Appendix 2: Dating Results

DENDROCHRONOLOGICAL DATES FROM THE THAMES CROSSING SITES

The table of dates (Table A2.1) is taken from J Hillam and D Miles 'Tree-ring Analysis of Timbers from the Oxford Shire Lake Project', English Heritage Ancient Monuments Laboratory Report 75/92, Table 12. Estimated felling date ranges are calculated using a sapwood estimate of 10–55 rings. A summary of the Laboratory Report can be found in Chapter 7 of the present volume, above.

RADIOCARBON DATES

The radiocarbon dates reported in this appendix were recalibrated in the summer of 2001 for the purposes of preparation of the current volume, and the authors are most grateful to Alex Bayliss and Peter Marshall of English Heritage Archaeometry Division for carrying out this work and supplying the following tables, figures and commentary. A number of these dates have been previously published but are superseded by the current recalibrations. The results given in Tables A2.2, A2.3 and A2.4 are conventional radiocarbon ages (Stuiver and Polach 1977), and are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986). The radiocarbon determinations have been calibrated with data from Stuiver *et al.* (1998), using OxCal (v3.5) (Bronk Ramsey 1995; 1998). The date ranges have been calculated according to the maximum intercept method (Stuiver and Reimer 1986), and are cited in the text at two sigma (95%) confidence. They are quoted in the form recommended by Mook (1986), with the end points rounded outwards to 10 years. The probability distributions shown in Figures A2.1, A2.2 and A2.4 are derived from the usual probability method (Stuiver and Reimer 1993). The ranges shown in italics in Tables A2.3 and A2.4 are derived from mathematical modelling of archaeological problems, which was undertaken for the dates from Christ Church and St Aldate's, and from All Saints Church. The probability distributions derived from the mathematical models are shown in Figures A2.3 and A2.5; the methodology and interpretation is discussed under the relevant section headings below.

Sites along the Thames Crossing

The results are presented in Table A2.2 and Figure A2.1.

Christ Church and St Aldate's Church

The results are presented in Table A2.3 and Figure A2.2.

Analysis and interpretation of radiocarbon determinations from Christ Church and St Aldate's Church by Peter Marshall

A Bayesian approach has been adopted for the interpretation of the chronological data (Buck *et al* 1996) using the program OxCal version 3.5 (http://www.rlaha.ox.ac.uk/orau; Bronk Ramsey 1995; 1998). Such a methodology allows the results of the radiocarbon analyses to be combined with other information, such as stratigraphy, to produce realistic estimates of dates of archaeological interest. The algorithms used in the models described below can be derived from the structure shown in Figure A2.3.

In the analyses undertaken we have chosen to impose a uniform prior distribution on the spread of dates while assuming that the dated samples represent independent events and a random sample of a relatively constant level of human activity (see Bronk Ramsey (2000) for further details of its implementation). Such an approach has been used because when radiocarbon dates are constrained by relative dating information it has been shown that there is a danger that the posterior density distributions may be spread evenly across a plateau in the calibration curve, irrespective of the actual age of the material dated (Steier and Rom 2000). This is due to the fact that the statistical weight of a group of measurements naturally favours longer overall spans. The model for the chronology of Saxon activity in Oxford is shown in Figure A2.3.

Christ Church and Tom Quad: Burials found in Tom Quad in 1972 (Hassall 1973) and Christ Church Cathedral Cloister 1985 (Scull 1988) are thought to be from the same cemetery. A sample of oak charcoal (identified as 'young wood') (HAR-190) from the layer of charcoal, up to 10 cm deep, that lined the bottom of the earliest of two graves excavated in 1972 in Tom Quad, cannot be stratigraphically related to the other burials excavated from the same cemetery; however, it can be assumed to relate to the same phase of activity. The model (Fig. A2.3) provides an estimate for the date of the burial of cal AD 810–970 (at 95% confidence). Human bone samples from four stratigraphically-related inhumations (F96, F119, F123, F127), two of which (F96, F123) bracketed the same stratigraphic sequence,

Table A2.1 Dendrochronological dates from the Thames Crossing sites

Sample	Context	Date of measured ring sequence (AD)	Felled (AD)	Comments
89–91 St Aldate's (Trill Mill Stream)				
TMS 701	776	871–1001	1011–?1056	
TMS 702	780	781–925	925–965	
TMS 703	782/1	641–887	897+	
TMS 704	782/2	637–883	893+	
TMS 708	794	758–880	890+	
TMS 710	785	787–910	918–963	
TMS 718	781	782–857	867+	
TMS 721 A	790	632–761	see 721B	
TMS 721B	790	770–854	864+	
TMS 725	783	787–868	878+	
24–26 St Aldate's (Police Station)				
PS 213	41/3	879–935+	945+	Outer rings broken off
PS 214	41/2	850–966	973–1018	
PS 218	41/8	847–909	919+	Inner rings broken off
56–60 St Aldate's				
SASL 318	55/4	968–1089	1099+	
BT Tunnel				
BT 823	823	435–577	577–619	

excavated in 1985 in Christ Church Cathedral Cloister were dated at the AERE Harwell Laboratory in 1986. Burial F96 (HAR-6817) is the earliest in the sequence and was cut by F119 (HAR-6818) and F123 (HAR-6818); F127 (HAR-6820) also cut F96 but could not be stratigraphically related to the other two burials (see Scull 1988 fig. 10 for site matrix). As the relationship between F96 and F127 is archaeologically well established we have included it in the model even though the index of agreement for HAR-6820 is rather low (A = 31.9%), and brings down the overall agreement undesirably (A = 61.1%).

Results from two other excavated cemeteries in Oxford have also been included in the model for Saxon burial activity: Christ Church Cathedral graveyard and St Aldate's Church. Excavations at St Aldate's Church in 1999 located a group of 19 burials, 3 of which (all 'charcoal' burials) were submitted for radiocarbon analysis at the Rafter Radiocarbon Laboratory. In addition, work undertaken in 1998 at Christ Church Cathedral graveyard in 1998 located 37 burials, 3 of which were also dated at Rafter.

St Aldate's Church: The three samples of human bone from St Aldate's Church (skeletons 855, 835, and 846) are all stratigraphically related with grave 858 containing skeleton 85 cut by grave 837 containing skeleton 835. Grave 837 was overlain by a disturbed grave (cut 843, fill 844) with no skeletal remains. This was in turn overlain by grave 845 containing skeleton 846. In the overall model the index of agreement for NZA-12348 (A = 52.3%) and NZA-12349 (A = 53.0%) is low even though these two burials have a well established archaeological relationship. However, because of the relationship they have both been included in the model.

Christ Church Cathedral graveyard: The samples of human bone from skeletons excavated at Christ Church Cathedral graveyard were from a group of stratigraphically related graves. Grave 402 was the earliest, with 418 above it. Above 418 was a layer of dumped material, and the dump layer was cut by 277. If all three of these samples are included in the model, then it shows poor agreement (A = 48.4%). Therefore it seems more likely that sample 402 (NZA-12343) relates to an early phase of Saxon activity in Oxford, probably at some time in the 7th century cal AD. If NZA-12343 is excluded from the overall model the index of agreement increases (A = 61.1%.) Given the number of excavated burials from the Christ Church Cathedral graveyard further radiocarbon determinations may help in confirming this early Saxon phase of activity in the city.

The model estimates that the start of this phase of burial activity in Oxford began in cal AD 870–1010 (at 95% confidence) (Fig. A2.3). As further Saxon burials are recovered and dated in Oxford it will become possible to further refine this estimate for the start of this phase of activity in the city.

All Saints Church

The results are presented in Table A2.4 and Figure A2.4.

Table A2.2 Radiocarbon determinations from sites along the Thames Crossing

Laboratory Number	Material	Context	Radiocarbon Age (BP)	$\delta^{13}C$ (‰)	Calibrated date range (68% confidence)	Calibrated date range (95% confidence)
65 St Aldate's						
HAR-5339	wood, remaining subsample previously waterlogged, now dry and structurally collapsed; *Fraxinus* sp., 1.82 g (82.35%); ?*Fraxinus* sp., 0.39 g (17.65%); unidentified, 1.60 g (R Gale 1999)	Wattles from silt above ford L318/2	830±70	−28.5	cal AD 1150–1280	cal AD 1020–1300
HAR-5340	Wet wood	Wattles from ford L319/1	1020±70	−27.7	cal AD 970–1160	cal AD 880–1190
HAR-5341	wood, remaining subsample previously waterlogged, now dry and structurally collapsed, *Fraxinus* sp., 4.68 g (98.9%); *Salix/Populus* sp., 0.05 g (1.1%); unidentified, 0.60 g (R Gale 1999)	Wattle from channel edge F401	1080±70	−29.3	cal AD 890–1030	cal AD 770–1160
89–91 St Aldate's (Trill Mill Stream)						
HAR-5342	wood, remaining subsample previously waterlogged, now dry and structurally collapsed, *Corylus* sp., 0.80 g (100%); unidentified, 0.37 g (R Gale 1999)	19/2 (organic silt)	2410±80	−28.6	760–390 cal BC	800–260 cal BC
HAR-5343	Wood	Fence 34	1080±80	−27.4	cal AD 880–1030	cal AD 770–1160
HAR-5344	wood, remaining subsample previously waterlogged, now dry and structurally collapsed, ?*Quercus* sp., but too degraded to verify 0.66 g (65.3%); ?*Alnus/Corylus* sp., but too degraded to verify, 0.35 g (34.7%); unidentified, 0.66 g (R Gale 1999)	17/1 (fill of gully)	920±100	−29.8	cal AD 1010–1230	cal AD 890–1290
HAR-5345 (TMS33)	wet wood		abandoned			

Table A2.2 (Continued)

Laboratory Number	Material	Context	Radiocarbon Age (BP)	$\delta^{13}C$ (‰)	Calibrated date range (68% confidence)	Calibrated date range (95% confidence)
HAR-5346	waterlogged wood, remaining subsample identified; probably *Corylus* sp., but too degraded to verify, roundwood, diameter 45 mm approx. 17 growth rings, 150.58 g (100%) (R Gale 1999)	Stake 10/2	980±70	−27.9	cal AD 990–1160	cal AD 890–1220
HAR-8360	leather offcuts, apparently new leather rather than scrap	815 (silt)	1020±70	−27.4	cal AD 970–1160	cal AD 880–1190
HAR-8361	marsh deposit with *Phragmites* rhizomes	657 (peat)	2280±100	−31.6	410–200 cal BC	760–50 cal BC
HAR-8362	wet wood; *Alnus/Corylus* twigs	Fence 652/2	1080±80	−25.0(assumed)	cal AD 880–1030	cal AD 770–1160
HAR-8363	wet wood; *Corylus*	Wood from 681/1 (peat)	1180±70	−25.9	cal AD 720–970	cal AD 680–1020
HAR-8364	wet wood; *Alnus/Corylus* twigs	Fence 664/1	1210±70	−26.2	cal AD 690–940	cal AD 660–990
79–80 St Aldate's						
HAR-79/85	wood; *Corylus* sp., 30 mm diameter	Wattle 434	1120±110	−27.9	cal AD 770–1030	cal AD 660–1160
HAR-125	wood; *Corylus* sp., 30 mm diameter	Stake 472	1140±110	−28.6	cal AD 730–1020	cal AD 660–1160
HAR-717	charcoal; twigs (15 mm diameter) with bark	Midden 123/2	870±70	−25.7	cal AD 1030–1260	cal AD 1010–1290
HAR-718	charcoal; preserved wattle stake (30 mm diameter)	Stake in hearth	1150±90	−25.4	cal AD 770–1000	cal AD 660–1030
Linacre College						
HAR-209	seed and vegetable deposit	46 (seed and vegetable deposit)	2600±120	−28.4	890–540 cal BC	1010–400 cal BC
BT Tunnel						
OxA-4353	wood; *Salix* sp., (M Robinson)	9 (peat)	1340±80	−27.4	cal AD 640–780	cal AD 560–890
GU-5333	wood; *Quercus* sp. (J Hillam)	825	1260±50	−24.5	cal AD 680–810	cal AD 660–900
GU-5334	dung; horse (M Robinson)	148 from 241	450±50	−28.9	cal AD 1420–1480	cal AD 1400–1620
OxA-4354	wood; *Acer* sp., (M Robinson)	from channel (fill 10)	8170±130	−28.5	7450–7050 cal BC	7530–6700 cal BC

Table A2.3 Radiocarbon determinations from Christ Church and St Aldate's Church

Laboratory Number	Material	Context number	Radiocarbon Age (BP)	$\delta^{13}C$ (‰)	Calibrated date range (68% confidence)	Calibrated date range (95% confidence)	*Estimated date range (95% confidence)*
St Aldate's							
NZA-12347	bone, human	846	1147±28	−19.3	cal AD 880–960	cal AD 780–990	*cal AD 860–980*
NZA-12349	bone, human	835	1210±36	−19.7	cal AD 770–890	cal AD 690–940	*cal AD 830–960*
NZA-12348	bone, human	855	1107±28	−19.2	cal AD 890–990	cal AD 880–1000	*cal AD 780–790 (1%) or cal AD 820–960 (94%)*
Christ Church, Cathedral Graveyard							
NZA-12343	bone, human	402	1369±32	−18.9	cal AD 640–680	cal AD 620–690	*cal AD 600–720 (93%) or cal AD 750–770 (2%)*
NZA-12344	bone, human	418	1197±33	−18.8	cal AD 770–890	cal AD 690–960	*cal AD 800–900 (64% or cal AD 910–960 (31%)*
NZA-12354	bone, human	277	1135±29	−18.9	cal AD 880–980	cal AD 780–990	*cal AD 830–840 (1%) or cal AD 860–970 (94%)*
Christ Church Cloister							
HAR-6817	bone, human	F96	1160±40	−21.1	cal AD 780–960	cal AD 770–990	*cal AD 780–900 (66%) or cal AD 910–950 (29%)*
HAR-6818	bone, human	F119	1150±40	−20.7	cal AD 780–970	cal AD 770–990	*cal AD 820–960*
HAR-6819	bone, human	F123	1110±40	−19.3	cal AD 780–960	cal AD 770–990	*cal AD 830–850 (1%) or cal AD 860–980 (94%)*
HAR-6820	bone, human	F127	1250±40	−20.0	cal AD 680–810	cal AD 660–890	*cal AD 820–900 (61%) or cal AD 920–960 (34%)*
Tom Quad							
HAR-190(S)	charcoal, *Quercus* sp. (young wood) (P G H Franklin)	Grave 2	1110±100	−28.4	cal AD 780–1030	cal AD 680–1160	*cal AD 810–970*

Analysis and interpretation of radiocarbon determinations from All Saints Church by Peter Marshall

A Bayesian approach has been adopted for the interpretation of the chronological data (Buck *et al.* 1996) using the program OxCal version 3.5 (http://www.rlaha.ox.ac.uk/orau; Bronk Ramsey 1995; 1998). Such a methodology allows the results of the radiocarbon analyses to be combined with other information, such as stratigraphy, to produce realistic estimates of dates of archaeological interest. The algorithms used in the models described below can be derived from the structure shown in Figure A2.5.

In the analyses undertaken we have chosen to impose a uniform prior distribution on the spread of dates while assuming that the dated samples represent independent events and a random sample of a relatively constant level of human activity (see Bronk Ramsey (2000) for further details of its implementation). Such an approach has been used because when radiocarbon dates are constrained by relative dating information it has been shown that there is a danger that the posterior density distributions may be spread evenly across a plateaux in the calibration curve, irrespective of the actual age of the material dated (Steier and Rom 2000). This is due to the fact that the statistical weight of a group of measurements naturally favours longer overall spans. The model for the chronology of activity All Saints Church is shown in Figure A2.5.

Figure A2.5 shows that the radiocarbon measurements are in good agreement with the stratigraphy (A = 110.2%). The two measurements (HAR-466-I and HAR-466-II) from the large heap of charred grain scattered through the earliest stratified layer on the site are statistically consistent (T′ = 0.0; T′(5%) = 3.8; v = 1, Ward and Wilson 1978) and so a weighted mean can be take before calibration (1064±53 BP). The model suggests an estimated date for this event at some time in the late 9th to early 11th century AD (cal AD 890–1030 at 95% confidence). Stratigraphically later than the deposit containing the charred grain, the remains of a charred wattle fence [118] were set into a yard surface [113/2]. Charred twigs (HAR-419) from the wattle fence have an estimated date of cal AD 980–1050 (at 95% confidence). A cellar pit cut these early deposits and a coin of Edward the Confessor dated to 1042–4 (Chapter 6, above) is stratigraphi-

Table A2.4 Radiocarbon determinations from All Saints Church

Laboratory Number	Material	Context	Radiocarbon Age (BP)	$\delta^{13}C$ (‰)	Weighted mean (BP)	Calibrated date range (68% confidence)	Calibrated date range (95% confidence)	*Estimate date range (95% confidence)*
HAR-418	human bone	Skeleton grave 55	920±70	−19.5		cal AD 1020–1220	cal AD 980–1270	*cal AD 1040–1250*
HAR-419	charcoal, charred twigs	Charred fence 118	980±70	−27.2		cal AD 990–1160	cal AD 900–1220	*cal AD 980–1050*
HAR-466-I	carbonised grain; (*Triticum aestivum*) and loam	Charred grain 113/9	1060±70	−21.9				
HAR-466-II	carbonised grain; (*Triticum aestivum*) and loam	Charred grain 113/9	1070±80	−22.1	1064±53 T′=0.0; T′(5%)=3.8; v=1	cal AD 890–1030	cal AD 880–1150	*cal AD 890–1030*
HAR-729	human bone	Skeleton grave 57	870±60	−19.4		cal AD 1030–1260	cal AD 1010–1290	*cal AD 1040–1270*
HAR-730	human bone	Skeleton grave 67	650±70	−19.3		cal AD 1280–1400	cal AD 1250–1430	*cal AD 1220–1410*

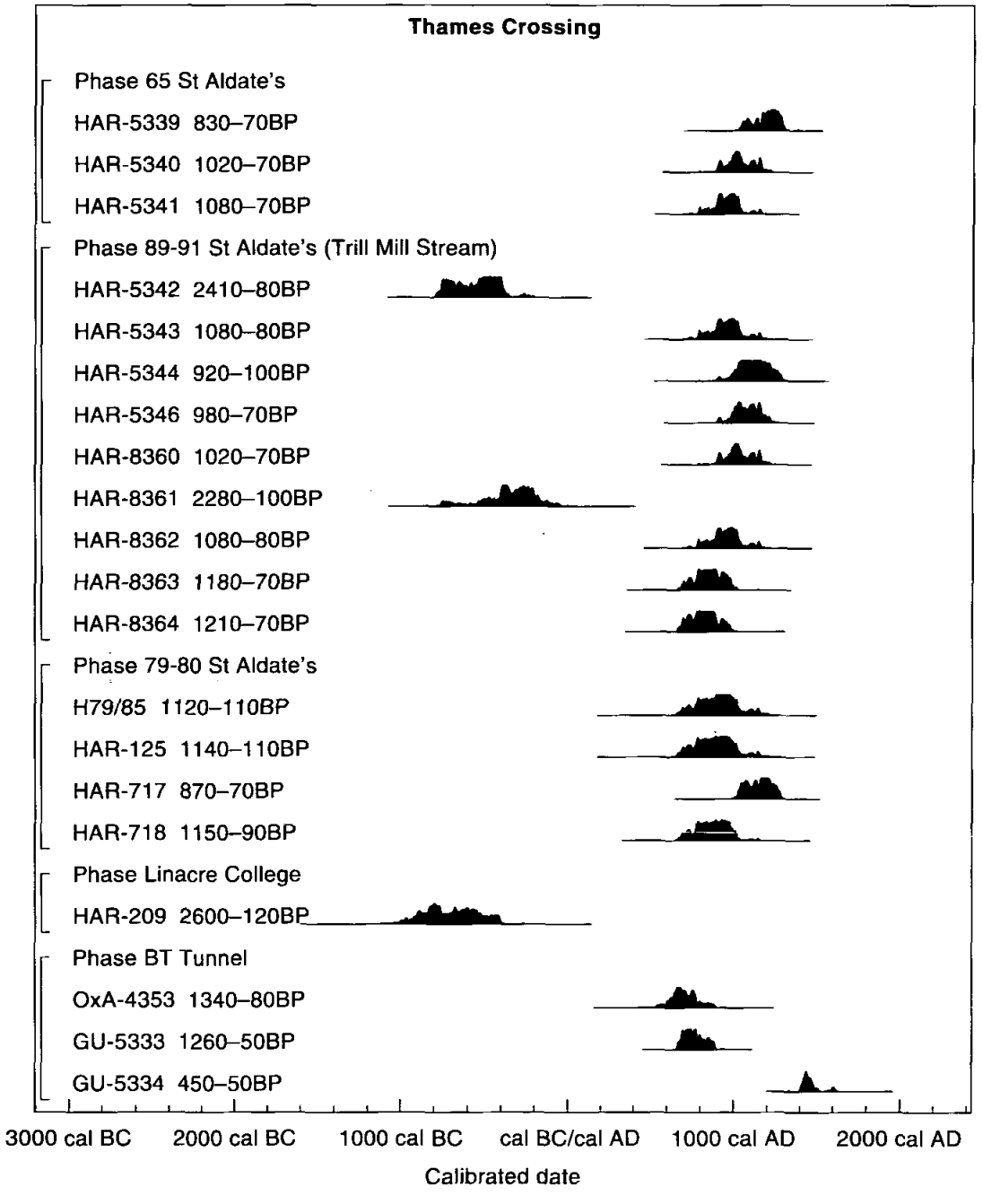

Figure A2.1 Probability distributions of dates from sites along the Thames Crossing (English Heritage).

cally earlier than a burial (HAR-418) on a bed of charcoal in a stone-lined grave (grave 55). The burial has an estimated date of cal AD 1040–1250 (at 95% confidence). A second sample from a burial adjacent to HAR-418 (grave 57) has an estimated date of cal AD 1040–1270 (at 95% confidence). The latest sample in the sequence (HAR-730) came from a burial (grave 67) overlying an unrobbed section of the east wall of the north aisle and was submitted to help to date the removal of this wall in the construction of the north chancel. The model shown in Figure A2.5 suggests an estimated date for the burial of cal AD 1220–1410 (at 95% confidence).

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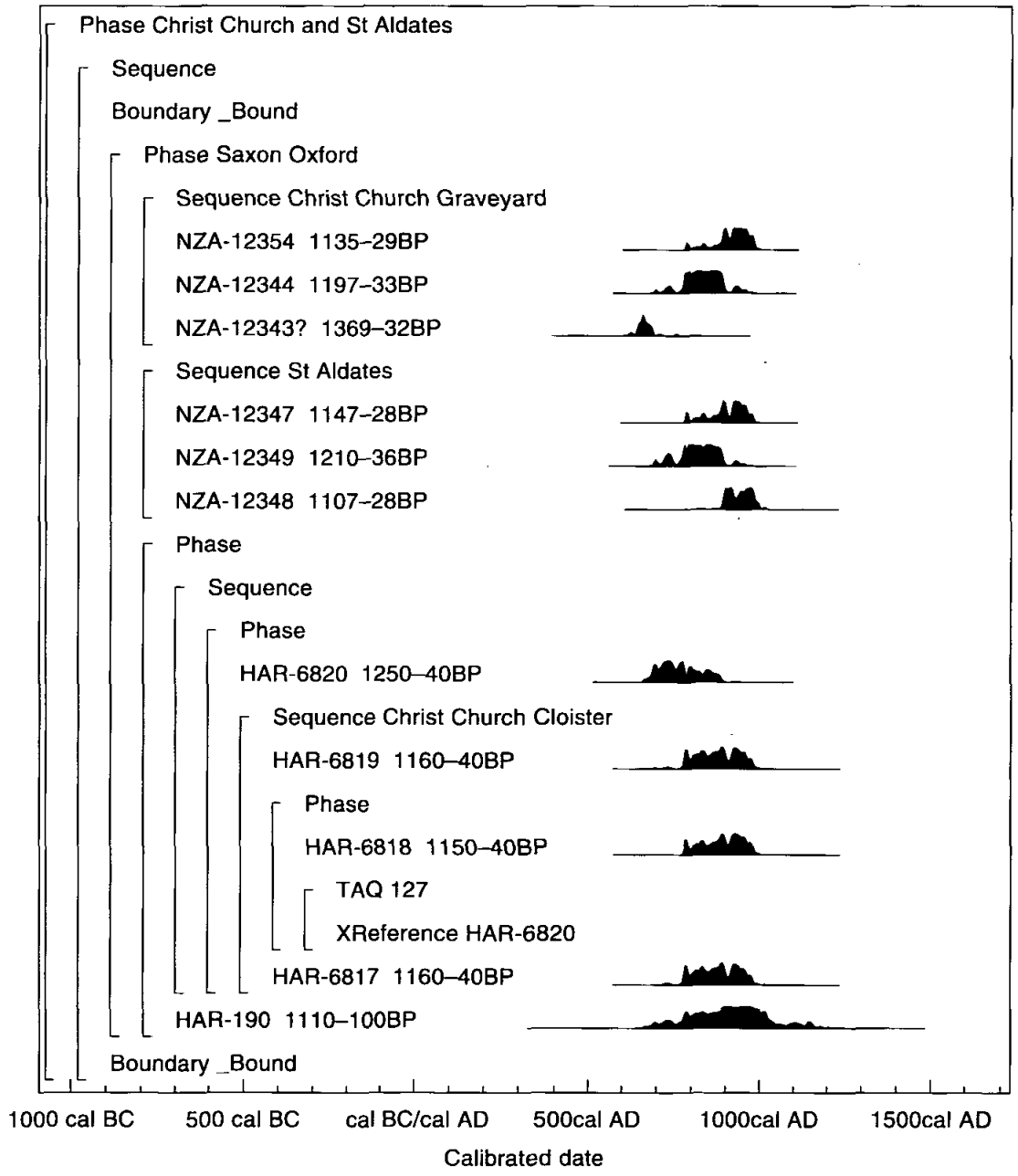

Figure A2.2 Probability distributions of dates from Christ Church and St Aldate's Church (English Heritage).

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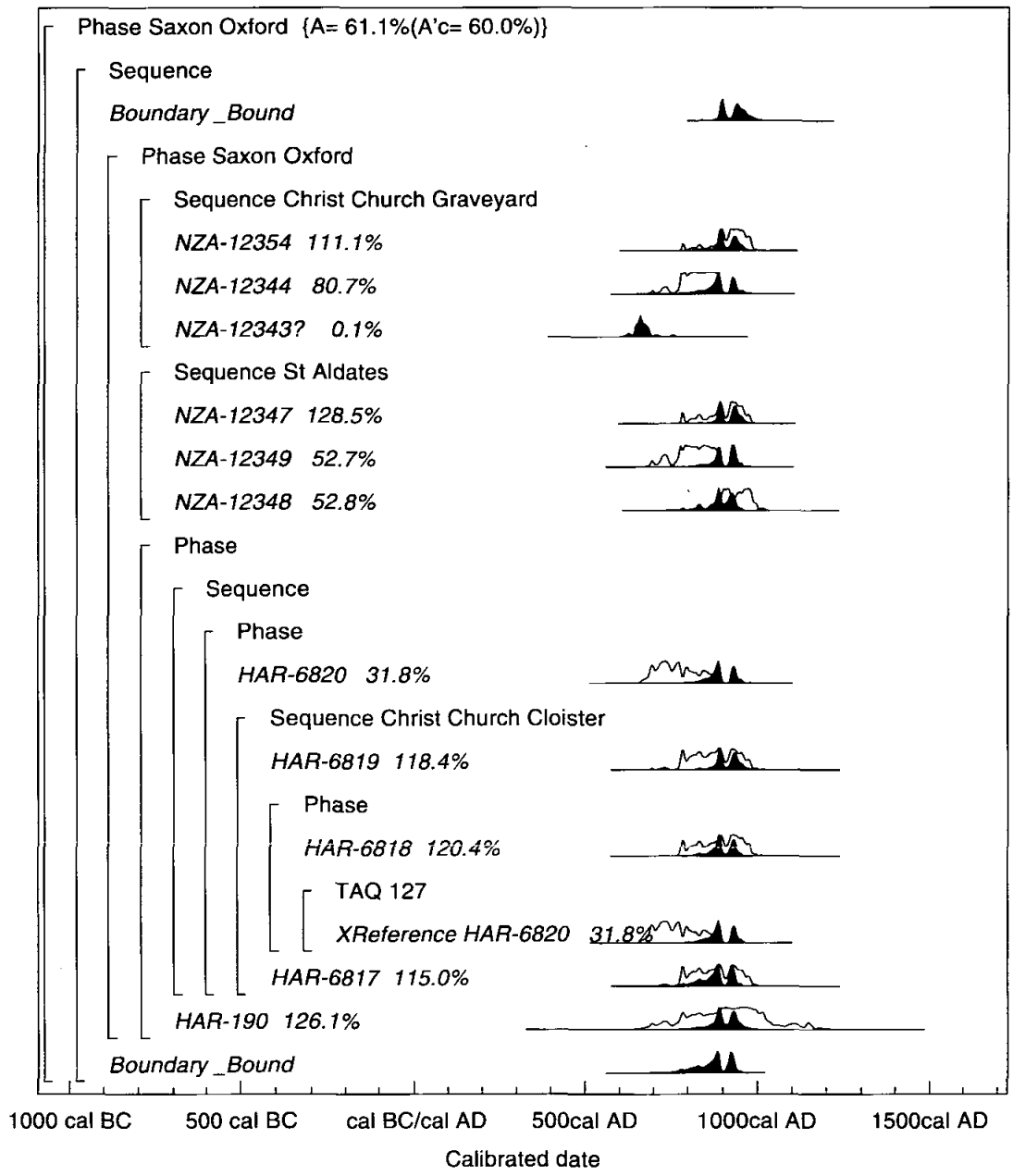

Figure A2.3 Probability distributions of dates from Christ Church and St Aldate's Church; Bayesian modelling (English Heritage).

Radiocarbon age calibration, 24,000–0 cal BP, *Radiocarbon* **40**, 1041–83

Analysis of radiocarbon determinations for the middle Saxon wattle fences and stakes at 89–91 St Aldate's and 79–80 St Aldate's by Mark Robinson

Five radiocarbon determinations (Table A2.2: HAR-8363, HAR-8364, HAR-79/85, HAR-125, HAR-718) were obtained on the stratigraphically early wattles which cut into the blue-grey clay, interpreted above as Roman alluvial sediment, at the Trill Mill site and 79–80 St Aldate's (this volume Chapter 3, and Durham 1977, 174). Their dates are centred on the middle Saxon period around cal AD 880 (Fig. A2.1) and it was thought useful to establish whether they could represent contemporaneous middle Saxon activity. The methods of Ward and Wilson (1978) were used to test whether the five wattle samples could be statistically regarded as of the same age. For the dates to be indistinguishable at a confidence level of at least 95%, they must give a T value <9.49. The value obtained of 0.68 is therefore highly significant, showing they are not statistically different.

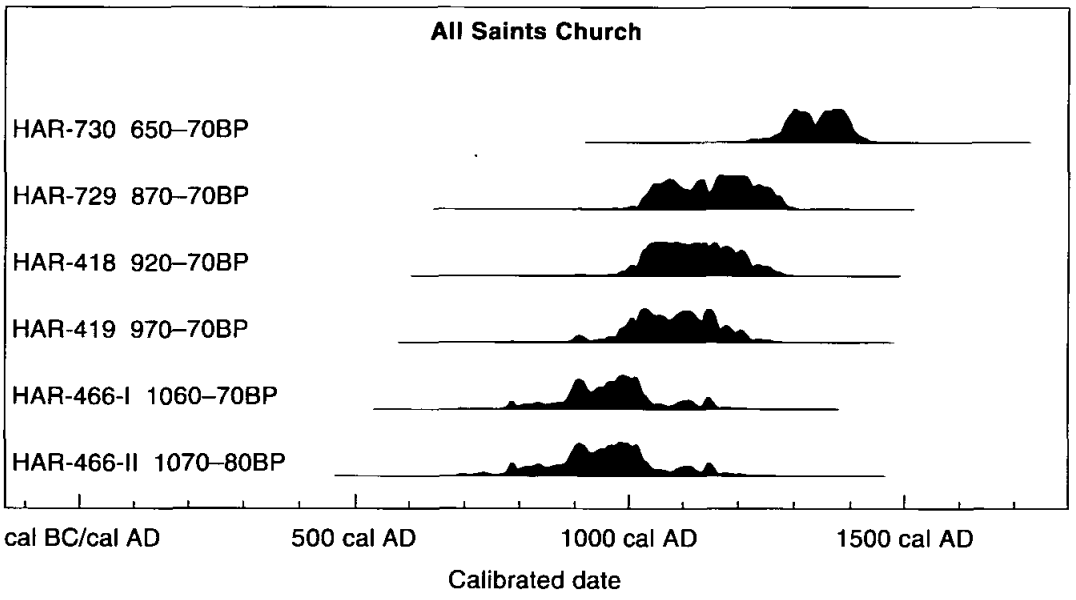

Figure A2.4 Probability distributions of dates from All Saints Church (English Heritage).

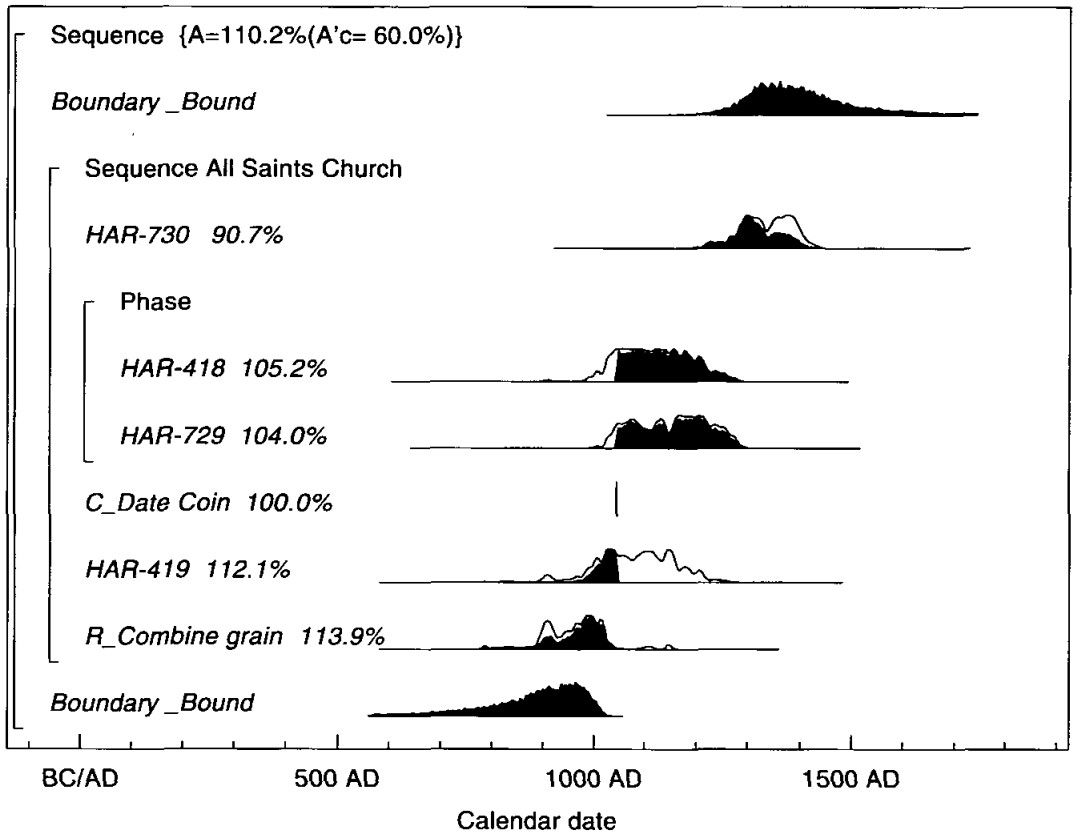

Figure A2.5 Probability distributions of dates from All Saints Church; Bayesian modelling (English Heritage).

The result does not, of course, prove that the wood for the wattles must have been felled in a single event; indeed it is much more plausible that the wattle construction occurred as a series of separate events over a relatively short time span in the middle Saxon period. There is much overlap of their date with the date obtained on the oak pile from the BT Tunnel (GU-5333).