder No. 1. The frame was of 'Type 36' and consisted of 22 standards – their associated bases last identified on a site plan dating to c.1950s (Figure 7). The construction was arranged over two tiers and rose to a height of 42m. The box-section standards comprised rolled 'H' sections forming the front and back chords, with the lower girders designed with a constant depth (English Heritage 2002, 96). No physical evidence of the former guide frame and/or bases remains visible.

5.3.5 The bell is of four lifts with a convex crown (Plate 38) constructed using eight rings of staggered riveted steel plates, laid vertically from the centre outwards with the three outer rings of the curb set horizontally. Each ring of the crown increases in width from the centre outwards. The crown occupies a surface area of *c.*3646.40 sq. m with a diameter of *c.*67m. A series of riveted inspection hatches are located to both the east and west sides of the bell; a single rectangular access hatch protrudes from the fourth tier of sheeting on the eastern edge and on the third tier on the western side, accompanied by a circular hatch within the second sheeting tier (Plate 39). Following the removal of the steel plates, it was observed that the crown is supported internally by a series of steel trusses radiating from a central cylindrical stanchion, which rests on top of a concrete dumpling when empty (Plate 40). The principal girders comprise paired L-shaped beams (welded and bolted at regular intervals) forming heavy T-shaped beams. Each truss is fixed to the next by a series of slender L-shaped steel raking struts. Struts of an identical nature also bridge the gap between each truss, forming the supportive frame of the underside of the crown, to which the outer steel sheeting is fixed. Every other truss is fixed to the base of the central stanchion via short sections of bolted steel tension rods (Plate 41). The trusses not fixed to the central stanchion are instead fixed to the top of a series of steel I-section uprights, which support the inner lift wall at regular intervals (Plate 42). The central stanchion is constructed from a series of welded sheets of steel forming a cylinder.

5.3.6 The width of each wall decreases in size from the outermost lift inwards, with Lift 1 (outer lift) measuring 370mm. Each lift is separated by a water-sealed channel (lute) which narrows relative to the decreasing lift wall width; the widest channel, of which there are three in total, separates Lifts 1 and 2 and measures 220mm (measurements for Lifts 2 to 4 were unobtainable during the recording exercise due to the condition of the structure). Lift 1 is separated from the tank platform by a channel measuring 500mm (Plate 43). During demolition it was seen that the inner face of each lift wall is constructed of horizontal steel sheets, supported vertically by a series of regularly-spaced I-section steel uprights. The inner lift wall is constructed using nine horizontal

sheets (Plate 44). The base of each lift wall rests on a series of concrete plinths set at intervals around the tank base.

5.3.7 The gasholder's lift water seals are fitted with continuous cup-level monitoring equipment, supplied by Cooper Crouse-Hinds Ltd, that, when operational, provide warning for high or low water levels. Tank overflow hoses are positioned in the same location to assist the regulation of the water level within the cups and tank. The cables for the pressure alarm systems are located to the northern edge of the tank, in the same manner as Gasholder No. 1 (See Section 5.2.14), secured by bolted steel plates to the tank platform (Plate 45).

5.3.8 The gasholder is also fitted with the same modern self-monitoring electrical modular heating pump system as found on Gasholder No. 1 (Section 5.2.14) (Plate 46), in addition to the associated electrical anti-freeze system. The steel casings of both systems are secured to the outermost guard rail at the south-western edge of the structure. The ancillary service wires are served by three triangular channels that enable their travel to the top of each lift channel when extended. The three steel structures comprise a 'V' shaped channel with associated guard rail with angled uprights and handrail with bolted crossed flat-bar bracing. Each service structure rises according to the direction of travel of the corresponding lift, the outermost structure turning in a clockwise motion (Plate 47).

5.3.9 A series of guide carriages of paired-wheel type are located at regular intervals around the perimeter of each lift. The guide carriages serving the inner lifts (2-4) are mounted to the top of the corresponding lift wall (lift grip). The guide carriages serving Lift 1 (outer lift) are fixed to the inner edge of the tank platform on a raised concrete base, 52mm in depth, set over the width of the outer channel. All guide carriages are secured with a bolted footplate (Plate 48). The guide carriages increase in size from the inner lift outwards, presumably due to their function in supporting the increasing lift weights. Each guide carriage is individually identified with a number: the numbers being assigned in a clockwise direction. A series of 56 carriages support Lift 1, 48 support Lift 2, Lift 3 is supported by 40 carriages and the innermost lift has 32.

5.3.10 Each guide carriage houses its respective 'I' section guide stay which is inclined at 45 degrees, and gripped between the paired carriage wheels and fixed to the sides of the individual lifts (see Appendix 3; Plate 49*).* The first spiral-guided designs originally housed the guide rails internally but they were later housed externally for ease of maintenance, giving significant operational advantages over column-guided holders (English Heritage 2000, 42). The lifts alternate in their operational rotation, starting in an anti-clockwise direction from the inner lift outwards.

5.3.11 The outer edge of each lift is served by runs of bolted-on guard rails, comprising angle-iron uprights and tubular rails, standing *c.*1.5m tall and measuring 25mm in diameter with an additional flat steel plate measuring 150mm secured around the base of rail's inner edge. The guard rail serving Lift 4 has slightly more slender tubular rails measuring 20mm in diameter and the steel footplate extends to a height of *c.*400mm (Plate 50).

5.3.12 When extended, each lift is accessed via a single slender spiral staircase mounted on the grip channel of each lift, situated to the western side of the gasholder when at rest. Each staircase is similar in form, comprising narrow serrated steps bolted between paired flat-plates, which are curved to match the profile of the lift. The outer edge of each staircase has a bolted handrail of angled section uprights and tubular rails (Plate 51). The inner face of each ladder is grooved to support the travel of a corresponding singular carriage wheel to provide additional support and stability when operational.

The base of the outermost staircase is accessed via a separate stair, comprising four steps of similar construction which extends over the first water-filled channel (Plate 52). The record of both the staircases and their corresponding supportive structures was limited due to their removal and shortening in recent years for increased site security.

5.3.13 At ground level, to the western edge, the gasholder is identified as 'No 2' by modern metal signage. The base of the structure is erected on an outer curbed ring of concrete measuring a width of 1.55m around the perimeter (Plate 53). A guard rail erected around the internal edge of the tank is fitted to the concrete base and comprises a series of cast tubular components comprising two uprights with combined mid- and top tier tubular rail, placed at regular intervals. The in-ground tank is constructed of concrete with a diameter of 67mm; a depth measurement was unobtainable due to the bottom being obscured by water and the location of the allocated safety viewing platform. The concrete tank is raised *c.*1m above the sloping ground level on the structure's eastern and south-eastern side. A sand-bank and earth revetment wall is situated towards the north-eastern tank edge, in the location of the former relief holder (Plate 54), presumably providing additional support against the resulting outward pressure within the tank on this side due to the lowered ground level. The tank base contains a large dumpling, covered in concrete, whose function is to support the crown when empty of gas. The dumpling is relatively steep, ramping up towards a flat central circular platform.

5.3.14 A single substantial pipe is located *c.*2m below ground level within a concrete channel, to the outer edge of the tank's concrete curb on the north-west edge. When operational the pipe served as a dual purpose gas inlet/outlet mains with associated manual and electrical syphon equipment above (Plate 55). The mains pipework attaches to the 'Donkin' pipework that runs in a west – east direction across the site's northern boundary, this pipework would have originally extended to the respective plant formerly located to the north of the site (Plate 56).

5.4 Gasholder No. 3

The General Design

5.4.1 Gasholder No. 3 (Plate 57), built in 1928 (Figure 19) by Samuel Cutler, represents a typical early 20th century column-guided water-sealed gasholder design. It has been identified under Historic England's typology as having a common 'Type 37' guide frame (English Heritage 2000, 54 & 55). The gasholder was designed to enable a storage capacity of 3,750,000 cubic feet per day. The gasholder is of four lifts with an above ground tank. The gasholder is predominantly constructed using riveted steel with cast components. Gasholder No. 3 forms the last phase of major development of the late 19th century gasworks.

The Principal Elements

5.4.2 The above-ground tank (Plate 58) is constructed using riveted steel and measures 57.8m in diameter. The significantly higher tensile strength of steel, in comparison to iron, led to the construction of above-ground tanks as opposed to the earlier in-ground design that utilised the surrounding ground to oppose the outward compressive force generated by the structure (English Heritage 2000, 59). In addition to this, the above-ground design would have been used to minimise any damage caused to the adjoining Gasholder No. 1 by resulting excavation works from a below-ground tank. The tank is constructed with riveted steel sheets arranged horizontally over eight tiers, each coated with acrylic paint covering to minimise corrosion. The sheets are strengthened

at regular intervals by 24 vertical angled steel uprights reinforced by angled-diagonal webbing. Each upright is secured to the tank's outer edge via a pair of triangular brackets comprised of flat-bar plates (Plate 59). Each upright is set within a riveted rectangular steel base, set within a flanged housing with blue engineering brick coping surround. Each base is fixed to a concrete pad, measuring 0.93m wide, 60mm deep, with a length of 1.23m (Plate 60). The tank base (Plate 61) comprises large steel sheets which are riveted together to form a level, flat surface. The tank interior is fitted on its western side with a pair of steel pipes (Plate 62) which rise to platform height and are connected to the base via L-section raking struts, which are riveted and welded in place.

5.4.3 At ground level the structure rests on a concrete base that measures a width of 1.8m and extends around the entire circumference. An earth revetment wall borders the eastern edge of the holder, held in place by an inclined concrete ridge 0.43m high (Plate 63). The revetment wall rises to the north and west of the structure's base to a height of approximately 1.5m, guarded by a rail (usual construction) and accessible via a short flight of steps situated to the northern side (Plate 64).

5.4.4 A pair of steel plaques (that appear contemporary to the holder) are attached to the structure; one to the eastern side, secured to a vertical tank support, the second is located at the base of the access stair to the north; they read: *1928, Sam-Cutler & Sons Ltd, Contractors, London* (Plate 65). In addition to this signage, is a modern metal *No. 3* identification sign, as described previously, on the northern edge (Plate 66).

5.4.5 A staircase is located on the north-west edge of the gasholder, providing access from ground level to a narrow platform that runs around the tank's perimeter (Plate 67). The staircase is of two flights, the half-landing is supported mid-way by paired triangular flat-bar brackets, bolted to the outer face of a vertical tank support. The stair is guarded on either side by a combination of mid- and top tubular handrails supported by solid-plate box-section balusters (Plate 68). The outer face of the staircase string reads 'Frodingham Iron & Steel Co Ltd, England'; the same company who produced the replacement top girder for Gasholder No. 1.

5.4.6 The tank platform is formed of riveted steel sheets set with textured perforations and measures 1.19m across. It is served by a continuous run of guard rails, comprising angle-iron uprights and tubular rails standing *c.*1.5m tall, with additional flat steel plates secured at the mid-height and as kick-boards at the base (Plate 69). The platform is supported by angled struts bolted between the underside of the platform and the tank's outer edge in a triangular arrangement, secured to both the exterior plates and the upright vertical supports (Plate 70).

5.4.7 The guide frame consists of 24 regularly-spaced steel standards comprising a 'Type 37' construction. The construction is arranged over five tiers, rising to a height of 55m, with supportive diagonal bracing. The front and back chord of each standard is constructed using rolled 'I' sections, joined by single rolled-steel angles on both side-faces to make a narrow box section (Plate 71). The rolled-steel angles that comprise the standard web are braced with alternating 45 degree and horizontally-laid bar configurations. The standards are tapered in form from their base, to the top (English Heritage 2000, 55). Each standard is made up of five panels, rectangular in plan that diminish in height towards the top (Plates 72 & 73). As the standards taper, the webbed strut-work diminishes in an identical arrangement as those aforementioned on Gasholder No. 1. The standards are secured to each girder tier using horizontal diaphragms, fixed to the underside of each girder. A rolled 'I' section guide rail is riveted to the inner face of each standard, which is where the guide rollers connect from the

individual bell lifts. A notable feature attached to the top of a standard to the northern edge of the gasholder comprises a large weathervane (Plate 74). Each standard is reinforced at its base by an open box of bolted steel sheets supported with riveted flange plate brackets, at each corner (Plate 75). Each steel plate base is rectangular in plan, measuring a depth of *c.*1.1m, a width of 0.56m and a length of 1.23m.

5.4.8 The intermediate girders (Plate 76) are of a narrow box-lattice construction, with the crown girders (Plate 77) comprised of box-section lattices. The girder forms a constant width and comprises flat-bar triangular lattice work set at 45 degrees to its upper and lower face, within a 'U' section box configuration. The lattice work is made of L-shaped bars. Both the crown and intermediate girders are fixed to their corresponding standard by a riveted rolled iron gusset plate to the front and by horizontal stiffening diaphragms the rear.

5.4.9 The guide frame is supported laterally using diagonal bracing rods fixed at either end to the intersection between each girder and standard join. The bracing rods which support the bottom standard tier, are set within cement bases upon the tank platform (Plate 78). This design improved stability against side-sway and the elimination of the use of tension rings (as found on Gasholder No. 1) allowed for greater structural movement as a combined circular unit, eradicating concentrations of excessive strain on any one area or standard.

5.2.10 The crown of the bell has a convex shape (Plate 79). It is made up of seven rings of staggered single-riveted steel sheets, laid vertically from the centre outwards with the two outer rings of the curb set horizontally, providing additional tensile strength. The bell formation comprises the use of a light, trussed crown. The generous crown-rise would have been intended to reduce the pressure and weight on the bell and provide additional robustness. The crown occupies a surface area of *c.*2662.9 sq. m with a diameter of *c.*55.7m (measurements obtained through historic site block plans). A pair of square inspection access hatches protrude from the bottom third tier of crown sheeting on the north side. These are accompanied by a single flush circular hatch situated on the same sheet tier on the south-western edge (bell sheeting has been assigned from the outer edge inwards) (Plate 80). The crown underside rests upon an internal domed umbrella-like frame constructed using a web of steel trusses (Plate 81). The frame comprises a lattice of gently curved L-section steel trusses, which radiate outward from the centre. These are arranged in triangular segments, reaching their widest point at the inner lift wall perimeter. The steel umbrella is connected by bolted regularly-spaced L-section girders, which provide a base upon which to lay the external crown sheeting. This upper tier of framing is supported at regular intervals to paired U-section steel uprights, which are welded and riveted to the tank base. The uprights are connected to the upper lattice using a series of slender L-section steel raking struts which are welded and bolted in place (Plate 82). Four upright tiers are arranged in a cylindrical manner around a central principal member of identical design. Six inner uprights surround the central member and are connected by bolted steel tension rods. Each additional outer tier of uprights is additionally connected to its corresponding inner upright, via cross-braced steel tension rods. Combined, these create an internal supportive web. The fourth upright tier frames the inner lift wall and comprises steel uprights as elsewhere, connected by central U-section girders (bolted). The upper and lower upright halves are strengthened by cross-braced steel tension rods (Plate 83).

5.2.11 Four lifts are present (Plate 84), the outer lift wall (1st lift) measuring 250mm in width. Each lift is separated by a water-sealed channel (lute); the widest channel, which separates the first lift from the tank edge measures 410mm, with the 2nd channel measuring 160mm, decreasing there after (exact measurements could not be taken of the two innermost lift walls and lutes due to access constraints. The inner face of each

lift wall comprises horizontal steel sheets, supported vertically by a series of regularly-spaced I-section steel uprights. The inner lift wall is constructed using 12 horizontal sheets, the top-most layer of which retains a series of painted numerical labels (north side) which are likely to relate to the structure's erection (Plate 85). The base of each lift wall rests on a series of I-section steel plinth bases set around the tank base.

5.2.12 At each standard, each lift is mounted by its own radial guide roller supported by an elongated 'goose-neck' cantilever bolted to the outer edge of each lift and engages with the rolled 'I' sections riveted to the rear of each standard (Plate 86). Each cantilever is constructed of riveted steel plates, and is individually numbered in a clockwise direction from the north side. The rollers increase in size as they extend from the external lift inwards, so that the inner guide roller is significantly larger than that serving the outer lift.

5.2.13 Each lift is served by a bolted steel guard rail around its perimeter, comprising angled uprights with mid- and top tier tubular rail; standing *c.* 1.5m tall and rails measuring 25mm in diameter with an additional flat steel plate measuring 150mm, secured at the base.

5.4.14 When fully-extended, each lift would have been accessed via a series of caged ladder shafts fitted to the north-western edge of the guide frame (Plate 87). The access ladders are arranged over all five tiers and each is inclined slightly to the north. Each ladder is bolted to either the tank platform or intervening girders and is situated centrally between a pair of standards, with the top ladder terminating a short distance above the top girder (Plate 88). Much like the access ladder serving Gasholder No. 1, the ladders have a caged surround to their outward-facing edge. Each tier is connected via a guarded narrow landing fixed to each corresponding girder as elsewhere. The bell is accessed via a rectangular platform which extends across all four lifts from the outer crown curb to the tank platform on the north side.

5.4.15 The gasholder's lift water seals are fitted with continuous cup-level monitoring equipment, that, when operational, provide warning for high or low water levels. Tank overflow hoses are positioned in the same location to assist the regulation of the water level within the cups and tank. The cables for the pressure alarm systems are located to the north-western edge of the tank, in the same manner as Gasholder Nos. 1 and 2, secured by bolted steel plates to the tank platform.

5.4.16 The gasholder is fitted with a self-monitoring electrical modular heating pump system, whose aim is to prevent cup water from freezing between the individual lifts and the tank which would inhibit the holder from rising. An electrical anti-freeze system works in conjunction with water circulating pumps to regulate the water temperature between 0.6 degrees Celsius and 1.1 degrees Celsius. The steel casings of both systems are secured to the outermost lift guard rail at the southern and south-western edges of the structure. Cables related to the antifreeze system are guided to the lifts by shepherd's-crook shaped guides that are bolted to the inner edge of the standards and lift guide rails at regular intervals (Plate 89).

5.4.17 A concentration of redundant gas pipework (Plate 90) is located a short distance to the west of the gasholder and presumably regulated the gas inlet and outlet flow for each gasholder on the site when in operation. The pipework is identified with a 'Donkin' maker's inscription, matching those found to the eastern extent of the site supplying Gasholder No. 2, this pipework would have originally combined with the respective plant formerly located to the north of the site.

6.0 DISCUSSION

6.1 Gasholder No. 1 is of particular interest due to its innovative guide frame design devised by Henry Jones in 1876 being one of the earliest examples of the use of wrought-iron standards and lattice construction of the period (English Heritage 2002, 95). The 'T' section and pronounced taper to the standards is an innovative design, taking influence from John Paddon's work in Hove and the cast-iron tripods used at Fulham. The distinctive lower girders of box-section design are unique to this gasholder, though adopted for crown girder use, with the addition of parallel chords in later years (such as those formerly used at Battersea). Combined with Jones's use of diagonal bracing the girder design provided increased horizontal stiffness (English Heritage 2002, 96). Gasholder No. 1 comprises the use of a light, untrussed crown. This design proved highly effective, influencing future projects, including the reconstruction works undertaken at Stepney (English Heritage 2002, 96). An additional early design feature includes the use of an exclusively concrete tank, waterproofed with internal render as opposed to the traditional use of puddled-clay. Both design developments reflect the progression in technological advancements emerging at the time.

6.2 The guide frame was soon overtaken conceptually by more sophisticated work elsewhere, including the gradual replacement of wrought-iron to cast-iron as a main construction material and tapers becoming less pronounced and 'I' section and box-sections replacing 'T' sections. Despite this, Gasholder No. 1 at Poplar was at the forefront of all aspects of gasholder design when it was conceived in 1876 and proved influential to future gasholder design across London. Its distinctive appearance and adventurous style remains as a reflection of an exciting period in gasholder design: a time where technological advancements spurred progressive thinking in terms of challenging traditional constructional elements, twinned with a concern over the resulting visual appearance. These changes are reflective of a wider aesthetic school of design found within other fields of structural engineering during the late 19th century (English Heritage 2002, 96).

6.3 Design features developed during the construction of Gasholder No. 1 were utilised and adapted for the fabrication of the late-19th century gasholder that preceded the current Gasholder No. 2. Adopted notable features of interest include the use of a light, untrussed crown with an unusually high crown-rise, successful in reducing the membrane forces acting upon the bell. In addition, the original standards of the guide frame were of an innovative construction, developed from the principles used in the construction of the standards for Gasholder No. 1, these standards comprised a box-section design with rolled 'H' sections for the front and back chords. Unlike the treatment of the girders to Gasholder No. 1, Jones made the lower girders of Gasholder No. 2 of a constant depth, presumably to decrease production costs. These adaptations are reflective of the continual innovation in gasholder design. The current Gasholder No. 2, constructed in 1974, represents a typical late-20th century water-sealed spiral-guided design, based on a developed design by Gadd & Mason of Manchester (1887). The redevelopment of Gasholder No. 2 represents a typical trend occurring from the 1950s onwards in which a new gasholder was constructed as a replacement of a former holder of a lesser capacity, utilising the original in-ground tank. In this case a typical 1970s spiral-guided gasholder replaced the former column-guided holder dated to 1882.

6.4 Gasholder No. 3 built in 1928 by Samuel Cutler represents a typical early 20th century column-guided water-sealed gasholder design. Its 'Type 37' lattice steel guide frame is noted by Historic England as common (English Heritage 2002, 55). The above-ground steel tank used to avoid damaging the adjoining Gasholder No. 1 by

excavation, utilises the higher tensile strength of steel in comparison to iron. The construction of Gasholder No. 3 forms the last phase of major development of the late-19th century gasworks and more generally reflects the advancements in gasholder design throughout the 20th century.

6.5 Combined, the gasholders represent examples of functional architecture, which symbolise the industrial heritage of the area and more widely, the emergence of industrial Britain. The site at Leven Road developed in response to the need for increased gas manufacture and storage capacity within the area at specific stages in history, in line with technological advancements in gas lighting and cooking appliances from the end of the 19th century onwards. In a broader view, the site is illustrative of general trends occurring in the gas industry throughout periods of both privatisation and nationalisation and its evolving nature following the discovery of natural gas reserves and associated nationwide conversion throughout the end of the 20th century.

6.6 The structures themselves are illustrative of the general evolution of both gasholder and plant design during the 19th and 20th centuries which was inextricably linked to broader trends in the gas, electric and by-product industries.

6.6 The remaining ancillary structures and associated gas distribution equipment serves to give context to the gasholders, while the nearby River Lea and road connections serve as a reminder of the influence that improved technology and transport links had in advancing the gas industry within Britain.

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Primary Resources

Archival documents supplied by the National Gas Archive:			
Title of Document	**Reference**	**Date**	**Figure No.**
Report of visit to the Poplar Gasworks of the Commercial Gas Company.	P00792	15th March 1913	N/A
Aerial photograph of Poplar Works.	COG_1931_1_81	1931	4
Plan of the Poplar Gasworks (North Thames Gas Board)	NT/CN/POP/E/E/4	April 1957	8
Plan of the Poplar Gasworks (North Thames Gas Board)	NT/CN/POP/E/E/5	May 1966	10
Plan of the Poplar Gasworks (North Thames Gas Board)	NT/CN/POP/E/E/6	June 1972	12
Plan of the Poplar Gasworks (North Thames Gas Board)	NT/CN/POP/E/E/10	Oct. 1976	14
Plan of the Poplar Gasworks (North Thames Gas Board)	NT/CN/POP/E/E/13	c.1950	7
Site plan of Poplar Works showing holders with capacity, relief holder, retort house & purifiers (Commercial Gas Company).	NT/COG//E/E/6	c.1890	3
Aerial photography of the Poplar Gasworks (The London Dockland Development Corporation - Black & White)	NT/NTG/E/F/3/23 Ref. 33 84 030	7th July 1984	15

Aerial Photography – Historic England Archives (Films held by NMR)								
Vertical's:								
Sortie No.	**Library No.**	**Frame No.**	**Centre Point**	**Held by:**	**Date**	**Scale 1:**	**Film Details**	**Figure No.**
RAF/241/AC5	6696	118	TQ 385 813	FDM	18 JUN 1941	12000	Black and White 5 x 5	N/A
RAF/106G/LA/30	8315	4343	TQ 385 813	MOD	07 AUG 1944	11000	Black and White 8.25 x 7.5	N/A
RAF/106G/UK/1624	410	6079	TQ 386 813	NMR	07 JUL 1946	4800	Black and White 8.25 x 7.5	5
RAF/543/1059	2078	102	TQ 386 818	NMR	13 SEP 1960	6000	Black and White 8.25 x 7.5	9
FSL/6641/4	2278	4856	TQ 383 808	BLU	23 JUL 1966	10000	Black and White 9 x 9	N/A
MAL/71072	5915	197	TQ 386 817	NMR	21 MAY 1971	5000	Black and White 9 x 9	11
MAL/73045	7104	95	TQ 386 813	NMR	22 AUG 1973	3000	Black and White 9 x 9	13
JAS/76021	39	132	TQ 386 813	JAS	19 APR 1976	2500	Black and White 9 x 9	N/A
MAL/76056	7388	101	TQ 388 810	NMR	01 JUL 1976	10000	Black and White 9 x 9	N/A

FSL/7703/2	8961	67	TQ 387 813	BLU	31 JAN 1977	5000	Black and White 9 x 9	N/A
MAL/83005	7811	72	TQ 385 821	NMR	15 APR 1983	10000	Black and White 9 x 9	N/A
OS/91314	13902	91	TQ 386 815	NMR	19 SEP 1991	6000	Black and White 9 x 9	16
OS/99138	23211	13	TQ 386 816	NMR	27 MAY 1999	5000	Colour 9 x 9	N/A

Military oblique's:

Date	Size	Film Details	Reference: NGR Index TQ:	Library No.	Frame No.	Centre Point	Figure No.
01 MAY 1949	8x7"	B&W	3881/19	RAF30041	SFFO-0027	TQ 386 813	6

Obliques:

Date	Size / Scale 1:	Film Details	Reference: NGR Index TQ:	Library No.	Frame No.	Centre Point	Figure No.
30 APR 1986	70mm	B&W	3881/1	2661	4	TQ 387 815	N/A
10 MAR 1994	70mm	B&W	3881/7	4860	31	TQ 385 813	17
06 SEP 2006	35mm	Digital Colour	3881/35	24469	8	TQ 386 814	18

8.0 DEPOSITION OF THE ARCHIVE

A full archive intended for deposition with the Tower Hamlets Local History Library and Archives has been prepared. In addition a digital copy of the written record will be made available to the Historic England Archive, Swindon and the National Gas Archive, Warrington. The archive has been assigned the site code LVG 15. The full site archive will be prepared in accordance with the principles of Management of Research Projects in the Historic Environment: The MoRPHE Project Managers' Guide *(*Historic England 2015) and the requirements of the recipient museum. The full archive will comprise a hard copy of the full report, a pdf version of the report on CD, the full photographic record with registers, field notes and drawings.

9.0 ACKNOWLEDGEMENTS

Archaeology South-East would like to thank Montagu Evans LLP, for commissioning this Historic Building Record, on behalf of National Grid. The author would like to thank all those who helped with archival enquiries, but particularly Alison Percival (National Gas Archive, Warrington) and Graham Deacon (Historic England Archive, Swindon).

Plate 1: Original boundary wall to the south of the site, facing north-east (223)

Plate 2: Gasholder No. 1, guide frame and bell, facing north from Leven Road (127)

Plate 3: Gasholder No. 1, girder and standard arrangement of the guide frame, facing north (125)

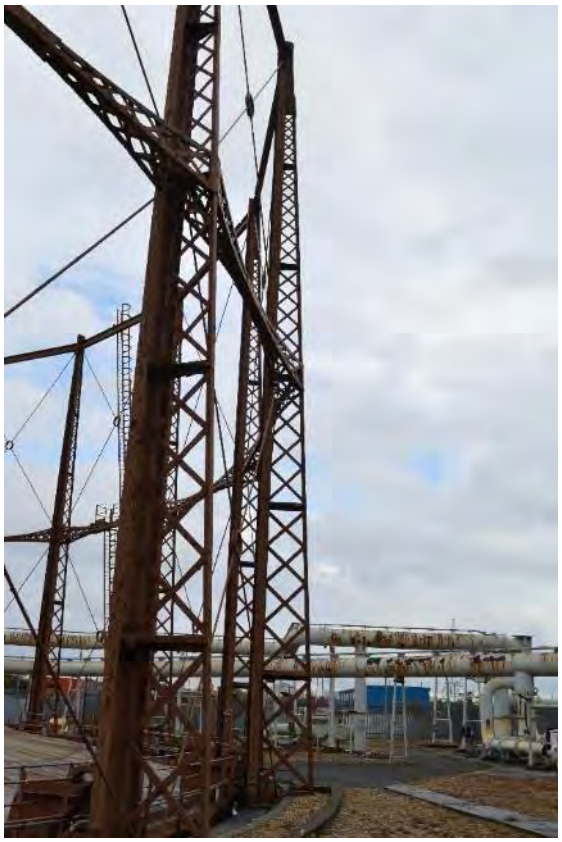

Plate 4: Gasholder No. 1, detail of the standard panels, facing north (160)

Plate 5: Gasholder No. 1, detail of the webbing and horizontal diaphragms attached to the standards, facing north-west (159)

Plate 6: Gasholder No. 1, rolled 'I' section guide rail, facing east (178)

Plate 7: Gasholder No. 1, constructional detail of the tapered mid girder, facing east (168)

Plate 8: Gasholder No. 1, detailed arrangement of the girder and standard joining components, facing east (207)

Plate 9: Gasholder No. 1, detail of the replacement top girders and associated bracket rods with tension rings, facing east (209)

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Plate 16: Gasholder No. 1, detail of the dumpling concrete platforms used to secure the former timber framework supporting the underside of the crown, facing south (406)

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Plate 32: Gasholder No. 1, electrical anti-freeze system with water level measuring equipment located to the north-eastern edge of the gasholder, facing south-west (194)

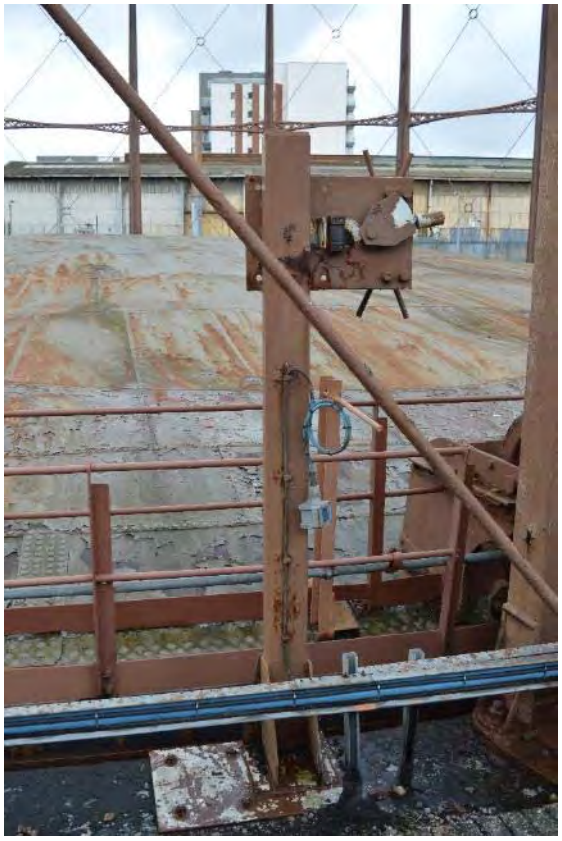

Plate 33: Gasholder No. 1, detail of the upright supports for the pressure alarm system, facing south-west (181)

Plate 34: Gasholder No. 1, detail of the shepherd's-crook cable guides for the pressure alarm monitoring equipment, facing north-east (195)

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Plate 36: Gasholder No. 1, detail of the ladder platform, facing west (216)

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Plate 50: Gasholder No. 2, access stair arrangement, facing south (25)

Plate 51: Gasholder No. 2, detail of lift stair and handrail, facing east (8)

Plate 52: Gasholder No. 2, detail of tank access stair to first lift, facing east (5)

Plate 53: Gasholder No. 2, concrete tank surround and guard rail, facing south-west (13)

Plate 54: Gasholder No. 2, view of the concrete tank curb to the eastern edge, facing south-west (32)

Plate 55: Gasholder No. 2, detail of the gas mains manual valve wheel to the north-west of the holder, facing north (19)

Plate 56: Gasholder No. 2, detail of the 'Donkin' gas distribution pipework to the north-east of the holder, facing north (20)

Plate 57: Gasholder No. 3, general view of the holder, facing west (70)

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Plate 65: Gasholder No. 3, detail of the eastern edge Cutler identification plaque, facing west (85)

Plate 66: Gasholder No. 3, modern identification signage to the northern edge, facing south (92)

Plate 67: Gasholder No. 3, tank access stair arrangement, facing south-east (220)

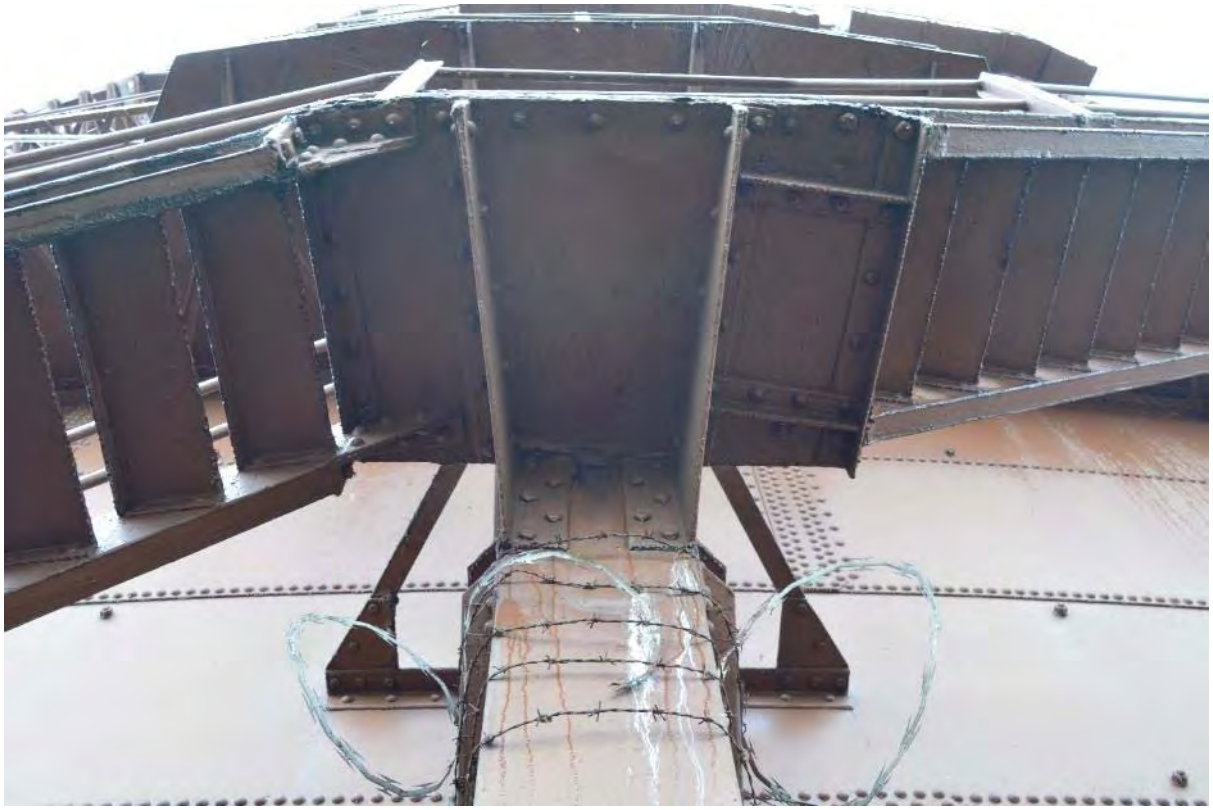

Plate 68: Gasholder No. 3, construction detail of tank stair half-landing, facing east (102)

Plate 69: Gasholder No. 3, detail of the tank platform, facing north (333)

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Plate 73: Gasholder No. 3, view of the guide frame stanchions and tension ties, facing north-west (330)

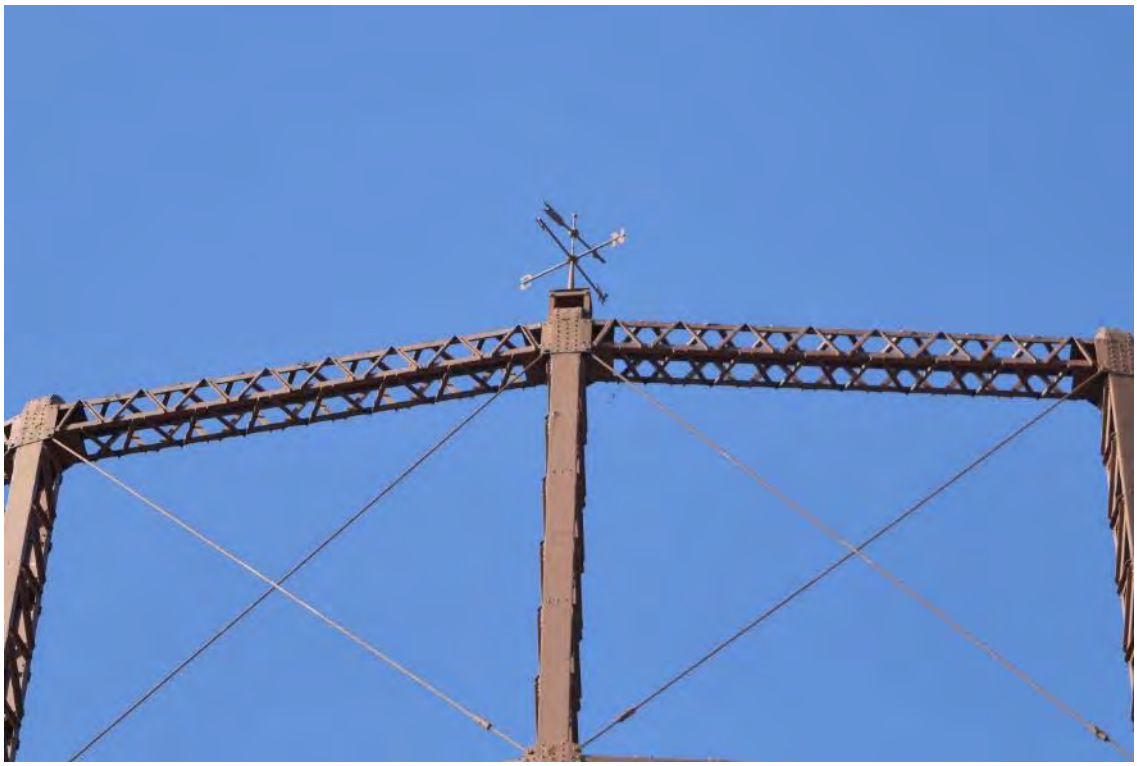

Plate 74: Gasholder No. 3, detail of the weathervane feature attached to the northern edge of the top girder tier, facing south-east (68)

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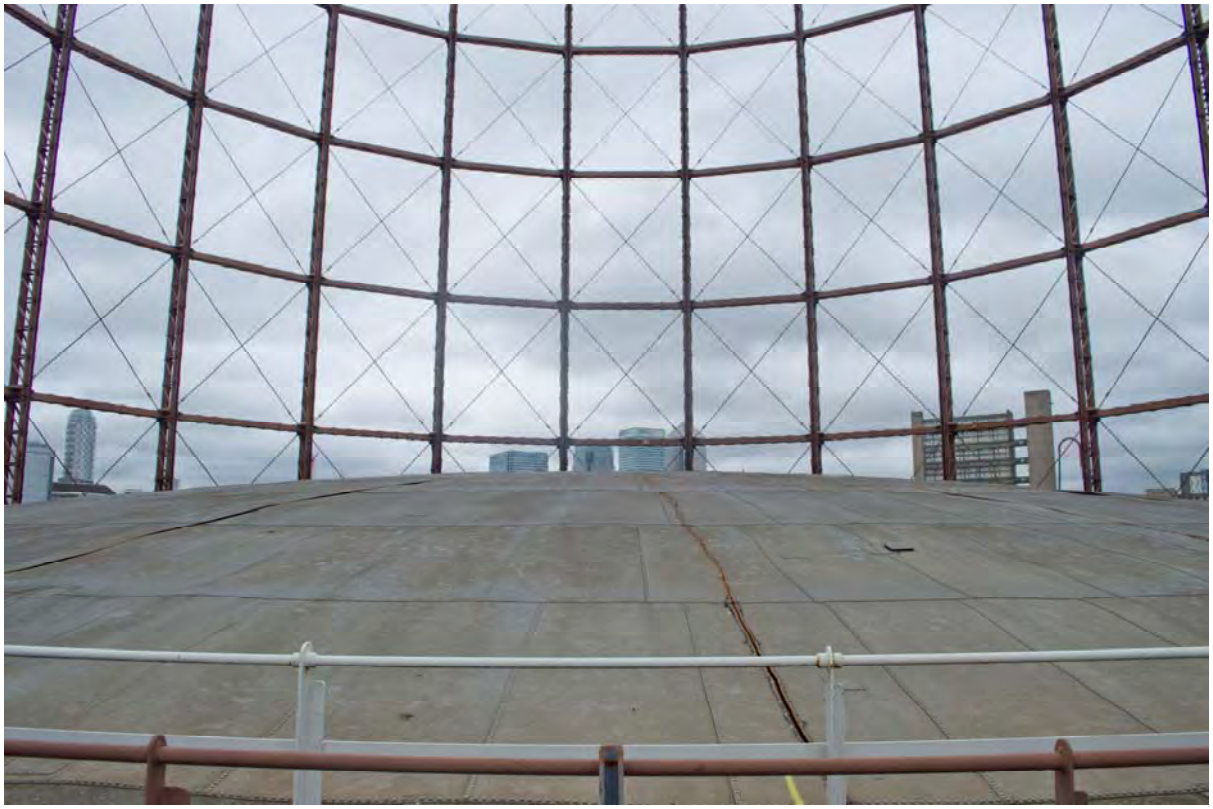

Plate 79: Gasholder No. 3, view of the crown, facing north-east (252)

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Plate 85: Gasholder No. 3, detail of the painted construction markings retained on the inner face of the top tier of sheeting forming the inner lift wall, facing north (372)

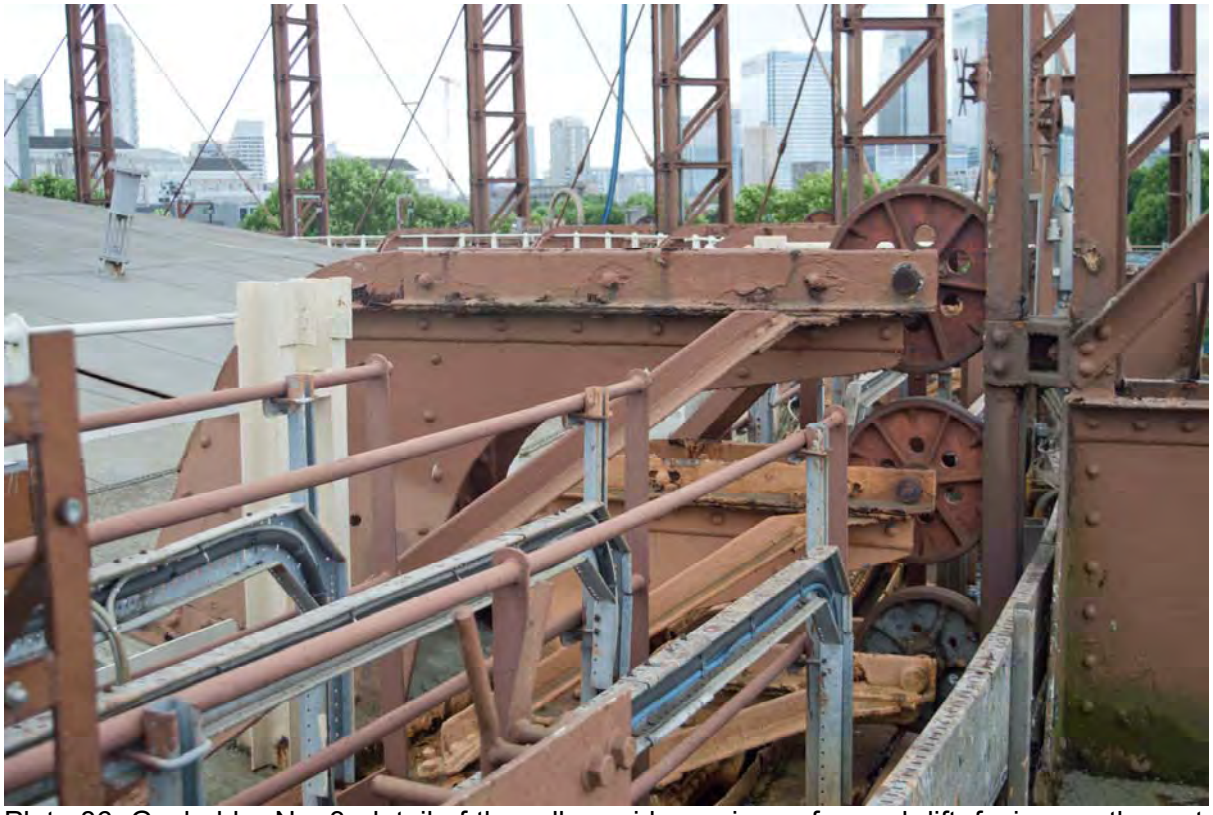


Plate 86: Gasholder No. 3, detail of the roller guide carriages for each lift, facing south-west (316)

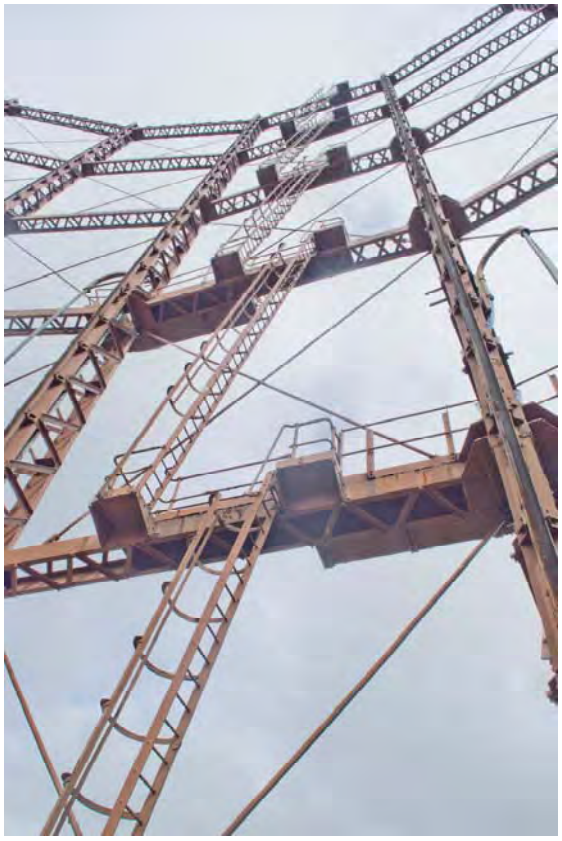


Plate 87: Gasholder No. 3, detail of the lift access ladders, platforms and guard cages, facing north-west (225)

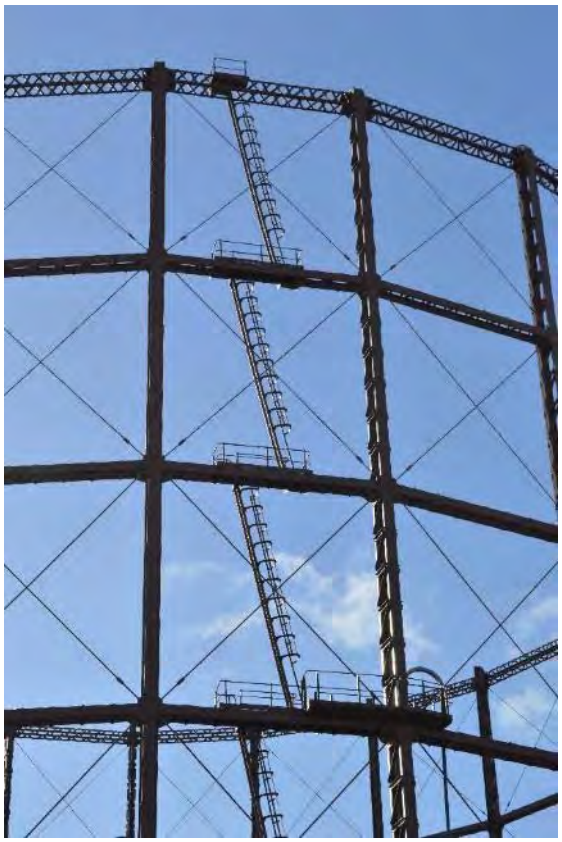
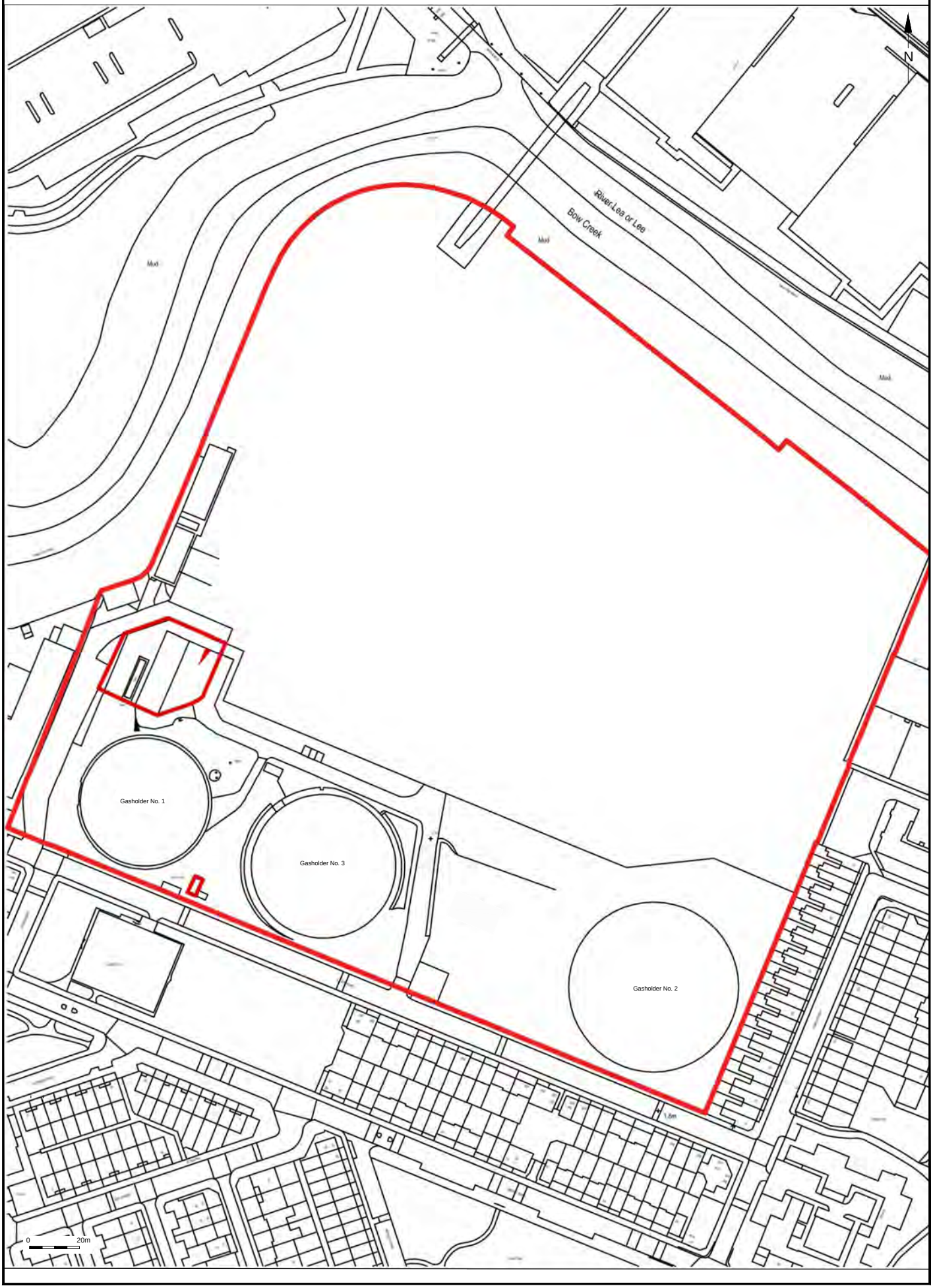


Plate 88: Gasholder No. 3, detail of the lift access ladders, platforms and guard cages, facing south-east (60)

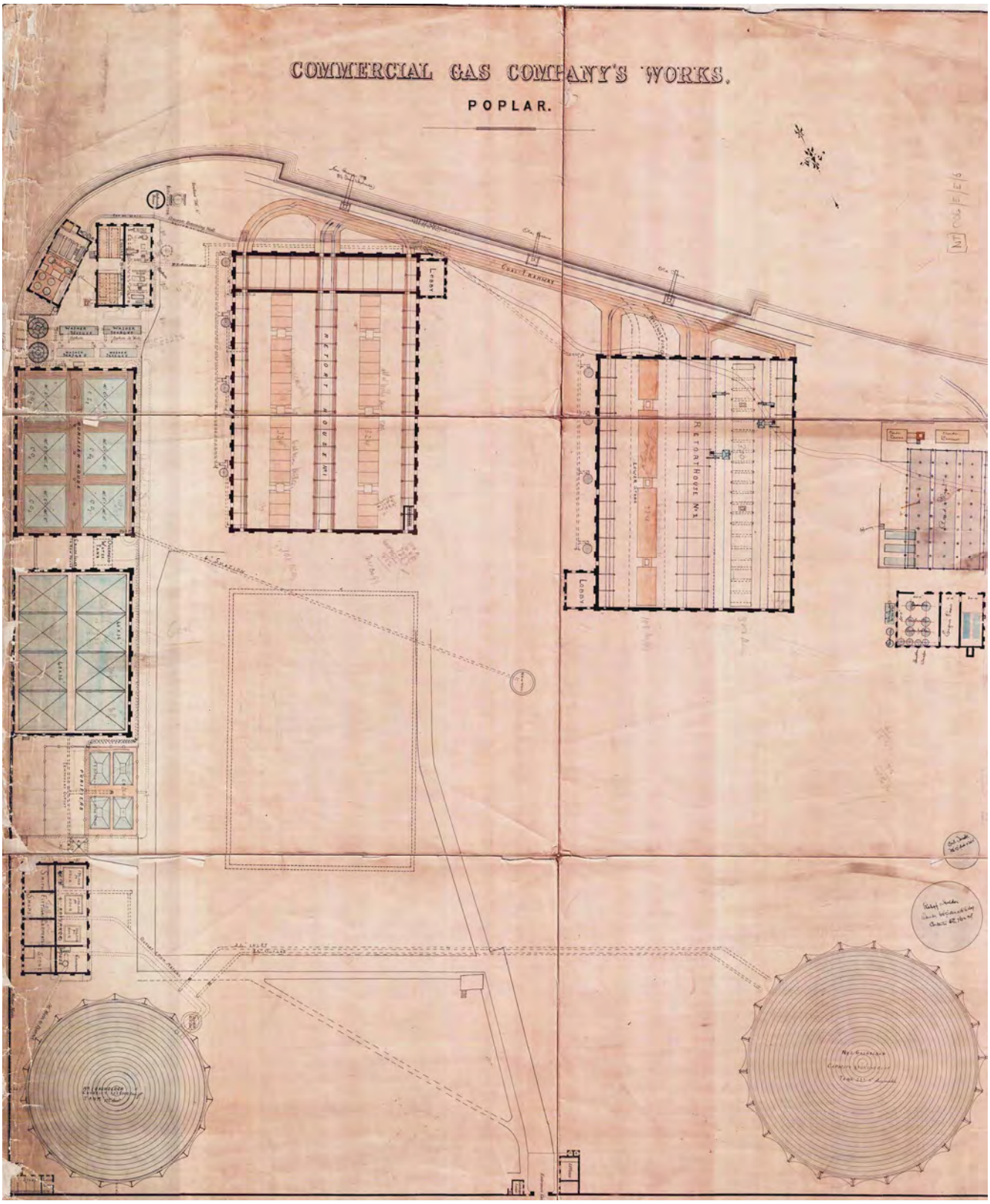
Plate 89: Gasholder No. 3, detail of the shepherd's-crook cable guides for the pressure alarm monitoring equipment, facing north-east (332)

Plate 90: General view of the retained 'Donkin' gas distribution pipework located between Gasholders 1 & 3, facing south-west (104)

© Archaeology South-East		Leven Road Gasholder Station, Poplar	Fig. 1
Project Ref: 7754	November 2015	Site location	
Report Ref: 2015376	Drawn by: HG		

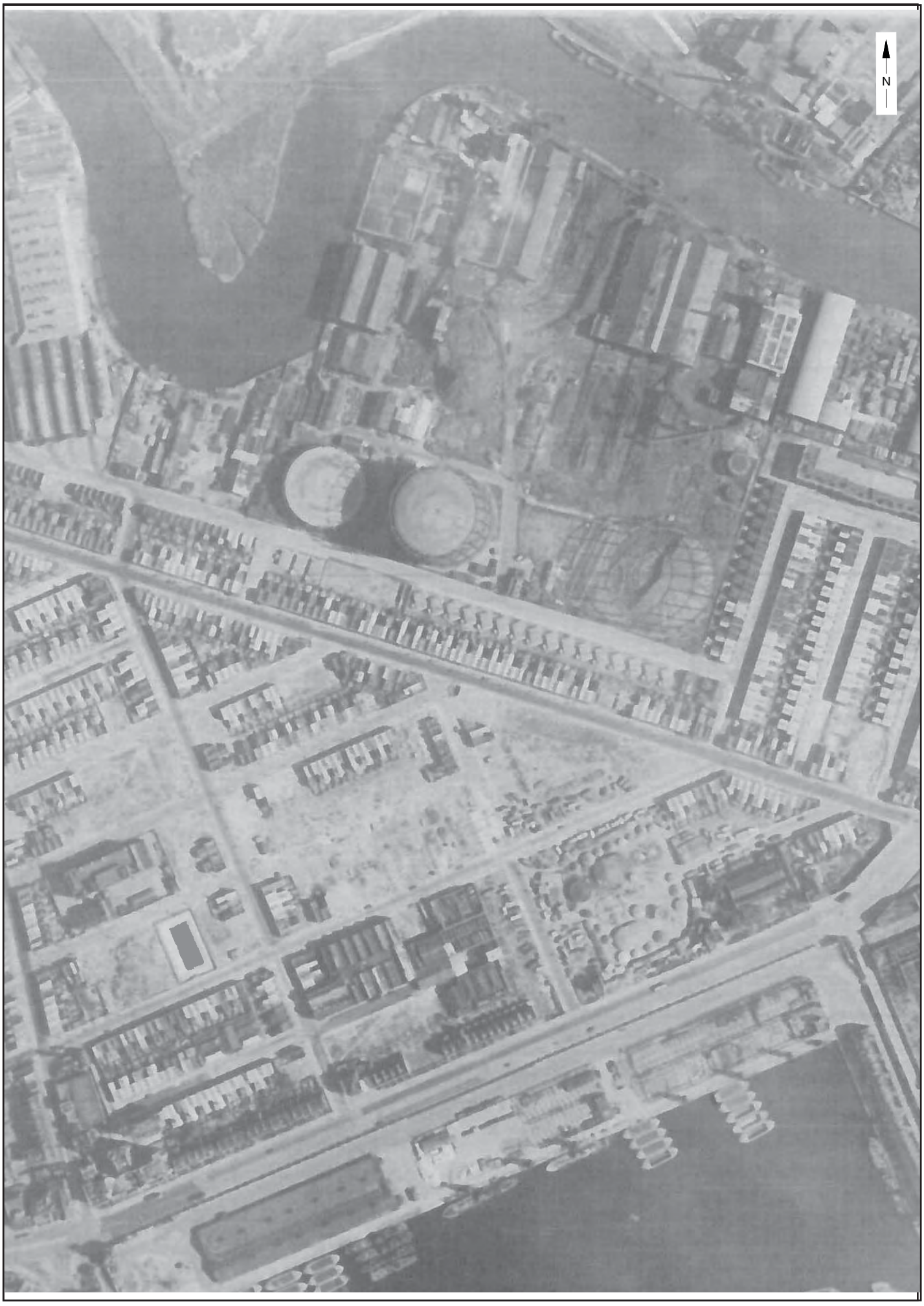


© Archaeology South-East		Leven Road Gas Holder Station, Poplar	Fig. 2
Project Ref: 7754	November 2015	Site Plan (1:2000)	
Report Ref: 2015376	Drawn by: HG		



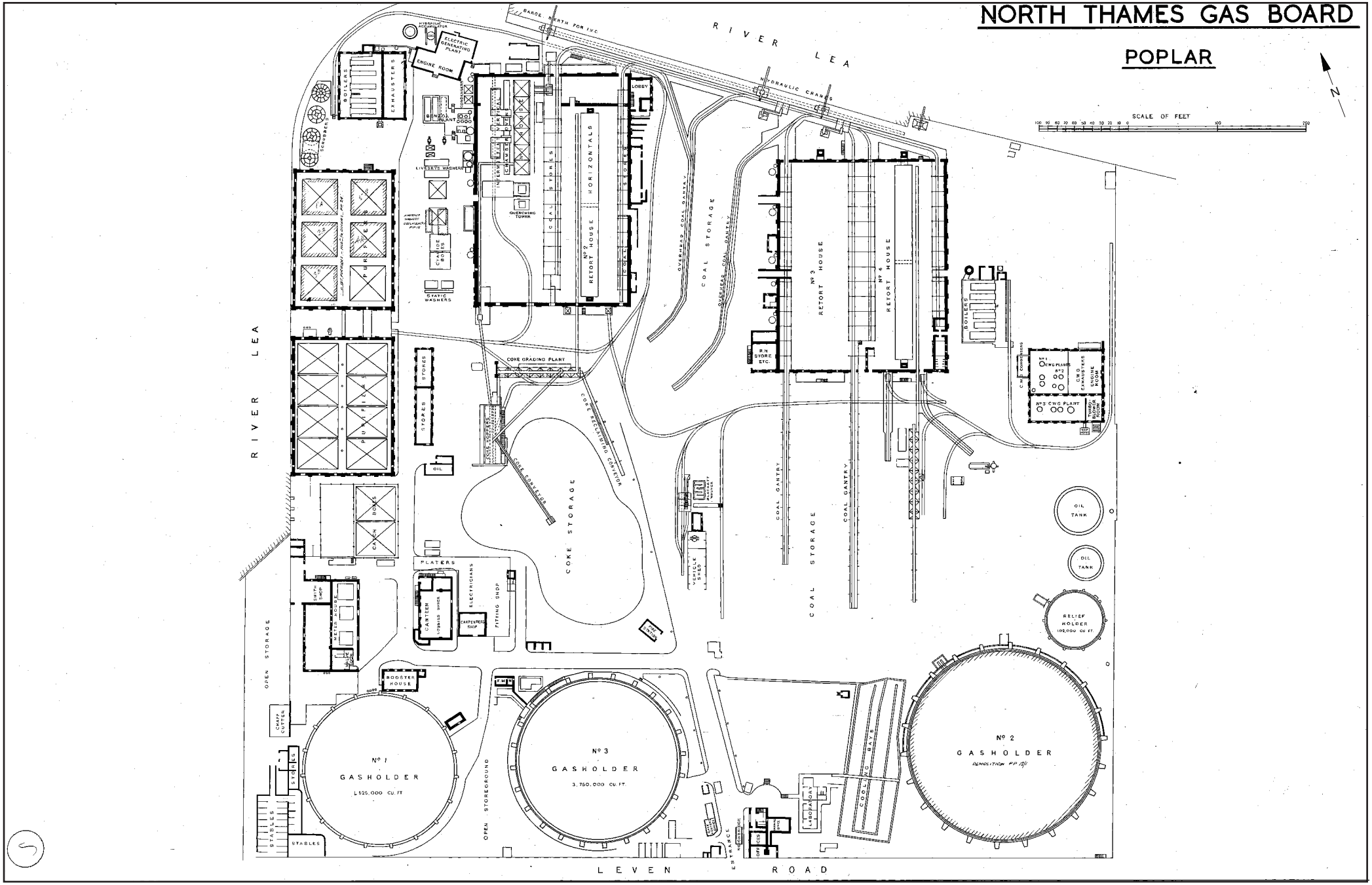
© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 3
Project Ref: 7754	November 2015	Site plan of Poplar Works showing holders with capacity, relief holder, retort house & purifiers, c.1890s (North Thames Gas Board) (Ref.NT/COG//E/E/6)	
Report Ref: 2015376	Drawn by: HG		

© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 4
Project Ref: 7754	November 2015	Aerial photograph of the Poplar Works, 1931 (Ref.COG_1931_1_81)	
Report Ref: 2015376	Drawn by: HG		

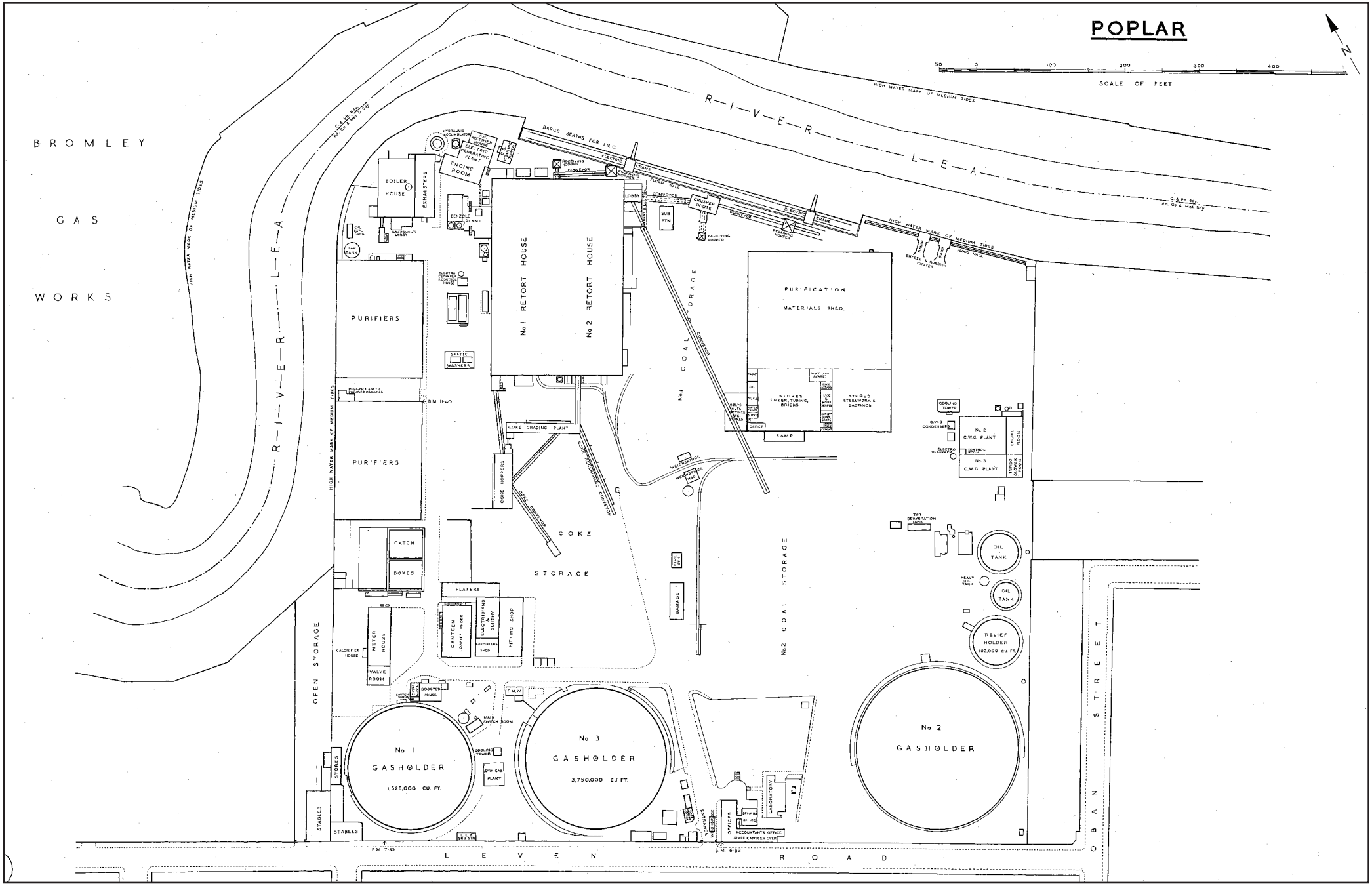


© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 5
Project Ref: 7754	November 2015	Aerial photograph of the Poplar Works, 7-07-1946 (RAF/10/6G/UK/1624)	
Report Ref: 2015376	Drawn by: HG		

© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 6
Project Ref: 7754	November 2015	Oblique photograph of the Poplar Works, 01-05-1949 (RAF30041)	
Report Ref: 2015376	Drawn by: HG		

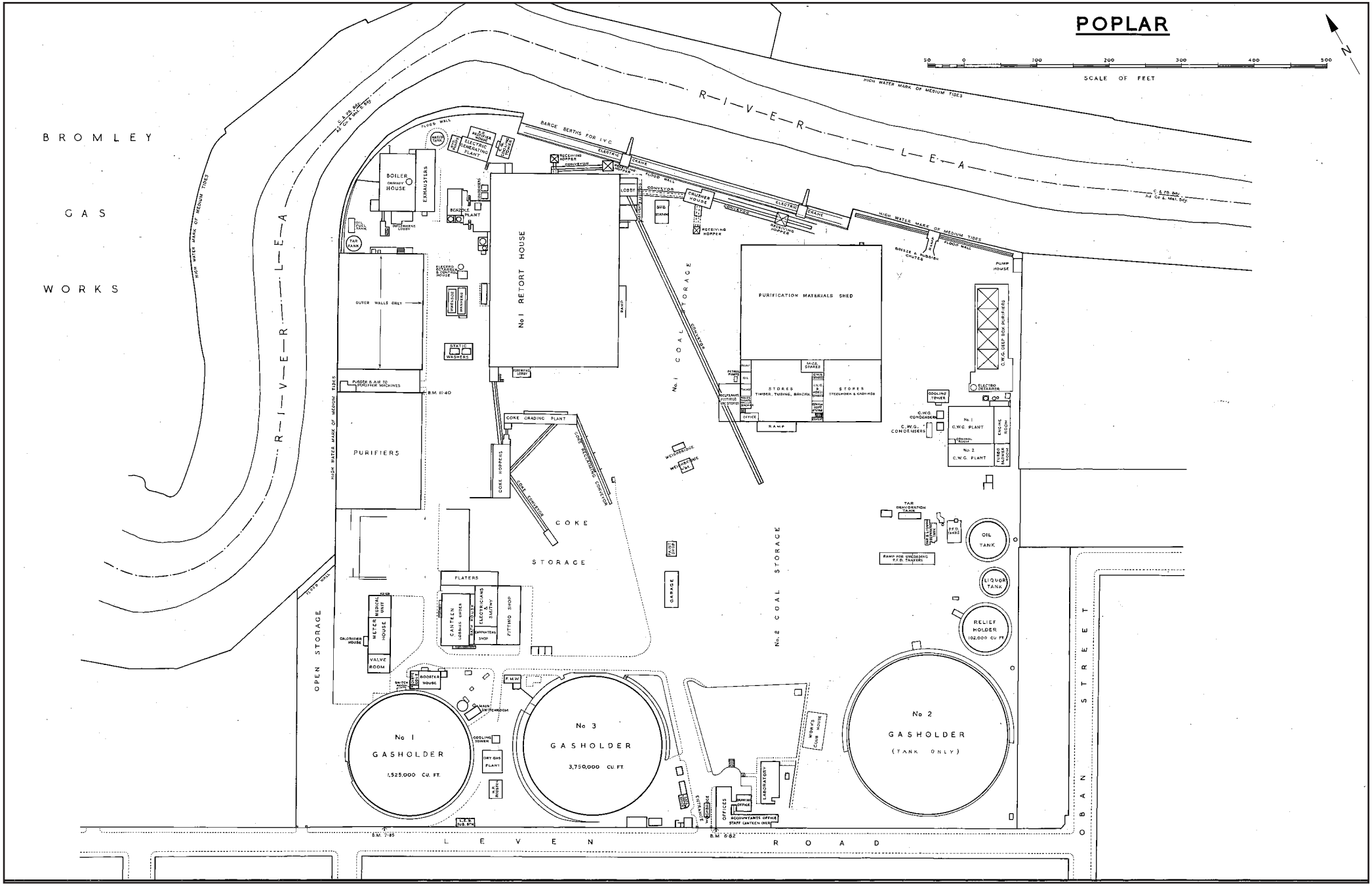


© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 7
Project Ref: 7754	November 2015	Plan of the Poplar Gasworks, c.1950s (North Thames Gas Board) (Ref.NT/CN/POP/E/E/13)	
Report Ref: 2015376	Drawn by: HG		

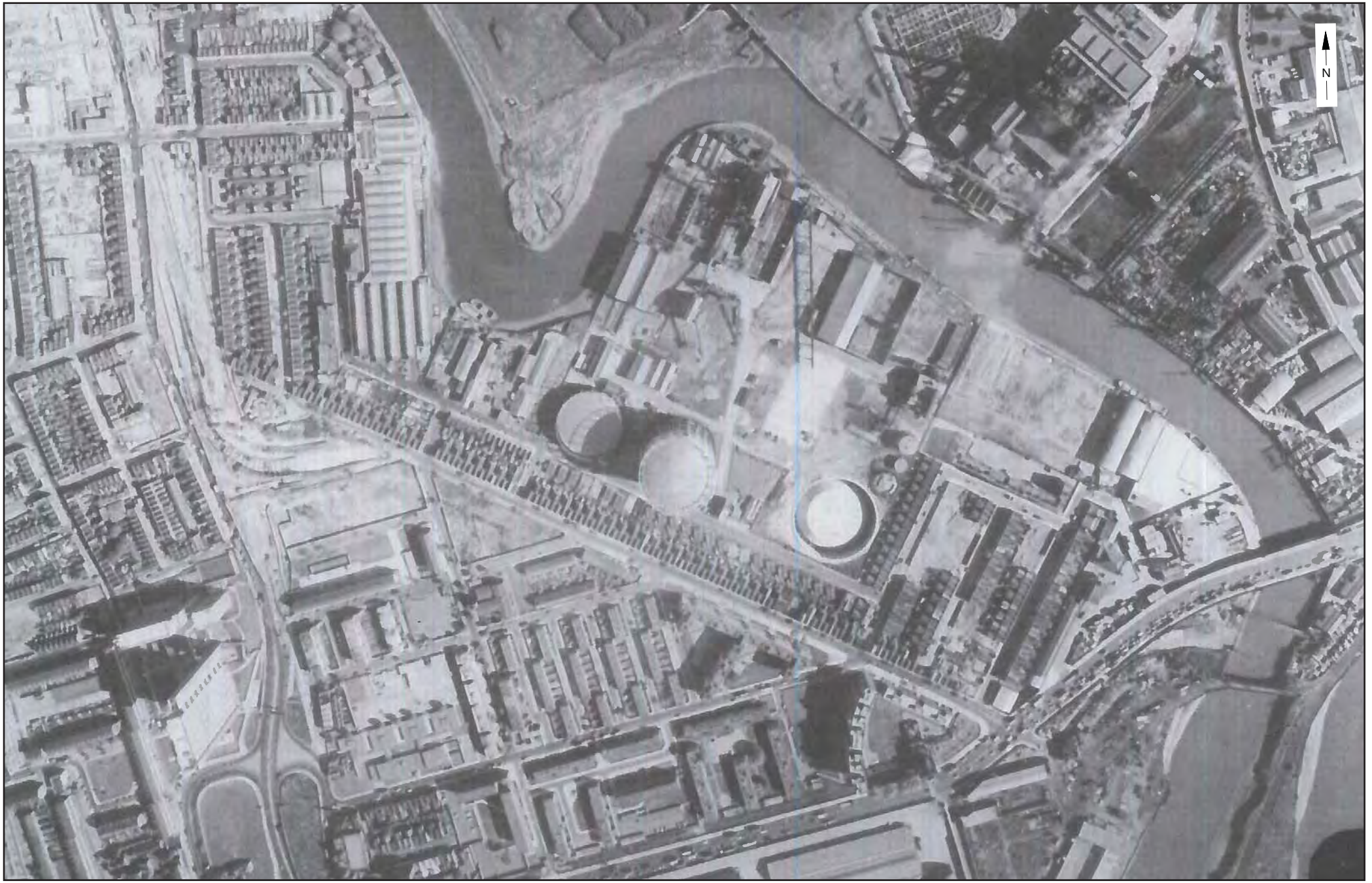


© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 8
Project Ref: 7754	November 2015	Plan of the Poplar Gasworks, April 1957 (North Thames Gas Board) (Ref.NT/CN/POP/E/E/4)	
Report Ref: 2015376	Drawn by: HG		

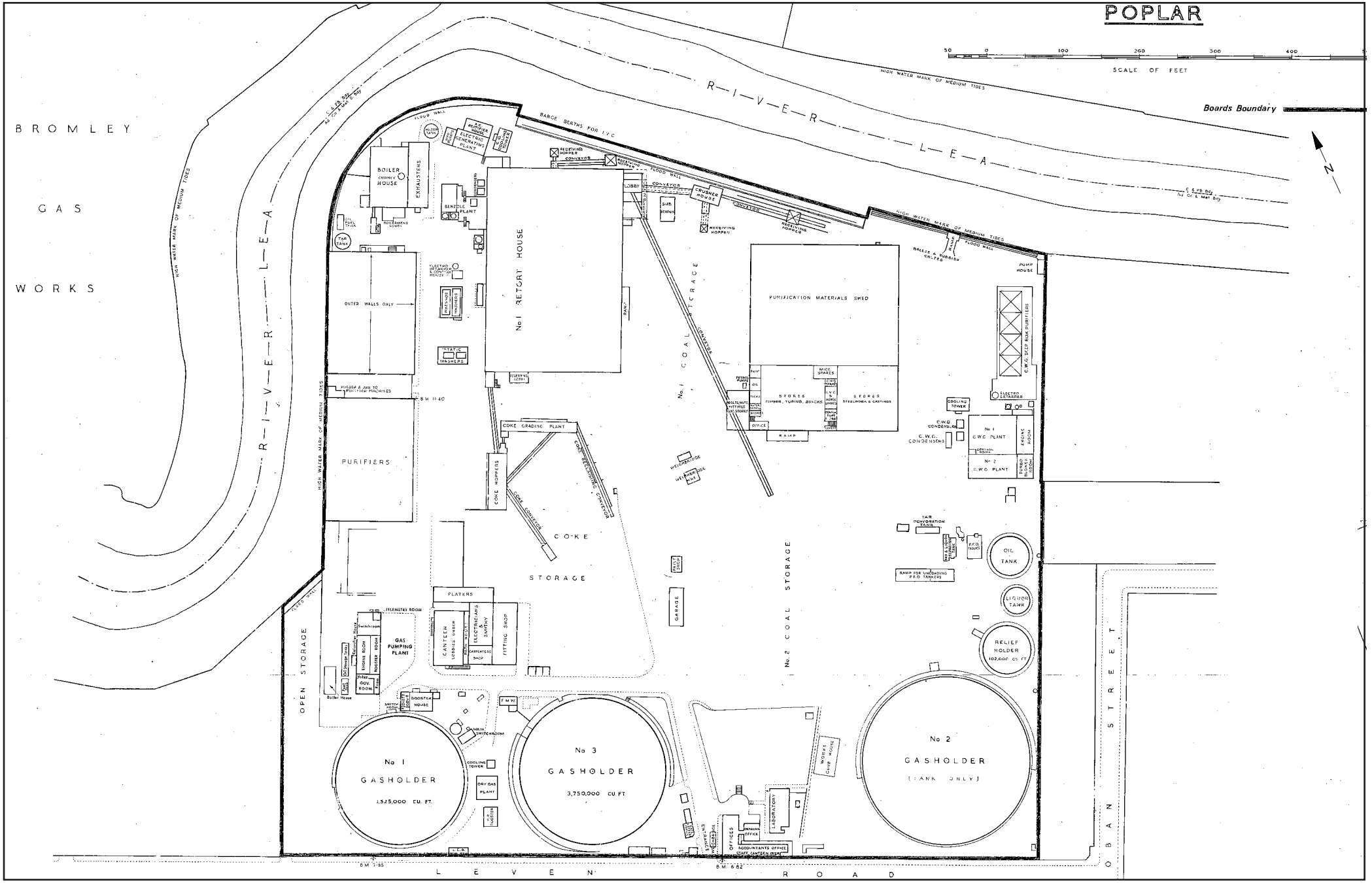
© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 9
Project Ref: 7754	November 2015	Aerial photograph of the Poplar Works, 13-09-1960 (RAF/543/1059)	
Report Ref: 2015376	Drawn by: HG		



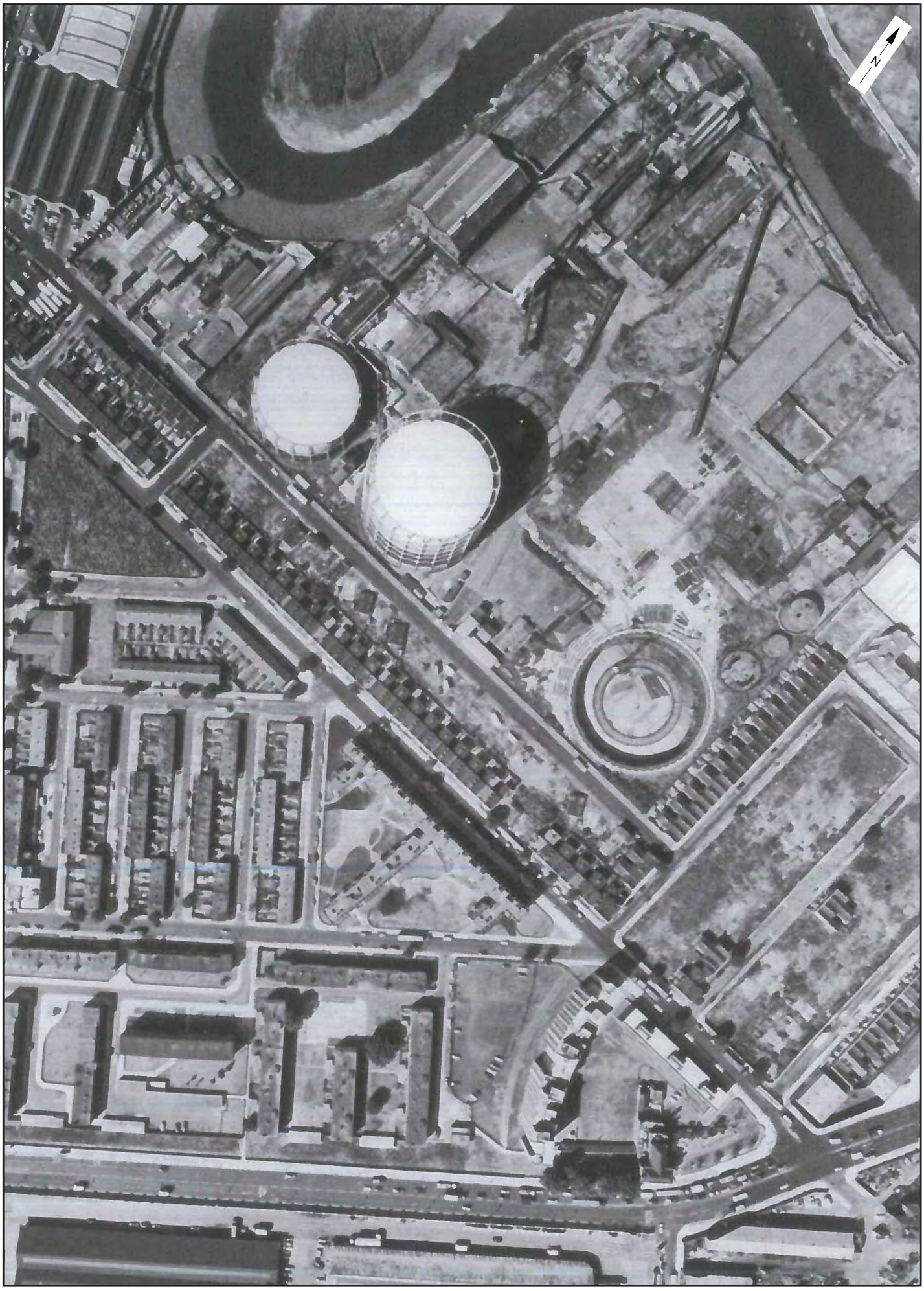
© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 10
Project Ref: 7754	November 2015	Plan of the Poplar Gasworks, May 1966 (North Thames Gas Board) (Ref.NT/CN/POP/E/E/5)	
Report Ref: 2015376	Drawn by: HG		



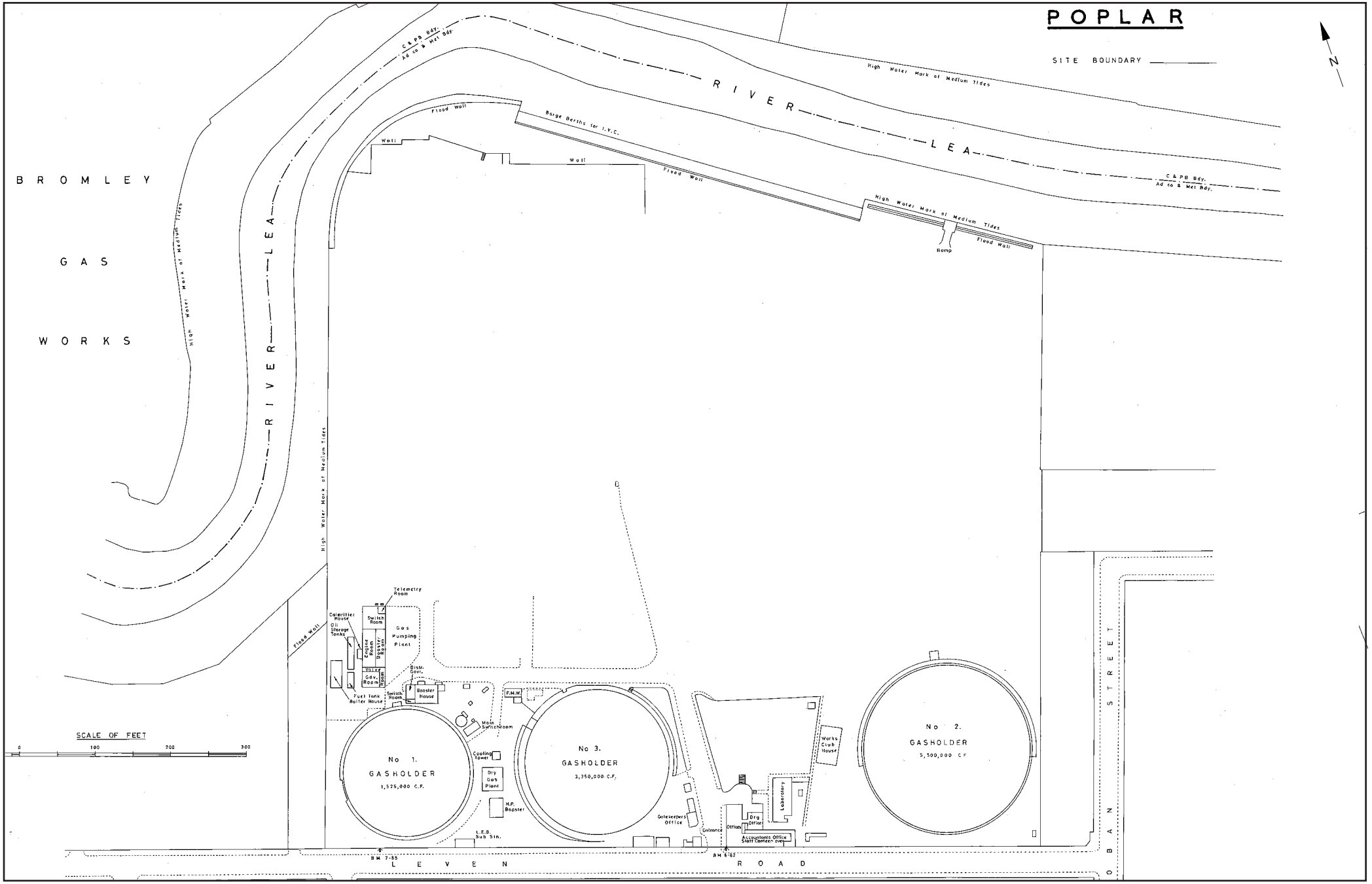
© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 11
Project Ref: 7754	November 2015	Aerial photograph of the Poplar Works, 21-05-1971 (MAL/71072)	
Report Ref: 2015376	Drawn by: HG		



© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 12
Project Ref: 7754	November 2015	Plan of the Poplar Gasworks, June 1972 (North Thames Gas Board) (Ref.NT/CN/POP/E/E/6)	
Report Ref: 2015376	Drawn by: HG		



© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 13
Project Ref: 7754	November 2015	Aerial photograph of the Poplar Works, 22-08-1973 (MAL/73045)	
Report Ref: 2015376	Drawn by: HG		



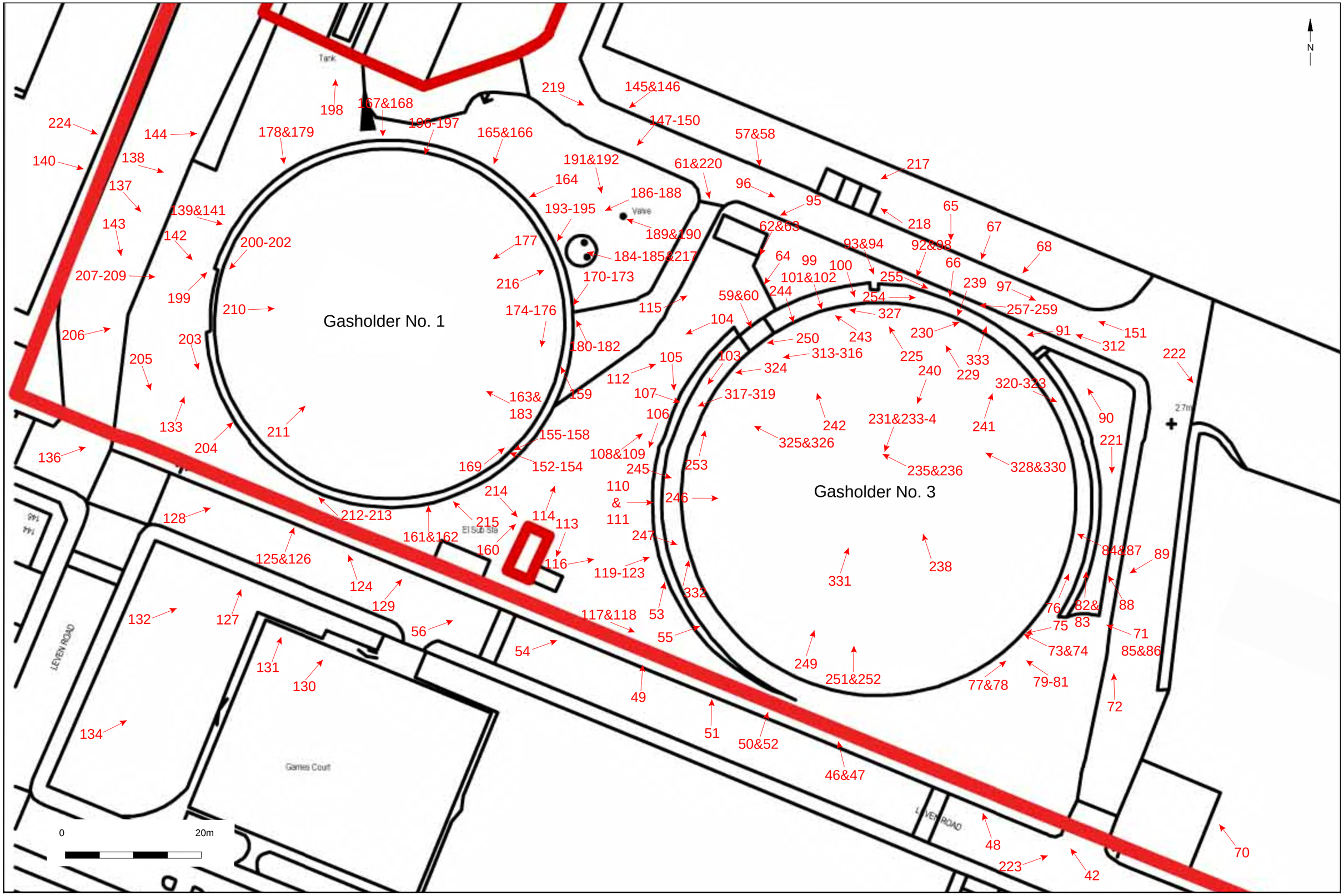
© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 14
Project Ref: 7754	November 2015	Plan of the Poplar Gasworks, October 1976 (North Thames Gas Board) (Ref.NT/CN/POP/E/E/10)	
Report Ref: 2015376	Drawn by: HG		

© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 15
Project Ref: 7754	November 2015	Aerial photography of the Poplar Gasworks, July 1984 (Ref.NT/NTG/E/F/3/23)	
Report Ref: 2015376	Drawn by: HG		

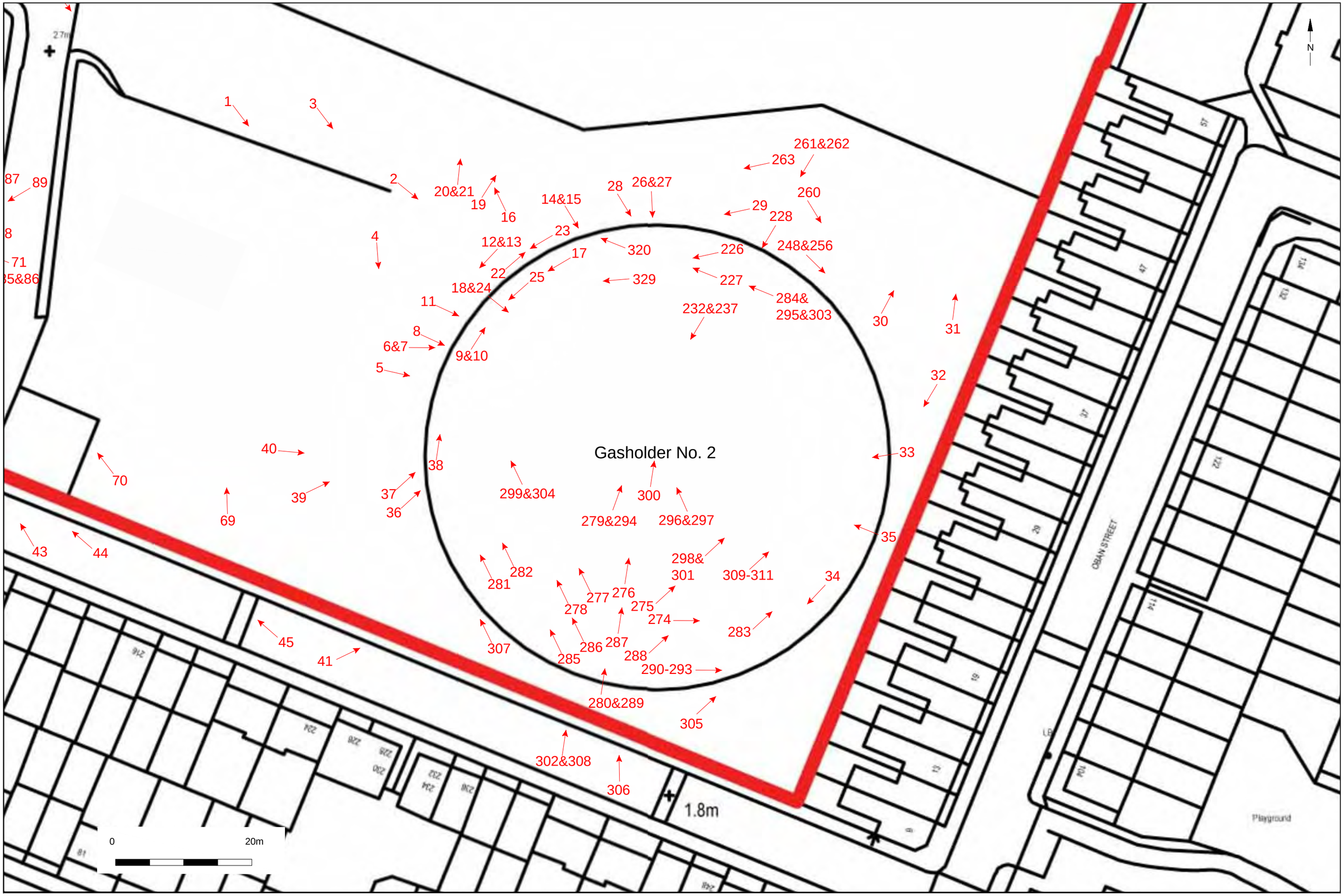
© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 16
Project Ref: 7754	November 2015	Aerial photography of the Poplar Gasworks, 19-09-1991 (OS/91314)	
Report Ref: 2015376	Drawn by: HG		

© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 17
Project Ref: 7754	November 2015	Oblique photograph of the Poplar Works, 10-03-1994 (Ref. 3881/7)	
Report Ref: 2015376	Drawn by: HG		

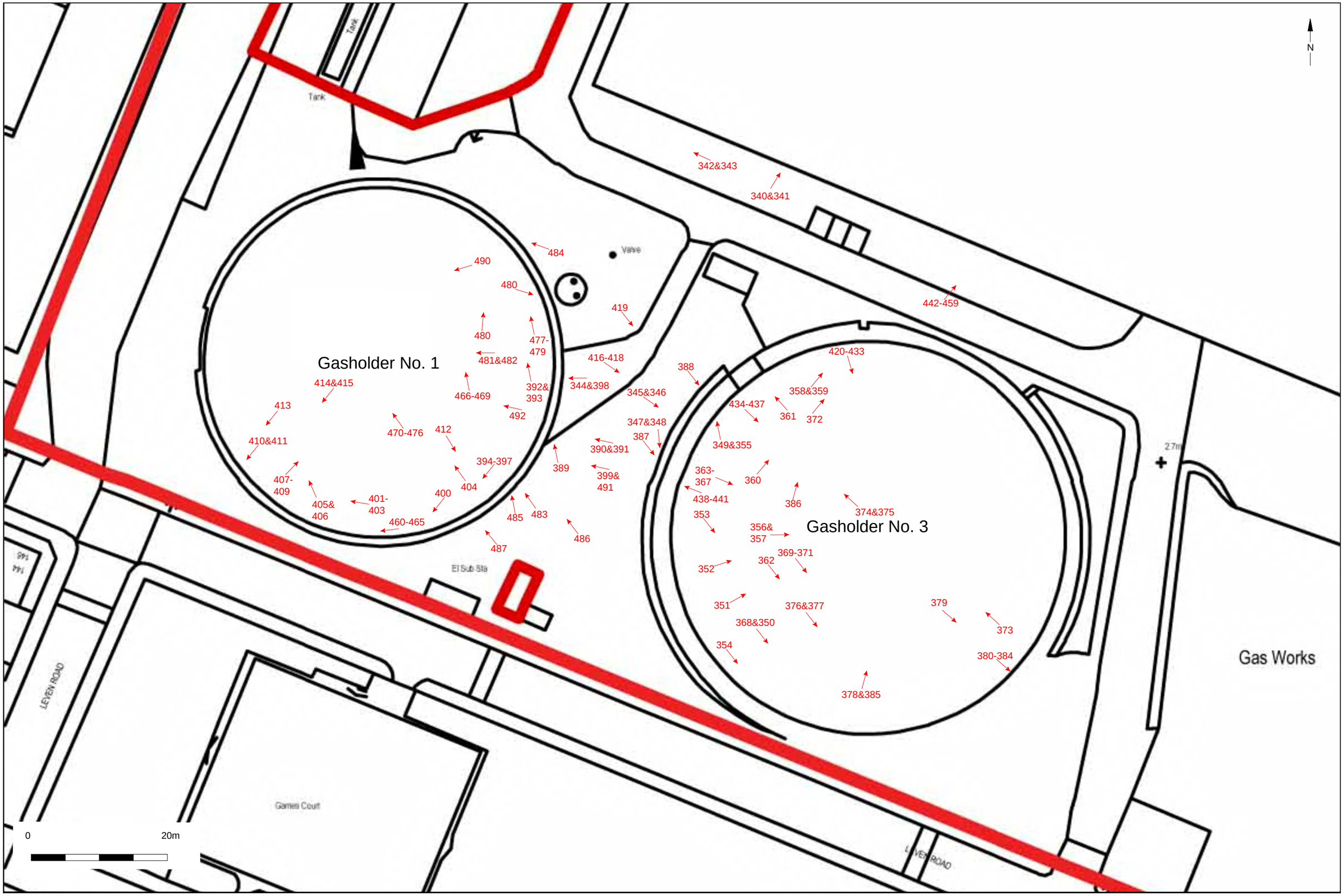
© **Archaeology South-East**		Leven Road Gasholder Station, Poplar	Fig. 18
Project Ref: 7754	November 2015	Oblique photograph of the Poplar Works, 06-09-2006 (Ref. 3881/35)	
Report Ref: 2015376	Drawn by: HG		



© Archaeology South-East		Leven Road Gas Holder Station, Poplar	Fig. 19
Project Ref: 170141	July 2017	Gasholder No. 1 & 3 Plan and Photo Locations-Exterior (1:500)	
Report Ref: 2015376	Drawn by: HG		



© Archaeology South-East		Leven Road Gas Holder Station, Poplar	Fig. 20
Project Ref: 1710141	July 2017	Gasholder No. 2 Plan and Photo Locations (1:500)	
Report Ref: 2015376	Drawn by: HG		



© **Archaeology South-East**		Leven Road Gas Holder Station, Poplar	Fig. 21
Project Ref: 170141	November 2017	Gasholder No. 1 & 3 Plan and Photo Locations-Interior (1:500)	
Report Ref: 2015376	Drawn by: HS		

Appendix 1 Overview of the Gas Industry in Britain

The gas industry was a British invention and flourished during the Victorian period, primarily because it was a cheaper, brighter and cleaner resource than its predecessors, such as candles or oil lamps. It became a requirement due to the sprawling nature of suburban living and the desire for heat and light in houses and along streets. An online paper on the social and environmental importance of the gas industry (Thomas and Brinckerhoff 2009), highlighted that gasworks enabled improved working conditions in industry due to its effective lighting properties and gas engines proved more efficient in powering plant, in comparison to steam engines. It states that the lighting of streets reduced crime levels and that the by-products of gas manufacture were the original feedstock for the chemical industry and motor fuel, both proving vital in the war efforts for World War 1 and 2. A combination of these factors ensured that the gas industry played a significant role in a social, economic and engineering context throughout the 19th and 20th centuries in Britain.

Most credit for coal gas production, but more specifically gas lighting and the term, 'gasometer', goes to William Murdoch (1754-1839) who first used coal gas to light his house and office in Redruth in 1792. Following successful demonstrations of gas lighting in a factory in Birmingham in 1795, Murdoch opened the first small gasworks at the Soho Factory of Boulton and Watt in Smethwick, Birmingham at the turn of the 19th century (Thomas and Brinckerhoff 2009) (Plate XPIC). By 1814, gasworks saw a rapid growth in order to provide light to over thirty industrial premises in Britain (The Gas Museum 2015).

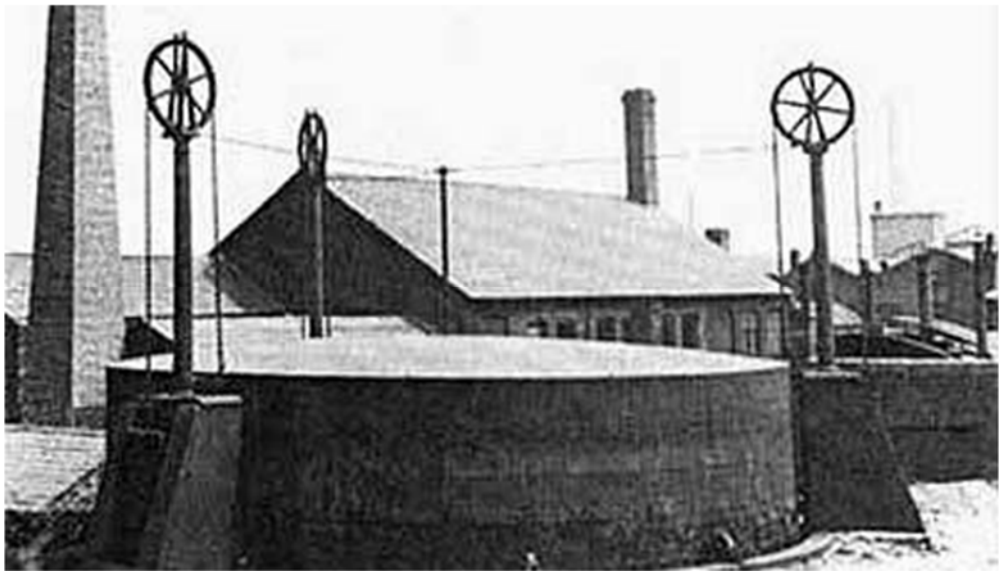
The Chartered Gas Light and Coke Company was the first gas undertaking in the world and responded to the new demand for gas by going into production in London around 1812 (Hatheway 2012). Until the 1880's they were chiefly concerned with the production of gas for lighting purposes (LMA ref: 4438). Originally, gas was only used for lighting purposes for short periods at the beginning and end of each day. However, it was soon realised that it would be more efficient to make gas over a longer period and store it; the result of which, was the invention of the gasholder. The first gasholders were of simple construction and consisted of a "bell" floating in a tank of water (The National Gas Museum 2015). A talk conducted by George Livesey in the 1890's which discussed the development of the gasholder, refers to an early gasholder built by the Gas Light and Coke Company at Brick Lane, which Livesey reminisces was the first he had seen in 1838 (Early London Gas Industry 2014). Throughout the 19th century they redeveloped the earlier gasholders into larger capacity structures, which were more technologically advanced and architecturally superior.

Gasholders continued to develop in design well into the 20th century. In 1920, an article in Popular Science Monthly, noted that ' *a gas-holder is the most expensive single piece of equipment that a gas company is called upon to provide; yet, in spite of this, from the standpoint of economical operation it is the cheapest*' (1920, 48). The North Thames Gas Board (1949-1973), which was one of twelve Area Boards, was formed when the gas industry was nationalised in 1949, following the passing of the 1948 Gas Bill.

Since the discovery of worldwide underground reserves since the 1970s, the need to store gas is negated, and therefore, gasholders increasingly became redundant. Due to imminent closure in recent times, many of these industrial structures have been at threat of demolition. In 1998 English Heritage commissioned Malcolm Tucker, a leading engineering historian and industrial archaeologist, to produce the London Gasholders Survey (Tucker 2000) to assist with informed recommendations to the Department of Culture, Media and Sport (DCMS) for the statutory protection of gasholders in London. Tucker assessed fourteen intact, unlisted later-19th century gasholders in detail and found that the study of these '*half-building and half-machine*' structures (English Heritage 2000, 6) had been generally neglected by architectural historians in the past.

The question which is often raised, is what to do with these decommissioned structures. The reuse and conversion of such structures is rare due to their complex and impractical nature, however some examples do exist. For example, in 2007, the Alliance Building in Dublin, was the result of a conversion of the 60 metre wide Dublin Gasholder into a multi-storeyed apartment block. Other successful conversions exist, but are frequently in the United States. Examples include the Gasholder Building in South Troy (5th Avenue, Jefferson Street), the Oberlin Building in Ohio and the Attleborough Falls Gasholder Building in Massachusetts. Gasholders represent an iconic part of Britain's industrial heritage, even following their disuse and as such, dismantling them is often hotly debated. Unfortunately, there is frequently no practical solution to the preservation of these structures, which leaves the question as to what to do with them, largely unanswered.

An early example of a gasholder at the first small gasworks (*c*.1800) at the Soho Factory of Boulton and Watt in Birmingham (source: Thomas and Brinckerhoff 2010)



Appendix 2 Glossary of Gasholder Terminology

'Guide-frame' *- the circular metal structure of vertical columns or standards linked by horizontal girders and sometimes, diagonal bracing, built around the perimeter of the tank and strongly bolted down.*

'Bell' *– the sheet-metal cylinder with a closed top which contains the gas in all water-sealed holders. It is the moveable part of the gasholder which rises and falls according to the volume of gas stored within. It descends back into the tank as it empties. The bell is usually telescopic and the upper part, known as the 'top curb', is constructed in thicker metal to provide strength.*

'Lift and guide rollers' *– the circumferential sections located around the bell which enable the bell to rise and fall telescopically. Each lift is mounted by a guide roller, which bears against vertical rails mounted on the standards of the guide frame. The guide rollers help to guide the bell by securing it against the wind.*

'Tank' *- the open-topped vessel into which the bell descends when empty of gas, and it is filled with water to provide a seal. Usually the tanks are constructed in cast iron or steel. Larger holders, such as those discussed in this study, have their tanks set in the ground in brick or mass concrete construction. The gasholder tank was the part of the gasholder which would house the lifts when down and contain the water in which the holder raised and descended depending on gas flow (Thomas and Brinckerhoff 2010, 5).*

Appendix 3 Patent description of spiral-guided gasholder design by Gadd & Mason of Manchester

Patent Specification

Gasholder - No. 405,702

Patented June 25, 1889.

William Gadd of Manchester, England

Patent Application filed:

February 18, 1889` Serial No. 800,884. Patented in England October 6, 1887, No. 13,521; iii Luxemburg August 13, 1888, No. 1,017: in Belgium August 16, 1888, No. 82,788; iii Turkey August 24,1888; in Canada August 28, 1888, No. 80,001; in Spain September 27,1888,No.8,584; in France October 6, 1888, No. 192,229; in New South Wales October 9, 1888, No. 988; in Gripe of Good Hope October 11, 1888, No. 477; in Italy October 13, 1888,No. 23,942; in Natal October 17, 1888; in Tasmania October 20, 1888, No. 6,278; in Brazil October 31, 1888, No. 626; in Victoria November 13, 1888,Nox 628/; in Sweden December 20,1888,No. 1,651, Norway December 29,1888, No. 1,040.

Be it known that I, William Gadd, a subject of the Queen of Britain, and a resident of the city of Manchester, England, have invented new and useful Improvements in Gasholder, of which the following is a specification.

The improvements relate to the construction of gasholders, and have for their object the supporting of the same in their working position in such a manner as to enable the external or upper guide-framing hitherto employed for that purpose to be dispensed with, and yet to give the requisite stability, although such a modified form of framing may be employed in connection with the improvements herein described when desired, and the present improvements form a modification of an invention for the same purpose, for which I have already applied for Letters Patent, filed August 28, 1888, Serial No. 284,024.

To accomplish these my present improvements, I affix round the well or tank, at or near the upper surface thereof and at any suitable intervals, tangential or angled radial rollers, or both, or in lieu thereof angled fixed friction-pieces. Attached to the outer surface of the bell or holder, and extending from top to bottom thereof, or thereabout, are rails of metal or other suitable substance, which are formed in the shape of quick helices or spirals or curved inclines of any working degree of inclination, which will be determined by the circumstances and design, forty-five degrees and sixty degrees from the horizontal being examples of working angles; but other angles may be employed. The spiral rails on the holder take or gear into the spaces between the rollers or their equivalent friction pieces, or it may be rollers and friction-pieces combined. As these spiral rails round the outer face of the holder rest and move upon the rollers or equivalents placed round the tank-by preference both over and under or between, according to the section of rail employed-it will be seen that as the holder becomes raised by being filled with gas a screw-like motion is imparted to it, thus causing it to partially turn as it rises, and in similar manner allowing it to fall by gravity as the volume of gas is reduced.

The stability of the holder lies in the fact that it is constantly at all working positions supported at an equal height round its circumference, and thus presents a position of firm resistance to wind-pressure and other lateral strains under conditions somewhat similar to that of a holder placed on the ground and resting on its lower edge or rim.

The wheels, rolling sliding blocks, or equivalent devices may either be fixed tangentially with the side of the tank, and so come in contact with the top, or top and bottom, surfaces of the rails on the holder. Or may be arranged radially with the tank, but at the angle of spiral, or, and by preference, the two kinds may be combined and the rolling-surface of the rails adapted thereto or in any other suitable manner, and the rollers or sliding pieces, or equivalent devices, when placed tangentially, may be employed above and beneath the rails alternately or in couples, or otherwise, the rails being constructed in double line or double headed or faced for the purpose.

The improvements are also applicable to telescopic gasholders by employing similar helical or spiral rails, curved purlins, or grooves attached to the inner lift or lifts thereof, which ride upon or between the rollers or equivalent devices attached to the inner surface of the outer lift or lifts of such telescopic gasholders; but that the invention may be better understood, I will, by the aid of the accompanying drawings, proceed more fully to describe means employed in carrying out the same.

In the drawings, Figure I represents an elevation with half-plan of a gasholder in single lift raised to about its full height, and with the tank shown in section, of one arrangement in accordance with my invention; and Fig. 2 shows some detail in application of the method described.

The same letters indicate corresponding parts wherever they occur.

A A is the holder; B B, the tank or well within which the holder rises and falls by means of the helical, spiral, or inclined rails or surfaces E E riding on or between the rollers or equivalents.

C C are the tangential and D D the angled radial rollers, which in Fig..l are shown arranged separately from and alternately with the tangential rollers OC; but the two kinds of rollers may be arranged together, as shown in Fig. 2, wherein the rail may be formed of channel or other iron, or other substance, having a tangential roller on each side, with the angled radial roller between or the angled radial rollers may be dispensed with by flanges on the tangential rollers; or other means may be employed for keeping the holder centrally or the rails or guides thereof on or between the rollers or equivalents.

Although, in the interests of safety, I greatly prefer to employ either two sets of roller sone above and the other below the inclined or spiral rails-or double rails with one or more sets of rollers between, in order to enable the same to securely grasp or to be grasped by the rails at various points around the edge of the holder, nevertheless it may be possible in some cases to dispense with the under set of rollers or the over set of rails, as other means may be sufficient to cause the rollers to follow the inclines of the single rails.

Having fully described my invention, what I desire to claim and secure by Letters Patent isl. In gasholders, the combination of rollers or equivalent friction-pieces, affixed to the edge or wall of the tank or well, with spiral guides on the outer face of the bell, substantially as set forth.

2. In gasholders, the combination of rollers or equivalent friction-pieces, affixed to the edge or wall of the tank or well, with spiral guides on or in the outer face of the bell, substantially as herein set forth.

3. In gasholders, the combination of angled radial rollers or equivalent friction-pieces, affixed to the edge or wall of the tank or well, with spiral guides on or in the outer face of the bell, substantially as herein set forth.

4. In gasholders, the combination of both angled radial rollers and tangential rollers or their equivalent friction-pieces, affixed to the edge or Wall of the tank or well, with spiral guides on or in the outer face of the bell, substantially as herein set forth.

5. In telescopic gasholders, the combination of rollers or equivalent friction-pieces, affixed to the inner face of an outer lift, with spiral guides on the outer face of an inner lift, substantially as herein set forth.

Signed at Manchester, England, December 31, 1838.

Witnesses:
John Lovelook
Edwin Mansfield

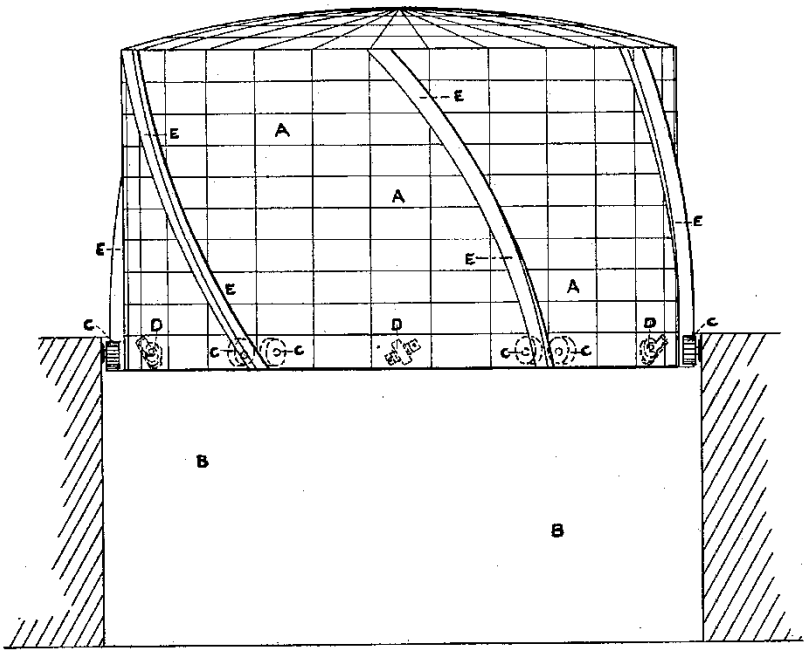
(No Model.) 2 Sheets—Sheet 1.

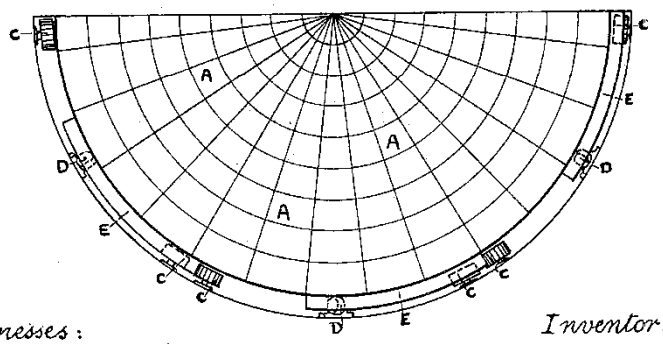
W. GADD.

GAS HOLDER.

No. 405,702. Patented June 25, 1889.

FIG 1.





Witnesses:
George Frederick Gadd.
John Alexander Lovelock

Inventor.
William Gadd.

N. PETERS, Photo-Lithographer, Washington, D. C.

(No Model.) W. GADD. 2 Sheets—Sheet 2.

GAS HOLDER.

No. 405,702. Patented June 25, 1889.

FIG 2.

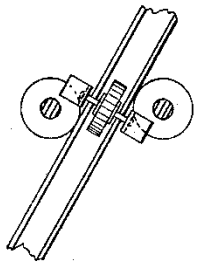


FIG 3.

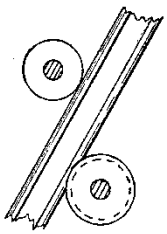


FIG 4.

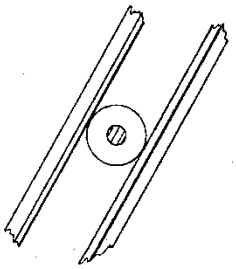


FIG 5.

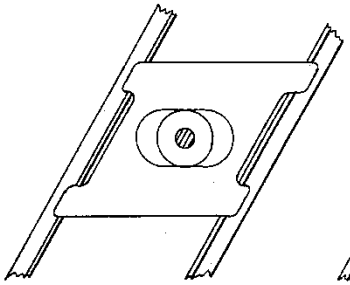
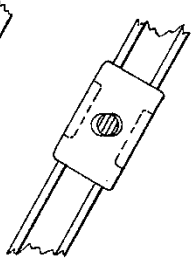


FIG 6.



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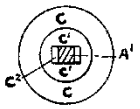

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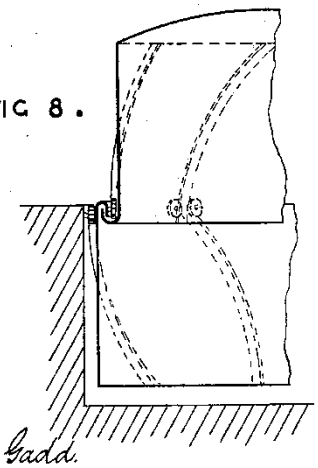

Witnesses:
George Frederick Gadd.
John Alexander Lovelock

Inventor.
William Gadd.

N. PETERS, Photo-Lithographer, Washington, D. C.

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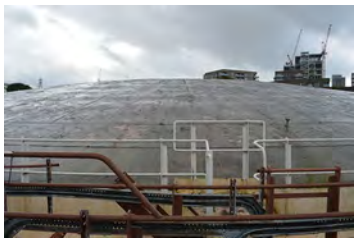
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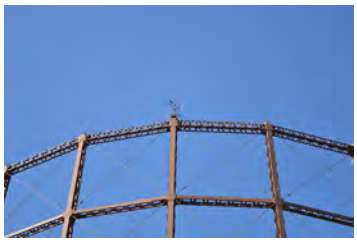
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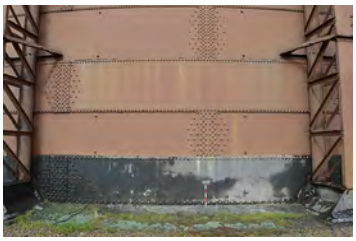

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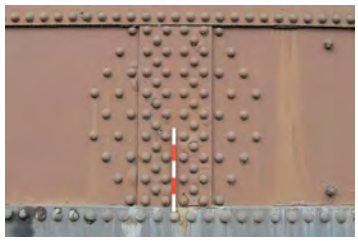

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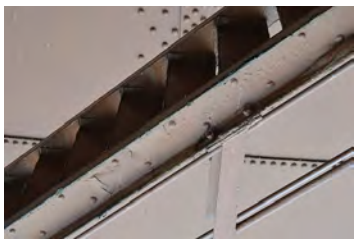

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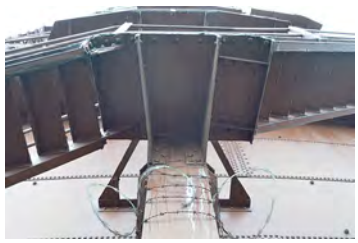

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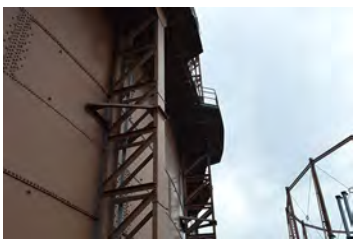

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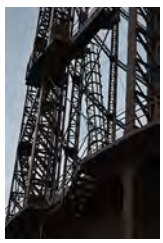

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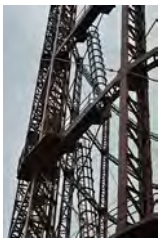
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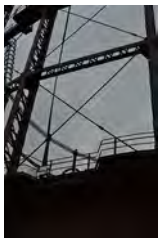
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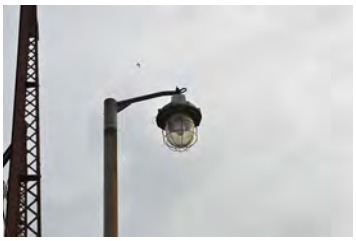
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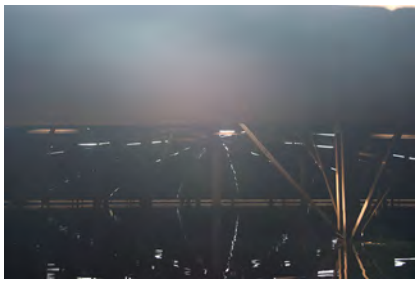
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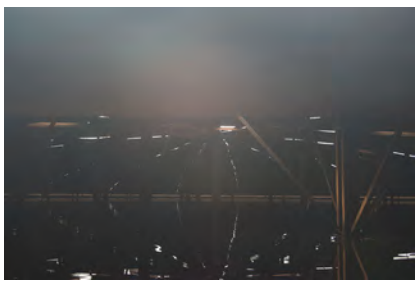
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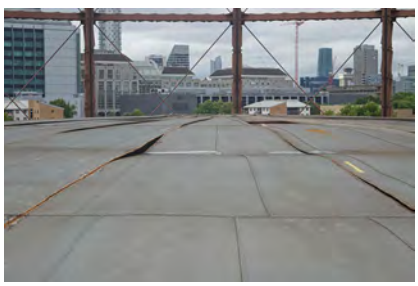
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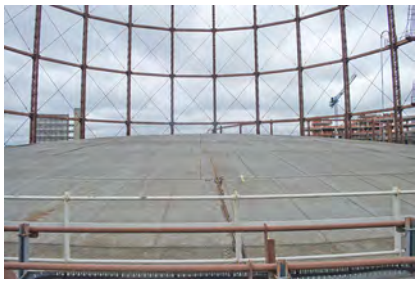
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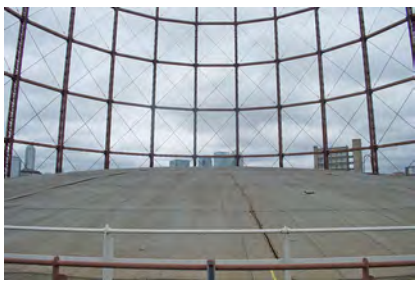
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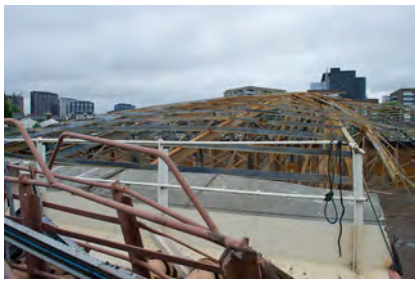
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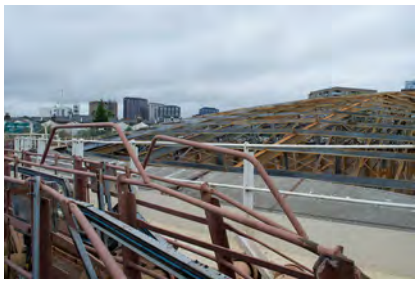
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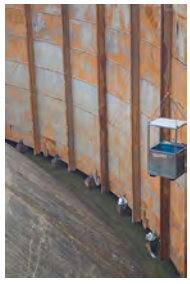
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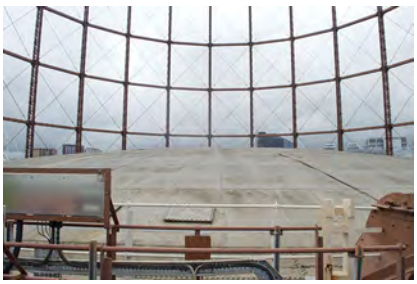
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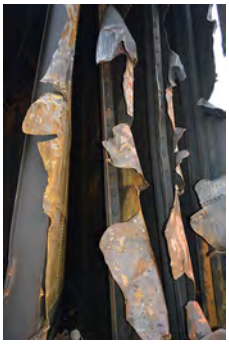

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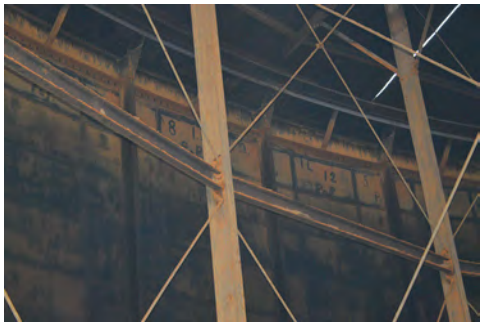

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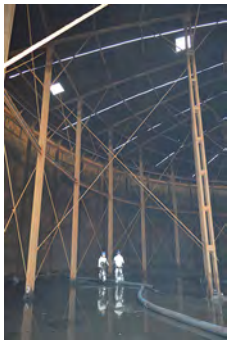

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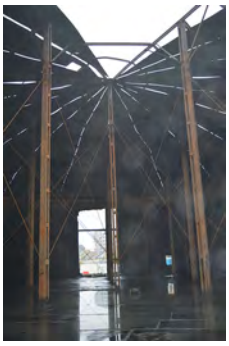

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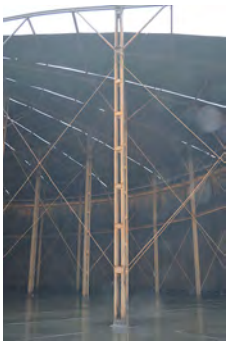

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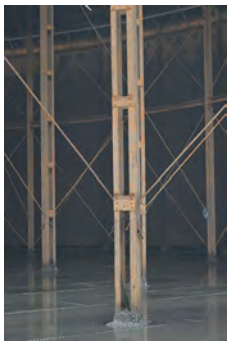

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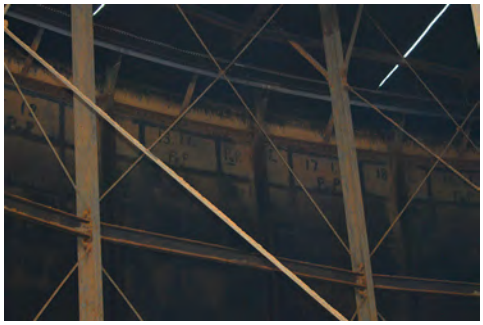

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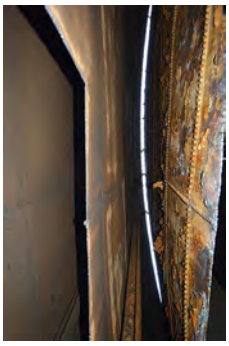

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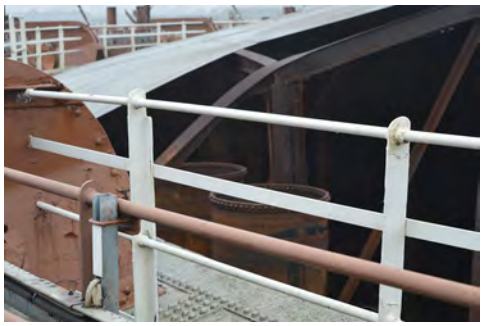

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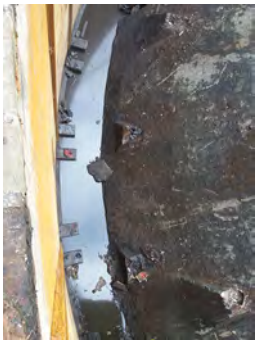

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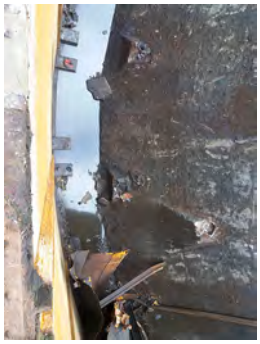

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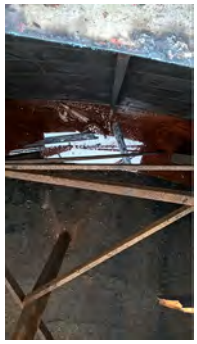

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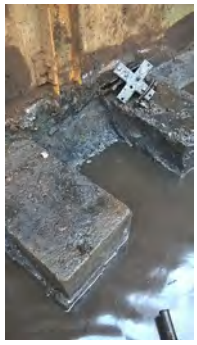

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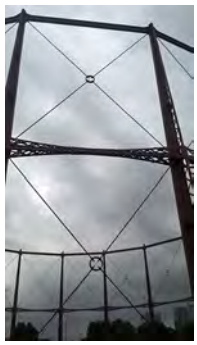

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Appendix 5 OASIS Data Collection Form

OASIS ID: archaeol6-226949

Project details	
Project name	LEven Road Gasholder Station, Poplar - Historic Building Recording
Short description of the project	In October 2015 Archaeology South-East (a division of the Centre for Applied Archaeology, University College London) carried out a programme of historic building recording of the three gasholders at Leven Road Gasholder Station, Leven Road, Poplar, London, E14 0LL (hereafter 'the site'; centred NGR:538672 181472). The work was commissioned by Montagu Evans LLP on behalf of National Grid, in advance of the demolition of the structures on the site as part of a scheme to remediate the site ahead of redevelopment. The former gasworks contains three gasholders of the water-sealed type. Gasholder No. 1 was the built as part of the gasworks initial phase of works in 1876-8. The gasholder is one of the earliest examples of the use of wrought-iron lattice guide standards and is a particularly early example of the use of lattice box-section middle girders, based on designs by Robert and Harry Jones. In addition, the holder utilises an early example of an entirely concrete tank without the use of puddled clay (English Heritage, 2002, 91). Gasholder No. 2 constructed in 1974, represents a typical late-20th century spiral-guided design, based on a developed design by Gadd and Mason of Manchester (1887). The redevelopment of Gasholder No. 2 represents a typical trend occurring from the 1950s onwards in which a new gasholder was constructed as a replacement of a former holder of a lesser capacity, utilising the original in-ground tank. In this case a typical 1970s spiral-guided gasholder replaced the former column-guided holder dated to 1882. Gasholder No. 3 has a construction date of 1928 and was designed by Samuel Cutler and Sons. The structure represents a typical early 20th century column-guided gasholder design. Its 'Type 37' lattice guide frame and above-ground steel tank, reflect the advancements in gasholder design throughout the 20th century. This gasholder forms the last phase of major development of the late-19th century gasworks.
Project dates	Start: 26-09-2015 End: 04-12-2017
Previous/future work	No / No
Any associated project reference codes	7754 - Contracting Unit No.
Any associated project reference codes	LVG15 - Sitecode
Type of project	Building Recording
Site status	None
Current Land use	Other 2 - In use as a building
Monument type	GASHOLDER Post Medieval
Monument type	GASHOLDER Modern
Significant Finds	NONE None
Project location	
Country	England
Site location	GREATER LONDON TOWER HAMLETS POPLAR Leven Road Gasholder Station
Postcode	E14 0LL
Study area	8.1 Hectares
Site coordinates	TQ 38672 81472 51.514628356989 -0.001286905835 51 30 52 N 000 00 04 W Point
Project creators	
Name of Organisation	Archaeology South-East
Project brief originator	Montagu Evans LLP
Project design originator	Archaeology South-East

Project director/manager	Ron Humphrey/Amy Williamson
Project supervisor	Hannah Green
Type of sponsor/funding body	National Grid
Name of sponsor/funding body	National Grid/Montagu Evans LLP
Project archives	
Physical Archive Exists?	No
Digital Archive recipient	Tower Hamlets Local History Library and Archives
Digital Archive ID	LVG15
Digital Contents	"none"
Digital Media available	"Images raster / digital photography","Text"
Paper Archive recipient	Tower Hamlets Local History Library and Archives
Paper Archive ID	LVG15
Paper Contents	"none"
Paper Media available	"Aerial Photograph","Correspondence","Photograph","Plan","Report","Unpublished Text"
Project bibliography 1	
Publication type	Grey literature (unpublished document/manuscript)
Title	Leven Road Gasholder Station, Poplar, London - Historic Building Record
Author(s)/Editor(s)	Green, H.
Other bibliographic details	2015376
Date	2015
Issuer or publisher	Archaeology South-East
Place of issue or publication	Archaeology South-East
Entered by	Hannah Samuels (hannah.samuels@ucl.ac.uk)
Entered on	4 December 2017

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