RESEARCH DEPARTMENT REPORT SERIES no. 16-2010 ISSN 1749-8775

HIGHTOWN, CASTLEFORD, WEST YORKSHIRE
AN ASSESSMENT OF BOTTLE GLASS FROM THE HIGHTOWN GLASSHOUSE

TECHNOLOGY REPORT

Victoria Lucas

ARCHAEOLOGICAL
SCIENCE

ENGLISH HERITAGE

Research Department Report Series 16-2010

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NGR: SE 4198 2527

ISSN 1749-8775

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SUMMARY

This report details the results of chemical analysis of bottle glass recovered from the Hightown glasshouse, Castleford, Yorkshire. It forms the second part of a series of three reports examining the material recovered from the Hightown site. Chemical analysis has confirmed the conclusions of Gardner (2009), who previously examined the Hightown glass working waste and found that there were two primary phases of production, before and after the establishment of the Albion Brickworks: Phase I (c1852-1874) producing essentially high-lime low-alkali glasses and Phase II (c1902-1983) glasses of a soda-lime-silica composition. This report is also able to expand upon this general picture of development to provide a more detailed chronology of glass production at Hightown, particularly during Phase II.

ARCHIVE LOCATION

Wakefield Museum, Wakefield, West Yorkshire.

DATE OF RESEARCH

October 2009 – January 2010

CONTACT DETAILS

English Heritage, Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth PO4 9LD

Victoria A. L. Lucas, Email: v.a.l.lucas@bradford.ac.uk/leireblackcat@gmail.com

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INTRODUCTION

Excavations in 2007 of the Hightown glassworks, of Castleford in Yorkshire produced considerable amounts of archaeological material including ceramics, glass waste and glass bottles. The glassworking waste has been examined previously (Gardner 2009); this report will deal with a selection of the bottles whilst a future report will look at the ceramic material including both furnace fragments associated with the glasshouse and bricks which were manufactured on site in the latter half of the nineteenth century.

In analysing the bottles, this reports aims to examine the types of glass made at Hightown, the relationship between the bottles and the glass working waste and to consider how composition relates to chronology.

The Hightown Glassworks

The Hightown glassworks were established c1852 for the manufacture of glass bottles, part of a growing bottle glass industry in Castleford. This original glasshouse operated for some twenty years, changing hands a number of times until its abandonment and demolition, to be replaced by the Albion brickworks, sometime around 1874. By1878 a Hoffman kiln had been built to fire bricks. The brickworks continued to operate on the site until 1902 when Hightown was bought by John Lumb and C^{o}, who constructed a gas-fired regenerative glass furnace, marking the second phase of glass making at the site which saw the introduction of first semi, and then fully, automated production. By 1905 Lumb's had become a limited company and was operating under the name John Lumb and C^{o} L^{d}. Lumb's retained ownership until 1937 when the company was bought up by United Glass Bottles (UGB). UGB continued to manufacture bottles at Hightown until the site's final closure in 1985 (Gardner 2009; Thorp & Thorp nd).

The Development of Bottle Forming Technologies

The first post-medieval bottle glass industry in England developed in the seventeenth century; initially bottles were free blown, ie formed without the aid of a mould. By the eighteenth century the simple two-part iron mould had been developed and was employed in the manufacture of cylindrical bottles. These early moulds often had to be open and shut by hand, a function that would be performed by a young boy, however, some later variants were sprung allowing them to be opened and closed by means of a foot peddle or 'mechanical boy'. Two-part moulds allowed standardisation of form for the body of the vessel; however, the 'finish' and often the neck of the bottle still had to be formed by hand. In order to do this a pontil rod was attached to the base of the bottle which left a distinctive mark when removed. The Ricketts 'three-part mould' was patented in 1822; its invention allowed two developments to the mouth-blown formation process. Firstly it allowed both the body and the neck of the bottle to be formed by the mould, although the finish still had to be hand applied, and secondly it changed the way the 'kick up' was created from being hand formed to being formed by a base plate in the mould. Bottles formed in a three-part mould are distinguishable by the vertical seam which runs from the shoulders of the bottle to the neck but not to the rim of the bottle and an additional horizontal seam across the shoulders (Wills 1974). Sometime in the 1840s an implement known as a 'snap' was introduced, which allowed the formation of the finish without the use of a pontil rod; bottles manufactured using a snap do not have a 'pontil scar'. The use of the pontil rod did however continue into the latter half of the nineteenth century as the snap was not universally taken up by all sectors of the industry or by all workers upon its introduction (Jones 1986).

The first semi-automatic forming machine for narrow mouthed bottles (the Ashley 'Plank') was patented in 1886; it operated by the press and blow process, using a plunger and compressed air to form first the neck and then the body of the bottle. Subsequent 'Ashley' models employed the blow and blow process and used separate parison and blow moulds as well as a neck ring which was held in place by tongs. The machine still had to be hand fed by a skilled gatherer. Although the 'Ashley' company did not prosper it provided the impetus for a range of semi-automatic machines to be invented in the subsequent years. It was not until 1903 that the first fully automatic machine was developed. The Owens' machine operated by filling the parison mould by suction, thus removing the need to employ a gatherer. The first Owens' machine to be brought to England was installed at Trafford Park, Manchester in 1906, however, despite its advantages in terms of relative speed of production and the lack of skilled workers required for its operation the Owens' was not widely taken up as it was uneconomic when employed in a small scale factory. The Owens' company also placed restrictive licences on its use which discouraged many manufactures from using the machines. Bottles manufactured on an Owens' are identifiable by the 'cut-off' scar on the base and a tendency for the bottle to be bottom heavy. Gob feeders were also developed which allowed the complete automation of press and blow and blow and blow machines. These machines were more flexible and cheaper to run and eventually supplanted the Owens'. In 1924 the Individual Section or IS machine came into being, this is the machine that is still widely employed in the manufacture of glass containers and caused all other devices to become virtually obsolete. The IS allows each pair of moulds on a machine to operate separately from the others (Cable 2001).

Common Bottle Forms, Closures and Finishes

There are several common forms of bottles, closures and finishes (Hedges 2002; Wills 1974) that are significant for dating the manufacture of a bottle.

Forms:

1. The egg: The egg shaped bottle was first patented in 1814 by William Hamilton and these bottles are known variously as eggs, torpedoes or Hamiltons. The bottle, as suggested by its name is ovoid in form with a curved body and base forcing it to be stored on its side. The idea behind the original Hamilton bottle was that by keeping the bottle on its side, the cork stopper would be kept moist by the contents preventing it from drying out thus ensuring a good seal which kept the contents pressurised. The majority of egg shaped vessels have blob-top finishes and were used almost exclusively for mineral waters. A later variant on the egg was brought in around 1870, the flat based egg, which achieved some success after the invention of the crown cork as it was easier to fill (see Figure 1).

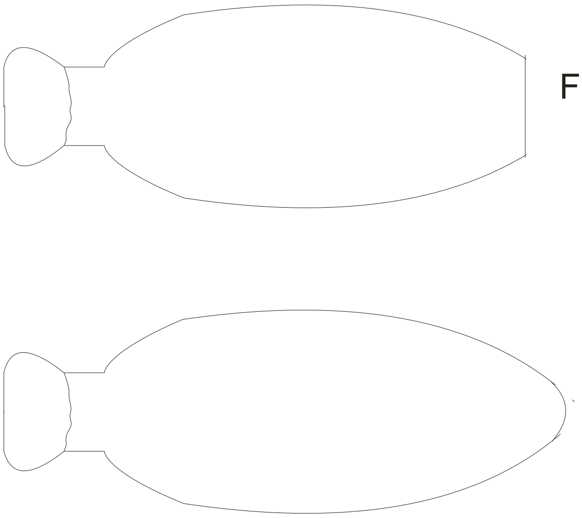

Figure 1: a flat-based egg and an original 'egg' shaped bottle

2. Marble stoppered bottles: The original marble stoppered bottle was invented by Hiram Codd in 1875 and this style of bottle is most commonly referred to as a Codd, although several rival designs were patented in later years. The basic principle is that a glass marble inside the vessel was held in place against a rubber ring in the neck by the pressure of the gas generated by the mineral water. The neck was specifically designed to trap the marble and prevent it from falling into the drink when the pressure was released. Marble stoppered bottles remained in production until about 1930 when they were eventually superseded by the crown cap.

Closures and Finishes:

1. Blob-tops: The blob-top was a common finish on mineral water bottles, particularly on 'eggs'. The finish consists of a bulbous lip; this was originally applied separately and later moulded as part of the neck. The principle behind the blob-top is that it reinforced the neck allowing the use of a tightly fitted cork under high pressure such as was necessary for storing mineral waters. There are several variations on the blob-top; some for instance possess a collar located just below the base of the lips. They were also later adapted to take early forms of internal screw-stopper on both minerals and beers.
2. Internal screw-stoppers: Internal screw-stoppers were patented in 1872 and solved many of the problems associated with closing beers and minerals using corks as they provided a good airtight seal. Early bottles with internal screw threads had blob-top finishes, however by the early twentieth century most had been replaced by straight sided finishes. Bottles designed to take these stoppers are easily distinguishable by the screw thread on the inside of the mouth (see Figure 2)

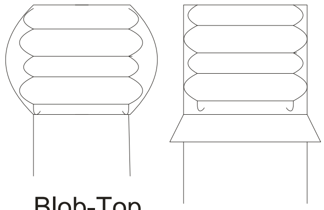

Figure 2: bottles with internal screw threads

3. Crown-corks: Patented in 1892 the crown cork became the most ubiquitous closure method in the twentieth century. Bottles with crown-tops are similar in appearance to blob-top bottles; however, they also have a 'bead' rim over which the crown-cap fitted, this bead rim is always c2.5cm in diameter. The crown-cork consists of a metal cap with a cork lining. It was widely used on both mineral and beer bottles throughout the twentieth century (see Figure 3)

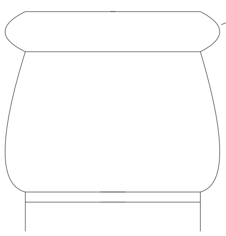

Figure 3: a bottle neck with a crown-top finish

Why Employ Chemical Analysis in the Study of Post-Medieval Bottle Glass?

Chemical analysis of bottle glass makes an important contribution to the wider understanding of the bottle industry. When used in combination with visual examination, archaeological information and historical reference it can provide a depth of information not attainable by these methods alone. For example whilst visual examination may be able to differentiate between a dark green glass and a colourless one and historical reference allow one to conclude that the dark green glass is likely to have been manufactured earlier than the colourless glass it does not allow differentiation between glasses which are visually indistinct but which may in fact form quite distinct compositional groups; which can then be related to phasing and dating information and differences in bottle form to understand what significance these distinct compositions hold. Chemical analysis also allows us to understand what raw materials were being used to manufacture bottle glass at different periods; this can provide insights into changing trends in manufacturing practice and also into economic considerations which were being made.

METHOD

A total of 67 bottles were selected for analysis, from an assemblage of several hundred, on the basis of context and bottle forms that were considered to be representative of the wider makeup of the assemblage, and a small sample removed from each. These bottles were then catalogued.

Each sample was mounted in epoxy resin, ground in order to ensure that the sample was flat and polished using diamond paste to a 3µm grade, creating a cross section in which the corroded outer surface which was avoided when conducting analysis in order to reduce problems with depletion or enhancement of certain elements associated with corrosion. The samples were analysed by two methods; ED-XRF (energy dispersive X-ray fluorescence) and SEM-EDS (scanning electron microscopy energy dispersive spectroscopy).

ED-XRF

ED-XRF analysis was carried out (using an EDAX Eagle II) on all 67 samples, as well as 22 standards, for 200 seconds of live time at 40kV and 1mA. Standards were used in order to create a calibration equation for each of the elements to be studied which would allow a conversion between the counts per second (CPS) for the element recorded by the detector and the weight percent. The calibration equation was found by plotting the CPS against the known wt% for each element, a line of best fit was then added and the equation of that line found. This equation was then used to calibrate the wt% of elements in the samples. The following standards were used: MPI-DING, Pilkington, Corning, NIST and DGG. The following elements were sought but not detected in any of the samples: V, Co, Ni, Cu, and Rb.

All standard errors were shown to be of the order of 0.01wt% or less and therefore the calibration can be taken to be accurate to ± 0.01 for data values within the range of concentrations present in the reference materials; for data outside this range the standard error will be larger.

SEM-EDS

The samples were dagged with silver paint to ensure that they would be grounded and carbon coated for conduction. All 67 samples were analysed as well as sixteen standards, for 100 seconds of live time, at a 10mm working distance, 25kV and a spot size of 5 at a magnification of 1000x with the back-scatter detector in order to identify corrosion (FEI Inspect F with Oxford Instruments X-act SDD detector and INCA software). The following standards were used: Pilkington, Corning, NIST and DGG.

All data was quantified as a compound percentage of its oxide. Based on similarity between the actual and analysed values for the standards it was deemed that data could be considered reliable where the compound percentages totalled to between 98% and 101%. All values obtained fell within these bounds and so normalisation of the data was not considered necessary. For each sample three spectra were obtained in order to highlight erroneous data and obtain reliable average values.

RESULTS

The results were analysed, examining first the chemical data and then arranging this into groups based upon their composition. These groups were then compared with context and typological data.

The 67 samples can be divided, broadly speaking, into two primary compositional groups; high-lime low-alkali (HLLA) and soda-lime-silica (SLS). Those that fall into the former category have greater amounts of lime (CaO) and lesser amounts of soda (Na_2O), (see Figure 4) whilst those that fall into the latter category have lesser amounts of lime and greater amounts of soda. Two pale green 'intermediate' groups were also identified where the glass was neither clearly HLLA nor SLS in composition having only marginally higher amounts of CaO compared to Na_2O. A final group, with similar values for lime and soda to SLS (2) but which much more closely resembles the HLLA glasses with regards to the rest of its composition, has been called Low Lime, Low Silica (LLLS).

Within these broad categories several distinct groupings were found to be present. The HLLA glasses can be divided into three types; a dark green glass and two types of pale green glasses, distinguished by the higher levels of impurities in one compared to the other and slightly differing amounts of lime and soda. The SLS glasses can likewise be subdivided, firstly between pale green, emerald green and colourless glasses. The colourless glasses form four clearly distinct groups, whilst the pale green glasses fall into one less distinct class. In two of the SLS groups there are samples with higher levels of lime than would be expected relative to their soda content.

This data has been compared against the data for the working waste analysed by Gardner (2009) and can be seen to correlate reasonably well, however some groups are poorly represented by the working waste, these include the second (lower lime, higher soda) pale green HLLA glass, the intermediate glasses the pale green SLS glass and the Low Lime, Low Silica glass (see Table 1).

Table 1: correlation between glass types identified by Gardner (2009) and this report

Phase	Waste (Gardner 2009)	Bottle Glass (this report)
1	Clear/blue/green (HHLA)	HLLA Pale Green (1)
	Not found	LLLS
	Dark Green (HLLA)	HLLA Dark Green
Between	Not found	HLLA Pale Green (2)
		Intermediate (1)
		Intermediate (2)
2	Colourless (SLS)	SLS (1)
		SLS (4)
		SLS (5)
	Not found	SLS (2)
		SLS (3)
	Green (SLS)	SLS (Emerald)

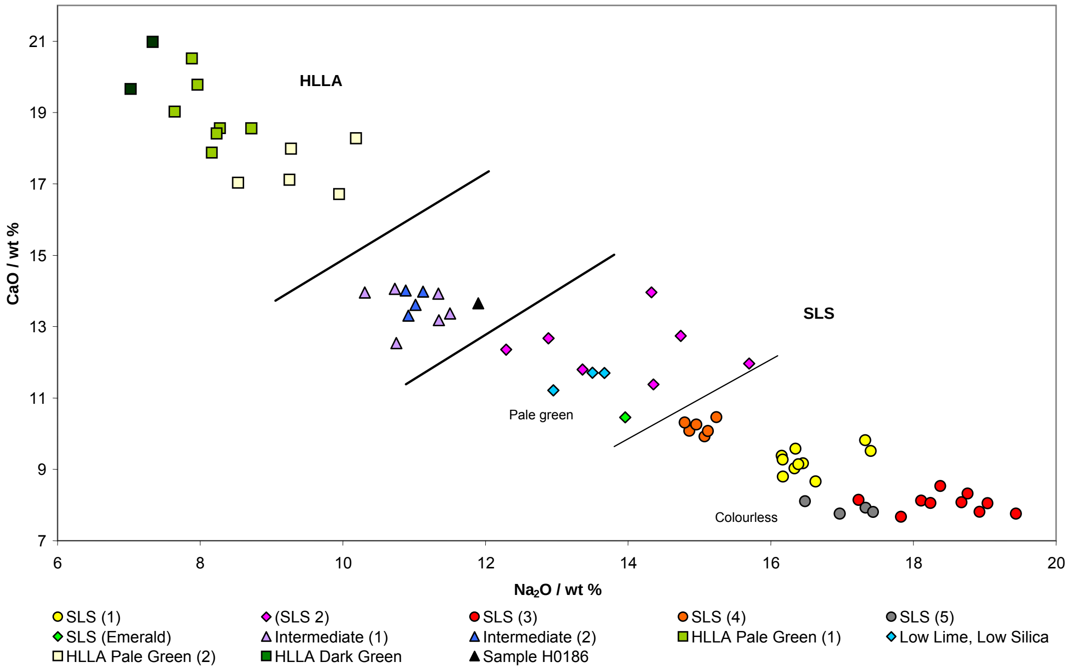

Figure 4: plot of soda (Na_2O) and lime (CaO) contents from bottle glass from Hightown

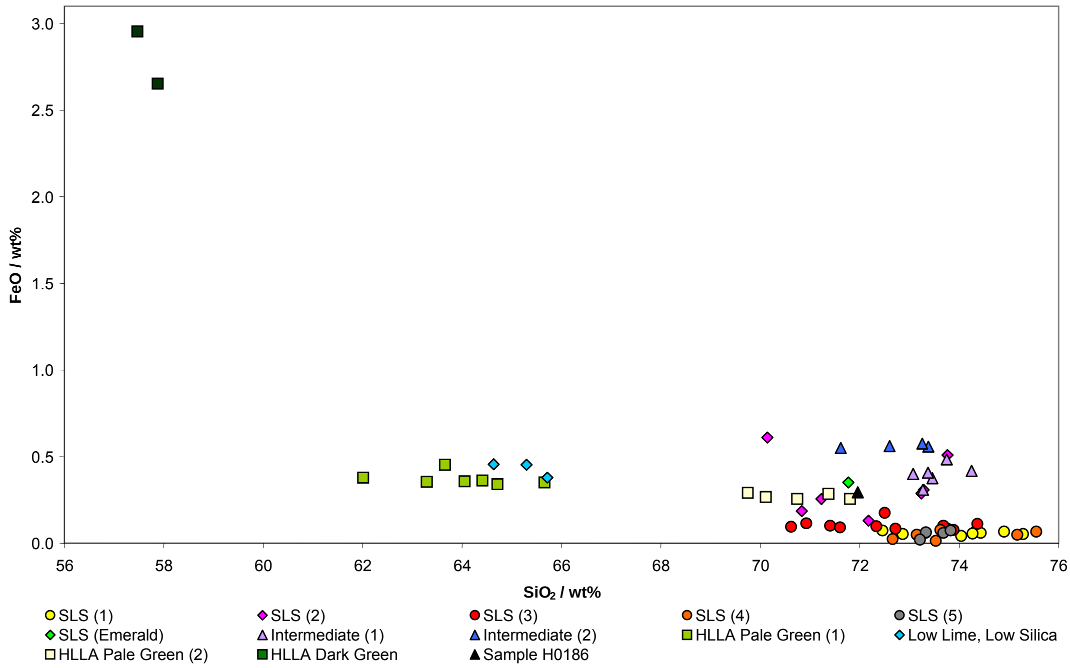

Figure 5: plot of silica (SiO_2) and iron (III) oxide (Fe_2O_3) content of bottle glass from Hightown

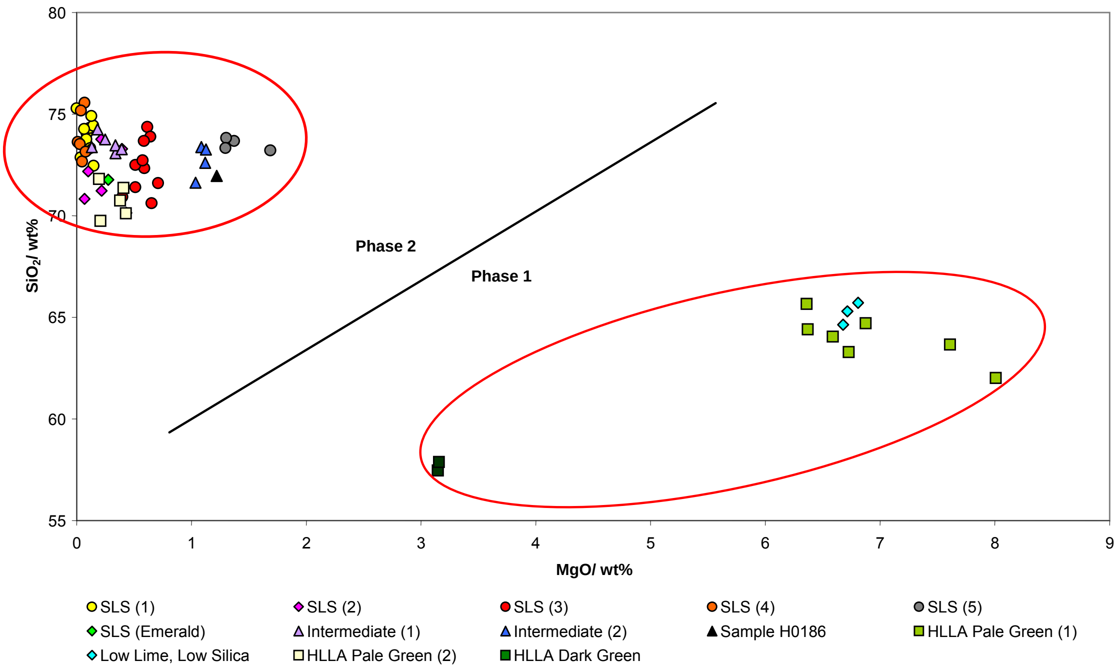

Figure 6: plot of magnesia (MgO) and silica (SiO_2) content of bottle glass from Hightown

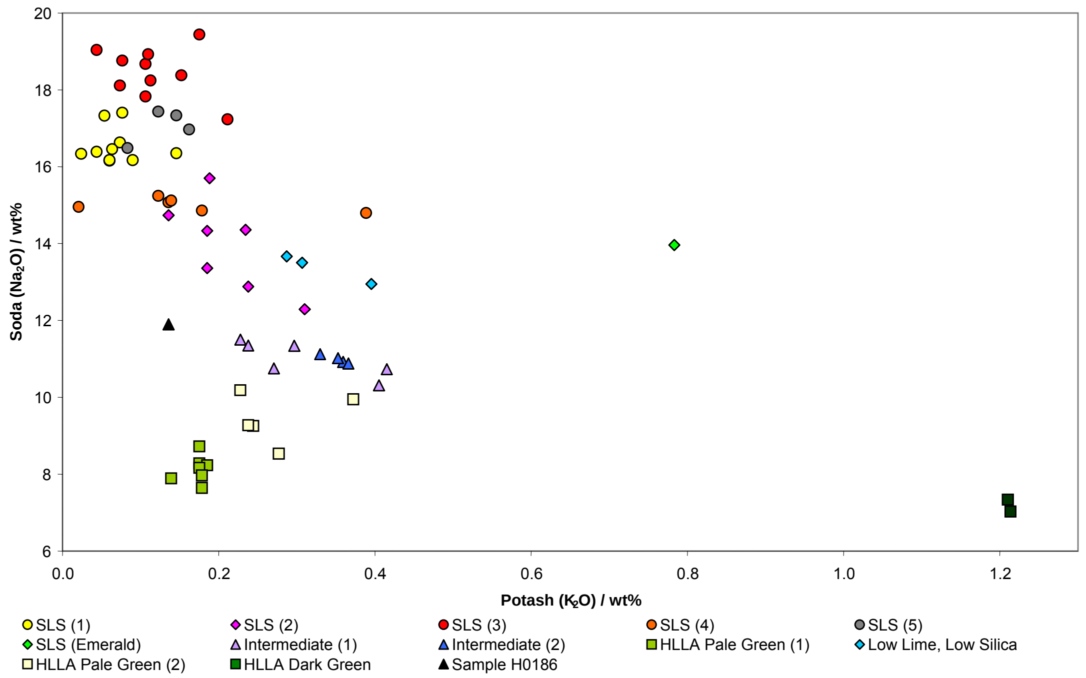

Figure 7: plot of potash (K_2O) and soda (Na_2O) content of bottle glass from Hightown

Table 2: average composition of the groups with associated standard deviations

Group	N° Samples		Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	Cr_2O_3	MnO	Fe_2O_3	As_2O_3
SLS Dark Green	2	Average	7.18	3.15	6.19	57.68	1.21	20.32	<0.01	0.04	2.80	0.03
		Standard Deviation	0.16	0.01	0.04	0.20	0.00	0.66	0.00	0.03	0.15	0.01
SLS Light Green (1)	7	Average	8.13	6.93	1.13	63.97	0.17	18.96	<0.01	0.02	0.37	0.11
		Standard Deviation	0.32	0.59	0.14	1.07	0.01	0.84	0.00	0.02	0.04	0.11
Low Lime, Low Silica	3	Average	13.37	6.73	1.52	65.22	0.33	11.54	<0.01	0.02	0.43	1.07
		Standard Deviation	0.31	0.05	0.04	0.44	0.05	0.23	0.00	0.02	0.04	0.09
SLS Light Green (2)	5	Average	9.44	0.32	1.21	70.76	0.27	17.42	<0.01	0.12	0.27	<0.10
		Standard Deviation	0.58	0.10	0.20	0.76	0.05	0.60	0.00	0.21	0.01	0.00
Intermediate (1)	6	Average	11.00	0.27	1.55	73.53	0.31	13.50	<0.01	0.02	0.40	<0.10
		Standard Deviation	0.43	0.09	0.16	0.38	0.08	0.54	0.00	0.02	0.05	0.03
Intermediate (2)	4	Average	10.99	1.09	1.63	72.72	0.35	13.73	<0.01	0.07	0.56	<0.10
		Standard Deviation	0.09	0.04	0.04	0.70	0.01	0.29	0.00	0.05	0.01	0.00
SLS (1)	10	Average	16.54	<0.10	0.84	73.97	<0.10	9.23	<0.01	0.01	0.06	0.14
		Standard Deviation	0.44	0.05	0.17	0.84	0.03	0.34	0.00	0.02	0.01	0.06
SLS (2)	7	Average	13.95	0.22	1.19	72.1	0.21	12.41	<0.01	0.12	0.33	<0.10
		Standard Deviation	1.08	0.13	0.25	1.29	0.05	0.78	0.00	0.27	0.15	0.01
SLS (3)	10	Average	18.46	0.58	0.72	72.41	0.12	8.05	<0.01	0.04	0.10	0.13
		Standard Deviation	0.61	0.08	0.23	1.22	0.05	0.25	0.00	0.04	0.03	0.02
SLS (4)	6	Average	15.01	<0.10	1.22	73.95	0.16	10.18	<0.01	0.02	0.05	<0.10
		Standard Deviation	0.15	0.02	0.18	1.05	0.11	0.18	0.00	0.04	0.02	0.01
SLS (5)	4	Average	17.05	1.41	0.60	73.51	0.13	7.90	<0.01	0.03	0.05	0.21
		Standard Deviation	0.37	0.16	0.07	0.25	0.03	0.14	0.00	0.02	0.02	0.01
SLS (Emerald)	1	Average	13.96	0.27	1.96	71.77	0.78	10.45	0.21	0.04	0.35	<0.10
		Standard Deviation	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table 3: phasing and contexts from which bottle glass from Hightown was recovered

Type	Group	Context	Samples	Phasing
HLLA	Dark green	3062	H0134	Unphased
		5603	H0171	Phase I glass, pre Hoffman
	Light green (1)	5563	H0166, H0167, H0169	Phase I glass, pre Hoffman
		5690	H0159	Phase I glass, pre Hoffman
		5525	H0157	Phase I glass, pre Hoffman
		5603	H0170	Phase I glass, pre Hoffman
		3085	H0037	Unphased
	Light green (2)	5601	H0151, H0152	mid 19th-c. 1880
		5146	H0179	Late C19
		5168	H0176	?Pre 1960's, post WWII
		5524	H0165	Unphased
Low Lime, Low Silica	Low Lime, Low Silica	5601	H0153	mid 19th-c. 1880
		5563	H0168	Phase I glass, pre Hoffman
		5168	H0162	?Pre 1960's, post WWII
Intermediate	(1)	5049	H0181	Post WW II, pre 1960s
		5019	H0199, H0200	Post 1960s
		5202	H0208	Pre WWII ?
		5146	H0180	Late C19
	(2)	5019	H0197, H0198	Post 1960s
		5523	H0164	Pre 1890
		5146	H0177, H0178	Late C19
SLS	(1)	5166	H0082, H0086, H0089, H0090	Late 19th/ early C20th
		5049	H0182, H0184, H0185	Post WW II, pre 1960s
		5064	H0194, H0195	Post WW II, pre 1960s
		5028	H0193	Unphased
	(2)	5019	H0196, H0201, H0202	Post 1960s
		1033	H0001, H0010	Unphased
		5202	H0206	Pre WWII ?
		5049	H0183	Post WW II, pre 1960s
	(3)	1033	H0002, H0003, H0004, H0005, H0006, H00014	Unphased
		5202	H0203, H0204, H0205 H0207	Pre WWII ?
	(4)	5028	H0187, H0188, H0189, H0190, H0191, H0192	Unphased
	(5)	5168	H0160, H0161, H0163	?Pre 1960's, post WWII
		5607	H0172	Pre Hoffman
	(Emerald)	3062	H0135	Unphased

The HLLA glasses were all recovered from Phase 1 or unphased contexts except sample H0176 which was recovered from a Phase II context. The SLS glasses were largely recovered from Phase II or unphased contexts, however one sample was found from a Phase I context (H0172), this bottle may be intrusive in this context. This is generally consistent with the recovery of the working waste. The intermediate type was recovered from two Phase I contexts and three Phase II contexts.

The clearest difference between phase 1 and phase 2 glasses is in the relative proportions of silica and magnesia (See Figure 6). Phase 1 glasses are characterised by low silica and high magnesia (between c58-65 wt % silica and c3-8wt% magnesia), whilst phase 2 glasses have high silica and low magnesia values (between c 0.1-1.7wt% magnesia).

High-Lime Low-Alkali

Visual examination identified only two types of HLLA glass; a dark green and a pale green glass, however chemical analysis has shown that there are in fact two quite distinct types of pale green HLLA glass present.

HLLA Dark Green

The dark green glass is distinguished from the pale green primarily by its much higher iron (III) oxide (Fe_2O_3) and lower silica (SiO_2) content. The dark green contains much greater quantities of potash (K_2O). Only two dark green HLLA bottles were sampled, this reflects the low quantity of this glass type recovered from the site. The composition correlates well with Gardner (2009).

The two HLLA Dark Green samples came from bottle bases, of two distinct forms(see Appendix I for details and Figure 8).

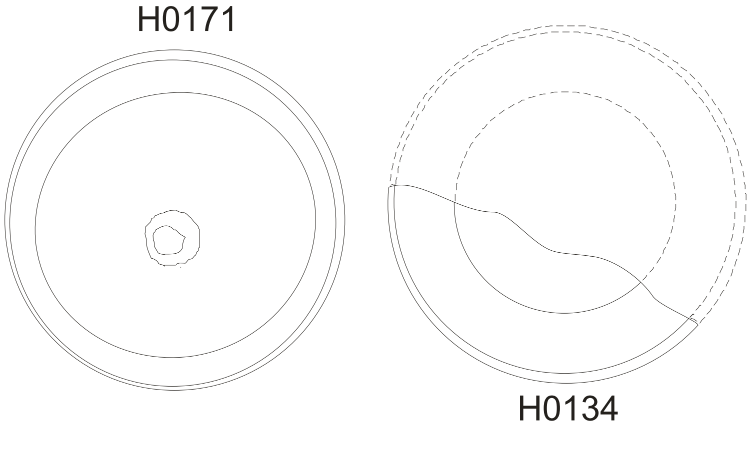

Figure 8: showing the different form of the bases of H0134 and H0171 (diameter c6cm)

HLLA Pale Green (1) and (2)

The two types of pale green HLLA glass are distinguishable from each other by differing lime and soda ratios and in particular by significant differences in the concentration of silica (SiO_2) and magnesia (MgO).

Pale Green (1) is a more typical HLLA glass, with greater amounts of CaO and lesser of Na_2O and higher levels of impurities. Whilst Pale Green (2) has values for MgO averaging at just c0.3wt% (very similar to those of the SLS glasses), the Pale Green (1) glass contains an average of c7wt%. Pale Green (1) has a higher SiO_2 content than traditional HLLA glasses at c64wt%. Pale Green (2) meanwhile contains exceptionally high quantities of SiO_2, much more consistent with the values obtained for some of the soda-lime-silica glasses, at c71wt%. The Hightown working waste (Gardner 2009) correlates very well with Pale Green (1), but not at all with Pale Green (2).

There are noticeable typological differences between the different pale green HLLA bottle necks. Of the Pale Green (1) bottles: H0037, has a distinctive style of finish with a deliberate groove formed between the lips and the string rim, a relatively rare style of finish that is, as a rule, only found on ales, liquors and occasionally bitters; it is virtually never found on minerals. H0166 and H0167 both have 'blob-top' style finishes, most often seen on minerals; particularly on 'egg' shaped bottles and some early marble stoppered bottles. H0169 has a much wider neck than the other bottles in this group; the actual form of the neck is slightly ovoid in section as opposed to circular and was most likely therefore also formed separately outside of a mould (see Appendix I for details). Of the Pale Green (2) necks four have been identified as having seams, H0151, H0152 and H0176 H0165. H0151 and H0176 are very similar in form; both these bottles are crown-top bottles, H0152 has a finish commonly seen on beer bottles lastly H0165 which is a moulded blob-top finish, as evidenced by the seams running down either side of the finish as well as the smooth interface between the finish and the neck (see Appendix I for details).

Low Lime, Low Silica

The Low Lime, Low Silica group has values for lime and soda very similar to those of SLS (2), however in terms of most other oxides it is much more closely related to HLLA Pale Green (1), most significantly in terms of the proportions of silica and magnesia. Estimates of the melting temperature and working range of this glass suggest that its behaviour would have been very similar to that of HLLA Pale Green (1). This group does not correlate with the working waste (Gardner 2009). The bottles belonging to this group are two pale green egg shaped vessels (H0153, H0168) and a colourless jar rim (H0162) (see Appendix I for details).

Soda-Lime-Silica

Six distinct types of SLS glass have been identified in the Hightown assemblage; four primarily consist of colourless glasses whilst one includes largely pale green specimens and another consists of a single emerald green bottle. The colourless glasses contain more soda and less lime than the pale green glass; they are also distinguishable in terms of proportions of Fe_2O_3 and K_2O, (see Figures 4 and 5) with the pale green glass having a higher concentration of both oxides relative to the colourless ones. The emerald green glass is distinguishable by a high value for chromium. The SLS glass was largely recovered from Phase II or unphased contexts.

Colourless SLS

The four groups which contain a majority of colourless glasses are: SLS (1), SLS (3), SLS (4) and SLS (5).

SLS (1) is characterised primarily by its CaO and Na_2O values which form a tightly distributed group with a low standard deviation for both oxides, it is also distinguishable from other groups by low concentrations of Fe_2O_3, MgO and K_2O.These samples come from four different contexts; three of which are Phase II and one unphased context. SLS (1) correlates well with the working waste (Gardner 2009). Several of the bottles that fall into the SLS (1) group are marked on the base with 'J.L. & C° L^{d}', this is the mark of 'J. Lumb and Company Limited' who owned the Hightown glasshouse between 1905 and 1937. One bottle within the group (H0193) is marked, on the base, with 'UGB' ('United Glass Bottles), who took over management of Hightown in 1937; it is of the same bulk composition as the other SLS (1) bottles, however, many of the minor constituents are in fact closer in proportions to those of the SLS (4) group to which the other 'UGB' bottles belong (see Appendix I for details).

SLS (3) is also chiefly characterised by the concentrations of CaO and Na_2O as well as by its MgO values which are higher than most of the other colourless groups, excluding SLS (6), and than the coloured groups: Intermediate (1), SLS (2) and HLLA Pale Green (2). Other distinguishing features include its Fe_2O_3 values which are higher than any of the other colourless SLS glasses (c0.1wt%) although still well below the concentrations of any of the coloured glasses, as well as the lowest average concentration of SiO_2 for the colourless glasses (c72wt%). The correlation with the working waste (Gardner 2009) is poor. The samples in this group come from just two contexts one of which is unphased. The SLS (3) samples come from nine bottle necks (all except H0006 have seams which run to the top of the mouth) and one bottle base fragment. H0014 is a square bottle base fragment, marked with what, based on evidence from a complete specimen (H0183), originally read Walker's Kilmarnock Whisky (see Appendix I for details).

SLS (4) is distinguished as a discreet group by its tightly distributed Na_2O : CaO values as well as its very low MgO values and by its low Fe_2O_3 content. All samples from this group come from a single context (5028); which is unphased. The samples in this group all come from bottle bases marked UGB. Two (H0187 and H0188) have a circular pattern of dots moulded onto the base, whilst another (H0190) has a series of concentric circles, the remaining three are plain. All the bottles have mould numbers excepting H0190 (see Appendix I for details).

SLS (5) is similar in composition to SLS (3), the main distinguishing feature being the higher concentration of MgO. This group is well represented by the working waste data (Gardner 2009) and is very likely to have been manufactured at Hightown. The four bottles belonging to this group are, a bottle neck (H0160), a jar mouth (H0161), a bottle finish (H0163) and an oval shaped bottle base and lower body (H0172). All of these specimens show evidence of being wasters (see Appendix I for details)

Pale Green SLS

The pale green SLS glass is SLS (2). It lies between c12 and c15wt% soda and c10 and c13wt% lime (see Figure 4) and is widely distributed. It has higher iron (III) oxide values than any of the other SLS glasses (see Figures 4 and 6) and a greater proportion of potash to soda. SLS (2) does not correlate with the working waste (Gardner 2009). The bottles with compositions belonging to the SLS (2) are one fragment of egg-shaped vessel (H0196), one three-faced body fragment (H0201), a bottle shoulder fragment (H0202), two bottle necks (H0001 and H0206) and two square bottle bases (H0010 and H0183) (see Appendix I for details).

Emerald Green SLS

One bottle originally categorised as 'dark green' proved when sampled to in fact be 'emerald' green in colour. This bottle sits loosely within the SLS (2) group, it is distinguished from the rest of this group by its high concentration of chromium. This sample correlates very well with the samples identified as containing high levels of chromium in the working waste and was almost certainly manufactured at Hightown. As this glass type was identified as a distinct group in the working waste this bottle has been classed as belonging to the group SLS (Emerald).

Intermediate

There are two intermediate glass groups which lie between c10wt% and c12wt% Na_2O and c12wt% and c14wt% CaO, and are neither clearly HLLA nor SLS in composition. The main distinguishing characteristic of the two groups is their MgO contents and slight differences in Fe_2O_3 content. Intermediate (1) has marginally but consistently lower values for Fe_2O_3. The two groups come from very similar contexts; three contexts also contain samples from SLS groups and one contains a sample from HLLA Pale Green (2). Neither Intermediate (1) nor Intermediate (2) are present in the working waste (Gardner 2009) samples.

DISCUSSION

The evidence from Hightown supports the general idea that there were two phases of glass production, one pre-Hoffman and one post-Hoffman (prior to and after the Albion Brickworks). Analysis of glassworking waste (Gardner 2009) showed that in Phase I high-lime low-alkali glasses were produced, whilst in Phase II soda-lime-silica glasses were manufactured. However, analysis of the bottles has shown a more complicated picture of the development of the Hightown glassworks and the types of glass being manufactured there.

High-Lime Low-Alkali

HLLA Dark Green

The seams on the two HLLA dark green bottles are indicative of a bottle formed using a three-part mould. The bases of the two bottles are very distinct from each other, suggesting some experimentation with different mould designs. The kick up on H0171 was probably not formed in the mould due to its irregular shape; H0134 however much more closely resembles the form of base seen in bottles formed in a Ricketts patented mould, with the wide, flat outer rim formed by a washer and the kick up of regular shape formed by the mechanical punty, the Hightown example does not appear to carry any lettering. A relative chronology for the two bottles can now be suggested, that H0171 is the earlier of the two and represents a simpler style of three piece mould used at Hightown whereas H0134 is the later bottle and represents improvements made to the moulds used at Hightown taking obvious inspiration from the Ricketts model.

H0171 has a possible pontil scar; its presence suggests that Hightown was still using pontils at a relatively late date despite the snap having been introduced c1840. It is suggested by Jones (1986) that this was quite normal practice and that many glass-hands were adverse to the snap's introduction even into the late nineteenth century.

HLLA Pale Green (1) and (2)

The HLLA Pale Green (1) bottles do not (with the exception of H0166) have any visible seams and all finishes are applied rather than moulded; this suggests that these bottles were not machine formed, and it is most likely that they were all mouth blown in moulds, the majority of which formed only the body of the bottle with the neck and finish formed separately, in most cases. It is possible that H0166 was produced at a slightly later date than the other bottles since the neck seam suggests that it was formed in an improved mould that included a neck segment. The composition of the glass is also indicative of mouth blown rather than machine manufacture since the silica content is low and the magnesia high. In addition to this the phasing of the bottles places them as having been manufactured sometime prior to c1874, the Ashley was not patented until 1886, some 12 years after.

The composition of HLLA Pale Green (2) is well suited for use with semi-automatic forming machines, being relatively high in silica and most importantly in lime which results in a quick setting glass ideal for hand operated machines. The composition is reasonably similar to that given by Turner (1926) for bottles manufactured 1900-1917, although the soda concentration is slightly lower (see Table 4). The seams on the bottle necks and finishes and in particular the fact that the finishes are moulded, not applied, would appear to confirm that they were machine, rather than hand, formed.

Table 4: average compositions for bottle glass: 1900-1917 (Turner 1926) and HLLA Pale Green (2)

(Wt%)	1900-1917	HLLA Pale Green (2)
SiO_2	69.7	70.8
Al_2O_3	0.5	1.2
Fe_2O_3	0.3	0.3
CaO	17.4	17.4
MgO	0.6	0.3
Na_2O	11.2	9.4

Since there is no correlation with the working waste it is not certain that these bottles were manufactured at Hightown. It is most likely then that this material was brought onto the site as cullet sometime in the early 1900s.

Soda-Lime-Silica

The context dating for Phase II is not precise enough to provide relative chronologies of the different types of SLS glasses so it is necessary to use evidence provided by the form of the bottles themselves.

Colourless SLS

The SLS (1) bottles marked 'J.L. & C^{o} L^{d}' have an earliest possible date of manufacture of 1905, bottles manufactured before this time would have been marked with 'J.L. & Co'. The presence of the UGB bottle within this group could suggest that this bottle represents a transitionary stage between the old glass recipe used by Lumbs and the new one later introduced under 'UGB' management. SLS (1) has an average composition very similar to that cited in Turner (1926) as being typical of post WWI colourless bottle glass (see Table 5). This suggests that SLS (1) represents the glass being manufactured at Hightown after the First World War up until the late 1930s after UGB took over management. This correlates well with the colourless SLS working waste (Gardner 2009) which was also found to have a very similar composition to the Turner data.

Table 5: average compositions for post WWI glass (Turner 1926) and SLS (1)

(Wt%)	> WWI	SLS (1)
SiO_2	73.8	74.0
Al_2O_3	0.6	0.8
Fe_2O_3	0.07	0.06
CaO	8.8	9.2
MgO	0.1	0.1
Na_2O	16.5	16.5

The bottles belonging to SLS (4) must have been manufactured post c1937 as they all bear the mark 'UGB' on the base. Since all the bottles belonging to SLS (4) came from a single context, 5028, they were probably deposited at roughly the same time as each other, and given the relative lack of compositional variation between them were most likely manufactured over a fairly short period of time.

SLS (3) and SLS (5) are similar in composition, except for the higher proportion of magnesia in SLS (5). Magnesia, was rarely added deliberately as it results in a glass which is hard and viscous in nature (Rosenhain 1919). The relatively high proportion of magnesia in SLS (5) may then account for the high proportion of wasters. If the glass was too viscous it may have been difficult to blow the glass evenly throughout the vessel, this could certainly be the explanation of the uneven distribution of glass in H0160. Although SLS (3) was not found in the working waste, its close compositional similarity with SLS (5) suggests that it was indeed a product of Hightown. It seems likely that SLS (5) represents an unsuccessful experimental variant of SLS (3) glass, and as such was probably fairly short lived in it usage. Contemporary window glass often contained 2-3wt% magnesia in place of lime an effort to compensate for devitrification in continuous drawn sheet glass; it is possible that SLS (5) was an (unsuccessful) effort to see whether the same could be applied to bottle glass.

Pale Green SLS

The range of bottle types represented by SLS (2) is quite wide, however this may be accounted for by the fact that the although it is referred to as a single group the range of compositions within it is in fact relatively large and there could well be several other compositional groups within SLS (2) that have not been separated as it is not clear where the boundaries between such groups may lie. Although SLS (2) is not represented by the working waste (Gardner 2009) the fact that H0010 is a 'J.L. & C^{o} L^{d}' suggests that this bottle at least may have been manufactured at Hightown. In fact H0010 sits relatively close to some of the working waste values obtained for the colourless glasses in terms of lime : soda content. However this is by no means definitive as Lumbs owned at least two other contemporary glasshouses (two properties on High Street) in Castleford (Thorp & Thorp nd) and it is possible that H0010 was manufactured at either of these two properties. The 'J.L. & C^{o} L^{d}' mark dates the bottle to having been manufactured no earlier than 1905. H0183 has a reasonably similar composition to H0010, the fact that it is marked Walker's Kilmarnock Whisky may also support it having been manufactured at Hightown as Walkers probably took over management of Lumb's in c1916 (Thorp & Thorp nd), although again it is possible that it was manufactured at one of the other Lumbs glasshouses. Assuming however, that these two bottles are products of the Hightown bottle works the possibility arises of them being roughly contemporary with either SLS (1) or (3) both of which contain similar bottle forms, yet have very different compositions. It is possible that SLS (2) represents a poorer quality ie cheaper alternative to the higher quality colourless glasses employing sands with higher iron contents in order to save on manufacturing costs.

Emerald Green SLS

Despite the fact that both the emerald working waste and the SLS (Emerald) bottle itself were recovered only from unphased contexts the fact that it is a SLS glass makes it very likely to belong to Phase II. Also, Muspratt in 1860 comments that '[chromium] … is too costly for common use', whilst in the twentieth century it is, according to Rosenhain (1919), a relatively cheep additive, suggesting that its use in bottle glass would be more likely to be confined to Phase II activity at Hightown. The chromium was probably added in the form of potassium dichromate since it melts at a lower temperature, where as chromium oxide melts at a higher temperature and therefore may not melt fully remaining as very dark green to black spots in the glass. The emerald glass is also distinguished by higher concentrations of zirconium suggesting that the source of the chromium also contained zirconium. The fact that this glass was being coloured in such a manner that when the bottle was viewed it very closely resembled dark green (iron rich) HLLA bottles is interesting. This could suggest that some consideration was being paid to 'product recognition' by continuity of the bottle colour, as well as the practical consideration that heavily green tinted glass prevents light from reaching the contents, which is important if the bottle is intended for holding a product such as wine or beer where the product itself is more easily affected by exposure to light.

Intermediate

Intermediate (1) contains two bottles manufactured for a company called 'Idris'. One is the body a bottle which is clearly 'egg' shaped whilst the other is a base which again displays the egg shaped profile but with a flat base. The flat base of the latter bottle suggests it was manufactured prior to c1920 as 'flat based eggs' generally went out of production in the early 1920s (Wills 1974). Intermediate (1) does not correlate with the Hightown working waste (Gardner 2009) and it is likely that it was not manufactured at Hightown; these bottles were probably imported as cullet. Alternatively it is also possible that the bottles were brought to Hightown because of what they contained. Idris and Schweppes were well known soda water manufacturers and it is entirely possible that bottles of soda water were brought to Hightown by the workers to drink.

Another bottle unlikely to have been manufactured at Hightown is H0186, it does not match with any of the other groups identified; the soda : potash ratio in particular is very distinct from any of the other bottles. There is also typological evidence for the bottle having been manufactured elsewhere. The base of the bottle is marked 'JRS', which probably stands for J.R. Sykes who briefly owned a glasshouse in nearby Whitwood between 1908 and 1910 (Thorp & Thorp nd). The bottle was probably brought to Hightown as cullet.

Vessel Forms Manufactured at Hightown

The evidence suggests that from at least post WWI Hightown did not manufacture soda water bottles and that the majority of its output was bottles intended for liquor, in particular whiskey. This is consistent with the probable takeover of Lumbs by J. Walkers in 1916.

Screw-stoppered and crown-topped bottles are very common in twentieth-century bottles. However, within the entire Hightown bottle assemblage (sampled and unsampled) only one neck with an external screw thread and one crown-topped bottle were found, both from contexts which have largely produced material unlikely to have been manufactured at Hightown. The majority of the necks had finishes similar to that in Figure 9.

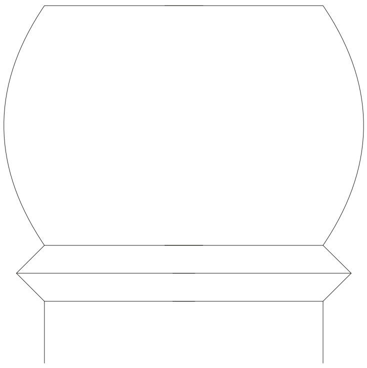

Figure 9: the most common form of finish on twentieth century bottle necks from the Hightown sample

This type of top is designed to take a cork stopper. Most mineral water manufacturers stopped using cork stoppers in the early 1900s, Schweppes for instance discontinued their use in 1903 and beers very rarely used corks after the introduction of the internal screw-stopper in 1872 (Hedges 2002). Where corks did continue to be used however was for liquor bottles.

An assessment of body fragments of both confirmed and suspected twentieth-century date reveals that a large number of the fragments were from square vessels. Square vessels are very much associated with liquor bottles, several of the bases are stamped with 'Walkers Whiskey' who, based on evidence from Thorp and Thorp (nd), may have taken over ownership of Lumbs in c1916. The remaining base fragments are all round, however the thickness is rather greater than would be expected for soda bottles and very similar to that exhibited in the square bases. One rounded base is stamped with 'Walkers Whiskey' confirming that round based whiskey bottles were manufactured.

Some fragments of 'egg' shaped vessels were recovered from Phase II contexts however these were exclusively from SLS (2) and Intermediate (1) and (2). Based on correlation with the working waste none of these groups can be said with any certainty to have been manufactured at Hightown. The earliest dated Phase II group is SLS (1) which was probably manufactured between the end of WWI and the late 1930s; this group contains three examples of the bottle necks shown in Figure 9.

Cullet

The SLS (3) bottles include several bottle necks that were recovered with corks in the mouths (see Appendix 1). These were considered in the original assessment to be the most likely candidates for bottles not manufactured at Hightown since bottles were not filled on site. However, chemical analysis shows that it is very probable that SLS (3) was manufactured at Hightown, supported by typological evidence including a Walker's Kilmarnock Whisky stamp on a bottle base and that Walkers is written on all of the corks, suggesting that the glassworks was getting its own bottles back as cullet. A possible explanation for this is that Walkers were attempting to prevent reuse of their bottles. The refilling of bottles belonging to a well known brand with a fake or cheaper product was a common problem, although usually the bottles were returned to the company producing the product rather than the bottle manufacturer (Wills 1974). However, in a case such as Hightown where the manufacturers were owned by the same parent company it would make sense for the bottles to be returned to the production site for use as cullet. Particularly given the fact that by the post WWI period the number of bottle glass manufacturing sites in England was much reduced, therefore the possible sources of cullet would be less and so by returning the bottles to the glasshouse a reliable source of cullet could be ensured.

Raw Materials

Unlike the gradual changes in glass type from HLLA to SLS, the evidence from Hightown indicates that the source and quality of the lime and sand being used changed drastically between phase 1 and 2.

In Phase 1 low values for silica indicate that a lower proportion of sand was being used and that more materials such as blast-furnace slag were being added. High iron (III) oxide and alumina values suggest that the sand probably contained an appreciable proportion of clay and would have provided inconsistent results between batches. Phase 2 glasses however show much greater values for silica, indicating that the sands used in this period were generally more pure. Differences are observed between the pale green and colourless phase 2 glasses, with the colourless glasses containing a noticeably higher proportion of iron (III) oxide and alumina; however the silica values for both glass types are roughly equal. This may suggest differences in the treatment of the sands. Angus-Butterworth (1948) notes that some manufactures chose to wash sands in order to remove clay impurities, this may have been employed in the case of the colourless glasses and not so with the pale green.

Proportions of magnesia show the inverse relationship between phase 1 and 2. Phase 1 glasses have high proportions of magnesia. The most probable source for such magnesia is the lime used in the batch. Castleford is situated on an outcrop of magnesian limestone and it is most likely that in phase 1 this local and therefore cheap resource was being utilised. The phase 2 glasses contain very little magnesia, those that do have in general produced wasters. It therefore seems likely that in phase 2 the use of the Castleford limestone was abandoned in favour of a source of lime free from magnesia.

Both these changes in raw materials can be linked to the change in glass forming technology observed between phases 1 and 2. In phase 1 the expense of employing skilled labour was high and the overall rate of production relatively low, necessitating the use of raw materials from the cheapest possible sources. This was of little consequence however to the mouth blown industry since skilled workers were able to adapt their work to the inevitable variations in composition from batch to batch that arose from using raw materials of uncertain purity and homogeneousness. Whilst the rate of overall production was much lower the time taken to form individual vessels by mouth blown techniques was much shorter than by machines and therefore the quick-setting nature of HLLA glasses was acceptable. Although semi-automatic forming machines continued to utilise quick-setting glasses the ability to adapt the way the bottle was blown to the composition of individual batches was much reduced; therefore although the glass could still be of an essentially HLLA composition, greater consistency was required and therefore the composition of the raw materials need to be more reliable. In phase 2 automatic forming machines dramatically cut the cost of employment and increased the overall rate of production. The time taken to form individual vessels on an automatic machine was greater than by mouth-blown or semi-automatic processes and therefore the HLLA glasses were no longer suitable; SLS glasses are by contrast much slower setting and therefore ideal for use with automatic machines. Since all processes were now fully automated there was essentially no scope for adapting how vessels were blown according to variations between batches and so purity and homogeneousness of raw materials became essential. Higher quality raw materials were necessary for the machinery to function properly and were therefore in fact more economic than cheaper ones. The change from mouth-blown to fully automated procedures resulted in not only a technological shift but also an economic one; from an industry whose greatest expense was labour to one where raw materials were the larger part of the outgoings. The bottle glass market had also changed by phase 2, the demand for colourless glass was much higher as consumers wanted to be able to see the products they were buying; it was therefore in the interests of the manufacturer to use sands with lower iron (III) oxide contents.

The SLS glasses (1), (3), (4) and (5) all have low values for manganese and for iron. Manganese was employed commonly as a decolouriser as it produces a pale pink tint which neutralises the green produced by the presence of ferrous iron oxide it also has some oxidising effect, thus promoting the conversion of ferrous iron oxide to ferric iron oxide which produces a much less noticeable yellow tint. According to Angus-Butterworth (1948) the glass industry tended to rely upon decolourises such as manganese to produce colourless glasses unless high light transmittance was required (which would not be of any particular consideration in the bottle glass industry). At Hightown however it would seem that the manufacturers opted to use higher quality sands rather than employ decolourisers as evidenced by the low proportion of iron in all the above glasses (not above c0.1wt%) despite the relative expense of doing so. This may speak to some degree as to the relative prosperity of Hightown in comparison to other glasshouses that it could afford to use high grade sands in the production of what is considered a relatively low grade glass type, it may also speak as to the relative position of the manufacture of Johnnie Walker whiskey bottles within the bottle glass trade, that unlike more everyday containers the high price paid by the consumer for the product would allow for a higher production price for the bottle to be economic.

CONCLUSIONS

In conclusion, chemical analysis of a sample of bottles taken from the Hightown assemblage has provided evidence for the manufacture of at least six glasses of different compositions used there.

Two of these were HLLA glasses; a dark green and a pale green glass which were manufactured between c1852 and c1874, although it is not known if these two glass types were contemporary to each other. Based on typological evidence from the bottles it has been deduced that the bottles produced in this period were mouth blown and that at least some were formed in a three-part mould. The dark green bottles have provided evidence for the development of the three-part moulds used at Hightown from a more simplistic design where the kick up was still hand formed to a more complex one closely modelled on the Ricketts mould. There is also evidence that pontil rods were still being used to form the finishes for at least part of this period. There is evidence for the production of bottles for beers, wines and mineral waters. Cheap and local raw materials were utilised; the sands used were of an impure variety being high in iron (III) oxide and alumina indicating a high clay content. The source of lime was probably the outcrop of magnesian limestone upon which Castleford sits.

There is no direct evidence for the manufacture of bottles during the period between the reopening of the glasshouse in 1902 and cWWI, however, based upon the compositions of the glasses probably being imported as cullet during this time it would seem likely that bottles at Hightown were being produced by semi-automatic forming machines, this fits in well with contemporary evidence which suggests that Hightown was operating this type of machinery in the pre WWI period (Thorp and Thorp nd). Unfortunately as no material identified as having been produced in this period has been recovered within the sample no comments can be made as to the types of containers being produced at this time.

By post WWI a SLS glass was being produced with a composition similar to that cited by Turner (1926) as being typical of that used for producing bottles by fully automated processes. This general glass recipe (SLS (1)) appears to have continued in use into the late 1930s; although by this time it seems that the concentrations of some minor oxides had changed slightly. Another compositional group (SLS (4)) in which all the bottles must have been produced post 1937 shows very similar minor oxide compositions compared to those produced in the latter period of production of SLS (1) glasses. This suggests more gradual changes over time in the glass composition being used rather than the sudden introduction of a completely different recipe.

The composition of the post WWI glasses suggests that the quality of the raw materials was higher. Sands with low iron (III) oxide and alumina contents, were likely treated by washing and grading in order to enhance these properties and ensure consistency (Angus-Butterworth 1948). The local magnesian limestone was no longer in use as necessitated by the use of the new fully automated forming machines where high levels of magnesia were likely to result in the production of wasters.

In terms of types of bottles being manufactured the evidence from the assemblage suggests that from at least post WWI Hightown was not manufacturing beer or mineral water bottles and that the majority of its output was focused on the production of liquor bottles. There is also limited evidence for the production of jars, however these have only been recovered from SLS (5) where the dating is not precise enough to place it clearly within a relative chronology of compositions other than that they were probably manufactured post WWI. Although the lower value for lime suggests that it may predate SLS (1).

The most immediately significant impact of the introduction of machine manufacture on bottle glass composition appears to have been a sharp increase in the proportion of silica and decrease in the proportion of magnesia, corresponding to an increase in the quality of the lime and sand used for bottle glass.

Table 6: summary of conclusions

Period	Groups	Relative Chronolgy of Samples	Types of Bottle	Method of Manufacture	Raw Materials	Made at Hightown?
1850s-1874	HLLA DG/ HLLA LG (1)	H0171 < H0134	Minerals, Beers, Wines	Mouth blown/3-part mould	Impure (high iron oxide) sand, local magnesian limestone	Yes
	Low Lime, Low Silica	–	Eggs, Jars	Mouth blown		No
1880s-1910s	HLLA LG (2)/ Intermediate (1)/(2)	–	Minerals, Beers	Semi-automatic	Impure (high iron oxide) sand, low magnesia lime	No
?	SLS (2)	–	Liquor, Minerals, Eggs, Jars (?)	Automatic		No
1910s-1940	SLS (1)	Other samples < H0193	Liquor	Automatic	Pure (low iron oxide) sand, low magnesia lime	Yes
> 1937	SLS (4)	_	?	Automatic		Yes
>WWI	SLS (3)/ SLS (5)	–	Liquor	Automatic	Pure (low iron oxide) sand: Low magnesia lime / Some magnesia	Yes
	SLS (Emerald)	_	?	Automatic	Pure (low iron oxide) sand, low magnesia lime, chromium	Yes

Limitations

The compositions of glass identified by the chemical analysis probably only represent a small number of the glass types used at Hightown, particularly in the twentieth century where experimentation with new glass recipes was an almost continual process. There may well have been compositions that were so short lived in terms of actual usage that they are represented by one bottle in the surviving excavated assemblage and further compositional groups that may not have survived in the record at all. It must be remembered that the results in this report are influenced by a number of biases imposed upon them; firstly by deposition and survival of the material in the archaeological record, levels of recovery and of course how truly representative the analysed sample in reality was.

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APPENDIX I (CATALOGUE)

Group	Context	Sample Nº	Notes	Text/Image
HHLA Dark Green	3062	H0134	Bottle base fragment. Two parallel mould seams around heal of base. Dark green. Wide, flat out rim with kick up of regular shape, no visible pontil mark.	
	5603	H0171	Bottle base and partial body fragment. Single mould seam around heal of base. Dark green. Narrow outer rim with kick up of irregular shape, possible pontil mark though non diagnostic. No visible seams on body.	
HHLA Light Green (1)	5563	H0166	Bottle neck fragment. Blob top finish, glass runs down from finish onto neck. Rim diameter c. 3cm. Pale green. Seam to top of neck but not on finish.	
		H0167	Bottle neck fragment. Blob top finish, glass runs down from finish onto neck. Rim diameter c. 3cm. Pale green. No visible seams.	
		H0169	Bottle neck fragment. Finish: short bulbous lips with string rim below, glass runs down from string rim onto neck. Rim diameter c. 4.2cm. Neck slightly oval in cross-section. Pale green. No visible seams.	
	5525	H0157	Possible bottle neck fragment. Probably blob top finish. Pale green. No visible seams.	
	5603	H0170	Flat bottle body fragment. Thickness varies throughout fragment. Pale green. No visible seams.	
	3085	H0037	Bottle neck fragment. Finish: Straight sided lips tapering inwards towards mouth, flattened string rim below, distinct groove divides string rim. Rim diameter 2cm. Pale green. No visible seams.	
HLLA Light Green (2)	5601	H0151	Bottle neck fragment. Crown top, with bead rim bulbous finish beneath, very small collar below finish. Rim diameter c. 2.5cm. Pale green. Seam on neck and finish but not on bead rim.	
		H0152	Bottle neck fragment. Finish: straight sided lips with flaring string rim below. Rim diameter c. 2.5cm. Pale green. Seam to top of finish.	
	5146	H0179	Bottle body fragment. Curvature in two planes - egg shaped vessel. Pale green. No visible seams.	
	H0168	H0176	Bottle neck fragment. Crown top, with bead rim bulbous finish beneath, very small collar below finish. Rim diameter c. 2.5cm. Pale green. Seam on neck and finish but not on bead rim.	
	5524	H0165	Bottle neck fragment. Blob top finish. Rim diameter c. 3cm. Pale green. Seam to top of mouth.	

Group	Context	Sample Nº	Notes	Text/Image
Low Lime, Low Silica	5601	H0153	Bottle body. Curvature in two planes - egg shaped vessel - missing neck and part of shoulder. Pale green. Seam around bottle including base.	_NMOND_ & C^O LEMINGTON J DAILY & C^O LATE
	5563	H0168	Bottle base fragment. Curvature in two planes - egg shaped vessel. Pale green. Seam around bottle including base.	
	5168	H0162	Jar rim and shoulder. Sloping shoulders. Rim diameter c. 7cm. Colourless. No visible seams.	
Intermediate (1)	5049	H0181	Bottle base and partial body fragment. Slight kick up. Pale green. Seam around base and on side.	& C^O L^D C 1887 (base) _LE_ (side)
	5019	H0199	Bottle body fragment. Curved in one plane - straight sided, round based. Pale green. Seam on side.	SCHWEP_ BY / crest (crown and lion)
		H0200	Bottle body fragment. Curvature in two planes - egg shaped vessel. Pale green. No visible seams.	IDRI_ _EAUX _C_
	5202	H0208	Bottle neck and shoulder fragment. Finish: straight sided lips with flaring string rim below, internal ledge. Cork lined glass stopper found in mouth. Rim diameter c 2.5cm. Pale green. No visible seams.	
	5146	H0180	Bottle body fragment. Pale green. No visible seams.	_Y ROYAL_ / crest (crown and lion)
Intermediate (2)	5019	H0197	Bottle body fragment. Curvature in two planes - egg shaped vessel. Pale green. Seam on side.	TO H. I. M. IM_ BY A_ _F/E R_ / crest (crown and lion)
		H0198	Body and partial base fragment. Curvature in two planes, with flat base - flat based egg shaped vessel. Pale green. No visible seams.	_RIS_
	5146	H0177	Bottle neck fragment. Blob top with small collar below. Rim diameter c. 2.5cm. Pale green. Seam to finish, ghost seam on finish.	
		H0178	Bottle body fragment. Curvature in both planes - egg shaped vessel. Pale green. No visible seams.	
SLS (1)	5166	H0082	Square bottle base fragment. Colourless. Circular seam on base, no visible seams on sides.	SHERRMAN AND ROSS ?

Group	Context	Sample No	Notes	Text/Image
SLS (1)	5166	H0086	Bottle neck fragment. Blob top with small collar below. Rim diameter c. 2.5cm. Colourless Seam to top of mouth.	
		H0089	Possible bottle neck fragment. Colourless. No visible seams.	
		H0090	Possible bottle neck fragment. Colourless. No visible seams.	
	5049	H0182	Round bottle base and partial body fragment. Colourless. No visible seams.	J. L & C^{O}_ (base) REG 826 (side)
		H0184	Square bottle base fragment. Colourless. Circular seam on base, no visible seams on sides.	151L3
		H0185	Round bottle base and partial body fragment. Angular sides. Colourless. No visible seams.	JL_ REG_
	5064	H0194	Round bottle base and partial body fragment. Colourless. Seam on side.	JL & C^{O} L^{D} C L_ 160L54
		H0195	Round bottle base. Colourless. No visible seams.	JL & C^{O} L^{D} C 142N1
	5028	H0193	Round bottle base. Colourless. No visible seams.	UGB
SLS (2)	5019	H0196	Bottle body fragment. Curvature in two planes - egg shaped vessel. Pale green. Seam on side.	
	5019	H0201	Bottle body fragment. 3 angular faces. Pale green. No visible seams.	
		H0202	Bottle shoulder fragment	
	1033	H0001	Bottle neck fragment. Finish: straight sided lips with small flaring string rim below. Rim diameter c. 2.5cm. Pale (yellow) green. Seam to top of mouth.	

Group	Context	Sample Nº	Notes	Text/Image
SLS (2)	1033	H0010	Square bottle base fragment. Colourless. square seam on base, Diagonal seams at two corners.	JL & C^O L^D 2528
	5202	H0206	Bottle neck fragment. Blob top finish with small collar below. Rim diameter c. 2.5cm. Pale green. Seam to top of mouth.	
	5049	H0183	Square bottle base. Slight circular kick up. Diagonal seams at top corners.	WALKER'S KILMARNOCK WHISKY 1801
SLS (3)	1033	H0002	Bottle neck fragment. Blob top with small collar below. Rim diameter c. 2.5cm. Colourless. Seam to top of mouth.	
		H0003	Bottle neck fragment. Blob top with small collar below. Rim diameter c. 2.5cm. Colourless. Seam to top of mouth.	
		H0004	Bottle neck fragment. Blob top with small collar below. Rim diameter c. 2.5cm. Colourless. Seam to top of mouth.	
		H0005	Bottle neck fragment. Finish: straight sided lips with small string rim below. Rim diameter c. 2.5cm. Colourless. Seam to top of mouth.	
		H0006	Bottle neck fragment. Blob top with small collar below. Rim diameter c. 2.5cm. Colourless. No visible seams.	
		H0014	Square bottle base fragment. Slight kick up. Pale green Circular seam on base, diagonal seams in two corners.	_ALKER'S S _MARNOC _ISKY _3
	5202	H0203	Bottle neck fragment. Blob top finish with small collar below. Cork in mouth. Rim diameter c. 2.5cm. Colourless. Seam to mouth.	WALKERS (cork)
		H0204	Bottle neck fragment. Blob top finish with small collar below. Cork in mouth. Rim diameter c. 2.5cm. Colourless. Seam to mouth.	WALKERS (cork)
		H0205	Bottle neck fragment. Blob top finish with small collar below. Cork in mouth. Rim diameter c. 2.5cm. Colourless. Seam to mouth.	WALKERS (cork)
		H0207	Bottle neck fragment. Blob top finish with small collar below. Cork in mouth. Rim diameter c. 2.5cm. Colourless. Seam to mouth.	WALKERS (cork)

Group	Context	Sample Nº	Notes	Text/Image
SLS (4)	5028	H0187	Round bottle base and partial body fragment. Dot pattern on base. Colourless. Seam on side	SA 102 L J UGB (base) AS_OW (side)
		H0188	Round bottle base. Dot pattern on base. Colourless. No visible seams.	SC 68 LRB UGB
		H0189	Round bottle base. Colourless. No visible seams.	16 C UGB
		H0190	Round bottle base. Concentric circles pattern on base. Colourless. No visible seams.	UGB
		H0191	Round bottle base and partial body fragment. Colourless. Seam on side.	W352 L2 UGB
		H0192	Round bottle base. Colourless. No visible seams.	Z 319 LRS UGB
SLS (5)	5168	H0160	Bottle neck fragment. Much thicker in neck than in mouth. Finish: straight sided lips, internal ledge. Rim diameter c. 3cm. colourless. No visible seams. Probable waster.	
		H0161	Jar neck. Tapers inwards, faults in side. Colourless. Seam to mouth. Waster.	
		H0163	Bottle neck fragment. Cracks run through finish, mouth blocked with glass. Colourless. No visible seams. Waster.	
	5607	H0172	Bottle body fragment. Oval base with straight sides, kick up, fault in side. Pale green. No visible seams. Waster.	

APPENDIX II (SAMPLE DATA)

Samples	Glass Type	Colour	Na_2O	MgO	Al_2O_3	SiO_2	SO_3	K_2O	CaO	TiO_2	Cr_2O_3	MnO_2	Fe_2O_3	BaO	As_2O_3	PbO	SrO	ZrO_2
H0001	SLS (2)	Clear	14.74	0.10	0.89	72.18	0.37	0.14	12.74	<0.10	< 0.01	< 0.01	0.13	<0.20	0.04	0.01	0.01	0.01
H0002	SLS (3)	Clear	18.11	0.65	0.56	70.62	0.27	0.07	8.12	<0.10	< 0.01	0.16	0.09	<0.20	0.12	0.01	0.01	< 0.01
H0003	SLS (3)	Clear	18.24	0.51	0.63	71.41	0.24	0.11	8.05	<0.10	< 0.01	0.01	0.10	<0.20	0.14	0.01	0.01	< 0.01
H0004	SLS (3)	Clear	18.38	0.40	0.76	70.93	0.38	0.15	8.53	<0.10	< 0.01	0.05	0.12	<0.20	0.10	0.01	< 0.01	0.01
H0005	SLS (3)	Clear	18.93	0.58	0.57	72.72	0.32	0.11	7.81	<0.10	< 0.01	< 0.01	0.08	<0.20	0.13	0.01	0.01	0.01
H0006	SLS (3)	Clear	19.04	0.59	0.57	72.33	0.26	0.04	8.05	<0.10	< 0.01	0.03	0.10	<0.20	0.13	0.02	0.01	0.01
H0007	SLS (2)	Pale green	16.31	0.02	0.71	70.11	0.43	0.13	10.96	<0.10	< 0.01	< 0.01	0.17	<0.20	0.01	0.02	0.02	0.01
H0010	SLS (2)	Clear	15.70	0.07	0.87	70.83	0.66	0.19	11.96	<0.10	0.01	< 0.01	0.19	<0.20	0.04	0.02	0.02	0.01
H0014	SLS (3)	Pale green	17.23	0.51	1.28	72.50	0.66	0.21	8.14	<0.10	< 0.01	< 0.01	0.17	<0.20	0.09	< 0.01	0.01	0.01
H0037	HLLA (LG 1)	Pale green	7.89	6.73	1.16	63.29	0.79	0.14	20.51	< 0.01	< 0.01	< 0.01	0.35	0.94	0.15	< 0.01	0.05	< 0.01
H0082	SLS (1)	Clear	16.63	0.09	0.86	74.04	0.21	0.07	8.66	< 0.01	< 0.01	< 0.01	0.04	<0.20	0.18	< 0.01	0.01	0.01
H0086	SLS (1)	Clear	16.15	0.08	0.59	73.77	0.21	0.06	9.38	< 0.01	0.01	< 0.01	0.08	<0.20	0.11	0.01	< 0.01	< 0.01
H0089	SLS (1)	Clear	16.17	0.12	0.76	73.33	0.23	0.06	9.27	<0.10	0.01	< 0.01	0.06	<0.20	0.11	< 0.01	0.01	0.01
H0090	SLS (1)	Clear	16.39	0.13	0.80	74.91	0.22	0.04	9.15	<0.10	< 0.01	< 0.01	0.07	<0.20	0.09	< 0.01	0.01	0.01
H0134	HLLA (DG)	Dark green	7.34	3.15	6.15	57.47	0.66	1.21	20.98	0.21	< 0.01	0.01	2.95	<0.20	0.02	< 0.01	0.02	0.01
H0135	SLS (E)	Emerald green	13.96	0.27	1.96	71.77	0.09	0.78	10.45	<0.10	0.21	0.04	0.35	<0.20	< 0.01	0.01	0.01	0.04
H0151	HLLA (LG 2)	Pale green	8.53	0.19	1.22	71.81	0.37	0.28	17.03	<0.10	< 0.01	0.02	0.26	<0.20	< 0.01	0.01	0.02	0.01
H0152	HLLA (LG 2)	Pale green	9.95	0.41	1.59	71.37	0.55	0.37	16.71	<0.10	< 0.01	0.01	0.28	<0.20	< 0.01	0.01	0.02	0.01
H0153	LLLS	Pale green	13.50	6.68	1.51	64.64	0.48	0.31	11.71	<0.10	< 0.01	0.02	0.46	<0.20	1.14	0.01	0.02	0.01
H0157	HLLA (LG 1)	Pale green	8.23	8.01	1.24	62.01	0.67	0.19	18.41	<0.10	< 0.01	0.03	0.38	<0.20	0.05	< 0.01	0.02	0.01
H0159	HLLA (LG 1)	Pale green	8.72	7.61	1.40	63.66	0.66	0.18	18.55	<0.10	< 0.01	0.06	0.45	<0.20	0.11	< 0.01	0.02	< 0.01
H0160	SLS (5)	Clear	16.48	1.69	0.49	73.21	0.15	0.08	8.11	<0.10	< 0.01	0.05	0.02	<0.20	0.20	< 0.01	0.01	< 0.01
H0161	SLS (5)	Clear	16.97	1.30	0.61	73.33	0.20	0.16	7.75	<0.10	< 0.01	0.04	0.06	<0.20	0.22	< 0.01	0.01	< 0.01
H0162	LLLS	Clear	12.95	6.81	1.57	65.72	0.54	0.40	11.21	<0.10	< 0.01	0.06	0.38	<0.20	0.94	< 0.01	0.01	< 0.01
H0163	SLS (5)	Clear	17.33	1.37	0.66	73.68	0.13	0.15	7.92	<0.10	< 0.01	0.03	0.06	<0.20	0.22	< 0.01	0.01	0.01
H0164	Intermediate (2)	Pale green	11.12	1.09	1.69	73.38	0.29	0.33	13.98	<0.10	< 0.01	0.11	0.56	<0.20	< 0.01	0.05	0.02	0.01
H0165	HLLA (LG 2)	Pale green	9.25	0.43	1.09	70.11	0.68	0.24	17.12	<0.10	< 0.01	0.02	0.27	<0.20	0.01	0.02	0.02	0.01
H0166	HLLA (LG 1)	Pale green	8.28	6.36	1.08	65.66	0.73	0.18	18.56	<0.10	< 0.01	0.03	0.35	0.91	0.34	0.01	0.04	< 0.01
H0167	HLLA (LG 1)	Pale green	8.17	6.59	1.07	64.05	0.62	0.18	17.88	<0.10	< 0.01	< 0.01	0.36	1.57	0.01	< 0.01	0.06	0.01

Continued

Samples	Glass Type	Colour	Na_2O	MgO	Al_2O_3	SiO_2	SO_3	K_2O	CaO	TiO_2	Cr_2O_3	MnO_2	FeO	BaO	As_2O_3	PbO	SrO	ZrO_2
H0168	LLLS	Pale green	13.67	6.72	1.48	65.30	0.50	0.29	11.70	<0.10	< 0.01	< 0.01	0.45	<0.20	1.12	< 0.01	0.01	< 0.01
H0169	HLLA (LG 1)	Pale green	7.64	6.88	0.95	64.71	0.66	0.18	19.02	<0.10	< 0.01	< 0.01	0.34	0.93	0.02	< 0.01	0.04	0.01
H0170	HLLA (LG 1)	Pale green	7.96	6.37	0.98	64.41	0.91	0.18	19.78	<0.10	< 0.01	0.03	0.36	0.64	0.08	0.02	0.04	0.01
H0171	HLLA (DG)	Dark green	7.03	3.16	6.23	57.88	0.46	1.21	19.66	0.28	0.01	0.07	2.65	<0.20	0.03	< 0.01	0.02	0.02
H0172	SLS (5)	Pale green	17.44	1.30	0.64	73.83	0.15	0.12	7.81	<0.10	< 0.01	< 0.01	0.07	<0.20	0.22	0.01	0.01	0.01
H0176	HLLA (LG 2)	Pale green	10.19	0.21	1.09	69.75	0.90	0.23	18.28	<0.10	< 0.01	0.02	0.29	<0.20	0.01	0.01	0.02	0.01
H0177	Intermediate (2)	Pale green	11.02	1.12	1.61	72.60	0.28	0.35	13.61	<0.10	< 0.01	0.03	0.56	<0.20	0.01	0.07	0.02	0.01
H0178	Intermediate (2)	Pale green	10.88	1.13	1.59	73.26	0.34	0.37	14.01	<0.10	< 0.01	0.13	0.57	<0.20	< 0.01	0.05	0.02	0.01
H0179	HLLA (LG 2)	Pale green	9.27	0.38	1.08	70.75	0.64	0.24	17.99	<0.10	< 0.01	0.53	0.26	<0.20	0.01	< 0.01	0.02	0.01
H0180	Intermediate (1)	Pale green	10.75	0.13	1.73	73.37	0.43	0.27	12.53	0.11	< 0.01	0.02	0.41	<0.20	0.01	0.01	0.02	0.01
H0181	Intermediate (1)	Pale green	11.35	0.34	1.34	73.07	0.35	0.24	13.18	<0.10	< 0.01	< 0.01	0.40	<0.20	0.01	0.05	0.02	0.01
H0182	SLS (1)	Clear	17.33	0.03	0.92	72.87	0.21	0.05	9.81	<0.10	0.01	0.05	0.05	<0.20	0.12	< 0.01	0.01	0.01
H0183	SLS (2)	Pale green	13.36	0.11	1.32	73.24	0.42	0.19	11.80	<0.10	< 0.01	< 0.01	0.29	<0.20	0.01	0.01	0.02	0.01
H0184	SLS (1)	Clear	16.17	0.14	0.99	74.44	0.12	0.09	8.79	<0.10	0.01	< 0.01	0.06	<0.20	0.25	< 0.01	0.01	0.01
H0185	SLS (1)	Clear	16.45	0.11	0.81	74.33	0.22	0.06	9.17	<0.10	< 0.01	0.02	0.07	<0.20	0.17	0.01	0.01	0.01
H0186		Pale green	11.90	1.22	1.50	71.96	0.50	0.14	13.65	<0.10	0.01	< 0.01	0.29	<0.20	0.02	0.02	0.01	0.01
H0187	SLS (4)	Clear	14.86	0.01	1.29	73.62	0.12	0.18	10.08	<0.10	< 0.01	< 0.01	0.08	<0.20	0.04	< 0.01	0.01	0.01
H0188	SLS (4)	Clear	14.79	0.05	1.50	72.66	0.26	0.39	10.31	<0.10	< 0.01	0.11	0.02	<0.20	0.02	0.04	0.01	0.01
H0189	SLS (4)	Clear	15.12	0.03	1.11	73.53	0.20	0.14	10.07	<0.10	< 0.01	0.01	0.01	<0.20	0.03	< 0.01	0.01	0.01
H0190	SLS (4)	Clear	14.96	0.08	0.89	73.15	0.19	0.02	10.25	<0.10	< 0.01	< 0.01	0.05	<0.20	< 0.01	< 0.01	0.01	0.01
H0191	SLS (4)	Clear	15.07	0.04	1.28	75.17	0.13	0.14	9.92	<0.10	< 0.01	< 0.01	0.05	<0.20	0.04	0.02	0.01	0.01
H0192	SLS (4)	Clear	15.24	0.07	1.26	75.55	0.20	0.12	10.46	<0.10	< 0.01	< 0.01	0.07	<0.20	0.02	< 0.01	0.01	0.01
H0193	SLS (1)	Clear	16.35	< 0.01	1.24	75.29	0.20	0.15	9.58	<0.10	0.01	0.03	0.05	<0.20	0.03	< 0.01	0.01	0.01
H0194	SLS (1)	Clear	17.40	0.15	0.76	72.46	0.15	0.08	9.52	<0.10	< 0.01	< 0.01	0.07	<0.20	0.23	0.01	0.01	< 0.01
H0195	SLS (1)	Clear	16.33	0.06	0.68	74.27	0.18	0.02	9.03	<0.10	< 0.01	0.01	0.06	<0.20	0.11	0.01	0.01	0.01
H0196	SLS (2)	Pale green	12.88	0.39	1.35	73.29	0.40	0.24	12.67	0.10	< 0.01	0.01	0.31	<0.20	0.02	0.05	0.02	0.01
H0197	Intermediate (2)	Pale green	11.50	0.34	1.36	73.46	0.35	0.23	13.37	<0.10	< 0.01	0.01	0.37	<0.20	0.01	0.03	0.02	0.01
H0198	Intermediate (2)	Pale green	11.34	0.18	1.55	74.25	0.41	0.30	13.92	<0.10	< 0.01	0.07	0.42	<0.20	< 0.01	0.02	0.02	0.01
H0199	Intermediate (1)	Pale green	10.92	1.04	1.64	71.62	0.27	0.36	13.31	<0.10	< 0.01	0.02	0.55	<0.20	0.01	0.05	0.02	0.01
H0200	Intermediate (1)	Pale green	10.31	0.25	1.71	73.75	0.26	0.41	13.95	<0.10	< 0.01	< 0.01	0.48	<0.20	0.01	0.02	0.02	0.01

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Samples	Glass Type	Colour	Na_2O	MgO	Al_2O_3	SiO_2	SO_3	K_2O	CaO	TiO_2	Cr_2O_3	MnO_2	FeO	BaO	A_s2O_3	PbO	SrO	ZrO_2
H0201	SLS (2)	Pale green	14.33	0.22	1.00	71.23	0.41	0.19	13.96	<0.10	< 0.01	0.04	0.26	0.01	0.03	0.01	0.02	0.01
H0202	SLS (2)	Pale green	12.29	0.21	1.58	73.77	0.32	0.31	12.36	<0.10	< 0.01	0.85	0.51	0.07	0.01	0.03	0.02	0.01
H0203	SLS (3)	Clear	18.67	0.62	0.65	74.37	0.24	0.11	8.07	<0.10	< 0.01	0.05	0.11	< 0.01	0.15	< 0.01	0.01	< 0.01
H0204	SLS (3)	Clear	19.44	0.71	1.02	71.61	0.20	0.18	7.76	<0.10	< 0.01	0.07	0.09	0.09	0.15	< 0.01	0.01	0.01
H0205	SLS (3)	Clear	17.82	0.64	0.59	73.89	0.23	0.11	7.67	<0.10	0.01	0.04	0.08	0.05	0.15	0.01	0.01	< 0.01
H0206	SLS (2)	Pale green	14.36	0.43	1.31	70.14	0.38	0.23	11.38	<0.10	< 0.01	0.05	0.61	0.16	0.01	0.01	0.02	0.01
H0207	SLS (3)	Clear	18.76	0.59	0.56	73.68	0.24	0.08	8.32	<0.10	< 0.01	0.01	0.10	< 0.01	0.13	< 0.01	0.01	0.01
H0208	Intermediate (1)	Pale green	10.73	0.39	1.63	73.27	0.34	0.42	14.06	<0.10	< 0.01	0.04	0.31	0.05	0.08	< 0.01	0.01	0.01

ENGLISH HERITAGE RESEARCH DEPARTMENT

English Heritage undertakes and commissions research into the historic environment, and the issues that affect its condition and survival, in order to provide the understanding necessary for informed policy and decision making, for sustainable management, and to promote the widest access, appreciation and enjoyment of our heritage.

The Research Department provides English Heritage with this capacity in the fields of buildings history, archaeology, and landscape history. It brings together seven teams with complementary investigative and analytical skills to provide integrated research expertise across the range of the historic environment. These are:

* *Aerial Survey and Investigation*
* *Archaeological Projects (excavation)*
* *Archaeological Science*
* *Archaeological Survey and Investigation (landscape analysis)*
* *Architectural Investigation*
* *Imaging, Graphics and Survey (including measured and metric survey, and photography)*
* *Survey of London*

The Research Department undertakes a wide range of investigative and analytical projects, and provides quality assurance and management support for externally-commissioned research. We aim for innovative work of the highest quality which will set agendas and standards for the historic environment sector. In support of this, and to build capacity and promote best practice in the sector, we also publish guidance and provide advice and training. We support outreach and education activities and build these in to our projects and programmes wherever possible.

We make the results of our work available through the Research Department Report Series, and through journal publications and monographs. Our publication Research News, which appears three times a year, aims to keep our partners within and outside English Heritage up-to-date with our projects and activities. A full list of Research Department Reports, with abstracts and information on how to obtain copies, may be found on www.english-heritage.org.uk/researchreports

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