



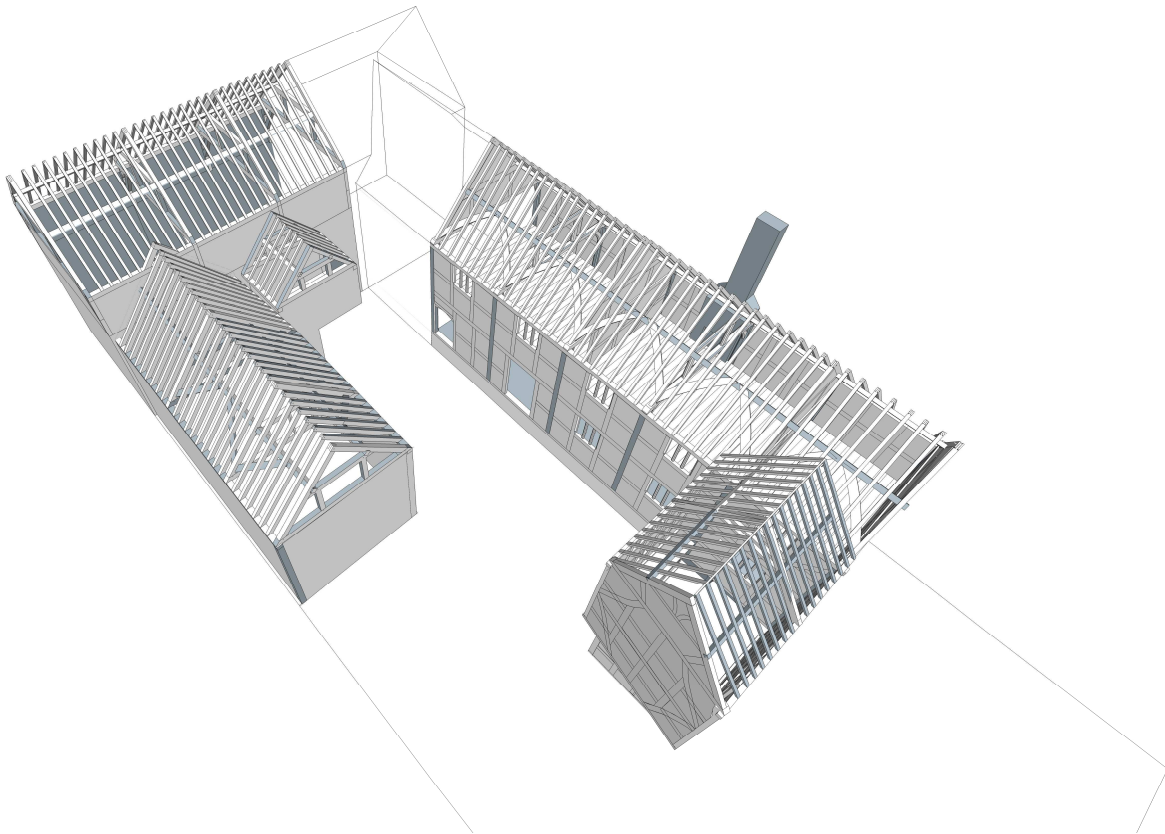
Historic England

The Fleece, Westgate Street, Gloucester, Gloucestershire

Tree-Ring Analysis of Oak and Elm Timbers

Martin Bridge and Cathy Tyers

Discovery, Innovation and Science in the Historic Environment



THE FLEECE,
WESTGATE STREET,
GLOUCESTER, GLOUCESTERSHIRE

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SUMMARY

Dendrochronological analysis of oak and elm timbers from the main range, the rear extension, the undercroft, and the Westgate range has resulted in the dating of 26 timbers. Twenty-five dated timbers from the main range and the Westgate range show that these two ranges are broadly contemporaneous. One timber in the Westgate range was felled in the summer of AD 1472, another in the main range was felled in the summer of AD 1476 with all other dated timbers all having similar likely felling dates. A beam in the undercroft was felled somewhat later in the summer of AD 1645. None of the elm timbers were dated.

CONTRIBUTORS

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ARCHIVE LOCATION

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DATE OF INVESTIGATION

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INTRODUCTION

The Fleece, a Grade 1 listed building, sits in a prominent position on Westgate Street in the historic centre of Gloucester approximately 200m south of the Cathedral (Figs 1–3). The complex under investigation consists of a long main range with a later extension and the Westgate range (Fig 4).

Much of the history of the site is to be found in an unpublished report by Fielden Clegg Bradley Studios (2009), from which the following is summarised. The main range, known for several centuries as the Great Inn, represents what is thought to be the single most important historic element of the site. It has no street frontage on Westgate Street but stands at right angles to the street and adjoins the rear of 17 Westgate Street. This range extends southwards into the Fleece Yard where it meets a rear cross-wing extension on the west side that runs parallel to Westgate Street. The main range is a two-storey masonry structure with basement, pitched roof, and cement rough-cast render to the ground floor elevation. The three-storey cross-wing returns into the yard from the main range. Steps lead up to the raised ground-floor level of the main range from the Fleece Yard, while a further set of masonry steps leads down into the twelfth-century undercroft. According to the Gloucester Rental of AD 1455, this plot is likely to date from the thirteenth century, when Benedict the Cordwainer held a number of properties on the south side of Westgate Street. The timber-framed element of the property is thought to date from the fifteenth century. The inn has its origins in accommodation which the Abbey of St. Peter provided for pilgrims attending the shrine of Edward II in the Abbey. *‘Unum Magnum Hospitium’* was built on top of the existing stone undercroft. The Westgate range has a three-storey frontage of mock timber-framing, but there are older elements behind. Although some of the framing also looks to be of fifteenth-century origin, its history is less well known.

The site has been on the Heritage at Risk Register since 2013 having being left empty for several years. Ownership passed to Gloucester City Council who carried out emergency repairs and is currently investigating potential development and future management of the site. As part of this on-going work, dendrochronological analysis was requested by Simon Robertshaw to provide independent dating evidence to better understand the building complex and its historic development, and hence to inform its significance, future protection, and use.

METHODOLOGY

Fieldwork for the present study was carried out in October 2016, following an initial assessment of the potential for dating a few weeks earlier. In the initial assessment, accessible oak (*Quercus* spp) and elm (*Ulmus* spp) timbers with more than 50 rings and, where possible, traces of sapwood were sought, although slightly shorter sequences are sometimes sampled if little other material is available. Following discussions with Historic England and consultation with Gloucester City Council it

was decided to proceed with sampling as per the assessment which, due to an on-going research project funded by Historic England (Project No 7350 - Developing the dendrochronology of elm in historic buildings), included the sampling of elm timbers. Those oak and elm timbers judged to be potentially useful were cored using a 15mm auger attached to an electric drill. The cores were glued to wooden laths, labelled, and stored for subsequent analysis.

The cores were polished on a belt sander using 80 to 400 grit abrasive paper to allow the ring boundaries to be clearly distinguished. The samples had their tree-ring sequences measured to an accuracy of 0.01mm, using a specially constructed system utilising a binocular microscope with the sample mounted on a travelling stage with a linear transducer linked to a computer, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004). Cross-matching was attempted by a combination of visual matching and a process of qualified statistical comparison by computer. The ring-width series were compared for statistical cross-matching, using a variant of the Belfast CROS program (Baillie and Pilcher 1973). Ring sequences were plotted on the computer monitor to allow visual comparisons to be made between sequences. This method provides a measure of quality control in identifying any potential errors in the measurements when the samples cross-match.

In comparing one sample, or site master, against other samples or chronologies, t -values over 3.5 are considered significant, although in reality it is common to find demonstrably spurious t -values of 4 and 5 because more than one matching position is indicated. For this reason, dendrochronologists require some t -values of 5, 6, and higher, and for these to be well replicated from different, independent chronologies with both local and regional chronologies well represented, except where imported timbers are identified. Where two individual samples match together with a t -value of 10 or above, and visually exhibit exceptionally similar ring patterns, they may have originated from the same parent tree. Same-tree matches can also be identified through the external characteristics of the timber itself, such as knots and shake patterns. Lower t -values, however, do not preclude same-tree derivation.

Ascribing felling dates and date ranges

Once a tree-ring sequence has been firmly dated in time, a felling date, or felling date range is ascribed where possible. With samples which have sapwood complete to the underside of, or including bark, this process is relatively straightforward. Depending on the completeness of the final ring (ie if it has only the spring vessels or early-wood formed, or the late-wood or summer growth) a precise felling date and season can be given for the sample. If the sapwood is partially missing, or if only a heartwood/sapwood transition boundary survives, then an estimated felling date range can be given for the sample. The number of sapwood rings can be

estimated by using an empirically derived sapwood estimate with a given confidence limit. If no sapwood or heartwood/sapwood boundary survives then the minimum number of sapwood rings from the appropriate sapwood estimate is added to the last measured ring to give a *terminus post quem* or felled-after date.

A review of the geographical distribution of dated sapwood data from historic timbers has shown that a sapwood estimate relevant to the region of origin should be used in interpretation, the empirically derived estimate for this area being 9–41 rings (Miles 1997).

It must be emphasised that dendrochronology can only date when a tree has been felled, not when the timber was used to construct the structure or object under analysis. Thus, the dates derived for the felling of the trees used in construction do not necessarily relate directly to the date of construction of the building. However, evidence suggests that, except in the reuse of timbers, construction in most historical periods took place within a very few years after felling (Salzman 1952; Hollstein 1965; Miles 2006).

RESULTS

A total of 55 timbers were sampled, 44 oak and 11 elm, with duplicate samples being taken from four timbers in order to maximise the information obtained from the timber. Details of the timbers are given in Table 1, and the timber locations are illustrated in Figures 5–23. These 55 timbers consisted of two beams in the undercroft, 25 in the main range, which were thought to be associated with the original construction, but most of the timbers thought to be associated with later alterations were not sampled as they were assessed as having too few rings for reliable analysis, however, the six that were sampled from this latter group proved to be a mixture of oak and elm. The rear extension to the main range was found to be constructed mostly of elm, the exception amongst the seven sampled timbers being the northwest corner-post, which was oak. A further 15 timbers were sampled in the Westgate range of which two, both ceiling beams, were elm.

Samples from 15 timbers, nine oak and six elm, were rejected prior to measurement as they had too few rings for reliable analysis. The remaining samples were measured (see Appendix) and the series from individual samples from the same timber were combined to produce a single series for the timber before further analysis. Cross-matching was identified between 25 series (Table 2) from both the main range and the Westgate range. Four series (flgl08, flgl12, flgl28, and flgl30) showed rather less good matching with the other dated series than was found between the rest of the group, and these were, therefore, dated independently as a means of checking the date assigned (Tables 3a–d). A 129-year long site master chronology, FLEECE, was formed from the 25 cross-matched series. This gave very strong matches to the reference material (Table 3e), with an interesting distribution of the highest *t*-values with sites to the north, up the Severn valley, when there are

other sites equally close in other directions (Fig 24). A bar diagram showing the relative positions of overlap of the dated timbers, along with their actual, or estimated felling date ranges, or felled after dates, is provided (Fig 25).

No further cross-matching was identified but flgl01, representing a beam over the bar area in the undercroft, was successfully dated when compared individually against reference material. A 46-year sequence like this would generally prove extremely difficult to date reliably, but the high *t*-values obtained for this series (Table 3f) against quite local chronologies, combined with the good visual cross-matching, gave confidence that this short sequence was correctly dated. It actually matched several individual sequences from the nearby Old Hat Shop (100 Church Street), Tewkesbury (Nayling 2000) with *t*-values ranging from 4.1 to 6.2, as well as individual series from two other Somerset sites, St Andrew's Church in Whitestaunton (Bridge 2014) and 8 Market Place in Shepton Mallet (Miles 2002a) with *t*-values ranging from 3.6 to 5.7.

INTERPRETATION AND DISCUSSION

Only two cores dated as part of the FLEECE site master chronology retained complete sapwood, resulting in the determination of two actual felling dates; summer AD 1472 for a purlin in the Westgate range, summer AD 1476 for a rafter in the main range. However, the level of cross-matching between the 25 series included in this site master chronology (Table 2) suggests that most of the timbers came from the same woodland source, with two pairs of series incorporating one common sample (flgl09 / flgl18 and flgl09 / flwg08) having high enough *t*-values (ie over 10.0) to suggest that they may possibly have come from the same parent tree. However, as flgl09 / flgl18 represent a large tiebeam and a large post on different trusses within the main range, and flgl09 / flwg08 both represent tiebeams but in two different wings, with no other evidence, the individual series were retained within the analysis as if they were from separate trees. The small difference in the two actual felling dates obtained suggests either that timber was gathered together over a number of years for this large building project, or perhaps that this large building was constructed over several years. It does, however, indicate that the main range and Westgate range were built within a few years of each other, if not at the same time. This interpretation is further supported by the close agreement in heartwood-sapwood boundary date between the dated timbers throughout the main range and the Westgate range (Fig 25).

The site master gave very strong matches, as is to be expected with a very well replicated chronology. It is interesting, however, that the strongest matches were with sites to the north, up the Severn valley, where several of these are more distant than sites of the same age in other directions. This may indicate that the source of the timbers was to the north, with the Severn being an obvious possible transport route down to Gloucester. A similar, more marked distribution, with sites even further north was found recently for timbers in the Merchant's House in

Tewkesbury (Bridge and Miles 2015), again suggesting transport was down river from the source woodland.

The individual dating of the beam in the bar area at the north end of the undercroft dates the felling of the tree used to the summer AD1645, and it seems likely, therefore, that this beam was inserted in that year, or within a year or two after this date, providing information about the development of this area. Again, the dating evidence (Table 3f) suggests a relatively close geographical source for this timber.

None of the timbers (many of them elm) were dated from the rear cross-wing extension, or from other timbers thought to be later alterations. The elm timbers will, however, provide additional information in relation to the on-going research project on elm funded by Historic England.

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TABLES

Table 1: Details of samples taken from the Fleece Hotel, Westgate Street, Gloucester

Sample number	Genus	Timber and position	No of rings	Mean ring width (mm)	Dates spanning (AD)	h/s boundary (AD)	Sapwood rings	Mean sensitivity	Felling date ranges (AD)
Undercroft									
flgl01	Q	North beam over bar	46	2.53	1599–1644	1628	16½C	0.21	Summer 1645
flgl02	Q	South beam by stair	76	2.02	-	-	h/s	0.24	-
Main range									
flgl03a	Q	West post frame F (F2/01)	43	2.60	1400–1442	-	-	0.19	
flgl03b	Q	ditto	37	2.92	1400–1436	-	-	0.13	
flgl03	Q	Mean of 03a and 03b	43	2.71	1400–1442	-	-	0.16	After 1451
flgl06	Q	West post frame D (D2/08)	102	2.21	1347–1448	1448	h/s	0.23	1457–89
flgl07	Q	Window sill (D2/02)	<40	NM	-	-	-	-	-
flgl08	Q	D2/06	89	1.85	1363–1451	1451	h/s	0.15	1460–92
flgl09	Q	West post frame C (C2/01)	50	3.12	1408–1457	1457	h/s	0.23	1466–98
flgl10	Q	Tie C (C2/02)	<40	NM	-	-	-	-	-
flgl11	Q	Girding beam, frame D (D2/09)	56	2.61	1393–1448	1448	h/s	0.15	1457–89
flgl12	Q	East post, frame D (D2/10)	76	1.77	1374–1449	-	-	0.25	After 1458
flgl13	Q	East wallplate D - C	74	1.94	1383–1456	1456	h/s	0.20	1465–97
flgl14	Q	East post frame C (C2/04)	46	2.37	1412–1457	1457	h/s	0.17	1466–98
flgl15	Q	West post frame B (B2/11)	104	2.39	1351–1454	1454	h/s	0.18	1463–95
flgl16	Q	Stud in west wall, B – C	<40	NM	-	-	-	-	-
flgl18	Q	Tie B (B2/12)	68	1.98	1389–1456	1456	h/s	0.25	1465–97
flgl19	Q	West principal rafter frame B (B2/16)	53	1.75	1386–1438	1438	h/s	0.19	
flgl22	Q	ditto	54	1.96	1387–1440	1440	h/s	0.19	
flgl1922	Q	Mean of 19 and 22	55	1.87	1386–1440	1439	1	0.19	1448–80
flgl21	Q	Common rafter west, 4th from frame B	47	1.25	-	-	23½C	0.18	-
flgl23	Q	Collar, frame C (C2/09)	49	1.93	1407–1455	1455	h/s	0.23	1464–96

Table 1: continued

Sample number	Genus	Timber and position	No of rings	Mean ring width (mm)	Dates spanning (AD)	h/s boundary (AD)	Sapwood rings	Mean sensitivity	Felling date ranges (AD)
flgl26	Q	Tie D (D2/11)	67	2.34	1391–1457	1457	h/s	0.13	1466–98
flgl27	Q	East queen strut frame D (D2/14)	<40	NM	-	-	-	-	-
flgl28	Q	Ceiling spine beam C – D	64	1.69	1392–1455	1451	4	0.23	1460–92
flgl29	Q	West queen strut frame D (D2/15)	57	2.76	1399–1455	1454	1	0.19	1463–95
flgl30	Q	East side, rafter north side of dormer, frame D - E	49	1.72	1427–1475	1462	13½C	0.20	Summer 1476
flgl31	Q	Tie E (E2/06)	55	2.35	1396–1450	1450	h/s	0.19	1459–91
flgl32	Q	Tie F (F2/02)	74	1.85	1383–1456	1456	h/s	0.17	1465–97
flgl33	Q	East principal rafter frame F (F2/06)	45	4.82	-	-	6	0.18	-
flgl34	Q	West post frame E (E2/04)	56	2.86	-	-	h/s	0.20	-
Main range - possible alterations									
flgl04	U?	Floor joist 4th from east E – D	<40	NM	-	-	-	-	-
flgl05	Q	Floor joist 2nd from east E - D	<40	NM	-	-	-	-	-
flgl17	Q	First floor north room floor joist	<40	NM	-	-	-	-	-
flgl20	Q	Ceiling beam A – B top floor	41	1.89	-	-	-	0.19	-
flgl24	U	Ceiling joist, west 5th from frame C	55	2.23	-	-	18C	0.27	-
flgl25	U	Ceiling joist, west 6th from frame C	71	1.66	-	-	?h/s	0.21	-
Rear cross-wing extension									
flglE01	U	Bottom rail, west side, frame I	<40	NM	-	-	-	-	-
flglE02	U	Storey post west side frame I	<40	NM	-	-	-	-	-
flglE03	U	South wallplate	<40	NM	-	-	-	-	-
flglE04	U	Top floor axial beam	52	2.19	-	-	-	0.21	-
flglE05	Q	North-west corner post	<40	NM	-	-	-	-	-
flglE06i	U	Top rail, east side, north wall - inner rings	77 (+13NM)	1.73	-	-	-	0.31	-
flglE07	U	Ground floor axial ceiling beam	<40	NM	-	-	-	-	-

Table 1: continued

Sample number	Genus	Timber and position	No of rings	Mean ring width (mm)	Dates spanning (AD)	h/s boundary (AD)	Sapwood rings	Mean sensitivity	Felling date ranges (AD)
Westgate range									
flwg01	Q	West wallplate at top of stairs – A - B	65	1.46	-	-	16C	0.19	-
flwg02	Q	Tiebeam, frame A	78	1.06	-	-	24C	0.16	-
flwg03	Q	East post, frame A	57	1.40	1391–1447	1447	h/s	0.23	1456–88
flwg04	Q	Tiebeam, frame A	49	2.12	1405–1453	1453	h/s	0.18	1462–94
flwg05a	Q	East queen strut, frame B	40	1.77	1415–1454	1454	h/s	0.23	
flwg05b	Q	ditto	34	1.77	1421–1454	1454	h/s	0.23	
flwg05	Q	Mean of 05a and 05b	40	1.78	1415–1454	1454	h/s	0.22	1463–95
flwg06	Q	East purlin, A - C	71	1.46	1401–1471	1452	19½C	0.17	Summer 1472
flwg07	U	Ceiling axial beam B – C	<40	NM	-	-	-	-	-
flwg08	Q	Tiebeam, frame C	50	1.98	1407–1456	1456	h/s	0.22	1465–97
flwg09	Q	Tiebeam, frame D	59	2.25	1400–1458	1456	2	0.18	1465–97
flwg10	Q	Post at top of stair (has renewed top)	90	1.82	1375–1464	1464	h/s	0.23	1473–1505
flwg11	Q	Post IV1/13	<40	NM	-	-	-	-	-
flwg12	Q	South wallplate to front section	52	2.59	-	-	12C	0.21	-
flwg13	U	Front bedroom (Rm 44) rear ceiling beam	49	2.76	-	-	½C	0.50	-
flwg14	Q	South wallplate front section at west end	<40	NM	-	-	-	-	-
flwg15a	Q	Frame V – beam separating rooms 43/44 (tiebeam?)	59	1.07	-	-	5	0.32	-
flwg15b	Q	ditto	31	0.94	-	-	22	0.31	-
flwg15	Q	Mean of 15a and 15b	70	1.04	-	-	22	0.32	-

Key: Q = *Quercus* (oak); U = *Ulmus* (elm); NM = not measured; h/s = heartwood-sapwood boundary; C = complete sapwood, winter felled; ½C = complete sapwood, felled during the following summer

Table 2: Cross-matching between the dated series included in site master chronology FLEECE from the Fleece Hotel, Westgate Street, Gloucester (t-values over 3.5 are statistically significant; t-values over 10 are highlighted)

Sample	t-values																							
	flgl06	flgl08	flgl09	flgl11	flgl12	flgl13	flgl14	flgl15	flgl18	flgl1922	flgl23	flgl26	flgl28	flgl29	flgl30	flgl31	flgl32	flwg03	flwg04	flwg05	flwg06	flwg08	flwg09	flwg10
flgl03	2.8	3.2	3.2	4.4	1.5	1.9	1.6	5.0	4.9	3.9	3.5	3.8	3.2	5.7	*	4.9	4.5	4.8	3.4	*	4.8	3.0	3.5	3.2
flgl06		3.9	5.0	3.9	5.1	1.5	2.5	3.5	5.6	6.5	2.9	4.3	1.5	3.4	*	5.0	3.7	3.5	4.2	2.0	3.8	3.7	2.9	3.3
flgl08			2.0	2.0	4.2	0	1.7	3.2	3.6	3.2	2.1	2.2	1.1	1.7	*	2.6	1.7	2.8	2.5	1.0	2.9	2.0	3.2	3.9
flgl09				6.4	2.4	3.2	5.2	2.3	11.9	4.1	5.2	5.1	2.5	5.2	5.2	6.3	9.7	5.2	6.6	6.3	3.7	10.2	5.3	3.4
flgl11					2.8	2.7	3.9	4.5	7.0	3.9	5.5	4.6	0.9	7.0	*	3.5	4.6	2.9	5.0	4.7	3.0	5.8	4.1	1.9
flgl12						0.7	2.8	3.2	3.7	3.1	1.9	2.3	1.7	2.8	*	2.9	2.7	1.1	1.9	1.6	1.2	2.2	1.9	5.2
flgl13							4.4	2.1	3.9	3.8	3.9	6.7	2.6	3.1	1.2	3.3	5.4	3.6	3.7	4.0	2.0	3.4	3.1	1.8
flgl14								2.6	4.7	*	4.7	8.1	3.1	5.0	2.8	3.7	6.6	2.5	5.3	4.3	1.7	5.1	3.7	2.5
flgl15									5.6	3.2	4.3	4.3	2.0	5.0	*	2.2	4.3	3.0	2.5	2.8	2.8	3.3	1.5	3.1
flgl18										6.8	7.3	6.3	2.9	7.0	3.6	6.9	8.3	7.8	6.6	5.7	6.0	8.5	5.2	5.2
flgl1922											3.3	6.4	2.6	3.0	*	6.0	3.8	4.5	5.5	*	6.0	5.7	2.5	4.9
flgl23												6.0	2.1	4.8	*	3.7	8.2	6.3	5.9	5.6	4.3	4.8	4.7	2.2
flgl26													2.3	5.0	1.9	5.9	8.2	4.3	6.5	5.3	3.6	5.0	4.6	2.9
flgl28														2.3	*	3.6	4.2	2.7	1.9	3.2	1.2	2.1	0.9	4.8
flgl29															*	4.8	5.3	4.2	4.3	4.2	2.6	4.8	3.9	2.2
flgl30																*	2.8	*	*	*	2.3	5.1	2.7	1.7
flgl31																	5.9	6.6	4.5	4.0	4.1	7.5	6.3	3.8
flgl32																		6.3	5.9	8.3	3.9	7.4	6.3	3.6
flwg03																			4.3	5.7	5.7	6.1	4.7	3.1
flwg04																				4.2	5.1	5.1	4.2	2.7
flwg05																					3.3	5.7	3.7	2.3
flwg06																						4.5	3.9	2.8
flwg08																							4.9	3.0
flwg09																								3.9

* indicates overlap less than 15 rings, no t-value calculated; 0 = zero or negative value calculated

Table 3a: Dating evidence for the site sequence flgl08 (AD 1363–1451)

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD):	Overlap (years):	t-value
Worcestershire	Barn at Butts Bank, Broadwas	(Bridge 2006)	BUTTSBNK	1322–1495	89	7.3
Worcestershire	The Commandery, Worcester	(Arnold <i>et al</i> 2006)	WORDSQ01	1284–1473	89	6.9
Worcestershire	Church House, Areley Kings	(Miles <i>et al</i> 2003)	ARELEY	1365–1535	87	6.4
Avon	Acton Court, Iron Acton	(Haddon-Reece and Miles 1994)	ACTON	1328–1575	89	5.5
Herefordshire	Cathedral Barn, Hereford	(Tyers 1996)	HERECB2	1359–1491	89	5.4
Worcestershire	The Farthings, Kemerton	(Miles and Bridge 2014)	KEMERTON	1363–1441	79	5.4
Gloucestershire	Ashleworth Tithe Barn	(Bridge 2002a)	ASHLEWTH	1319–1475	89	5.3
Gloucestershire	Mercer's Hall, Gloucester	(Howard <i>et al</i> 1996)	GLOUCMH	1289–1541	89	5.2

Table 3b: Dating evidence for the site sequence flgl12 (AD 1374–1449)

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD):	Overlap (years):	t-value
Shropshire	Upton Cressett	(Miles and Haddon-Reece 1994)	CRESSETT	1298–1498	76	5.4
Herefordshire	Church House, Allensmore	(Miles <i>et al</i> 2006)	CHAM	1357–1551	76	5.2
Shropshire	Homeside, Boraston	(Miles and Worthington 2002)	HOMESIDE	1352–1457	76	5.1
Worcestershire	Bower Court, Rock	(Bridge 2002b)	BOWERCT	1359–1475	76	5.1
Leicestershire	Ulverscroft Priory	(Arnold <i>et al</i> 2008)	ULVASQ01	1219–1463	76	4.9
Herefordshire	Leominster Priory	(Haddon-Reece unpubl)	LEOMST	1353–1464	76	4.8
Herefordshire	Wigmore Abbey	(Tyers 2002)	WIGALL46	1055–1729	76	4.7
Shropshire	Nine Worthies, Great Binnal	(Miles and Haddon-Reece 1996)	GTBINNAL	1321–1529	76	4.7

Table 3c: Dating evidence for the site sequence flgl28 (AD 1392–1455)

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD):	Overlap (years):	t-value
Gloucestershire	New Inn House, Kingswood	(Arnold <i>et al</i> 2004)	KGWBSQ01	1191–1519	64	7.4
Dorset	Nave, Sherborne Abbey	(Bridge 1993)	SHERNAVE	1339–1474	64	6.4
Somerset	16-18 High Street, Bruton	(Miles and Worthington 1997)	BRUTON3	1363–1453	62	6.3
Hampshire	44-46 Chesil Street, Winchester	(Bridge <i>et al</i> 2010)	CHESIL2	1300–1443	52	5.9
Wiltshire	Bromham Church	(Arnold and Howard 2008a)	BRMBSQ01	1359–1483	64	5.9
Gloucestershire	Ashleworth Tithe Barn	(Bridge 2002a)	ASHLEWTH	1319–1475	64	5.9
Gloucestershire	Brockworth Court Barn	(Howard <i>et al</i> 2000)	BRKASQ02	1352–1541	64	5.9
Hampshire	Verderers' Court, Lyndhurst	(Bridge <i>et al</i> 2016)	VRDRRST	1361–1660	64	5.8

Table 3d: Dating evidence for the site sequence flgl30 (AD 1427–1475)

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD):	Overlap (years):	t-value
Shropshire	Bank Farm, Aston Piggot	(Bridge 1996)	ASTONPIG	1418–1581	49	6.6
Worcestershire	Old School Ho, Bayton	(Bridge 1996)	BAYTON	1348–1525	49	6.5
Shropshire	28 Watergate, Whitchurch	(Miles and Worthington 2001)	WHGHWHIT	1416–1596	49	5.8
Devon	Pridhamsleigh Manor, Staverton	(Arnold and Howard 2008b)	PRDASQ01	1420–1557	49	5.7
Yorkshire	Kirkburton Church	(Arnold and Howard 2007)	KRKCSQ02	1306–1633	49	5.7
Shropshire	Clungunford Master Chronology	(Miles 2002 unpubl)	CLNGNFRD	1273–1653	49	5.7
Yorkshire	Elland Old Hall	(Hillam 1984)	ELLAND	1372–1574	49	5.6
Warwickshire	Gorcott Hall	(Nayling 2006)	GORC_T17	1385–1531	49	5.5

Table 3e: Dating evidence for the site master FLEECE AD 1347–1475)

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD):	Overlap (years):	<i>t</i> -value
Worcestershire	The Commandery, Worcester	(Arnold <i>et al</i> 2006)	WORDSQ01	1284–1473	127	11.8
Worcestershire	Bower Court, Rock	(Bridge 2002b)	BOWERCT	1359–1475	117	11.6
Worcestershire	Old School Ho, Bayton	(Bridge 1996)	BAYTON	1348–1525	128	10.7
Shropshire	Bush Cottage, Stottesdon	(Miles and Bridge 2013)	BUSHCOTT	1369–1547	107	10.7
Gloucestershire	100 Church St, Tewkesbury	(Nayling 2000)	TEWKES1	1325–1458	112	10.7
Shropshire	Bodenhams, Ludlow	(Miles <i>et al</i> 2003)	LUDLOW9	1358–1459	102	10.7
Gloucestershire	Mercer's Hall, Gloucester	(Howard <i>et al</i> 1996)	GLOUCMH	1289–1541	129	10.6
Worcestershire	Hartlebury Castle Saloon Roof	(Tyers 2008)	HARTSALN	1339–1608	129	10.5
West Midlands	Oak House, West Bromwich	(Arnold and Howard 2009)	OAKHSQ01	1405–1590	71	10.3
Worcestershire	Abberley	(Arnold pers comm)	ABLYSQ01	1342–1540	129	10.1
Herefordshire	Cathedral Barn, Hereford	(Tyers 1996)	HERECB2	1359–1491	117	9.7
Worcestershire	Barn at Butts Bank, Broadwas	(Bridge 2006)	BUTTSBNK	1322–1495	129	9.7

Table 3f: Dating evidence for the site sequence flgl01 (AD 1599–1644)

Source region:	Chronology name:	Publication reference:	File name:	Span of chronology (AD):	Overlap (years):	<i>t</i> -value
Gloucestershire	100 Church St, Tewkesbury	(Nayling 2000)	TEWKES2	1484–1664	46	7.0
Somerset	St Andrew's Church, Whitestaunton	(Bridge 2014)	WHTSTNBF	1582–1676	46	6.5
Somerset	8 Market Place, Shepton Mallet	(Miles 2002a)	SHPTNMLT	1518–1677	46	6.4
Somerset	Church of St Mary the Virgin	(Tyers and Wilson 1999)	YATTON 2	1564–1691	46	5.7
Wiltshire	Salisbury Cathedral	(Miles 2002b)	SARUM5	1558–1662	46	5.3
Shropshire	Buildwas Abbey	(Miles 2002c)	BUILDWS3	1563–1687	46	5.2
Nottinghamshire	South Wheatley bellframe	(Bridge 2015)	SHWHTLY	1579–1665	46	4.9
Rutland	Old Hall, Belton-in-Rutland	(Miles <i>et al</i> 2008)	BELTON	1558–1669	46	4.8

FIGURES

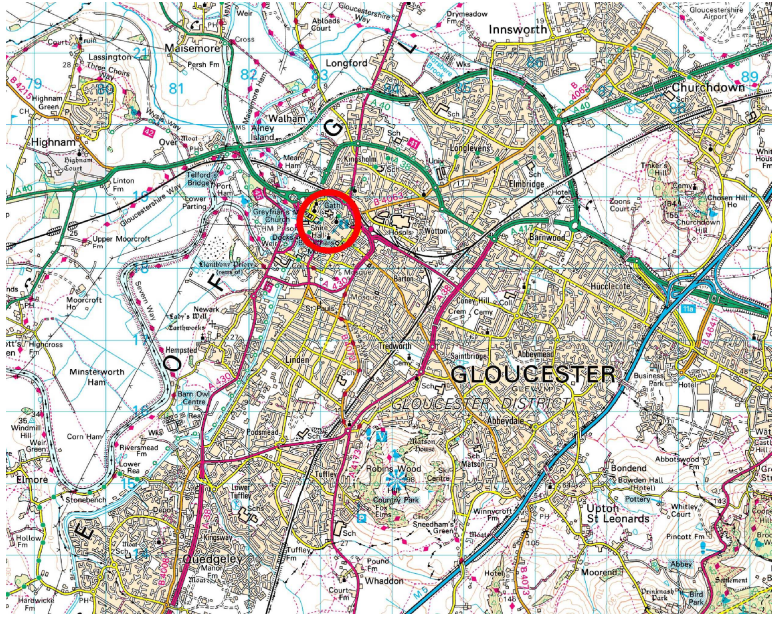


Figure 1: General location of The Fleece within the historic centre of the City of Gloucester. © Crown Copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100024900

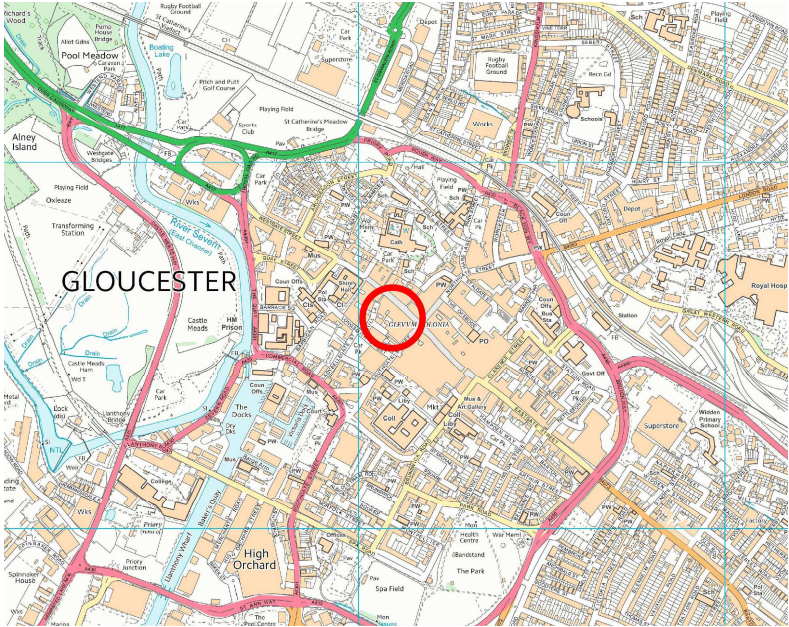


Figure 2: Location of The Fleece showing the proximity of the Cathedral. © Crown Copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100024900



Figure 3: Detailed location of The Fleece. © Crown Copyright and database right 2017. All rights reserved. Ordnance Survey Licence number 100024900

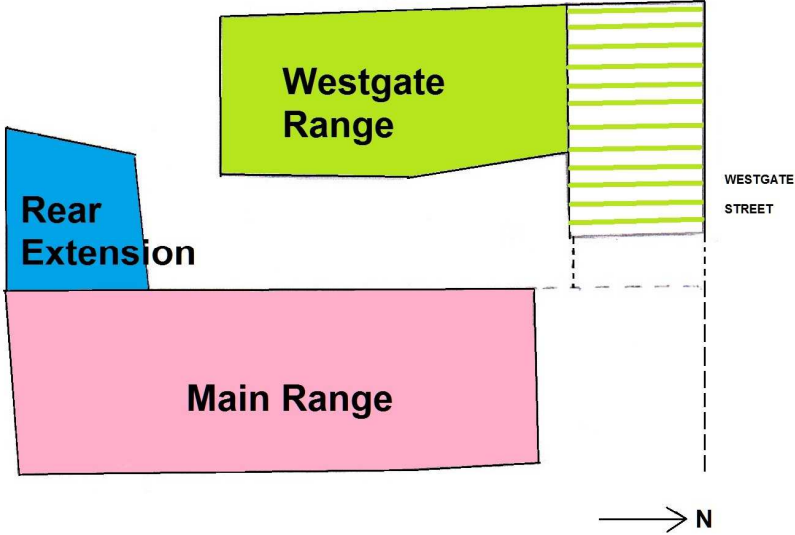


Figure 4: Plan of the site showing the relationship between the main range/rear extension and Westgate range. The section fronting the road (green stripes) is counted as part of the Westgate range, but was built later.

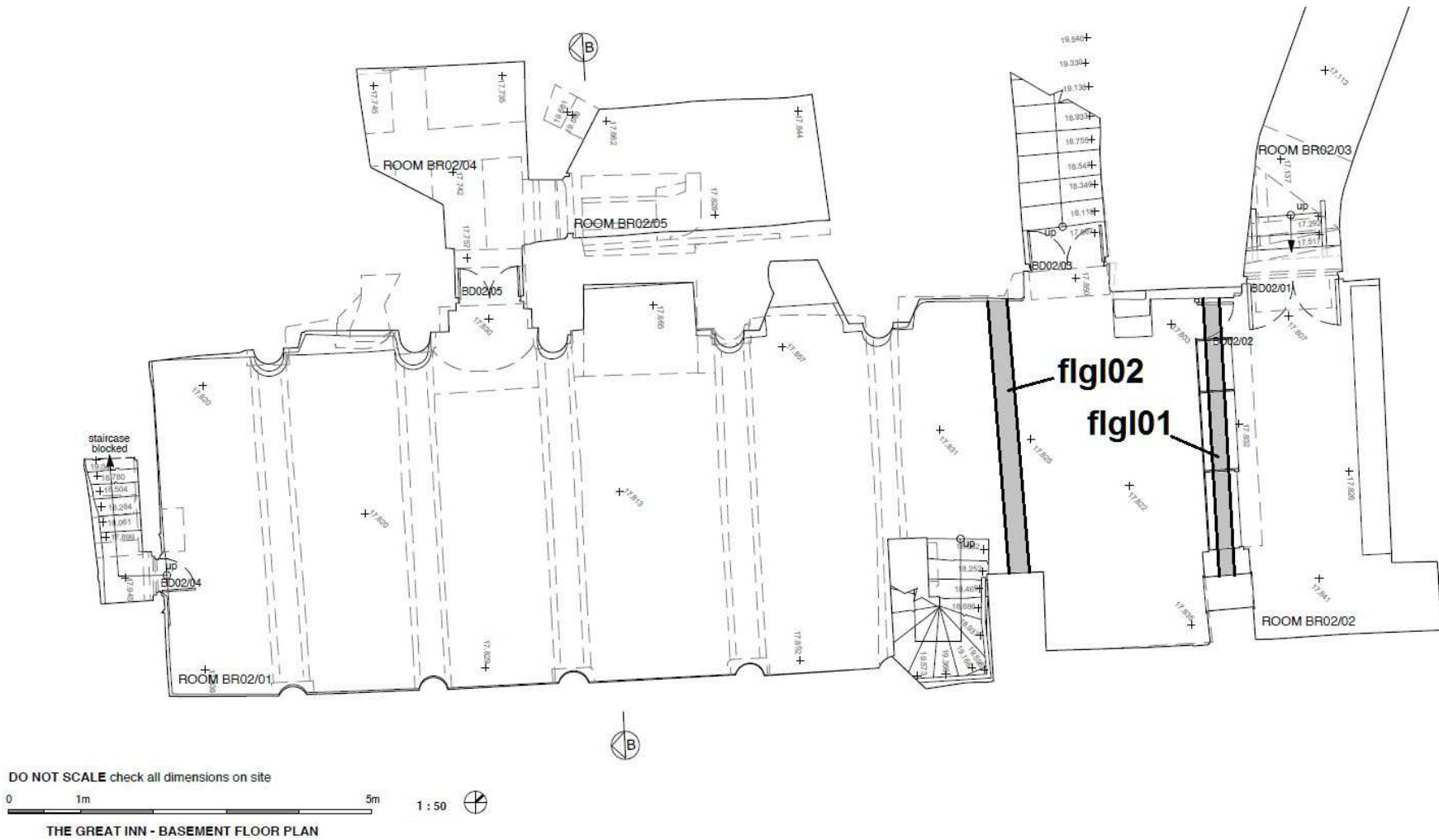


Figure 5: Basement plan showing the location of timbers sampled for dendrochronology (after Butler Hegarty Architects)

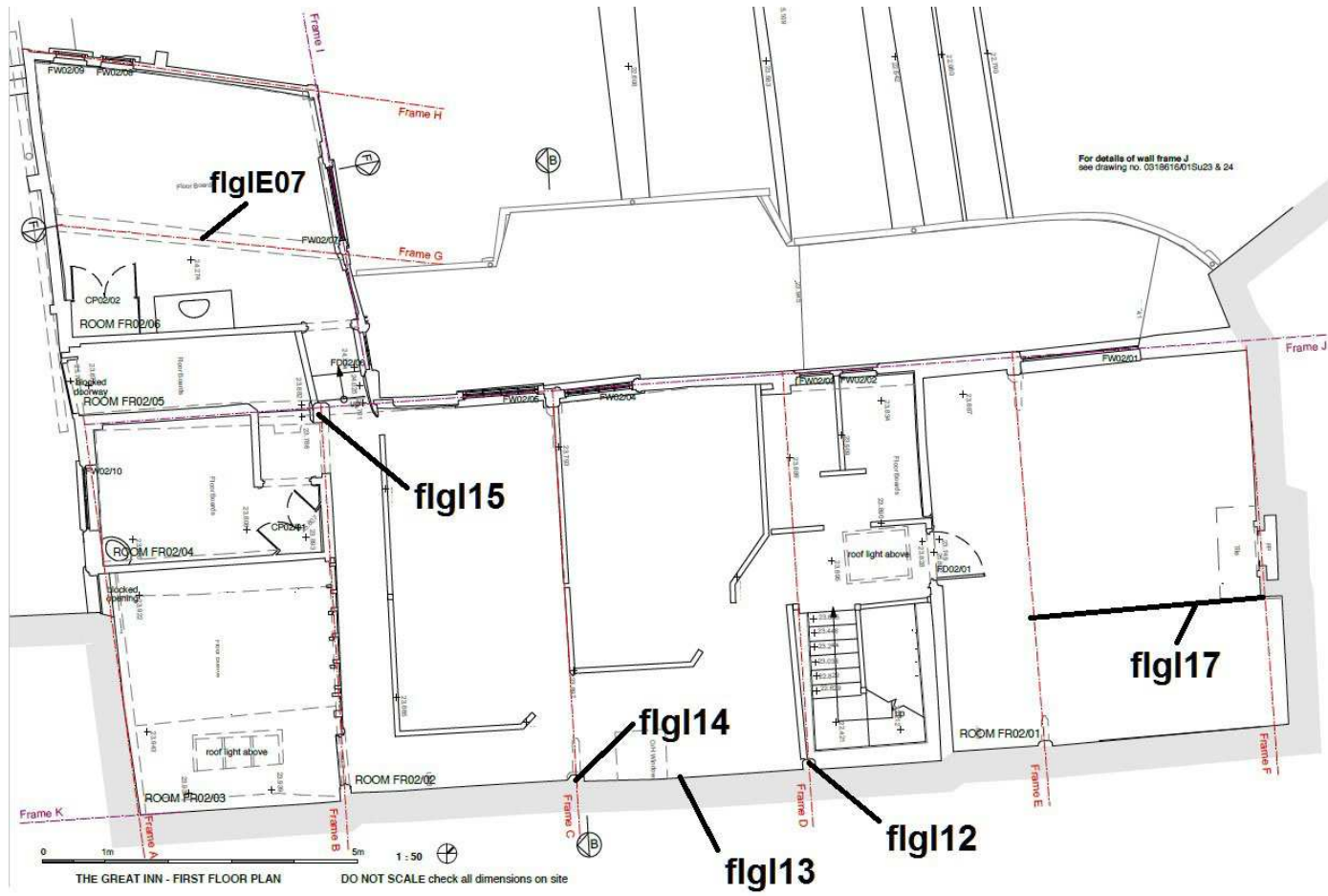


Figure 7: First-floor plan, showing the locations of timbers sampled for dendrochronology (after Butler Hegarty Architects)

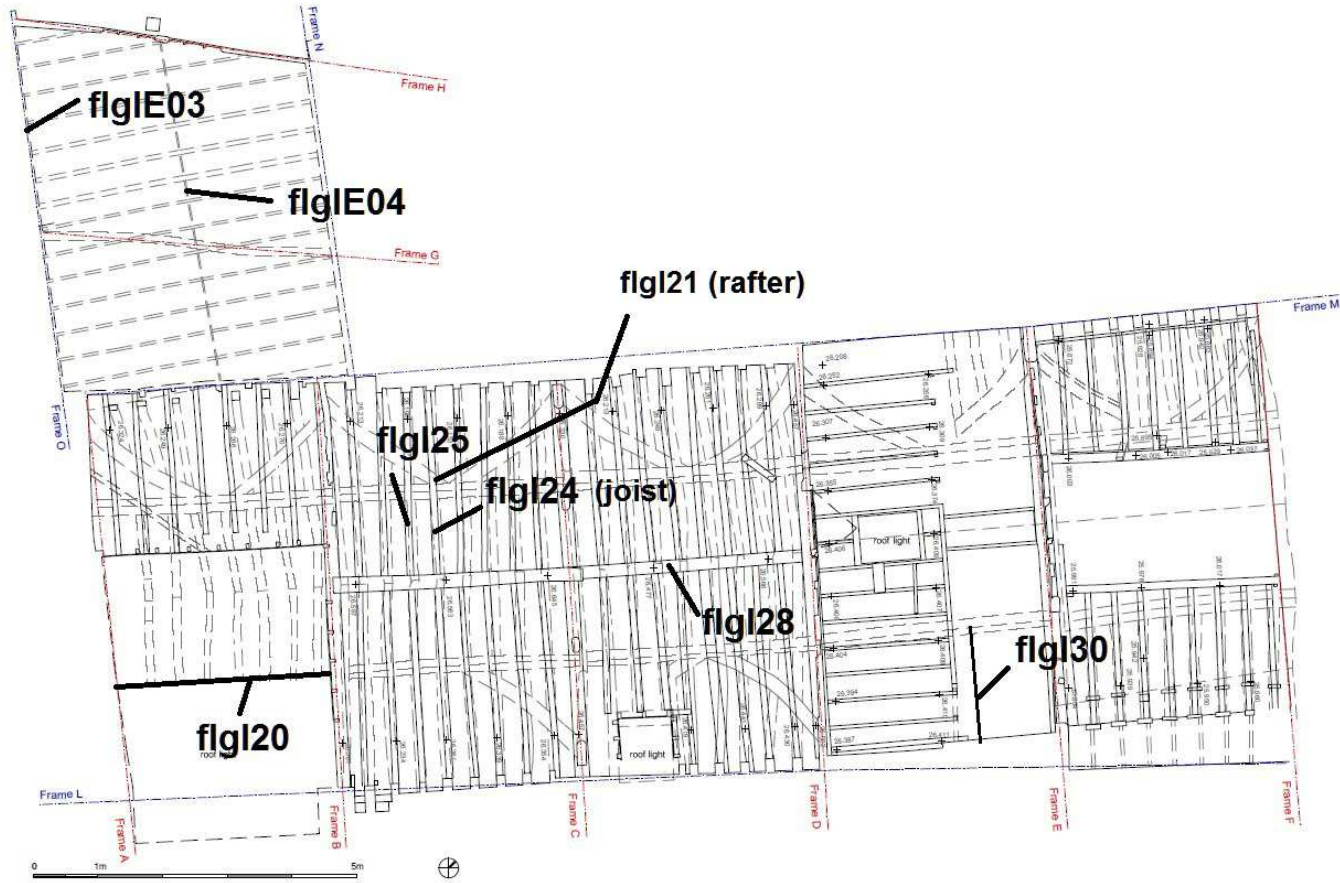


Figure 8: Plan of the roof areas of the main range and southern extension, showing timbers sampled (after Butler Hegarty Architects)

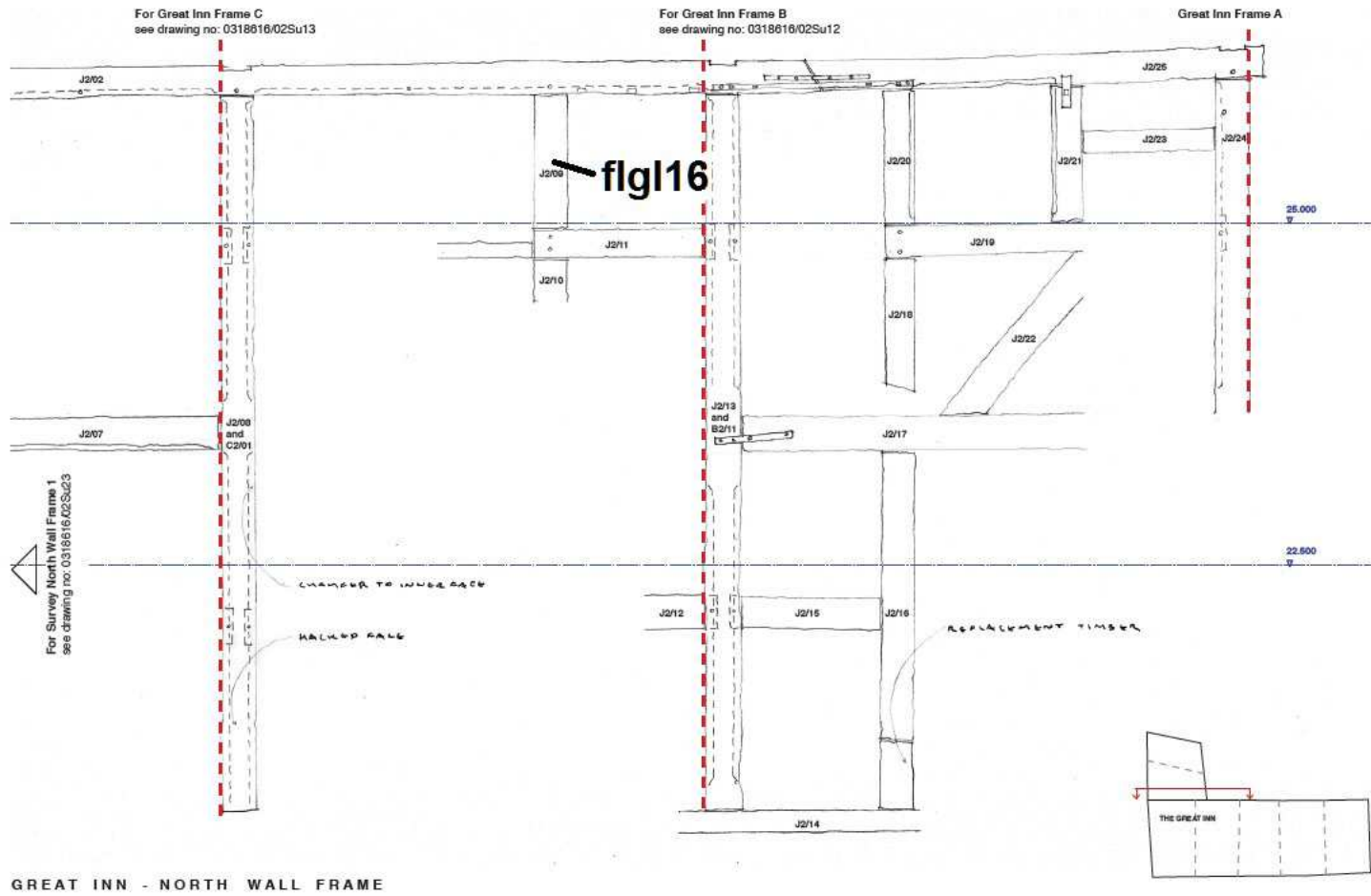


Figure 9: Drawing of the north wall of the main range, showing the timber sampled (after Butler Hegarty Architects)

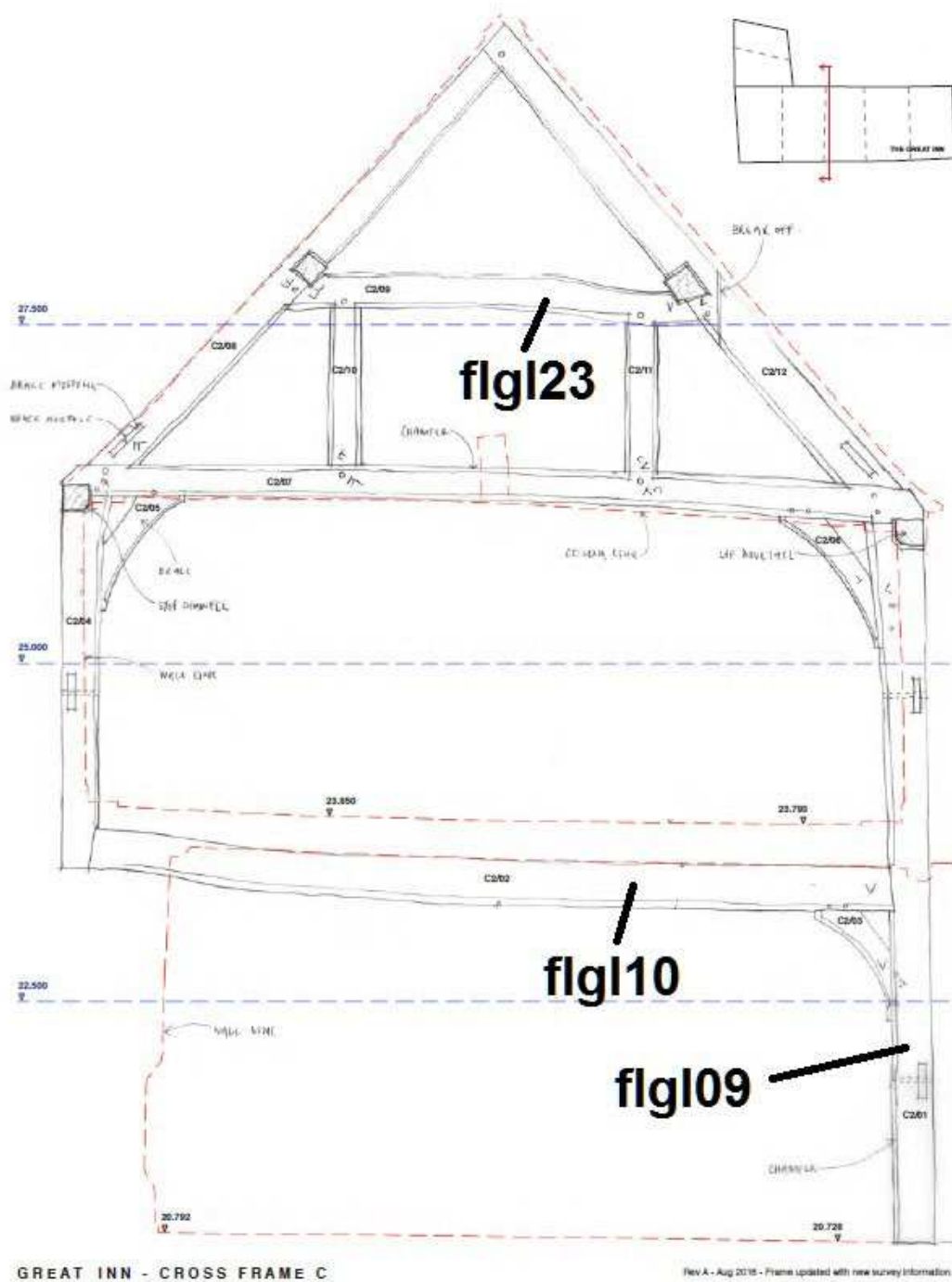


Figure 11: Drawing of frame C of the main range showing timbers sampled (after Butler Hegarty Architects)

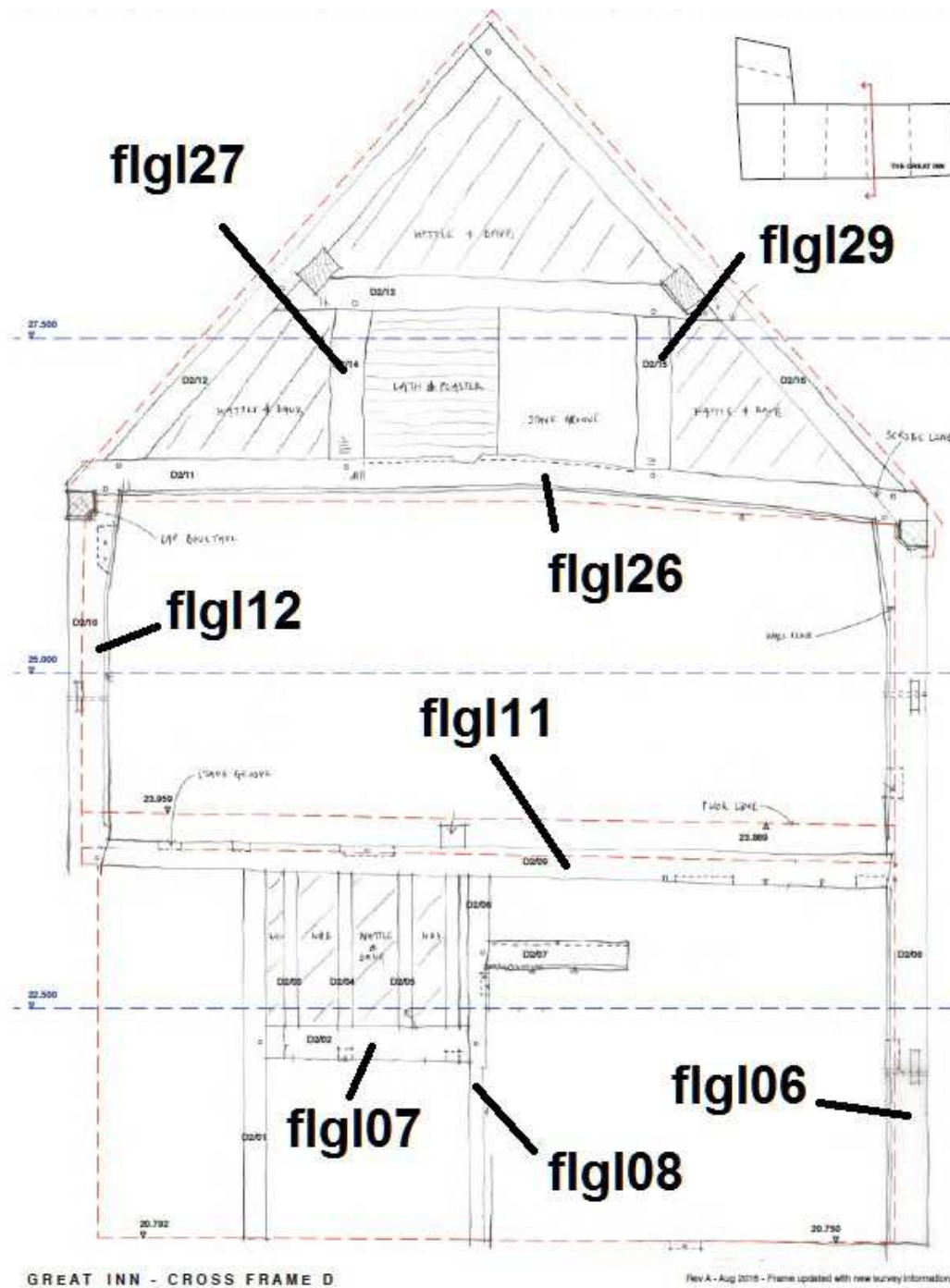


Figure 12: Drawing of frame D of the main range showing timbers sampled (after Butler Hegarty Architects)

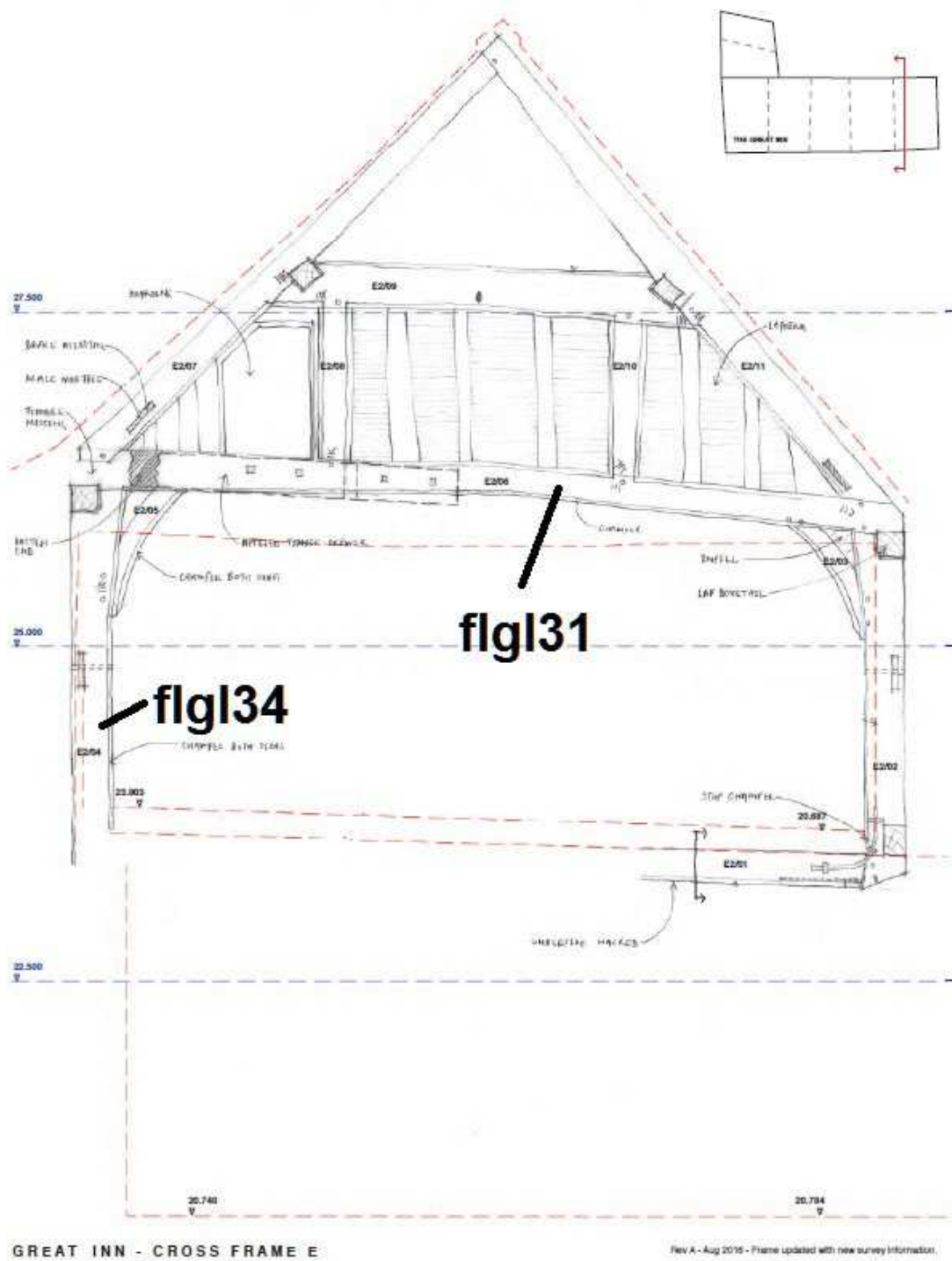


Figure 13: Drawing of frame E in the main range showing timbers sampled (after Butler Hegarty Architects)

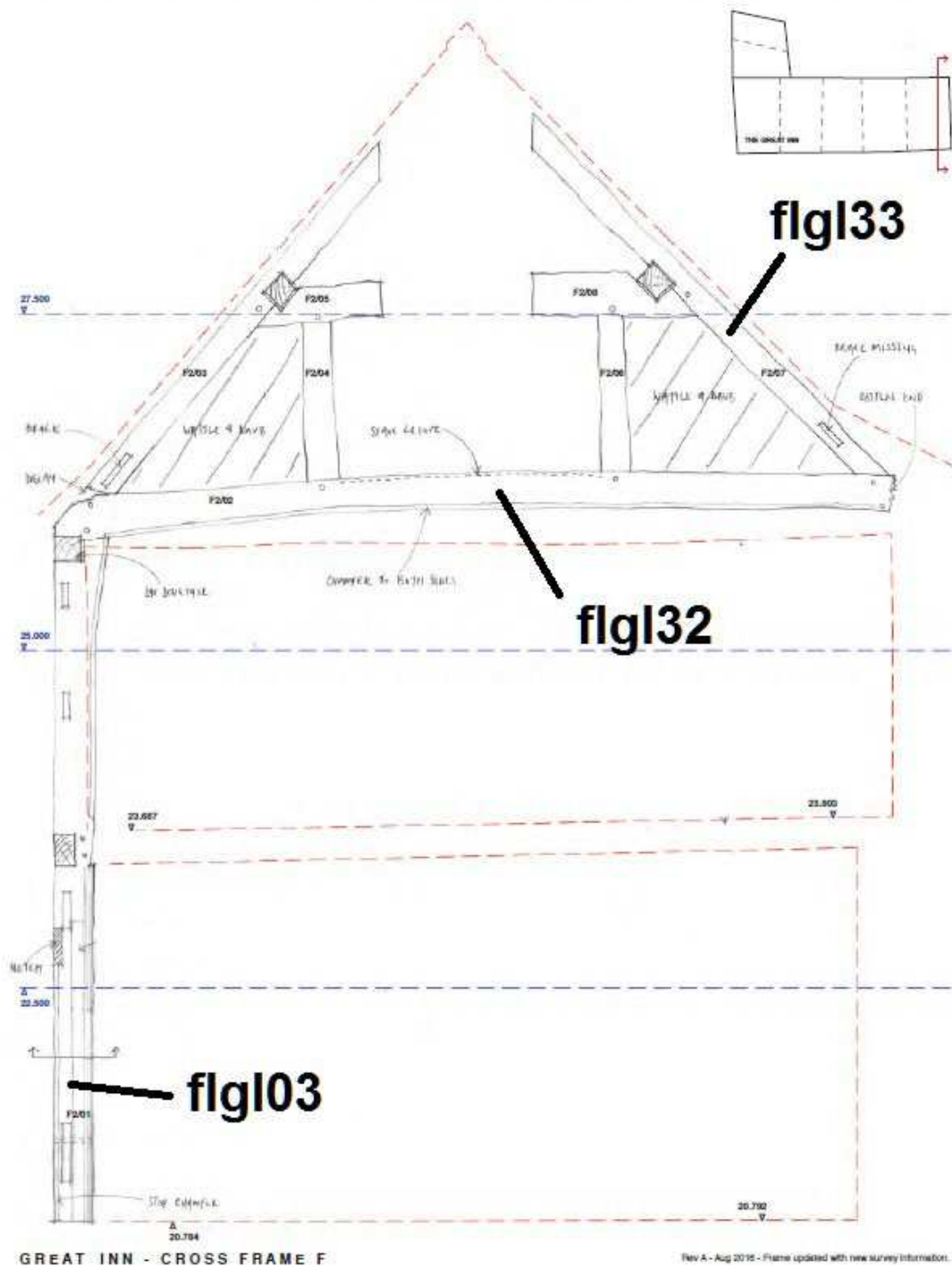


Figure 14: Drawing of frame F in the main range showing timbers sampled (after Butler Hegarty Architects)

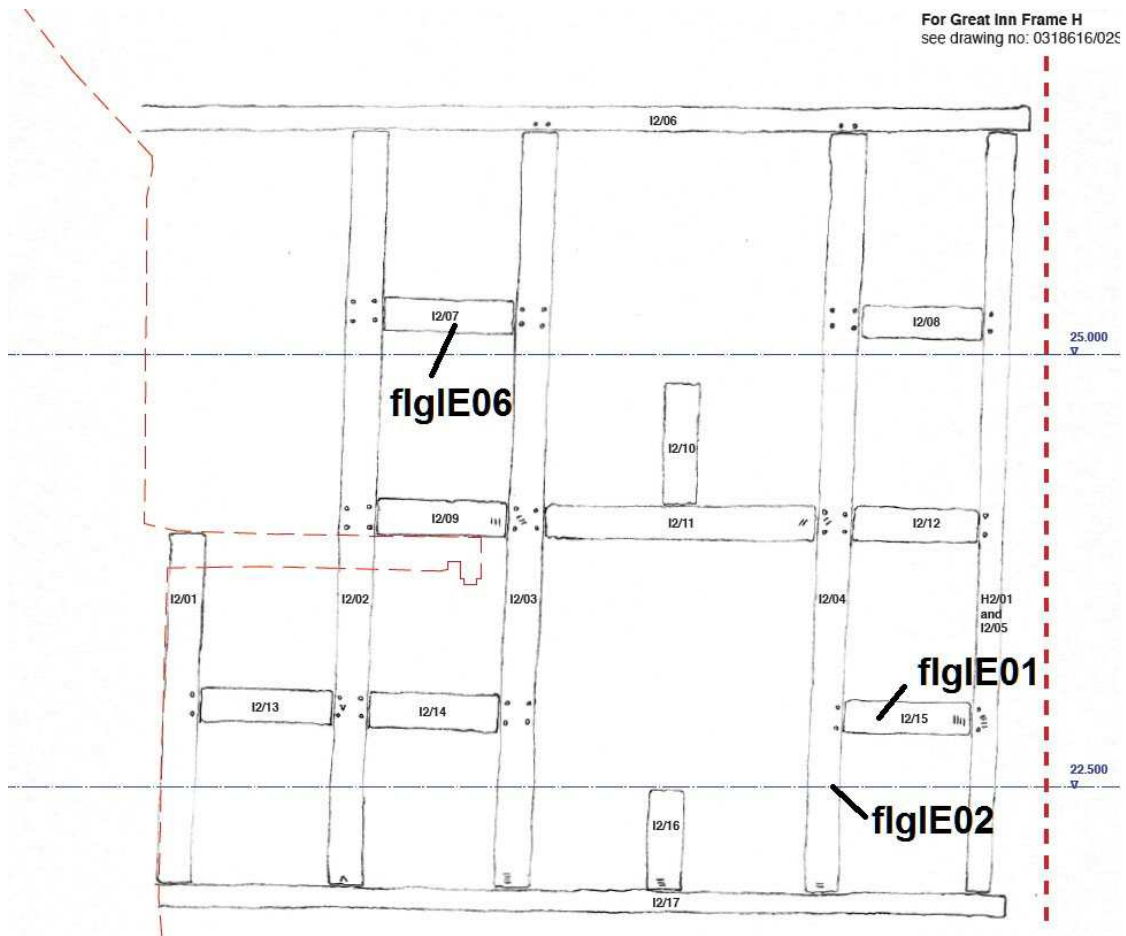
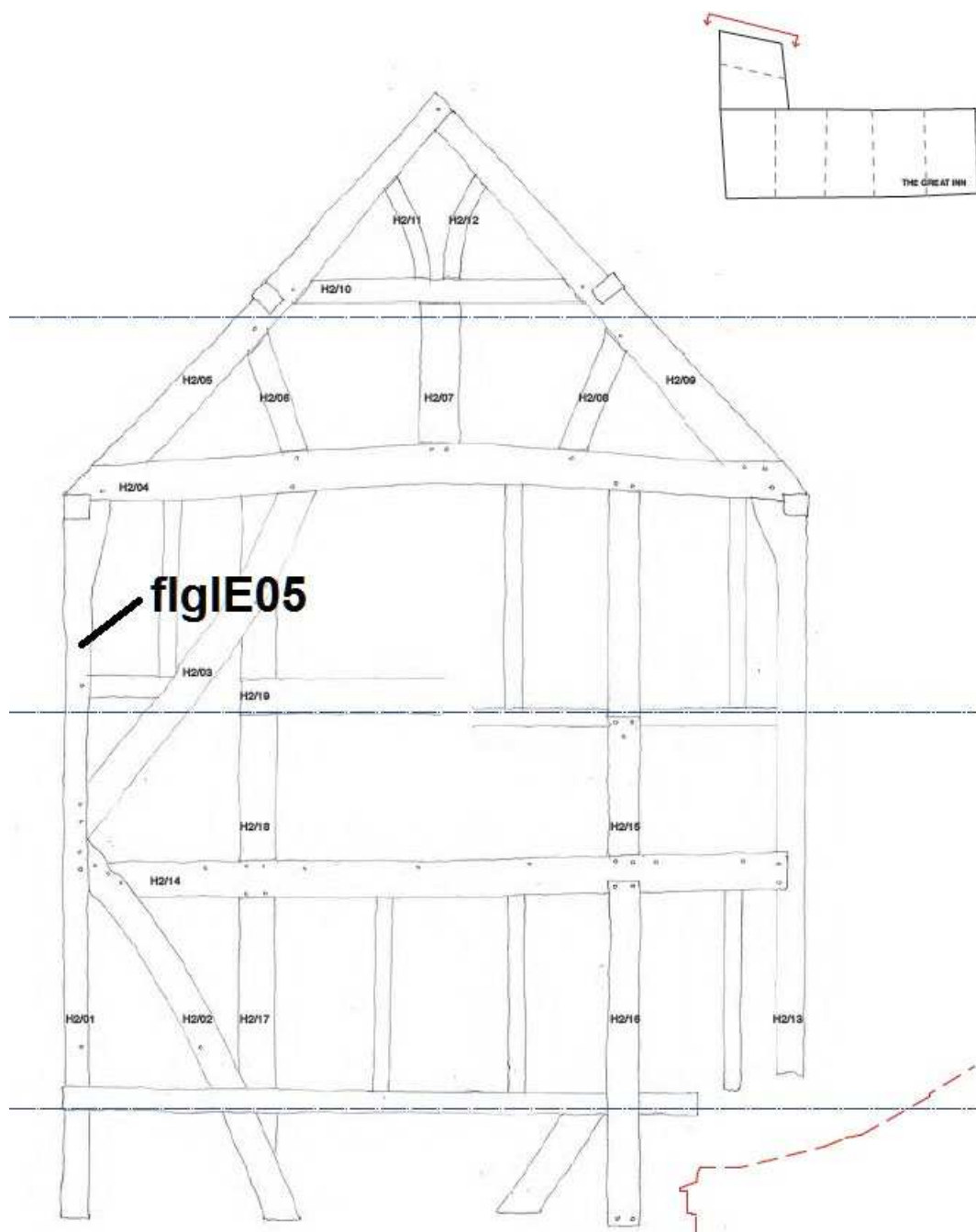


Figure 15: Drawing of the north wall of the southern extension showing the timbers sampled (after Butler Hegarty Architects)



figIE05

Figure 16: Drawing of the west wall of the southern extension showing the timber sampled (after Butler Hegarty Architects)



Figure 17: Plan of the Westgate range showing the locations of some of the sampled timbers (after Butler Hegarty Architects)

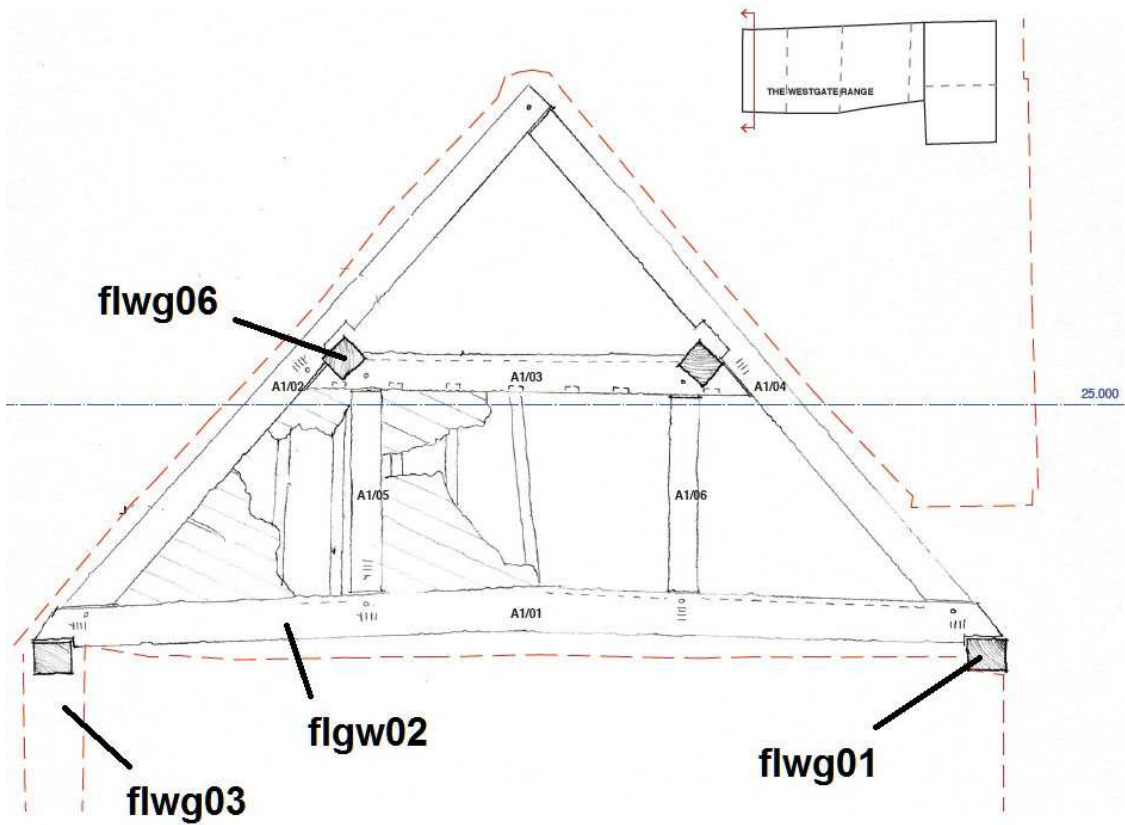


Figure 18: Drawing of frame A of the Westgate range showing timbers sampled (after Butler Hegarty Architects)

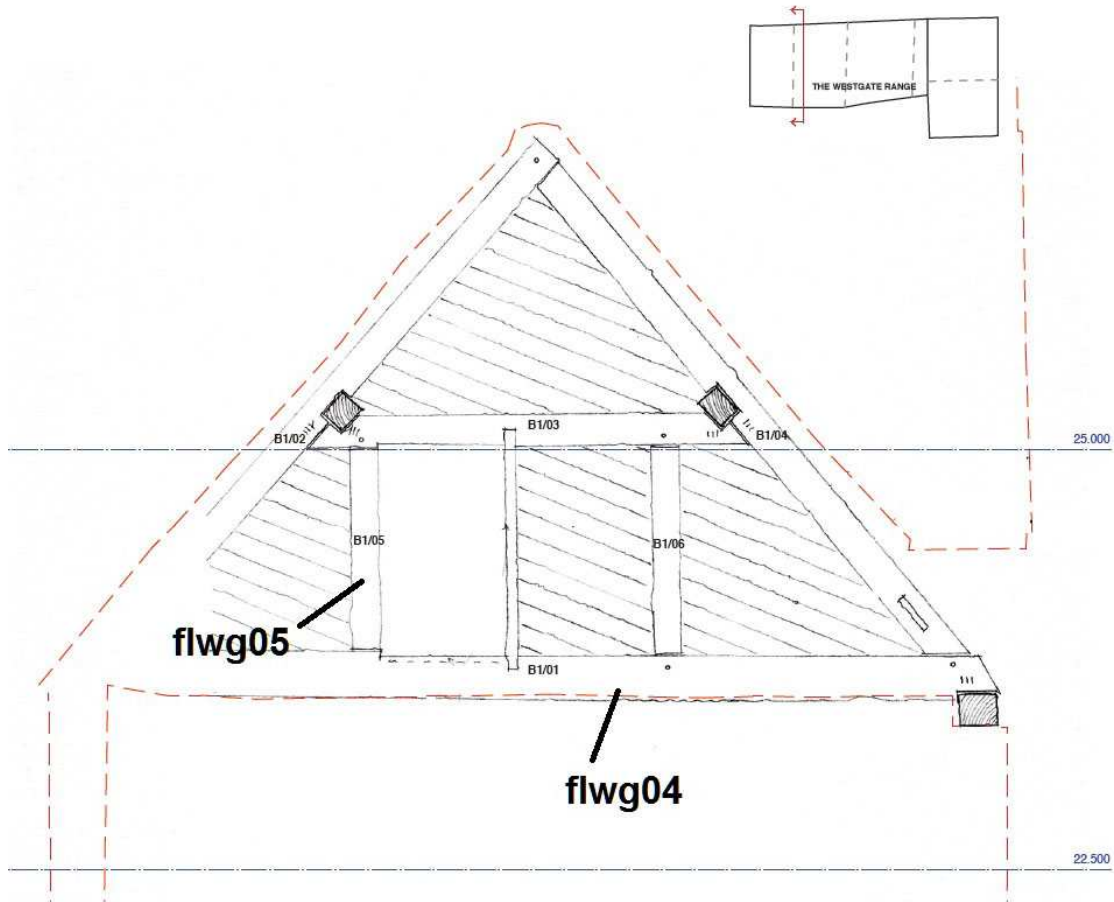


Figure 19: Drawing of frame B of the Westgate range showing timbers sampled (after Butler Hegarty Architects)

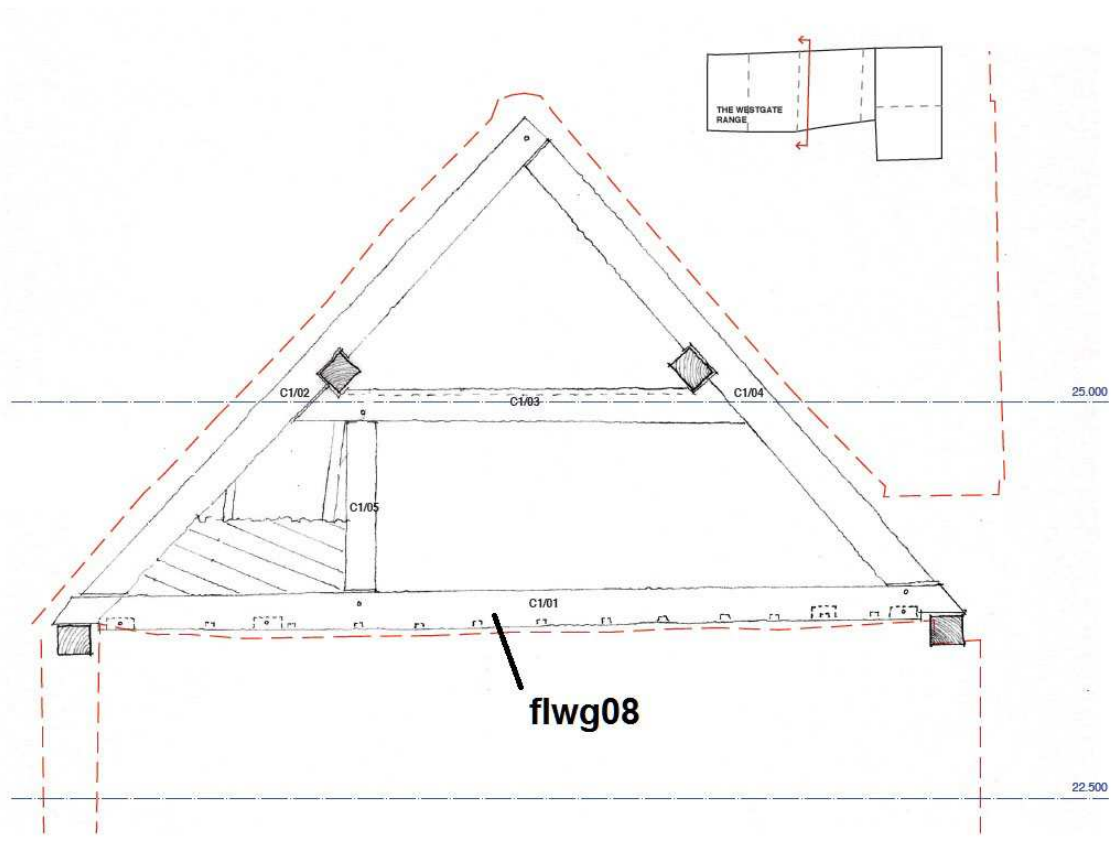


Figure20: Drawing of frame C of the Westgate range showing timber sampled (after Butler Hegarty Architects)

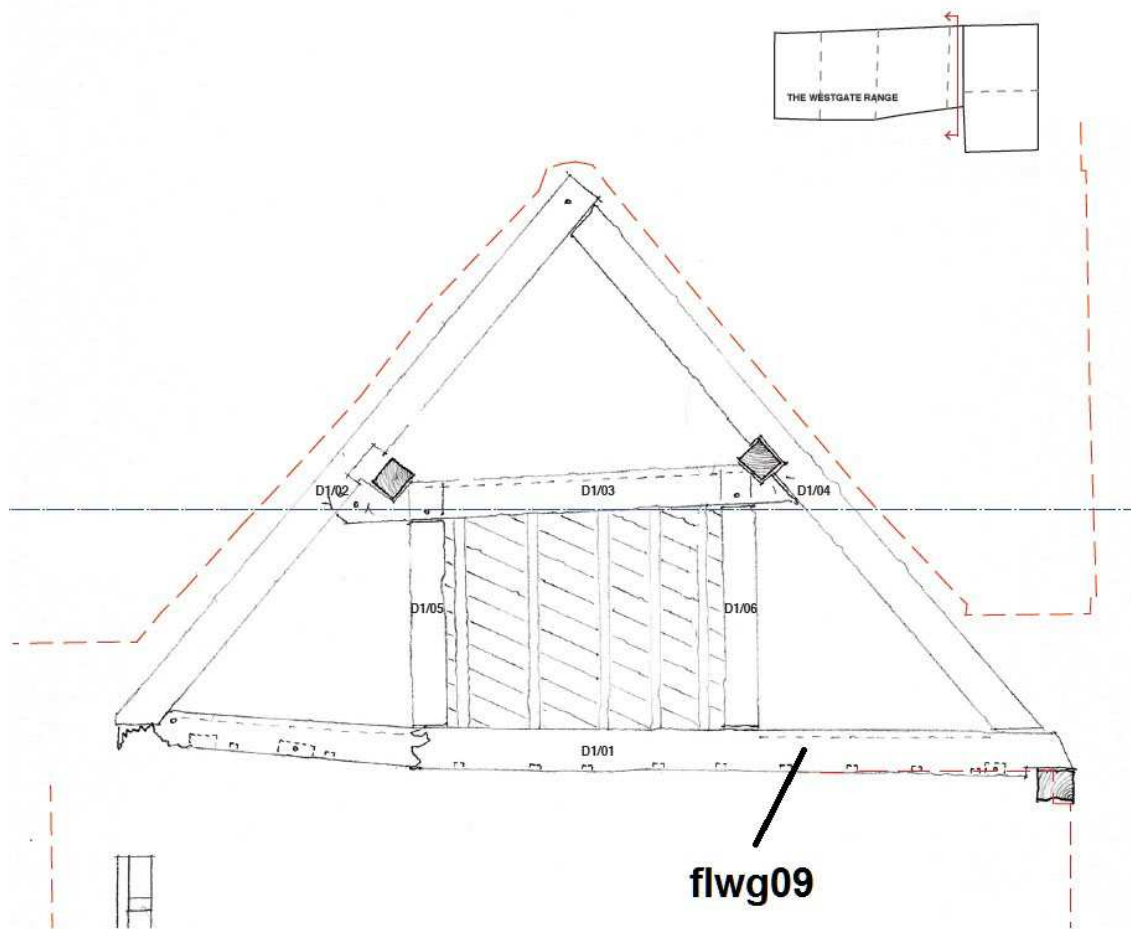


Figure 21: Drawing of frame D of the Westgate range showing timber sampled (after Butler Hegarty Architects)

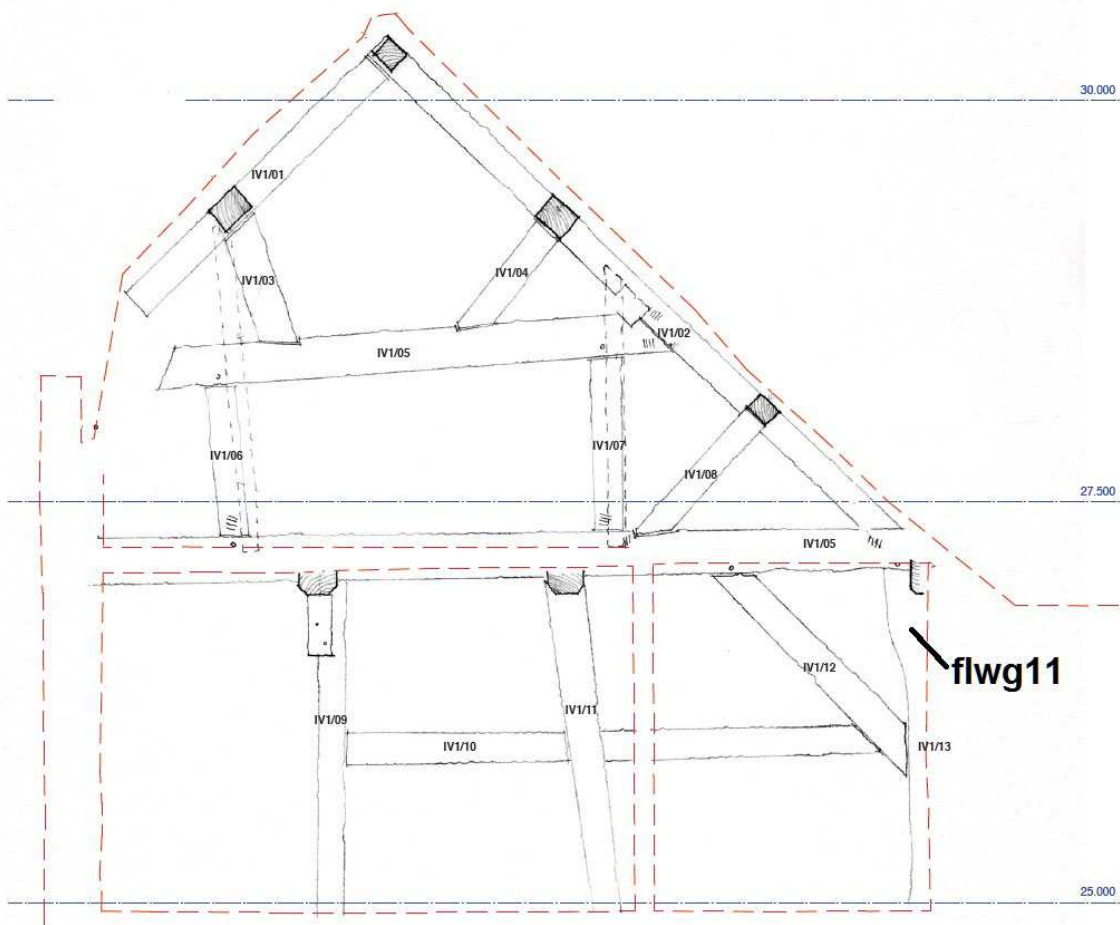


Figure 22: Drawing of frame IV of the Westgate range showing timber sampled (after Butler Hegarty Architects)

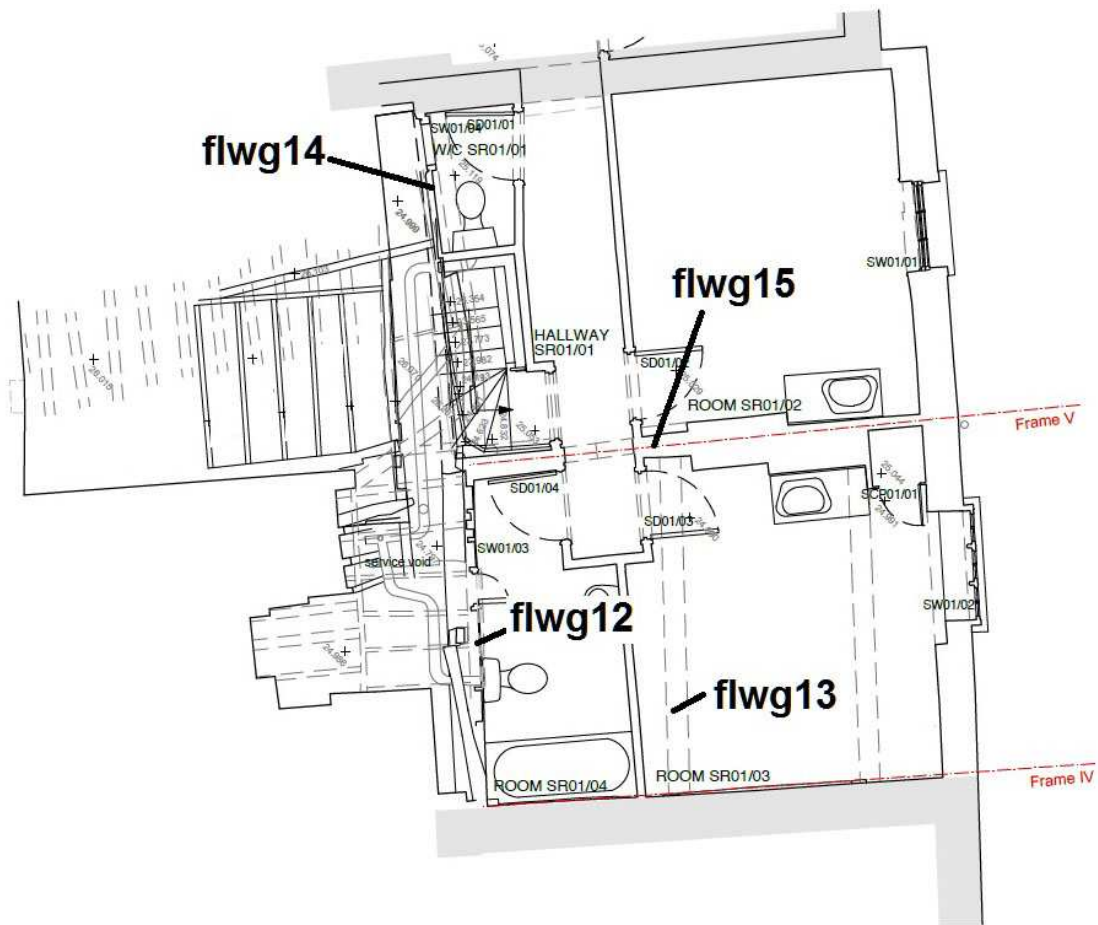


Figure 23: Plan of the northern rooms of the Westgate range (fronting on Westgate Street) showing timbers sampled (after Butler Hegarty Architects)

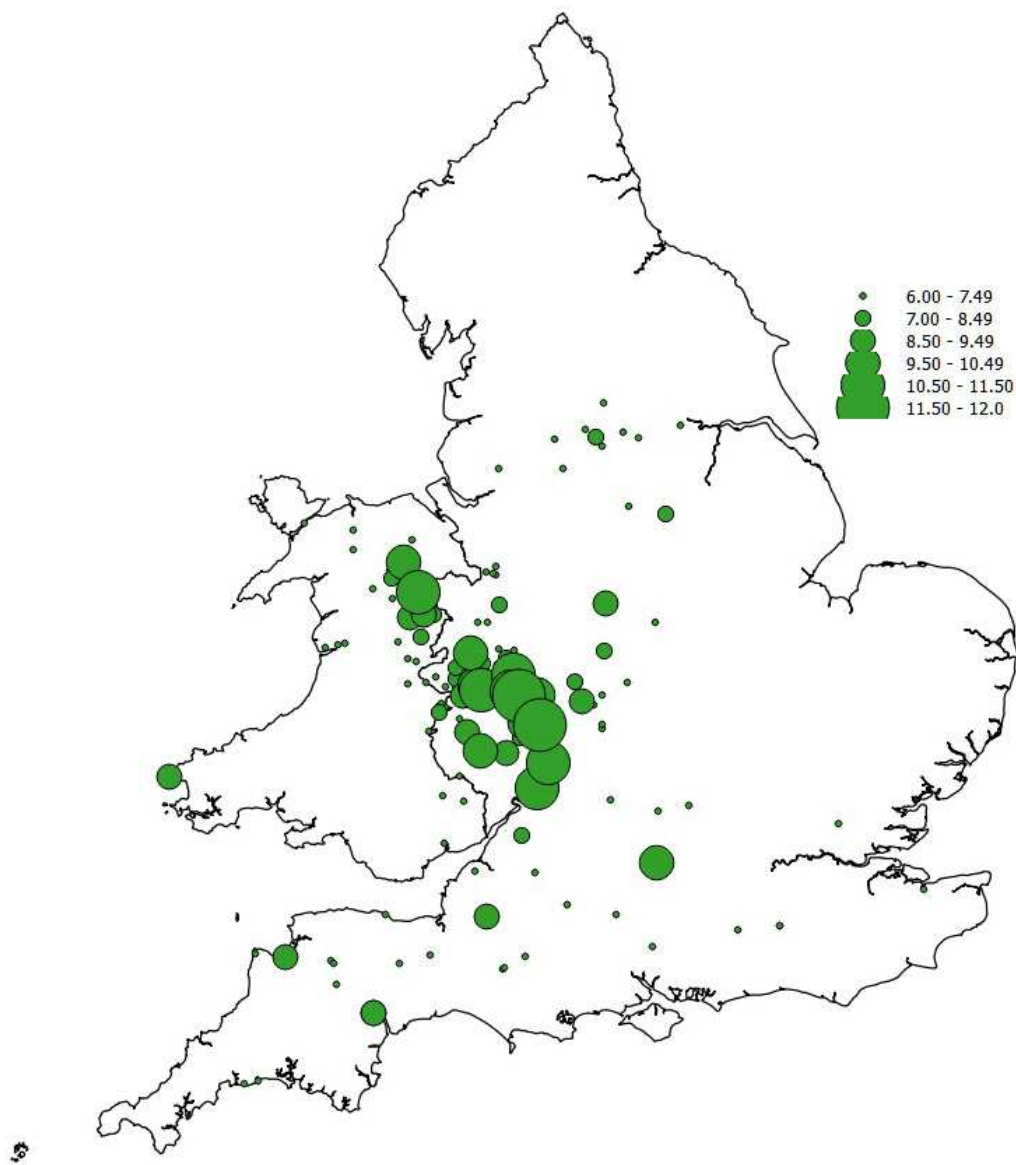


Figure 24: Map showing the distribution of sites giving t-values in excess of 6 with the site master FLEECE, showing the preponderance of sites to the north, up the Severn valley (made in open source software QGIS)

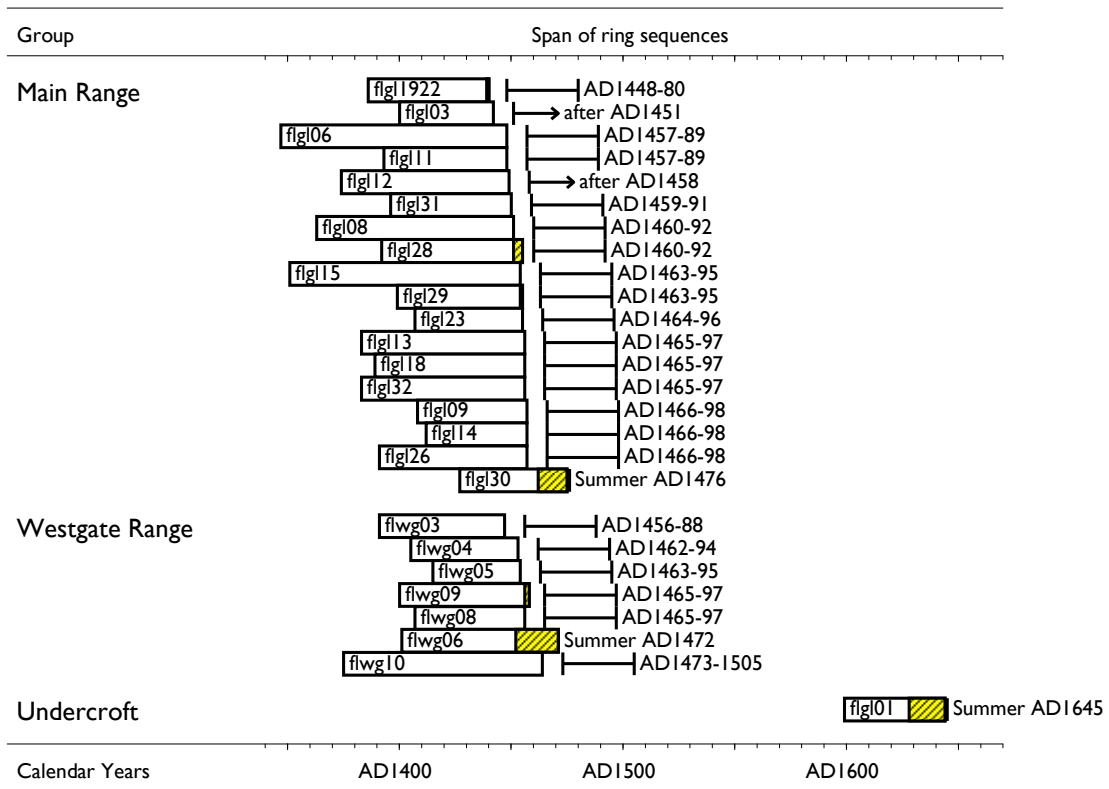


Figure 25: Bar diagram showing the relative positions of overlap of the dated samples, along with their actual felling dates or likely felling date ranges. White bars represent heartwood rings, yellow hatched bars represent sapwood rings

APPENDIX

Ring width values (0.01mm) for the sequences measured

fgl01

344	258	289	277	187	132	103	164	152	169
179	272	265	171	298	258	264	301	382	360
343	359	441	554	462	322	390	333	310	304
416	322	283	346	278	159	131	107	125	170
104	140	96	85	112	103				

fgl02

365	406	549	460	495	516	287	403	489	683
617	437	220	241	219	169	220	118	119	219
279	262	212	218	185	203	173	206	166	114
105	107	101	107	83	66	31	84	117	122
125	237	136	116	236	294	191	185	168	222
308	304	193	185	117	52	36	61	59	58
63	72	89	98	130	125	115	112	103	152
147	101	157	182	132	149				

fgl03a

483	477	334	340	308	255	216	209	290	396
312	252	317	241	205	234	198	203	233	160
228	271	244	330	328	262	196	193	275	253
237	208	253	192	202	236	253	190	302	181
214	261	211							

fgl03b

489	461	365	347	318	330	310	264	326	428
354	281	322	248	240	227	226	222	245	161
235	240	213	233	245	254	222	224	335	357
368	285	333	265	301	262	251			

fgl06

328	340	382	360	378	213	314	281	232	173
247	258	270	170	196	297	256	311	206	308
284	196	303	347	216	200	180	275	231	185
186	187	233	168	156	188	253	393	281	292
224	211	246	240	368	212	215	161	105	231
198	308	240	214	221	153	230	149	138	180
187	216	239	198	176	166	158	188	218	184
140	111	95	211	189	172	240	203	235	204
244	221	221	258	194	254	152	165	216	135
160	189	150	177	225	122	230	228	143	244
176	194								

flgl08

350	383	304	392	416	408	459	390	285	315
278	398	305	337	266	261	310	295	262	371
266	272	290	310	219	220	215	182	174	117
125	111	101	123	110	89	124	117	154	165
175	133	161	214	157	170	240	204	169	162
146	142	162	100	95	89	78	107	106	119
161	138	154	120	110	139	138	156	142	149
118	101	113	93	86	98	99	91	90	99
111	117	94	98	112	91	86	79	98	

flgl09

461	510	433	371	504	342	467	409	418	342
365	198	413	364	221	387	320	354	276	379
358	240	320	368	473	267	268	307	291	255
287	228	263	286	176	249	352	240	217	197
268	306	241	289	222	199	228	223	262	197

flgl11

223	254	258	368	377	338	268	270	240	294
309	241	269	208	295	367	419	370	319	355
285	281	307	279	225	247	161	266	278	215
235	242	290	238	252	272	283	268	254	268
207	274	290	277	263	243	198	218	200	153
155	248	168	156	182	169				

flgl12

395	274	209	205	232	270	171	216	314	315
340	272	462	378	276	215	196	280	146	169
115	96	168	245	175	237	172	295	205	289
170	172	263	246	189	202	224	179	196	218
140	169	114	108	97	90	107	142	131	234
138	162	112	130	173	139	143	81	122	109
130	134	111	99	68	60	75	87	63	94
122	66	70	89	71	80				

flgl13

220	212	132	217	232	168	168	186	198	190
151	154	136	136	139	186	193	223	212	137
216	177	146	165	124	164	208	159	213	252
237	368	320	264	170	173	118	140	221	150
147	202	176	215	262	234	219	202	199	241
150	193	162	182	160	161	158	176	132	115
116	233	370	255	301	259	239	159	199	166
181	248	195	192						

flgl14

212	187	257	259	230	194	213	138	206	308
250	305	239	221	229	288	271	254	315	247
356	250	280	269	288	224	221	270	263	250
186	224	241	206	172	185	263	209	203	262
193	206	230	200	238	201				

flgl15

277	439	418	419	365	344	346	279	365	288
211	254	254	224	171	176	190	238	223	217
191	140	148	177	260	275	256	277	277	212
157	181	245	252	305	312	322	292	328	375
484	285	244	250	187	308	288	278	282	374
351	414	327	272	204	213	204	264	280	289
193	310	224	230	281	237	169	170	95	146
169	166	208	228	214	134	134	175	222	205
199	271	165	224	156	200	176	157	129	148
181	158	160	136	190	174	229	241	184	171
229	188	204	147						

flgl18

121	100	264	110	140	121	133	226	186	184
174	241	284	244	345	283	280	255	245	338
444	322	205	265	166	252	256	215	184	200
117	234	253	133	290	195	206	145	213	197
156	160	154	239	119	138	168	180	180	176
125	124	150	91	107	177	138	118	164	172
192	177	223	247	171	199	205	238		

flgl19

451	314	290	259	232	381	158	218	183	150
227	248	277	259	300	291	166	261	196	180
179	177	183	228	182	136	153	124	170	183
163	145	164	97	126	133	96	123	110	116
115	99	86	109	95	80	79	71	72	131
104	101	114							

flgl20

93	124	120	105	156	186	248	234	242	189
196	174	258	213	133	220	141	148	199	122
186	208	234	304	233	248	236	152	149	152
199	174	166	142	172	189	230	223	259	196
195									

flgl21

137	156	119	132	213	242	203	153	176	215
214	148	204	231	168	248	132	156	119	92
149	136	128	132	119	122	105	110	83	71
92	84	83	72	62	63	67	85	81	62
62	67	57	53	76	101	104			

flgl22

388	397	377	288	398	210	258	233	208	239
281	295	301	314	333	190	296	209	227	205
207	176	244	209	226	200	147	198	195	185
167	190	102	184	158	118	133	133	117	93
108	110	113	98	84	90	79	92	179	130
125	128	82	154						

flgl23

389	285	432	347	204	214	126	229	269	248
195	204	134	199	215	137	204	194	199	188
241	223	187	249	190	236	198	245	173	161
138	164	114	130	160	119	117	212	182	131
148	167	125	150	191	138	114	114	144	

flgl24

471	483	616	591	121	123	187	207	265	283
288	303	349	410	431	304	290	340	337	494
544	526	88	137	175	169	165	152	189	197
160	222	69	293	281	313	220	70	80	71
69	77	74	95	98	98	124	70	36	59
46	57	101	130	144					

flgl25

307	398	272	229	237	211	245	159	164	167
299	354	388	377	327	380	291	283	330	186
191	184	84	91	113	191	222	243	215	183
243	112	94	98	92	137	149	148	166	58
59	76	141	130	147	168	124	116	102	90
107	129	66	49	51	72	84	92	67	78
86	101	134	117	128	133	101	66	90	115
122									

flgl26

259	207	260	218	206	274	275	322	299	367
364	296	348	288	280	302	257	295	347	272
231	265	258	305	290	277	240	235	169	226
246	189	216	219	221	225	245	227	227	242
197	240	184	200	198	207	166	163	165	177
168	145	161	189	210	181	177	218	182	162
241	189	163	245	218	219	212			

flgl28

229	292	231	236	262	231	315	327	296	402
173	209	218	248	311	287	269	299	192	276
216	178	111	157	133	177	125	61	62	108
81	130	120	89	80	110	146	110	101	115
205	130	167	139	123	105	125	139	103	143
130	115	139	131	125	132	118	94	122	130
97	121	92	152						

flgl29

368	405	386	380	429	386	460	309	329	400
367	253	190	310	307	333	359	308	260	272
176	335	366	267	347	308	345	271	336	391
362	310	208	338	228	269	235	249	188	218
144	226	199	144	167	191	173	146	180	192
175	211	220	204	203	217	161			

flgl30

255	183	152	257	266	299	145	169	188	151
133	94	104	144	150	131	242	266	198	169
171	185	246	171	252	309	229	236	178	226
170	127	144	163	131	156	140	107	122	145
124	136	126	136	127	113	105	100	133	

flgl31

253	259	285	301	298	348	219	288	224	241
235	202	239	318	244	234	309	249	286	252
174	225	200	130	189	247	190	354	263	290
195	278	234	238	269	241	256	200	246	288
220	204	200	159	192	205	138	197	217	215
220	175	185	219	187					

flgl32

180	183	134	157	157	148	120	92	110	99
82	83	80	126	103	130	139	182	235	175
196	244	274	340	323	439	489	436	285	308
227	263	262	258	205	212	125	201	216	164
230	215	204	162	206	231	151	174	156	188
131	152	142	145	160	153	145	147	156	110
133	183	178	140	132	172	149	124	172	127
134	178	141	161						

flgl33

407	594	470	531	410	436	438	448	521	552
760	837	712	721	571	376	370	347	625	583
424	477	509	460	332	319	407	432	331	425
527	404	536	422	421	511	513	456	492	610
485	520	276	304	409					

flgl34

260	194	311	448	600	464	388	367	364	387
353	282	338	354	325	224	230	171	197	222
194	272	317	209	438	316	365	412	269	355
341	270	400	392	419	288	295	211	241	240
209	174	266	151	162	199	181	196	242	284
243	202	196	159	199	203				

flglE04

373	261	224	278	212	218	284	186	396	396
465	459	449	451	360	124	71	79	92	93
130	124	163	158	162	107	203	183	308	322
250	373	408	371	336	239	225	139	154	150
83	87	93	84	91	78	91	118	125	147
214	194								

flglE06i

178	126	148	195	294	241	166	161	284	277
326	239	158	286	272	335	144	283	180	208
418	459	247	127	133	174	211	215	157	225
159	184	160	365	231	245	329	327	136	284
258	130	116	167	120	88	120	99	108	130
118	84	100	245	93	108	79	90	124	137
225	127	179	99	79	65	88	116	61	53
58	45	49	57	72	72	63			

flwg01

481	291	352	233	168	148	122	230	240	277
219	192	254	205	196	299	228	198	213	150
147	148	185	172	155	162	129	149	167	131
71	105	97	108	99	111	107	115	123	108
115	117	89	112	76	69	55	77	80	91
79	91	94	83	102	101	117	77	78	62
78	100	101	63	85					

flwg02

101	98	153	149	177	172	222	203	151	203
166	214	241	509	298	388	284	168	158	104
94	92	86	103	106	69	69	72	77	106
97	71	74	65	57	67	68	63	64	54
65	69	64	52	59	56	53	58	60	45
46	58	47	62	68	57	81	88	94	82
82	72	64	59	44	57	82	82	86	79
63	66	74	69	84	101	89	75		

flwg03

294	184	206	170	195	197	136	186	168	183
224	143	174	171	173	164	118	121	200	123
108	139	96	142	171	108	93	138	84	157
151	114	166	112	133	109	145	132	123	146
128	158	88	106	109	102	135	143	77	93
140	103	101	120	120	85	101			

flwg04

221	151	182	193	305	260	286	306	196	251
248	284	222	223	155	309	239	210	284	264
225	235	265	237	267	334	218	309	209	225
247	214	172	185	164	175	172	127	148	200
188	127	131	144	144	125	158	136	140	

flwg05

190	199	177	241	154	205	236	186	224	258
288	217	313	339	217	282	230	303	145	174
225	168	159	161	115	128	157	111	103	143
139	87	87	118	96	91	126	92	97	148

flwg06

274	180	188	223	180	218	177	207	263	233
166	194	168	215	207	194	199	207	154	224
171	124	150	164	142	146	168	162	193	193
149	161	117	124	163	112	117	128	99	82
120	103	103	131	120	123	146	135	135	88
134	146	125	117	109	126	135	104	72	119
93	109	100	79	83	93	103	113	86	94
103									

flwg08

289	273	282	274	198	271	171	266	235	198
199	270	118	256	246	146	235	192	234	181
247	230	184	231	216	261	165	189	214	171
156	120	128	154	204	136	140	156	137	132
138	173	226	155	182	164	158	196	158	220

flwg09

235	224	211	191	194	206	168	117	164	190
170	145	153	146	197	171	116	141	178	116
202	169	198	319	292	314	297	344	348	299
295	275	258	218	286	268	238	256	297	233
286	240	178	252	374	278	248	249	226	231
157	245	170	185	252	201	226	196	220	

flwg10

130	189	176	150	189	115	157	191	165	255
303	343	257	192	140	160	247	161	198	150
100	160	156	196	184	230	294	174	243	235
231	293	189	210	222	225	247	253	209	179
255	157	184	237	126	155	120	95	193	155
88	101	95	144	125	116	139	148	111	130
141	126	101	88	68	70	56	67	76	109
91	108	189	188	213	222	300	219	244	203
276	294	294	334	244	322	186	164	264	120

flwg12

527	444	445	473	401	387	359	264	383	259
279	328	408	484	406	343	264	283	283	267
249	235	313	259	299	284	158	260	179	189
238	134	145	160	219	292	338	371	285	226
78	74	72	104	89	120	87	113	120	167
191	138								

flwg13

745	111	512	660	868	747	132	124	486	788
785	114	134	270	85	110	286	316	406	1056
137	219	249	364	451	924	164	129	162	202
242	68	61	80	124	231	117	145	153	94
53	64	52	51	38	38	80	50	56	

flwg15

211	247	275	66	77	90	131	138	186	128
178	135	158	154	45	30	35	80	138	103
142	114	63	55	37	37	39	42	85	99
68	63	79	71	114	149	134	157	37	48
60	76	107	73	72	21	34	53	62	67
77	112	101	142	151	163	198	157	120	29
47	39	88	129	127	119	112	170	228	139



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