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Tree-Ring Dating of the Roof and Entrance Door

Martin Bridge and Cathy Tyers

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SUMMARY
A seventeen-timber chronology was formed from samples from roof timbers covering the period AD 1263–1376, with a further sample from a roof timber being dated individually. Two of these 18 samples retained complete sapwood and were found to have been from trees felled in winter AD 1376/77, with the other samples having likely felling date ranges incorporating this date. Construction seems likely, therefore, to have occurred in AD 1377 or shortly afterwards. The door boards were found to be of oak imported from the Baltic region, three samples forming a site chronology covering the period AD 1253–1439 and a further sample being dated individually. In the absence of sapwood a *terminus post quem* date for felling of AD 1461 is obtained for the boards.

CONTRIBUTORS
Martin Bridge and Cathy Tyers

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Access to the roof was arranged through Mike Jackson of the Bury Preservation Trust, and subsequent work on the door was arranged with James Mellish of JM Environmental (East Anglia) Ltd, both of whom were very helpful and supportive of this investigation. Micro-boring of the door was carried out along with Dan Miles (Oxford Dendrochronology Laboratory) whose efforts are much appreciated. Shahina Farid, Historic England Scientific Dating Team, is thanked for commissioning and facilitating this programme of dendrochronological analysis.

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INTRODUCTION

This Grade I Listed building is in the central area of the Suffolk town of Bury St Edmunds (Figs 1a–c). It is often described as one of the largest and most impressive secular medieval buildings in the country, and a rare survival of a civic building from this period. The oldest part is reported to be the thirteenth-century stone entrance arch, now within a late fifteenth-century porch. Its unique roof structure combines East Anglian queen posts with king posts (Fig 2) and has been attributed to the fifteenth century, although the County Archaeologist, Bob Carr, and local building historian, Leigh Alston (Alston 2014), suggest that it is mid-fourteenth century. The roof, aligned north-south, is ten bays long spanning a length of 38m. There is a decorated crown post near the southern end (Fig 3), which was over a southern dais. Many timbers are covered in yellow ochre (Fig 4), usually a sixteenth-century feature (Alston 2014).

Dating of this roof was requested by Trudi Hughes, Historic England Heritage at Risk Architect/Surveyor, to inform on-going restoration work prior to the re-opening of the Guildhall for public use. The entrance door was noted as a fine example of a probable late fifteenth-century door (Fig 5) and the original brief was extended to include dating of this as well.

METHODOLOGY

An assessment of the timbers for dendrochronological study sought accessible oak timbers with more than 50 rings and where possible traces of sapwood, although slightly shorter sequences are sometimes sampled if little other material is available. Those timbers judged to be potentially useful were cored using a 15mm auger attached to an electric drill. The cores were labelled and stored for subsequent analysis. The door was sampled using a micro-borer specially developed for such work. This uses a small 8mm external diameter hollow drill bit which extracts a 5mm diameter core. The drill bit is cooled and cleared of dust with the aid of compressed air which is channelled through the inside of the cutting tube and clears the waste from around the outside of the bit. The drill bit is accurately aligned by the use of a series of guides fitted to a jig which is clamped to the face of the door. In this manner the drill can be used to bore through a number of boards as thin as 15mm thick and as wide as one metre or more. Thus, the boards on each door leaf could be drilled in succession with the need to make only a single hole, which is afterwards plugged with an oak pellet and stained appropriately. The micro-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 PC, which recorded the ring widths into a dataset. The software used in measuring and subsequent analysis was written by Ian Tyers (2004a). 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 prefer to see some *t*-value ranges 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 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 latewood or summer growth) a precise felling date and season can be given. 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 each 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, which in this area is 9–41 rings (Miles 1997). Baltic oak is taken as having a likely sapwood number range of 8–24 rings (Tyers 1998a). 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 study.

RESULTS

Details of the samples taken from the hall, both in the roof and at first-floor level, and the doors are given in Table 1. The roof trusses are numbered from north to south (Fig 6), with individual timbers then further identified as appropriate. The framework timbers of the doors were clearly derived from fast-grown oak with too few rings for reliable dating purposes and, hence, were not sampled, but the boards

were straight-grained and narrow-ringed and were cored at positions evident in Figures 7 and 8.
Two samples from roof timbers were found to have too few rings for reliable dating purposes and were discarded from further analysis. Several samples had bands of narrow rings resulting in their tree-ring series being measured in either two separate sections, where the ring series was sufficiently long, or as either just an inner or outer section. Seventeen of the 24 measured samples from the hall were cross-matched (Table 2a; Fig 9). These 17 series were combined to produce a 114-year long site master chronology, BURYGDHL, which was compared to an extensive range of reference chronologies and dates to the period AD 1263–1376 (Table 3a). The remaining seven individual series were compared with the site master and the reference chronologies, this resulting in the successful individual dating of bseg21 (Table 3b; Fig 9) in spite of it only producing a *t*-value of 2.4 with BURYGDHL.

The 5mm diameter cores extracted from the doors had in some cases fragmented as is to be expected with such thin cores. Samples bsegD03, bsegD04, and bsegD05, were measured in two or three separate sections with, in each instance, a number of rings potentially missing between each section (Table 1). Three ring series matched each other (Table 2b; Fig 10) and were combined into a single 244-year long site master chronology, BURYDOOR, which was dated to the period AD 1253–1439 against reference chronologies representing the Baltic region, including imports into the British Isles (Table 3c). The remaining series were compared to the two site master chronologies and an extensive range of reference chronologies from both the British Isles and elsewhere in Europe. This confirmed a tenuous match identified between bsegD01 and BURYDOOR (*t*-value = 3.7) but demonstrated that this board is potentially from a different source area within the overall Baltic region (Table 3d).

INTERPRETATION AND DISCUSSION

Two of the samples from roof timbers retained complete sapwood and were derived from trees felled in winter AD 1376/77 (Fig 9). The remaining dated samples, all of which, except one, have some sapwood or heartwood/sapwood boundary, produce likely felling date ranges which incorporate the precise felling date identified (Fig 9). Thus, all 18 dated samples appear to represent a single group of timbers most likely felled at the same time, in winter AD 1376/77. This indicates that construction was most likely in AD 1377, or within a year or two after this. This date accords well with an observation by Statham (1968) that there is documentary evidence in the form of a letter close to this date. This puts the responsibility for the repair of the building as the concern of the townsmen in AD 1377. The date also confirms the findings of Alston (2014) and the thoughts of the Bob Carr (County Archaeologist), who put the date of the roof in the fourteenth century, somewhat earlier than others had previously suggested. It had also previously been suggested that this medieval roof comprised two separate phases but no dendrochronological evidence has been found to support this suggestion, although it should be noted that neither of the two samples from the arch-braces visible in the Court Room could be successfully cross-matched or dated.

The entrance porch (Fig 5) is dated stylistically, and with evidence from the heraldry employed, to *c* AD 1485, with the extant doors thought to be original. Although the timbers of the framework of the doors were derived from fast-grown oak, the boards were considered characteristic of imported Baltic boards being derived from straight-grained, much slower-grown, trees. This proved to be the case for the door boards (Tables 3c and 3d), with the ring series matching material from Poland and further north on the eastern edge of the Baltic Sea. All four dated boards appear likely to be broadly coeval (Fig 10). No sapwood was evident on the boards, but previous analyses have shown that minimal amounts were usually trimmed from imported board groups (eg Groves 2004, Tyers and Tyers 2007, Bridge and Miles 2012). The outermost dated ring was formed in AD 1453, giving a felled-after date of AD 1461 for these door boards. It seems likely that these doors are indeed the original doors, and the dendrochronological dating evidence agrees well with the suggested likely date of the porch.

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TABLES

Table 1: Details of samples taken from The Guildhall, Guildhall Street, Bury St Edmunds

Sample No.	Location	Total number of rings	Mean ring width (mm)	Dates spanning (AD)	Sapwood	Mean sens	Felling date range (AD)
Hall roof and Court Room							
bseg01	Truss 10, west lower (curved) brace	74 *(+40-45NM)*	1.24	-	- *(+23½CNM)*	0.25	-
bseg02	Truss 10, king post	97	1.14	1269–1365	22	0.27	1365–84
bseg03	Truss 10, tiebeam	81 *(+7NM)*	1.35	1283–1363	4 *(+7NM)*	0.26	1370–1400
bseg04	Bay T10-T9, east common rafter, 2nd south of T10	82	1.53	1273–1354	h/s	0.24	1363–95
bseg05	Truss 9, east lower (curved) brace	84	1.11	1276–1359	28	0.26	1359–72
bseg06	Truss 9, east upper (straight) brace	66 *(15NM)*	0.94	1284–1349	h/s *(15NM)*	0.20	1364–90
bseg07	Truss 9, west lower (curved) brace	87 *(+11NM)*	1.25	1276–1362	h/s *(+11NM)*	0.27	1373–1403
bseg08	Truss 9, tiebeam	<40	NM	-	h/s	-	-
bseg09	Bay T9-T8, west common rafter 2nd south of T9	40 *(+32 NM)*	1.29	1279–1318	-	0.31	After 1359
bseg10	Truss 8, west queen post	<40	NM	-	h/s	-	-
bseg11	Truss 8, west lower (curved) brace	74	1.16	1283–1356	h/s	0.30	1365–97
bseg12	Truss 7, east lower (curved) brace	54 *(+17NM)*	1.06	-	h/s *(+17NM)*	0.22	-
bseg13	Truss 6, tiebeam	70	2.46	1290–1359	h/s	0.19	1368–1400
bseg14	Truss 6, west lower (curved) brace	84	1.43	1281–1364	13	0.22	1364–92
bseg15	Truss 6, east upper (straight) brace	41	2.31	-	15	0.25	-
bseg16	Truss 6, east lower (curved) brace	80	1.19	1285–1364	15	0.27	1364–90
bseg17	Bay T6-T5, east common rafter, 2nd south of T6	80	1.10	1271–1350	h/s	0.25	1359–91
bseg18	Truss 4, east lower (curved) brace	42	2.39	1335–1376	20C	0.23	Winter 1376/77

Table 1: (continued)

Sample No	Location	Total number of rings	Mean ring width (mm)	Dates spanning (AD)	Sapwood	Mean sens	Felling date range (AD)
bseg19	Truss 4, east upper (straight) brace	85	0.88	1263–1347	1	0.23	1355–87
bseg20i	Truss 4, east queen post	47	1.75	-	-	0.35	-
bseg20ii	*ditto*	56	1.34	1306–1361	8	0.32	1362–94
bseg21	Truss 4, king post	63	1.40	1314–1376	22C	0.27	Winter 1376/77
bseg22	Truss 4, tiebeam	71 *(+3NM)*	1.69	1297–1367	16 *(+3NM)*	0.30	1370–92
bseg23	Truss 4, west lower (curved) brace	81	1.36	1268–1348	3	0.21	1354–86
bseg24	Truss 2, west up-brace from crown post	71	1.36	-	11	0.25	-
bseg25	Truss 8, east arch-brace (in Court Room)	56	1.37	-	-	0.23	-
bseg26	Truss 9, east arch-brace (in Court Room)	50	1.09	-	-	0.26	-
Entrance Doors							
bsegD01	Outer board, north door leaf	244	1.29	1210–1453	-	0.12	After 1461
bsegD02	Middle board, north door leaf	159	1.49	1281–1439	-	0.26	After 1447
bsegD03i	Inner board, north door leaf, inner rings	73	1.09	-	-	0.15	
bsegD03ii	Inner board, north door leaf, middle rings	28	0.74		-	0.19	
bsegD03iii	Inner board, north door leaf, outer rings	89	0.94	-	-	0.16	-
bsegD04i	Inner board, south door leaf, inner rings	28	0.82	-	-	0.28	
bsegD04ii	Inner board, south door leaf, outer rings	95	1.55	1310–1404	-	0.28	After 1412
bsegD05i	Middle board, south door leaf, inner rings	113	1.69	-	-	0.20	
bsegD05ii	Middle board, south door leaf, outer rings	23	2.08	-	-	0.18	-
bsegD06	Outer board, south door leaf	185	1.57	1253–1437	-	0.14	After 1445

Key: C = complete sapwood, felled the following winter; ¼C = complete sapwood, felled the following spring;
½C = complete sapwood, felled the following summer; h/s = heartwood/sapwood boundary; NM = not measured

Table 2a: Cross-matching between the dated samples from the roof of The Guildhall

	t-values																
Sample	bseg02	bseg03	bseg04	bseg05	bseg06	bseg07	bseg09	bseg11	bseg13	bseg14	bseg16	bseg17	bseg18	bseg19	bseg20ii	bseg22	bseg23
bseg02	*	3.16	5.77	-	-	5.35	4.55	5.76	3.39	5.32	4.98	4.69	-	4.60	-	4.63	9.15
bseg03	*	*	4.06	-	-	5.09	-	4.26	3.59	-	4.97	4.34	3.22	4.02	3.07	3.77	3.36
bseg04	*	*	*	4.27	3.27	6.38	3.11	5.31	4.10	4.61	6.02	6.17	-	4.83	-	3.03	3.73
bseg05	*	*	*	*	-	5.90	-	-	3.86	-	3.88	-	-	3.72	-	-	-
bseg06	*	*	*	*	*	4.43	-	7.06	-	6.99	3.63	4.72	-	4.95	-	-	-
bseg07	*	*	*	*	*	*	3.72	7.31	4.08	4.77	6.77	6.10	-	5.80	4.21	-	5.48
bseg09	*	*	*	*	*	*	*	4.73	-	-	-	-	\	4.08	\	-	6.26
bseg11	*	*	*	*	*	*	*	*	-	5.50	5.74	6.17	-	5.85	3.75	3.29	6.04
bseg13	*	*	*	*	*	*	*	*	*	4.58	4.49	3.58	4.19	4.66	4.88	3.21	-
bseg14	*	*	*	*	*	*	*	*	*	*	6.66	3.26	-	4.43	5.34	-	-
bseg16	*	*	*	*	*	*	*	*	*	*	*	4.88	-	6.26	5.90	-	4.15
bseg17	*	*	*	*	*	*	*	*	*	*	*	*	-	4.93	-	-	5.23
bseg18	*	*	*	*	*	*	*	*	*	*	*	*	*	\	-	3.15	\
bseg19	*	*	*	*	*	*	*	*	*	*	*	*	*	*	4.62	-	4.76
bseg20ii	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-
bseg22	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-
bseg23	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Key: \ = overlap less than 15 years; - = *t*-values less than 3.0; * = empty triangle

Table 2b: Cross-matching between the dated samples from the entrance doors of The Guildhall

Sample	bsegD04ii	bsegD06
bsegD02	7.5	5.8
bsegD04ii	*	5.7

Table 3a: Dating evidence for the site chronology BURYGDHL, AD 1263–1376

Source region	Chronology:	Publication reference:	Filename:	Span of chronology (AD)	Overlap (years)	*t*-value
Cambridgeshire	Peterborough Cathedral tower	(Tyers 2004b)	PCF7_T11	1154–1371	109	8.8
Essex	Blackmore Church	(Miles *et al* 2005)	BLCKMORE	1266–1399	111	8.4
Rutland	The Bede House, Lyddington	(Arnold *et al* 2015)	LYBHSQ03	1245–1494	114	8.1
Hampshire	Sheet Farm Barn, Petersfield	(Bridge *et al* 2012)	SHEETBN	1244–1411	114	7.8
Gloucestershire	Twyning bell tower	(Tyers 1996)	TWYNING	1251–1452	114	7.4
Hampshire	Prior's Hall roof	(Bridge and Miles 2018)	DWCx2	1284–1375	92	7.4
Norfolk	Dragon Hall, Norwich	(Boswijk and Tyers 2005)	DRAGON	1289–1426	88	7.1
Suffolk	23 High Street, Debenham	(Miles *et al* 2009)	DEBNHM4	1273–1417	104	7.0
Bedfordshire	St George's Church, Toddington	(Bridge 2001)	TODDNGTN	1226–1392	114	6.9
Norfolk	Prior's House, Castle Acre	(Tyers 2000a)	CAP-LOW	1237–1356	94	6.9
Norfolk	Oxburgh Hall	(Cooper *et al* 2012)	OXBURGH	1221–1591	114	6.7
Norfolk	New Buckenham	(Cooper *et al* 2012)	NEWBUCK1	1271–1472	106	6.6

Table 3b: Dating evidence for the individually dated ring series, bseg21, AD 1314–1376

Source region	Chronology:	Publication reference:	Filename:	Span of chronology (AD)	Overlap (years)	*t*-value
London	Receiver General's House, Westminster	(Bridge and Miles 2015)	WaRecGen	1313–1386	63	6.1
Kent	Court Lodge Farm barn, Bilsington	(Arnold and Howard 2009)	BLSNSQ01	1224–1401	63	6.0
Essex	Netteswellbury barn, Harlow	(Tyers 1997)	NETTLESB	12451439	63	5.9
Warwickshire	Guildhall, Stratford-on-Avon	(Arnold *et al* 2006a)	SUABSQ01	1305–1403	63	5.9
Hampshire	Trees Cottage, Froxfield	(Miles and Haddon-Reece 1993)	TREES1	1294–1359	46	5.9
West Sussex	St Andrew's Church, Ford	(Bridge 2000)	FORD	1286–1511	63	5.8
Worcestershire	The Commandery, Worcester	(Arnold *et al* 2006b)	WORDSQ01	1284–1473	63	5.6
Essex	Cressing Temple Barns	(Tyers and Hibberd 1993)	CRBCR2	1323–1410	54	5.4
London	White Tower, Tower of London	(Miles 2007)	WHTOWR5	1260–1489	63	5.4
Kent	T.S.Hazard, Faversham	(Bridge 2019 unpubl)	HAZARD	1322–1428	55	5.3
Shropshire	Easthope	(Miles and Haddon-Reece 1994)	EASTHOPE	1308–1454	63	5.2
Somerset	Birdcombe Court, Wraxall	(Miles and Worthington 1999)	BRDCMBCT	1276–1441	63	5.2

Table 3c: Dating evidence for the site chronology BURYDOOR, AD 1253–1439

Source region	Chronology:	Publication reference:	Filename:	Span of chronology (AD)	Overlap (years)	*t*-value
Regional Chronologies						
Baltic	Baltic imports into the Netherlands	(Jansma *et al* 2004)	DutchB	1167–1637	187	10.9
Baltic	Baltic Master Chronology	(Hillam and Tyers 1995)	BALTIC1	1156–1597	187	10.2
Site chronologies						
Baltic	Bowhill, Exeter, Devon	(Groves 2004)	BOWHILLB	1161–1483	187	10.5
Baltic	Winchester College, Hampshire	(Miles and Haddon-Reece 1996)	WNCHSTR1	1207–1495	187	9.3
Baltic	Fulham Palace Gates, London	(Bridge and Miles 2004)	FULHAM2	1319–1484	121	7.7
Baltic	Tudor House, Southampton, Hampshire	(Miles and Bridge 2011)	TUDORHS7	1252–1475	187	6.8
Baltic	Magdalen College, Oxford, Oxfordshire	(Miles and Worthington 2000)	MAGDALN3	1222–1494	187	6.6
Baltic	Sutton House, London	(Tyers 1991)	SUTHSE14	1259–1516	181	6.4
Baltic	Christ Church Great Hall, Oxfordshire	(Miles and Bridge 2016)	CHCHGH3	1156–1492	187	6.4
Baltic	Otley Hall, Suffolk	(Tyers 2000b)	OTLEY_B1	1296–1519	144	6.3
Baltic	Stoke Newington Church, London	(Tyers unpubl)	171SNCS	1266–1470	174	6.2
Baltic	Salisbury Cathedral, Wiltshire	(Miles *et al* 2004)	SARUM15	1117–1354	102	6.0

Table 3d: Dating evidence for the individually dated ring series, bsegD01, AD 1210–1453

Source region	Chronology:	Publication reference:	Filename:	Span of chronology (AD)	Overlap (years)	*t*-value
Regional Chronologies						
Baltic	Pultusk regional chronology	(Krapiec pers comm)	POL_PULT	1192–1452	243	9.1
Baltic	Baltic Master Chronology	(Hillam and Tyers 1995)	BALTIC2	1257–1615	197	8.6
Baltic	Gdansk regional chronology	(Wazny pers comm)	GDANSK	996–1985	244	6.4
Site chronologies						
Baltic	Christ Church Great Hall, Hampshire	(Miles and Bridge 2016)	CHCHGH2	1307–1498	147	10.2
Baltic	King Charles Gate, Christ Church College, Oxford, Oxfordshire	(Miles and Bridge 2012)	KGCHASGT	1070–1433	224	9.2
Baltic	Chapel Lane Staith, Hull	(Tyers 2000c)	CLS2000	1110–1393	184	8.6
Baltic	Magdalen College, Oxford, Oxfordshire	(Miles and Worthington 2000)	MAGDALN2	1080–1416	207	8.2
Baltic	Bede House, Lyddington, Rutland	(Arnold *et al* 2015)	LYBHSQ02	1110–1414	205	8.1
Baltic	Icomb Place door, Icomb, Gloucestershire	(Bridge 2018 unpubl)	ICOMBDOR	1189–1403	194	8.1
Baltic	Portrait of Sir Henry Neville	(Tyers 2014)	os0918	1181–1592	244	7.7
Baltic	Hull Magistrates Court	(Tyers 1998b)	HMC_T165	1078–1369	160	7.6
Baltic	Copper wreck 1, Poland	(Bonde and Wazny pers comm)	COP1_T29	1094–1402	193	7.6

FIGURES

Figure 1a: Map to show the general location of Bury St Edmunds. ©Crown Copyright and database right 2019. All rights reserved. Ordnance Survey Licence number 100024900

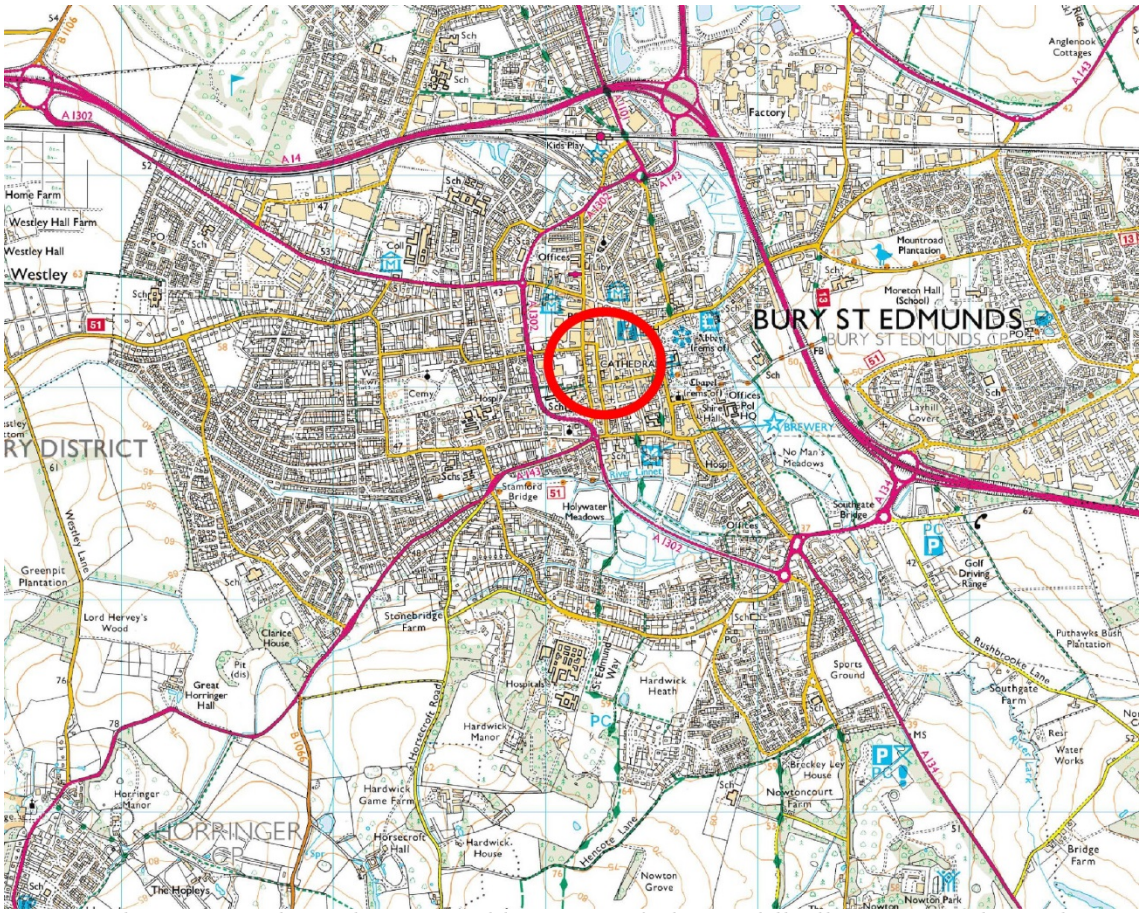

Figure 1b: Map to show the general location of The Guildhall in Bury Edmunds. © Crown Copyright and database right 2019. All rights reserved. Ordnance Survey Licence number 100024900

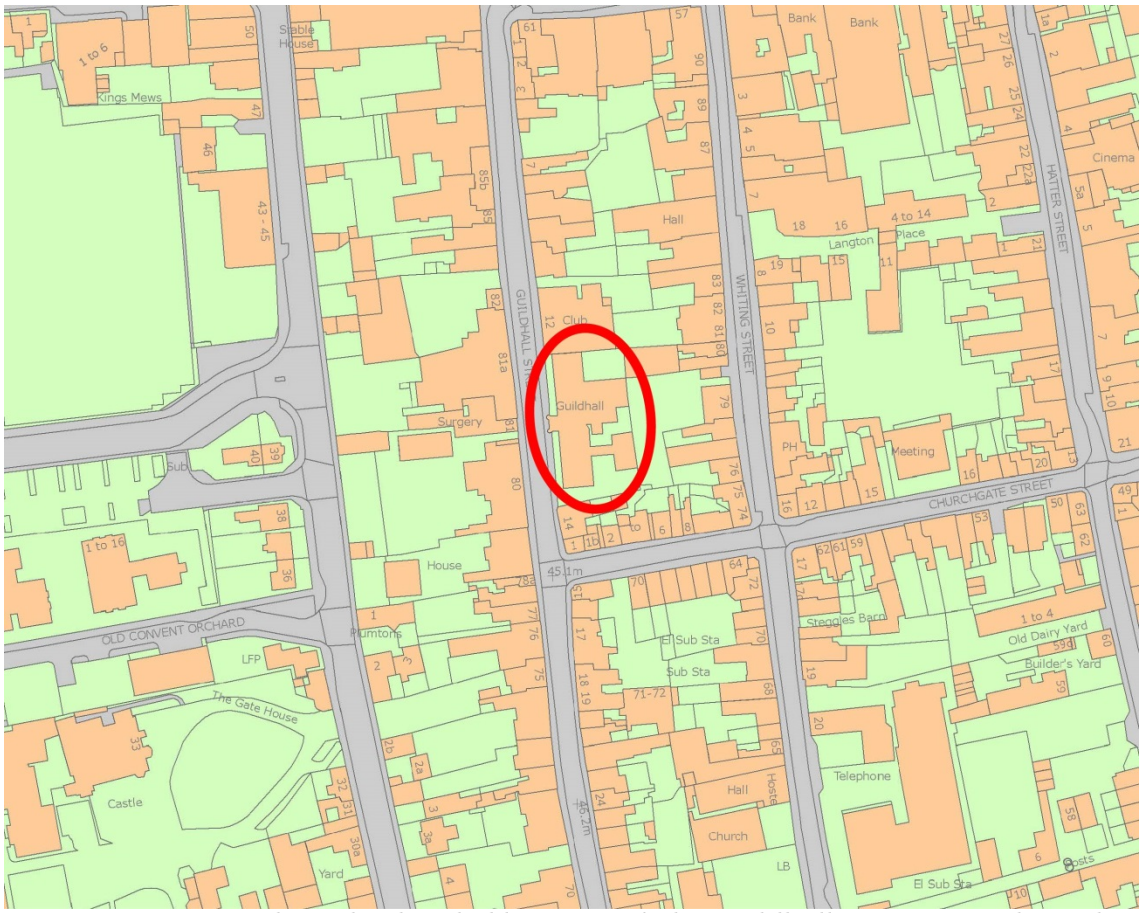

Figure 1c: Map to show the detailed location of The Guildhall in Bury St Edmunds. © Crown Copyright and database right 2019. All rights reserved. Ordnance Survey Licence number 100024900

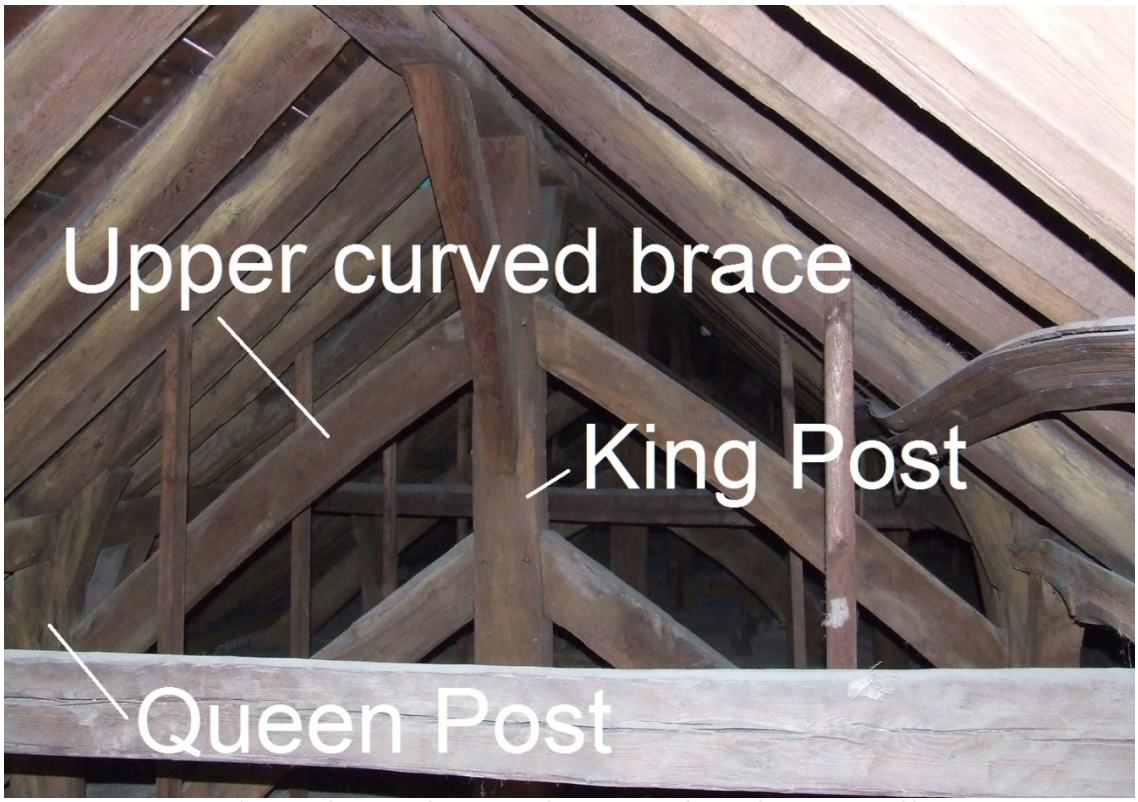

Figure 2: View of a roof truss showing the unusual combination of king post, queen post, and curved struts (photograph Martin Bridge)

Figure 3: View of the decorated crown post at the southern end of the roof (photograph Martin Bridge)

Figure 4: View of a queen post and other truss elements showing the yellow ochre decoration (photograph Martin Bridge)

Figure 5: View of the front of the entrance doors, showing the heraldic features in the stonework and general style of the porch, attributed to c AD1485 (photograph Martin Bridge)

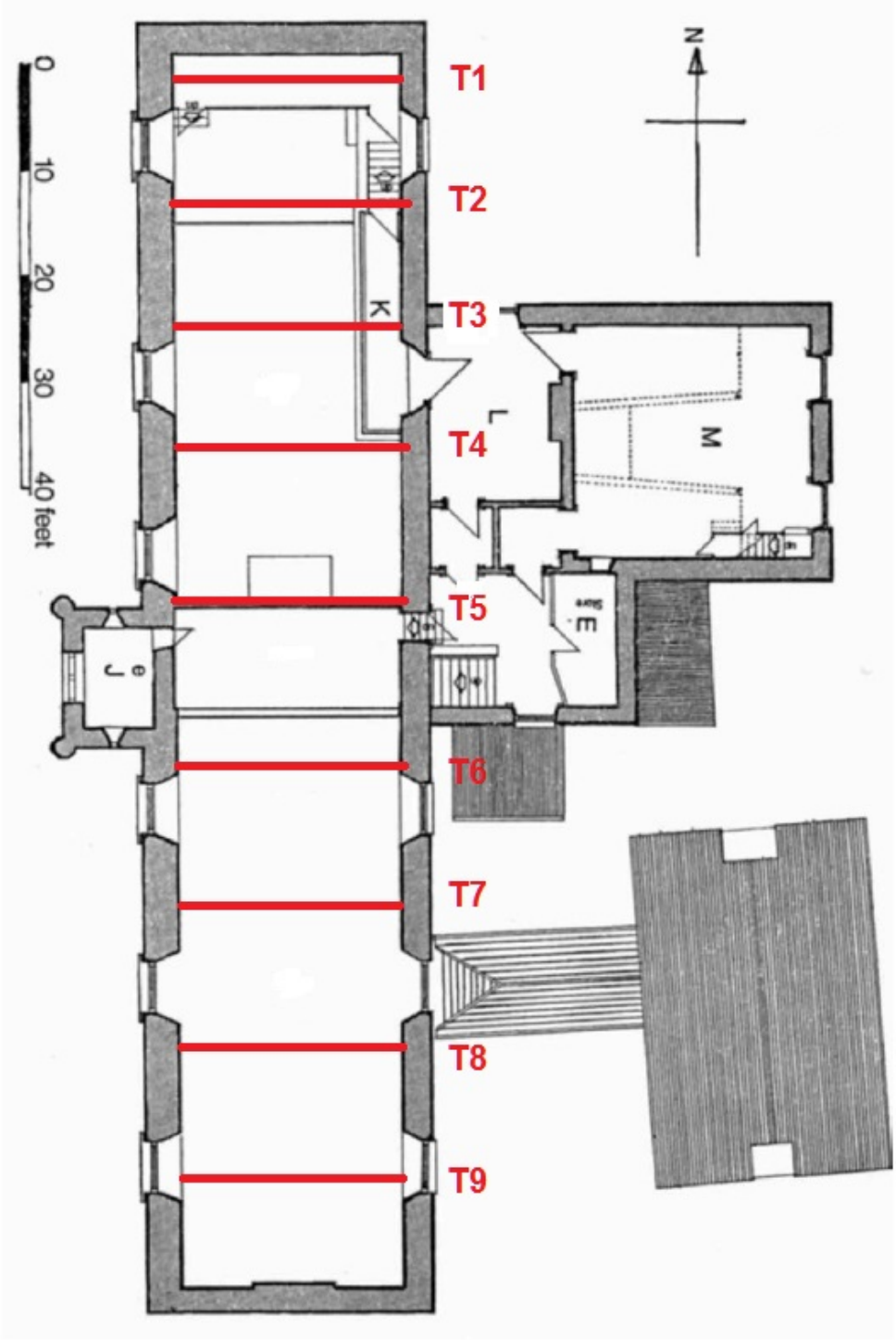

Figure 6: Approximate positions of the trusses superimposed on the first-floor plan from Statham (1968)

Figure 7: Coring of the north door leaf with Dan Miles using the micro-borer and jig which allows the coring bit to pass through successive boards within the thickness of the board (photograph Martin Bridge)

Figure 8: Jig in position on the south-door leaf, prior to coring (photograph Martin Bridge)

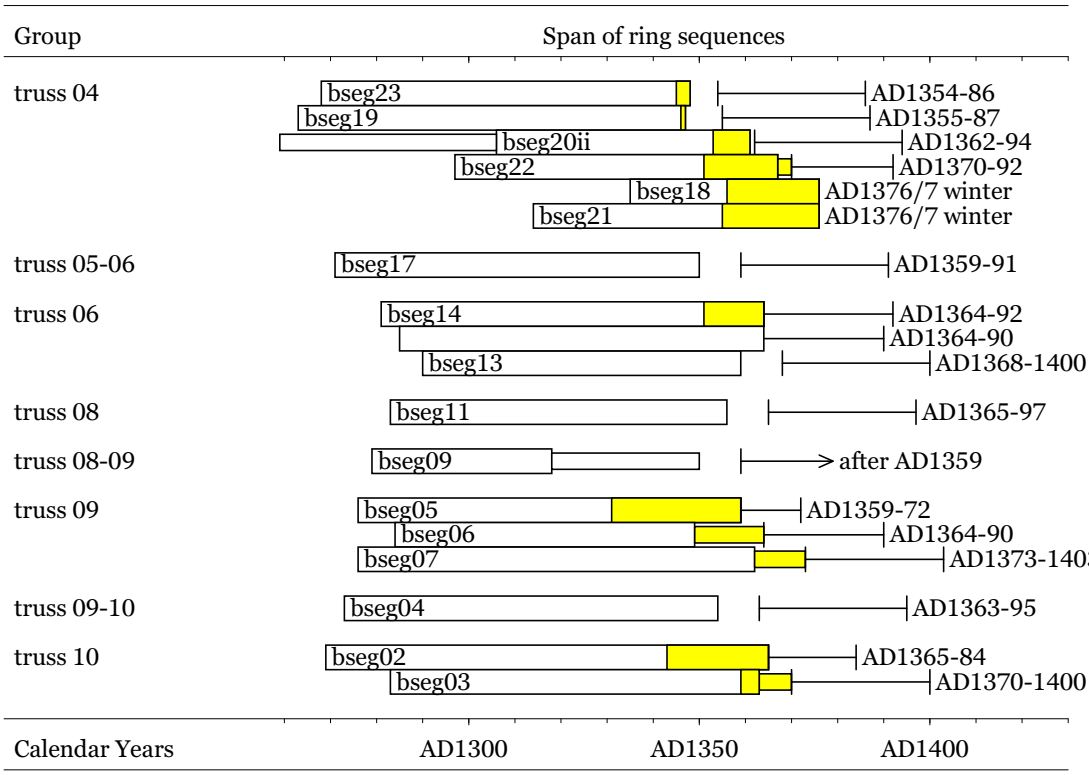

Figure 9: Bar diagram showing the relative positions of overlap of the dated roof samples, along with their actual felling dates or likely felling date ranges. White bars represent heartwood rings, yellow bars represent sapwood rings, and narrow sections of bar represent additional unmeasured or undated rings

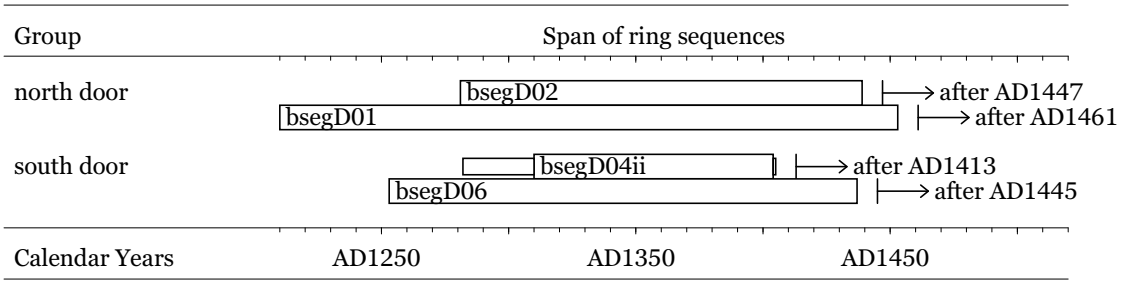

Figure 10: Bar diagram showing the relative positions of overlap of the dated door samples, along with their likely felling date ranges. White bars represent heartwood rings, narrow sections of bar represent additional unmeasured rings

APPENDIX

Ring width values (0.01mm) for the sequences measured

bseg01

448	180	115	200	211	217	228	366	329	229
243	179	293	263	236	156	255	168	232	131
217	140	159	156	128	202	191	136	130	146
90	48	48	54	41	64	75	131	82	80
70	88	80	62	106	71	63	73	58	90
60	63	48	60	57	68	85	69	96	73
81	67	77	72	84	65	42	34	41	48
35	37	36	40						

bseg02

346	370	320	235	287	195	276	175	335	251
199	235	283	249	168	170	133	124	83	58
100	114	88	71	89	149	93	81	78	115
64	76	104	87	51	59	68	71	91	127
151	88	75	102	104	129	120	110	105	114
74	102	122	81	58	33	54	49	54	60
66	33	34	33	42	49	62	48	73	36
70	73	100	74	99	62	105	95	101	55
39	72	102	77	92	90	124	109	118	85
91	125	72	83	134	112	123			

bseg03

232	233	106	151	116	184	260	217	186	221
285	166	94	102	112	131	115	129	176	171
121	132	120	180	247	187	88	77	53	64
77	76	127	94	97	66	77	98	138	115
70	56	65	67	81	101	128	116	96	75
81	111	154	134	125	106	149	187	93	141
90	71	135	195	207	253	218	173	255	138
148	151	182	132	170	93	112	95	69	123
205									

bseg04

440	249	293	180	391	464	441	457	428	350
224	216	203	210	73	118	168	141	112	149
132	128	110	92	70	74	82	129	121	174
99	105	105	124	151	118	121	125	86	156
148	145	177	146	133	94	84	156	164	122
74	59	82	57	73	76	95	43	46	84
109	140	174	122	113	83	129	131	117	117
142	125	150	102	114	89	91	121	201	150
193	175								

bseg05

200	312	196	239	236	290	358	304	272	260
238	97	117	133	178	117	136	179	153	123
200	165	162	114	71	61	53	42	33	42
84	94	121	122	58	74	105	107	170	153

107 87 50 54 68 72 106 81 66 77
45 41 42 66 50 41 50 55 54 96
52 55 45 71 65 68 73 83 121 86
52 59 98 77 89 102 63 112 57 57
64 117 98 125

bseg06
284 277 286 142 50 42 42 37 57 61
73 88 69 67 61 64 34 43 38 35
34 51 78 94 85 115 103 67 67 77
97 117 125 98 74 89 127 150 112 69
85 80 73 74 78 62 49 48 58 65
80 112 106 99 114 144 136 111 123 68
117 136 151 167 104 95

bseg07
230 354 296 196 264 335 308 220 297 196
162 82 90 142 150 120 190 236 209 217
245 204 167 116 71 124 105 62 63 71
114 130 105 143 83 80 114 124 171 179
177 103 57 68 73 120 109 82 56 76
60 49 47 52 36 39 50 51 87 102
85 104 59 96 94 76 101 84 69 84
94 116 97 69 93 130 81 159 163 81
92 136 90 82 90 60 163

bseg09
245 193 276 309 200 158 160 183 100 81
172 175 113 153 95 146 92 73 87 67
55 65 153 86 69 103 68 102 122 130
92 85 67 85 107 144 203 171 120 51

bseg11
366 252 232 234 102 68 90 94 77 95
73 78 69 66 56 44 52 36 93 90
51 50 53 84 113 139 163 128 60 126
136 213 260 276 271 173 159 187 194 137
78 46 68 59 52 57 45 48 45 55
77 94 179 116 95 51 98 133 67 91
42 94 147 211 189 102 69 97 159 158
190 156 119 72

bseg12
157 201 152 311 292 211 180 124 94 104
123 122 155 145 122 184 142 138 138 134
92 93 152 143 144 90 57 65 72 57
45 69 83 55 48 44 45 53 64 66
55 50 72 63 73 55 76 62 115 91
56 51 46 73

bseg13
316 241 275 333 321 360 311 323 302 160
163 248 232 186 115 131 180 205 216 208

150 134 150 160 191 211 162 209 184 186
203 226 201 204 189 161 93 147 159 195
162 119 212 362 499 520 438 358 348 402
487 391 330 297 250 303 247 252 287 259
249 301 180 212 282 233 218 249 178 246

bseg14
435 469 403 476 448 369 206 94 81 74
77 116 132 159 199 162 138 147 136 122
136 192 145 108 119 118 99 164 215 108
76 105 120 141 204 164 124 111 95 139
160 136 75 75 49 33 48 74 54 42
52 53 79 99 131 100 96 97 122 129
119 121 114 117 176 162 157 118 100 191
228 127 134 127 112 82 123 96 105 113
96 151 185 133

bseg15
113 155 247 304 227 330 462 464 287 328
366 349 319 191 286 164 218 374 225 223
217 129 178 274 197 199 210 179 245 224
145 122 123 168 172 217 222 141 194 166
134

bseg16
393 147 56 85 100 161 141 155 171 194
167 150 159 149 153 112 143 215 149 122
137 118 104 134 180 90 97 115 141 181
255 237 159 115 82 133 143 118 74 56
46 32 30 30 37 28 22 31 46 61
104 129 127 101 178 216 94 93 61 39
56 75 124 100 99 144 182 91 124 140
132 75 105 86 82 91 77 136 158 139

bseg17
427 182 133 116 138 140 284 248 214 276
333 114 56 67 66 71 48 79 113 136
89 144 181 211 166 140 187 128 89 57
66 53 46 52 54 73 87 80 101 117
69 82 93 109 105 117 88 59 69 96
112 92 70 49 59 53 73 69 68 45
36 59 68 104 147 92 80 88 98 111
88 97 80 75 117 141 130 76 71 118

bseg18
414 313 316 312 359 456 387 298 186 230
283 237 207 298 255 202 388 185 305 292
316 311 221 123 115 130 107 215 248 227
197 223 241 187 240 192 154 190 184 122
89 103

bseg19
36 34 67 54 50 54 73 79 125 65

80 90 40 65 107 110 74 82 76 76
54 35 33 37 25 30 66 129 76 83
115 94 108 70 90 83 47 54 66 103
110 99 89 103 111 99 102 87 42 58
62 100 114 121 88 70 68 82 97 116
79 86 80 74 78 94 87 73 66 99
93 141 139 138 112 87 163 175 123 133
112 88 145 160 183

bseg20i
314 86 93 187 119 146 144 302 169 457
366 334 343 121 101 69 71 91 178 166
101 234 154 104 206 243 264 315 187 237
161 84 71 158 214 192 255 210 178 170
134 145 128 58 42 44 57

bseg20ii
49 51 57 54 27 26 26 27 54 73
63 50 35 56 76 71 106 126 164 56
29 32 51 46 40 38 65 83 139 216
216 233 113 267 386 122 123 75 87 178
229 263 153 172 251 408 248 290 372 159
173 264 148 161 242 209

bseg21
391 446 290 125 101 109 114 140 166 166
88 50 40 81 94 146 132 119 173 192
207 150 114 87 114 135 56 111 110 72
71 115 137 147 194 209 118 247 148 165
145 92 84 126 85 117 113 95 174 146
150 95 99 105 114 187 166 142 133 175
138 168 127

bseg22
85 80 96 204 295 227 109 102 161 144
272 257 245 175 205 226 337 419 442 322
279 179 194 171 221 224 233 120 101 101
94 89 71 62 55 67 89 129 150 112
161 111 126 264 103 130 167 215 286 208
94 101 67 98 150 110 187 142 290 247
232 97 186 264 112 177 122 94 111 71
126

bseg23
538 345 352 360 275 236 166 207 156 283
184 178 215 220 200 154 170 146 146 89
95 126 145 125 129 136 133 126 71 109
95 67 64 121 82 75 101 92 86 155
200 236 191 156 172 149 198 211 236 198
183 142 131 147 99 69 54 71 59 49
40 35 29 27 31 37 51 83 65 71
36 59 83 85 87 81 66 79 97 115
62

bseg24

124	112	97	98	144	243	148	158	203	126
127	155	215	108	67	71	88	88	186	244
197	206	149	234	243	330	405	371	349	254
154	190	179	85	98	113	77	82	88	70
68	73	56	53	69	85	119	170	148	114
91	139	154	102	76	96	74	111	137	96
74	56	90	108	106	163	98	60	64	69
46									

bseg25

205	115	113	193	220	213	238	137	119	144
134	108	202	236	214	188	242	189	139	122
184	175	123	140	157	105	98	98	174	176
147	112	184	86	98	137	217	165	117	122
88	121	128	112	93	105	99	61	62	63
79	61	44	82	98	105				

bseg26

122	124	201	212	214	210	211	65	61	65
61	60	41	88	84	67	88	124	96	121
93	118	117	89	73	113	129	89	118	172
101	57	72	50	43	56	43	36	45	52
42	61	108	82	110	95	123	132	289	431

bsegdr1

178	167	165	152	165	145	128	155	133	159
195	170	157	163	145	160	153	174	136	117
154	131	160	155	186	155	117	146	156	160
121	100	133	141	110	125	121	140	117	120
147	146	140	157	138	167	156	163	136	144
133	113	120	124	142	144	162	140	152	143
124	164	139	117	158	145	122	111	105	141
131	154	128	127	117	121	140	139	125	95
140	191	149	137	133	106	131	143	139	148
123	136	167	156	130	106	95	114	131	128
117	85	112	169	147	155	196	135	143	154
148	163	184	166	126	131	129	116	103	103
114	109	98	92	108	117	140	104	107	104
109	107	100	95	93	109	104	106	97	78
95	88	89	105	101	121	107	99	96	95
109	73	97	92	88	87	114	109	107	99
109	89	86	102	114	123	122	108	135	106
123	134	135	123	114	134	122	142	131	134
103	124	132	100	108	81	86	73	111	116
118	118	140	108	116	126	152	145	126	109
122	111	130	137	135	139	151	119	123	102
92	127	106	100	100	121	117	116	129	150
144	134	148	149	128	110	124	119	139	116
148	155	152	145	178	199	176	140	134	163
163	157	144	196						

bsegdr2

228	253	246	242	227	151	105	111	202	130
134	77	44	47	90	189	219	197	173	228
222	205	222	167	89	94	72	81	155	125
190	298	228	167	133	145	177	104	157	145
260	214	188	252	233	326	198	199	185	187
162	252	255	254	247	282	154	140	327	333
349	271	138	147	143	113	168	123	129	178
160	121	85	102	145	65	52	57	87	141
82	146	136	93	60	84	70	55	38	38
37	38	44	49	52	49	72	98	88	94
110	92	67	81	67	111	156	170	167	126
85	87	119	130	87	141	116	193	165	118
105	151	84	194	180	212	164	125	125	89
133	154	203	149	172	194	177	150	89	181
165	164	75	165	204	101	100	107	195	200
224	162	156	158	154	184	143	105	151	

bsegdr3i

165	230	204	181	137	148	106	56	65	52
50	57	106	122	102	92	115	114	96	130
135	129	123	128	108	135	107	102	98	146
132	122	111	129	140	112	69	77	78	92
132	133	142	125	145	139	119	96	116	111
90	97	76	60	80	87	111	104	116	123
91	81	99	100	96	94	99	82	86	70
77	78	79							

bsegdr3ii

74	92	75	62	63	54	60	47	60	72
75	94	63	48	50	71	99	99	72	82
63	83	114	111	89	68	75	54		

bsegdr3iii

66	92	90	99	114	144	143	128	125	114
135	155	135	113	87	128	100	103	107	135
128	104	141	113	95	91	66	67	76	75
58	94	64	86	72	76	85	60	82	62
87	72	71	57	65	61	50	58	50	57
63	76	49	79	86	92	88	96	77	87
82	93	93	96	108	80	94	91	73	72
70	88	96	73	88	92	81	97	96	85
87	105	115	144	167	134	192	133	117	

bsegdr4i

76	70	43	40	28	61	79	49	47	68
60	68	62	89	97	129	63	113	143	141
99	103	148	84	104	61	84	100		

bsegdr4ii

99	160	217	146	118	101	181	144	121	140
154	202	173	149	115	101	155	143	147	108
137	172	183	145	231	149	264	125	159	220

305 245 158 140 123 140 127 203 113 165
186 140 168 140 114 109 74 56 105 163
234 134 219 253 219 107 181 154 152 115
143 87 85 152 138 167 177 253 254 171
149 257 202 184 262 124 115 140 114 251
188 164 155 129 135 79 135 109 186 122
126 74 98 87 108

bsegdr5i
201 231 162 180 192 113 136 177 97 116
155 208 168 160 136 159 165 169 137 127
97 113 104 119 184 162 148 141 150 158
143 133 143 143 137 131 88 88 153 196
192 146 170 182 149 129 180 177 190 205
181 185 155 172 96 150 189 191 173 119
153 199 131 162 199 157 208 115 126 220
147 97 104 103 141 208 199 183 168 148
117 179 176 193 131 97 121 195 192 205
197 170 298 282 294 223 290 361 228 185
135 193 141 153 153 170 188 220 236 199
236 313 202

bsegdr5ii
154 161 143 210 244 260 220 296 234 204
144 181 131 141 205 216 209 236 198 219
221 315 234

bsegdr6
253 267 324 298 178 121 197 189 218 233
169 184 137 192 228 177 238 251 286 249
275 239 307 214 146 232 221 219 183 199
219 168 181 168 171 208 230 246 168 160
137 175 214 173 173 204 194 197 199 234
201 177 150 176 135 145 161 146 170 210
143 167 132 196 188 138 148 147 169 166
159 141 169 165 154 147 118 168 147 152
160 169 185 296 162 131 158 156 138 158
141 137 148 146 153 117 146 154 121 134
139 121 162 137 88 100 128 119 123 117
153 141 132 127 137 106 94 112 132 97
135 105 95 119 123 142 141 157 149 156
164 130 117 124 137 135 135 124 138 139
163 176 159 177 138 170 143 144 127 141
114 101 153 137 142 141 142 144 154 132
124 98 121 116 102 97 71 78 91 93
98 120 115 110 112 133 133 131 110 118
86 89 80 103 93

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