Soho Loop, Dudley Road, Birmingham, West Midlands

Post-excavation Assessment and Updated Project Design

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Summary

Wessex Archaeology was commissioned by RPS Consulting, on behalf of Soho Loop Ltd, to conduct an archaeological excavation on the site of the late 18th century Park Glasshouse and late 19th century German Silver Works at Soho Loop, Dudley Road, Birmingham, B18 7BS. The excavation, in 2020, covered 0.17 hectares centred on NGR 404962 287621. The work was undertaken to fulfil a planning condition relating to archaeology following the approval of an application for the construction of six residential blocks of between six and fourteen storeys and other buildings (2018/10294/PA).

The excavation followed on from a desk-based assessment and two trial trench evaluations and was carried out in two phases. The initial phase focussed on exposing and recording the floor plan of the 1896 Barker and Allen German Silver Works, these investigations limited by the presence of a number of suspected asbestos-containing materials present across the site.

Following removal of the suspected asbestos, the second phase of work involved taking up the German Silver Works floors to allow for the excavation and recording of the remains of the Park Glasshouse. This investigation revealed elements of the central cone, one of the sieges, and parts of the flue system and a Siemens gas regenerator within the central portion of the site. Some further walls and possible workshop areas were also recorded in the surrounding area, however much of the Glassworks had been heavily truncated by the construction of the Silver Works, with the main structural walls and deep drainage systems of this cutting through the earlier remains. Nevertheless, sufficient of the Glassworks survived for three tentative structural phases to be identified. How closely these phases correlate with the three historical phases of the Glassworks is somewhat uncertain, though the principal surviving remains appear to date to the mid-19th century. In the early 1860s the Park Glasshouse was used as an important trial for the adoption of the Siemens gas regenerator system within the glass making industry, the successful results published in *The Engineer* in 1862.

Finds recovered include a significant assemblage of waste material deriving from the former glassworks (raw glass, cullet, paraisons etc), other industrial residues, building material, and metalwork including possible glassworking tools. A minor industrial component comprises a small quantity of button-making debris. There are also limited quantities of pottery, clay tobacco pipe, animal bone and oyster shell representing domestic refuse dumped on the site probably at various times from the late 18th century onwards.

The results from the archaeological excavation in 2020 (and previously related work) of the Park Glasshouse, as well as those from the related technological investigations proposed, are worthy of publication. It is considered that the most appropriate place for this will be as an article in the county archaeological journal, the *Transactions of the Birmingham and Warwickshire Archaeological Society*, a peer-reviewed journal with a broad readership. In addition, the full results of the technological investigations can be made available on-line to a more specific scientific audience.

Acknowledgements

Wessex Archaeology would like to thank RPS Consulting, in particular Dr Nick Cooke, for commissioning the archaeological mitigation works. We are also grateful for the advice of Chris Patrick, Principal Conservation Officer for Birmingham City Council, who monitored the project for Birmingham City Council. Hace Enabling provided much help and co-operation on site; and our thanks are also extended to Nick Stawiszynski from H.E. Services.

The expertise of Dr David Dungworth is warmly acknowledged, his considerable experience of historic glassworks and glassworking guiding both the excavation (including artefact retrieval and sampling strategies) and this post-excavation assessment.

Soho Loop,
Dudley Road, Birmingham

Post-excavation Assessment and Updated Project Design

1 INTRODUCTION

1.1 Project and planning background

1.1.1 Wessex Archaeology was commissioned by RPS Group, on behalf of Soho Loop Ltd, to undertake archaeological mitigation works comprising an excavation covering 0.17 ha, centred on NGR 404962 287621, at Soho Loop, Dudley Road, Birmingham, West Midlands, B18 7BS (**Figure 1**).

1.1.2 The work was carried out as a condition of planning permission, granted by Birmingham City Council (2018/10294/PA), for six residential blocks of between six to fourteen storeys, some of which will include ground floor retail units, and terraced and semi-detached town houses. The development will also include parking, amenity spaces, site access and highway works. The excavation area was in the proposed location of Block C which will contain 170 apartments split between a fourteen-storey eastern end and eight-storey west end. The overall development area encompasses 4.0 ha. A planning application (2018/10294/PA), submitted to Birmingham City Council, was granted on 30 January 2020, subject to conditions. The following condition (Condition 16) relates to archaeology:

> The development is only to proceed in full accordance with a written scheme of investigation for a programme of archaeological mitigation works including excavation, post-excavation analysis and reporting, which has been submitted to and approved in writing by the local planning authority. The scheme is to be implemented in full accordance with the approved details.
>
> Reason: This is required as a pre-commencement condition in accordance with the SI 2018 566 The Town and Country Planning (Pre-Commencement Conditions) Regulations 2018. The information is required prior to development commencing to protect important features which contribute to the special architectural or historic character of the listed building in accordance with Policies PG3 and TP12 of the Birmingham Development Plan 2017, the National Planning Policy Framework and Regeneration through Conservation SPG.'

1.1.3 Two further conditions also relate to archaeological and historical recording of the site, Condition 17 for structural building recording and Condition 18 for evaluation, the results of these not covered by this Post-excavation Assessment, except where their results are relevant to the excavation.

1.1.4 The excavation was the final stage in a programme of archaeological works which had included a desk-based assessment (DBA) that identified the potential of the site as the location of a late 18th to 19th century glassworks (Park Glasshouse) and late 19th century Barker and Allen German Silver works (Birmingham Archaeology 2005), two archaeological evaluations (AJ Archaeology 2018; Oxford Archaeology 2020) and building recording (Oxford Archaeology 2020).

1.1.5 The excavation was undertaken in accordance with a written scheme of investigation (WSI), which detailed the aims, methodologies and standards to be employed, for both the fieldwork and the post-excavation work (Wessex Archaeology 2020). The Principal Conservation Officer for Birmingham City Council (PCO for BCC) approved the WSI, on behalf of the Local Planning Authority (LPA), prior to fieldwork commencing. The excavation was undertaken between the 28th September – 18th December 2020.

1.2 Scope of the report

1.2.1 The purpose of this report is to provide the provisional results of the excavation and to assess the potential of the results to address the research aims outlined in the WSI. Where appropriate, it includes recommendations for a programme of further analysis, outlining the resources needed to achieve the aims (including the revised research aims arising from this assessment), leading to dissemination of the archaeological results via publication and the curation of the archive.

1.3 Location, topography and geology

1.3.1 The development site is situated approximately 2 km north-west of Birmingham city centre and is bounded by the Birmingham Canal Old Line on its east, the mainline railway between Birmingham and Wolverhampton to the south-west, beyond which is the Birmingham Canal (Birmingham Level), with St Patrick's Roman Catholic Church and Infant School to the west and Dudley Road/Spring Hill to the north (**Figure 1**). The area of excavation is located in the north-east corner of the development site.

1.3.2 Existing ground levels are approximately 141.5 m above Ordnance Datum (aOD).

1.3.3 The underlying geology is mapped as Wildmoor Sandstone Member – sandstone, whilst the superficial geology is mapped as Devensian Till – diamicton, sand and gravel (British Geological Survey online viewer 2021).

2 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

2.1 Introduction

2.1.1 The archaeological and historical background was assessed in a prior DBA (Birmingham Archaeology 2005), which considered the recorded historic environment resource of the proposed development.

2.2 Previous works related to the development

Archaeological Evaluation (2018)

2.2.1 The initial evaluation (AJ Archaeology 2018) identified the buried remains of both the Park Glasshouse and 19th century Barker and Allen German Silver works. It demonstrated that some below-ground structural remains of the glassworks and associated deposits had survived later disturbance, and in the proposed excavation area it identified up to 0.50 m of stratified deposits, together with several building phases, including walls and floor surfaces. The glassmaking remains in other parts of the complex were less well preserved, but elements were found to survive underneath the floors of the German Silver works. Other remains identified by the trenching comprised brick and iron floors, brick walls and furnace remains of the German Silver works, which had been demolished to floor slab level in the 1970s.

Archaeological Evaluation and Building Recording Survey 2020

2.2.2 The second phase of evaluation (Oxford Archaeology 2020) further characterised and defined the areas in which the Park Glasshouse remains survived. The façade of the Barker and Allen German Silver Works was also recorded.

2.3 Archaeological and historical context

2.3.1 The Birmingham glass industry was established in the 18th century with numerous factories producing a wide variety of glass artefacts. The largest producer (Chance Brothers) is best known for its manufacture of window glass (they made the glass for the Crystal Palace of the 1851 Great Exhibition); however, most Birmingham glass manufacturers were relatively small-scale producers of tableware, 'novelties' and 'toys' (Buckley 2003; Crossley 2003; Timmins 1866).

2.3.2 The Park Glasshouse was established in 1788 (or shortly afterwards but certainly by 1792) by Isaac Hawker. Isaac had an established business, making and selling flint glass (and other articles) in Birmingham and (for a short while) operated a glass furnace in the town centre. The new development at Parkhouse took place on what was then a 'greenfield' site (**Figure 2a**) and is presumed to have replaced the town centre furnace, the new works concentrating on flint glass. The business passed to Isaac's son John; however, by 1808 it was owned by John Biddle and David Lloyd (**Figure 2b**). John Biddle is listed by the Excise Glass Commission as the owner of a Birmingham flint glasshouse in 1830 (HMSO 1835) and it is likely that this was the Park Glasshouse. It is not known whether the glasshouse continued to produce flint glass or began to include the manufacture of other glasses. The traditional distinction between glass compositions (flint, crown and bottle) had been reinforced by the system of taxation, and the repeal of this in 1845 allowed glassmakers more latitude in the recipes that could be used.

2.3.3 By the 1850s, the works had passed into the ownership of Lloyd and Summerfield who produced both flint glass and window glass. They exhibited in the Crystal Palace as part of the Great Exhibition of 1851, including:

> The Patent Crystal Window Bars, adapted for domestic Windows, Shop Fronts, Conservatories, Skylights, Verandahs, Exhibition and Counter Cases, Aquariums, Fern Cases, &c. &c., combining perfect transmissions of light, durability against rust or decay, and economy in the facility with which they are kept clean. Aquariums with Slate or Marble Bottoms of various sizes, with or without Fountains, also of glass. Manufactured by Lloyd & Summerfield, Park Glass Works, Birmingham. All kinds of Flint Glass, cut and plain, Coloured Window Sheet, Optical Sheet, Coloured Lenses, &c. &c.

2.3.4 The glasshouse became famous under Lloyd and Summerfield for the early demonstration of Siemens' regenerative principles in glass melting (Cable 1999–2000; *The Engineer* 1862). Since the early 19th century, industrialists and scientists had become aware that coal-fired furnaces could be made more efficient if some of the waste heat could be used to preheat air on its way into the furnace. The principle of regeneration had been established (and even patented) in the early 19th century. In the first step, waste gas from a furnace would be directed through a chamber filled with bricks in a chequer-board arrangement which allowed the free passage of hot gases which would heat up the bricks. Once the chamber was hot, valves would be used to direct incoming (cold) air through the regeneration chamber (thereby heating it). By pre-heating the air before combustion, higher temperatures could be achieved and/or less coal used. The application of regeneration in glass-melting encountered some difficulties as the waste gas contained a proportion of volatile waste ash (especially the alkali it contained) which would attack the bricks.

Regeneration only achieved its initial success by the use of gaseous fuel (Cable 1999–2000). An entirely separate ('gas producer') furnace was used to heat coal which evolved combustible gas that was then piped into the furnace. A gas producer eliminated the impurities which attacked bricks and allowed the successful use of regenerators. The first description of the successful application of regenerators in glass melting appears in an article by William Siemens in *The Engineer* (1862) which contains a contribution from Dr Lloyd (of Lloyd and Summerfield),

> Dr. Lloyd replied that they had had one of the regenerative ten pot furnaces in operation nearly twelve months for flint glass making, and every month's experience of its working convinced him that the high opinion he originally formed of its value was fully deserved, notwithstanding some difficulties that had been met with. The regenerative system appeared to him one of the most beautiful adaptations of science to practical art, and he was so much struck with the soundness of the principle that he went at once to see a small glass furnace that was working on that plan in Yorkshire; and being satisfied of the theoretical perfection of the plan, he adopted the new furnace immediately at his own works for flint glass making. In this case, the melting pots were all closed in at the top, and he had therefore no apprehension of the regenerators getting clogged after working a length of time, since all the vapour in melting escaped at the mouths of the pots and did not pass directly into the regenerators at all. Some inconvenience had arisen occasionally at first by pots breaking near their bottom, in consequence of the siege being too thin; but this was effectually remedied by raising the siege with fireclay by degrees in setting new pots. He had adopted the new furnace mainly with a view to saving fuel, and particular attention had been paid to ascertain the real economy in this respect. It was built of about the same capacity as an old ten pot furnace, which they had had in use for several years previously, heated with large, best coal; the large coal was found more economical in the end than coal of an inferior and cheaper description, but the consumption was considerable. The result of the comparison between the two furnaces was that the old furnace consumed nearly as possible double the quantity of fuel required in the regenerative furnace, the average of the year being about 35 tons per week in the old and only 16 or 17 tons per week in the new: but the coal now used in the new furnace cost only one-third as much per ton, being entirely small coal as 4s per ton instead of large coal at 12s; so that the actual cost of fuel in the new furnace was reduced to one-sixth of that in the old, doing the same amount of work.

2.3.5 This was a very important economy in manufacture, but there were also other prospective advantages in the new furnace to be taken into account, in respect of durability and maintenance. In the old furnace the cost and inconvenience of rebuilding were a serious consideration; but the durability of the new furnace seemed likely to be much increased by the heat being kept so equable, with an entire freedom from cutting draughts; the experience of the twelve months' working of their new furnace was that the wear and tear was so trifling, although a very high temperature was maintained, that he expected it would last three to four times as long as the old furnace, judging from the state of the edges of bricks in the new furnace, which was still nearly as sharp as when it was built. This increased durability might, indeed, be reasonably anticipated, because no alkaline and earthy matters from the fuel were now carried into the furnace, but they were all left behind in the gas producer, and nothing went into the furnace but gases that were wholly combustible and almost free of impurities.

2.3.6 Although Lloyd and Summerfield were early adopters of this new technology, and were registering new tableware designs through the 1860s, the business seems to have gone bankrupt in 1874 (*The London Gazette* March 13, 1874). The site was demolished in the

1880s, with the site subsequently developed for non-ferrous metal manufacture (the Barker and Allen German Silver Works).

3 AIMS AND OBJECTIVES

3.1 Aims

3.1.1 The general aims of the excavation, as stated in the WSI (Wessex Archaeology 2020) and in compliance with the Chartered Institute for Archaeologists' *Standard and guidance for archaeological excavation* (CIfA 2014a), were to:

- examine the archaeological resource within a given area or site within a framework of defined research objectives;
- seek a better understanding of the resource;
- compile a lasting record of the resource; and
- analyse and interpret the results of the excavation and disseminate them.

3.2 Research objectives

3.2.1 The Park Glasshouse is significant as one of Birmingham's earliest glassworks and has the potential to contribute to our understanding of the development of glassmaking in Birmingham, which was a nationally important industry. The below-ground remains of the Park Glasshouse have additional significance since they belong to the 'shed' rather than the 'cone' type glassworks, a type of glassworks which has been less intensively studied.

3.2.2 The site functioned for nearly 100 years and has the potential to help elucidate changes resulting from the adaptation of new glass technologies and changing industries over this period.

3.2.3 Following consideration of the archaeological potential of the site and the regional research framework (Belford 2011), the research objectives of the excavation were to:

- establish the historic development sequence;
- establish and record the extent and layout of the Park Glasshouse complex;
- establish the technology employed in the glass manufacturing process employed at a 'shed' type glass manufactory;
- establish variations in how different parts of the complex functioned and what this can tell us about the processes employed in the manufacturing process;
- establish how the above changed over time and how this reflects the adoption of new technologies;
- establish and record the extent and layout of the Barker and Allen German Silver Works.

4 METHODS

4.1 Introduction

4.1.1 All works were undertaken in accordance with the detailed methods set out within the WSI (Wessex Archaeology 2020) and in general compliance with the standards outlined in CIfA

guidance (CIfA 2014a). The post-excavation assessment and reporting follows advice issued by the Association of Local Government Archaeological Officers (ALGAO 2015). The methods employed are summarised below.

4.1.2 The excavation was undertaken in two stages. The initial stage focused on mapping and recording the floor plan of the German Silver Works, but this work was severely limited by Health and Safety (H & S) considerations, namely the presence of considerable quantities of potentially asbestos-containing materials across the site. Following removal of the suspected asbestos by specialist contractors, the second phase of work focused on the excavation and recording of the remains of the Park Glasshouse. However, a portion of the southern part of the proposed excavation area remained inaccessible.

4.2 Fieldwork methods

General

4.2.1 The excavation area was set out using a Global Navigation Satellite System (GNSS), in the same position as that proposed in the WSI (**Figure 1**). The overburden was removed in level spits (where possible) using a 360º excavator equipped with a toothless bucket, under the constant supervision and instruction of the monitoring archaeologist. Machine excavation proceeded until the first significant archaeological horizon, in this case the walls, floors and related features associated with the Barker and Allen German Silver Works.

4.2.2 Where necessary, the surfaces of archaeological deposits at this level were cleaned by hand. A sample of archaeological features and deposits was hand-excavated, sufficient to address the aims of the excavation.

4.2.3 A second stage of machine excavation then took place, removing the floors and other remains of the German Silver Works floors to reveal surviving elements of the Park Glasshouse. Archaeological deposits and structural remains were cleaned and then hand-excavated as appropriate, sufficient to address the aims of the excavation. Subsequently, some deeper machine-excavation was undertaken to establish, for example, the depth and nature of the building foundations.

4.2.4 Spoil derived from machine stripping and hand-excavated archaeological features was visually scanned for the purposes of finds retrieval. Artefacts were collected and bagged by context. In consultation with Dr David Dungworth, a selection of glass making material and associated debris were retained from the glassworks; a similar selection process was used for the German Silver Works, with finds pertinent to the factory and the people who worked there being retrieved, where H & S conditions permitted.

Recording

4.2.5 All archaeological features and deposits were recorded using Wessex Archaeology's pro forma recording system. A complete record of excavated features and deposits was made, including plans and sections drawn to appropriate scales (generally 1:20 or 1:50 for plans and 1:10 for sections) and tied to the Ordnance Survey (OS) National Grid.

4.2.6 A Leica GNSS connected to Leica's SmartNet service surveyed the location of archaeological features. All survey data is recorded in OS National Grid coordinates and heights above OD (Newlyn), as defined by OSTN15 and OSGM15, with a three-dimensional accuracy of at least 50 mm.

4.2.7 A full photographic record was made using digital cameras equipped with an image sensor of not less than 16 megapixels. Digital images have been subject to managed quality control

and curation processes, which has embedded appropriate metadata within the image and will ensure long term accessibility of the image set.

Photogrammetry

4.2.8 All works were undertaken in accordance with the detailed methodology set out within the WSI (Wessex Archaeology 2020) and in general compliance with the standards outlined in CIfA (CIfA 2014b) and Historic England (Historic England 2017) guidance. The methods employed are summarised below.

4.2.9 The survey was carried out using a Pentax K50 with a Pentax-DA L 18–55 mm AL WR lens and a Leica GNSS GS07.

4.2.10 Survey was undertaken on ten of the Park Glasshouse structures, including all the cone walls, the siege, and other structures and floor surfaces associated with the cone (contexts 293, 337, 343, 348, 354, 373, 385, 394, 410 and 416). These features were photographed using manual settings suitable for the light conditions present on site; images collected are 4928x3264 pixels.

4.2.11 The targets for georeferencing were surveyed with a Leica GPS GS 07 with an average 3D CQ below 50 mm. The coordinate system used is OSGB36(15). The average ground sample distance of the photos is 0.349 mm/pix.

4.3 Finds and environmental strategies

General

4.3.1 Strategies for the recovery, processing and assessment of finds and environmental samples were in line with those detailed in the WSI (Wessex Archaeology 2020). The treatment of artefacts and environmental remains was in general accordance with: *Guidance for the collection, documentation, conservation and research of archaeological materials* (CIfA 2014c), *Environmental Archaeology: A Guide to the Theory and Practice of Methods, from Sampling and Recovery to Post-excavation* (English Heritage 2011) and CIfA's *Toolkit for Specialist Reporting* (Type 2: Appraisal).

4.4 Monitoring

4.4.1 The PCO for BCC monitored the works on behalf of the LPA. Any variations to the WSI, if required to better address the project aims, were agreed in advance with the client and the PCO for BCC.

5 STRATIGRAPHIC EVIDENCE

5.1 Introduction

Summary of archaeological features and deposits

5.1.1 Most of the archaeological features were structural remains including walls, floors and machine pits (**Figure 3**). Features associated with the Park Glasshouse included the cone, a siege, flues, retaining walls, part of a gas regenerator system, a chimney base and a coal chute; away from the cone, fragments of walls, floors, part of a brick courtyard and drainage associated with the glassworks were recorded.

5.1.2 Features associated with the Barker and Allen German Silver Works were predominantly floors and walls; rectangular brick structures and stone and concrete pads are interpreted as possible machine pits.

5.1.3 Made ground deposits were recorded across the site, with natural deposits exposed in the western and central portions, but not in the eastern third.

Methods of stratigraphic assessment and quantity of data

5.1.4 All hand-written and drawn records from the excavation have been collated, checked for consistency and stratigraphic relationships. Key data has been transcribed into a database, which can be updated during any further analysis. Preliminary phasing of archaeological features and deposits was principally undertaken using stratigraphic relationships and cartographic evidence from the preceding DBA.

5.2 Natural deposits

5.2.1 Natural deposits, where encountered, comprised pale yellow sand with very rare gravels. Where features cut deep enough through the sand a band of compacted gravels was exposed. The natural deposits were encountered at much shallower depths in the west and central parts of the site; along the eastern edge no natural deposits were noted, despite mechanical excavations to depths of approximately 4.5 m (137 m aOD). The water level of the canal, on the western side of the site, is at 137.95 m aOD.

5.3 Park Glasshouse

Cone

5.3.1 Six sections of the cone wall survived, forming a circle with an internal diameter of 11 m and an external diameter of 13 m (**Figures 4, 5** and **6**). The cone wall was constructed using pinkish red bricks, measuring 220 x 100 x 70 mm, laid in English Bond and strongly mortared with a light grey/white sandy cement; the lowest five courses were laid with the basal one in header bond, courses two to four in stretcher bond, and course five in English Bond, the mortar in these lower courses poorly snagged. A slight change in coursing was noted at floor level where the bricks were laid in header bond. A maximum of 15 courses were recorded, the number which survived varying from section to section. One section of cone wall (394) was constructed slightly differently using predominantly red and dark grey bricks, measuring 220 x 100 x 60 mm, and mortared together with a fine yellow sandy cement, neatly pointed. This section may have been repaired or repointed as patches of white cement were also noted. Furthermore, wall 394 did not have the general inward curve that the other sections had but stepped outwards in several places. Wall 394 lay closest to the areas where most of the flue systems were recorded and it may be that it had been repaired or replaced at some point. Close to wall 394, the westernmost section of wall 373 appeared to have possibly been underpinned, and a drain constructed with three courses of un-mortared light red/orange bricks.

5.3.2 Most of the features within the cone had been truncated by a later drainage system bisecting it east–west, with two substantial manholes more-or-less central to the cone, and a wall (98) bisecting it north–south. However, despite the damage caused by these deep features, a portion of a siege survived.

Siege

5.3.3 In order to construct the siege, which supported the crucibles containing molten glass, a large pit (418) approximately 5.5 m diameter with a depth in excess of 2 m had been excavated and the vertical sides lined with a single skin of bricks to retain the sand (wall 419 on the northern side and more substantial wall 408/428 (**Figures 4** and **5**)); the whole area had subsequently been subjected to intense heat which helped stabilize the sides. Within this pit the siege was set upon a wide, winged base (structure 474); it was not possible to fully excavate the basal structure of the siege due to the ground water level. The

two retaining walls (419 and 408/428) were different in their construction, implying at least one phase of rebuilding within the cone. Wall 428 was constructed using dark reddish grey bricks (220 x 110 x 80 mm) laid in English bond, mortared together with a pale pinkish cement; 22 courses were visible, surviving to a height of at least 1.90 m (**Plate 1**). Wall 428 continued beneath the water level and was cut by wall 98; on the western side of wall 98 the retaining wall was recorded as wall 408, where it had been cut by flue 325 (see below). Three (demolished) projections towards the north were present (two on wall 428, one on wall 408). Retaining wall 419 had 15 visible courses, built with pinkish red bricks (230 x 110 x 70 mm), some with bevelled edges (**Plate 2**). This wall butted a solid brick structure which in turn butted the siege wall.

5.3.4 The siege base was built using a mixture of bricks, including two stamped bricks, one marked KINGS STOURBRIDGE and the other … PEARSON STOURBRIDGE. The southern part of the base appeared to have a wing which protruded 1 m south-east from the siege, with a maximum width of 0.95 m, this with a flat, level surface with raised edges forming parts of the flue system.

5.3.5 The remains of the siege itself were recorded as two separate features, 413 and 416. The surviving parts were a maximum of 1.61 m in height (18 courses) above the base and were constructed in a form resembling an 'ashlar-and-rubble' technique in which the 'ashlar' was yellow refractory bricks and the rubble core comprised devitrified glassmaking waste, in one place incorporating part of a (used) crucible (see Section 7). The siege structure showed signs of repair with additional bricks butting the north and south sides respectively (**Plate 3**).

Siemens gas regenerator

5.3.6 One of the latest features associated with the construction of the Park Glasshouse was a Siemens gas regenerator, discussed in more detail in Section 7. Extending from siege 413 was the springing for the arch of the flue feeding the regenerator. The remains of the regenerator included a chequer-board arrangement of bricks between the flue and a brick chamber (354) (**Figures 4** and **5**). Chamber 354 was constructed of pale yellow and pink bricks and the inside was coated with a hard glaze. It had external dimensions of 3.80 m long by 1.70 m at its broadest, and the arch of the main chamber measured 1.07 m wide. The internal dimensions were harder to ascertain and excavation within the chamber was very limited, however, the arched part of the structure was 0.50 m wide. To the west of this (and later wall 98) was a possible floor surface (387) and two low walls (385 and 387), constructed using the same bricks and identical mortar.

Flues

5.3.7 A series of flues and a brick feature interpreted as a coal chute were recorded below ground level in the southern part of the glassworks cone (**Figures 4** and **5**. Flue 325 was constructed with distinctive red, fine textured bricks (220 x 110 x 70 mm), bonded with a pinkish white sandy mortar (**Plate 4**), and was excavated to a maximum depth of 1.2 m (it continued below this level). The flue measured 0.58 m across internally, the walls one brick thick in the lower parts, increasing to two bricks thick where the covering arch would have sprung. This flue cut wall 408 and also appeared to cut a possible coal chute (361), before turning north where it was cut by the main drain line and a little beyond this by wall 81. To the east of wall 98 the evidence of the flue system was equally fragmentary, but structure 474 and wall 477 may have been part of this. A deep flue (structure 334, **Plate 5**) outside of the cone wall was constructed of greyish red bricks (230 x 110 x 70 mm) and had been cut by one of the 1896 Silver Works walls. Flue 334 was machine-excavated to a depth of 2.80 m below ground level (approximately 1.36 m aOD), where a short section of wall crossed the flue, this interpreted as a baffle or 'doorway' used to control the airflow. Where

this flue turned and entered the cone was uncertain, although the most likely place would be where the modern drain bisected the cone. Finally, a north– south aligned brick structure (361) with a concave base and arched roof was recorded on the south-west side of the cone, entering the cone adjacent to wall 373 (**Plate 6**). Structure 361 measured in excess of 4.50 m long, 1.15 m wide and at least 0.5 m deep, with 11 courses of bricks recorded to the south, where the possible springing for an arch was visible; it was constructed using similar bricks to flue 325, with the same scored marking on some of the sides. Because of the shallow, concave nature of this feature it has been interpreted as a coal chute, the base sloping down at approximately 45º with occasional small steps in the brickwork.

Other internal features

5.3.8 A few features survived at what would have been floor level or above within the cone (**Figures 4** and **5**). These were all constructed using a variety of bricks and suggest that the glassworks had undergone various repairs and alterations during its working life. The remaining features were located on the northern side of the cone and included a small chimney base (351) which butted a rectangular flue (357) that cut through the cone wall, the chimney base built above part of the flue from the gas regenerator (structure 354) and constructed from the same dark red and blueish grey bricks. Flue 357 was constructed with the same bricks as chimney base 351 and incorporated a heavily sooted chequer-board arrangement of bricks. A deep U-shaped brick structure (135) also cut through the cone wall, this feature built of red bricks (220 x 100 x 70 mm), measuring 1.85 m long, 1.29 m wide and 0.96 m deep, the northern part removed by a machine pit in the German Silver Works. Structure 135 has been interpreted as a possible annealing oven, given its proximity to the cone. A short section of brickwork (392) with no clear facing lay to the south-west of this, comprising red and yellow bricks (220 x 100 x 70 mm) mortared together with a very distinctive dark brown mortar (**Plate 7**). Two small areas of brick floors were recorded in the southern part of the cone, both constructed of (burnt) red bricks, floor 343 butting up to the cone wall, whilst floor 344 crossed through the cone wall and is likely to represent one of the main entrances into the cone. Approximately 0.6 m beneath floor 343 was a very short, curvilinear section of wall (431), this lying 2.1 m above the lowest recorded part of flue 477.

Workshops and other external features

5.3.9 Away from the cone, several short lengths of walls were recorded, predominantly to the north and west, these interpreted as possible workshop areas. To the north-west the walls were associated with a possible fireplace and drain (Group 501, **Plate 8, Figure 4**). Overall, this workshop area measured at least 4.90 m long and 1.85 m wide. The walls were aligned NNE–SSW and WSW–ENE and constructed of red bricks (220 x 100 x 50 mm) bonded with a pink sandy mortar, laid in English bond. The walls were narrow, 0.22 m wide, and unlikely to have supported any substantial structure. Walls 229 and 241 butted wall 146 but were of almost identical construction and appeared contemporary. Walls 229 and 241 were truncated along their southern sides by structures associated with the German Silver works. At the north-west corner of the junction of walls 146 and 229 was a triangular shaped brick structure (227), this sat on a thin layer of concrete, possibly indicating the original floor level, and interpreted as a fireplace. Finally, aligned north–south, was a small brick drain which connected with a deeper drainage run to the east.

5.3.10 A second room or workshop (Group 502, **Figure 4**) was located to the south of workshop 501, this rectangular in form, measuring 3.9 m east–west by 2.9 m north–south. It was constructed with light reddish bricks in a light greyish pink mortar, the bricks not laid in a clear pattern. The walls all measured 0.23 m thick, with wall 277 appearing to have wall 253 added to it, which was angled slightly differently (**Plate 9**).

5.3.11 Along the northern part of the site were seven further short sections of narrow brick walls and drains, the most substantial walls adjacent to Group 501 (see above). Wall 204 and 207 formed a 0.6 m high L-shaped stretch of wall (**Plate 10**). Other, isolated walls which are thought to belong to the glassworks include a short section (133) between wall 27 and machine pit 108, this very similar to wall 392 and of poorly finished brick bonded lime mortar (**Plate 11**). Two further walls were recorded along the southern edge of the main excavation area, but these were too fragmentary to be very informative.

5.3.12 To the north-east of the cone was a yard surface (160) laid using very dark grey/red bricks (230 x 80 x 70 mm), which butted wall 161 built of red and yellow bricks. Surface 160 was cut by wall 27 to the south as well as machine pits 157 and 171, which showed it to be sat on a layer of made ground and redeposited natural 0.55 m thick, with a thin skin of concrete beneath it; a further 0.45 m of redeposited soils overlay natural (**Plate 12**), together suggesting that yard 160 was one of the later phases of the glassworks.

5.3.13 Various drainage runs associated with the glassworks were mapped and investigated. The main run (190) was aligned west to east (towards the canal) and extended from workshop Group 501. This drain run was cut by walls 16 and 35 and feeding into it from the south-west was a second drain that appeared to start from a pit (341; 1.8 m square and 1.2 m deep), the fills of which were appeared burnt (**Plate 13**), the brick-lined drain in a cut 0.7 m wide and 1.1 m deep.

5.3.14 The only other feature identified that may have been associated with the glassworks was a possible well (183) along the northern edge of the site, this having straight, vertical sides and located close to well 39 associated with the German Silver Works.

5.3.15 After the Park Glasshouse was demolished, the site was levelled in preparation for the construction of the German Silver Works. The deposits of demolition and levelling materials mainly comprised ash, sand and similar materials (**Plate 14**). For ease of recording all these deposits were given one number (132) outside of the cone and one number (137) within it.

5.3.16 In the south-west corner of the site was an area of disturbance that corresponded with the location (indicated on maps) of the large house which adjoined the Park Glasshouse, but no surviving *in situ* remains of this building were identified.

5.4 Barker and Allen German Silver Works

5.4.1 The cleaning and recording of floors, features and deposits within the German Silver Works was limited by Health and Safety considerations (see para. 4.1.2).

5.4.2 Three main types of floor surface were recorded (**Figures 1** and 7, constructed with dark grey blue Staffordshire Blue bricks, metal tiles 0.30 m square laid over concrete, and concrete (**Plate 15**). In the northern part of the site was an earlier floor, with a bricked-up doorway, interpreted by the 2018 evaluation as a glassworks floor (**Plate 9**)

5.4.3 The earliest walls (Group 497) were constructed with very dark red and grey bricks (230 x 100 x 70 mm), bonded with a yellowish-brown mortar, laid in English bond (**Plate 16**). The walls had stepped footings built on concrete foundations in the northern part of the site, while in the south there were no concrete foundations. The foundations were of variable depth and the footings in places stepped because of the changing slope across the site, with the foundation cut for the western part of wall 27 in the north 4 m deep.

5.4.4 Later walls were built in a similar fashion to the earlier ones, but the bricks used were much redder.

5.4.5 Most of the machine pits/bases in the works were in the southern and western parts of the site. All investigation of these pits was severely hampered by the extensive presence of asbestos-containing materials. However, the use/disuse of one machine base, formed of concrete, was dated to 1956 by a piece of newspaper containing an article discussing parliamentary debates on the proliferation of nuclear fuel, recovered from the bottom of the backfill. The machine pits/bases fall into two categories: one in which concrete or sandstone pads were used as bases for the, now removed, machinery, and the other being deep, brick-built pits, often with metal rods protruding from them. The machine pits were up to 4 m deep (where it was possible to investigate them) and varied in length and width (**Figure 7**).

5.4.6 In the north-west corner of the site was a weighbridge, the walls of this butting a series of cellars. It was agreed with the CA and the client that the cellars would not be investigated (partly because of Health and Safety concerns), the cartographic evidence suggesting that no construction had been undertaken in this part of the site until between 1908 and 1918 (Birmingham Archaeology 2005).

5.4.7 A probable well was recorded along the northern edge of the site, this feature not investigated, but it lay close to a possible well feature recorded as part of the Park Glasshouse.

5.4.8 Extensive and deep drainage were recorded, predominantly in the vicinity of the cone of the earlier glassworks, the drain runs connected by a series of manholes. The earlier drains were seen to exit into the adjacent canal through outlets in the canal wall, while the more recent drain runs appeared to flow away from the canal and probably joined the main sewer.

6 FINDS EVIDENCE

6.1 Introduction

6.1.1 A finds assemblage of moderate size was recovered from the site. Of most significance here is the material relating to the use of the site as a glass works: waste material (raw glass, cullet, paraisons etc) and other industrial residues, building material including firebricks, and metalwork including tools. A minor industrial component comprises a small group of button-making debris. There are also limited quantities of domestic refuse represented by pottery, clay tobacco pipe, animal bone, oyster shell.

6.1.2 All finds have been quantified by material type within each context, and the totals by material type are given in **Tables 1** (glassworking debris) and **2** (all other finds), with full list of pottery by context in **Appendix 1**.

Table 1 Summary of glassworking debris

Material	Weight (g)
Glass and Glassworking Waste (see Table 3)	26,674
Black Vitreous Waste	8855
Clinker	2942
Brick	5497
Crucible (not glassworking)	3427
Other Ceramic	4028
Miscellaneous	1053
ALL	**52,476**

Table 2 Other finds totals by material type

Material type	No.	Weight (g)
Pottery	121	5551
Ceramic Building Material	22	24,733
Clay Tobacco Pipe	69	286
Metalwork *Coins* *Copper alloy* *Iron*	94 *3* *88* *3*	 - - -
Worked Flint	1	13
Stone	5	8066
Animal Bone	6	108
Marine Shell *Oyster shell* *Button-making waste*	107 *3* *104*	1374 *58* *1316*

6.2 Glass and associated debris

Assessment methods

6.2.1 The excavation recovered a little over 50 kg of material that required assessment to determine its potential to provide further details on the nature of the glassworking at Park Glasshouse. All of the material submitted was examined visually and recorded following standard guidance (Historic England 2018). The material identified includes the following categories:

Material	Description
Glassworking waste	Material which has a form and/or nature that suggests a link with glassworking. The most obvious (and useful) examples of such waste are *moils*, *paraison ends* and *threads*. Moils are cylindrical fragments of glass that adhered to a blowing iron (or occasionally a pontil/punty). The inner surface of moil fragments usually shows some iron scale from the iron tool. Paraison ends are 'marbles of glass that have been pinched away from an object, such as happens when a stem is formed. Threads could be produced to make applied decoration; however, it is suspected that most were tests of glass viscosity. Other categories of glassworking waste include large fragments of glass (far thicker than any glass artefact), which usually display a high proportion of fracture surfaces. In so far as the form of such glass can be reconstructed, they appear to derive from relatively large masses of glass. While casting glass (before re-melting) is occasionally cited as a technique for refining glass, it is likely that much of this sort of material was produced accidentally when a crucible suffered a catastrophic failure. This suggestion is supported by the general observation that this sort of glass waste is almost always never colourless. It is usually green but the colour can vary even in the same fragment. Some of the examples from Park Glasshouse have regions that are blue. The final category of glass waste comprises devitrified glassworking waste. This covers material which escaped from a crucible and accumulated inside a furnace. The long exposure to high temperatures, as well as reactions with successive spillages of glass, and with fuel ash and bricks, encourages the near complete devitrification/crystallisation of this material. Some of this material may have undergone microphase separation rather than devitrification (cf Dungworth and Paynter 2011).
Crucible	Refractory ceramic vessel in which glass or metal was melted. None of the Park Glasshouse crucibles were used for glassmaking.
Refractory ceramic	Refractory ceramic but lacking a form that allows the certain identification as crucible or brick (usually because present as relatively small fragments).

Brick	Ceramic with extensive black or maroon glazed surfaces, confirming exposure to high temperatures (and probably coal-fired).
Black Vitreous Waste	An opaque black vitreous material which (in the context of Park Glasshouse and the succeeding silverworks) might be slag or glass waste. The material rarely shows original surfaces but the few examples that do tend to be rather flat with no sign of flow. Some fragments show a gradation towards ceramic suggesting that the material rested against a ceramic container. Some fragments show colour variations; this is most commonly maroon (cf clinker), but green colour is also seen.
Clinker	The vitrified ash of coal, usually black (sometimes maroon at the surface), and often porous.

Glossary

6.2.2 It is hoped that the terms used in this report have transparent meanings; however, to avoid confusion, some terms are discussed below:

Anneal	A glass can only be formed if it cools quickly enough (to prevent atoms solidifying in a regular lattice); however, such cooling can leave the glass in a stressed state that can eventually lead to spontaneous fracture. This fragility is removed by reheating the glass and then allowing it to cool slowly (annealing is also used in metalworking but it achieves slightly different effects).
Crystal	Crystal has two meanings in the context of glassmaking: 1. A crystal is any material where the atoms are arranged in a regular lattice. 2. The finest grades of colourless glass are sometimes called 'crystal' in reference to the ancient practice of carving vessels from a single lump of rock crystal.
Devitrification	If a glassy (vitreous) material is suitably heated, then its atoms can re-arrange themselves and form crystals. Prolonged melting and heating of glass can occasionally lead to devitrification/crystallisation. These crystals reduce the clarity of the glass (in extreme cases they can render it opaque) and the phenomenon was dreaded by most glassmakers.
German Silver	An alloy of copper, zinc and nickel which has a colour resembling that of silver. The alloy had originated in China but was developed in Germany (hence the name) and became increasingly popular in the second half of the 19th century due to its resemblance to actual silver and its corrosion resistance.
Glass	Any solid material can be a glass if it has cooled sufficiently quickly that it lacks any long-term atomic order. Slower cooling will provide more opportunities for atoms to arrange themselves in a regular, crystalline layout.
Nickel silver	See German Silver. The alloy was known in English as German Silver through the 19th century because of its origins, but the name was changed to Nickel Silver at about the time of the First World War.
Vitreous	A vitreous material is one which resembles glass, that is it lacks long-term atomic order. Some vitreous materials can be formed by heating a crystalline material to a temperature at which it begins to melt: the crystals will tend to dissolve in the glass.

Assessment results

6.2.3 The extensive truncation of the glassworks stratigraphy at Park Glasshouse leaves few opportunities to date contexts either stratigraphically or through the artefacts they contain. The assemblage is, therefore, treated as a whole, with limited regard to context. The initial categorisation of the material from the excavations shows that over half of this material is glass or glassworking waste (see **Table 1**). This material includes diagnostic working waste that has great potential to provide information on the nature of the glass manufactured.

6.2.4 The other major categories of material have much less potential. The most significant category (by weight) is also the least understood: Black Vitreous Material (**Plates 17–21**). This usually comprises broken fragments from larger masses, but the overall size and form of the original mass is uncertain (largely due to the abundance of fracture surfaces — (**Plates 17–19**). While most of this material is black, some examples show some maroon colouration (**Plate 19**), which recalls the colour of some examples of clinker (see below). One fragment of this material (**Plate 20**) showed abundant ceramic inclusions, and it is possible that these derive from the catastrophic failure of a crucible during use (a 'pot burst'). Another fragment (**Plate 21**) shows black vitreous material with an intact upper surface (one which is relatively smooth and flat) but an under-surface which transitions into a pale yellow highly vesicular material. It is not currently certain whether this lower zone is a glass or a ceramic. There are few features of this material which would (at the present time) lead to a certain explanation of the processes which produced it. It is possible that it was accidentally produced during glass melting. Any glass that fell into a furnace could react with clinker to form a thorough black vitreous material; however, subsequent heat would encourage devitrification and the fracture surfaces suggest that this material is largely free of crystals. Melting non-ferrous alloys (such as would occur in a silverworks) could result in reactions between non-ferrous metals and clinker which could produce a black vitreous material. If this material did derive from the silverworks, then it might be expected to display some green colouration due to the presence of copper corrosion products. While some of the clinker does show some green spots that suggest a link with the silverworks, the absence of any green colour in examples of the black vitreous waste suggests that it does not derive from melting copper alloys.

6.2.5 Clinker (vitrified coal ash) was produced by any process which employed coal fires that achieved sufficiently high temperatures, and, in some cases, this would include domestic fires. Clinker is found on numerous industrial sites, including glassworks, ironworks and various non-ferrous metalworking sites. Most examples of clinker have highly irregular shapes (**Plates 22** and **23**) that offer no clues to the specific process that produced them. In a few cases, the clinker showed occasional green spots that suggest it was used to heat a furnace in which copper alloys were melted.

6.2.6 None of the crucible fragments examined appear to have been used for melting glass. Most have been used and show severe external vitrification with colours that suggest a coal-fire. The interior surfaces (**Plate 24**) often display green patches that indicate the presence of copper corrosion products. It is most likely that these crucibles were employed to melt copper alloys and should be associated with the silverworks phase. One crucible fragment (**Plate 25**) is clearly unused: there is no vitrification and a (pasted?) label is present under the pouring spout. This appears to celebrate various European prizes and identifies the manufacturer as the Morgan Crucible Company, which indicates that the crucible was made after 1881.

6.2.7 The remaining materials recovered during excavation include durable residues from high-temperature industries which cannot currently be identified. The most numerous (and

distinctive) category of material included here comprises fragments of a ceramic cylinder (at least 0.3 m in diameter). This has almost no vitrification on the outer surface, but the interior surface has a prominent vitrified surface (dark grey to maroon) that suggests exposure to high temperature and coal ash/vapour. This vitrification extends to some fracture surfaces. This object would appear to have been a pipe or chimney.

6.2.8 The glass and glassworking debris provide the main material evidence for the manufacture of glass at Park Glasshouse. This material has been divided into four categories (**Table 4**).

Table 3 Summary of glass assessed

Material	Weight
Fractured Green Glass Lumps	7522
Amorphous Devitrified Glass	10,529
Colourless Glassworking Waste	3189
Other Glass and Glassworking Waste	5434
ALL (Glass)	**26,674**

6.2.9 Much of the glass is present as relatively large fragments but with abundant fracture surfaces (**Plates 26–29**) that suggest the glass was originally part of a much larger mass. The contemporary literature has relatively little to offer in the way of explanation. One suggested method of refining glass was to melt the glass, cast it, and then re-melt. Lumps of glass (or 'pot metal') have occasionally been linked to this idea (Tyler and Willmott 2005, 15); however, such lumps are almost always strongly coloured (usually green). Only the best colourless glass might have been improved by the suggested refining technique; and large fractured lumps of *colourless* glass are very rare.

6.2.10 A more mundane explanation for fractured lumps of glass such as these can be deduced from contemporary accounts of crucible failures (Anon 1846). In the mildest cases, a crucible might develop a slight crack which could be remedied by simply rotating the crucible so the crack faced the cooler outer part of the furnace. The most severe failure was a sudden and profound collapse that allowed hundreds of kilos of glass to escape into the furnace. If the furnace was coal-fired, with the bed adjacent to the crucibles, then the escaping glass could smother and extinguish the fire. Such an event would halt furnace operation for days or weeks and could produce substantial quantities of glass (although at least some should have fragments of partially burnt coal embedded in it). Any glass escaping into the furnace would tend to react with the vitrified surfaces as well as clinker: this would tend to make the glass dark green in colour. The colour variation observable in the large, fractured fragments of glass suggests that this glass has been contaminated to some extent (by clinker, other glass, etc). This model fits observations that can be made on the colour/transparency of this type of waste material (**Plates 26–29**). While some glass chunks have relatively uniform colour characteristics (**Plates 28**), most display significant variation consistent with mixing and/or contamination (**Plates 29**).

6.2.11 The most abundant glassworking material from Park Glasshouse comprises devitrified chunks of glass (**Plates 30** and **31**), but this category is usually the least useful for any reconstruction of details of the glassmaking processes employed.

6.2.12 Devitrification (the crystallisation of the glass) occasionally occurred during production, but it would reduce the transparency of the glass and, in all but the lowest quality bottle glass, made the artefacts almost unsaleable. Devitrification might not become apparent until the

objects had been formed and annealed. The size and form of the devitrified glass waste from Park Glasshouse shows that it has not been blown or otherwise formed into objects; this material resembles the fractured glass lumps discussed above but lacks transparency. It is likely that this material began as glass that had escaped into the furnace but the following weeks and months at high temperatures converted almost all the glass into crystals (devitrification). It is common for lumps of devitrified glass waste to incorporate some glassy regions — perhaps these represent later spillages? Some devitrified glass also shows contamination with distinct regions of clinker.

6.2.13 Previous examination of devitrified glass has shown that some of this material has undergone *microphase separation* rather than devitrification (cf Dungworth and Paynter 2011). Microphase separation involves the separation of a glass into two distinct glasses with sub-micron-sized droplets of one glass in a matrix of another glass. This separation is driven by the immiscibility of these two glasses but requires prolonged exposure to temperatures close to the melting temperature of the glass. In either case (devitrification or microphase separation), the physical properties of the glass are altered. The most obvious change is the loss of transparency but devitrified (or microphase separated) glass is also much harder to melt than the corresponding glass. Glassmakers were aware of this phenomenon and avoided using devitrified glass as cullet. Devitrified glass waste would have few other uses (road metalling?), but the increase in the melting temperature probably explains why so much of this debris was used in the rubble core of the siege. The presence of devitrified glass waste in the core of the siege confirms that this siege was not the first built on site.

6.2.14 The remaining material includes good examples of colourless glassworking waste with considerable potential to shed light on the nature of the glass manufactured. Two contexts (346) and (390) contained large quantities of small fragments of glassworking waste. The most distinctive type of material present (and often the most abundant) comprises fragments of moils (**Plates 32–33, Figure 8a**). These cylindrical fragments were ‘collars’ of glass that were left on the end of the blowing iron after the object had been formed and removed. They can often be identified by the presence of iron scale (from contact with the blowing iron) on the interior surface. Moils in other colours are also present, especially pale green ones (**Plate 34**). Moils are positive evidence for the production of mouth-blown glass. Moils have considerable potential for further analysis as they provide unequivocal evidence for the chemical nature of the glass that was produced. While many types of glassworking debris discussed above have the potential for extensive and misleading contamination by multiple materials, the moil was contiguous with a blown artefact and should have an identical chemical composition.

6.2.15 Another category of diagnostic working waste that shares a direct link with manufactured glass comprises waste glass known as paraison ends (**Plate 35**, cf Willmott 2005, 13). These are usually associated with the manufacture of mouth-blown drinking glasses.

6.2.16 The Park Glasshouse assemblage includes some colourless glass threads and puddles that are likely to be tests or proofs of glass viscosity. The high degree of heating necessary to melt the raw materials into glass produces a glass which is too fluid for most working operations. Once the glass had been formed it would be necessary to reduce the furnace heat and allow the glass to cool (and thicken) a little. Periodically, a lump of molten glass would be gathered to test its viscosity (runniness). The glass was held aloft and allowed to drop off the iron tool: the speed with which the glass stretched and detached would provide all the information that was required. Such tests or proofs are likely to be representative of the glass manufactured, although some could derive from an early stage of melting before the raw materials had fully reacted.

6.2.17 The remaining glass includes a limited variety of finished glass which is generally of too varied nature for any of it to be linked to manufacture on site. The base of a paraffin table lamp (**Plate 36**) has YPL&MO Co Ltd moulded on the underside: Young's Paraffin Lamp & Mineral Oil Company Limited was established in 1865. While the shade of glass is similar to the green moils in Plate 34, there is no certainty that the lamp was made on site. There are fragments from four separate glass bottles impressed with the maker's name: WALSH WALSH (**Plate 37**). These bottles would have been made in the Soho & Vesta glasshouse less than 1 km to the north (Holt *et al* 2014). It is ironic that the excavations at that glasshouse yielded no glass that could be dated to its earliest phase of activity, but it is present here (where it was almost certainly not made).

6.3 Pottery

Introduction

6.3.1 The pottery assemblage amounts to 121 sherds, weighing 5496 g, and is entirely of post-medieval/modern date. Condition is fair to good; although the assemblage is fragmentary, sherds are relatively unabraded. Mean sherd weight is 45.4 g, although this is slightly skewed by the presence of the thicker-walled sherds and heavier rims of some of the utilitarian wares. Despite the condition, the assemblage can be considered as largely redeposited; roughly one-quarter derived from deposits of demolition debris, and much of the remainder had been incorporated in construction cuts.

Table 4 Pottery totals by ware type (MNV = maximum number of vessels)

Ware type	No. sherds	Wt. (g)	MNV
Black-glazed redware	19	1203	16
Bone china	1	53	1
Developed creamware	5	85	5
English stoneware (salt-glazed)	23	2723	3
Feldspathic-glazed stoneware	2	111	2
Jackfield ware	2	27	2
Pearlware	16	280	13
Porcelain	1	4	1
Redware	4	113	4
Refined redware	1	26	1
Refined whiteware	27	278	23
Rockingham-type ware	1	65	1
Staffs-type mottled ware	2	102	2
Tinglazed earthenware	1	26	1
White salt glaze	3	63	3
Yellow ware	13	392	9
Total	**121**	**5551**	**87**

Methods of assessment

6.3.2 The assemblage has been quantified (sherd count and weight) by ware type within each context; **Table 4** gives a quantified breakdown of the assemblage by ware type. Details of identifiable vessel form (where known) and decoration have also been recorded. Estimated Vessel Equivalents (EVEs) have not been used as many of the rims have unmeasurable diameters; as an alternative means of quantification, the Maximum Number of Vessels

(MNV) has been used, counting each non-joining sherd as a separate vessel except where there is a high probability of a context containing same-vessel sherds (the fragmentation of the assemblage is reflected in the total MNV, which is 87, with many of the conjoins on fresh breaks). The level of recording accords with the 'basic record' advocated for the purpose of characterising an assemblage rapidly (Barclay et al 2016, section 2.4.5). A full breakdown of pottery by context is given in **Appendix 1**.

The assemblage

6.3.3 The assemblage shows an equal division (in terms of sherd count) between utilitarian wares (coarse redwares, stonewares and buff/yellow ware) and finer wares, mostly refined tea-/tablewares, with a few sherds of white salt glaze, mottled wares and tinglazed earthenware.

6.3.4 The redwares are mostly black-glazed, with one brown-glazed sherd. Three unglazed sherds belong to horticultural wares (flowerpot and saucer), but the remainder appear to belong mostly to bowls of varying sizes and include some large, thick-walled vessels, although the brown-glazed sherd is a handle, probably from a jug.

6.3.5 All but one of the 24 stoneware sherds are from a single salt-glazed vessel from context 426, a large, handled bottle for liquid (beverage) storage, featuring rouletted decoration around the shoulder (see Green 1999, fig. 134, no. 388). The remaining salt-glazed piece is a complete, small, flared blacking pot from the same context (ibid., fig. 139, no. 427; in Fulham mainly produced after 1865). The two feldspathic-glazed stoneware sherds are also from containers. The yellow/buff wares were used for kitchen bowls (in small to medium sizes), some with slipped decoration (banding or cabling).

6.3.6 The earliest finewares, dating to the later 17th or 18th centuries, were provided by mottled wares (hollow wares: bowls or cups), tinglazed earthenware (flatware, probably plate/dish) and white salt glaze (plates with scalloped edges and moulded decoration, flared bowl). Tea-/tablewares from the late 18th century and later are seen here in creamware, pearlware, refined whiteware and redware, Rockingham-type and Jackfield wares, bone china and porcelain, and comprise plates, cups, saucers and tea/coffeepots (but no serving dishes). There is one tiny saucer from a dolls' tea-set. Some are transfer-printed but no designs are complete enough to be recognisable. Other decoration includes hand-painting and sponging.

6.3.7 The redwares have a broad potential date range, but the associated wares suggest that there is little or nothing here that is earlier than 18th century. The refined wares extend the date range into the 19th century and probably into the early 20th century. The assemblage is entirely typical of working-class domestic refuse, with a range of cheaply produced and widely available kitchen- and tea/tablewares but lacking the element of table display in the form of serving dishes.

Provenance and dating

6.3.8 Pottery was recovered from 16 contexts, including two demolition deposits (132, 137), but the majority of the pottery came from the backfill of cut features. For five construction cuts (cut 191 for drain 190, cut 228 for wall 229, cut 381 for drain 382, cut 421 for the cone wall and cut 436 for wall 98) the pottery provides a terminus post quem for the construction, and this appears to focus on the 19th century, although some of the wares could extend into the early 20th century. Other feature backfills (well 183, cut 285, ditch 295, drainage cuts 422, 424, backfill of flue continuation) must be associated with their disuse, and the pottery is thus of lesser significance; wares from these features more frequently include those such as refined whiteware which could indicate a date range extending into the early 20th century.

6.4 Ceramic building material (CBM)

6.4.1 This category includes fragments of brick, tile, possible roof furniture and drainpipe. The assemblage is listed by context in **Table 5**.

Table 5 CBM by context

Context	CBM type	No.	Wt. (g)	Description
132	Firebrick	1	4000	curved refractory brick with square cross-section (80 x 85 mm)
137	Firebrick	2	3600	2 square-sectioned refractory bricks, 1 used and heavily burnt; the other unused, with longitudinal perforation
230	?roof furniture	2	166	conjoining frags from squared rim of cylindrical redware vessel (pale-firing); unglazed and blackened internally
267	Drainpipe	1	88	drainpipe, salt-glazed
267	Tile	1	562	tile fragment (width 115 mm) stuck on to a thick layer of mortar
363	Firebrick	4	6465	partial refractory bricks (pale-firing clay) dimensions ? x 100 x 70 mm; all with slaggy residues adhering; 2 stamped ...NN.. & Co / ...NWORTH
380	Drainpipe	1	119	drainpipe, unglazed
380	Firebrick	4	6000	3 square-sectioned refractory bricks (225–235 x 65–70 x 60 mm), all used and with surface residues/extreme burning; 2 marked KING BROTHERS / STOURBRIDGE; 1 partial brick, v heavily burnt/slaggy, ? x 105 x 55 mm
406	Drainpipe	1	144	drainpipe, salt-glazed
423	?Roof furniture	1	137	squared rim from cylindrical redware vessel, unglazed and blackened internally and over rim
426	Brick/tile	4	3452	2 frags heavily vitrified brick and tile; 2 frags floor tile with residues over broken edges (thickness 35 mm, 45 mm)

Firebricks

6.4.2 Of most relevance to the use of the site as a glassworks are 11 firebricks, all of which are likely to be local products. Fireclay extracted in the Black Country was considered to be of particularly good quality, and the brickyards in the region produced millions of firebricks in the 19th century, supplying all the industries of the British Empire.

6.4.3 Five of these, all complete examples, are rectangular firebricks with a near-square cross-section (lengths 225–35 mm, widths 55–75 mm, depths 57–65 mm). These were found in demolition deposit 137 and construction cut 378 (drain 379). The smallest example has a central longitudinal perforation; this appears to be an unused brick, but all the others show signs of use and are heavily burnt and/or have slaggy residues adhering. Two of the bricks (both from context 380) are stamped with the manufacturer's name: King Brothers of Stourbridge. This company operated 1860–1955 as manufacturers of 'firebricks, glasshouse pots, crucibles, retorts and all fireclay goods' (Old Bricks:England 13: K (brocross.com); King Brothers (Stourbridge) - Graces Guide).

6.4.4 Five other fragments all appear to be of one type, all pale-firing firebricks with dimensions of 100–105 mm (widths) by 55–70 mm (depths); no complete lengths survived. All have

slaggy residues adhering and one example is particularly heavily burnt. Examples came from pit 135 and construction cut 378 (drain 379). Two examples from pit 135 are stamped with the manufacturer's name, but this is only partially legible: …NN…& Co / …NWORTH (or possibly …MWORTH). The only possible candidate located is J D Canning of Tamworth (recorded as a manufacturer in 1877 and moved to Devon by 1881: Old Bricks:England 5 - Ca to Ch (brocross.com)).

6.4.5 There is one other firebrick, a curved example with roughly square cross-section (85 x 80 mm), from demolition deposit 132. This too shows signs of use and has been fairly heavily burnt.

Other CBM

6.4.6 Four further brick/tile fragments, all from construction cut 421 (for the cone wall), also show signs of industrial use. One fragment of tile and one of brick have been particularly heavily burnt, to vitrification, so that their original nature cannot be determined, while two tile fragments, both corners from plain unglazed floor tiles with chamfered edges, are not burnt but have residues over surfaces and broken edges.

6.4.7 One tile fragment from bedding layer 267, possibly another floor tile (width 115 mm), is stuck to a thick layer of mortar.

6.4.8 Two joining fragments from construction cut 228 (for wall 229) and one from drainage cut 422 may represent roof furniture, possibly chimney pots or louvers. In each case the fragments come from the squared 'rim' of a cylindrical or very slightly convex vessel, unglazed but with internal surfaces smoke-blackened (the blackening extends over the rim of the fragment from 422).

6.4.9 Fragments of drainpipe, two salt-glazed, were recovered from bedding layer 267, construction cut 378, and backfill layer 406 around a modern drain.

6.5 Other ceramics

6.5.1 This category consists largely of crucible fragments, with one telegraph insulator.

Crucibles

6.5.2 No complete crucibles were recovered, although the almost complete profile of a small example was found in demolition layer 132. This is a squat, cylindrical crucible with a pulled pouring spout; the part of the original paper label survives and identifies this as a product of the Morgan Crucible Company of Battersea. The Morgan brothers set up their factory in Battersea in 1856, and as the Patent Plumbago Syndicate made graphite crucibles as well as importing ceramic crucibles. The company adopted the name of Morgan Crucible Company in 1888 (Morgan Crucible Co - Graces Guide). The remaining crucible fragments are all from thicker-walled vessels in coarse fabrics; again, all appear to be from cylindrical vessels, but only body and base sherds are present.

Insulator

6.5.3 A telegraph insulator from demolition deposit 132 is in feldspathic-glazed stoneware.

6.6 Clay tobacco pipe

6.6.1 The breakdown of the clay pipes by context is given in **Table 6**. Of the 69 fragments recovered, 56 are stems, of which four are from spurred pipes, two of them with decorated bowls. Datable bowls came from four contexts; all are spurred forms and all are London types. Six bowls from demolition deposit 137 are all of the same type, dated c 1780–1820

(Atkinson and Oswald 1969, type 27). All the other bowls (one each from demolition context 132, backfill layer 406 and flue fill 492) are dated c 1850–1910 (ibid., type 31). The bowls are undecorated apart from moulded leaf motifs along the seams of two examples (one of type 27 and one of type 31), and there are no makers' marks.

Table 6 Clay pipes by context

Context	No. stems	No. bowls	Date of bowls	Comments
132	4	1	1850–1910	1 stem with spur
137	12	6 + 1 frag	1780–1820; 1850–1910	1 stem with spur
230	1			
363	2			
383	9			
406	7	1	1850–1910	
426	2			1 stem with spur
492	19	1 frag		undatable bowl frag; 1 stem with spur

6.7 Metalwork

6.7.1 The metalwork includes coins (3) as well as objects of copper alloy (88) and iron (3).

Coins

6.7.2 Two of the coins are British West African issues, one dated 1920 (the date on the other is illegible); these came from made ground 2 and demolition layer 11 respectively. The third coin, found unstratified, has been neatly cut in half but appears to be a 20th-century British issue. The recovery of the two British West African coins might be considered unusual in the context, but their occurrence here may be related to the fact that these are perforated coins, possibly utilised in a similar way to the perforated copper alloy discs (see below).

Copper alloy

6.7.3 Apart from a single button, the copper alloy objects appear to relate exclusively to the industrial use of the site, including possible structural fittings as well as items which could have some function in the glassworking process.

6.7.4 Three rods could be glassworking tools. The best preserved came from construction cut 436 (for wall 98) and comprises a slightly tapering rod with roughly ovoid cross-section (length 180 mm). Two objects from demolition deposit 137 could have been similar but are very badly damaged and corroded. A group of objects from demolition deposit 132 are of uncertain function. These comprise 49 discs, all but two of them with small, opposed perforations at the edge, roughly half of which were found threaded on two separate short lengths of wire. Most conform to a diameter of 39 mm, with two at 49 mm, and the two unperforated examples at 33 mm. Four further discs of similar form (with diameters ranging from 32–45 mm) came from made ground 2.

6.7.5 A squashed hollow spheroid made from sheet metal in two halves (construction cut 228) could have been a handle of some kind. Other objects consist of miscellaneous wire, strip, bar and plate fragments of unknown function.

Iron

6.7.6 The iron objects include an S-hook and a large screw from construction cut 228 (for wall 229). A heavily corroded curving rod/bar fragment from demolition deposit 132 is of unknown function.

6.8 Animal bone

6.8.1 Six pieces of animal bone were recovered, including a sheep metapodial and a cattle-size long bone shaft fragment.

6.9 Marine shell

6.9.1 The 107 fragments of shell recovered include three oyster shells; the remainder comprises button-making waste.

Oyster shell

6.9.2 The oyster shell, recovered from pit 341 and construction cut 381 (for drain 382), represents very small-scale deposition of domestic refuse. The three shells comprise one right valve (preparation waste) and two left valves (consumption waste).

Button-making waste

6.9.3 The remainder of the shell consists of fragments of mother-of-pearl, all showing the removal of circular blanks of various sizes (Bevan et al 2009, fig. 8.7). Most of these fragments came from demolition deposit 137, with small quantities from drainage cuts 422 and 424 and construction cut 421 (for the inner part of the cone wall). It could well have been introduced to the site from elsewhere, but its provenance suggests that it resulted from button-making which pre-dated the construction of the glassworks.

6.9.4 Birmingham was a major centre of button-making from the 1760s onwards, and the industry is relatively well documented there, although as yet there has been little published archaeological evidence (White 1977; Bevan et al 2009, 179–80). Pearl button manufacture used imported shells from various far-flung sources, including the East Indies, the Philippines and the Persian Gulf. The waste material seen here comprises various fragments of cut shell showing the removal of multiple circular blanks with a tubular saw (Bevan et al 2009, fig. 8.7). The pearl button industry in Birmingham and elsewhere was hit in the 1850s by the cessation of trade with the United States after the American Civil War, and the subsequent rise of the button industries of America, Paris and Vienna, and it was further affected by the growing popularity of other raw materials, such as corozo nut (a form of vegetable ivory) and horn. It was to be finally superseded by plastic (the earliest plastic was patented in 1862) around the turn of the 19th century. The site lies just to the west of the main concentration of mechanised button-making in 19th-century Birmingham (White 1977, fig. 2), but may have resulted from the output of a small workshop as shell button-making (in comparison to the manufacture of metal buttons) required relatively low levels of mechanisation (Bevan et al 2009, 180).

6.10 Conservation

6.10.1 Objects in potentially unstable condition, and therefore possibly in need of conservation treatment, comprise the metalwork. The ironwork in particular is in poor condition and heavily corroded. The metalwork is currently packed in as stable a condition as possible, in airtight polythene tubs with drying agent (silica gel).

7 STATEMENT OF POTENTIAL

7.1 Stratigraphic potential

Discussion

7.1.1 Several truncated sections of curved wall were identified which formed the base of the cone, that acting as the combined cover building and chimney for the furnace (**Plates 38** and **39**). The existence of a cone is somewhat at odds with the only illustration of the Park Glasshouse (Crossley 2003, 183; **Figure 2b**) which shows a rectangular building with a large central chimney; however, that illustration is from 1800, while the excavated furnace remains are probably from 60 years later, dating to the mid-19th century.

7.1.2 The remains of the cone wall (**Plates 38** and **39**) suggest that the cone had an internal diameter of 11 m and an external diameter of 13 m. This is close to the lower end of the range given by Ure of '50 to 80 feet' (Ure 1839, 577) but somewhat smaller than excavated furnaces of the late 18th and early 19th centuries (**Figure 8b**). Only Gawber (Ashurst 1970) is comparably small, but that was dated to the 1730s. It is not clear why the Park Glasshouse cone was so small.

7.1.3 The only remains of the actual furnace were parts of a single siege or pot bank (**Plates 38**–**43**), and presumably a second had existed a few metres to the west. The top of the siege was missing and so it was not possible to determine how many crucibles were placed on it (or how large the crucibles were). The west side of the siege showed extensive vitrification and erosion, suggesting prolonged exposure to very high temperatures. This part of the furnace also contained bricks arranged in a chequer-board fashion (**Plates 40** and **41**) that are presumed to have been part of the application of regenerative principles.

7.1.4 A later cut through the siege provided a rare opportunity to record its construction (**Plates 42** and **43**). Contemporary descriptions (*eg* Muspratt 1860, 199–200) often stress the use of the finest refractory clay for bricks used to construct furnaces. Stourbridge is regularly cited as the source of the most refractory clay, and many authorities recommended the additional use of copious quantities of ground crucible (grog). The section through the Park Glasshouse siege showed refractory bricks forming the walls (**Plate 42**), with the core comprising devitrified glass 'rubble' and also incorporating part of a (used) crucible (**Plate 43**). Much of the material (especially the bricks forming the walls) had partially fused as a result of heat.

7.1.5 Devitrified glass is much harder to melt than glass in a vitreous state, and it is likely that this material forming the core of the siege derived from spillages in an earlier furnace. Contemporary accounts record accidents in which a crucible pot burst, and while attempts would also be made to remove spilt glass from inside the furnace (especially during periodic re-builds), it is likely that spilt glass would build up in the lower parts. Such waste would be suitable for re-use as 'rubble' in the core of a later furnace.

7.1.6 In addition, remains of a regenerator chamber were identified by the chequer-board arrangement of the bricks. This probably relates to the one described in Siemen's initial (1862) exposition of the use of regenerator technology in glass furnaces.

7.1.7 Whilst these and other remains of the Park Glasshouse were fragmentary, there appears to have been two or three phases represented, although the stratigraphic relationships between these phases are limited. Certainly, the structures associated with the glassworks underwent a number of changes and alterations in the century of use.

7.1.8 The evidence for structures away from the cone, with the possible exception of floor 160, cannot be phased, and it may be that these buildings continued to be used with little modification throughout the life of the glassworks, with the only major structural changes occurring within and around the furnace and cone.

Discussion

7.1.9 The excavation of the Park Glasshouse uncovered some remains of the glass furnace and an associated cone building, this mainly relating to the phase 3 (1861–74) period of operation. The demolition of the glassworks and the construction (and demolition) of the late 19th-century Barker and Allen German Silverworks has resulted in almost no survival of above ground stratigraphy associated with the glassworks; in addition, much of the below-ground stratigraphy has been truncated by later activity. Several sections of curving wall represent the remains of the brick cone that would have acted as cover building and chimney to the furnace. The furnace itself is represented by the remains of one (of two) sieges or banks on which the crucibles were set, with a section through it providing (rare) details of its construction. To one side of this siege were the remains of a regenerator chamber, this of some importance in the history of the Industrial Revolution as it is mentioned in some detail in Siemen's first (1862) publication on the application of regenerator technology in the glass industry.

7.1.10 While much of the glassworking debris that has been recovered shows some signs of mixing, and so is of limited value in understanding the nature of the glass that was manufactured, several deposits yielded useful debris such as moils, paraison ends and threads. The potential for further analysis is greatest in terms of the early application of regenerative heat technology, siege construction, and glass composition (see below).

7.1.11 The historical evidence suggests three main phases of glassworks activity; however, identifying contexts which relate specifically to these three phases may not always be possible.

Phase 1: 1788/1792–1808 Hawkers. Presumed flint glass. Mouth-blown. Potentially free-blown but some use of moulds might be expected.

Phase 2: 1808–1861 Biddle & Lloyd, Lloyd and Summerfield. Flint glass with diversification(?) after 1845 repeal of Glass Excise. Potential introduction of press-moulding. Ends with the introduction of Siemens' regenerative furnace.

Phase 3: 1861–1874 Lloyd & Summerfield. Flint (and other?) glass. The new furnace would have enabled changes in glass recipe.

7.2 Finds potential

Glassworking evidence

7.2.1 Research questions which the glassworking evidence has the potential to answer focus on three technological aspects of the process:

- Heat regeneration
  The analysis of the regenerator bricks/chamber in relation to the development of this technology (especially the specific contemporary description of its application on this site) is impeded by the limited survival of the relevant stratigraphy. The analysis should be based on a comparison of the historical and archaeological records.

- Siege construction
  The analysis of the siege construction should compare the results of this excavation with other excavated glass-melting furnaces and include a review of contemporary written sources. A selection of the devitrified glass 'rubble' fill should be characterised in terms of chemical composition in order to test assumptions about what this material is and how it formed. Although devitrified glass waste is often contaminated and provides limited information on the nature of the glass that was made, in this case it might provide the only opportunity to study the glass made *before* the regenerative furnace was constructed.

- Glass composition
  Useful glassworking waste (especially moils) have been recovered from several contexts and have considerable potential to show what sorts (recipes) of glass were being produced. Some of the materials that might normally be seen as of limited value (the devitrified waste from the core of the siege) should also be analysed as it might provide the only opportunity to investigate glass produced on this site before 1861.

Domestic refuse

7.2.2 This material (pottery, clay tobacco pipe, animal bone, oyster shell) occurred in small quantities and is more incidental to the main use of the site. It may represent either material brought in from elsewhere during backfilling episodes, or perhaps small-scale messing facilities for workers. The pottery has provided some (fairly broad) dating for some features, but these finds have very limited archaeological potential and little or no further research potential.

7.3 Summary of potential

7.3.1 The Park Glasshouse is an important part of Birmingham's early industrial history. This glasshouse was run by a series of innovators, shown in the early adoption of the canal as a method of transporting materials, and also in the adaption of the furnace to incorporate a Siemens gas regenerator.

7.3.2 The archaeological assessment has shown that the greatest potential for additional research lies in the technological analysis of the glassworking waste, as well as in further examination of the recorded structural remains associated with the cone. The photogrammetric recording of these remains will enable digital reconstruction with the potential to recreate this and other types of cone; the 1800 illustration of the Park Glasshouse shows a different type of building, suggesting a 'shed' structure (**Figure 2b**).

8 UPDATED PROJECT DESIGN

8.1 Updated project aims

8.1.1 Taking into account the historical significance of the Park Glasshouse, the predominantly mid-19th-century date of the excavated remains and the associated assemblage of glassworking debris recovered it is considered appropriate that some further analysis of the structural sequence be undertaken, as well as technological investigation of some of the related waste materials. This will enable as full as possible an account to be produced of these regionally important glassworks, and the results more widely disseminated.

8.1.2 No further analysis of the remains of the 1896 Barker and Allen German Silverworks is proposed, particularly given the limited evidence recovered (primarily the ground floor plan).

8.2 Stratigraphic and historical evidence – recommendations for analysis

8.2.1 The Park Glasshouse excavation revealed remains of furnace structures that are of considerable importance in the history of glass manufacture and the associated furnace technologies. The post-excavation analysis of the stratigraphic and photographic records and preparation of a report will be enhanced by dialogue between the archaeological report writer (Rachel Williams) and the glassworking specialist (David Dungworth).

8.2.2 Analysis will focus on refining the chronology of the cone and related structures.

8.2.3 Digital reconstruction of the cone will be attempted to provide possible alternative structures that the recorded cone walls could have supported.

8.2.4 Further background historical research will be undertaken, specifically relating to furnace/siege construction.

8.2.5 The regenerator stratigraphy and comparison with historical records will be discussed, particularly with reference to early generator technology.

8.3 Finds evidence – recommendations for analysis

Glassworking debris

8.3.1 The Park Glasshouse assemblage includes a substantial collection of diagnostic glassworking waste (finished glass is rare and might have no direct connection with the glass that was made there). This material is significant and has considerable potential to reveal glass manufacturing technologies in the 19th century. It is recommended that a selection of material is subjected to scientific analysis to realise this potential. Some targeted further analysis is proposed in order to explore various technological aspects of the glassworking process, and to set this in its historical context.

8.3.2 The selection of samples for analysis (**Table 7**) should be structured by the following principles:

- Representative. Sampling should respect the overall proportions of material present but be modified by the potential of each context and material type. Material categories which have previously been shown to have limited potential will not be sampled;
- Site phasing. Can any stratigraphy be assigned to the phases of glass manufacture outlined above? Does any glassworking waste derive from these contexts?
- Glass colour. All colours present as glassworking waste should be sampled at least once. Sampling finished vessels in colours not present in the glassworking waste should be approached cautiously as such vessels could have been produced elsewhere.

8.3.3 Forty selected samples will be analysed using inductively coupled plasma (ICP) spectroscopy. This will provide detailed information on chemical composition for a wide range of elements and to a great sensitivity (detection limit). The ICP analysis will be carried by the British Geological Survey (Keyworth laboratories) and will include the analysis of reference material to ensure good data quality. The data will comprise an Excel spreadsheet listing chemical concentration of all analysed elements for each sample (as well as reference materials).

Table 7 Contexts from which glassworking samples should be selected for analysis

Context	Comments	Weight
132	Colourless and green working waste	1.7 kg
136	Colourless working waste	0.2 kg
137	Colourless and green working waste	4.4 kg
230	?	0.3 kg
287	?	0.2 kg
342	Mixed working waste	0.4 kg
346	Colourless and coloured working waste	1.5 kg
363	Mixed working waste	0.9 kg
383	Mixed working waste	3.1 kg
390	Mixed working waste	0.9 kg
401	Mixed working waste	0.2 kg
406	?	0.4 kg
425	?	0.2 kg
426	Mixed working waste	0.5 kg
437	Colourless working waste	0.1 kg
492	Colourless working waste	0.1 kg

8.3.4 The results of chemical analysis will be discussed in relation to glasshouse history and other analyses of contemporary glass (*eg* Dungworth and Brain 2009; 2013; Dungworth 2019; Holt *et al* 2014; Willmott *et al* 2012).

Other finds

8.3.5 Given the very limited potential of the remainder of the finds assemblage, no further analysis is proposed. The information presented in this report can be adapted for incorporation in the publication report if required.

Conservation

8.3.6 On the basis of the condition of the metal objects, their nature, date range and provenance, no conservation work in terms of cleaning and/or stabilisation is proposed. It is proposed that all identifiable objects (other than nails, or miscellaneous bar fragments) are photographed and/or X-radiographed to create a basic archive record for this material type, for which selective retention is proposed (see **Appendix 2**, Selection Strategy).

8.4 Proposals for publication

8.4.1 The results from the archaeological excavation in 2020 (and previously related work) of the Park Glasshouse, as well as those from the related technological investigations proposed, are worthy of publication.

8.4.2 It is considered that the most appropriate place for publication will be as an article in the 'Industrial Archaeological Review' (IAR), a peer-reviewed journal with an international readership. The IAR has agreed to publish the piece based on an abstract. In addition, the full results of the technological investigations can be made available on-line to a more specific scientific audience.

9 STORAGE AND CURATION

9.1 Museum

9.1.1 The archive resulting from the excavation is currently held at the offices of Wessex Archaeology in Salisbury. Birmingham Museum Service has agreed in principle to accept the archive on completion of the project, under the accession code **2020.20**. Deposition of any finds with the museum will only be carried out with the full written agreement of the landowner to transfer title of all finds to the museum.

9.2 Preparation of the archive

Physical archive

9.2.1 The physical archive, which includes paper records, graphics, artefacts and ecofacts, will be prepared following the standard conditions for the acceptance of excavated archaeological material by Birmingham Museum Service and in general following nationally recommended guidelines (SMA 1995; CIfA 2014d; Brown 2011).

9.2.2 All archive elements will be marked with the **accession code 2020.20**, and a full index will be prepared. The physical archive currently comprises the following:

- 10 boxes of artefacts, ordered by material type, plus unboxed large stones;
- 2 files/document cases of paper records and A3/A4 graphics;
- 1 sheet A1 graphic.

9.2.3 Archive quantities, particularly for finds boxes, are likely to be reduced significantly following implementation of the proposed archive selection strategy (see below).

Digital archive

9.2.4 The digital archive generated by the project, which comprises born-digital data (eg site records, survey data, databases and spreadsheets, photographs and reports), will be deposited with a Trusted Digital Repository, in this instance the Archaeology Data Service (ADS), to ensure its long-term curation. Digital data will be prepared following ADS guidelines (ADS 2013 and online guidance) and accompanied by metadata. Full details of the collection, processing and documentation of digital data are given in the project Digital Management Plan (available on request).

9.3 Selection strategy

9.3.1 It is widely accepted that not all the records and materials (artefacts and ecofacts) collected or created during the course of an archaeological project require preservation in perpetuity. These records and materials will be subject to selection in order to establish what will be retained for long-term curation, with the aim of ensuring that all elements selected to be retained are appropriate to establish the significance of the project and support future research, outreach, engagement, display and learning activities, ie the retained archive should fulfil the requirements of both future researchers and the receiving Museum.

9.3.2 The selection strategy, which details the project-specific selection process, is underpinned by national guidelines on selection and retention (Brown 2011, section 4) and generic selection policies (SMA 1993; Wessex Archaeology's internal selection policy: available on request) and follows CIfA's *Toolkit for Selecting Archaeological Archives*. It should be

agreed by all stakeholders (Wessex Archaeology's internal specialists, external specialists, local authority, museum) and fully documented in the project archive.

9.3.3 In this instance, the main interest of the site lies in the recovery of evidence for its former use as a glassworks; the element of domestic refuse is of lesser significance.

9.3.4 Detailed selection proposals for the complete project archive, comprising finds, environmental material and site records (analogue and digital), are made in the site-specific Selection Strategy (Appendix 2). The proposals are summarised below.

Finds

9.3.5 The most significant part of the assemblage is the glassworking debris, but this is quite repetitive; selective retention is recommended, to preserve a representative sample. Very selective retention of other material types is recommended, focusing on items of intrinsic interest (marked refractory bricks, gunflint, shell button-making waste).

Documentary records

9.3.6 Paper records comprise site registers (other pro-forma site records are digital), drawings and will also include hard copies of reports (Written Scheme of Investigation, client reports, publication report). All will be retained and deposited with the project.

Digital data

9.3.7 The digital data comprise site records (tablet-recorded on site) in spreadsheet format; finds records in spreadsheet format; survey data; photographs; reports. All will be deposited, although site photographs will be subject to selection to eliminate poor quality and duplicated images, and any others not considered directly relevant to the archaeology of the site.

9.4 Security copy

9.4.1 In line with current best practice (eg, Brown 2011), on completion of the project a security copy of the written records will be prepared, in the form of a digital PDF/A file. PDF/A is an ISO-standardised version of the Portable Document Format (PDF) designed for the digital preservation of electronic documents through omission of features ill-suited to long-term archiving.

9.5 OASIS

9.5.1 An OASIS (online access to the index of archaeological investigations) record (http://oasis.ac.uk) has been initiated, with key fields completed (Appendix 3). A .pdf version of the final report will be submitted following approval by the CO for BCC on behalf of the LPA. Subject to any contractual requirements on confidentiality, copies of the OASIS record will be integrated into the relevant local and national records and published through the Archaeology Data Service (ADS) ArchSearch catalogue.

10 COPYRIGHT

10.1 Archive and report copyright

10.1.1 The full copyright of the written/illustrative/digital archive relating to the project will be retained by Wessex Archaeology under the *Copyright, Designs and Patents Act 1988* with all rights reserved. The client will be licenced to use each report for the purposes that it was produced in relation to the project as described in the specification. The museum, however, will be granted an exclusive licence for the use of the archive for educational purposes,

including academic research, providing that such use conforms to the *Copyright and Related Rights Regulations 2003*.

10.1.2 Information relating to the project will be deposited with the Historic Environment Record (HER) where it can be freely copied without reference to Wessex Archaeology for the purposes of archaeological research or development control within the planning process.

10.2 Third party data copyright

10.2.1 This document and the project archive may contain material that is non-Wessex Archaeology copyright (eg, Ordnance Survey, British Geological Survey, Crown Copyright), or the intellectual property of third parties, which Wessex Archaeology are able to provide for limited reproduction under the terms of our own copyright licences, but for which copyright itself is non-transferable by Wessex Archaeology. Users remain bound by the conditions of *the Copyright, Designs and Patents Act 1988* with regard to multiple copying and electronic dissemination of such material.

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APPENDICES

Appendix 1 Pottery by context

Context	Ware	No. sherds	Wt. (g)	MNV	Comment
132	White salt glaze	2	44	2	plate rims, scalloped & moulded dec
132	Pearlware	1	80	1	chamberpot rim, transfer-printed
132	Refined whiteware	1	16	1	flared cup profile; handle stumps; hand-painted dec
132	Tinglazed earthenware	1	26	1	flatware base
132	Refined whiteware	1	5	1	flatware body sherd
132	Refined whiteware	1	13	1	plate rim, transfer-printed
132	Pearlware	1	7	1	plate base
132	Pearlware	2	24	1	transfer-printed plate rim sherds, non-joining but prob same vessel
132	Feldspathic-glazed stoneware	1	16	1	body sherd
132	Staffs-type mottled ware	1	62	1	base sherd,, glazed int & ext
132	Black-glazed redware	1	81	1	base of cylindrical vessel (?tankard); glazed ext & int
132	Black-glazed redware	1	165	1	body sherd; int black glaze over red slip
137	Refined whiteware	1	15	1	jug rim, sponged dec
137	Refined whiteware	1	9	1	transfer-printed plate rim
137	Refined whiteware	1	1	1	transfer-printed (green) cup rim
137	Pearlware	1	1	1	transfer-printed body sherd
137	White salt glaze	1	19	1	flared bowl rim
137	Refined whiteware	1	15	1	hollow ware body sherd, hand-painted dec
137	Refined whiteware	1	5	1	flatware base with backstamp [?D]ORIS
137	Rockingham-type ware	1	65	1	tea/coffepot lid, knop missing; moulded dec
137	Redware	1	23	1	brown-glazed handle (?jug)
137	Black-glazed redware	3	24	1	thin-walled rims & body sherd, non-joining but probably all 1 vessel (convex bowl)
137	Jackfield ware	1	8	1	cylindrical cup rim
137	Jackfield ware	1	19	1	teapot handle
137	Black-glazed redware	1	23	1	body sherd, glazed ext & int
137	Black-glazed redware	1	14	1	base of cylindrical vessel (?tankard); glazed ext & int
137	Black-glazed redware	1	28	1	base sherd, glazed int
137	Redware	2	40	2	unglazed flowerpot rim & base, poss same vessel
191	Pearlware	1	10	1	flatware base
230	Refined redware	1	26	1	teapot body/handle, black-glazed
230	Porcelain	1	4	1	complete saucer from dolls' teaset

Context	Ware	No. sherds	Wt. (g)	MNV	Comment
230	Black-glazed redware	2	300	1	large flared bowl; overhanging collared rim pressed in at regular intervals; surface concretion over all
249	Refined whiteware	1	30	1	saucer profile, transfer-printed
249	Refined whiteware	1	2	1	flatware rim, banded dec
249	Refined whiteware	2	46	2	body sherds, plain
249	Refined whiteware	2	17	1	flatware base
287	Pearlware	1	4	1	small bowl rim
287	Refined whiteware	1	4	1	body sherd, hand-painted dec
287	Yellow ware	1	8	1	body sherd, banded dec
296	Redware	1	50	1	unglazed flowerpot saucer profile
297	Pearlware	2	38	1	plate profile, blue feathered edge
383	Developed creamware	1	9	1	jug rim
383	Refined whiteware	1	3	1	bowl rim, blue banded dec
383	Pearlware	2	23	1	plate profile, blue feathered edge
383	Developed creamware	1	12	1	flatware base sherd
383	Developed creamware	1	38	1	flatware base sherd, slightly burnt
383	Refined whiteware	1	10	1	cup rim, sponged dec
383	Pearlware	1	16	1	hollow ware base, hand-painted dec; slightly burnt
383	Black-glazed redware	1	61	1	base sherd; int black glaze over red slip
406	Black-glazed redware	1	12	1	body sherd, glazed int & ext
406	Refined whiteware	2	8	2	transfer-printed flatware body sherds
406	Refined whiteware	1	13	1	hollow ware base sherd; transfer-printed (green, seaweed pattern)
423	Black-glazed redware	1	9	1	small rim, open form, trailed slip on rim
423	Yellow ware	2	182	1	flared bowl rim
423	Feldspathic-glazed stoneware	1	95	1	base sherd
423	Staffs-type mottled ware	1	40	1	hollow ware body sherd, glazed ext & int
423	Black-glazed redware	1	24	1	flanged bowl/dish rim
423	Black-glazed redware	1	15	1	body sherd, glazed int & ext
423	Pearlware	1	12	1	saucer rim, hand-painted dec
423	Pearlware	1	56	1	thick-walled base, marbled (?washstand bowl?)
425	Black-glazed redware	1	263	1	base sherd, glazed int
426	Bone china	1	53	1	cup profile; mauve sprigged dec
426	English stoneware	21	2655	1	large handled flagon, most of vessel present; rouletted on shoulder (Green 1999, fig. 134, no. 388)
426	English stoneware	1	63	1	complete small flared blacking pot (Green 1999, fig. 139, no. 427)

Context	Ware	No. sherds	Wt. (g)	MNV	Comment
426	Black-glazed redware	1	58	1	base sherd, glazed int
426	Black-glazed redware	1	34	1	narrow base sherd, glazed int & ext; firing scar on base
426	Yellow ware	1	32	1	flared bowl rim
426	Yellow ware	1	17	1	body sherd
426	Yellow ware	4	117	3	base sherds
437	Refined whiteware	4	47	1	small plate profile; transfer-printed
492	Black-glazed redware	1	92	1	thick-walled body sherd, glazed int
492	Pearlware	1	2	1	small rim ?(bowl), transfer-printed
492	Refined whiteware	1	6	1	flatware body sherd, transfer-printed
492	Refined whiteware	1	4	1	plain body sherd
492	Refined whiteware	1	9	1	bowl rim, banded dec
492	Pearlware	1	7	1	plain body sherd
492	Developed creamware	1	3	1	body sherd, banded dec
492	Yellow ware	1	6	1	rim (?jug) with banded dec
492	Yellow ware	3	30	1	slip-decorated body sherds, non-joining but prob all 1 vessel
492	Developed creamware	1	23	1	base of cylindrical vessel (?jar)

Appendix 2 Selection strategy

Appendix 3 OASIS record

OASIS ID: wessexar1-408532

Project details

Project name	Soho Loop, Dudley Road, Birmingham, West Midlands
Short description of the project	Wessex Archaeology was commissioned by RPS Consulting, on behalf of Soho Loop Ltd, to conduct an archaeological excavation covering 0.17 hectares at the site of a late 19th century German Silver Works and late 18th century Glassworks at Soho Loop, Dudley Road, Birmingham, B18 718.The excavation followed on from a Desk-based Assessment and two previous trial trench evaluations, was undertaken in two phases with the initial phase focussing on recording the floor plan of the 1896 Barker and Allen German Silver Works, works within this phase were severely limited by the presence of suspected asbestos containing materials scattered across the area. The main investigation comprised the recording of the Park Glasshouse which revealed the cone, one of the sieges, parts of the flue system, part of a Siemens gas regenerator within the central portion of the Site. Some walls and possible workshop areas were also recorded, however much of the Glassworks had been heavily truncated by the construction of the Silver Works. Natural deposits were noted in the western and central parts of the Site, natural deposits were not reached in the eastern part of the Site, this was also the most heavily contaminated part of the Site. Artefacts recovered from the Site include material relating to the use of the site as a glassworks: waste material (raw glass, cullet, paraisons etc) and other industrial residues; building material including firebricks; metalwork including tools. A minor industrial component comprises a small group of button-making waste. There are also small quantities of domestic refuse (pottery, clay tobacco pipe, animal bone, oyster shell. Most of the artefacts were recovered from made ground. Dr David Dungworth was consulted throughout the project to ensure suitable and appropriate artefact retrieval and sampling strategies were employed.
Project dates	Start: 28-09-2020 End: 18-12-2020
Previous/future work	Yes / No
Any associated project reference codes	238300 - Contracting Unit No.
Any associated project reference codes	2018/10294/PA - Planning Application No.
Any associated project reference codes	20.2020 - Museum accession ID
Type of project	Recording project
Site status	None
Current Land use	Vacant Land 3 - Despoiled land (contaminated derelict and ?brownfield? sites)
Monument type	GLASSWORKS CONE Post Medieval

Monument type	GLASSWORKS FLUE Post Medieval
Monument type	GAS REGERATOR Post Medieval
Monument type	GLASSWORKS SIEGE Post Medieval
Monument type	WALL Post Medieval
Monument type	FLOOR Post Medieval
Monument type	MACHINE PIT Post Medieval
Monument type	WELL Post Medieval
Significant Finds	GLASS Post Medieval
Significant Finds	DEVITRIFIED GLASS Post Medieval
Significant Finds	CRUCIBLE Post Medieval
Significant Finds	CLAY TOBACCO PIPE Post Medieval
Significant Finds	POTTERY Post Medieval
Significant Finds	BRICK Post Medieval
Investigation type	"Full excavation"
Prompt	Planning condition

Project location

Country	England
Site location	WEST MIDLANDS BIRMINGHAM Soho Loop, Dudley Road
Postcode	B18 7BS
Study area	0.17 Hectares
Site coordinates	SP 04962 87621 52.486116199501 -1.926919699371 52 29 10 N 001 55 36 W Point
Height OD / Depth	Min: 137m Max: 141m

Project creators

Name of Organisation	Wessex Archaeology
Project brief originator	RPS Consulting Services
Project design originator	Wessex Archaeology
Project director/manager	John Winfer

Project supervisor	Rachel Williams
Type of sponsor/funding body	Construction company
Name of sponsor/funding body	Soho Loop Ltd

Project archives

Physical Archive recipient	Birmingham Museums Trust
Physical Archive ID	20.2020
Physical Contents	"Animal Bones","Ceramics","Glass","Industrial","Metal"
Digital Archive recipient	Birmingham Museums Trust
Digital Archive ID	20.2020
Digital Media available	"Database","Images raster / digital photography","Moving image","Spreadsheets","Survey"
Paper Archive recipient	Birmingham Museums Trust
Paper Archive ID	20.2020
Paper Media available	"Aerial Photograph","Diary","Drawing","Photograph"

Entered by	Rachel Williams (r.williams@wessexarch.co.uk)
Entered on	23 April 2021

Date:	02/06/2021	Revision Number:	0
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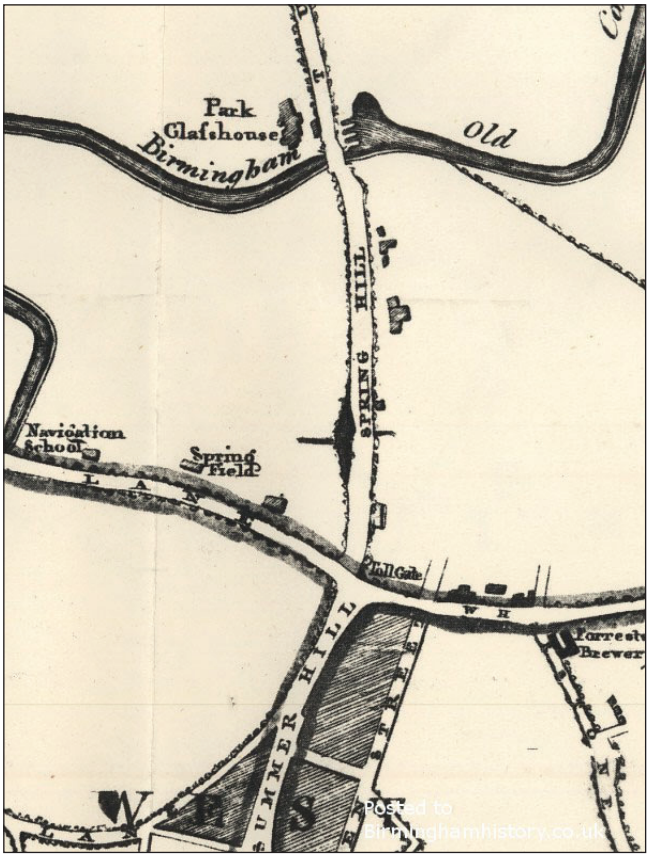
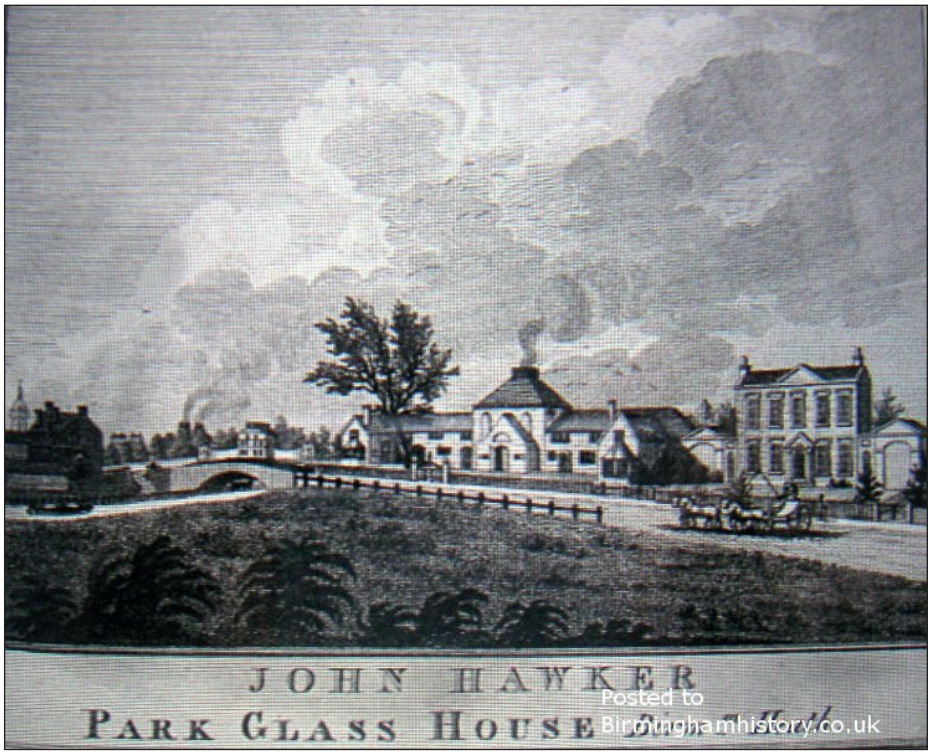
Site location and overhead view with principal structural remains and other features superimposed Figure 1



2a - Extract from Kempston's 1810 map (west is to the top of the map) showing Park Glasshouse



2b - 1808 Illustration of the Park Glasshouse (Birminghamhistory.co.uk)

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Figure 2

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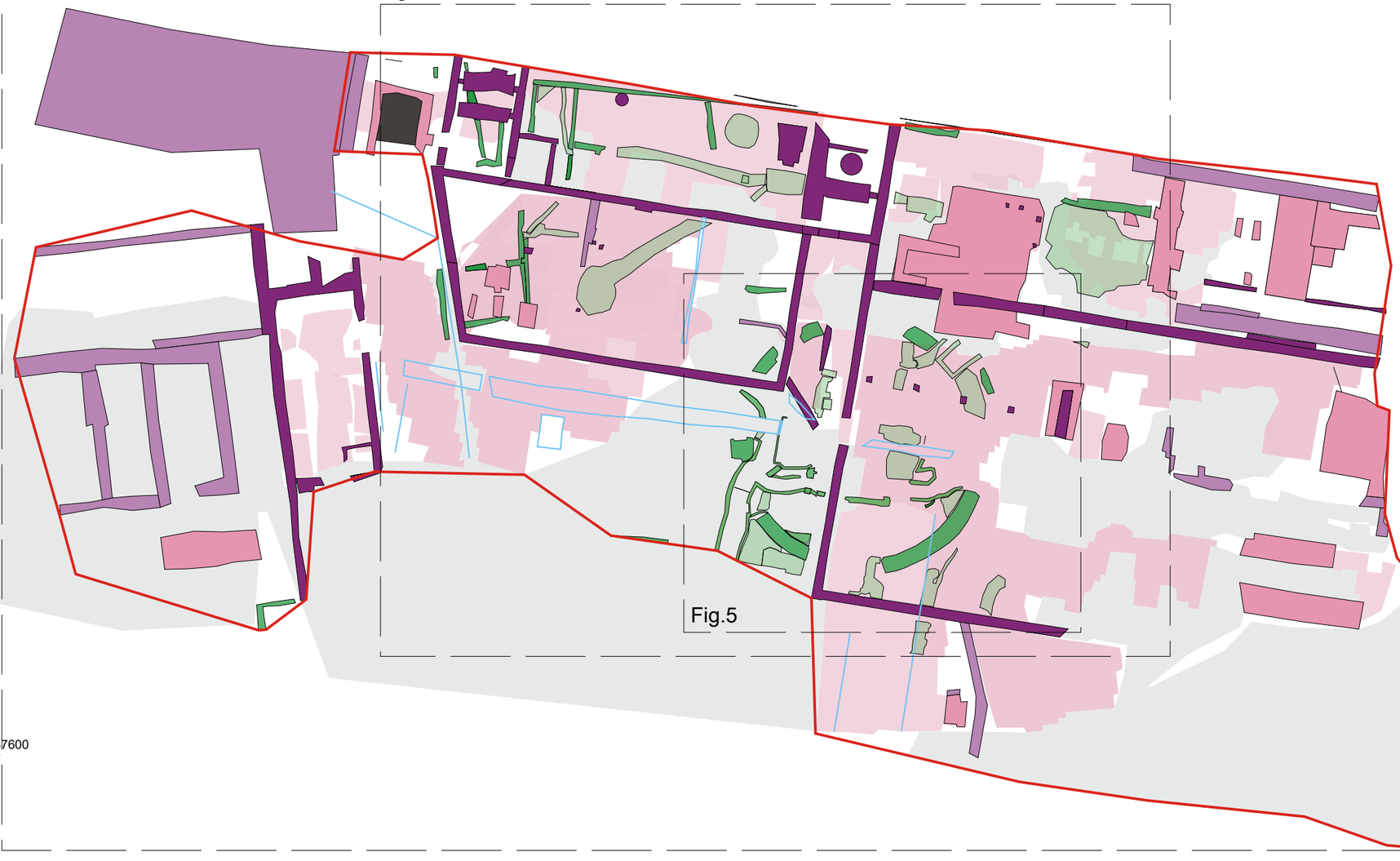
Fig.7

Fig.4



287600

- Site boundary
- Archaeology feature
- Glassworks structure
- Glassworks wall
- Silverworks Phase 1 structure
- Silverworks Phase 2 structure
- Silverworks machine pit
- Silverworks floor
- Disturbance
- Utilities

0 10 m

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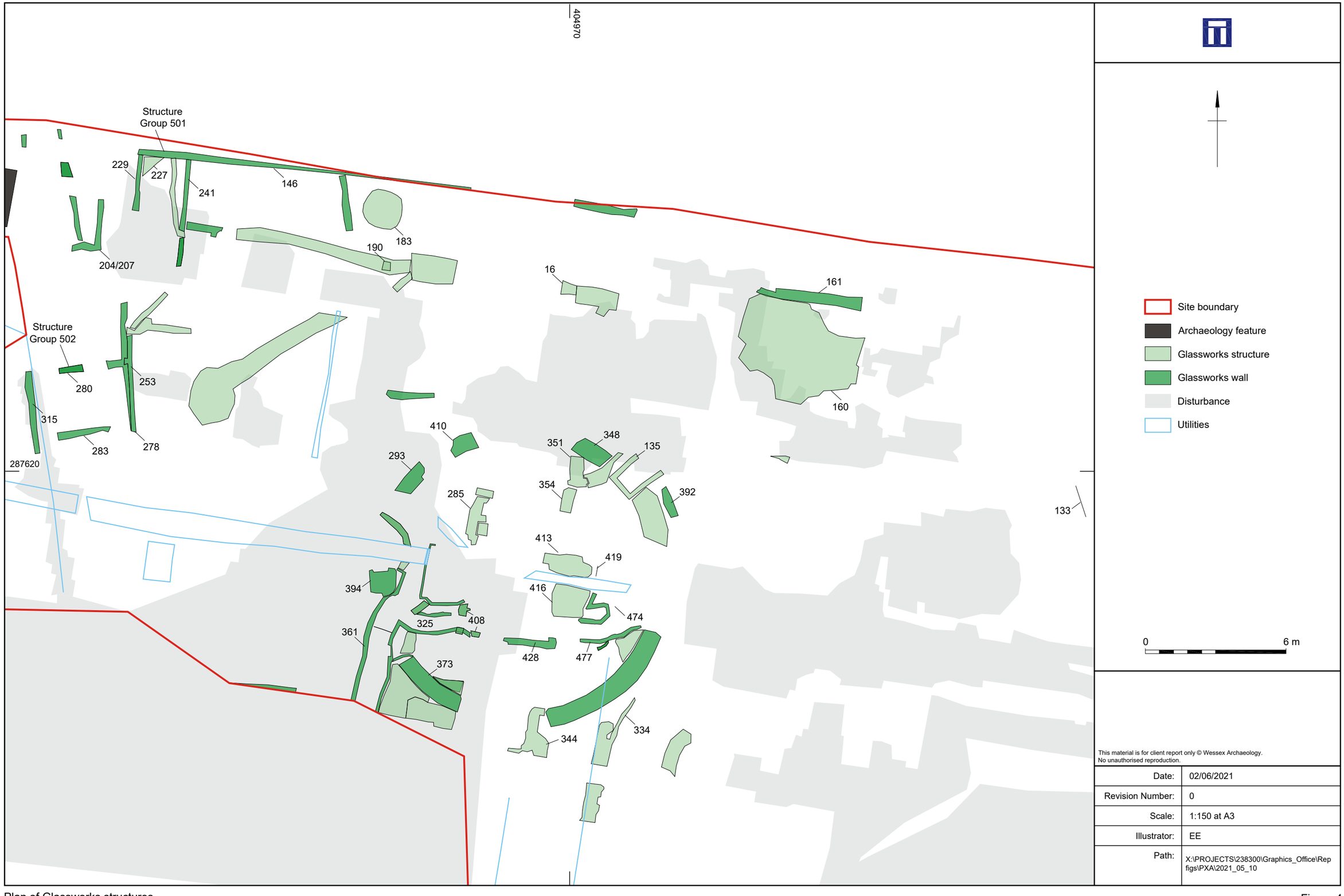
All phases plan

Figure 3



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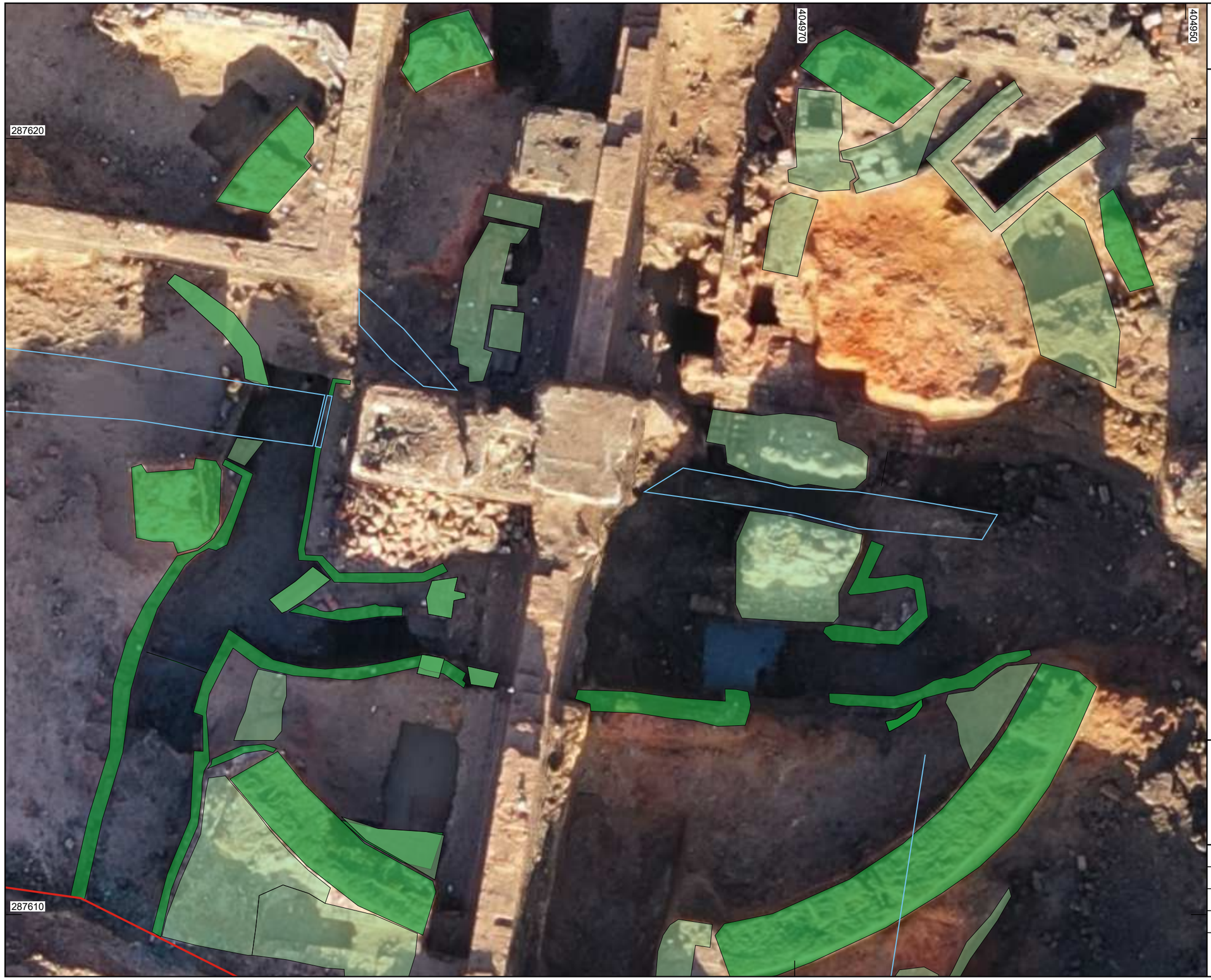
Plan of Glassworks structures

Figure 4



Site boundary
Archaeology feature
Glassworks structure
Glassworks wall
Utilities

0 10 m

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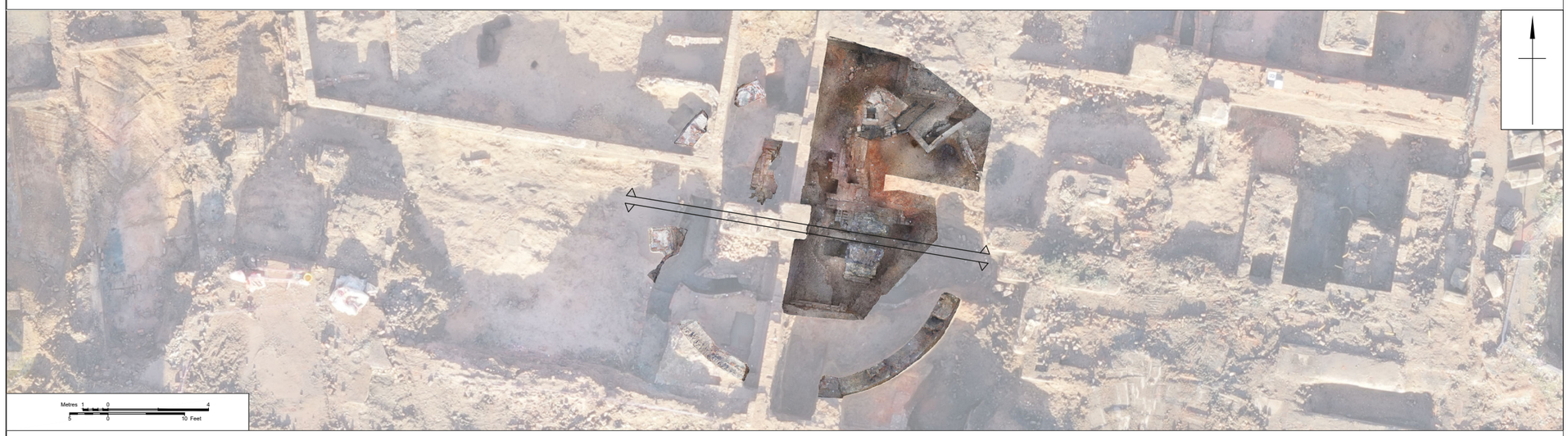
Detail of the Glassworks cone

Figure 5

South-West Facing Elevation



North-East Facing Elevation

ORTHOGRAPHIC VIEWS

SW FACING ELEVATION

PLAN VIEW

NE FACING ELEVATION

Key:
△ Elevation View (SW Facing)
▽ Elevation View (NE Facing)

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Photogrammetric model of glassworks cone.

Figure 6

Site boundary
Archaeology feature
Silverworks Phase 1 structure
Silverworks Phase 2 structure
Silverworks machine pit
Silverworks floor
Disturbance
Utilities

0 10 m

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Revision Number:	0
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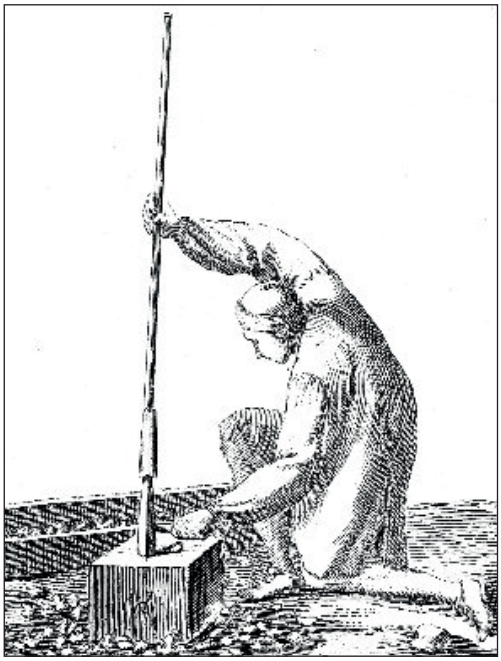
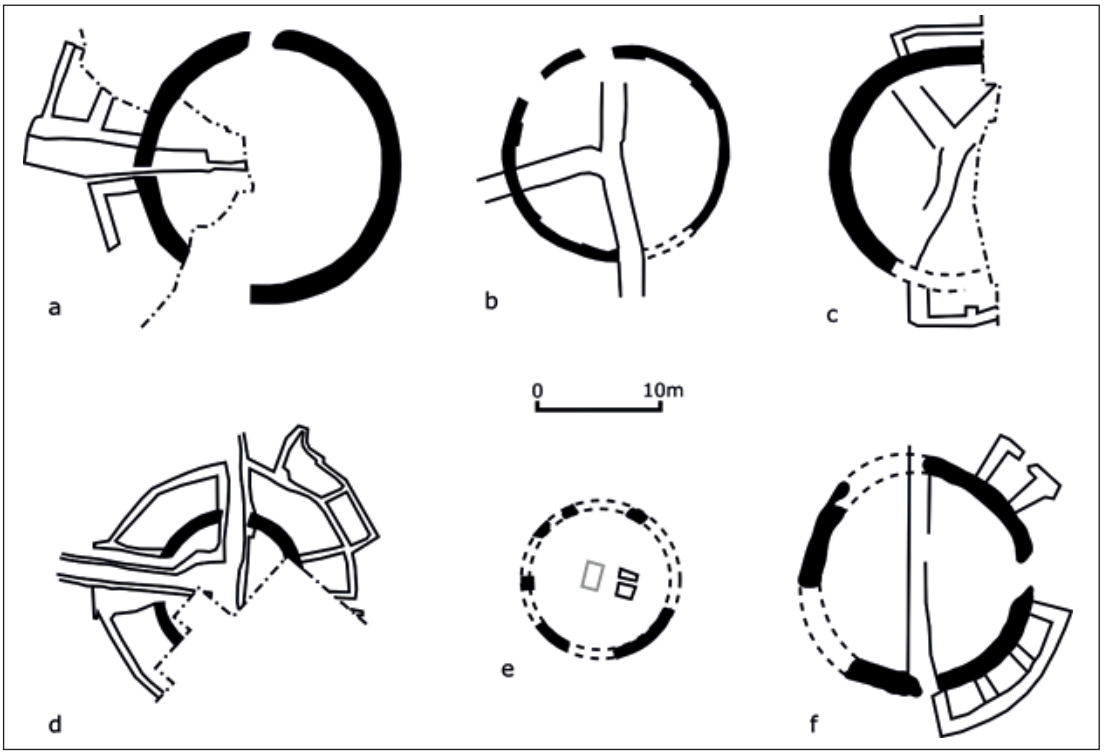
Plan of German Silver Works structures

Figure 7



8a - A glass blower removing moils



8b - Plans of excavated glass cones. Each shows the cone walls in black with flues and additional walls in outline. a Nailsea (1788), b Audnam Canalside (1788–1816), c Portwall Lane Old Cone (1780s), d Gawber (1730), e Park, Soho Loop, f Portwall Lane New Cone (1790s).

Drawings after Crossley (2003) and Reg Jackson personal communication

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Figure 8

Plate 1: Wall 428 viewed from the north (1m scale)

Plate 2: Wall 419 viewed from the south (0.5m scale)

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Plate 3: Sieges 413 and 416 with base 474, flue 477 and wall 428 viewed from the east (1m scale)

Plate 4: Flue 325 (1m and 0.5m scale)

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Plate 5: Flue 334 after mechanical excavation, wall 119 clearly cuts through this flue

Plate 6: Coal chute 361 (0.5m scale)

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Plate 7: Wall 392 (1m scale)

Plate 8: Room 501 with later floor 237 in the foreground, viewed from the south-west (2m scale)

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Plate 9: Room 502 with associated drains, viewed from the north-east (2m scale)

Plate 10: Walls 204 and 207, adjacent to wall 3 viewed from the north (2m scale)

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Plate 11: Wall 133 between wall 27 and machine pit 108, viewed from the south-west

Plate 12: South-west facing Section 3 through floor showing earlier possible floor levels, courtyard area 160 lies to the north and was cut by wall 119, the crowd barriers cover an open drain. The 1 m scale sits on the top of the natural deposits (2m scale)

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Plate 13: Drain 341, viewed from the east (1m scale)

Plate 14: West facing Section 4 showing the lenticular deposits beneath the German Silver Works (1m scale)

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Plate 15: Floors of the German Silver Works, viewed from the west (1m and 2m scales)

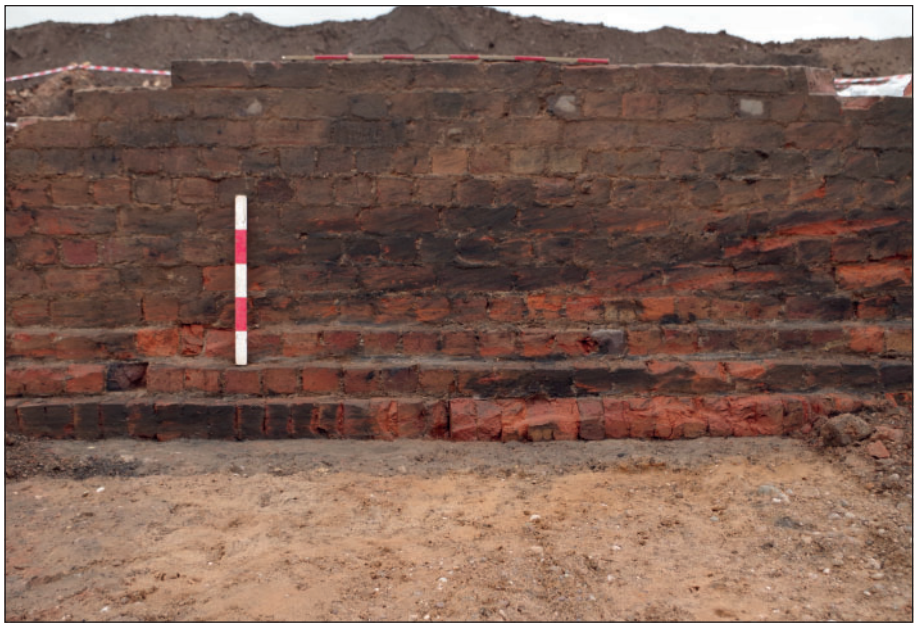

Plate 16: Wall 81 viewed from the north (0.5m scale)

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Plate 17: Black Vitreous Waste: upper surface (fractured) from (406)

Plate 18: Black Vitreous Waste: lower surface (ceramic inclusions) from (406)

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Plate 19: Black Vitreous Waste: showing some reddish colouration from (406)

Plate 20: Black Vitreous Waste with abundant crucible fragment inclusions (pot burst?) from (269)

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Plate 21: Black Vitreous Waste overlying highly vesicular material (ceramic/glass?) from (437)
(Left to right: seen from top, underneath, and side view)

Plate 22: Clinker from (345)

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Plate 23: Clinker from (406)

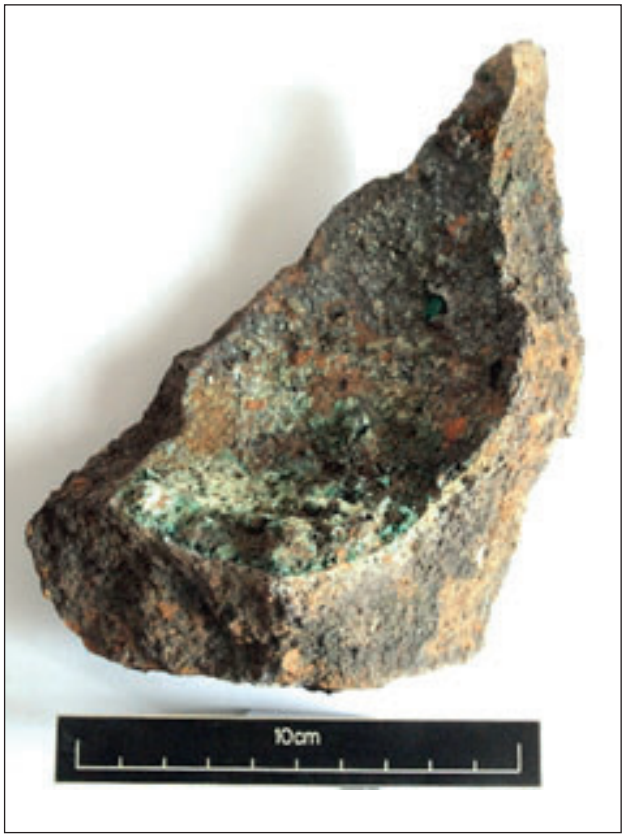

Plate 24: Crucible fragment from (426). The presence of green copper corrosion products suggests that this crucible was used to melt copper alloys rather than glass.

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Plate 25: Crucible fragment (unused) from (426). This fragment has a Morgan Crucible Company of Battersea label

Plate 26: Large fragments of green glass from (383) displaying abundant fracture surfaces and some variation in colour

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Plate 27: Large fragments of green glass from (383) displaying abundant fracture surfaces and some variation in colour

Plate 28: Large fragment of green glass from (383) under transmitted light showing limited variation in colour

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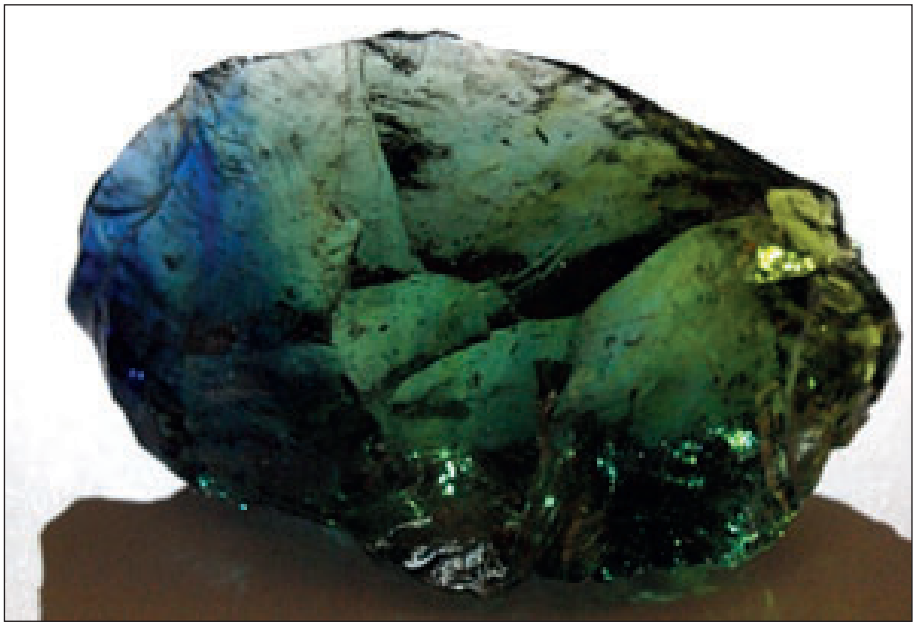

Plate 29: Large fragment of green glass from (383) under transmitted light showing extensive variation in colour.

Plate 30: Fragment of devitrified glass waste from (383)

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Plate 31: Devitrified glass waste from (426)

Plate 32: Colourless moils from (346)

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Plate 33: Colourless moils from (390)

Plate 34: Green moils and paraison end from (390)

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Plate 35: Colourless paraison ends from (136)

Plate 36: A table oil lamp base from (425). The base is moulded with the following “Y.P.L.&M.O. CO LD”

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Plate 37: Two examples of Hamilton bottles from (132). Both have moulded decoration which confirms that they were made to contain carbonated drinks and that they were manufactured by Walsh Walsh of Soho

Plate 38: Photograph taken from just outside the south side of the glass cone (looking north). A section of curving cone wall can be seen on the right. The excavator in the green helmet is standing just to the east of the remains of a siege.

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Plate 39: Photograph taken from just inside the north side of the glass cone (looking south east). The remains of a siege are visible in the centre, with regenerator bricks visible on the right side. This siege was cut in two by a trench for a drainage pipe which ran left to right through the image.

Plate 40: Photograph taken on the west side of the siege remains (looking south). This shows the regenerator bricks arranged in a chequer-board formation to ensure the through flow of air. The bricks have been preserved in position by a subsequent flow of glass (opaque white?) from the left (siege) side.

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Plate 41: Photograph taken on the west side of the siege remains (looking east). The side of the siege (above the regenerator bricks) shows extensive vitrification and erosion of the siege by glass

Plate 42: Photograph taken of the cut through the siege (south-facing section). The cut for a drainage pipe was made sometime after the 1880s but by the time of the excavation was disused. The cut was extremely narrow, making photographic recording challenging. This image shows the upper part of the siege, while Plate 43 shows the lower part. These two images demonstrate that the construction method used resembled an ashlar-and-rubble technique in which the 'ashlar' was refractory brick while the rubble core was composed of miscellaneous devitrified glassworking waste

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Plate 43: Photograph taken of the cut through the siege (south-facing section). This image shows the lower part of the siege, while Plate 42 shows the upper part. These two images demonstrate that the construction method used resembled an ashlar-and-rubble technique in which the 'ashlar' was refractory brick while the rubble core was composed of miscellaneous devitrified glassworking waste. This image also appears to show the reuse of a crucible

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