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Bear Steps Complex 8–15 St Alkmond's Place Shrewsbury Shropshire

Tree-ring Analysis of Timbers

D W H Miles

Discovery, Innovation and Science in the Historic Environment



Front Cover: Bear Steps complex. Photo kindly provided by Sula Baugh.

**BEAR STEPS COMPLEX
8–15 ST ALKMOND'S PLACE
SHREWSBURY
SHROPSHIRE**

TREE-RING ANALYSIS OF TIMBERS

D W H Miles

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SUMMARY

Twenty-seven tree-ring samples were taken from 23 timbers from four phases at the Bear Steps Complex (St Alkmund's Square, 12 Fish Street, 12a Butcher Row), Shrewsbury. Two site chronologies were produced, spanning the years AD 1224–1358 and AD 1478–1607, the latter of which is well replicated. A precise felling date of winter AD 1358/9 was obtained for 12 Fish Street and 12a Butcher Row, identifying it as one of the earliest examples of fully-developed cusping in Shropshire. It also had a splayed and tabled scarf joint in the collar purlin. Whilst dendrochronology failed to date the Bear Steps Hall itself, felling dates of AD 1576/7 and AD 1607/8 marked its westward extension. Finally, felling dates of AD 1601 marked the construction of 'The Orrel'.

CONTRIBUTORS

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CONTENTS

Introduction and Objectives.....	1
Methodology	1
Results	2
Phase 1: 12 Fish Street and 12a Butcher Row	3
Phase 2: Bear Steps Hall	3
Phase 3: Bear Steps Gallery	4
Phase 4: The Orrel.....	5
Conclusions.....	5
References.....	7
Tables	9
Figures	13
Appendix.....	24

INTRODUCTION AND OBJECTIVES

The Grade II* listed Bear Steps complex, Shrewsbury (Figs 1–3), occupying a strategic position in the centre of the town adjacent to St Alkmund's Square, is a development consisting of one long jettied range, which originally looked out over the churchyard and market-place. Phase 1 is a range on the corner of Fish Street and Butcher Row, which incorporates a crown-post roof with cusped longitudinal braces. Cusping also occurs on the quatrefoil panels of the framing above the jetty, suggesting a date after *c* AD 1400. Phase 2 saw the addition of an unjettied open hall (Bear Steps Hall) set tightly against the jettied front of the earlier building, thus obliterating its outlook. The Hall also has a crown-post roof construction, but of a plainer form. Sometime later, the Phase 3 extension towards Fish Street was constructed with a side-purlin and windbraced roof, with a western external gallery added to overlook Fish Street. Phase 4 is the block known as 'The Orrel' which incorporates shops at two levels with chambers above, and is reminiscent of the Chester Rows in basic design. It is thought to be known as the 'Orrel' because it formed the entrance to what was then the town centre. 'The Orrel' is linked to the Phase 3 extension to Bear Steps Hall through a small stone-built block, which contains a fireplace with sixteenth-century moulding. In the early 1960s Bear Steps Hall and 'The Orrel' were restored by F W B Charles. Further details of the buildings can be found in Moran and Miller (1982) and Charles (1984).

The primary objective was to date the four main phases of the complex in order to pinpoint when this area of Shrewsbury was developed. Dates for both the crown-post roofs would, in addition, allow them to be fitted within a typological framework, as with the cusped decoration in 12 Fish Street and 12a Butcher Row.

METHODOLOGY

All samples were of oak (*Quercus spp*) from what appeared to be primary first-use timbers, or any timbers which might have been reused from an early phase. Those timbers which looked most suitable for dendrochronological purposes with complete sapwood or reasonably long ring sequences were selected. Samples with less than 40 rings are usually rejected, unless they are either from duplicate cores or the outer sections of a longer core in which case they may be included in the analysis as appropriate. *In situ* timbers were sampled through coring, using a 16mm hollow auger. The timbers sampled are shown on the ground-floor, first-floor, and attic plans (Figs 4–7).

The samples were sanded on a linisher using 60 to 1200 grit abrasive paper, and were cleaned with compressed air, to allow the ring boundaries to be clearly distinguished. They were then measured under a x10/x30 microscope using a travelling stage electronically displaying displacement to a precision of 0.01mm.

After measurement, the ring-width series for each sample was plotted as a graph of width against year on log-linear graph paper. The graphs of each of the samples in the phase

under study are then compared visually at the positions indicated by the computer matching and, if found satisfactory and consistent, are averaged to form a mean curve for the site or phase. This mean curve and any unmatched individual sequences are compared against dated reference chronologies to obtain an absolute calendar date for each sequence.

Here, this was accomplished by using a combination of both visual matching and a process of qualified statistical comparison by computer. The samples were first matched visually, and then independently matched by computer. The ring-width series were compared on an IBM compatible 486SX computer for statistical cross-matching using a variant of the Belfast CROS program (Baillie and Pilcher 1973). A version of this, and other programmes, were written in BASIC by D Haddon-Reece, and subsequently re-written in Microsoft Visual Basic by M R Allwright and P A Parker with the original bar diagram graphics software being written by M R Coome.

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 straight forward. Depending on the completeness of the final ring, ie if it has only the spring vessels or earlywood 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 a statistically derived sapwood estimate with a given confidence limit. A review of the geographical distribution of dated sapwood data from historic building timbers has shown that a 95% range of 11–41 rings is appropriate for Wales and the Border Counties (Miles 1997) and will be used throughout this report. 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.

Some caution must be used in interpreting solitary precise felling dates. Many instances have been noted where timbers used in the same structural phase have been felled one, two, or more years apart. Wherever possible, a group of precise felling dates should be used as a more reliable indication of the construction period. 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 under study. However, it is common practice to build timber-framed structures with green or unseasoned timber and that construction usually took place within twelve months of felling (Miles 1997).

RESULTS

All samples were numbered in order of sampling, which for various logistical reasons did not entirely accord with the assumed phasing, and were designated bs1, bs2, etc. Sampling was carried out in two phases in 1997, samples bs1–bs17 being extracted during the first

session, which were then analysed, then a second session of sampling was undertaken to core selectively where results were less satisfactory. Samples bs18–bs23 were obtained during this second visit. Details of each sample, including date, number of rings, sapwood complement, location, and other characteristics are summarised in Table 1, and scale section drawings of each timber are shown in Figure 8. The dated samples aligned in chronological position are shown in Figure 9 using Tyers (2004).

Phase 1: 12 Fish Street and 12a Butcher Row

Six timbers were sampled from this range. The first three samples (bs15, bs16, bs17) taken on the initial sampling visit were analysed and bs16 was found to date against the reference chronologies at AD 1329. This was from a longitudinal crown brace with only the heartwood/sapwood transition remaining. Therefore a felling date range of AD 1340–1370 was given.

During the second visit particular attention was given to sampling timbers with complete sapwood. A common rafter (bs20) and a transverse crown brace (bs21) both retained complete sapwood, although a second core was taken from the latter to ensure a good replicated sequence. A crown post (bs22) had the appearance of complete sapwood under the thick accumulation of black paint, but on extracting the core it was discovered to be only a heartwood/sapwood boundary and, as it contained only 29 rings, it was rejected from further analysis.

Although sample bs20 from the common rafter had complete sapwood, it contained only 45 rings and failed to match any of the other samples from the site.

Sample bs21a had an unbroken sequence of 105 rings and complete sapwood. The second core from this timber ran into a fault and produced two sequences, bs21bi, and bs21bii, again with complete sapwood. These matched bs21a with t -values of 11.84 and 7.42 respectively, and were combined to form a mean timber sequence, bs21. This mean was compared with the previously dated bs16 and matched with a t -value of 7.36, spanning the years AD 1254–1358. The two samples were then combined to form the site master BEARSTP1 of 135 rings and the dating again checked with the reference chronologies (Table 2). As sample bs21 had complete sapwood with a full final ring, a precise felling date of winter AD 1358/9 was given.

No matches, either with the other samples or with the reference chronologies, were found for samples bs15, bs17, or bs20.

Phase 2: Bear Steps Hall

Very little original timber survived in the Hall, most having been renewed or replaced during the recent restoration. During the first sampling visit, four timbers were sampled

with scaffolding access: bs9 and bs10 from the longitudinal and transverse crown braces respectively, bs11 from the collar purlin, and bs12 from the south principal rafter of the east end truss. During the initial analysis stage, bs11 failed to match on account of having only 43 rings. Sample bs12, despite having 58 rings (bs12a) plus another 13½ rings (bs12b) of detached complete sapwood, failed to match any of the other samples or the reference chronologies. Sample bs9 had 131 rings and bs10 had 122 rings, both with complete sapwood. These two were compared and were found to match with a *t*-value of 5.70, and were combined to form the mean bs910 of 131 rings. Surprisingly, despite being replicated and having over 100 rings, no matches were found with the reference chronologies or the other site masters, either individually or together.

During the second visit, a tiebeam was sampled, with five rings of sapwood (bs23). This produced a sequence of 113 rings, but again this failed to match conclusively with any of the other samples, site masters, or reference chronologies. All other remaining timbers which were accessible were assessed, and did not appear to have a sufficient number of rings to be suitable for dendrochronology. However, should the suspended gallery lighting ever require replacement in the future, then there might be some scope in gaining access to the lower sections of the end trusses, and it is possible some of those principal timbers may prove suitable.

Phase 3: Bear Steps Gallery

Very few of the timbers comprising bay 4, or the external balcony, appeared suitable for dendrochronology. However, four timbers were sampled: the south purlin, bs13, had 84 rings including complete sapwood; the axial beam to the floor (bs14) was cored twice to obtain a complete sequence to the bark edge; the two individual radii bs14a and bs14b were successfully compared and were found to match with a *t*-value of 7.77 and were combined to form the 121-ring mean bs14 with complete sapwood; bs18 and bs19 were from the balcony posts containing 79 and 115 rings respectively, one with the heartwood/sapwood boundary and the other with 31 rings of incomplete sapwood.

None of the four samples matched each other, but samples bs13 and bs14 matched against the reference chronologies, as well as with the samples from phase 4 below (Table 3). The south purlin (bs13) dated to span the years AD 1493–1576, and gave a precise felling date of winter AD 1576/7, and the axial beam (bs14) dated to span the years AD 1487–1607 and gave a precise date of winter AD 1607/8. Sample bs19 from the balcony matched individually with the reference chronologies and dated, spanning the years AD 1452–1566 (Table 4). As there remained 31 rings of sapwood, an estimated felling date range of AD 1567–1576 was obtained. Sample bs18 failed to match any of the other samples, site masters, or reference chronologies.

Phase 4: The Orrel

Few suitable timbers remained at ground-floor level, and much of the first-floor level had been damaged by a fire in the past. However, samples were taken from eight timbers from the upper storey and roof of this range. The west principal rafter to Truss 2 (bs1) was cored twice, sample bs1a having incomplete sapwood, with about 10–15mm lost to the bark edge, and sample bs1b having sapwood complete to the bark edge. The two samples were compared visually and successfully matched and were therefore combined to form the mean bs1.

Five samples were found to match (Table 3), all of them with complete sapwood. These were combined, along with samples bs13 and bs14 from the Phase 3 Gallery extension, to form the 130-ring site master BEARSTP2. This matched against the reference chronologies to span the years AD 1478–1607 (Table 5).

Of the timbers which dated, samples bs3, bs4, and bs7 all had last measured rings dating to AD 1600, plus some spring growth for the following year, thereby giving precise felling dates of spring AD 1601. The last measured ring of sample bs5 was full and complete and dated to AD 1600 giving a precise felling date of winter AD 1600/1, where as the last measured ring date of sample bs1 dated to AD 1599 with some spring growth for the following year, thereby giving a precise felling date of spring AD 1600.

Samples bs2, bs6, and bs8 all failed to date, despite the latter having 115 rings.

CONCLUSIONS

Three main phases of building have been dated by dendrochronology. The earliest is 12 Fish Street\12a Butcher Row where two samples dated. Although the estimated felling date range of AD 1340–1370 for the first sample is consistent with the precise felling date of AD 1358/9 given by the second sample, caution should be used in interpreting this as the building date as only two timbers have been dated. Nevertheless, this has identified the building as having one of the earliest fully-developed examples of cusping in Shropshire. The collar purlin also had a fine example of a splayed and tabled scarf. This has also contributed useful chronology-building material as very few buildings dating from the fourteenth century have been identified and dated in Shropshire.

Whilst dendrochronology failed to date the Bear Steps Hall itself, structurally it had to postdate the AD 1358/9 building whose jettied outlook it obscured, and to predate the westward extension of the Hall which has two felling dates of AD 1576/7 and AD 1607/8 associated with it. Reconciling these two dates for the Phase 3 gallery and balcony are not straightforward, for the earlier date is supported by the felling date range of AD 1567–1576 from one of the principal posts of the gallery balcony, which obviously could not predate the building to which it was attached. Either most of the gallery extension of the hall was constructed out of second-hand timbers, of which the two late sixteenth-century

dates relate, and the axial beam actually identifies the real building date of *circa* AD 1607/8, or, the axial beam is an insertion some 30 years after the construction of the rest of the gallery extension. Further structural analysis of the building will be needed to resolve this conflict. No other samples with sapwood suitable for dendrochronology were noted in the gallery or balcony extension. Fortunately, no such uncertainties apply to The Orrel, where multiple felling dates ranging from spring AD 1600 to spring AD 1601 clearly identify the timber as having been felled for the construction of that particular structure, and as such a building date of summer AD 1601 or shortly thereafter is suggested.

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TABLES

Table 1: Details of the samples from the Bear Steps complex, Shrewsbury, Shropshire

Sample number		Timber and position	Dates spanning (AD)	H/S bdry	Sapwood	No of rings	Mean ring width (mm)	Std devn (mm)	Mean sens (mm)	Felling seasons and dates/date ranges (AD)
Phase 1: 12 Fish Street / 12a Butcher Row										
bs15	c	South-west corner post 12 Fish St	-		14	52	4.24	1.78	0.269	
bs16	c	West crown brace 12 Fish St	1224–1329	1329	h/s	106	1.46	0.51	0.238	1340–1370
bs17	c	1st floor transverse beam T2	-		5	44	1.88	1.37	0.184	
bs20	c	East rafter N dormer bay 2, No. 12a Butcher Row	-		22¼C	45	1.49	0.68	0.187	
bs21a	c	North crown brace T2	1254–1358	1337	21C	105	0.92	0.45	0.207	Winter 1358/9
bs21b1	c	ditto	1271–1324			54	1.20	0.57	0.209	
bs21b2	c	ditto	1326–1358	1337	21C	33	0.59	0.33	0.241	Winter 1358/9
bs21		Mean of bs21a & bs21b1 and bs21b2	1254–1358	1337	21C	105	0.98	0.49	0.202	Winter 1358/9
bs22	c	Crown post T2	-		h/s	29	5.07	0.95	0.150	
<i>BEARSTPI</i>		<i>Mean of bs16 and bs21a</i>	<i>1224–1358</i>			<i>135</i>	<i>0.82</i>	<i>0.85</i>	<i>0.305</i>	
Phase 2: Bear Steps Hall										
bs9	c	East crown brace open truss bay 2	-		19C	131	1.11	0.71	0.193	
bs10	c	North crown brace open truss	-		15¼C	122	0.93	0.30	0.196	
bs11	c	Collar purlin bay 2	-		7	43	1.48	0.42	0.191	
bs12a	c	South principal rafter east end truss	-		h/s	58	1.56	0.43	0.210	
bs12b	c	ditto	-		13¼C	13	1.87	0.68	0.336	
bs23	c	Tiebeam west end truss	-		5	113	1.70	0.78	0.235	
<i>bs910</i>		<i>Mean of bs9 and bs10</i>				<i>131</i>	<i>1.07</i>	<i>0.63</i>	<i>0.153</i>	
Phase 3: Bear Steps Gallery (bay 4)										
bs13	c	South purlin	1493–1576	1553	23C	84	1.69	0.83	0.239	Winter 1576/7
bs14a	c	Axial beam	1487–1575			89	1.18	0.50	0.187	
bs14b	c	ditto	1487–1607	1578	29C	121	1.11	0.47	0.192	
bs14		mean of bs14a and bs14b	1487–1607	1578	29C	121	1.08	0.46	0.183	Winter 1607/8

Table 1: (cont)

Sample number		Timber and position	Dates spanning (AD)	H/S bdry	Sapwood	No of rings	Mean ring width (mm)	Std devn (mm)	Mean sens (mm)	Felling seasons and dates/date ranges (AD)
bs18	c	South-west corner post to Balcony	-		h/s	79	2.27	1.25	0.185	
bs19	c	Centre post to Balcony	1452-1566	1535	31	115	1.67	0.61	0.173	1567-1576
Phase 4: The Orrel										
bs1a	c	West principal rafter T2	1517-1594	1582	12	78	1.88	0.45	0.198	1595-1623
1b	c	ditto	1571-1599	1583	16¼C	29	1.68	0.31	0.133	
bs1		Mean of 1a and 1b	1517-1599	1583	16¼C	83	1.85	0.45	0.191	Spring 1600
bs2	c	2nd rafter S of T3, west side, bay 2	-		21¼C	79	1.24	0.38	0.178	
bs3	c	1st rafter S of T3, west side, bay 2	1478-1600	1570	30¼C	123	0.77	0.27	0.214	Spring 1601
bs4	c	West upper purlin bay 3	1508-1600	1587	13¼C	93	1.57	0.56	0.178	Spring 1601
bs5	c	East upper purlin bay 3	1489-1600	1587	13C	112	1.54	0.87	0.187	Winter 1600/1
bs6	c	Rail T3	-		26C	66	1.30	0.46	0.220	
bs7	c	East lower purlin bay 3	1485-1600	1587	13¼C	116	1.75	0.97	0.211	Spring 1601
bs8	c	Tiebeam T3			22¼C	115	1.24	0.50	0.234	
BEARSTP2		Mean of bs1, bs3, bs4, bs5, bs7, bs13, and bs14	1478-1607			130	1.42	0.52	0.169	

Key:

c = core

¼C, C = bark edge present, partial or complete ring

¼C = spring felled (ring not measured)

C = winter felled (ring measured)

H/S bdry = heartwood/sapwood boundary - last heartwood ring date

std devn = standard deviation

mean sens = mean sensitivity

Table 2: Dating of BEARSTP1 against reference chronologies at an end date of AD 1358

Reference chronology	Spanning	Overlap	t-value
STOKE2 (Miles and Worthington 1997)	1046–1289	66	6.25
STMRI245 (Miles and Bridge 2014)	1208–1323	100	6.18
PLOWDENI (Miles and Haddon-Reece 1993)	977–1301	78	6.15
LUDLOW5 (Miles and Haddon-Reece 1995)	1175–1358	135	5.88
HERE20C (Tyers 1996)	1174–1317	94	5.30
WGATEI (Tyers and Wilson 2000)	1209–1518	135	5.18
BEVERLEY (Hillam 1981)	858–1310	87	4.87
ASTNEYRI (Miles and Worthington 1998)	1230–1335	106	4.85

Table 3: t-values and overlaps for components of BEARSTP2. Note that t-values of 3.5 or over are considered significant

Sample:	bs1	bs3	bs4	bs5	bs7	bs13	bs14
end date (AD):	1599	1600	1600	1600	1600	1576	1607
bs1		<u>4.28</u>	<u>5.75</u>	<u>4.04</u>	<u>3.38</u>	<u>7.25</u>	<u>4.31</u>
		83	83	83	83	60	83
bs3			<u>3.64</u>	<u>3.59</u>	<u>1.95</u>	<u>3.74</u>	<u>4.47</u>
			93	112	116	84	114
bs4				<u>10.40</u>	<u>9.38</u>	<u>5.79</u>	<u>5.15</u>
				93	93	69	93
bs5					<u>8.36</u>	<u>3.00</u>	<u>3.74</u>
					112	84	112
bs7						<u>4.26</u>	<u>5.05</u>
						84	114
bs13							<u>3.70</u>
							84

Table 4: Dating of bs19 against reference chronologies at an end date of AD 1566

Reference chronology	Spanning	Overlap	t-value
OVERTON3 (Miles and Worthington 1997)	1397–1543	92	7.09
BOYES (Bridge 1999)	1470–1553	84	7.02
BAYASQ02 (Arnold and Howard 2006)	1469–1550	82	6.69
SWANHHS (Miles <i>et al</i> /2009)	1386–1628	115	6.63
MCPREES (Miles and Haddon-Reece 1995)	1421–1553	102	6.24
KIMPTON2 (Miles and Worthington 2002)	1417–1558	108	5.92
DISCOEDI (Miles and Worthington 1998)	1375–1535	84	5.69
EXTON (Miles and Haddon-Reece 1995)	1376–1546	95	5.44

Table 5: Dating of BEARSTP2 against reference chronologies at AD 1607

Reference chronology	Spanning	Overlap	t-value
BROOKGT (Miles and Haddon-Reece 1993)	1362–1611	130	8.83
CBMASQ01 (Howard <i>et al</i> /2003)	1371–1564	87	8.43
LANGLEY (Hillam and Groves 1993)	1491–1600	110	8.15
UPLAKE (Miles and Worthington 2000)	1418–1546	69	8.12
BLTCHMNR (Bridge 1983)	1481–1593	113	7.68
WIMPOLE1 (Bridge 1998)	1469–1615	130	7.58
UFTNFLDS (Miles and Bridge 2012)	1270–1588	111	7.57
IGHTFELD (Groves 1997)	1341–1566	89	7.56

FIGURES

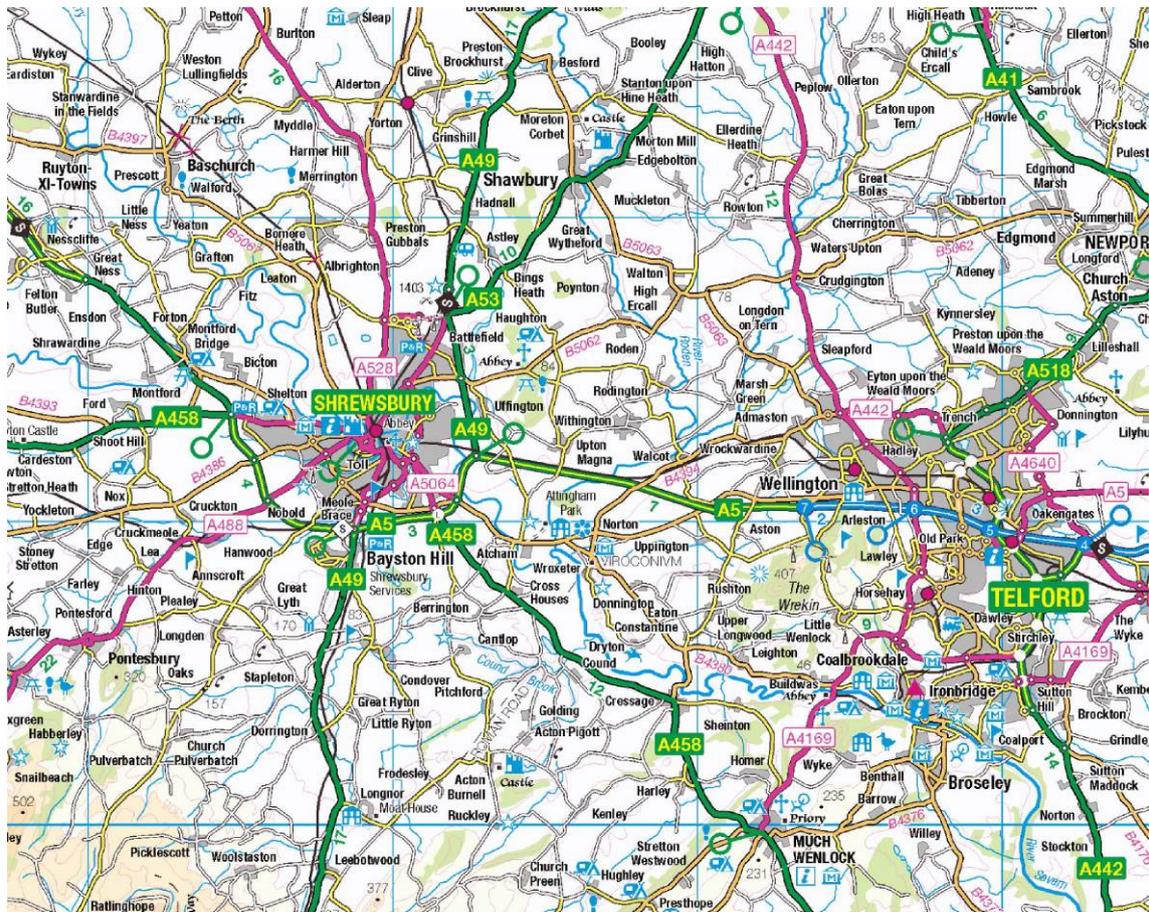


Figure 1a: Map to show the general location of Shrewsbury. © Crown Copyright and database right 2019. All rights reserved. Ordnance Survey Licence number 100024900

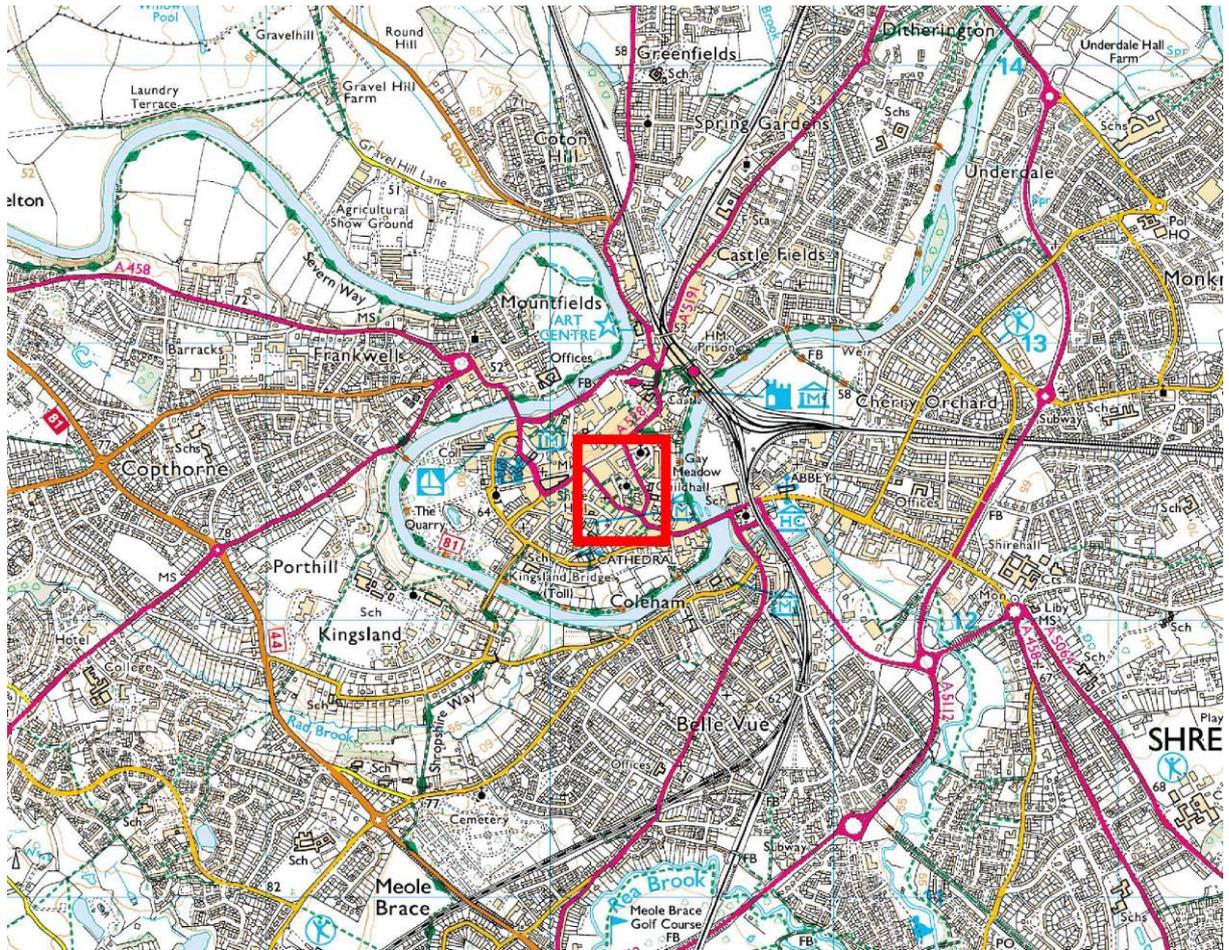


Figure 1b: Map to show the general location of the Bear Steps complex (red rectangle) in Shrewsbury. © Crown Copyright and database right 2019. All rights reserved. Ordnance Survey Licence number 100024900

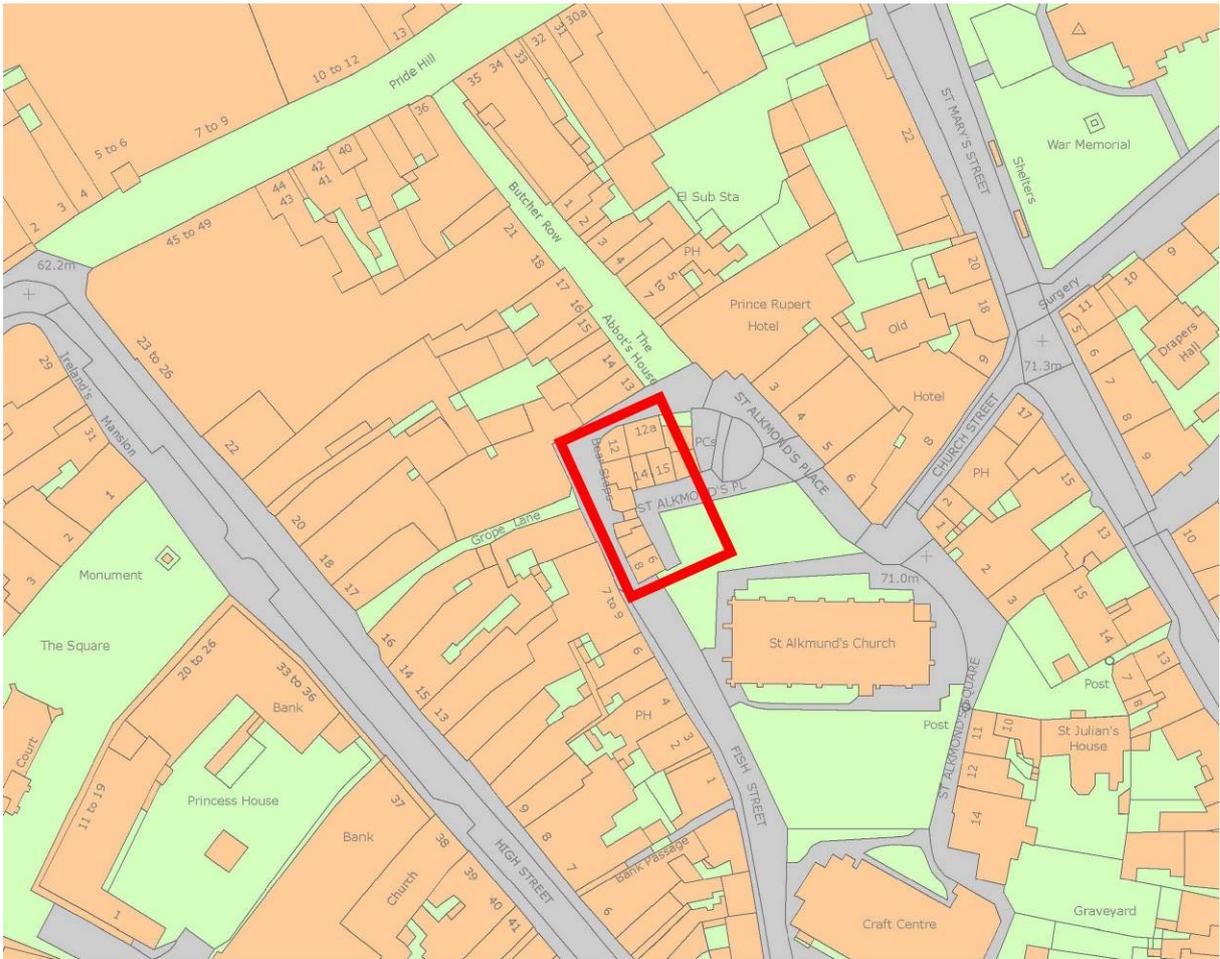


Figure 1c: Map to show the detailed location of the Bear Steps complex (red rectangle) in Shrewsbury. © Crown Copyright and database right 2019. All rights reserved. Ordnance Survey Licence number 100024900



Figure 2: The Bear Steps complex, from the east, with The Orrel on the left and the Bear Steps Hall on the right (photograph Sula Baugh)

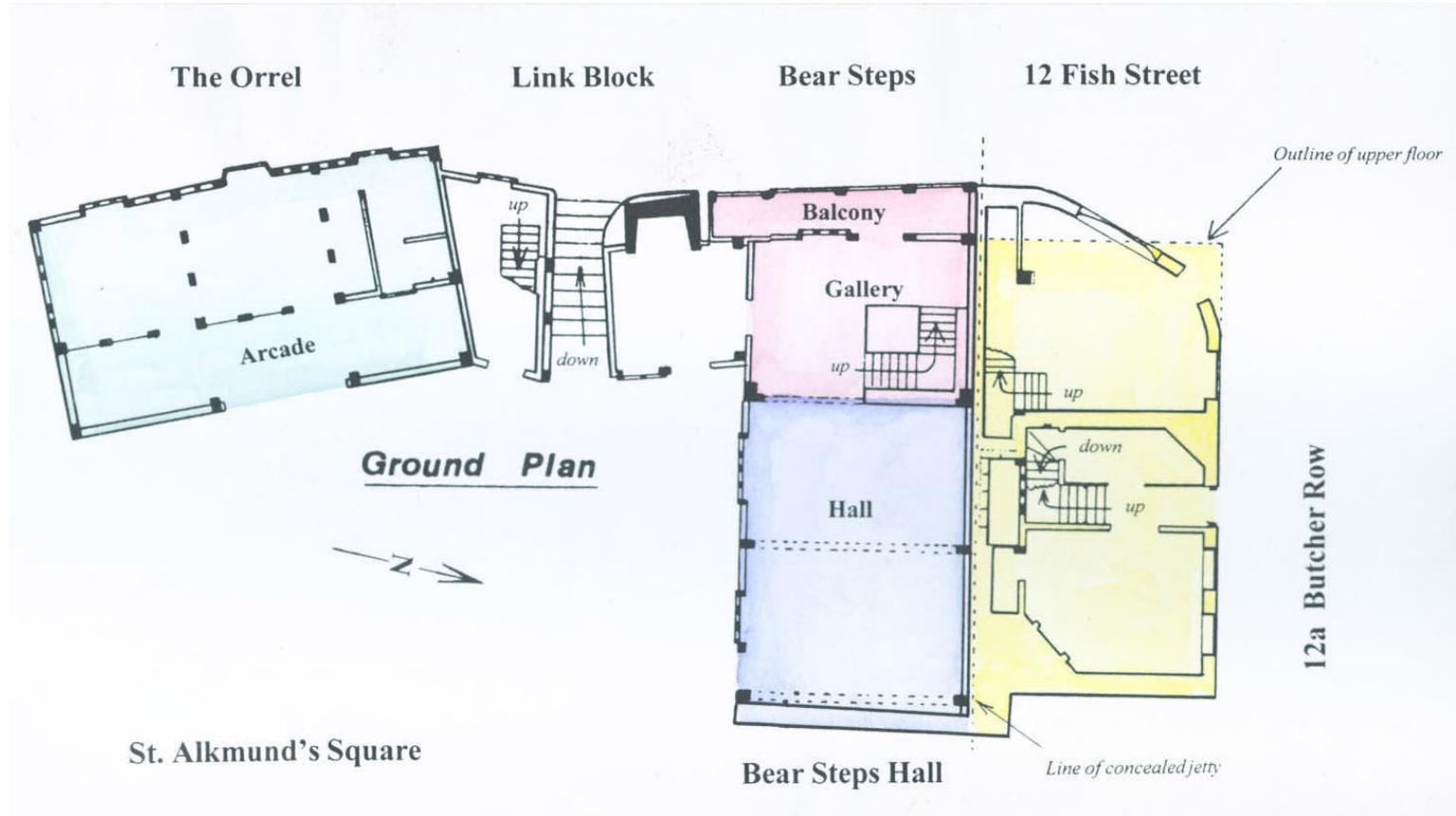


Figure 3: Block plan of Bear Steps complex (after Moran and Miller 1982 and Moran 2003). Phase 1: 12 Fish Street and 12a Butcher Row (Yellow); Phase 2: Bear Steps Hall (Blue); Phase 3: Bear Steps Gallery (Red); Phase 4: The Orrel (Green)

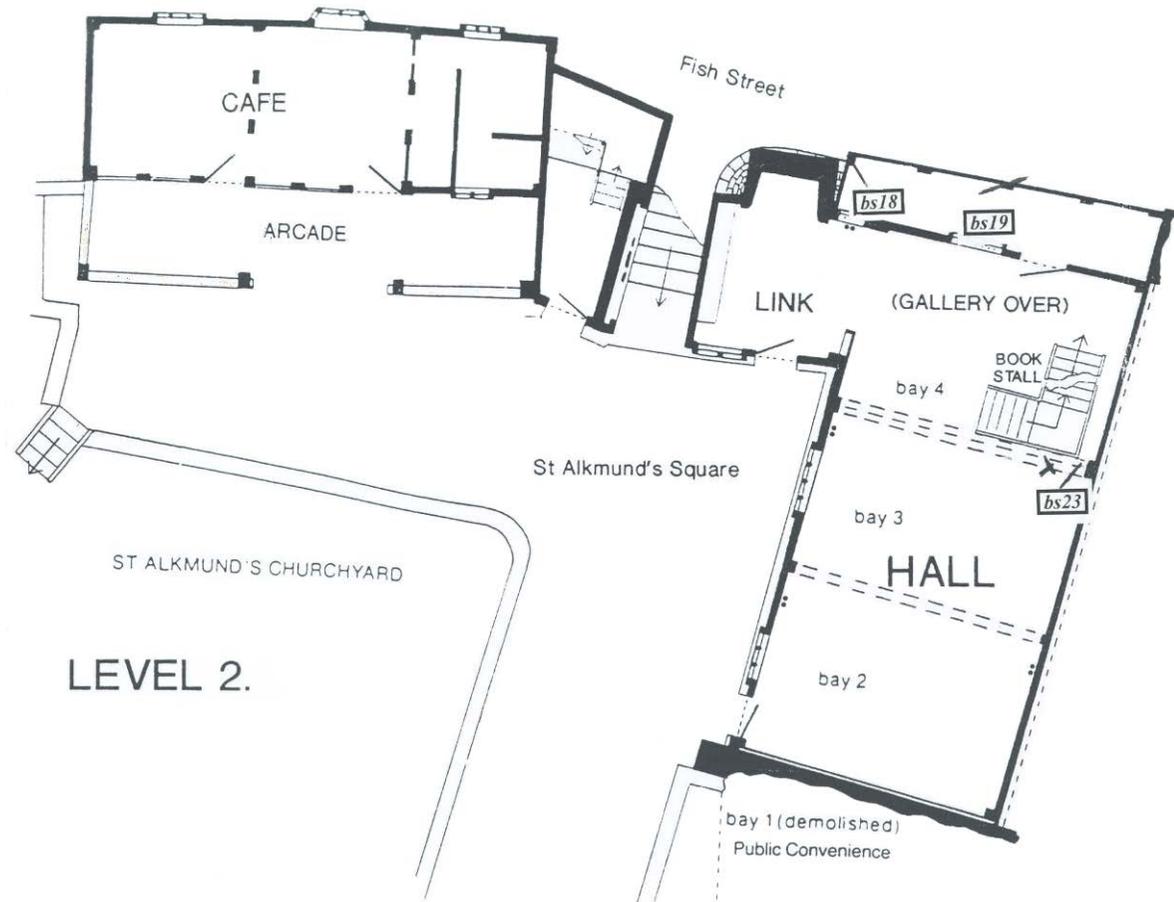


Figure 4: Ground-floor plan, showing the location of timbers sampled in Bear Steps Hall, Gallery, and The Orrel (after Moran 1989 © Shrewsbury Civic Society)

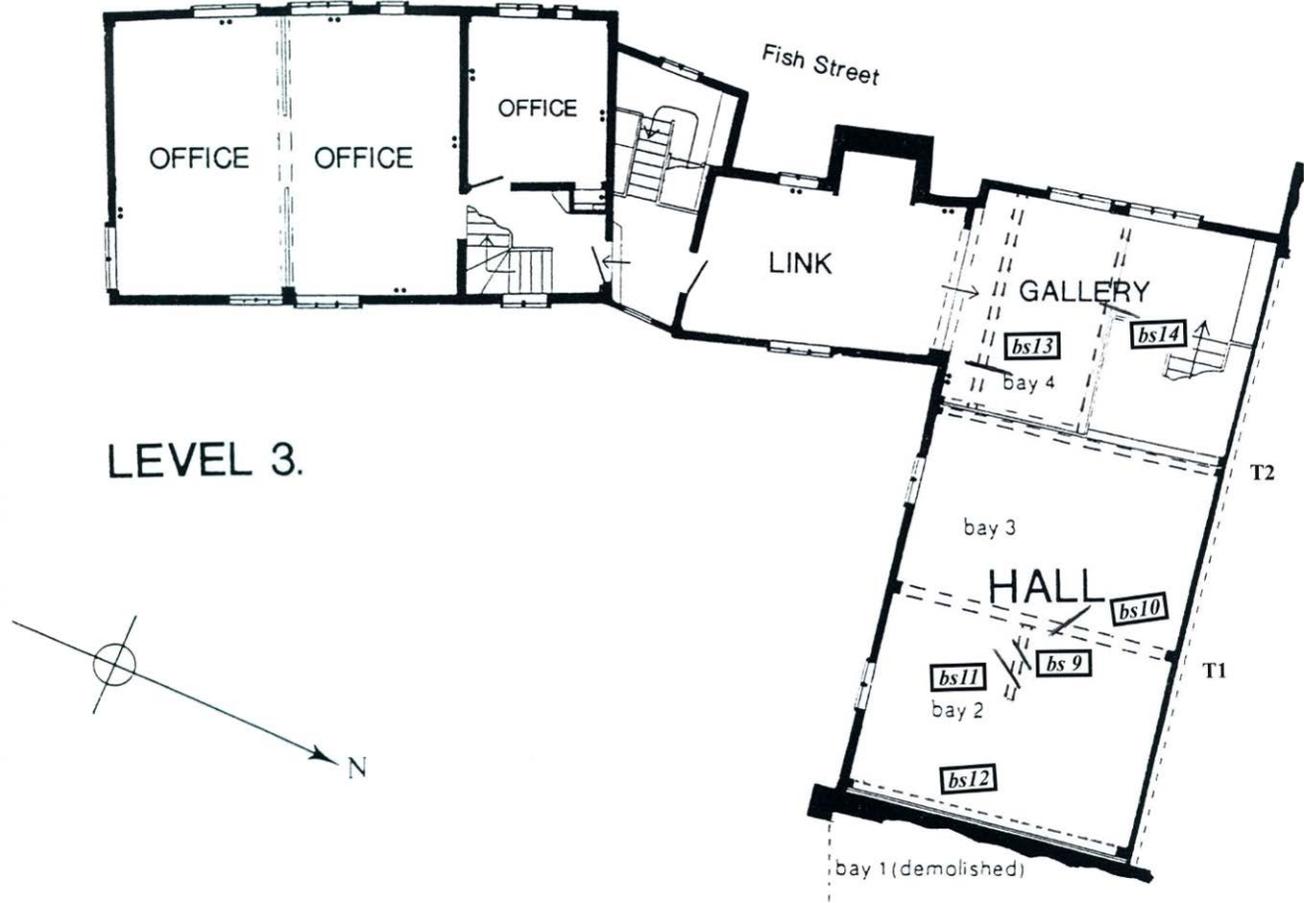
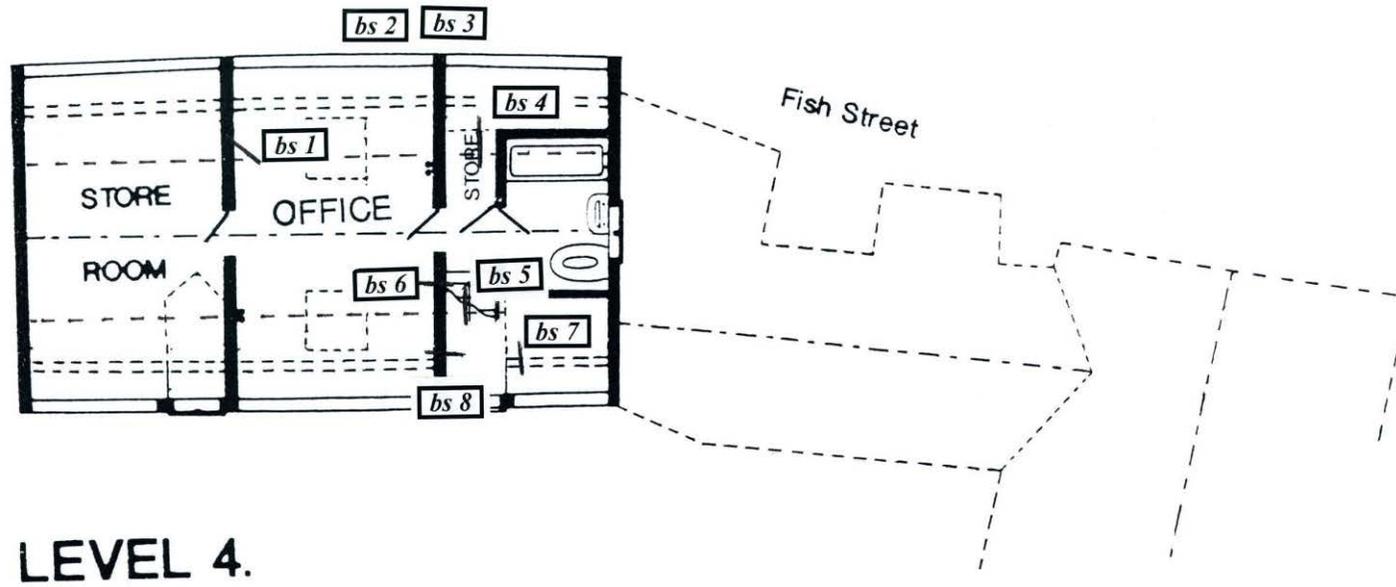
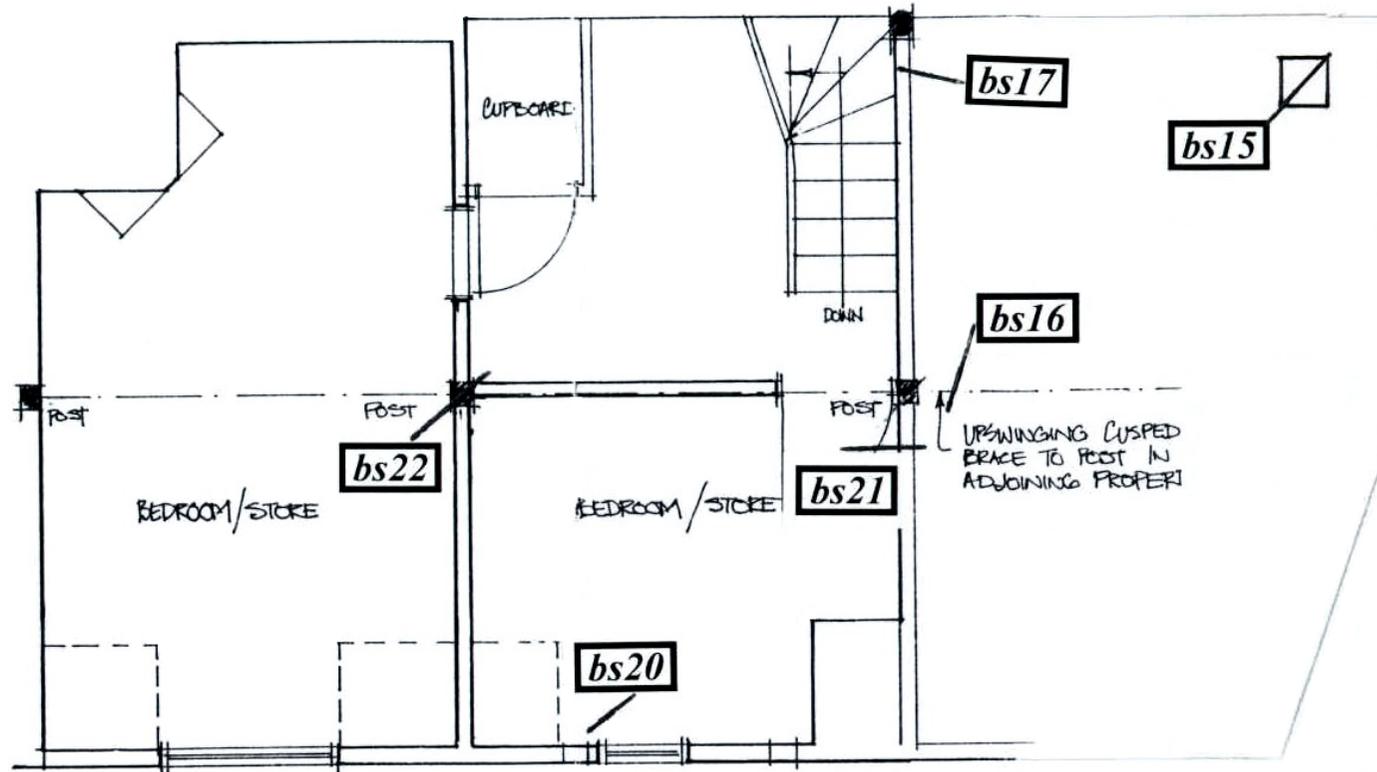


Figure 5: First-floor plan, showing the location of timbers sampled in Bear Steps Hall, Gallery, and The Orrel (after Moran 1989 © Shrewsbury Civic Society)



LEVEL 4.

Figure 6: Second-floor plan, showing the location of timbers sampled in Bear Steps Hall, Gallery, and The Orrel (after Moran 1989 © Shrewsbury Civic Society)



second floor plan

Figure 7: Location of timbers sampled in 12 Fish Street and 12a Butcher Row (after Pooks Chartered Building Surveyors 1994)

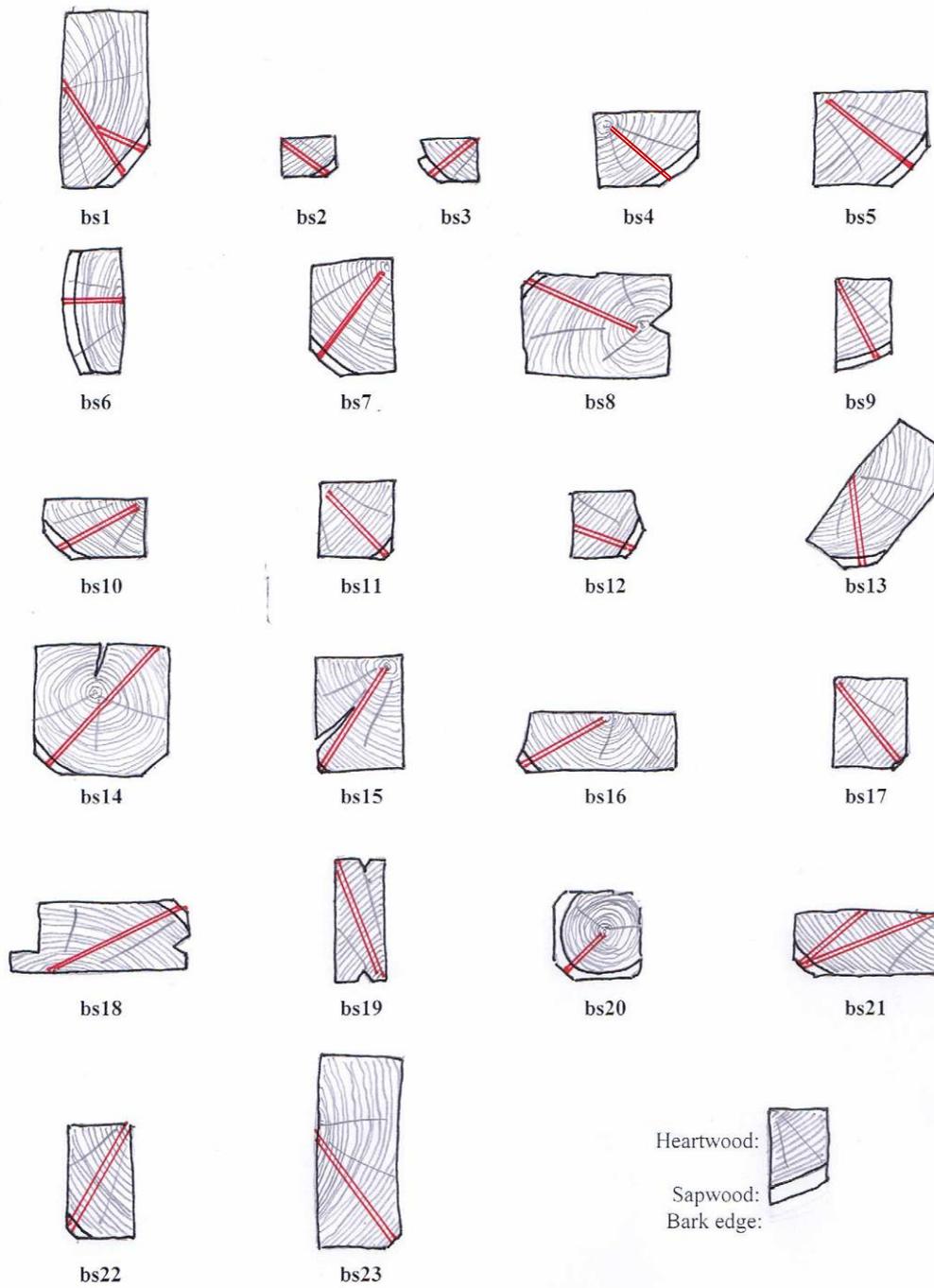


Figure 8: Sections of timbers sampled (scale 1:8); cores are marked in red

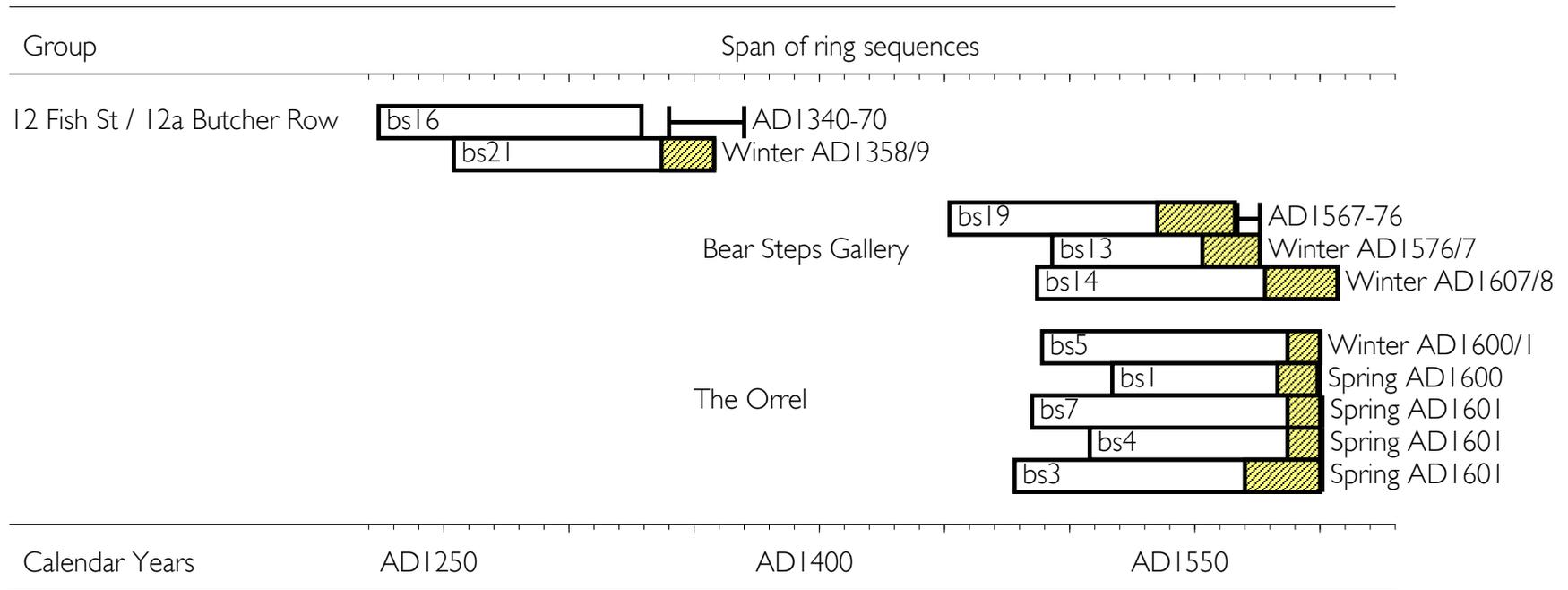


Figure 9: Dated samples in chronological position. White bars represent heartwood rings, yellow hatched sections represent sapwood rings

APPENDIX

Ring-width data for individual samples

bs1a

86	177	218	203	220	204	146	151	114	147
220	308	219	163	293	174	220	176	207	242
205	165	191	319	191	141	174	213	308	188
213	206	223	215	239	199	189	159	138	108
104	135	158	141	147	163	187	222	183	146
207	224	249	280	197	171	185	206	230	166
177	145	194	223	187	142	174	197	194	170
152	142	150	150	183	144	174	167		

bs1b

174	172	199	224	232	173	168	149	145	172
170	133	146	163	185	177	130	122	210	161
200	189	209	200	162	156	135	113	112	

bs2

94	74	109	145	153	101	167	176	179	154
114	136	211	224	150	157	119	148	139	157
179	181	143	142	178	112	96	187	171	189
161	123	154	157	162	116	133	114	147	152
129	128	133	143	108	120	155	124	123	131
129	151	98	93	134	100	71	85	96	122
133	103	86	99	89	66	77	62	76	76
78	69	80	75	71	58	76	81	85	

bs3

100	118	124	178	93	102	129	134	148	142
107	99	95	107	99	87	87	93	133	105
90	91	103	99	85	97	103	91	64	51
72	91	52	69	77	84	93	60	60	52
60	82	80	67	77	66	59	34	52	71
73	61	56	69	50	61	76	33	73	63
48	49	60	73	50	80	71	48	68	63
58	89	102	94	61	77	51	45	28	49
52	67	67	61	84	48	65	57	37	43
53	62	81	62	44	45	54	55	44	32
47	55	84	60	57	63	101	100	93	73
76	88	71	97	104	111	122	135	86	72
65	98	111							

bs4

140	224	193	267	256	244	226	129	105	84
111	183	150	185	211	186	124	104	142	182
244	206	216	277	209	149	133	159	215	206
214	227	219	156	100	111	126	129	144	134
162	157	164	146	156	169	113	68	68	69
88	159	145	168	130	131	86	77	89	90
125	125	106	88	93	86	98	141	108	93

65	89	99	109	100	121	174	176	174	154
156	211	177	193	181	202	255	236	278	256
262	228	209							

bs5

154	195	121	167	166	137	196	416	353	197
136	157	202	295	313	478	462	275	245	189
335	325	375	388	319	321	163	103	81	142
178	166	202	220	162	119	87	112	124	153
165	163	219	139	113	89	119	180	173	142
166	143	107	92	90	82	83	96	103	135
133	133	128	118	117	94	69	59	55	57
100	92	113	119	85	60	68	69	76	90
80	91	79	68	73	81	110	79	91	64
63	62	82	80	101	133	128	138	154	135
166	159	167	165	169	159	165	197	167	174
175	175								

bs6

109	142	131	160	231	130	106	107	150	156
166	128	102	98	85	92	133	150	157	215
255	147	139	88	83	135	201	268	184	220
200	121	88	107	186	143	145	152	146	139
127	153	144	146	166	94	75	48	60	91
94	113	114	126	96	50	56	89	111	118
135	100	92	83	101	71				

bs7

215	152	202	286	380	454	302	283	294	362
356	525	469	289	248	370	256	391	295	304
318	234	209	161	247	219	236	194	199	188
147	91	72	105	281	218	308	343	262	138
107	154	177	191	199	205	256	214	155	116
126	175	199	170	204	224	140	109	101	158
164	185	152	181	146	181	163	147	129	103
71	72	62	71	111	121	142	123	102	69
52	48	51	61	91	77	86	77	64	67
75	97	100	49	69	35	57	70	81	120
122	119	131	115	145	132	139	126	127	151
175	185	175	187	159	157				

bs8

186	236	334	144	132	179	180	200	135	172
127	167	125	127	108	114	124	88	81	99
75	138	83	63	74	54	108	67	136	143
164	248	147	120	95	147	217	191	203	162
136	143	102	102	147	166	175	132	209	200
173	169	162	224	179	164	162	139	179	101
114	109	124	116	198	120	114	168	157	129
148	132	93	55	69	47	89	81	98	75
51	47	71	50	57	74	73	92	90	79
70	59	97	66	93	66	70	71	50	91
116	119	94	111	95	121	117	113	142	135

145 108 89 102 109

bs9

446 438 510 104 72 68 88 144 184 161
179 210 208 120 121 121 147 163 97 171
160 171 140 165 158 214 194 165 173 150
91 131 148 241 163 141 163 236 222 181
138 123 132 104 135 124 86 99 123 187
156 105 69 88 75 81 92 87 79 84
96 72 87 83 91 93 90 70 85 86
58 75 92 89 110 75 52 62 51 51
58 54 44 64 44 38 30 50 39 39
46 55 47 42 41 55 71 67 66 74
67 71 82 88 78 74 87 79 72 76
87 72 59 59 91 61 81 98 102 101
103 83 100 92 76 78 104 135 86 92
103

bs10

89 81 74 126 124 75 77 104 134 139
112 172 143 143 77 101 98 54 53 61
46 74 53 63 57 71 41 45 67 78
96 73 83 78 71 67 95 71 66 61
104 140 106 91 127 116 96 132 139 109
62 56 79 85 92 107 88 107 95 104
129 107 80 78 112 106 112 83 93 87
74 77 88 83 75 95 37 34 42 50
58 64 73 55 74 45 42 80 83 100
113 99 91 97 89 95 63 84 128 89
87 107 103 91 100 123 118 102 133 118
130 146 137 135 129 116 129 98 133 142
162 167

bs11

208 192 259 187 178 184 182 240 204 180
191 158 121 88 168 163 184 174 146 89
95 122 155 168 112 104 78 90 135 122
93 131 172 158 148 136 151 106 112 100
141 119 113

bs12a

233 146 125 110 124 192 180 221 203 186
137 91 111 142 199 237 222 158 159 171
148 93 73 104 205 209 194 186 209 154
87 85 109 141 120 93 76 140 172 198
164 178 204 172 192 160 155 118 146 192
209 176 187 162 111 99 131 153

bs12b

306 268 228 155 113 89 127 231 149 158
200 282 119

bs13

290	458	318	331	269	207	433	431	336	319
192	225	218	269	160	159	219	184	210	189
208	193	119	147	86	145	149	186	219	207
177	125	97	126	199	207	174	130	203	167
159	180	163	227	187	191	176	182	105	68
152	170	228	159	138	150	194	164	159	125
128	87	67	47	52	72	91	121	108	104
133	102	95	88	105	98	111	117	78	60
97	104	48	139						

bs14a

253	339	280	250	203	156	128	180	182	189
168	114	166	161	117	159	153	131	108	136
143	107	152	113	125	162	128	102	98	73
73	92	167	157	167	157	106	88	108	127
146	122	117	81	141	83	98	98	62	126
122	119	119	116	93	91	90	111	94	101
69	67	83	112	99	64	69	76	60	60
62	69	88	102	113	80	73	74	71	61
75	96	99	84	65	69	70	79	129	

bs14b

256	262	252	220	143	164	124	218	184	211
217	128	138	163	149	165	171	212	184	153
160	106	168	146	157	186	139	109	80	69
58	76	102	97	120	124	97	99	109	133
116	118	109	72	114	79	92	102	84	102
140	135	145	122	111	108	120	146	152	142
115	138	127	126	149	111	90	94	93	78
85	104	141	120	152	102	82	76	86	63
67	82	99	82	54	76	73	69	98	87
66	55	70	77	96	57	97	117	103	101
85	52	60	65	87	81	75	91	82	58
54	52	39	49	63	46	74	82	45	49
65									

bs15

776	723	615	676	716	674	574	647	552	684
661	645	609	491	405	498	571	396	355	431
465	473	388	499	227	609	523	574	381	168
294	320	419	183	133	117	247	307	284	312
181	216	81	341	286	364	420	353	246	282
320	337								

bs16

168	207	237	187	143	176	150	122	70	83
193	229	128	249	165	202	223	142	167	204
168	169	191	249	257	268	130	221	159	258
208	243	224	183	154	132	71	101	129	111
122	149	121	145	134	106	71	127	136	147
127	118	100	103	77	55	103	113	125	162
154	146	145	107	83	126	189	191	158	203
199	155	122	129	96	59	81	87	80	79

70	93	70	78	110	127	107	77	117	169
237	224	189	163	89	136	93	98	118	200
161	156	168	128	152	134				

bs17

291	275	250	334	365	279	459	437	458	317
279	256	375	562	374	277	267	164	142	140
113	98	91	87	99	82	86	77	119	106
94	73	65	103	88	74	77	71	61	58
76	58	67	69						

bs18

491	658	480	535	374	371	384	407	437	380
312	372	336	442	397	339	352	349	347	261
266	450	408	270	231	228	263	173	195	141
197	155	163	168	157	230	215	201	157	193
157	135	138	148	166	182	182	178	129	172
134	113	152	138	143	103	81	99	70	84
134	156	185	215	190	206	199	149	134	151
110	184	115	131	153	133	105	48	47	

bs19

227	252	264	235	278	242	237	197	206	189
235	229	173	127	181	270	336	261	201	205
193	230	285	352	280	185	127	212	191	203
192	167	212	202	222	246	179	160	176	141
132	149	214	175	256	284	155	137	153	125
152	162	186	216	131	174	133	181	161	152
197	181	182	168	136	135	219	245	159	174
166	148	165	160	160	123	136	127	101	126
120	139	155	174	144	169	157	154	159	191
117	109	103	105	87	88	97	98	102	138
114	113	108	121	98	112	103	126	50	35
32	48	59	68	60					

bs20

353	326	331	306	256	186	168	224	180	160
136	164	111	116	66	83	108	92	124	70
104	108	123	149	114	105	109	127	103	124
110	122	126	167	162	144	147	199	149	146
123	108	116	81	62					

bs21a

159	163	160	154	156	136	99	117	153	130
121	140	109	174	153	108	70	137	124	137
133	103	99	103	73	67	123	141	142	190
161	167	144	75	72	91	140	162	127	181
136	113	112	128	93	52	64	75	68	71
74	90	86	74	88	94	74	69	57	82
100	105	96	99	87	61	58	76	40	44
40	38	38	34	43	44	44	28	21	28
30	43	54	43	69	57	217	184	123	71
40	59	59	55	61	60	60	63	41	43

44 72 46 48 51

bs21b1

145 137 137 141 103 105 125 91 67 148
224 231 283 226 204 188 99 98 114 183
186 158 244 234 166 121 148 99 58 67
74 72 78 75 91 74 86 97 92 74
88 66 80 100 120 111 115 101 61 80
74 44 39 52

bs21b2

49 34 37 44 35 33 37 28 24 50
53 37 61 64 184 160 116 74 41 64
63 58 62 64 62 67 39 41 43 65
51 49 55

bs22

451 632 528 634 461 590 457 451 530 371
326 458 542 657 621 546 526 607 597 523
540 580 564 526 521 451 380 361 284

bs23

337 271 174 220 263 204 287 302 319 261
244 256 209 176 185 200 162 269 177 204
176 148 169 295 259 225 298 309 341 304
204 170 190 212 267 271 293 384 247 357
299 227 239 192 117 74 71 85 97 81
113 135 121 140 128 151 117 126 86 105
124 159 130 85 73 46 92 74 68 80
79 87 94 126 118 111 96 77 114 103
145 142 112 116 163 126 104 143 158 197
142 216 293 100 70 85 106 144 207 153
122 218 135 167 140 161 132 191 129 70
102 85 145



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