

Centre for Archaeology Report 83/2003

**Tree-Ring Analysis of Oak Timbers from Combermere Abbey,  
Whitchurch, Cheshire**

R E Howard, Dr R R Laxton and Dr C D Litton

© English Heritage 2003

ISSN 1473-9224

*The Centre for Archaeology Report Series incorporates the former Ancient Monuments Laboratory Report Series. Copies of Ancient Monuments Laboratory Reports will continue to be available from the Centre for Archaeology (see back cover for details).*

## **Tree-Ring Analysis of Oak Timbers from Combermere Abbey, Whitchurch, Cheshire**

R E Howard, Dr R R Laxton and Dr C D Litton

### **Summary**

Ninety-seven samples obtained from a wide range of locations at Combermere Abbey produced two site chronologies, one of sixty-six samples, 202 rings long, spanning AD 1363 - AD 1564, the second, eleven samples, 126 rings long, spanning AD 1602 - AD 1727.

Three phases of work are suggested, the earliest being the roof of the Abbot's lodging. All the timbers here being felled in AD 1502, though one may be slightly earlier.

Timbers for the wall- and floor-frames of bedroom A, the floor-frame of the Oak room and the inserted ceiling of the Abbot's lodging were probably all cut in AD 1564. Although possibly felled any time in the period AD 1546 - 81, the timbers of the Orange room were most probably cut shortly before AD 1564 and are to be seen as part of the same general late-sixteenth century programme of work.

### **Keywords**

Dendrochronology  
Standing Building

### **Author's address**

University of Nottingham, University Park, Nottingham, NG7 2RD.

*Many Cfa reports are interim reports which make available the results of specialist investigations in advance of full publication. They are not subject to external refereeing, and their conclusions may sometimes have to be modified in the light of archaeological information that was not available at the time of the investigation. Readers are therefore advised to consult the author before citing the report in any publication and to consult the final excavation report when available.*

*Opinions expressed in Cfa reports are those of the author and are not necessarily those of English Heritage.*

## Introduction

The remains of Combermere Abbey, a grade I listed structure on the English Heritage Buildings at Risk register, stand in a superb position within a beautiful parkland estate overlooking a nearby mere, or lake (SJ 598440; Figs 1 and 2). The Abbey was established as a monastic house of the Cistercian order, or white friars, in AD 1133. There were substantial original donations of land and endowments, including revenues from salt extraction and trading, and the house was, for a time, particularly wealthy. It had, however, a history of indiscipline and maladministration. There are accounts of accusations against the brothers of rape, pillage, and murder, and the Abbey was taken in to Royal custody on several occasions. At the time of the Dissolution in AD 1536 the Abbey and its estate were granted to Sir George Cotton, an Esquire of the Body to Henry VIII.

Very little of the original extensive range of monastic buildings now remain, and indeed there is little certainty as to their original position or actual layout. However, assuming a standard Cistercian plan form was adopted, a reasonable assessment of the site may be made, as postulated in Figure 3. To the south of the central church is placed a rectangular cloister off which would have been a rere-dorter and kitchens. To the north of the church is a second possible cloistered or courtyard area believed to have contained the Abbot's lodging, Guest Hall, Refectory, and Infirmary.

It is believed that it was Sir George who began the conversion of the monastic buildings for his own domestic use. This involved the demolition of the church and most of the other abbey buildings particularly those of the southern cloistral area, with only a part of the northern buildings, believed to contain the Abbot's lodging, being retained and redeveloped. It is the remains of the north courtyard area which now comprises the present-day house. Further work was carried out by Sir George's son, Richard, in the later sixteenth century, with the medieval buildings being enlarged further. A date stone, discovered in AD 1795, reads:

*"Master Richard Cotton and his sons three  
both for their pleasures and commoditie  
This building did edifie  
In fifteen hundred and sixty three"*

The demolition of the monastery buildings appears to have been extensive and thorough, and nothing within the present structure can be assigned, on the basis of stylistic interpretation, to the twelfth century apart from a few fragments of Romanesque carving found in the gardens.

There exist two historic views of the later house. The first is an engraving by S and N Buck, shown in Figure 4 which dates to AD 1727 and shows the east elevation. In this we see what appears to be a colonnaded front to the main range of the house (now the Library wing), with what appears to be the possible remains of a medieval stone wing to the left or south. This portion appears to retain a truncated pair of vaults, or possibly blocked openings. The extent and style of the decorative timber-framing to the first floor and gables is also clearly illustrated.

Another view of the later house is shown in an oil painting of c AD 1730 and still hung at Combermere. It portrays a similar looking west façade with stone to the ground floor and timber-framing above. Both illustrations give some impression of the extent of the sixteenth- or seventeenth-century alterations.

Further alterations occurred in AD 1795 and again after AD 1814, including the addition of new service wings and the covering of the house with cement render applied to wooden battens.

## Sampling

Sampling and analysis by tree-ring dating of timbers from Combermere Abbey were commissioned by English Heritage. The purpose of this analysis was to provide independent dating evidence for the construction of a number of elements of the house and to illuminate the sequential development of various parts of the building. Although areas of the building, including the former Abbot's lodging, have been repaired in the past through English Heritage grant aid, a new scheme of repairs, to be carried out through enabling development, is now proposed. The information supplied through tree-ring analysis will help inform this new work and assist with the future management of the building. To this end sampling was commissioned for a number of different elements of the building.

In a number of instances sampling was limited by the general state of dilapidation of the north-west wing. In many areas parts of roofs, walls and floors were missing, or the beams loose or weakened through decay. In some cases there was a real danger of collapse and it may be worthwhile obtaining further samples when scaffolding or safety boarding is in place. General plans locating areas of sampling referred to in the text are shown in Figures 5a/b. In these plans room names or numbers are used following those shown on the drawing provided by English Heritage.

### *Abbot's lodging – main roof, spere and closed trusses, and inserted timbers*

The roof of the Abbot's lodging consists of the six trusses of a first-floor open hall, with central smoke bay and louvre, dais canopy, at the north end, and elaborately decorated carpentry. Truss one, the northern most, is a closed, square panel truss of collar and stud posts infilled with wattle and daub. Truss 2 is a closed truss, this having tension braces, a collar, stud posts, and a moulded tiebeam with quatrefoils in relief. The next three trusses, truss 3 - 5, are of false hammerbeam form with moulded and carved arched braces rising to richly carved central bosses on the collars. The lower portions of the arched braces have coats of arms including ecclesiastical arms.

The south-most truss of the roof, truss 6, was again a spere truss originally but it appears to have been damaged, with braces having been cut through and other timbers added in. On the basis of stylistic evidence Pevsner (1971) suggests that this roof is of mid fifteenth-century date. The site listing description, however, suggests that the roof of the Abbot's lodging was remodelled shortly before the Dissolution, but how soon before is not stated.

Associated with the hammerbeam trusses of this roof are three cambered tiebeams. It is believed that the arch-braced roof truss may have failed structurally by the time the Cotton family acquired the Abbey in AD 1536. These cambered tiebeams may have been inserted into the roof space not only to strengthen the trusses but also to provide support for the new ceiling. These three timbers show evidence for reuse by way of empty mortices which at one time may have taken joists.

### *Bedroom A, Oak room, and the Orange room - floor joists and wall-frames*

At the north end of the house are to be seen a series of timber-framed rooms at first- and attic-floor level. These are referred to as bedroom A, the Oak room, and the Orange room. Within them are the substantial remains of wall framing, some of it highly decorative, as well as floor joists. On stylistic grounds it is believed that these rooms may date to the late-sixteenth century.

In addition, samples were obtained from a small amount of oak paneling in the Orange room. Parts of this paneling, being in one of the more dilapidated and dangerous parts of the hall, and that most open to the elements, had fallen from the wall and become detached from its framing. The date of this plain square paneling is unknown. It has no diagnostic stylistic decoration, such as linen-fold, and the opportunity was taken to obtain tree-ring data from it. It was hoped that the data might contribute to local reference data, perhaps bridging the gap between building timber data, and that obtained from

local living oak trees. The boards were sampled by preparing exposed edges and read on a travelling stage and microscope. In due course the boards will be returned to site to be included in any programme of renovation and repairs.

#### *Attic roofs - rooms A8 / A10*

Immediately to the north of the Abbot's lodging is a small single-bay roof over attic rooms A8 and A10. This roof consists of two principal rafter trusses with collars, the northern truss also retaining a tiebeam. Between the trusses are found common rafter frames, the whole supporting single purlins. Some of these timbers have been cut, possibly to allow the insertion of a chimney stack. The date of these rooms was largely unknown, though there was some suggestion that they might be of late-sixteenth or early-seventeenth century date.

#### *Parkland trees*

Combermere Abbey is set in parkland with a variety of trees including a substantial number of mature oaks. Beyond the park the estate consists of a substantial acreage of arable and pastoral lands. During the winter of AD 2002 / 03 the opportunity was taken to sample a small number of the oak trees to provide material for a local reference chronology anchored to the present day. At the time of sampling it was hoped that any modern chronology that might be established could possibly help with the cross-matching and dating of any late post-medieval oak timber that the Abbey might contain, there being very little recent reference data available for north-west England. Samples were taken from twenty living oaks in a random sample from the grounds immediately around the Abbey.

#### *Softwood timbers*

It is believed that the late post-medieval development and alteration of Combermere Abbey continued into the eighteenth and nineteenth centuries. By this time the use of oak was declining, its place being taken by various conifers and other softwoods. This has been used extensively in the northern ranges. Sampling and analysis of this later material has been undertaken by The University of Sheffield Dendrochronology Laboratory who have a specialism in the dating of softwood and is the subject of a separate specialist report (Groves forthcoming).

Thus, after on-site discussions with Robin Green of Arrol and Snell Ltd, Architects, and in conjunction with the English Heritage brief, a total of ninety-seven samples was obtained from the available oak timbers of the Abbey itself. Eighty-six of these were obtained by coring, two by slicing loose timbers, and nine by reading exposed edges of oak paneling. Each building sample was given the code CBM-A (for Combermere, site "A"), and numbered 01 - 97. The twenty samples from the living trees were obtained with a Swedish increment corer, and though numbered 98 - 117, they were given the code CBM-"M" for Combermere "modern".

Building timbers were selected for sampling on the basis of their appearing to be integral to the individual structure under investigation, and for having sufficient rings for satisfactory analysis by tree-ring dating (see Appendix). Where possible timbers were also selected on the basis that they had sapwood, or at least the heartwood/sapwood boundary. This last requirement was not always available given that many of the wall-frame timbers, and particularly the floor joists, had been heavily trimmed very squarely cut, removing much of the sapwood. In some cases, again particularly with the floor joists, only small sections of timber were visible, it not being possible to lift the floorboards of some rooms because of collapsed material.

For the purposes of analysis, and in an attempt to provide dating for discrete structures, rooms or areas were treated as separate elements; Abbot's lodging hammer beams as one element, common rafters as

another, plus wall-frames and floor-frames, etc, of the other rooms. These elements were then sampled accordingly. The sampling programme attempted to obtain material from as wide a range of timber within each element as possible, in terms of structural features, to ensure that no earlier or later timbers went undetected.

In some cases it was not always possible to obtain this range. As indicated above, access to some timbers was difficult, the floor timbers of the Orange room for example, or in the floor-frame of the Oak room. In other instances it was not possible to core some timbers at all. This was particularly so with the party walls between the Oak and Orange rooms where the timbers are hidden beneath wall coverings and paneling. This is also the case with some of the external walls of these rooms, and the walls of the rooms above. The timbers of some walls and floors were also very loose and in danger of collapse. Such timbers could not be sampled.

It is thus strongly suggested that at such time that repairs or other building work is carried out, when wall coverings and floorboards might be removed, and safe and secure scaffold platforms are put in place, the timbers are inspected again. It may be possible to obtain samples from areas with better preservation of sapwood.

Where possible the approximate positions of the building timbers sampled are shown on drawings provided by English Heritage. Where necessary sketch plans were made on site by the authors. These are reproduced here as Figure 6a - e. The approximate positions of the living tree samples are shown on a map, Figure 7. Details of all the samples are given in Table 1. In this report the trusses, frames and other features have been numbered and described on a north - south, or east - west basis, as appropriate, except where otherwise indicated.

The Laboratory would like to take this opportunity of thanking the owner of Combermere Abbey, Mrs Sarah Callender-Becket, for allowing sampling and for being so enthusiastic about the project. We would also like to thank the House staff who were always most accommodating and very pleased to help. We would also like to thank Cathy Groves of Sheffield Dendrochronology Laboratory for her considerable help during the pre-sampling survey stage and at the time of sampling. We also thank Rob Green for not only providing much of the material used in the introductory paragraphs above, but also for his advice and discussion about the possible phasing of the timbers.

## Analysis

Each of 117 samples obtained, including those from the parkland oak trees, was prepared by sanding and polishing and their annual growth-ring widths were measured. The data of these measurements are given at the end of the report. These data were then compared with each other by the Litton/Zainodin grouping procedure (see appendix).

At a minimum *t*-value of 4.5 three main site chronologies can be reliably formed. The first of these site chronologies, CBMASQ01, consists of sixty-six samples and is 202 rings long, and represents every area of sampling at Combermere except for the roof of rooms A8 / A10. The relative positions of the cross-matching samples in this site chronology are shown by sampling area in last ring order in the bar diagram, Figure 8. Site chronology CBMASQ01 is dated against a number of reference chronologies as spanning the years AD 1363 to AD 1564. Evidence for this dating is given in the *t*-values of Table 2.

The second major site chronology, CBMASQ02, consists of eleven samples, all of them from the roof of rooms A8 / A10. The relative positions of the cross-matching samples in this site chronology are shown in the bar diagram Figure 9. This site chronology is 126 rings long, these being dated as spanning the years AD 1602 to AD 1727. Evidence for this dating is given in the *t*-values of Table 3.

Each of these site chronologies was then compared with the remaining seventeen ungrouped building timber samples. The seventeen ungrouped building samples were also compared individually with a full

range of reference chronologies. While some tentative cross-matching and dating was identified there was no cohesion or reliability to any of these, and all seventeen individual samples must remain undated for the moment. It may be possible to successfully date these if additional samples are taken during repair work when safe access is provided.

The third site chronology to form at a value of  $t=4.5$  comprises ten of the twenty samples from the living parkland oak trees, CBMMSQ01. The relative positions of the samples in this site chronology are shown in the bar diagram, Figure 10. These samples combine to form a site chronology of 247 rings which was dated against a number of reference chronologies as spanning the years AD 1756 to AD 2002.

### **Interpretation**

Analysis by dendrochronology has produced three main site chronologies, one of sixty-six samples being 202 rings long, CBMASQ01, the other of eleven samples being 126 rings long, CBMASQ02. These two site chronologies are dated as spanning the years AD 1363 to AD 1564, and AD 1602 to AD 1727 respectively. All areas of sampling are represented by these two site chronologies. The third site chronology, CBMMSQ01, consists of ten parkland oak trees. It is 247 rings long and spans the years AD 1756 to AD 2002.

#### *Roof over the Abbots lodging*

Interpretation of the sapwood on the dated samples of site chronology CBMASQ01 would indicate that the earliest major phase of felling is represented by timbers of the roof over the Abbots lodging or Library. Two samples from these timbers, samples CBM-A16 and A23, retain complete sapwood, that is, they have the last rings produced by the trees before they were felled. In both cases the last, complete, sapwood ring date is the same, this being AD 1502.

The relative position of the heartwood/sapwood boundary on most, but not all, of the samples from the roof, as shown in the bar diagram of Figure 8, varies by only twelve years. The ranges from relative position 113, AD 1475, on sample CBM-A26, to relative position 125, AD 1487, on sample CBM-A12. Such consistency of the heartwood/sapwood boundary is generally indicative of a group of trees cut in a single felling operation, in this case all being cut in AD 1502, or perhaps over a one or two year period at most.

A variation in the consistency of the heartwood/sapwood boundary might be seen on sample CBM-A28, this being at relative position 99, AD 1461. The felling date range of this individual does, however, cover AD 1502.

There are, however, some anomalies with the timbers from the roof, as seen in samples CBM-A03, CBM-A13, and CBM-A18. In the first instance the heartwood/sapwood boundary is at relative position 88, AD 1450, with the sample having a further sixteen extant sapwood rings, the last sapwood ring being dated to AD 1466. Were this timber felled along with all the others from the roof in AD 1502 it would have a total of 52 sapwood rings. Such a figure is very slightly higher than the usual maximum number of sapwood rings on mature oaks, 50, and while not unknown, the timber represented might have been felled earlier and is possibly a reused piece. There was, though, no evidence for reuse seen at the time of sampling.

In the second instance, sample CBM-A13, the heartwood/sapwood boundary is at relative position 127, AD 1489. This timber would have had only 13 sapwood rings were it felled in AD 1502 too. Such a figure is very slightly lower than the usual minimum number of sapwood rings, 15, on mature oaks. These interpretations on the relative positions of the heartwood/sapwood boundaries of the samples is based on a 95% confidence range of 15 - 50 sapwood rings for mature oaks. This thus means that the

sapwood on one in twenty samples is likely to lie outside this range.

In the final case sample CBM-A18 has a heartwood/sapwood boundary at relative position 182, AD 1544. The timber this sample represents is thus unlikely to have been felled before AD 1559, some fifty-seven years later at least than all the other dated timbers in this roof. It is probable that this is a later repair timber. Truss 6 shows clear signs of having been altered.

Another period of timber felling is probably represented by the cambered tiebeams, or ceiling beams, of the Abbot's lodging. It is believed that the three timbers were inserted into this roof to strengthen the failing hammer beam trusses and to allow for the insertion of a ceiling to the Abbot's lodging. All three tiebeams were sampled and dated, samples CBM-A86 - A88. The average heartwood ring date on these three is AD 1544. Using a 95% confidence limit of 15 - 50 for the number of sapwood rings on mature oaks again would give the timbers represented an estimated felling date in the range AD 1559 - 94.

#### *Bedroom A / Oak room*

Interpretation of the samples in site chronology CBMASQ01 also dates the felling of the timbers of the wall and floor-frame of bedroom A, and the floor-frame of the Oak sitting room, samples CBM-A42 - A64. Four of the twenty-three samples from this area retain complete sapwood, CBM-A43, A61, A63, and A64. In each case the last measured complete sapwood ring date is the same, AD 1564. Given that the relative position of the heartwood/sapwood boundaries on all the samples from bedroom A and the Oak room is similar, varying by only thirteen years, and averaging AD 1542, it is likely that all the timbers were felled at the same time, in AD 1564, or at least over a very short period of time about then.

#### *Orange room*

The dated felling is also represented by the timbers of the floor and external wall-framing of the Orange room, samples CBM-A65 - A81, and by the one dated sample from the inserted timber of the room, A11, above, sample CBM-A83. Due to the heavily trimmed nature of these timbers, only four samples in this group have the heartwood/sapwood boundary, the average date of these being AD 1531. Using a 95% confidence limit of 15 - 50 for the number of sapwood rings on mature oaks would give the timbers represented an estimated felling date in the range AD 1546 - 81. However, given that the heartwood/sapwood boundaries of these samples are earlier than those on samples from bedroom A and the Oak room (AD 1542, see above), it is probably that their felling took place before those of bedroom A and the Oak room, ie, no later than AD 1564.

However, it is quite possible that the majority of timbers discussed above, particularly those of the wall and floor-frame of bedroom A, the floor joists of the Oak room, and the inserted timbers, and possible repair of the roof of the Abbot's lodging, were all felled as part of a short programme of tree cutting. The relative position of the heartwood/sapwood boundaries on these samples is very similar and not inconsistent with trees having a very similar, if not virtually identical, felling date of *c* AD 1564. The timbers of the Orange room may be slightly earlier by perhaps ten or twelve years.

#### *Rooms A8 / A10*

The latest phase of felling detected is represented by the eleven samples (CBM-A31 - A41) from the timbers of the roof of rooms A8 / A10 in site chronology CBMASQ02. Despite the friable nature of the timber due to damp and decay, four of the samples in this site chronology, CBM-A31, A32, A33, and A39 all retain complete sapwood. Three of the samples have the same complete sapwood ring date, AD 1727. During sampling it was noted that small amounts of sapwood were lost from other samples where it was complete. Consequently it is almost certain that all but one of the timbers were felled at this time.



The fourth sample with complete sapwood is CBM-A39, having a last, complete, sapwood ring date of AD 1702. There is no evidence that this timber is reused and it probably represents a timber felled for earlier works and kept in store.

### *Parkland trees*

The parkland trees appear to show considerable variation in their ring patterns. Some samples, mostly those that cross-match with each other and date, show clear moderately wide rings. Other samples show either very indistinct rings, or have bands of compacted very narrow, and almost unmeasurable rings. There does appear to be a tendency for groups of adjacent trees to show these problems. The ten cross-matching and dated samples form a single site chronology of 247 rings spanning AD 1756 to AD 2002.

### Conclusion

The dating of the two site chronologies created from the Combermere material, CBMASQ01 and CBMASQ02, suggests that three major programmes of work, in the early-sixteenth century, in the mid-sixteenth century, and in the early-eighteenth century are represented.

The earliest programme of work is that of the roof of the Abbot's lodging, including the three false hammer beam trusses. The timbers here were probably all felled in AD 1502, though one timber might have been felled earlier and either reused or kept in store. The very early sixteenth-century date for this roof is later than the fifteenth-century date proposed by Pevsner (1971) and generally ascribed to it. Such a date does, however, fit in with that proposed in the site listing description, and indeed might be a little earlier than suggested there. The analysis indicates that some development work was certainly undertaken prior to the Dissolution.

The next major programme of works is of mid-sixteenth-century date. This work includes the timbers for the wall- and floor-frames of bedroom A, the floor-frame of the Oak room, and the timbers of the inserted ceiling of the Abbot's lodging. These timbers appear to have been cut no later than AD 1564.

This mid-sixteenth century programme of work also includes the timbers from the floor and wall-frame of the Orange room, and one timber of the room above. However, although the overall estimated felling date range for the Orange room timbers is AD 1545 – 80, they are likely to have been cut before those of bedroom A and the Oak room. This is because the relative position of the average heartwood/sapwood boundary of those samples from the Orange room is earlier (AD 1531) than that on the samples from bedroom A and the Oak room (AD 1542). Given the extent of work undertaken it might not be unreasonable to assume that timber was cut as and when needed rather than all at once in a single felling. The date plaque may indicate completion of the superstructure by AD 1563, but it is evident that some timber was still being felled in AD 1564.

The analysis of these timbers includes the samples from the oak panels of the Orange room. Six of these samples cross-match within site chronology CBMASQ01. The latest dated ring on any of them is AD 1542, on sample CBM-A90. Given the nature of the samples, paneling, none of them have any apparent sapwood. It is thus not possible to say with certainty when the timber used for them was felled. It is unlikely, however, to have been felled before AD 1557, this figure being based on a minimum of 15 sapwood rings.

It thus appears entirely possible that this paneling is part of the late sixteenth-century phase of work. If it can be shown, perhaps structurally, that the paneling was affixed to the structural timbers of the Orange room it would suggest that they were in place to receive the panels at least by AD 1557. What is perhaps a little surprising is the plain modern stylistic taste of the panels in their simple unmoulded and undecorated form. Of further interest is the fact that the timber used for them appears to come from the same source as that used for the building timbers of this date. The panels are certainly not made of

foreign material which was believed to be a possibility.

It is worth noting that the three tiebeams of the inserted roof of the Abbott's lodgings have empty mortices in their side faces. This has led to the suggestion that they are reused in their present position. If this were the case, and given that they may not have been cut until the late-sixteenth century, it would mean that the Library ceiling was not in place until perhaps the early seventeenth-century at the earliest, allowing time for these timbers to have been used somewhere else first. Such a date for the ceiling would perhaps be inconsistent with the style of painting. It is thus perhaps possible that the empty mortices were originally designed to take the common ceiling joists of this ceiling, with the design being changed during insertion.

In the context of alterations or repairs to the roof of the Abbot's lodging, it might be worth noting that the estimated felling date of the timber used for the inserted tiebeams or ceiling is the same as that for the timber represented by the anomalous sample CBM-A18. This sample is from the tiebeam of truss 6, which, as indicated earlier, shows signs of alteration. However, although the timbers are of the same date there is no other indication that CBM-A18 is related to the cranked tiebeams of the inserted ceiling. Sample CBM-A18 does not cross-match particularly well with any of the other three samples, maximum value being  $t=4.2$ .

The final phase of felling detected is that of the timbers for the roof of rooms A8 / A10. Most of these were all cut in AD 1727, though one was certainly felled earlier in AD 1702.

We thus have strong indications that work was undertaken on parts of the house in the very early sixteenth century, perhaps slightly later than might have been expected on stylistic and historical grounds, but also earlier than others have suggested. Further work was then carried out during the third quarter of the same century, and is almost certainly that commemorated by the date plaque of AD 1563. It is perhaps something of a surprise that there is no certain evidence from the tree-ring analysis that any alteration work was undertaken in the immediate post-Dissolution period by Sir George Cotton, given that he was granted Combermere in AD 1536. There is also no indication for the reuse of any timber from the earlier monastic building.

The next phase of development is to be seen in the early eighteenth century, probably representing the repair or replacement of the gabled roofs. It is perhaps in this context that the S and N Buck view of the house, done in AD 1727 (the same date as the eighteenth century timber felling), and the *c* AD 1730 oil painting, is to be seen. The Cottons appear desirous to have their contemporary tastes and style recorded.

From the oak material obtained at Combermere two good chronologies have been formed. Site chronology CBMASSQ01 in particular is long and well replicated, while site chronology CBMASQ02 is particularly useful in that it continues forward into a relatively late period. At this later time it starts to become more difficult to find datable material for reference chronologies.

Indeed, it will be seen from Table 3 that all the reference chronologies used for dating are from the East Midlands, and are, in fact, constituent parts of the East Midlands master chronology. This in itself illustrates the need for reference chronologies from other regions which are anchored into the present day. It is possible that with further work on buildings and living trees in this region a chronology continuous from the present day might be formed for north-west England.

It would appear that much of the oak timber felled for use at Combermere Abbey came from the same woodland, or from woods very close to each other. This is particularly so with the early sixteenth century material used in for the roof of the Abbott's lodgings. Cross-matches with values of  $t=6$  and 7 are common-place between samples from this roof, with values in excess of  $t=10$ , 11 and 12 also being seen.

There is also high  $t$ -value cross-matching between the samples of the later sixteenth-century felling, and between those of the eighteenth-century material. This again suggests that the trees for each phase were

growing very close to each other. The exact location of this woodland is of course unknown. However, it is likely to be a local north-west England source, as evidenced by the cross-matches with the reference material in Tables 2 and 3. It may be seen that the cross-matches with the highest *t*-values are against reference chronologies from northern England, and in particular a reference chronology from Shropshire.

A total of thirty samples remain undated. Twenty of them are from the Abbey itself. Some of these are short with low, though still satisfactory, numbers of rings; other samples show distorted or stressed rings. It is probable that these bands of narrow or distorted rings make cross-matching difficult and account for the lack of dating. It is possible that with further sampling these presently undated ones might be cross-matched.

A further ten undated samples, a surprisingly high number, are represented by samples from the parkland oak trees. This lack of cross-matching and dating is almost certainly due to the indistinct nature of the rings on these samples, as well as the compaction and distortion that the ring shows. It is perhaps notable from the map. Figure 7, that the majority of undated samples are from closely adjacent clumps of trees. It is possible that some malign effect has influenced this closely associated group.

As suggested above, if and when renovation work is undertaken at Combermere it is strongly recommended that a further inspection of presently inaccessible timbers should be undertaken with a view to further sampling. This would be particularly useful with the wall-framing of the Orange room, and the room above. At the time of sampling for this programme this area was particularly unsafe. The timbers of the adjacent bedrooms might also repay further sampling when floors boards might be more easily lifted.

## **Bibliography**

- Baillie, M G L, and Pilcher, J R, 1982 unpubl A master tree-ring chronology for England, unpubl computer file *MGB-EOI*, Queen's Univ, Belfast
- Groves, C, 1997 *Dendrochronological Analysis of Timbers from Inglefield Hall Barn, Shropshire*, Centre for Archaeol Rep, **91/97**
- Groves, C, forthcoming *Dendrochronological Analysis of Conifer Timbers from Combermere Abbey, near Whitchurch, Cheshire*, Centre for Archaeol Rep
- Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1992 List 46 nos 6, 14a-d - Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect*, **23**, 51 – 6
- Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1994 List 57 nos 4a, 10a - Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect*, **25**, 36 – 40
- Howard, R E, Laxton, R R, Litton, C D, Morrison A, Sewell, J, and Hook, R, 1995 List 61 no 1 - Nottingham University Tree-Ring Dating Laboratory: Derbyshire, Peak Park and RCHME dendrochronological Survey 1994 - 95, *Vernacular Architect*, **26**, 53 – 4
- Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1995 unpubl site chronology from Cropwell Bishop, unpubl computer file *CRWBSQ03*, Nottingham University Tree-Ring Dating Laboratory
- Howard, R E, Laxton, R R, and Litton, C D, 1997 List 75 no 9 - Nottingham University Tree-Ring Dating Laboratory results, *Vernacular Architect*, **28**, 124 –7
- Howard, R E, Laxton, R R, and Litton, 1998 *Tree-ring analysis of timbers from 26 Westgate Street, Gloucester*, Anc Mon Lab Rep, **43/98**
- Howard, R E, Laxton, R R, and Litton, forthcoming *Tree-ring analysis of timbers from the Little Castle, Bolsover Castle, Bolsover, Derbyshire*, Centre for Archaeol Rep
- Laxton, R R, and Litton, C D, 1988 An East Midlands master tree-ring chronology and its use for dating vernacular buildings, University of Nottingham, Dept of Classical and Archaeol Studies, Monograph Series, **III**
- Pevsner, N, and Hubbard E, 1971 *The Buildings of England: Cheshire*, London (Penguin)
- Siebenlist-Kerner, V, 1978 Chronology, 1341-1636, for hillside oaks from Western England and Wales, in *Dendrochronology in Europe* (ed J M Fletcher), BAR Int Ser, **51**, 295-301
- Tyers, I, 1997 *Tree-ring Analysis of Timbers from Sinai Park, Staffordshire*, Anc Mon Lab Rep, **80/97**
- Tyers, I, and Groves C, 1999 unpubl England London, unpubl computer file *LONI175*, Sheffield Univ

Table 1: Details of samples from Combermere Abbey, near Whitchurch, Cheshire

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
	Abbot's lodging roof					
CBM-A01	East strut, truss 2	97	12	AD 1400	AD 1484	AD 1496
CBM-A02	Lower stud no 2, truss 2	71	h/s	AD 1406	AD 1476	AD 1476
CBM-A03	East principal rafter, truss 2	80	16	AD 1387	AD 1450	AD 1466
CBM-A04	Collar, truss 2	60	h/s	AD 1425	AD 1484	AD 1484
CBM-A05	Lower stud no 5, truss 2	87	h/s	AD 1394	AD 1480	AD 1480
CBM-A06	West arched brace, truss 2	78	h/s	AD 1399	AD 1476	AD 1476
CBM-A07	East lower purlin, truss 2 - 3	84	h/s	AD 1396	AD 1479	AD 1479
CBM-A08	East lower purlin, truss 3 - 4	85	no h/s	AD 1373	-----	AD 1457
CBM-A09	West principal rafter, truss 4	95	h/s	AD 1388	AD 1482	AD 1482
CBM-A10	East principal rafter, truss 4	100	14	AD 1388	AD 1473	AD 1487
CBM-A11	West principal rafter, truss 3	77	3	AD 1405	AD 1478	AD 1481
CBM-A12	North-east smoke-hood rafter	91	4	AD 1401	AD 1487	AD 1491
CBM-A13	South-east smoke-hood rafter	96	h/s	AD 1394	AD 1489	AD 1489
CBM-A14	Smoke-hood ridge beam	111	h/s	-----	-----	-----
CBM-A15	Collar, truss 5	55	h/s	-----	-----	-----
CBM-A16	West principal rafter, truss 6	110	17C	AD 1393	AD 1485	AD 1502
CBM-A17	Collar, truss 6	112	18	AD 1386	AD 1479	AD 1497
CBM-A18	Tiebeam, truss 6	71	h/s	AD 1474	AD 1544	AD 1544
CBM-A19	East arch brace, truss 6	89	h/s	AD 1390	AD 1478	AD 1478
CBM-A20	West common rafter no 3, truss 3 - 4	69	no h/s	AD 1386	-----	AD 1454
CBM-A21	West common rafter no 4, truss 3 - 4	54	no h/s	-----	-----	-----
CBM-A22	West common rafter no 5, truss 3 - 4	80	3	AD 1406	AD 1482	AD 1485
CBM-A23	East common rafter no 2, truss 3 - 4	105	19C	AD 1398	AD 1483	AD 1502
CBM-A24	West common rafter no 4, truss 5 - 6	54	no h/s	AD 1384	-----	AD 1437
CBM-A25	West common rafter no 5, truss 5 - 6	114	5	AD 1363	AD 1471	AD 1476

Table 1: continued

Sample Number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
Abbot's lodging roof continued						
CBM-A26	West principal rafter, truss 1	89	h/s	AD 1387	AD 1475	AD 1475
CBM-A27	East principal rafter, truss 1	91	h/s	AD 1386	AD 1476	AD 1476
CBM-A28	Upper stud no 2, truss 1	85	29	AD 1406	AD 1461	AD 1490
CBM-A29	East brace, truss 1	60	no h/s	AD 1403	-----	AD 1462
CBM-A30	Lower stud no 3, truss 1	74	no h/s	AD 1392	-----	AD 1465
Attic/roof room 8/10						
CBM-A31	Collar, truss 1	121	23C	AD 1607	AD 1704	AD 1727
CBM-A32	West principal rafter, truss 1	106	33C	AD 1622	AD 1694	AD 1727
CBM-A33	East principal rafter, truss 1	93	15C	AD 1635	AD 1712	AD 1727
CBM-A34	West strut, truss 1	117	20	AD 1607	AD 1703	AD 1723
CBM-A35	West principal rafter, truss 1A	117	27c	AD 1609	AD 1698	AD 1725
CBM-A36	East principal rafter, truss 2	54	no h/s	AD 1616	-----	AD 1669
CBM-A37	West principal rafter, truss 2	123	23c	AD 1603	AD 1702	AD 1725
CBM-A38	West purlin. Truss 1 - 2	124	18c	AD 1602	AD 1707	AD 1725
CBM-A39	East purlin. Truss 1 - 2	108	24C	AD 1595	AD 1678	AD 1702
CBM-A40	West stud post, truss 2	86	5	AD 1623	AD 1703	AD 1708
CBM-A41	West common rafter no 2, truss 1 - 2	71	25	AD 1654	AD 1699	AD 1724

Table 1: continued

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
Bedroom A - floor joists						
CBM-A42	North joist no 1	103	no h/s	AD 1431	-----	AD 1533
CBM-A43	South joist no 2	93	27C	AD 1472	AD 1537	AD 1564
CBM-A44	South joist no 7	76	6	AD 1470	AD 1539	AD 1545
CBM-A45	North joist no 7	91	no h/s	AD 1439	-----	AD 1529
CBM-A46	South joist no 5	65	no h/s	-----	-----	-----
CBM-A47	North joist no 11	96	24	-----	-----	-----
CBM-A48	Main central east - west beam	97	no h/s	AD 1418	-----	AD 1514
CBM-A49	North joist no 12	73	no h/s	AD 1463	-----	AD 1535
Bedroom A - wall-framing						
CBM-A50	East wall, mid rail at north end	81	h/s	AD 1458	AD 1538	AD 1538
CBM-A51	North wall, principal wall post no 3 (from E)	110	no h/s	AD 1404	-----	AD 1513
CBM-A52	North wall, lower stud post	111	h/s	AD 1428	AD 1538	AD 1538
CBM-A53	East wall, principal wall post no 1 (from N)	63	h/s	-----	-----	-----
CBM-A54	North wall, principal wall post no 4 (from E, corner post)	58	no h/s	-----	-----	-----
CBM-A55	East wall, principal wall post no 2 (from N)	112	20	AD 1450	AD 1541	AD 1561
CBM-A56	North wall upper stud post	144	no h/s	AD 1380	-----	AD 1523
CBM-A57	North wall, mid rail at west end	66	h/s	-----	-----	-----
CBM-A58	East wall, mid rail at south end	88	h/s	AD 1456	AD 1543	AD 1543
CBM-A59	Loose timber	96	no h/s	-----	-----	-----
CBM-A60	Loose timber	86	no h/s	-----	-----	-----

Table 1: continued

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
Oak room - floor joists						
CBM-A61	North joist no 10	55	14C	AD 1510	AD 1550	AD 1564
CBM-A62	South joist no 1	65	no h/s	AD 1458	-----	AD 1522
CBM-A63	North joist no 8	54	15C	AD 1511	AD 1549	AD 1564
CBM-A64	North joist no 5	64	16C	AD 1501	AD 1548	AD 1564
Orange room - floor joists						
CBM-A65	South wall joist	69	h/s	AD 1469	AD 1537	AD 1537
CBM-A66	Joist no 1 (from south)	62	h/s	AD 1464	AD 1525	AD 1525
CBM-A67	Joist no 2	54	no h/s	AD 1436	-----	AD 1489
CBM-A68	Joist no 3	57	no h/s	AD 1444	-----	AD 1500
CBM-A69	Joist no 4	59	no h/s	AD 1387	-----	AD 1445
CBM-A70	Joist no 5	80	no h/s	AD 1439	-----	AD 1518
CBM-A71	Joist no 11	63	no h/s	AD 1387	-----	AD 1449
CBM-A72	Joist no 13	78	no h/s	AD 1390	-----	AD 1467
CBM-A73	Joist no 14	68	no h/s	AD 1435	-----	AD 1502
Orange room – wall infill						
CBM-A74	South main post of infill timbers	96	no h/s	AD 1384	-----	AD 1479
CBM-A75	Mid-rail to infill	54	h/s	-----	-----	-----
CBM-A76	Wall plate / floor beam	54	no h/s	AD 1422	-----	AD 1475
CBM-A77	Lower stud post	111	no h/s	AD 1406	-----	AD 1516



Table 1: continued

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
Orange room – wall infill						
CBM-A78	North main post (corner post) of infill timbers	67	h/s	AD 1465	AD 1531	AD 1531
CBM-A79	Rail to corner post	66	no h/s	-----	-----	-----
CBM-A80	Infill piece	54	h/s	-----	-----	-----
CBM-A81	Upper rail	56	no h/s	-----	-----	-----
Other timbers						
CBM-A82	Post to north west corner of room over Orange room	54	h/s	-----	-----	-----
CBM-A83	Inserted post, room over Orange room	124	h/s	AD 1407	AD 1530	AD 1530
CBM-A84	Post to rear of chimney above Orange room	54	h/s	-----	-----	-----
CBM-A85	Post to rear of chimney above Orange room	64	h/s	-----	-----	-----
Abbott's Lodging roof – inserted tiebeams						
CBM-A86	Cranked tiebeam no. 1	106	h/s	AD 1440	AD 1545	AD 1545
CBM-A87	Cranked tiebeam no. 2	149	h/s	AD 1397	AD 1545	AD 1545
CMB-A88	Cranked tiebeam no. 3	91	h/s	AD 1545	AD 1544	AD 1544
Orange room – oak wall panels						
CBM-A89	Wall panel	118	no h/s	AD 1409	-----	AD 1526
CBM-A90	Wall panel	69	no h/s	AD 1474	-----	AD 1542
CMB-A91	Wall panel	58	no h/s	AD 1481	-----	AD 1538

Table 1: continued

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
Orange room – oak wall panels continued						
CBM-A92	Wall panel	58	no h/s	-----	-----	-----
CBM-A93	Wall panel	54	no h/s	-----	-----	-----
CBM-A94	Wall panel	54	no h/s	AD 1484	-----	AD 1537
CMB-A95	Wall panel	102	no h/s	AD 1416	-----	AD 1517
CBM-A96	Wall panel	80	no h/s	-----	-----	-----
CBM-A97	Wall panel	88	no h/s	AD 1441	-----	AD 1528
Modern tree samples						
CMB-M98	Parkland oak tree 1	81	38C	-----	-----	-----
CBM-M99	Parkland oak tree2	63	no h/s	-----	-----	-----
CBM-M100	Parkland oak tree3	150	22	-----	-----	-----
CBM-M101	Parkland oak tree4	104	no h/s	-----	-----	-----
CMB-M102	Parkland oak tree5	141	21	-----	-----	-----
CBM-M103	Parkland oak tree6	100	no h/s	-----	-----	-----
CMB-M104	Parkland oak tree7	179	28C	AD 1824	AD 1974	AD 2002
CBM-M105	Parkland oak tree8	247	47C	AD 1756	AD 1955	AD 2002
CMB-M106	Parkland oak tree9	215	24C	AD 1788	AD 1978	AD 2002
CBM-M107	Parkland oak tree10	187	25C	AD 1816	AD 1977	AD 2002
CMB-M108	Parkland oak tree11	112	16C	AD 1891	AD 1986	AD 2002
CBM-M109	Parkland oak tree12	145	24C	AD 1858	AD 1978	AD 2002
CMB-M110	Parkland oak tree13	95	21C	-----	-----	-----
CBM-M111	Parkland oak tree14	89	13C	-----	-----	-----
CMB-M112	Parkland oak tree15	128	35C	AD 1875	AD 1967	AD 2002

Table 1: continued

Sample number	Sample location	Total rings	*Sapwood rings	First measured ring date	Last heartwood ring date	Last measured ring date
Modern tree samples continued						
CBM-M113	Parkland oak tree16	57	no h/s	-----	-----	-----
CMB-M114	Parkland oak tree17	71	no h/s	-----	-----	-----
CBM-M115	Parkland oak tree18	121	19C	AD 1882	AD 1983	AD 2002
CMB-M116	Parkland oak tree19	139	20C	AD 1864	AD 1982	AD 2002
CBM-M117	Parkland oak tree 20	188	11	AD 1802	AD 1978	AD 1989

h/s = heartwood/sapwood boundary is last ring on sample  
 C = complete sapwood retained on sample  
 c = complete sapwood on timber, all or part lost during sampling

Table 2: Results of the cross-matching of site chronology CBMASQ01 and relevant reference chronologies when first ring date is AD 1363 and last ring date is AD 1564

Reference chronology	Span of chronology	<i>t</i> -value	
Inglefield Hall Barn, Salops	AD 1341 – 1566	16.9	( Groves 1997 )
East Midlands	AD 882 – 1981	12.2	( Laxton and Litton 1988 )
England	AD 401 – 1981	10.3	( Baillie and Pilcher 1982 unpubl )
Sinai Park, Staffs	AD 1227 – 1750	9.9	( Tyers 1997 )
26 Westgate St, Gloucester	AD 1399 – 1622	9.0	( Howard <i>et al</i> 1998 )
Ordsall Hall, Salford, Cheshire	AD 1385 – 1512	9.0	( Howard <i>et al</i> 1994 )
Wales and West Midlands	AD 1341 – 1636	8.9	( Siebenlist-Kerner 1978 )
Speke Hall, The Wirral, Cheshire	AD 1387 – 1574	8.7	( Howard <i>et al</i> 1992 )
England London	AD 413 – 1728	8.2	( Tyers and Groves 1999 unpubl )

Table 3: Results of the cross-matching of site chronology CBMASQ02 and relevant reference chronologies when first ring date is AD 1602 and last ring date is AD 1727

Reference chronology	Span of chronology	<i>t</i> -value	
Bolsover, Little Castle, Derbys	AD 1532 – 1749	11.9	( Howard <i>et al</i> forthcoming )
East Midlands	AD 882 – 1981	9.0	( Laxton and Litton 1988 )
Sinai Park, Staffs	AD 1227 – 1750	8.9	( Tyers 1997 )
St John's St, Wirksworth, Derbys	AD 1586 – 1676	8.7	( Howard <i>et al</i> 1995 )
Home Farm, Formark, Derbys	AD 1605 – 1752	7.6	( Howard <i>et al</i> 1992 )
Brewhouse Yard, Nottm	AD 1544 – 1701	7.6	( Howard <i>et al</i> 1994 )
Cropwell Bishop, Notts	AD 1604 – 1703	7.5	( Howard <i>et al</i> 1995 unpubl )
Ragnall barn, Ragnall, Notts	AD 1607 – 1717	6.5	( Howard <i>et al</i> 1997 )
England	AD 401 – 1981	6.4	( Baillie and Pilcher 1982 unpubl )
England London	AD 413 – 1728	5.7	( Tyers and Groves 1999 unpubl )

Table 4: Results of the cross-matching of site chronology CBMMSQ01 (parkland oak tree samples) and relevant reference chronologies when first ring date is AD 1756 and last ring date is AD 2002

Reference chronology	Span of chronology	<i>t</i> -value	
East Midlands	AD 882 – 1981	7.2	( Laxton and Litton 1988 )
Sherwood Forest, Notts	AD 1426 – 1981	6.4	( Laxton and Litton 1988 )
Thorseby Park, Notts	AD 1810 – 1976	6.3	( Laxton and Litton 1988 )
Bradgate Park, Leics	AD 1595 – 1975	5.9	( Laxton and Litton 1988 )

Figure 1: Map to show general location of Combermere Abbey

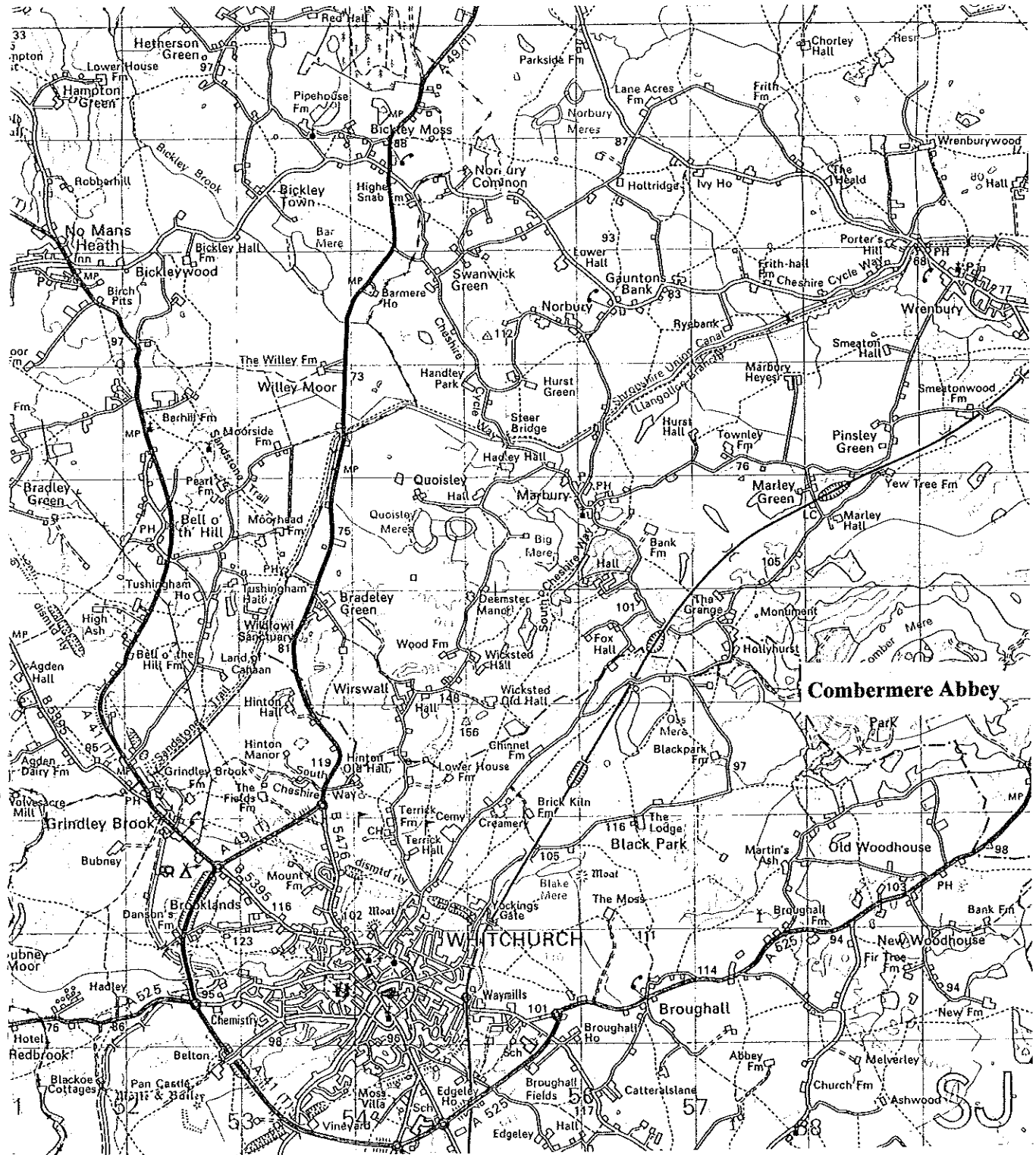


Figure 2: Map to show specific location of Combermere Abbey

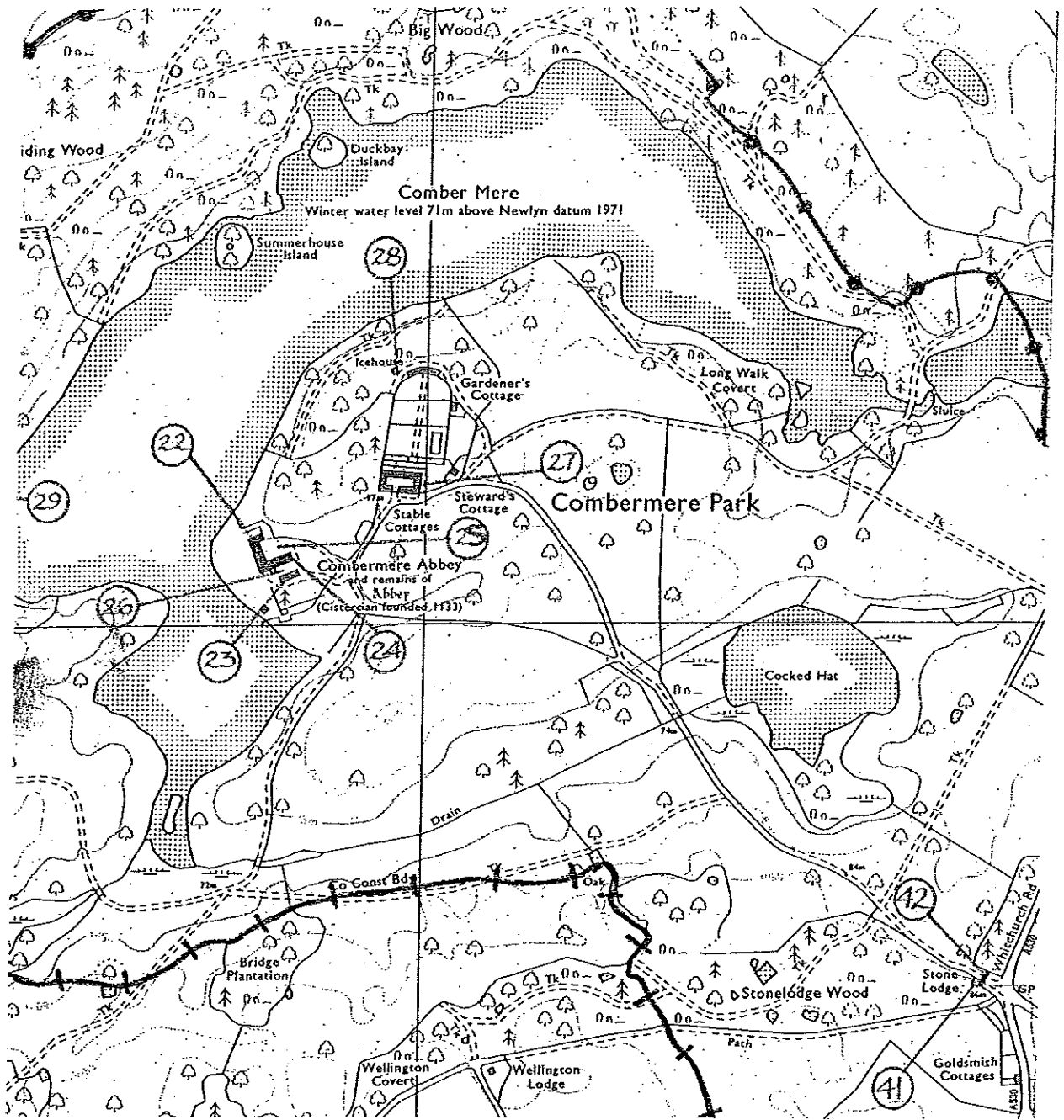
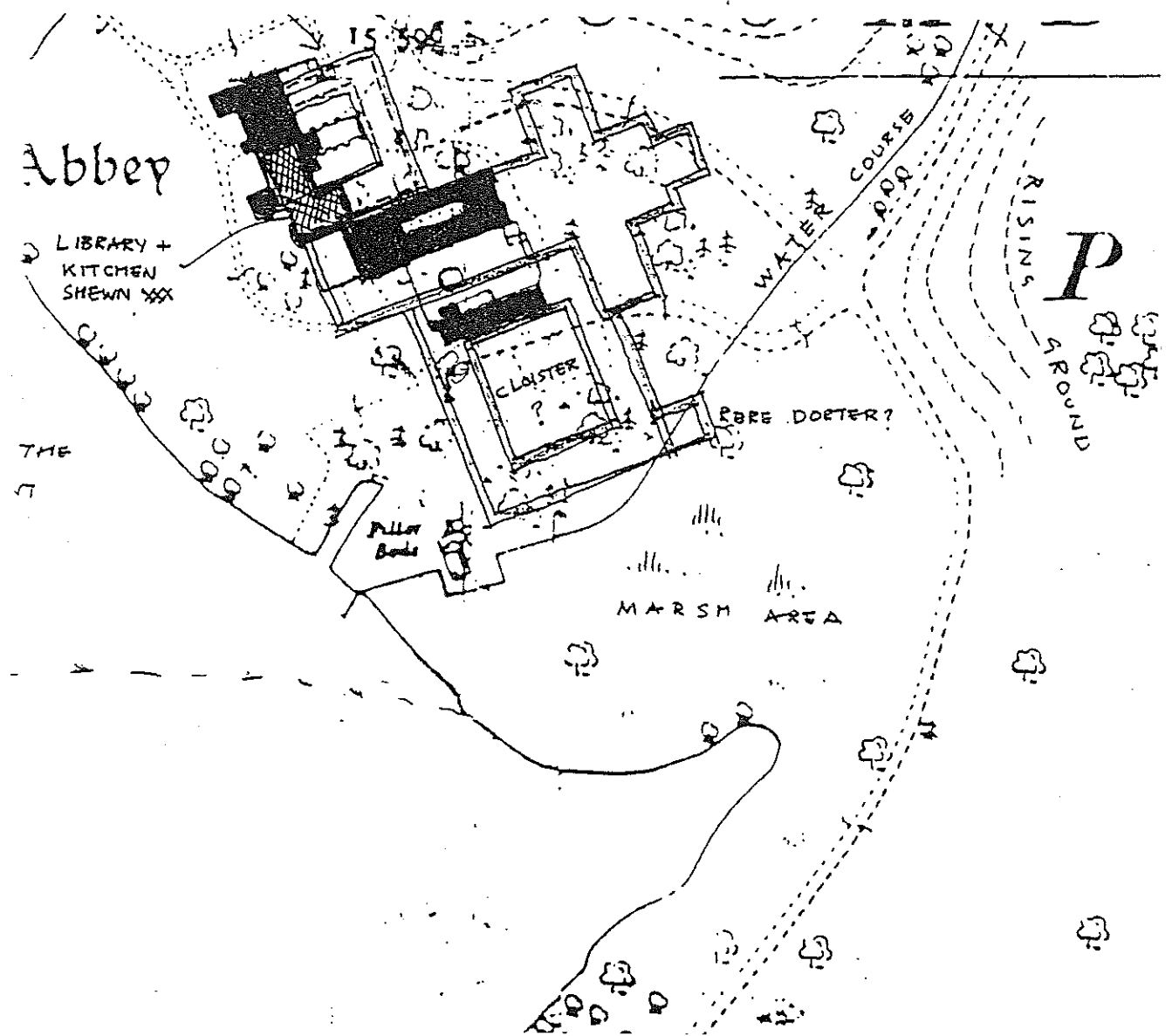


Figure 3: Plan to show possible arrangement of Abbey buildings





**Figure 4: Engraving by S and N Buck dated AD 1727  
showing the east façade of Combermere Abbey**

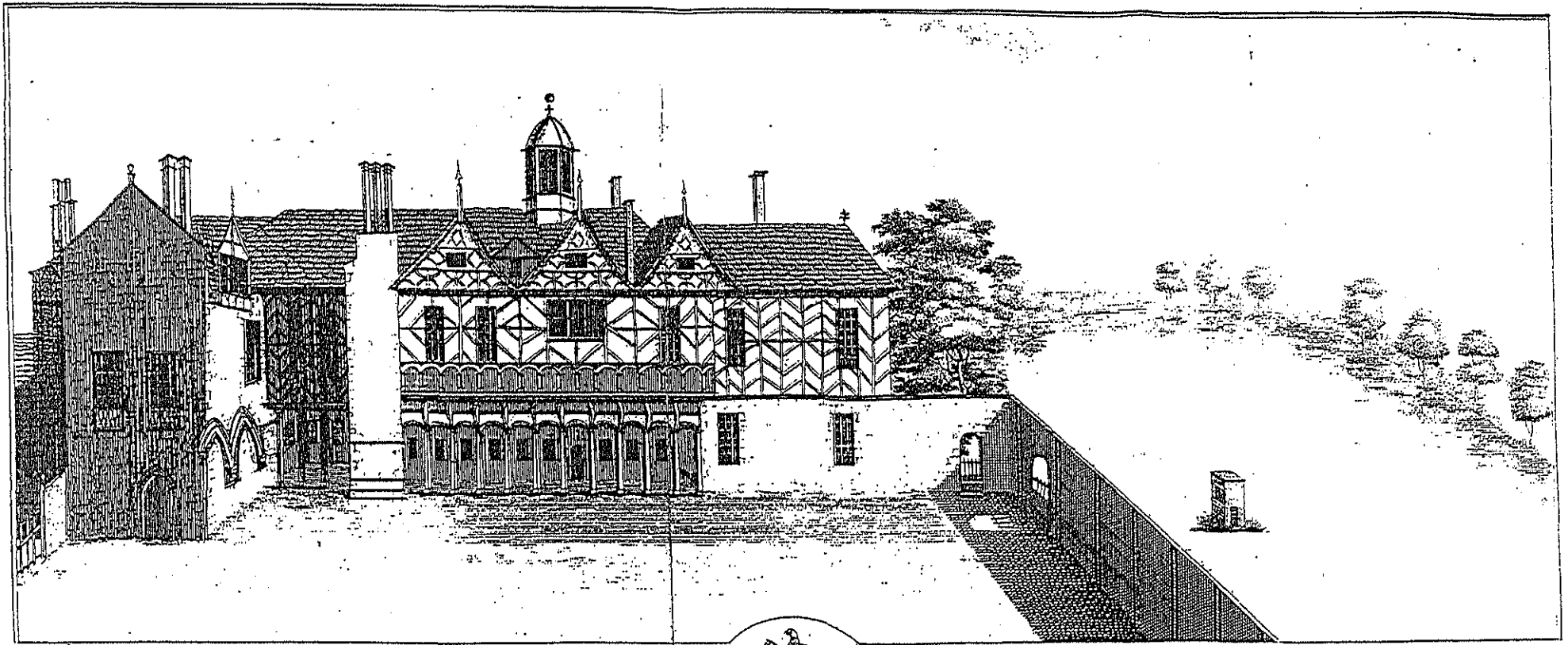


Figure 5a: Plan of the first floor to show areas of sampling

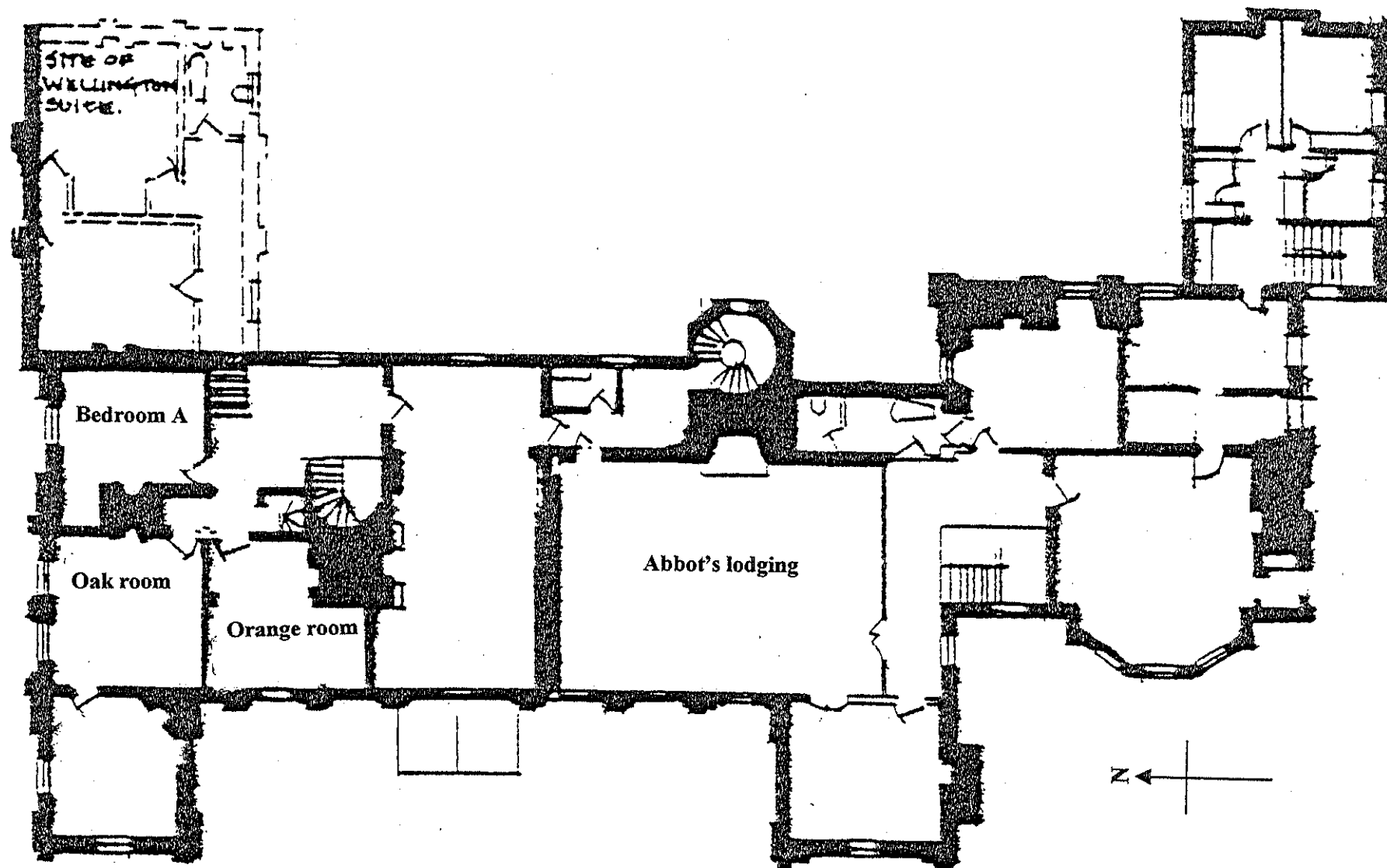


Figure 5b: Plan of the attic to show areas of sampling

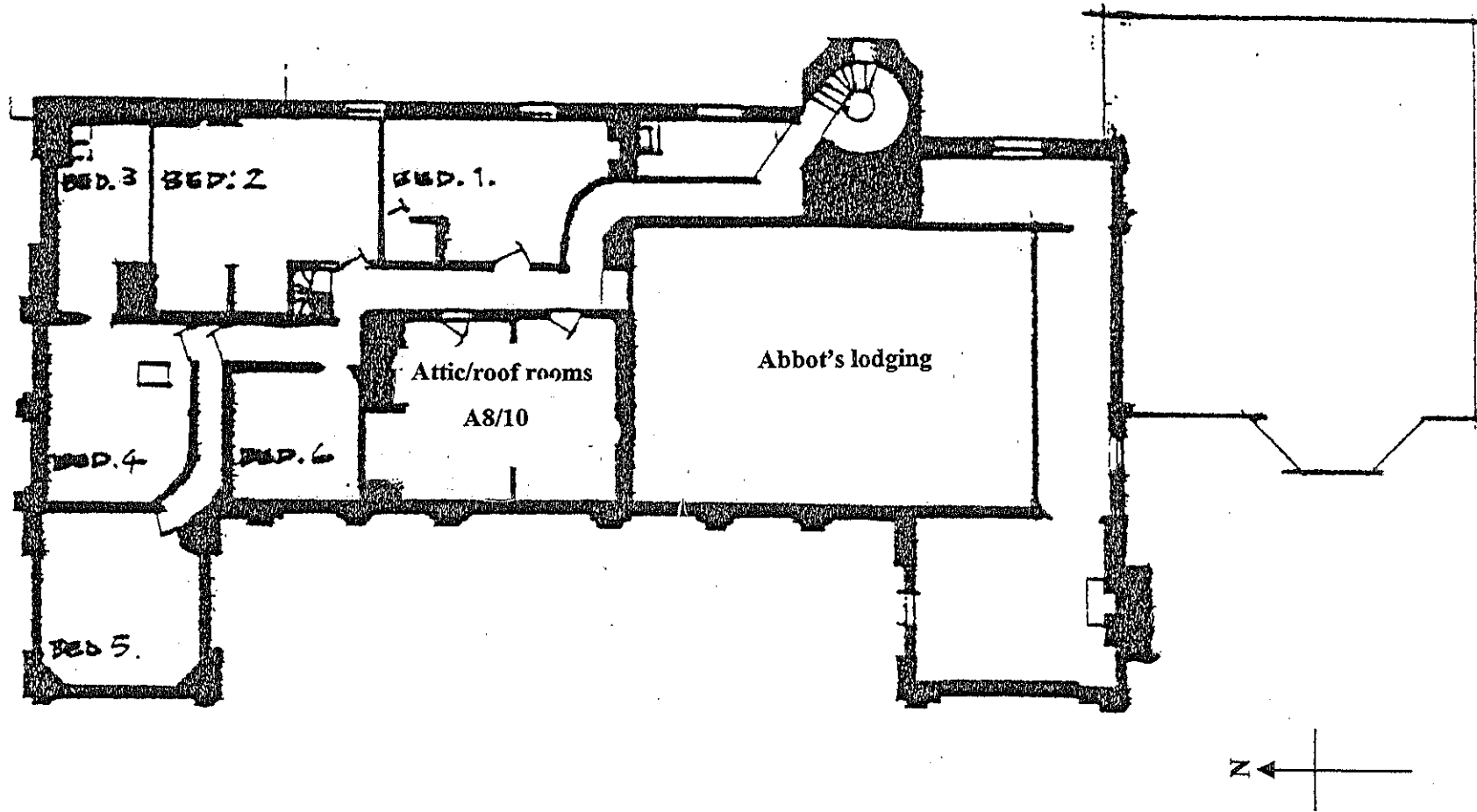


Figure 6a: Plan of attic areas to show approximate positions of timbers sampled

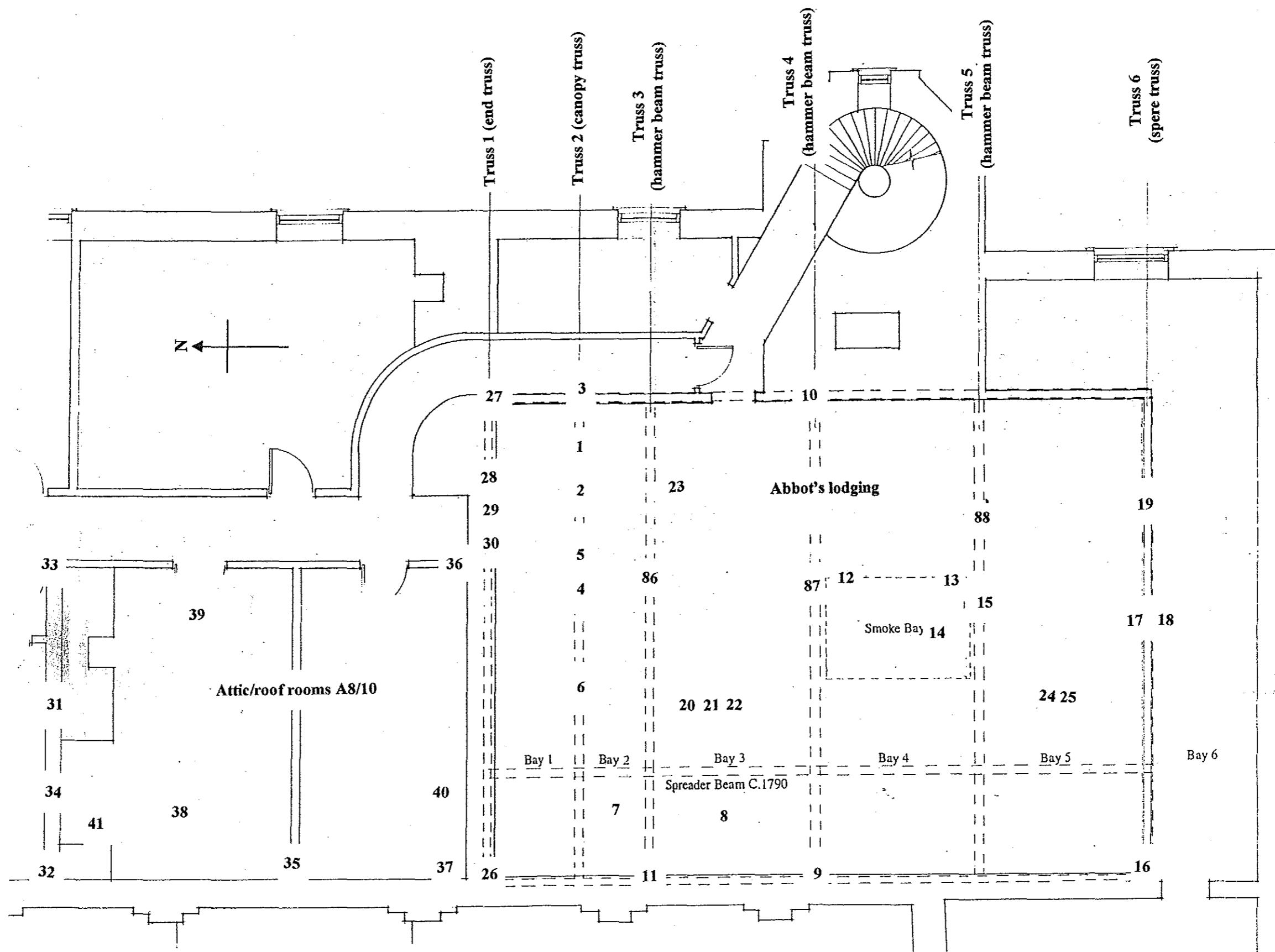


Figure 6b: Plan to show approximate positions of timbers sampled  
 (samples CBM-A59 and A60, loose timbers, not shown)

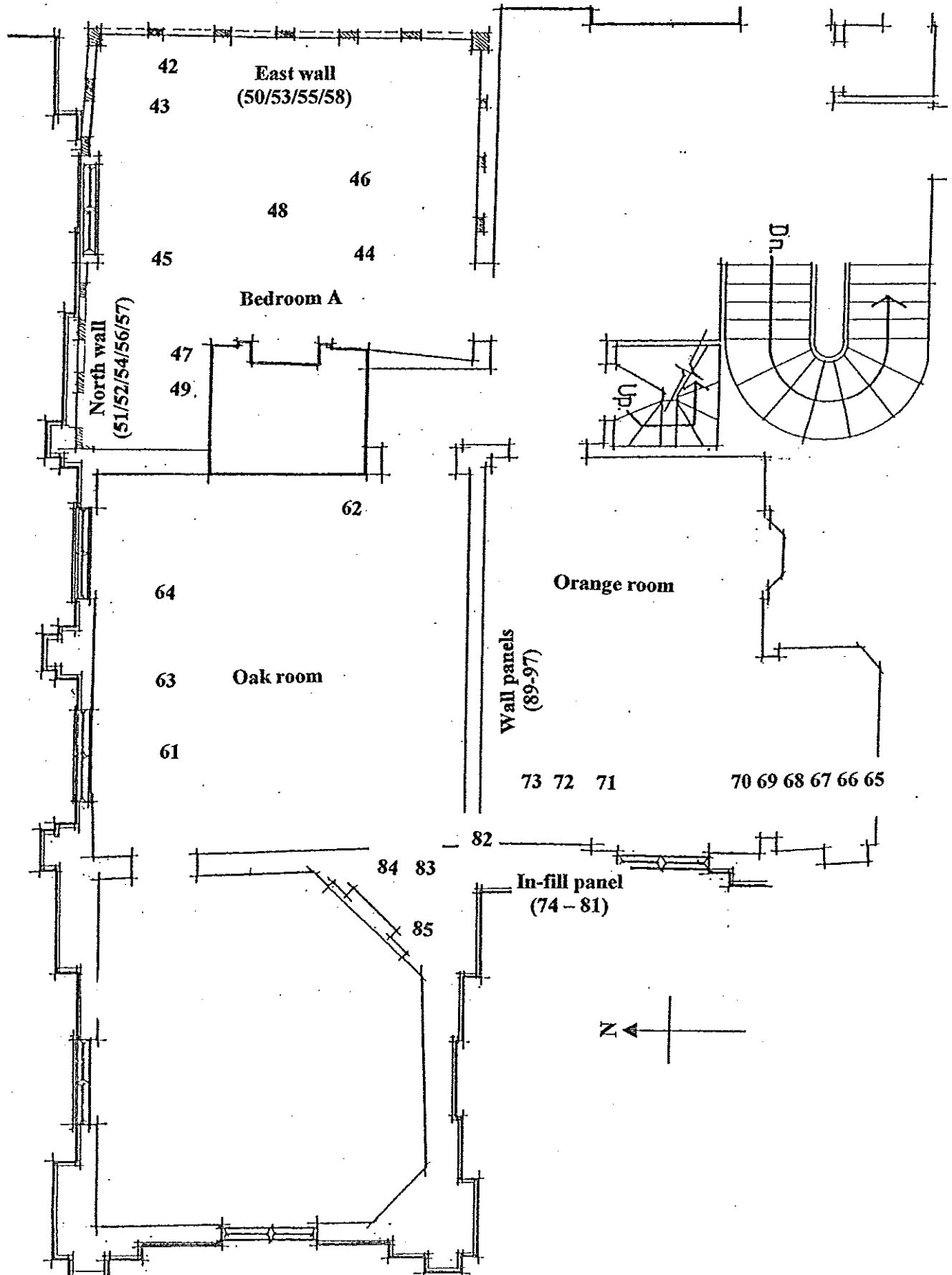


Figure 6c: Sketch drawing of the east wall of bedroom A to show position of timbers sampled (viewed from the west looking east)

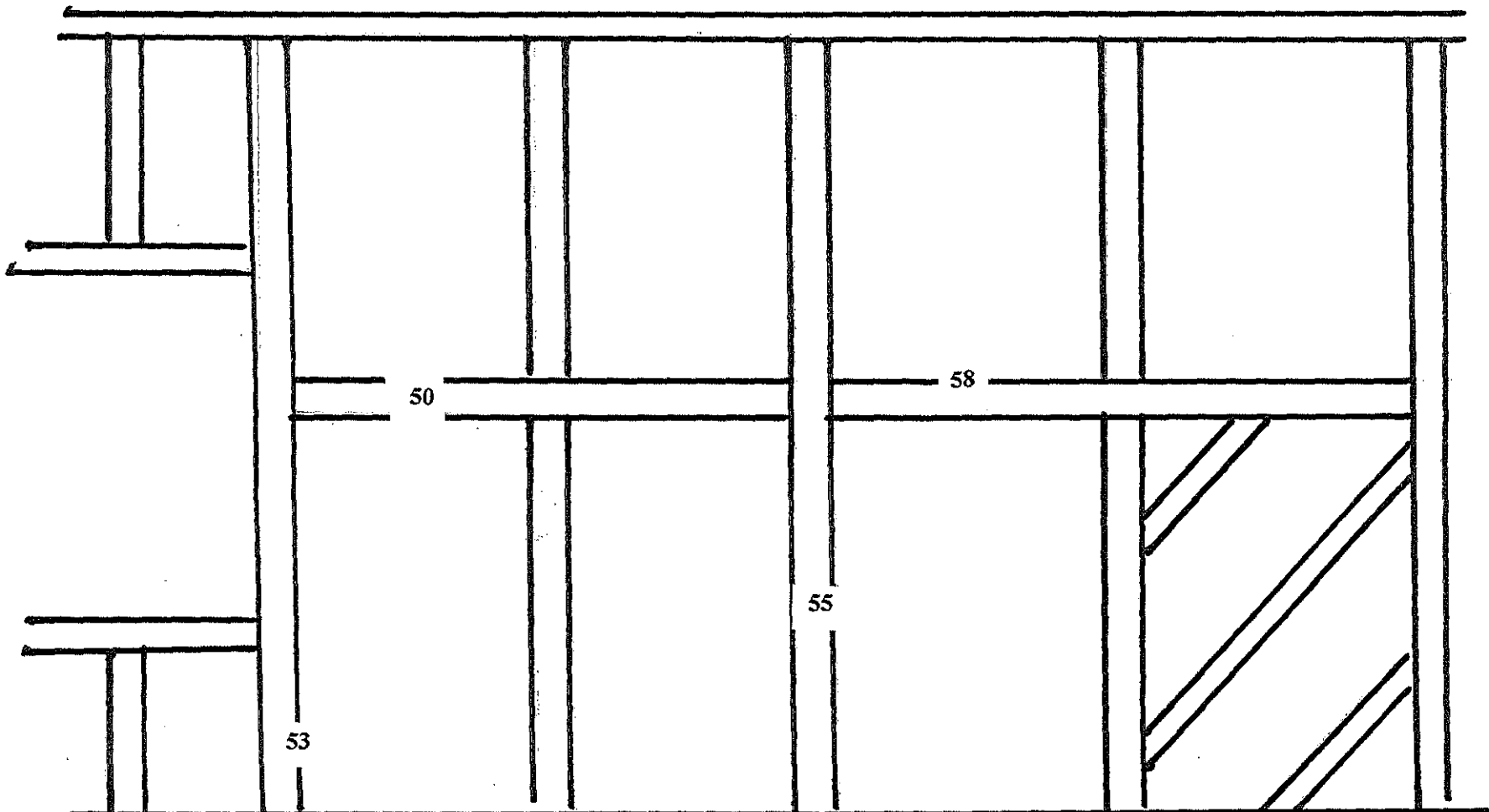


Figure 6d: Sketch drawing of the north wall of bedroom A to show position of timbers sampled (viewed from the south looking north)

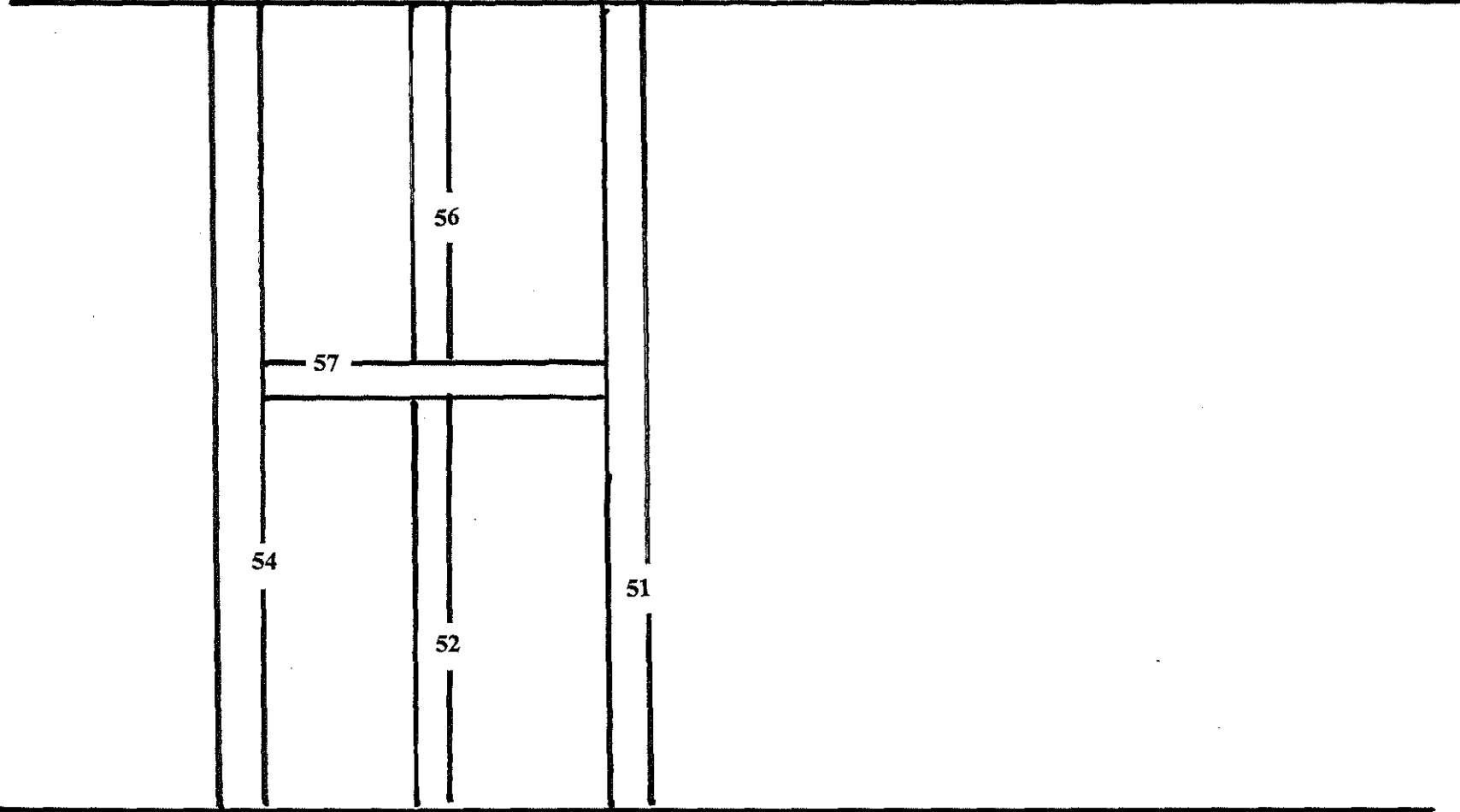


Figure 6e: Sketch drawing of the infill panel of the west wall of the Orange room to show position of timbers sampled (viewed from the east looking west)

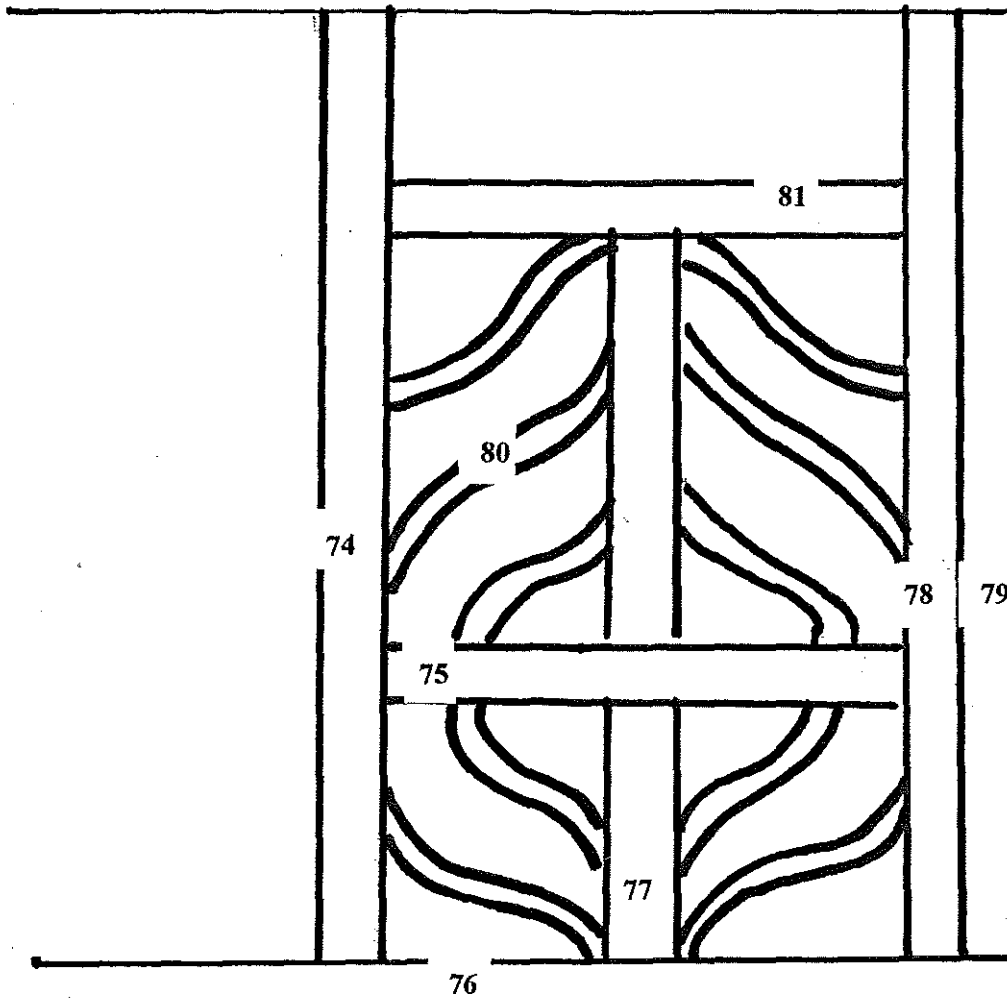




Figure 7: Map to show approximate positions of modern parkland trees sampled

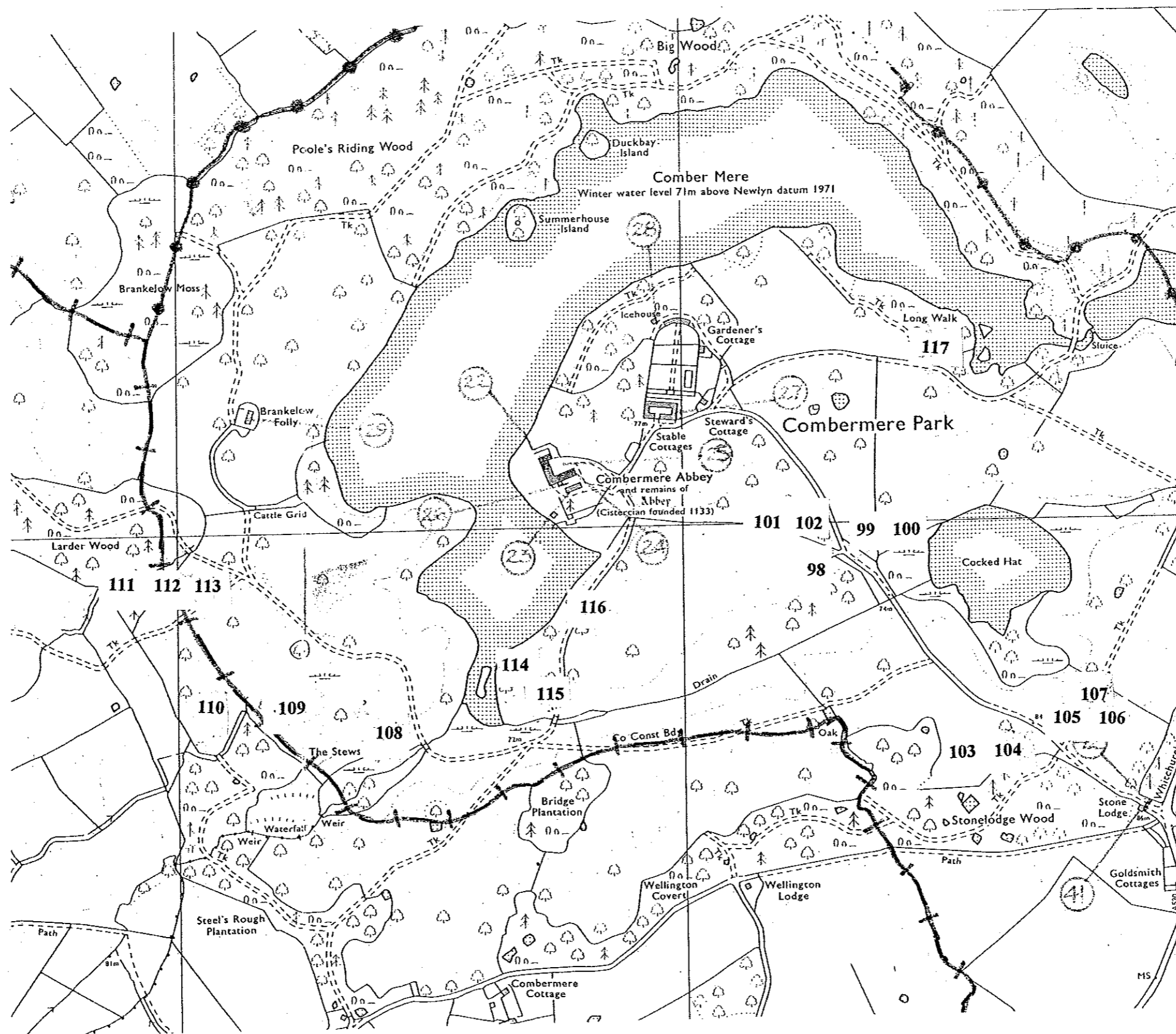
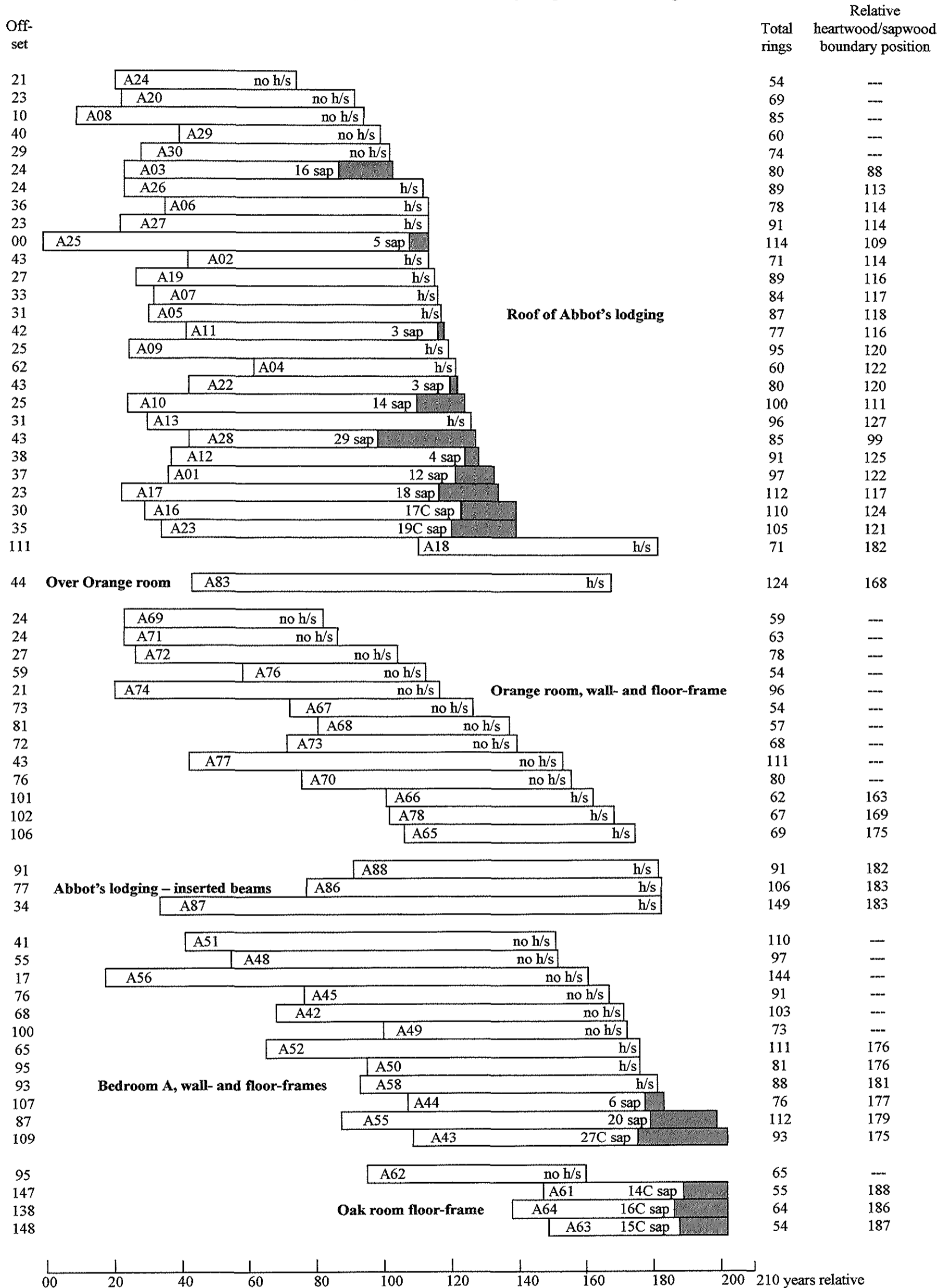
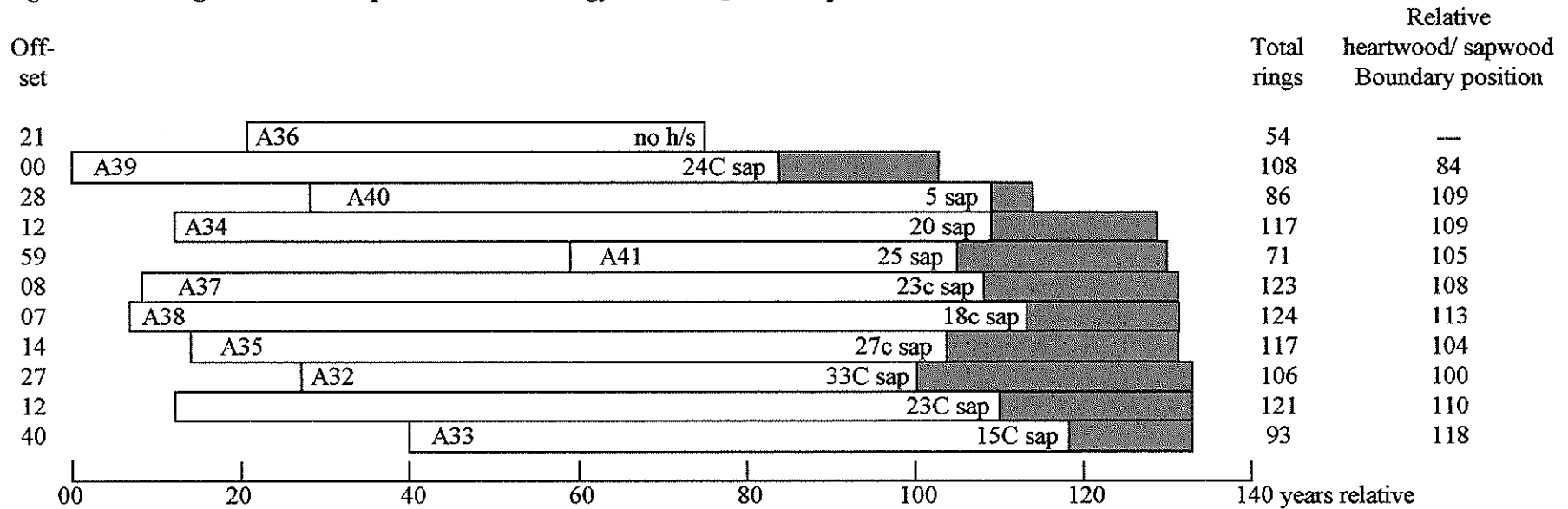


Figure 8: Bar diagram of the samples in site chronology CBMASQ01, sorted by sample area in last ring order



White bars = heartwood rings, shaded area = sapwood rings  
 h/s = heartwood/sapwood boundary is last ring on sample  
 C = complete sapwood retained on sample, last measured ring date is the felling date of the timber

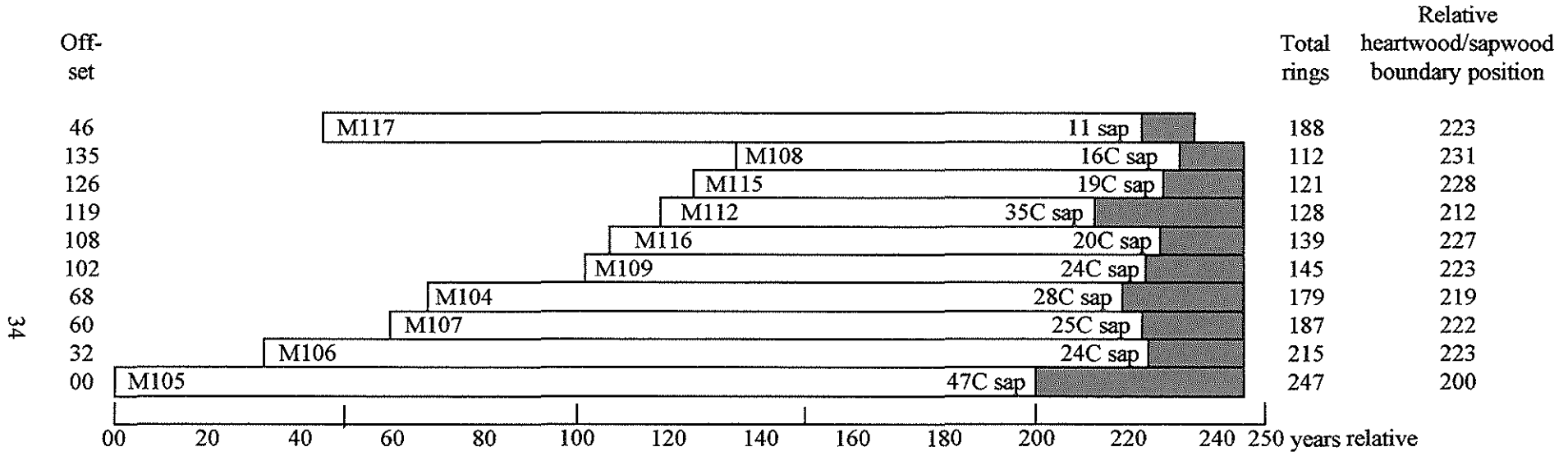
Figure 9: Bar diagram of the samples in site chronology CBMASQ02 – samples from the roof over rooms A8 /10



33

White bars = heartwood rings, shaded area = sapwood rings  
 h/s = heartwood/sapwood boundary is last ring on sample  
 c = complete sapwood on sample, all or part lost during coring  
 C = complete sapwood retained on sample, last measured ring date is the felling date of the timber

**Figure 10: Bar diagrams of the samples in site chronology CBMMSQ01 (parkland tree samples)**



white bars = heartwood rings, shaded area = sapwood rings

C = complete sapwood retained on sample, last measured ring date is the felling date of the tree

Data of measured samples – measurements in 0.01 mm units

CBM-A01A 97

244 161 105 146 136 165 200 147 193 194 161 146 193 226 236 197 160 172 228 179  
332 326 226 262 219 219 208 242 254 215 163 191 183 148 161 181 164 189 249 274  
318 408 288 427 387 294 193 190 213 207 164 232 198 145 195 191 225 238 203 174  
267 164 220 167 86 81 94 87 140 129 103 98 94 109 114 126 127 98 95 133  
85 134 171 135 135 165 144 183 164 203 165 193 137 134 164 126 188

CBM-A01B 97

186 166 106 144 131 172 186 189 183 244 166 129 197 232 224 188 164 179 231 174  
346 305 221 296 202 242 217 229 245 215 152 209 177 135 171 176 173 184 249 264  
323 417 279 430 384 301 187 191 214 197 165 234 188 164 190 186 220 236 193 195  
264 178 217 165 78 80 89 93 147 113 108 96 93 90 111 123 127 85 90 125  
100 131 153 138 141 161 141 170 185 200 172 154 144 152 149 136 167

CBM-A02A 71

231 362 303 306 203 183 271 280 182 153 171 213 147 179 461 322 223 342 227 224  
158 123 197 170 190 202 235 139 212 176 141 133 186 72 66 71 93 132 151 103  
64 91 91 96 120 211 147 102 98 88 87 51 51 77 89 96 117 110 74 98  
196 285 228 377 355 228 181 212 211 415 411

CBM-A02B 71

217 350 303 291 212 183 263 276 185 153 160 213 165 181 455 326 205 359 228 213  
141 117 189 184 191 200 219 126 216 163 133 128 193 81 64 73 91 125 160 100  
67 85 92 96 114 208 151 107 92 91 73 53 62 75 101 95 99 124 80 116  
172 292 208 339 350 236 166 214 209 400 452

CBM-A03A 80

573 424 474 362 496 273 410 253 396 465 289 351 409 381 336 211 292 323 180 233  
139 195 204 175 96 46 26 53 61 64 43 61 73 120 116 117 201 151 161 119  
101 143 167 179 190 199 104 169 165 122 114 113 73 74 46 83 91 104 62 51  
42 68 85 81 94 98 77 73 70 64 60 52 46 69 41 66 69 61 87 87

CBM-A03B 80

685 427 463 371 472 296 404 282 367 471 311 351 418 372 348 240 296 322 173 277  
154 200 206 175 84 50 31 49 57 67 47 55 77 115 115 122 180 143 171 122  
111 150 157 176 190 216 113 180 162 121 117 116 77 77 72 63 84 101 63 61  
46 67 77 83 106 92 86 65 68 67 59 55 47 59 51 62 69 60 85 88

CBM-A04A 60

297 246 382 380 302 308 352 379 241 285 286 237 217 208 242 287 316 261 441 408  
249 163 233 317 274 231 422 286 158 267 217 337 221 166 176 326 208 248 220 94  
117 134 191 214 156 155 131 125 126 148 181 189 129 119 160 112 167 130 124 145

CBM-A04B 60

255 243 357 376 286 314 364 383 231 288 244 236 226 214 240 265 356 231 426 417  
259 155 247 289 273 213 417 272 146 264 216 338 208 188 181 330 224 250 217 110  
119 129 187 224 154 143 139 127 124 159 192 193 133 105 169 105 164 140 132 160

CBM-A05A 87

153 119 169 152 140 151 182 178 156 253 257 211 224 201 215 242 218 122 125 124  
104 102 85 74 85 110 174 164 129 238 178 181 140 96 140 192 164 234 212 174  
180 124 92 107 101 98 80 92 102 138 192 117 75 128 150 152 123 165 139 130  
98 117 110 107 77 83 118 131 146 172 139 237 285 222 166 261 230 204 175 243  
185 249 217 148 88 114 92

CBM-A05B 87

163 113 176 151 146 145 185 172 165 246 245 212 240 202 223 237 223 121 125 119  
104 99 93 67 71 117 177 158 142 234 183 178 144 89 145 185 179 234 213 177  
176 129 94 105 100 98 86 83 105 134 191 116 79 124 155 143 134 163 145 122  
126 120 125 115 74 104 114 120 168 164 138 235 288 222 171 260 231 209 166 226  
180 237 213 154 100 120 97

CBM-A06A 78

127 166 124 84 147 155 143 183 125 135 149 128 123 153 193 178 116 125 134 187  
154 247 291 223 373 238 259 184 316 387 228 212 244 216 121 180 120 115 120 181  
180 213 304 195 272 276 281 164 156 227 172 166 248 203 116 195 169 230 182 137  
144 218 146 160 127 62 68 72 98 176 115 93 82 87 99 86 107 135

CBM-A06B 78

101 170 117 88 143 148 145 168 125 137 157 124 112 189 168 150 144 126 129 208  
141 261 292 221 372 242 272 191 314 390 219 214 262 210 121 169 124 110 124 202  
187 221 287 195 280 287 277 154 166 220 180 143 238 206 109 188 157 246 168 140  
142 202 159 154 144 68 80 71 100 162 99 90 87 83 87 97 108 137

CBM-A07A 84

267 185 230 329 478 311 271 347 306 210 269 261 333 262 314 304 370 292 192 206  
193 183 272 210 445 227 238 312 243 247 139 134 180 234 276 272 304 209 232 150  
132 216 173 106 103 133 161 262 199 117 84 120 181 211 214 267 246 199 181 189  
190 137 104 108 140 145 165 153 115 208 203 253 243 392 337 283 232 262 271 361  
255 163 163 193

CBM-A07B 84

250 179 228 336 469 302 280 333 322 220 265 270 327 261 320 302 369 301 192 190  
202 185 265 211 450 229 231 310 248 249 139 134 177 216 263 267 306 220 225 139  
134 209 175 110 100 139 157 269 180 115 94 118 182 211 209 270 245 199 183 190  
182 134 117 100 136 146 161 153 113 210 212 247 242 381 343 284 254 240 290 346  
267 148 174 216

CBM-A08A 85

515 553 308 495 355 423 398 368 424 328 517 284 282 433 548 402 410 239 393 240  
244 204 307 229 148 244 309 280 270 186 240 194 118 176 151 164 225 95 70 50  
48 49 73 67 95 146 142 266 159 88 160 81 81 81 97 170 133 102 145 99  
60 108 75 97 116 112 79 84 103 81 157 86 70 74 64 87 73 87 139 110  
40 61 70 57 75

CBM-A08B 85

516 556 294 485 332 428 378 371 406 358 490 290 278 440 514 402 415 242 380 230  
238 207 307 236 141 254 309 276 278 191 249 185 119 168 152 169 222 92 74 52  
48 47 70 65 99 142 147 258 167 97 159 79 82 82 96 169 138 99 149 107  
70 101 81 89 119 114 76 88 104 75 155 88 68 67 73 88 66 84 134 89  
75 55 72 63 84

CBM-A09A 95

382 372 350 363 318 283 261 248 339 310 308 277 332 253 234 279 294 223 196 270  
237 229 185 272 322 363 227 212 150 169 197 379 400 312 274 416 312 185 136 127  
218 221 275 279 275 60 108 76 97 91 86 38 67 70 212 203 130 68 73 84  
116 121 118 138 141 120 110 107 106 84 69 73 111 95 137 149 130 114 130 169  
143 109 123 142 139 139 175 187 150 110 121 134 195 204 217

CBM-A09B 95

363 361 351 368 277 290 254 217 366 310 305 279 346 274 216 281 296 225 201 242  
226 233 189 269 303 366 254 218 164 187 225 363 409 306 270 403 313 190 136 131  
214 229 270 275 257 70 101 80 88 88 85 36 56 76 218 200 132 67 70 89  
116 122 117 131 156 113 113 98 108 83 76 73 107 92 139 136 126 120 136 158

142 111 136 139 148 130 173 180 161 108 126 124 204 119 142

CBM-A10A 100

234 348 292 447 271 202 145 211 363 267 208 251 340 246 179 241 266 202 223 77  
68 52 42 57 62 60 63 79 52 120 95 82 151 103 69 108 131 117 121 157  
173 131 114 194 249 151 147 165 108 99 151 71 87 143 98 126 200 128 90 91  
109 89 94 183 171 141 127 116 139 172 224 192 310 190 75 66 56 86 125 105  
99 91 119 89 82 91 72 128 172 159 151 175 114 106 89 113 124 127 131 170

CBM-A10B 100

206 348 288 446 251 207 141 209 361 266 204 262 334 244 180 247 261 196 232 69  
70 50 48 60 56 51 60 86 64 144 109 79 150 111 70 104 129 122 112 157  
175 136 112 191 249 148 146 164 106 109 139 76 85 133 84 139 167 136 99 86  
107 77 91 175 153 140 134 103 131 166 206 192 292 198 91 48 56 101 125 98  
97 92 112 88 85 89 85 131 159 153 167 164 123 110 89 111 104 116 141 135

CBM-A11A 77

287 347 282 356 366 278 264 300 240 187 214 198 188 301 242 359 361 246 271 241  
264 179 150 252 227 196 208 263 170 233 200 181 167 163 95 98 140 146 164 231  
177 112 191 213 243 191 279 217 222 228 167 157 148 171 143 192 220 236 273 161  
200 216 275 278 296 273 235 200 255 229 341 257 239 194 170 164 192

CBM-A11B 77

252 349 281 364 379 261 263 302 228 175 206 198 184 303 240 361 350 255 279 231  
258 174 160 246 229 210 197 266 164 197 205 177 168 165 95 102 131 152 161 227  
183 108 191 218 240 189 272 222 230 218 181 164 155 161 149 223 213 245 241 158  
197 211 274 283 300 273 242 208 267 207 346 251 245 204 176 172 219

CBM-A12A 91

402 214 252 276 231 294 270 385 462 275 266 271 387 281 306 311 287 321 283 555  
461 341 559 409 447 357 424 477 411 294 391 314 219 343 175 195 227 193 124 118  
235 225 394 354 225 123 242 303 316 255 370 346 271 321 258 292 273 219 197 272  
256 248 327 96 53 70 62 59 63 101 83 92 95 106 129 123 72 92 132 149  
167 109 152 180 207 213 260 222 213 200 170

CBM-A12B 91

399 211 259 260 237 296 262 397 481 269 246 265 331 284 275 304 307 330 270 590  
443 351 577 411 461 366 417 476 415 288 392 315 211 334 187 196 223 188 134 111  
232 216 403 344 243 111 241 304 310 260 388 335 271 339 259 319 264 226 188 282  
258 268 310 101 53 70 68 47 71 95 85 95 100 99 135 118 81 84 134 148  
176 108 147 181 204 216 283 191 218 190 180

CBM-A13A 96

172 244 361 218 268 318 357 337 199 222 271 169 202 177 234 360 173 191 235 186  
124 145 175 181 196 145 258 170 163 311 224 246 180 237 275 235 246 338 315 244  
219 186 292 289 226 194 195 305 248 289 282 179 129 220 281 272 238 323 348 218  
265 212 232 196 187 195 248 213 228 233 117 108 188 176 135 195 225 196 177 191  
238 233 217 154 175 225 202 225 116 192 160 221 227 285 208 225

CBM-A13B 96

200 234 366 222 260 322 372 329 200 214 267 167 196 179 232 356 178 185 228 179  
127 135 170 198 188 152 263 148 167 323 229 244 183 253 264 253 247 343 312 254  
235 187 295 300 239 170 198 324 246 279 295 193 117 216 283 278 248 307 341 231  
259 221 225 208 185 189 238 216 229 221 129 108 183 182 129 200 226 200 182 190  
236 234 225 143 164 229 208 219 123 175 179 222 227 270 220 238

CBM-A14A 111

254 477 496 392 438 505 339 409 322 247 294 307 266 264 299 488 527 427 456 356  
159 55 57 44 41 44 61 85 84 92 92 84 88 58 142 149 155 170 171 149  
182 161 115 39 37 62 58 55 89 132 153 169 81 104 134 114 116 95 136 237

263 127 79 68 53 79 106 141 219 115 123 79 174 201 154 247 202 97 42 35  
29 35 55 55 61 62 67 87 102 108 175 210 240 171 132 226 131 227 166 190  
329 115 38 42 51 81 41 114 122 108 129

CBM-A14B 111

250 480 510 410 426 476 357 412 325 251 302 300 276 270 307 485 546 382 428 365  
160 57 53 50 41 44 59 83 82 103 90 90 82 57 137 150 149 157 174 168  
180 164 109 38 41 61 51 64 86 132 154 174 85 105 133 111 132 92 141 234  
271 122 82 65 58 82 104 144 219 114 124 74 163 207 149 235 198 83 41 38  
33 38 48 56 65 57 70 87 95 111 176 205 222 177 135 216 144 234 172 175  
315 133 24 52 56 80 46 106 118 115 118

CBM-A15A 55

232 271 351 561 381 76 44 98 82 179 139 124 92 135 107 114 95 117 85 85  
142 139 159 198 235 78 72 76 137 97 97 87 107 110 115 116 195 168 92 75  
97 120 128 138 73 116 84 68 87 70 127 128 93 67 99

CBM-A15B 55

249 271 317 465 352 69 44 66 93 168 145 140 88 128 100 116 102 114 92 96  
125 148 193 231 271 74 68 85 153 88 109 82 88 111 117 94 202 183 82 96  
84 134 129 143 69 114 84 82 85 69 108 115 89 67 88

CBM-A16A 110

241 183 232 458 329 387 430 424 384 205 265 240 173 226 169 192 197 163 161 179  
152 162 159 145 100 137 139 285 311 204 328 198 238 180 173 190 133 108 175 216  
125 147 183 158 180 152 91 96 145 113 149 163 105 82 109 151 129 94 123 112  
84 86 96 85 91 60 67 132 122 170 201 154 208 188 235 238 197 175 145 152  
205 218 254 205 230 210 278 213 287 285 315 202 222 188 198 167 137 119 117 134  
124 95 143 219 195 144 184 209 145 156

CBM-A16B 110

286 175 232 477 369 383 419 432 367 219 276 236 180 212 156 193 203 168 152 177  
147 158 168 142 111 136 135 284 315 195 328 203 238 178 170 189 148 96 174 216  
125 147 177 167 183 142 99 97 137 110 146 159 107 79 122 146 124 104 118 112  
90 85 83 94 81 67 73 125 122 176 210 152 209 180 244 241 187 167 155 162  
189 200 249 213 234 221 262 225 287 282 326 196 212 212 182 187 114 119 131 96  
137 100 134 230 181 156 184 207 144 166

CBM-A17A 112

505 580 442 547 474 595 361 457 337 449 480 402 346 328 436 347 256 387 322 325  
350 321 264 298 106 100 153 136 85 129 116 86 79 104 180 177 141 189 200 187  
101 147 176 176 177 203 287 207 277 217 173 225 243 205 141 133 133 200 187 137  
122 126 164 150 163 215 185 149 165 146 138 116 90 112 106 110 113 145 153 189  
234 228 193 198 212 196 151 191 187 250 248 148 170 206 183 154 99 160 156 160  
194 210 175 151 159 132 126 141 134 154 172 128

CBM-A17B 112

497 548 443 528 489 602 365 452 341 445 476 401 346 329 439 345 261 357 301 300  
344 326 264 300 108 101 146 142 78 130 121 79 72 113 194 168 143 183 208 175  
98 151 161 176 177 197 296 208 270 221 166 231 247 201 139 139 125 204 186 135  
104 133 151 150 159 227 191 154 164 143 149 116 86 108 112 99 120 142 165 200  
246 233 189 199 211 215 158 181 198 249 229 145 179 210 177 154 107 146 157 154  
178 207 186 150 162 124 132 140 135 153 185 143

CBM-A18A 71

233 125 192 230 323 597 514 294 292 464 472 362 380 411 371 428 425 361 334 430  
472 362 526 237 182 389 384 612 360 271 340 454 554 248 177 443 458 452 340 261  
210 169 161 158 233 350 143 231 236 252 214 152 83 149 230 269 291 191 190 185  
153 176 134 134 201 127 114 74 77 206 250



CBM-A18B 71

224 120 208 224 319 616 495 312 295 450 483 356 369 393 370 438 423 359 340 434  
441 361 528 233 185 365 397 611 335 263 348 447 552 241 178 462 451 448 332 259  
213 157 170 155 251 338 151 234 240 250 220 150 90 141 232 277 294 190 188 178  
156 166 144 136 189 135 104 84 75 220 258

CBM-A19A 89

705 540 602 568 468 454 489 357 399 388 298 277 263 303 309 194 298 236 246 346  
329 243 248 195 168 199 232 180 272 241 280 190 195 236 192 152 118 140 140 181  
175 163 135 96 110 82 86 112 114 70 61 81 97 106 110 99 70 102 79 101  
107 113 140 113 79 102 89 97 69 95 90 87 128 179 208 198 231 227 225 202  
169 151 139 160 205 146 81 116 132

CBM-A19B 89

726 537 588 569 473 470 508 336 402 367 311 287 263 296 301 186 304 218 263 363  
323 231 260 181 170 192 244 181 268 242 279 185 193 244 182 188 106 168 124 187  
162 152 149 95 103 88 81 110 114 67 64 84 94 99 108 124 72 73 88 96  
97 134 133 112 87 101 74 96 84 87 85 85 143 183 203 205 254 224 212 212  
165 141 133 168 203 145 95 110 126

CBM-A20A 69

213 432 282 270 189 245 281 235 156 192 204 146 178 173 202 274 181 263 255 281  
353 249 257 288 236 187 192 163 98 112 98 106 127 135 181 187 120 179 181 230  
179 203 307 256 240 296 261 178 164 228 220 153 143 112 95 106 117 172 189 152  
110 119 110 127 139 175 180 198 237

CBM-A20B 69

208 435 285 243 187 249 279 234 158 196 198 137 171 158 210 250 188 272 259 272  
368 238 246 276 250 190 184 156 99 108 105 93 121 142 184 185 120 179 172 227  
202 210 319 262 219 292 244 185 172 215 218 156 149 101 88 88 132 174 194 165  
123 104 116 133 134 173 186 202 232

CBM-A21A 54

199 335 208 195 147 212 170 89 138 152 121 104 115 150 172 99 67 76 74 121  
105 133 180 140 150 120 109 90 107 99 90 82 136 210 152 107 110 97 88 103  
111 152 158 98 62 86 70 120 81 171 194 174 154 163

CBM-A21B 54

166 333 195 185 175 189 173 75 151 165 99 89 114 154 179 92 75 81 73 114  
102 130 182 135 148 131 106 88 102 108 87 87 132 197 142 114 109 99 84 98  
120 144 154 87 66 77 71 107 72 144 204 166 156 146

CBM-A22A 80

228 228 237 189 149 182 202 176 157 153 112 79 120 122 128 187 114 128 142 150  
109 140 142 125 127 171 225 127 132 138 108 101 96 62 56 72 98 105 122 85  
56 71 104 105 92 142 140 133 144 133 122 104 96 81 50 73 117 138 117 102  
113 123 112 131 162 117 98 141 153 225 191 134 108 131 89 72 53 52 54 53

CBM-A22B 80

235 218 226 206 161 172 202 200 155 159 118 88 109 114 141 175 116 129 149 131  
113 142 121 118 130 154 198 155 131 138 121 107 75 68 55 75 93 106 116 87  
54 74 105 99 89 134 147 116 145 141 116 118 87 89 58 61 118 138 105 106  
109 121 103 137 161 123 92 141 157 225 200 126 112 140 86 69 51 63 52 73

CBM-A23A 105

181 148 148 150 104 109 88 67 56 85 98 85 94 155 192 238 236 203 170 103  
141 176 143 172 177 162 156 141 121 152 199 202 176 190 205 161 171 93 70 103  
126 107 88 129 188 133 150 91 60 149 127 137 135 152 159 134 88 106 120 102  
76 90 149 146 136 163 139 136 185 161 112 120 147 158 110 154 109 153 150 103  
146 155 111 144 110 135 95 53 88 116 71 71 87 72 75 65 73 110 99 62  
59 67 85 80 101

CBM-A23B 105

141 159 133 152 88 120 76 77 57 74 92 82 109 152 208 228 246 210 162 82  
157 169 149 175 168 163 159 133 125 175 202 191 179 180 218 160 162 98 75 96  
138 121 85 142 176 128 166 94 73 134 119 139 136 149 154 141 95 107 119 76  
90 91 174 143 121 173 134 132 186 157 120 126 147 162 99 149 103 161 145 95  
136 159 110 142 110 127 99 50 109 100 59 76 78 85 70 67 75 97 98 62  
53 73 79 80 94

CBM-A24A 54

169 252 338 329 225 202 192 263 261 261 203 248 295 221 271 282 306 246 241 237  
259 194 252 252 253 359 180 177 231 186 137 127 161 155 196 170 286 198 112 199  
127 162 141 161 195 193 182 229 231 165 158 115 99 75

CBM-A24B 54

173 257 330 312 250 199 200 271 244 258 211 256 280 229 283 287 312 267 219 236  
259 188 257 231 264 364 189 197 230 188 139 123 163 157 197 157 270 194 117 201  
120 165 135 138 191 181 181 208 251 141 158 108 96 83

CBM-A25A 83

143 207 297 403 349 243 376 262 261 280 298 288 189 206 204 221 221 216 211 194  
173 194 147 237 249 155 130 116 165 102 94 76 71 105 79 95 109 117 101 75  
103 115 79 79 62 84 74 39 44 40 53 42 36 35 40 46 60 77 72 64  
96 66 70 39 66 97 85 74 98 126 73 77 82 73 67 54 43 51 69 63  
78 95 84

CBM-A25B 106

214 285 299 288 180 201 200 222 237 221 202 193 164 192 148 241 250 165 126 121  
156 106 96 93 60 102 74 100 111 115 98 77 98 103 75 73 87 118 128 82  
59 72 73 67 55 56 48 60 68 99 101 90 134 98 105 69 83 101 107 85  
108 139 104 111 137 113 98 87 53 52 81 77 101 121 106 63 95 115 120 107  
172 163 102 117 115 95 77 85 75 124 84 127 116 72 79 94 123 98 113 162  
127 131 135 109 128 169

CBM-A26A 89

396 282 353 307 455 283 262 209 368 375 207 194 266 269 256 229 320 399 228 294  
208 234 201 178 178 207 220 172 152 115 100 209 153 300 257 157 254 174 210 146  
125 196 194 183 228 230 163 157 114 99 74 97 54 40 63 51 84 90 76 62  
54 97 86 91 119 119 121 104 86 60 72 60 67 77 75 68 58 53 70 57  
87 77 97 91 70 81 81 78 96

CBM-A26B 89

365 280 358 306 442 282 269 206 369 382 215 194 259 269 260 225 310 388 231 288  
213 236 208 175 174 210 223 168 163 106 99 217 149 308 249 159 251 178 208 148  
146 190 180 182 209 250 142 159 108 97 84 97 55 40 58 49 80 93 71 67  
60 94 82 94 116 118 122 105 84 67 63 67 64 78 73 56 54 54 71 63  
87 78 90 100 67 82 86 71 54

CBM-A27A 91

372 410 269 329 260 385 270 244 208 275 216 129 166 185 185 216 158 260 371 230  
274 228 234 235 163 153 190 191 129 152 97 94 152 126 224 200 145 194 143 141  
88 99 195 148 114 160 182 109 130 112 107 136 130 67 75 97 80 137 145 106

85 85 102 107 97 177 138 118 116 109 67 77 68 68 112 75 65 50 60 97  
109 134 126 135 127 105 92 89 98 143 152

CBM-A27B 91

290 418 265 331 263 384 265 253 203 273 208 135 165 185 184 215 155 265 373 229  
281 222 236 241 170 150 190 183 136 142 105 92 153 123 220 191 150 181 144 146  
85 102 190 147 117 160 186 108 118 118 99 142 122 68 77 97 81 136 152 100  
86 87 105 105 101 167 131 118 107 116 72 77 70 63 106 82 62 55 53 102  
104 126 128 137 122 103 94 96 94 154 170

CBM-A28A 85

401 276 325 376 195 245 279 218 158 170 149 129 145 158 286 262 197 175 194 246  
163 219 308 295 260 316 286 161 194 209 207 166 195 138 127 152 130 163 213 224  
144 100 115 125 94 196 135 107 81 105 97 82 74 78 87 79 69 113 83 80  
89 154 219 121 167 116 99 100 88 127 93 105 70 66 66 61 58 59 67 64  
47 73 79 73 72

CBM-A28B 85

402 282 325 369 212 256 268 223 165 159 162 121 141 161 284 260 198 176 197 242  
167 223 311 319 262 305 282 174 183 213 205 169 192 131 122 159 142 192 212 210  
140 100 107 133 102 197 144 97 86 97 98 75 86 72 92 72 73 108 82 97  
85 162 177 158 159 111 100 101 94 138 103 107 69 68 48 70 61 60 62 65  
50 79 75 79 77

CBM-A29A 60

444 516 402 280 245 255 162 126 104 137 225 160 167 110 123 170 189 338 184 153  
193 153 183 115 123 212 204 189 283 181 139 144 96 85 117 157 64 75 97 93  
150 133 75 69 71 111 125 89 132 123 92 89 64 67 61 50 55 124 99 52

CBM-A29B 60

409 491 399 284 229 262 158 130 118 145 211 165 160 101 136 171 174 335 199 157  
211 132 187 120 124 221 225 203 262 196 118 143 95 84 122 154 68 74 96 100  
140 135 80 62 74 114 118 92 129 120 86 108 68 56 49 61 71 111 90 65

CBM-A30A 74

193 255 214 271 364 236 340 409 392 399 278 421 407 269 356 288 283 429 203 219  
255 201 143 156 118 150 111 144 228 252 172 172 181 217 133 162 299 256 211 224  
251 152 196 174 177 157 160 106 120 181 127 178 219 193 136 122 160 154 150 253  
209 127 127 126 127 111 99 95 96 83 84 110 93 118

CBM-A30B 74

169 245 196 288 357 230 343 416 389 402 252 420 415 282 338 267 270 422 202 245  
254 196 140 154 128 144 112 147 226 251 169 174 188 206 141 164 308 255 207 214  
267 150 198 176 178 150 164 107 127 173 134 177 225 206 147 114 164 166 156 284  
207 140 118 121 130 114 97 94 104 81 86 111 91 124

CBM-A31A 121

234 187 230 233 195 176 183 143 184 208 179 225 184 189 169 167 186 170 152 149  
167 154 173 134 126 140 138 116 140 135 259 324 378 303 337 184 236 346 339 326  
315 241 206 169 210 183 158 244 219 310 187 212 208 231 153 183 153 139 98 134  
164 137 198 152 185 175 172 100 111 143 139 120 148 136 101 128 72 55 54 84  
97 83 91 67 89 39 85 62 74 73 93 127 92 74 73 72 97 116 63 77  
122 122 180 115 168 143 121 97 96 108 148 172 125 97 163 186 198 175 102 185  
182

CBM-A31B 121

249 181 223 240 193 190 173 153 186 202 171 223 182 190 164 169 167 183 156 147  
161 167 166 129 119 140 141 116 151 135 253 315 371 313 346 170 271 335 322 327  
302 251 212 184 196 195 151 229 212 288 181 216 195 232 151 188 142 148 100 128  
164 145 205 158 166 169 165 106 108 144 145 111 150 151 97 125 48 67 58 87

92 81 89 68 72 60 86 63 81 74 96 135 103 83 73 72 87 123 63 84  
113 125 173 110 166 128 115 104 92 104 154 157 140 99 157 176 203 184 138 153  
183

CBM-A32A 104

216 222 216 168 182 230 234 294 226 211 221 235 160 127 122 149 226 139 189 222  
140 177 208 232 235 205 182 175 157 179 119 157 196 233 197 150 153 132 169 159  
145 135 100 128 158 131 123 133 103 128 126 98 97 91 108 120 115 120 140 108  
97 98 83 93 134 145 97 92 89 84 77 95 77 73 58 81 87 73 69 69  
46 90 102 69 80 87 100 125 92 112 107 180 136 180 182 194 152 118 126 155  
187 184 162 141

CBM-A32B 102

106 164 179 204 207 186 258 205 142 111 92 137 195 128 153 170 105 116 164 193  
196 162 143 169 133 147 100 110 127 144 182 116 128 110 133 121 101 115 83 90  
83 92 87 106 77 123 117 83 92 79 180 89 75 88 74 117 81 53 68 110  
95 85 91 87 87 69 61 66 65 60 57 79 79 63 53 58 51 70 74 53  
63 80 81 86 53 65 60 74 58 75 69 71 88 71 70 106 116 205 126 137  
134 178

CBM-A33A 93

118 140 171 199 151 188 212 199 165 183 216 244 197 184 139 120 123 109 156 156  
200 168 150 175 176 144 138 127 84 139 112 103 96 129 118 153 167 135 199 125  
110 104 93 122 128 140 125 155 88 99 74 103 115 124 106 106 122 78 108 85  
104 73 121 106 95 110 119 87 126 128 106 121 141 188 198 136 193 177 168 97  
213 174 166 171 124 96 164 186 197 174 103 186 181

CBM-A33B 93

134 156 160 202 161 182 209 201 175 191 257 223 209 184 144 112 128 109 157 150  
216 179 180 152 185 144 137 125 95 129 113 104 105 123 122 148 166 139 193 133  
122 97 95 121 129 137 124 160 92 86 80 113 106 119 112 115 119 78 108 96  
82 87 116 119 79 117 122 91 122 158 108 108 149 180 214 133 176 191 161 108  
202 191 162 167 130 95 158 179 201 181 130 159 181

CBM-A34A 117

148 166 186 169 143 200 171 141 185 180 130 164 146 147 138 132 170 166 134 124  
152 121 178 124 113 114 103 91 73 113 158 186 150 151 176 100 124 146 150 149  
130 116 93 105 115 98 85 111 130 121 88 127 117 103 84 106 87 87 102 123  
111 137 156 163 210 148 131 87 122 120 113 119 112 122 116 119 67 51 52 91  
107 89 92 68 94 57 71 59 75 66 72 115 77 80 73 65 87 104 59 67  
85 86 133 101 155 147 116 97 91 102 150 128 117 108 190 64 60

CBM-A34B 117

138 164 191 163 138 193 205 142 186 168 136 179 137 149 121 150 169 169 136 110  
132 129 178 103 107 111 102 77 79 79 146 200 142 156 163 91 114 147 157 129  
128 131 90 119 100 98 100 120 124 124 84 116 135 84 90 97 86 101 78 135  
120 125 150 148 192 115 128 92 116 112 132 96 116 129 110 127 85 45 72 80  
88 85 91 63 96 57 71 61 72 61 75 127 75 75 73 63 87 108 48 73  
77 99 135 96 144 136 110 103 82 106 155 133 110 113 188 52 90

CBM-A35A 117

191 364 299 257 355 245 251 168 186 268 306 361 377 358 381 245 193 240 233 261  
382 270 284 261 216 146 194 156 185 277 228 224 194 165 105 112 172 186 180 146  
178 139 141 103 100 154 196 200 178 184 97 92 117 114 147 82 71 80 88 105  
110 117 129 109 126 87 75 69 132 156 166 137 139 154 97 83 73 115 133 139  
102 82 106 94 87 87 99 81 83 111 91 83 86 75 76 162 121 129 137 187  
196 138 153 152 115 121 149 163 188 183 147 129 208 231 183 182 248

CBM-A35B 117

220 369 308 269 321 245 252 182 184 255 308 366 356 362 379 256 187 232 242 266  
391 275 263 266 229 139 196 163 191 295 225 214 211 163 90 118 142 226 166 159  
185 133 130 114 101 150 197 199 176 164 107 91 109 120 144 79 81 71 93 107  
112 107 138 101 144 88 76 67 135 140 134 159 130 154 95 84 64 117 143 135  
104 85 86 104 100 87 93 75 86 121 111 85 101 88 103 150 104 130 130 171  
210 146 151 156 107 104 165 153 191 180 133 139 199 225 182 188 261

CBM-A36A 54

174 196 201 184 196 236 242 237 181 157 147 203 237 244 208 194 242 181 153 124  
100 122 183 159 181 130 97 95 116 146 196 151 158 170 118 122 98 87 92 135  
170 127 151 119 157 119 133 138 92 108 90 134 120 160

CBM-A36B 54

160 200 200 191 197 268 271 203 176 184 141 191 198 240 213 179 222 166 148 115  
99 123 165 173 175 132 85 103 115 157 192 151 156 140 136 127 95 63 119 134  
157 136 148 107 149 130 143 141 91 107 91 128 125 146

CBM-A37A 123

264 284 258 234 293 273 246 229 189 216 184 203 198 221 208 304 286 291 314 238  
245 157 121 96 147 178 245 194 190 330 276 159 114 144 142 219 112 183 152 96  
91 122 128 194 143 99 139 85 90 79 69 94 132 90 85 65 78 64 80 75  
69 61 62 78 83 85 86 94 81 90 57 67 80 72 81 84 74 93 75 83  
62 56 58 89 55 96 79 70 67 58 64 57 53 47 62 86 57 55 59 57  
62 78 57 66 80 106 119 71 94 106 172 130 151 164 177 172 95 113 118 179  
155 115 163

CBM-A37B 123

238 280 249 237 279 257 261 227 202 197 210 200 181 223 207 292 284 308 313 228  
243 158 121 85 163 166 245 181 183 336 277 169 98 149 138 232 122 159 151 111  
82 133 122 191 126 124 127 91 83 89 78 87 126 92 77 86 63 80 70 86  
75 55 55 72 81 79 86 95 80 98 58 73 70 77 78 84 74 102 74 84  
61 51 57 78 73 87 75 69 73 53 71 55 53 45 64 80 62 44 57 58  
67 79 63 63 78 102 123 81 89 94 164 125 147 167 171 156 101 109 133 176  
136 142 159

CBM-A38A 124

183 234 233 221 186 197 203 211 228 160 184 139 130 125 143 138 178 130 113 99  
97 111 102 83 84 83 76 85 87 71 56 61 53 53 54 122 164 134 140 196  
76 115 143 156 154 176 175 141 124 168 153 123 202 158 181 145 187 139 145 125  
161 137 144 116 133 158 165 204 198 197 167 126 74 102 121 149 126 172 161 107  
151 84 54 59 92 87 86 96 95 100 64 73 61 68 70 88 100 66 75 77  
68 95 115 60 81 144 125 166 96 131 111 121 89 84 93 131 126 111 88 195  
176 205 248 333

CBM-A38B 124

210 229 233 217 191 197 202 216 230 159 170 140 126 128 140 155 158 133 112 89  
107 112 95 83 89 100 89 95 73 60 65 67 53 53 59 116 166 136 135 181  
79 121 148 145 164 163 181 138 124 159 160 120 201 164 182 155 154 151 132 142  
154 130 151 116 127 174 150 200 202 206 165 129 72 96 132 138 122 149 168 97  
147 78 53 63 91 91 74 103 83 115 60 84 59 71 80 87 103 82 65 75  
78 85 100 58 81 141 126 155 103 132 102 132 92 84 88 136 132 92 95 183  
188 235 243 270

CBM-A39A 108

294 260 235 260 305 273 311 262 303 319 276 238 261 252 270 241 190 198 186 134  
101 150 197 192 160 191 180 231 201 175 166 132 138 118 152 144 164 189 181 112  
117 128 141 266 178 211 193 167 196 172 226 239 195 209 136 134 100 84 98 140

189 139 122 122 166 147 147 157 109 69 40 37 54 68 75 108 115 113 151 93  
79 76 142 168 150 168 121 93 42 56 34 44 66 77 99 74 105 88 62 83  
84 67 110 121 82 123 117 102

CBM-A39B 108

294 263 230 261 306 266 313 263 305 320 287 241 252 243 276 242 200 187 205 132  
114 142 201 189 155 189 186 240 193 175 164 137 130 101 143 152 163 208 174 121  
119 129 155 248 193 203 186 156 211 176 226 218 193 222 144 130 90 85 101 133  
186 137 107 147 147 165 146 150 111 70 39 40 49 53 81 109 109 113 143 97  
76 79 138 165 140 168 132 99 39 52 41 41 66 78 100 80 117 80 65 86  
85 65 103 119 93 108 121 98

CBM-A40A 86

546 462 265 269 383 276 318 247 276 279 229 178 212 179 236 327 305 352 282 165  
179 242 299 321 233 224 209 148 152 168 76 193 337 284 166 130 95 150 141 193  
137 120 108 116 98 101 140 152 115 85 55 58 67 75 92 89 106 138 96 122  
107 66 65 107 105 117 95 81 65 57 73 60 40 34 53 55 43 44 62 57  
50 78 63 58 108 111

CBM-A40B 86

547 453 260 267 396 297 315 237 286 282 227 181 214 178 224 340 310 349 289 151  
165 248 287 321 231 221 211 142 147 165 77 196 330 289 167 145 85 135 148 197  
146 138 110 110 98 107 113 144 115 83 65 52 65 64 101 88 106 132 101 113  
96 68 53 118 107 113 100 85 58 51 77 58 47 36 52 52 43 48 63 49  
49 81 55 53 97 135

CBM-A41A 71

405 482 428 257 235 165 263 191 213 185 109 164 148 173 209 288 311 288 192 158  
93 79 87 101 107 100 103 98 100 77 60 63 85 117 126 132 106 106 87 70  
91 83 65 93 93 71 52 45 27 35 70 52 59 45 61 77 67 84 84 71  
78 80 119 136 105 75 59 60 76 90 90

CBM-A41B 71

380 487 431 252 237 177 262 186 208 183 139 153 158 151 187 254 335 293 210 133  
94 90 72 109 114 90 104 103 90 91 50 64 82 123 125 127 121 95 71 78  
74 75 76 91 91 76 54 41 29 41 67 55 55 48 60 81 65 81 79 65  
89 85 109 137 94 85 71 55 78 85 118

CBM-A42A 103

347 291 162 168 168 136 146 142 128 152 160 138 112 85 60 89 121 93 118 63  
80 117 88 120 118 204 204 185 176 139 85 142 311 173 148 164 162 135 196 194  
160 128 100 112 145 123 133 95 144 149 222 154 176 180 187 182 264 170 172 194  
125 127 108 174 182 238 114 78 99 136 157 89 79 90 54 52 46 35 63 47  
60 81 81 79 71 77 68 93 103 94 106 123 71 110 70 69 108 143 117 109  
111 108 132

CBM-A42B 103

319 297 161 167 172 146 148 142 131 147 172 129 115 86 60 85 112 91 118 68  
76 100 89 125 114 198 215 179 158 149 97 158 310 175 145 167 153 132 207 199  
153 129 112 111 136 135 130 96 138 154 219 161 177 188 179 192 245 165 173 192  
128 118 112 174 185 256 93 87 105 125 139 84 79 95 56 57 41 37 60 50  
62 77 88 76 74 78 64 89 111 85 114 126 70 108 64 67 135 145 114 100  
113 123 130

CBM-A43A 93

133 173 156 188 167 128 130 206 194 237 233 222 199 203 205 277 172 202 245 208  
232 171 215 318 471 192 162 166 209 177 106 86 85 53 56 45 73 102 79 107  
95 149 122 103 117 139 175 228 231 212 238 170 184 132 102 152 229 213 140 182  
132 152 129 95 162 147 150 160 169 218 62 88 104 97 136 137 147 157 133 150  
96 135 179 114 102 102 85 91 116 142 141 130 126

CBM-A43B 93

181 146 168 232 169 130 134 221 187 235 237 224 194 210 198 273 175 209 242 202  
238 178 206 328 476 189 163 171 211 175 107 85 85 60 55 49 69 101 76 114  
102 142 126 102 119 127 186 219 220 211 246 168 196 116 94 156 232 207 146 172  
129 142 125 99 160 145 146 161 171 213 67 94 95 99 143 129 156 154 127 110  
116 123 171 116 94 100 93 102 126 137 133 115 145

CBM-A44A 76

313 269 229 241 265 399 276 167 133 175 231 261 178 199 221 223 283 288 207 228  
243 202 204 233 236 218 402 164 130 179 213 174 95 93 118 84 72 53 73 108  
61 104 101 130 152 100 110 127 142 201 136 132 143 125 137 91 67 133 196 167  
149 152 127 129 97 101 174 176 132 168 172 219 80 85 102 106

CBM-A44B 76

276 265 221 249 259 369 272 166 128 177 231 266 173 203 217 230 278 282 213 229  
229 217 202 224 228 218 400 170 161 174 218 180 93 91 111 85 69 54 83 98  
76 91 98 146 147 103 112 127 140 201 132 129 146 123 139 85 71 132 198 165  
151 149 123 128 90 107 176 180 124 185 184 219 78 87 93 90

CBM-A45A 91

168 334 383 251 203 196 189 184 441 378 260 171 187 210 115 151 148 247 292 199  
189 171 158 217 301 203 262 262 266 199 243 264 249 149 168 156 231 220 152 152  
189 170 253 179 202 212 227 227 316 198 168 190 175 199 211 205 271 346 174 168  
154 159 120 88 55 71 45 47 36 46 71 47 88 70 88 93 67 81 65 93  
105 115 97 106 102 90 66 50 67 87 85

CBM-A45B 91

223 321 362 249 203 226 158 214 427 438 258 162 194 218 121 141 177 225 291 186  
202 164 157 211 311 206 248 293 263 202 252 259 252 150 167 151 245 213 150 152  
197 155 245 177 192 227 214 239 307 198 166 195 179 201 212 202 275 349 199 158  
153 156 119 82 58 57 44 50 43 48 70 58 67 76 91 85 79 75 71 82  
102 113 99 105 104 81 58 54 70 88 110

CBM-A46A 64

137 141 143 189 222 122 123 82 89 120 137 124 107 56 100 118 99 70 121 157  
257 241 123 263 239 326 252 193 267 260 450 396 483 254 266 360 203 268 318 285  
354 363 242 191 225 213 206 298 291 213 171 251 265 167 179 191 324 333 294 204  
151 129 214 406

CBM-A46B 65

214 156 134 133 198 229 127 117 78 82 130 136 132 104 58 91 111 98 76 131  
146 267 292 112 263 243 329 243 180 270 259 446 392 469 261 272 376 205 253 332  
251 359 366 242 202 202 181 222 300 312 206 182 236 266 172 171 192 305 318 290  
201 147 128 227 396

CBM-A47A 96

644 686 189 126 134 125 102 145 175 157 171 131 179 187 184 178 201 165 254 238  
246 306 170 177 164 154 166 202 112 114 85 142 164 68 48 49 45 40 44 46  
82 90 86 94 122 132 131 142 121 92 138 135 180 222 153 181 153 132 159 158  
133 174 185 146 128 120 185 170 155 178 156 204 220 175 174 160 216 155 147 178  
168 193 156 71 45 43 32 47 51 47 57 64 71 75 114 147

CBM-A47B 96

628 689 187 142 132 125 100 150 172 160 174 141 173 191 192 167 187 199 250 252  
235 302 161 176 171 143 167 193 115 110 95 135 160 56 53 49 50 42 46 41  
82 78 91 88 111 140 121 142 134 118 140 131 185 213 158 176 146 141 154 151  
142 153 188 143 138 119 176 182 166 144 159 213 225 148 190 150 194 143 224 153  
171 191 151 64 58 30 35 43 53 44 52 61 65 89 107 135

CBM-A48A 97

71 99 125 75 59 74 70 75 43 56 70 68 82 93 73 58 52 58 34 66  
66 32 39 40 55 68 71 52 63 69 66 63 89 120 76 74 100 112 89 87  
83 71 96 98 133 105 99 94 109 139 165 88 135 127 116 112 145 121 100 72  
102 114 101 87 70 88 118 116 92 132 115 105 101 77 72 103 76 87 68 62  
51 73 111 131 121 83 88 101 95 103 81 160 133 117 165 131 135

CBM-A48B 97

78 98 113 81 59 75 73 71 44 52 72 69 89 85 67 59 56 56 45 81  
59 34 35 41 56 68 66 57 63 62 71 62 90 119 78 70 108 103 92 90  
86 70 93 98 135 106 83 102 108 148 167 94 135 111 114 124 137 127 102 76  
90 113 97 87 72 87 110 105 99 130 112 98 99 68 77 103 68 86 77 55  
51 66 123 128 113 80 94 104 91 113 70 148 135 122 167 131 137

CBM-A49A 73

316 232 293 335 339 284 308 287 194 240 252 288 392 225 204 140 143 143 198 112  
94 179 199 281 303 160 134 158 146 162 122 211 206 298 132 142 162 228 245 146  
98 106 70 78 58 59 97 67 95 103 142 127 84 104 126 135 174 128 143 176  
97 141 83 64 101 98 94 83 105 87 133 120 133

CBM-A49B 73

288 241 302 344 331 279 316 286 189 237 253 287 381 232 204 135 136 151 196 107  
112 177 196 273 305 162 151 161 136 161 130 195 198 288 102 151 170 218 225 125  
101 109 72 73 57 64 92 78 81 109 138 121 77 106 126 146 166 132 148 162  
99 142 76 69 104 104 85 92 100 85 133 119 110

CBM-A50A 81

123 70 111 110 135 146 87 102 135 167 178 164 211 182 132 126 141 182 163 134  
166 130 102 121 109 112 146 124 138 173 170 156 145 117 139 138 120 158 140 104  
96 94 145 153 130 106 119 105 109 90 75 142 89 120 124 114 124 81 81 84  
66 106 77 63 77 95 91 52 85 89 141 100 85 108 80 101 89 81 127 129  
177

CBM-A50B 81

134 77 114 106 146 128 80 98 114 194 182 165 197 174 122 147 148 149 154 127  
165 113 115 119 123 102 114 135 130 187 166 147 141 121 111 134 137 157 132 114  
80 110 136 157 126 111 122 115 97 100 75 99 95 114 126 113 84 111 75 82  
74 82 46 81 79 101 81 49 97 90 134 89 97 107 87 101 84 96 131 128  
164

CBM-A51A 110

398 298 331 208 226 221 127 124 103 100 71 68 81 73 80 69 173 137 108 243  
144 201 96 104 132 132 118 174 232 106 157 179 173 93 89 41 73 63 76 160  
130 68 72 79 127 165 141 218 170 123 149 82 108 93 88 74 70 73 134 177  
132 158 160 198 185 134 105 94 87 114 145 188 104 72 56 47 56 71 51 67  
75 91 126 142 131 111 150 65 64 67 72 99 115 64 85 132 166 140 178 157  
164 145 122 174 104 156 188 192 200 143

CBM-A51B 110

376 291 335 215 237 219 126 121 97 114 75 59 88 75 79 67 175 145 113 242  
152 189 97 100 138 138 109 175 230 102 181 179 154 85 93 45 70 54 78 162  
122 68 63 91 129 160 132 225 175 126 137 82 112 94 88 77 62 89 126 184



132 160 157 202 181 134 124 95 86 118 153 158 99 61 67 55 57 61 52 67  
76 99 107 148 123 110 173 75 62 60 71 103 151 69 76 134 166 143 174 154  
164 138 130 178 97 165 178 196 208 150

CBM-A52A 111

218 232 201 244 331 180 216 159 167 175 136 128 109 180 145 226 239 166 95 140  
197 162 105 237 124 100 116 104 125 96 75 74 75 104 119 103 81 88 84 171  
169 138 141 133 93 95 131 202 138 139 128 135 111 88 79 92 117 118 115 177  
135 129 123 79 94 117 101 126 131 79 63 83 150 123 98 81 74 122 76 88  
64 78 103 89 73 82 75 66 41 56 71 84 64 79 103 108 120 97 112 118  
161 120 106 147 96 134 93 91 108 124 142

CBM-A52B 111

173 232 199 239 342 178 217 162 160 169 169 118 124 160 163 227 242 143 101 137  
206 163 112 234 136 99 109 113 135 91 83 72 74 108 112 111 75 90 92 159  
162 144 150 115 103 90 123 201 146 136 126 134 111 89 93 90 104 119 117 170  
129 129 120 85 92 117 94 124 155 74 57 84 119 127 96 79 84 111 75 80  
57 78 108 88 97 80 67 77 42 58 63 75 75 74 103 105 114 103 104 129  
146 129 101 145 115 124 94 96 103 115 172

CBM-A53A 63

216 133 178 255 85 164 146 180 154 272 159 248 177 229 197 186 135 150 117 156  
176 178 179 134 258 258 246 204 197 216 211 187 136 164 202 172 195 280 167 106  
81 107 128 149 121 113 127 145 130 178 95 120 116 134 154 102 180 147 129 126  
125 196 185

CBM-A53B 63

181 133 179 258 107 164 162 187 152 247 162 244 181 237 234 186 135 145 127 147  
196 153 181 111 238 261 301 215 190 211 239 162 150 165 240 167 204 282 178 107  
76 104 135 148 117 133 119 133 122 163 93 113 127 126 149 105 184 148 137 117  
119 199 227

CBM-A54A 58

52 64 66 57 65 49 93 86 92 74 52 56 80 61 82 73 108 98 137 112  
101 129 236 156 141 181 193 155 141 116 114 138 138 86 107 165 155 123 154 127  
111 145 106 97 75 150 127 134 161 124 136 124 106 116 140 106 99 156

CBM-A54B 57

54 65 62 64 59 54 87 91 96 66 51 64 79 70 67 77 118 99 127 110  
100 139 243 154 142 172 191 157 138 110 119 143 125 95 96 152 140 142 149 118  
109 140 128 76 72 148 136 140 148 123 148 117 112 129 143 120 147

CBM-A55A 112

127 176 188 143 124 174 188 164 141 129 130 159 182 204 155 173 228 219 146 186  
222 247 161 257 155 161 221 150 192 191 160 204 112 185 202 190 243 243 158 186  
188 96 130 147 158 166 163 93 110 164 212 245 152 143 152 122 112 112 92 168  
164 171 143 164 96 83 106 74 101 125 75 75 79 96 78 56 86 128 157 122  
123 166 121 113 92 80 118 150 129 201 198 146 68 93 90 123 129 161 175 214  
222 243 177 222 161 164 119 114 149 118 77 136

CBM-A55B 112

124 179 196 143 122 168 188 154 150 123 135 151 187 204 163 170 219 219 151 196  
199 268 156 226 186 166 202 150 186 184 158 216 83 183 200 179 258 226 153 175  
187 100 134 123 195 165 164 85 114 162 215 250 153 125 137 126 105 115 90 180  
146 176 157 145 107 81 111 72 95 128 93 75 93 87 84 66 79 126 157 118  
119 181 125 130 93 87 124 158 150 206 197 148 64 96 79 133 129 149 195 211  
232 225 179 214 162 161 119 116 152 129 89 129

CBM-A56A 144

201 211 157 138 157 133 196 176 151 129 121 156 148 123 161 154 211 152 178 137  
134 126 149 121 93 97 82 69 92 132 78 80 93 94 115 110 58 87 127 130  
113 121 102 175 116 113 73 70 85 69 81 80 60 54 38 34 49 65 52 46  
37 41 36 40 37 28 33 54 56 67 56 92 95 65 91 82 93 71 82 80  
102 84 103 124 94 90 129 166 166 120 100 108 90 93 99 126 117 94 101 99  
139 109 120 112 87 90 113 132 87 88 76 74 75 58 60 72 54 49 45 52  
35 46 47 61 77 113 96 63 81 98 134 91 76 88 78 79 73 61 58 74  
76 80 68 83

CBM-A56B 144

205 222 130 148 152 135 195 188 150 129 115 155 140 124 152 161 206 154 184 129  
133 124 149 116 100 102 76 70 96 120 82 86 88 89 117 113 52 92 130 123  
117 111 109 172 117 115 70 78 81 63 78 86 60 51 36 37 50 66 47 47  
40 39 35 39 35 28 37 50 59 69 53 96 91 66 93 76 95 67 86 82  
100 90 100 123 87 101 122 163 167 125 98 113 85 104 87 129 120 87 84 116  
127 131 103 98 96 90 106 124 103 83 77 76 67 58 62 67 58 56 39 48  
40 49 53 59 79 109 96 71 86 97 113 94 96 91 74 82 74 53 56 80  
75 76 96 86

CBM-A57A 66

87 71 66 70 61 54 38 55 59 61 51 47 60 68 74 62 75 97 80 70  
96 62 92 129 92 114 136 109 134 120 136 69 88 67 89 68 96 77 68 56  
76 95 115 160 122 74 93 115 112 95 74 70 74 82 54 55 93 91 118 113  
85 76 93 66 76 125

CBM-A57B 66

93 64 67 69 73 50 38 56 64 51 55 53 66 54 70 67 68 106 88 72  
75 64 95 120 100 118 141 106 145 132 148 96 79 65 84 72 95 81 70 58  
69 71 108 134 118 83 97 112 116 83 83 73 70 75 56 70 78 109 99 119  
89 79 88 63 78 108

CBM-A58A 88

167 124 126 143 116 142 242 320 189 173 153 240 168 160 186 171 188 168 232 313  
211 159 142 121 118 113 73 117 122 172 157 223 172 145 178 95 120 92 103 130  
162 100 97 131 212 221 139 102 153 169 122 160 101 208 128 177 164 166 132 154  
124 90 102 108 48 107 67 77 80 65 46 59 109 112 114 135 101 132 77 83  
112 158 145 162 213 141 91 106

CBM-A58B 88

126 158 130 143 114 158 227 321 191 176 159 233 166 149 196 145 158 168 237 313  
207 168 136 105 131 120 76 109 127 150 173 224 174 139 179 102 105 107 100 124  
177 85 94 142 207 220 125 122 146 166 131 159 112 194 128 185 164 164 121 147  
127 104 94 96 59 92 73 79 73 56 52 74 106 103 106 130 105 123 67 86  
123 156 139 170 221 143 108 92

CBM-A59A 96

229 150 208 213 212 207 215 247 178 123 118 189 169 223 174 210 152 144 142 180  
409 355 324 449 413 257 354 394 342 361 314 353 313 214 227 233 193 180 205 242  
147 177 239 142 147 174 175 121 205 128 92 135 136 85 97 110 121 184 228 223  
163 241 151 200 205 148 137 112 148 185 152 172 190 163 192 204 180 195 190 119  
193 267 260 205 188 249 152 144 153 257 241 123 263 239 326 252

CBM-A59B 96

178 147 197 222 203 226 196 245 170 120 110 196 169 227 174 214 175 142 130 175  
420 375 311 416 418 239 338 399 360 353 316 349 319 211 227 219 183 186 191 252  
167 233 206 155 139 173 160 143 203 150 98 134 146 68 97 117 119 185 220 219  
165 243 159 193 204 145 137 113 142 199 147 161 194 171 192 207 176 209 179 122

223 280 270 200 169 226 154 157 144 246 267 218 254 233 343 229

CBM-A60A 86

64 62 87 95 78 103 108 97 115 108 155 118 75 81 115 94 113 127 116 105  
109 90 46 57 62 71 132 120 92 57 70 53 68 42 52 54 98 80 80 83  
106 104 138 152 157 84 61 70 74 85 98 131 154 119 101 151 86 120 115 104  
48 70 66 65 50 80 68 81 85 77 122 132 111 135 155 54 34 48 43 59  
122 102 69 62 87 105

CBM-A60B 86

64 62 79 98 78 104 105 98 109 99 156 122 66 96 111 97 115 130 114 99  
99 97 51 51 51 88 113 125 92 69 61 59 67 42 48 53 90 80 77 81  
104 108 139 157 156 90 57 66 70 79 105 135 160 112 104 149 85 116 101 119  
47 60 74 62 43 91 68 95 72 85 114 126 111 134 162 55 35 44 47 57  
118 99 73 58 79 102

CBM-A61A 55

266 181 294 253 605 344 268 173 366 552 468 562 421 338 322 154 224 322 456 296  
271 317 163 177 126 158 378 268 334 309 246 153 78 102 132 231 151 199 227 184  
190 180 257 253 355 336 253 212 212 468 396 526 547 497 354

CBM-A61B 55

269 183 294 261 601 336 261 184 360 558 450 554 414 338 312 170 216 330 441 298  
271 328 177 150 144 152 368 268 347 310 242 152 84 99 123 237 144 205 235 178  
210 167 250 279 357 302 221 194 218 431 414 500 559 560 364

CBM-A62A 65

218 406 277 195 322 329 186 203 212 329 315 395 328 275 453 314 391 527 440 283  
201 376 281 433 399 313 258 217 131 217 128 143 179 203 205 150 183 315 419 205  
149 211 241 200 104 75 88 42 52 44 49 71 63 92 100 92 94 54 85 120  
180 111 112 157 145

CBM-A62B 65

208 400 293 218 290 344 196 209 229 294 312 384 323 287 443 322 374 533 449 275  
210 377 286 480 376 305 260 207 143 224 136 146 190 186 224 137 192 310 429 210  
162 199 243 207 81 75 78 55 60 49 53 69 67 99 87 96 87 53 92 112  
185 127 105 126 164

CBM-A63A 54

314 295 277 330 380 286 337 379 498 320 445 318 284 223 137 293 326 437 230 373  
377 227 222 156 125 444 256 277 249 193 154 69 154 145 334 145 202 222 297 284  
272 331 362 360 255 162 208 213 356 353 401 421 261 272

CBM-A63B 54

314 294 278 333 315 294 340 402 468 324 428 305 296 234 131 289 317 425 257 383  
359 220 238 162 122 425 282 287 233 195 160 69 137 138 316 146 209 218 280 311  
275 317 380 356 254 161 206 211 348 362 412 418 253 359

CBM-A64A 64

312 369 273 377 335 336 254 211 286 156 315 293 178 233 192 148 115 193 565 409  
428 267 304 225 151 225 267 409 263 333 429 171 226 147 174 370 248 345 273 326  
212 87 146 143 385 251 269 365 377 334 332 328 328 390 270 150 129 126 233 376  
350 415 281 254

CBM-A64B 64

271 361 281 376 329 337 243 226 271 157 322 293 171 230 189 166 110 189 564 397  
422 277 311 220 168 194 264 421 258 328 414 179 220 156 176 363 247 345 281 411  
230 95 175 135 220 151 265 359 334 345 328 329 313 400 255 164 128 130 226 372  
367 424 309 264

CBM-A65A 69

208 172 103 187 173 228 174 115 115 96 157 90 147 101 150 201 197 164 288 314  
324 257 184 198 111 101 122 154 107 72 87 134 182 175 133 108 148 129 51 79  
105 113 108 164 194 213 170 169 97 207 353 612 585 480 305 150 67 106 127 144  
111 121 146 90 155 104 62 146 147

CBM-A65B 69

275 170 97 198 159 236 173 114 113 91 159 98 135 102 151 202 201 156 299 308  
308 252 187 198 106 106 120 144 118 65 90 138 179 177 123 119 147 128 57 71  
115 114 108 173 185 215 168 168 105 178 375 622 576 471 296 160 63 107 130 133  
117 126 145 83 154 109 74 146 154

CBM-A66A 62

204 193 297 425 329 206 178 147 127 252 390 445 287 162 316 284 410 241 135 159  
339 263 338 516 248 235 258 148 219 183 216 352 181 121 120 178 172 199 182 175  
212 278 119 124 65 140 153 182 186 189 176 118 61 96 119 130 70 64 90 84  
77 109

CBM-A66B 62

220 195 285 402 361 200 173 155 125 244 402 449 288 163 314 291 428 239 133 143  
340 263 316 502 270 236 248 160 209 187 222 351 183 130 116 195 183 217 188 156  
201 266 119 129 56 137 167 178 184 202 181 119 59 99 107 108 71 73 88 84  
96 102

CBM-A67A 54

175 176 184 139 137 166 148 218 235 162 170 381 305 210 214 243 181 150 94 85  
150 111 92 99 176 118 152 180 125 125 164 239 227 176 165 172 175 191 215 300  
228 97 201 210 266 192 77 132 169 194 261 263 198 225

CBM-A67B 54

178 172 182 134 141 158 161 208 241 161 185 378 382 213 229 263 190 121 121 90  
115 137 102 99 163 92 154 171 128 134 159 240 218 164 159 161 154 205 194 307  
249 97 189 206 270 196 69 134 181 197 259 296 186 200

CBM-A68A 57

309 124 82 142 181 153 150 298 177 195 98 87 124 147 76 82 143 48 96 86  
96 98 138 192 214 110 131 96 97 108 175 205 186 171 179 256 332 194 134 186  
274 260 307 436 225 160 171 146 213 158 184 290 193 114 126 151 187

CBM-A68B 57

302 116 98 131 176 152 154 299 176 188 89 94 133 152 55 89 125 85 96 97  
74 94 137 188 219 140 143 105 100 112 177 200 182 171 185 255 335 181 126 182  
282 246 253 428 238 170 178 141 194 156 186 313 201 106 108 164 190

CBM-A69A 59

161 108 132 136 260 182 328 224 345 381 297 372 330 340 386 321 394 377 287 249  
297 258 167 144 152 217 167 150 146 121 116 249 198 319 254 200 276 233 207 193  
219 241 240 182 223 325 234 226 169 202 183 161 139 145 162 136 196 142 204

CBM-A69B 59

166 102 133 132 265 177 326 230 349 372 288 362 325 346 380 308 390 375 286 252  
284 258 164 150 151 214 163 143 155 113 113 242 189 332 247 198 277 235 210 196  
205 262 232 197 219 317 251 217 174 192 172 171 150 142 167 148 179 189 219

CBM-A70A 80

62 62 99 139 199 192 88 78 158 175 165 174 187 139 131 109 100 138 126 81  
133 151 107 157 97 105 120 139 180 173 64 65 48 60 64 98 136 116 148 170  
224 234 199 86 114 210 215 244 304 204 213 210 184 220 159 200 261 167 123 106  
224 221 238 182 148 180 219 163 149 87 191 140 181 187 232 184 86 79 80 151

CBM-A70B 80

45 61 104 138 197 182 84 90 147 163 162 173 183 142 125 109 97 139 130 75  
137 158 103 153 101 105 121 140 173 168 67 62 55 54 65 86 126 123 131 161  
218 240 190 89 124 202 221 236 289 213 218 212 184 213 160 197 258 170 121 111  
209 224 247 176 154 177 224 166 138 96 179 152 177 192 217 202 86 76 87 139

CBM-A71A 63

361 631 544 603 540 330 314 245 257 304 150 142 140 137 110 144 135 114 154 117  
141 170 146 166 183 168 265 207 187 144 89 77 147 226 137 134 185 158 132 53  
55 85 51 48 56 37 32 43 36 26 44 54 44 46 104 230 333 279 108 74  
193 237 218

CBM-A71B 63

326 608 552 608 512 309 330 270 245 320 149 143 136 138 124 125 135 116 136 100  
153 172 138 161 193 184 259 240 204 136 92 82 148 204 145 121 190 160 122 72  
47 90 41 58 55 38 31 39 38 30 40 48 46 51 97 244 326 293 89 87  
196 241 294

CBM-A72A 78

516 559 294 262 212 287 291 172 140 138 137 109 134 127 115 124 104 156 146 129  
162 178 187 264 238 220 116 76 59 124 182 131 133 197 200 148 90 63 109 74  
91 69 67 43 64 64 46 46 59 51 59 113 266 342 312 100 80 154 220 238  
187 262 188 181 134 100 128 128 70 77 161 171 224 326 242 153 280 189

CBM-A72B 78

522 574 288 252 195 264 300 185 147 137 153 100 140 128 102 108 114 165 151 128  
147 183 165 265 204 198 115 75 64 128 187 131 120 186 194 154 84 69 109 65  
93 74 59 53 47 56 48 53 52 53 58 108 266 339 312 98 83 151 228 220  
184 262 189 179 130 96 136 118 79 87 156 168 223 350 223 149 279 206

CBM-A73A 68

110 176 175 183 138 136 166 149 217 234 163 138 159 233 236 206 220 275 209 179  
209 202 195 166 161 186 184 221 239 158 183 232 232 159 176 199 234 173 192 196  
187 203 123 191 209 203 257 130 192 211 187 210 284 213 185 174 140 130 124 148  
175 185 138 121 155 209 187 184

CBM-A73B 68

136 179 170 181 133 145 157 162 207 242 168 134 157 218 229 201 241 267 202 180  
217 208 186 176 154 190 184 233 231 158 196 230 234 149 181 199 232 183 169 203  
172 195 139 177 221 205 258 119 180 210 198 214 286 211 184 169 148 122 134 127  
187 193 136 116 158 195 203 175

CBM-A74A 96

202 146 247 332 252 250 202 307 257 281 201 358 256 153 284 204 159 154 86 129  
149 94 160 83 52 63 65 105 164 146 94 155 195 141 164 185 384 263 141 262  
138 200 132 178 195 193 196 176 124 94 108 114 95 108 152 122 91 105 87 124  
104 77 97 81 120 95 89 193 144 91 179 163 252 221 180 174 270 239 308 326  
151 228 260 367 334 449 398 234 238 304 299 392 265 280 292 330

CBM-A74B 96

204 140 251 322 250 242 208 314 257 270 208 380 264 163 295 201 161 155 84 135  
150 94 161 80 57 65 65 105 174 120 100 146 187 144 158 199 400 271 136 259  
143 194 123 185 211 185 195 159 120 108 107 116 93 119 144 120 102 107 80 123  
101 76 96 80 126 87 91 179 160 90 179 157 219 223 180 188 296 262 297 333  
143 234 270 357 345 453 412 251 238 281 265 375 273 290 307 358

CBM-A75A 54

485 480 394 459 544 491 314 371 493 476 432 476 406 414 370 359 243 390 394 383  
335 416 400 509 351 395 325 283 386 375 479 419 487 407 358 444 391 440 411 421  
234 164 138 158 233 120 176 175 183 138 137 162 149 217

CBM-A75B 54

442 494 393 492 545 449 330 333 516 485 444 496 392 411 377 360 246 387 388 397  
365 392 397 486 368 415 345 317 378 329 483 405 478 375 348 510 342 458 406 455  
242 167 134 157 218 136 179 170 181 133 145 157 160 208

CBM-A76A 54

142 263 136 201 132 179 196 194 197 176 123 104 109 174 158 178 152 87 87 163  
123 213 260 122 110 147 181 180 164 318 212 144 118 142 180 91 85 54 82 89  
133 125 75 116 111 122 149 109 139 129 115 102 118 159

CBM-A76B 54

137 258 141 196 127 181 210 187 196 159 121 108 109 128 169 246 133 88 119 144  
119 224 266 142 123 144 193 172 166 291 213 147 126 129 180 110 82 54 89 84  
130 127 68 100 123 118 152 113 139 142 89 126 133 131

CBM-A77A 111

336 313 351 342 195 182 229 223 160 153 179 119 162 135 176 192 160 187 127 174  
100 160 206 99 102 106 138 81 103 90 110 104 90 62 60 91 96 108 88 57  
63 70 95 90 76 156 73 86 98 121 115 70 72 59 89 72 103 92 89 109  
93 137 97 114 85 84 74 179 138 212 113 97 102 144 116 159 84 119 171 151  
162 163 132 107 108 92 78 110 106 92 111 69 84 103 101 100 84 87 103 104  
64 70 67 117 88 92 96 92 95 83 116

CBM-A77B 111

330 307 348 336 200 186 220 239 166 153 174 124 165 127 176 196 160 187 128 173  
103 161 199 106 99 99 135 90 103 92 126 101 93 66 56 91 92 112 83 61  
64 66 86 95 85 140 80 84 103 122 120 74 60 72 75 81 98 93 86 111  
91 134 97 120 86 83 76 178 137 216 124 98 112 143 125 152 86 131 137 143  
137 167 137 122 100 93 78 99 101 94 104 71 91 102 97 119 76 86 106 94  
72 59 61 124 111 85 89 91 90 92 100

CBM-A78A 67

95 129 181 221 245 211 172 158 169 243 335 205 153 128 143 135 98 77 113 124  
136 128 215 181 212 147 101 112 143 153 155 167 123 81 135 184 179 158 140 168  
208 135 113 120 180 156 200 180 260 198 167 153 174 192 157 119 194 200 157 187  
145 161 154 272 194 191 222

CBM-A78B 67

121 122 177 221 241 223 160 163 176 251 319 213 151 127 147 127 114 69 108 133  
125 136 208 172 229 136 116 110 135 149 171 159 109 99 133 191 173 161 112 163  
213 142 120 113 197 161 189 186 258 206 193 133 166 173 163 118 199 194 159 178  
151 160 159 267 181 197 220

CBM-A79A 66

221 237 691 386 320 358 358 328 418 317 292 277 317 335 328 290 293 275 199 180  
177 270 305 256 136 155 347 347 310 348 440 526 484 410 425 293 351 475 360 416  
539 557 606 434 471 351 563 417 572 580 360 343 284 381 558 471 658 529 644 565  
284 355 342 502 414 549

CBM-A79B 55

224 231 680 379 322 351 355 321 416 310 297 265 311 325 316 296 284 267 199 178  
171 267 300 257 126 149 341 343 311 337 429 517 454 405 412 291 362 471 349 409  
527 549 609 438 473 554 553 409 567 571 349 342 278 379 550

CBM-A80A 54

500 448 595 574 637 526 424 567 395 348 103 62 143 147 144 173 272 190 201 169  
261 382 189 394 399 348 284 227 250 316 200 313 235 202 282 166 177 267 180 161  
147 127 252 151 94 103 162 204 194 297 425 329 206 178

CBM-A80B 54

522 410 593 579 638 535 430 560 394 354 91 63 157 155 164 183 289 191 189 172  
259 381 194 397 381 345 278 238 244 315 198 328 237 210 272 179 176 251 192 136  
155 125 244 163 110 96 159 220 195 285 403 361 200 173

CBM-A81A 56

280 200 214 317 231 186 190 161 157 153 222 242 213 133 209 436 354 358 416 507  
539 504 502 488 336 446 567 449 425 479 550 644 610 577 441 645 462 695 802 636  
642 508 378 545 565 725 626 804 668 372 454 394 612 481 592 488

CBM-A81A 56

256 193 219 311 228 179 193 169 157 153 224 239 215 138 211 446 364 361 421 511  
542 507 501 479 321 440 559 438 421 482 551 633 601 572 439 641 448 673 787 621  
638 499 381 487 559 652 618 758 681 348 429 357 622 427 541 462

CBM-A82A 54

127 251 259 270 293 227 297 327 207 215 158 169 160 215 284 212 192 181 166 209  
110 149 173 171 212 114 148 139 152 127 123 156 212 209 174 174 267 240 134 160  
191 221 130 176 175 181 138 136 165 148 217 234 270 194

CBM-A82B 54

153 247 264 301 297 214 292 329 235 238 181 190 161 219 265 222 205 187 159 183  
111 162 185 193 232 124 118 135 158 126 91 168 212 192 178 201 269 245 128 159  
197 221 135 179 170 182 133 145 158 160 207 242 268 181

CBM-A83A 124

303 413 511 226 152 75 70 93 134 103 119 199 210 313 217 280 325 284 247 212  
183 392 326 292 351 434 305 257 230 293 245 370 143 202 232 191 325 331 229 133  
223 265 257 222 332 220 181 185 226 190 132 51 46 69 43 44 84 94 105 111  
119 109 122 110 123 117 120 153 155 222 184 140 130 136 97 139 64 65 99 138  
146 204 169 147 155 94 104 109 135 155 150 140 104 231 311 232 162 107 150 182  
134 160 122 230 174 142 171 145 170 138 93 116 126 147 110 133 122 144 123 96  
106 148 106 112

CBM-A83B 124

339 413 501 242 154 75 71 92 136 105 128 205 196 326 220 271 411 283 247 220  
212 400 307 305 339 418 311 273 213 280 250 356 155 196 229 216 323 333 214 143  
222 276 250 249 337 229 175 193 221 201 129 45 50 67 45 46 87 87 109 104  
124 109 119 109 122 122 118 154 136 224 176 131 136 145 99 137 50 87 94 141  
150 200 162 147 141 95 97 97 140 150 151 144 105 226 305 231 157 132 127 189  
128 159 120 228 172 168 170 158 169 120 81 114 120 147 112 131 113 151 120 88  
129 148 102 119

CBM-A84A 49

377 292 233 184 144 290 368 379 319 176 247 416 327 383 165 329 256 316 278 262  
192 204 108 89 126 174 131 93 92 90 153 113 81 128 124 168 117 186 92 100  
87 112 86 70 81 67 105 163 138 108 100 137 127 80

CBM-A84B 54

284 348 252 178 144 259 354 388 316 183 279 411 348 371 164 325 262 321 279 261  
197 207 113 87 125 172 129 91 90 86 154 116 78 132 116 184 119 172 106 110  
87 106 98 71 78 71 84 170 171 109 99 139 130 76

CBM-A85A 64

138 337 336 250 259 238 276 268 290 255 260 249 218 167 144 168 189 137 119 157  
142 174 151 187 287 407 252 251 325 368 311 304 250 250 210 249 175 127 166 153  
143 145 125 99 94 118 69 130 216 178 206 205 164 141 106 184 150 193 166 193  
254 184 180 171

CBM-A85B 64

147 337 327 250 243 255 252 258 317 245 258 233 231 182 133 152 221 137 112 149  
134 173 168 215 269 396 237 237 284 426 295 296 268 245 205 237 175 140 159 153  
140 140 118 107 101 116 76 124 197 168 189 213 159 144 107 148 179 190 171 188  
239 172 179 199

CBM-A86A 106

157 203 176 256 196 120 106 128 146 181 162 255 195 188 191 190 190 162 156 236  
251 179 207 237 177 209 243 271 264 359 252 159 154 207 219 338 217 170 158 150  
150 182 140 140 141 160 191 227 201 221 150 128 107 122 136 157 214 135 125 156  
238 196 194 157 195 214 159 122 114 237 176 163 183 259 159 159 167 163 189 281  
191 135 154 207 156 71 54 61 73 76 90 106 103 127 124 112 137 136 144 133  
175 157 92 141 146 183

CBM-A86B 106

160 209 183 256 202 122 101 126 144 175 173 251 198 192 207 189 204 171 143 241  
246 181 194 234 174 216 247 257 271 351 236 160 148 207 208 342 211 177 158 146  
175 169 150 154 111 144 192 214 198 200 144 128 106 110 125 154 195 126 132 161  
229 200 185 162 197 186 156 126 121 240 170 167 191 272 143 163 161 164 191 275  
190 143 147 213 139 86 45 59 75 74 90 109 103 128 116 114 141 132 142 141  
181 161 85 146 135 192

CBM-A87A 149

333 443 415 350 412 270 388 435 423 346 341 357 358 279 215 219 219 153 180 108  
189 179 345 400 375 355 261 307 326 227 241 262 307 298 302 265 191 235 172 138  
155 169 122 84 74 132 158 174 144 119 131 167 194 199 189 180 143 129 105 118  
96 74 88 102 105 139 120 140 144 194 267 300 244 194 199 182 145 173 176 153  
153 188 191 146 108 69 74 107 164 148 188 129 116 113 99 76 87 108 120 102  
79 75 105 124 132 112 103 116 173 174 103 143 203 189 167 181 170 150 140 189  
124 195 184 170 140 156 156 207 159 198 136 139 134 112 138 131 162 117 113 130  
151 140 134 163 178 119 93 79 126

CBM-A87B 149

406 433 384 361 397 273 381 406 376 351 360 296 354 297 204 224 221 156 177 127  
200 186 340 422 386 334 281 306 304 227 258 255 307 280 301 269 193 227 165 141  
161 171 113 93 73 123 165 181 140 116 160 167 189 187 186 173 140 138 97 113  
96 71 94 112 97 132 124 141 144 197 270 292 226 192 192 178 139 166 182 156  
150 187 193 142 112 78 65 113 158 152 196 129 122 103 101 81 92 85 125 111  
76 79 105 135 120 120 101 111 176 173 111 147 220 167 174 180 167 154 154 184  
118 207 177 165 131 166 148 199 158 205 125 149 127 114 136 128 162 117 110 122  
140 139 123 176 169 132 90 88 112

CBM-A88A 91

120 121 140 111 97 152 181 114 119 132 109 140 154 210 191 188 183 140 145 144  
173 187 151 158 117 84 115 115 128 126 117 159 145 184 161 156 114 124 111 103  
109 137 138 82 110 120 137 133 136 119 132 170 157 137 116 187 154 139 191 184  
140 162 137 130 156 209 155 120 131 218 145 67 78 71 84 80 74 82 71 67  
79 84 93 123 112 108 141 144 76 86 132

CBM-A88B 91

115 128 142 113 95 147 176 114 130 156 90 153 163 204 204 211 176 132 149 145  
176 192 155 143 118 88 105 129 112 118 124 153 147 179 152 150 102 125 97 99  
120 135 128 84 104 122 136 128 133 116 144 164 153 129 124 204 137 160 171 175  
127 158 133 134 158 205 157 107 141 211 151 79 68 72 81 82 77 79 72 67  
82 79 101 113 107 110 143 132 82 94 122



CBM-A89A 118

431 297 244 301 280 251 237 181 166 266 266 613 641 346 557 337 516 234 187 349  
253 260 328 287 204 208 213 173 175 134 99 92 99 116 224 200 106 80 93 134  
124 105 265 183 171 154 148 87 97 88 98 123 94 126 169 136 132 155 154 140  
91 94 87 86 124 144 167 133 128 94 116 67 95 108 82 101 108 160 160 177  
112 139 125 99 135 104 128 94 109 176 136 191 145 124 177 141 164 112 105 141  
164 202 214 188 157 129 114 131 119 139 113 106 114 101 139 112 120 128

CBM-A89B 118

401 295 251 281 286 256 248 171 170 291 295 599 624 349 533 325 513 228 185 347  
245 266 259 289 201 191 219 175 164 133 93 95 114 102 201 218 108 78 86 130  
123 164 216 177 142 172 122 111 122 81 90 116 92 132 151 131 165 131 161 148  
76 112 95 80 138 126 163 144 116 102 97 88 86 121 85 84 119 144 156 139  
125 83 135 111 133 105 123 111 84 172 202 129 155 124 169 156 153 124 104 133  
130 194 208 197 123 145 127 131 128 127 99 103 117 93 134 109 129 148

CBM-A90A 69

168 223 281 222 299 313 326 414 372 346 360 432 442 400 473 406 369 381 337 356  
341 435 398 439 285 307 329 329 357 331 302 376 455 339 312 274 357 305 301 348  
307 253 287 223 298 308 315 203 320 284 285 339 276 293 323 297 247 295 291 258  
318 226 303 324 316 339 303 334 283

CBM-A90B 69

168 236 267 237 285 318 326 414 407 326 362 426 435 379 478 404 379 389 358 360  
311 442 390 445 285 307 328 328 364 324 305 393 444 366 301 266 379 289 321 362  
321 273 283 253 284 291 318 264 242 300 313 288 300 385 297 277 255 284 290 270  
343 238 296 311 317 350 293 328 377

CBM-A91A 58

154 107 102 135 126 131 131 103 121 131 128 145 108 144 153 202 124 134 204 257  
145 202 163 236 196 215 142 146 190 174 213 165 161 140 164 124 107 139 148 167  
145 172 124 165 145 131 150 166 97 165 169 143 186 173 143 213 185 197

CBM-A91B 58

138 112 113 126 129 136 137 109 132 121 145 112 148 119 144 224 124 136 210 247  
156 204 173 218 203 225 134 146 193 177 205 177 153 132 174 121 102 134 151 170  
136 176 110 163 123 148 159 147 117 153 183 116 202 156 163 200 168 210

CBM-A92A 58

150 126 140 156 176 279 175 167 95 126 140 195 176 117 140 131 204 129 155 199  
199 169 187 170 256 172 130 115 133 202 124 183 134 185 220 187 171 120 187 202  
252 261 188 145 110 189 117 156 251 215 155 173 187 192 180 184 195 373

CBM-A92B 58

121 138 133 170 177 279 167 153 108 116 136 226 170 118 134 138 200 153 147 158  
219 174 190 190 218 226 117 114 145 163 149 181 139 176 217 187 167 125 185 211  
254 267 175 132 109 171 117 146 243 238 162 165 201 185 168 179 202 377

CBM-A93A 54

354 397 493 407 281 355 373 410 277 229 228 287 288 249 274 238 202 234 216 286  
254 231 172 206 218 191 179 278 264 215 224 181 179 190 149 185 87 85 76 113  
133 163 233 302 259 277 195 154 131 208 213 97 73 133

CBM-A93B 54

368 406 482 413 276 360 377 406 272 221 245 295 290 224 295 227 213 222 209 301  
237 223 174 192 213 168 174 290 265 224 218 177 182 201 150 164 102 87 70 115  
140 148 229 291 282 276 206 143 147 204 221 96 74 135

CBM-A94A 54

263 362 284 412 308 306 242 158 160 160 193 253 224 154 128 172 334 290 270 186  
237 253 281 254 199 327 221 342 302 276 207 214 218 171 227 312 168 134 164 282  
186 126 194 265 348 253 306 320 252 203 163 177 409 405

CBM-A94B 54

304 331 260 416 297 330 206 159 180 162 185 273 203 175 127 130 353 300 268 200  
207 274 272 246 217 328 221 347 296 268 210 212 209 171 231 319 115 164 170 286  
196 126 202 256 341 251 314 312 258 210 147 178 393 420

CBM-A95A 102

196 124 103 216 153 143 167 222 187 191 171 175 201 170 208 228 227 154 234 151  
135 142 118 97 119 91 128 105 104 100 88 117 94 103 108 154 156 167 167 145  
147 131 103 114 119 113 174 203 118 135 159 195 179 295 339 347 259 349 401 440  
331 263 295 302 256 286 178 195 279 251 281 358 260 270 227 195 226 183 202 213  
174 130 102 141 147 153 147 120 143 172 125 98 86 130 159 155 168 131 150 128  
105 135

CBM-A95B 102

197 121 75 248 128 153 169 185 202 209 173 188 186 162 211 213 250 167 203 164  
121 138 116 106 90 96 124 120 99 118 80 97 122 109 109 157 122 180 154 156  
150 120 103 89 137 126 173 191 122 127 167 193 184 275 353 340 280 326 390 441  
332 254 301 308 256 287 156 217 263 254 263 356 277 253 222 182 244 189 195 199  
166 138 99 148 134 129 158 121 136 161 140 91 97 129 158 167 136 150 114 153  
91 107

CBM-A96A 80

438 361 255 220 309 404 281 223 231 306 280 405 276 273 301 312 279 196 219 220  
207 213 192 277 291 179 131 218 270 307 251 264 209 233 362 454 325 329 317 129  
127 217 393 294 365 270 184 199 272 340 342 301 325 277 393 170 229 259 330 204  
266 352 362 233 130 192 180 250 284 203 167 383 323 427 118 123 119 130 211 164

CBM-A96B 73

391 370 265 201 350 358 292 235 253 258 269 381 237 288 337 286 282 242 187 247  
156 260 197 242 279 183 191 160 286 312 246 259 220 236 347 439 328 322 302 165  
136 200 379 271 404 276 184 205 238 349 345 307 351 243 423 167 231 272 269 283  
254 327 424 206 148 190 181 220 300 401 341 354 483

CBM-A97A 88

274 251 301 461 203 240 305 673 548 476 715 660 387 615 450 592 573 264 203 390  
546 563 748 371 444 600 702 456 422 383 434 308 404 427 495 432 250 247 439 277  
514 451 238 301 245 438 496 320 332 240 169 277 460 409 399 456 250 278 214 355  
386 478 271 506 385 231 237 163 402 375 343 311 390 398 219 234 209 276 388 358  
217 304 335 263 182 233 284 177

CBM-A97B 88

320 341 319 483 191 228 295 660 508 468 698 668 404 616 435 605 541 280 208 375  
551 576 761 371 442 592 679 466 406 391 436 305 412 393 494 415 269 231 455 285  
498 444 241 292 264 413 517 315 332 256 157 283 463 430 398 458 247 293 224 361  
381 483 271 507 388 261 233 163 383 385 331 315 399 341 222 226 212 277 387 357  
198 303 341 252 176 217 281 213

CBM-M01A 81

93 75 61 102 90 63 143 142 112 157 134 113 129 121 113 103 121 82 100 52  
76 98 101 77 96 106 118 106 83 99 26 43 85 169 139 62 113 80 77 99  
79 100 73 92 177 106 125 102 100 78 72 100 105 139 153 116 114 134 83 160  
64 50 130 152 91 98 85 87 88 125 104 97 62 82 104 74 93 97 131 69  
86

CBM-M01B 81

100 68 64 101 87 77 132 135 136 144 132 107 133 133 109 100 116 79 113 40  
64 103 120 72 104 106 121 104 85 99 31 43 92 170 133 61 115 82 82 96  
89 101 70 96 165 123 112 102 108 81 59 103 111 131 147 114 122 122 93 159  
76 45 138 138 104 100 79 92 82 122 98 95 64 81 104 80 95 100 138 56  
94

CBM-M02A 63

123 89 64 113 80 146 117 92 112 59 46 49 91 92 95 89 60 103 89 93  
67 118 144 67 118 155 102 118 126 111 132 116 128 113 138 132 82 166 182 130  
86 92 127 120 139 149 98 120 140 100 78 57 119 106 119 89 116 101 85 123  
95 150 131

CBM-M02B 63

124 83 72 97 94 151 103 102 104 64 35 49 90 92 96 85 67 100 92 90  
69 115 146 73 107 159 105 109 128 116 115 119 131 116 131 136 85 162 188 123  
86 92 128 121 136 158 84 136 119 98 70 59 112 110 123 89 111 108 79 118  
101 147 132

CBM-M03A 150

450 183 176 166 151 151 138 124 111 145 120 131 177 152 115 100 111 90 119 129  
140 126 127 104 88 123 116 91 108 80 106 85 90 96 104 127 114 114 127 98  
93 104 97 110 118 118 110 163 167 111 120 101 111 83 89 103 125 119 76 131  
113 96 104 143 147 164 194 156 124 134 141 141 120 114 171 139 116 120 123 119  
110 127 125 152 178 158 81 115 57 90 92 110 90 99 105 80 78 115 55 81  
98 122 103 114 136 77 144 161 92 116 88 125 116 100 141 73 101 115 82 51  
77 78 30 42 40 34 29 44 33 80 90 93 126 74 39 50 59 29 38 34  
90 99 92 86 101 78 52 57 63 80

CBM-M03B 150

185 181 184 167 158 163 119 134 131 101 147 139 166 157 114 105 112 95 94 125  
139 133 126 102 98 121 106 99 110 86 69 106 78 101 107 120 125 115 121 101  
96 105 107 106 116 124 108 126 140 132 91 105 126 77 78 110 119 118 86 127  
104 112 102 121 167 165 188 152 131 156 131 141 106 140 154 119 136 123 124 117  
114 122 130 154 173 144 75 109 73 87 87 104 104 88 111 81 84 109 57 38  
39 118 105 108 120 124 86 140 155 119 92 128 110 103 149 65 101 126 86 54  
67 82 34 40 36 41 37 39 31 74 91 92 139 70 29 47 59 33 36 31  
91 97 93 92 108 71 55 62 76 81

CBM-M04A 104

150 136 122 217 174 179 174 174 170 173 126 132 124 120 129 131 176 159 121 82  
136 88 109 118 161 125 121 109 92 130 117 83 106 83 92 98 87 103 94 128  
121 116 128 89 93 117 100 116 108 120 119 113 144 127 136 99 128 82 78 102  
130 103 91 125 108 105 103 130 143 174 201 146 118 147 122 139 110 127 169 138  
114 120 141 111 116 125 119 160 167 147 75 111 69 89 89 101 98 99 105 84  
81 105 62 76

CBM-M04B 104

156 134 139 193 180 181 170 195 146 172 130 128 118 120 138 123 170 152 119 102  
132 100 91 121 151 143 111 109 100 122 116 94 92 96 89 105 83 103 90 133  
128 106 120 103 81 121 92 113 114 123 87 136 123 119 119 108 129 82 74 115

121 112 81 128 100 100 110 134 155 175 181 159 119 141 137 139 106 137 159 133  
122 127 124 130 92 134 128 165 161 153 77 128 44 104 99 108 88 103 119 70  
83 100 75 75

CBM-M05A 141

167 125 127 114 126 136 124 171 150 135 102 113 110 91 127 151 115 116 121 89  
120 122 83 120 82 97 83 91 106 96 126 124 104 123 107 89 115 84 117 115  
122 119 115 157 129 97 106 123 80 84 109 118 115 87 123 85 96 108 129 153  
170 190 153 133 139 141 134 110 137 156 125 141 117 125 116 110 128 126 147 175  
149 71 118 62 97 78 111 90 97 106 81 82 117 57 80 104 118 91 118 139  
96 119 159 112 110 85 123 116 100 147 76 102 104 86 59 73 74 36 36 36  
41 38 41 25 74 96 97 119 73 26 57 64 33 28 31 84 94 100 92 95  
78

CBM-M05B 141

145 127 136 114 125 138 128 171 160 109 108 129 100 97 109 149 146 115 101 111  
109 112 96 103 88 91 99 79 108 90 123 129 111 118 103 87 119 103 102 129  
118 101 125 133 129 112 107 118 81 83 109 129 106 81 133 106 107 100 127 156  
182 182 148 118 134 144 129 124 141 150 124 127 121 123 116 118 135 114 164 168  
157 66 112 61 106 69 113 103 89 100 92 81 110 58 85 104 106 111 117 136  
94 129 143 128 121 78 130 101 111 149 77 89 124 84 48 74 78 37 41 28  
41 47 31 28 76 94 91 118 78 34 56 56 37 37 28 80 101 95 83 109  
81

CBM-M06A 100

466 448 196 223 285 427 274 412 199 233 224 141 296 185 248 202 219 257 250 201  
176 271 176 147 170 230 215 185 302 247 321 197 254 306 223 273 180 223 167 247  
289 280 290 213 255 283 483 298 287 174 208 137 161 181 199 203 196 109 175 259  
218 154 166 207 152 156 178 220 209 187 196 176 223 207 231 176 238 249 181 178  
215 186 249 154 164 157 108 160 174 146 121 119 204 195 144 158 163 112 94 109

CBM-M06B 100

416 505 191 177 279 428 265 399 205 232 183 145 290 208 229 189 221 237 241 207  
181 234 176 143 165 223 189 153 331 248 250 237 235 291 204 286 184 247 152 260  
292 261 265 221 238 294 434 290 304 220 205 133 166 165 206 200 167 126 195 240  
204 154 173 197 146 167 170 223 191 189 183 182 201 215 218 188 226 253 199 186  
179 187 264 156 145 168 107 145 127 184 125 104 230 147 151 143 168 105 110 98

CBM-M07A 179

546 520 330 500 696 660 516 449 438 531 602 570 468 522 385 477 208 405 450 453  
293 338 456 311 210 357 350 439 386 405 332 319 311 375 227 303 205 308 277 254  
285 397 283 256 244 233 285 245 194 152 112 152 201 233 194 105 121 79 143 182  
204 169 164 131 98 171 143 168 193 194 100 144 97 148 95 148 82 73 111 142  
129 91 97 73 142 61 151 132 112 155 99 103 102 147 68 150 90 177 119 163  
136 161 153 178 138 161 141 151 131 105 63 114 109 80 82 107 111 101 105 126  
132 88 64 164 84 93 68 104 63 72 32 79 48 34 51 101 118 111 133 123  
98 209 160 162 68 154 148 187 213 304 82 132 148 161 166 271 162 316 202 140  
108 76 102 72 100 52 92 104 91 92 63 63 94 96 108 217 132 135 156

CBM-M07B 179

566 525 334 488 701 665 514 450 450 515 578 613 467 521 383 480 205 410 442 453  
275 344 454 320 197 362 357 466 353 402 326 319 300 389 219 300 212 314 271 262  
278 391 301 256 244 248 290 235 189 152 121 142 187 252 193 101 117 78 143 181  
209 172 163 147 99 161 150 166 166 190 91 152 113 149 81 157 65 83 106 150  
134 98 97 68 142 62 154 125 115 153 94 105 97 146 85 138 95 175 126 166  
138 158 160 176 135 161 143 157 122 110 61 113 107 79 79 109 107 108 110 136  
124 79 65 166 81 99 64 96 65 67 46 67 49 29 49 111 110 128 118 120

92 209 161 161 69 141 150 185 217 321 75 148 127 154 170 277 156 313 198 138  
117 68 96 73 93 77 89 94 110 81 55 63 100 68 124 215 131 155 152

CBM-M08A 247

181 224 233 181 348 256 214 186 280 271 184 202 176 215 237 212 179 179 209 234  
238 214 243 247 195 206 209 207 236 229 159 188 205 240 220 188 167 208 181 245  
177 195 186 228 222 176 171 189 184 190 128 154 158 228 184 63 85 64 54 76  
55 54 65 42 70 89 82 99 139 121 103 116 120 225 197 131 124 202 133 202  
100 104 149 103 108 98 137 148 137 149 145 201 128 157 142 147 92 122 137 125  
111 116 97 95 110 109 132 129 109 133 113 98 112 83 96 98 105 115 62 59  
87 90 82 80 55 64 84 59 82 73 77 78 64 67 158 90 136 94 93 99  
136 98 82 109 103 89 94 119 112 84 85 73 113 88 92 107 94 135 148 77  
79 75 88 111 92 114 98 105 96 71 95 103 91 97 58 96 82 77 64 116  
103 98 80 91 83 83 91 148 146 100 92 114 127 139 109 118 83 95 81 83  
77 64 86 90 79 83 89 72 73 87 92 86 71 79 76 71 66 76 54 60  
48 62 55 83 60 77 100 97 64 72 73 75 75 78 69 92 86 53 49 52  
34 63 66 38 26 39 39

CBM-M08B 247

144 237 227 172 351 270 209 186 302 275 189 198 172 221 230 214 170 184 196 213  
221 238 230 239 219 206 202 200 215 199 173 181 208 241 223 196 161 194 176 255  
161 198 191 225 208 162 230 186 153 181 143 148 153 235 182 69 68 74 77 49  
53 53 49 46 65 75 93 88 143 118 126 118 119 227 201 128 128 191 133 197  
104 96 120 105 95 118 129 143 131 157 155 180 152 178 117 151 101 109 128 129  
125 100 111 88 106 124 121 117 119 135 114 89 100 77 102 79 106 109 72 55  
92 95 75 80 49 65 77 62 88 65 76 74 76 66 129 90 122 113 91 93  
137 92 93 104 113 82 107 102 112 91 79 77 113 92 79 120 79 143 150 80  
64 93 83 106 95 98 104 102 92 86 87 102 89 86 76 88 89 83 68 107  
93 106 75 90 71 95 92 148 142 104 99 115 109 113 145 125 71 97 75 86  
75 63 95 80 92 82 90 64 80 85 97 79 70 80 77 76 66 63 65 59  
50 64 55 76 62 78 104 78 76 61 80 63 72 93 58 96 71 70 51 45  
39 59 65 38 27 38 37

CBM-M09A 215

232 248 274 237 304 206 220 200 187 230 233 229 238 208 231 198 158 146 158 171  
202 165 193 244 223 243 261 193 228 158 140 202 247 172 307 226 250 265 165 226  
253 300 273 222 240 262 183 192 194 214 178 148 123 142 159 153 212 184 229 158  
140 139 165 197 155 190 154 151 143 208 138 182 118 162 122 129 126 176 221 166  
180 194 196 207 185 165 162 184 193 150 155 183 96 81 113 140 160 129 185 142  
115 120 165 150 167 201 133 179 171 203 123 124 131 141 138 151 164 150 90 120  
134 76 147 146 106 136 113 79 99 137 183 128 102 129 93 118 124 126 104 173  
126 162 121 130 119 88 76 108 129 153 70 115 128 106 120 119 174 124 165 93  
77 98 111 125 106 144 115 68 93 108 114 127 139 79 159 110 114 126 167 177  
73 156 140 193 142 242 105 170 120 141 109 207 118 233 177 176 67 119 82 93  
95 96 78 164 101 131 72 61 81 196 152 185 154 144 122

CBM-M09B 215

238 235 280 228 310 201 205 202 188 245 218 218 244 212 222 200 153 150 154 175  
195 168 194 235 228 242 259 183 227 170 141 192 273 150 293 245 246 242 186 212  
244 286 257 227 243 235 180 206 183 220 151 154 122 139 161 150 195 195 237 148  
134 138 175 189 168 163 140 139 147 187 139 199 114 164 114 124 131 170 211 161  
194 193 204 216 194 150 141 192 189 147 151 174 96 83 120 148 155 128 190 152  
111 124 164 147 159 203 134 182 175 196 119 122 142 141 140 149 146 139 106 125  
127 93 130 154 125 136 117 88 84 131 200 139 94 138 90 117 116 137 103 168  
119 174 106 132 122 85 67 110 129 170 72 105 126 115 121 104 179 135 134 115

99 91 110 126 108 132 91 94 91 107 117 125 138 89 162 100 117 139 179 165  
72 151 144 183 147 241 101 175 108 142 117 215 111 232 188 174 72 101 81 101  
87 97 75 176 103 128 76 62 69 194 155 192 153 144 103

CBM-M10A 187

204 170 133 211 225 147 270 293 262 287 202 364 339 431 420 335 417 502 410 452  
357 414 337 262 186 228 257 314 238 364 411 336 274 272 363 313 340 300 317 354  
346 350 327 327 405 441 297 198 259 244 250 289 240 253 306 350 289 265 213 342  
222 294 232 245 190 90 108 135 168 149 214 152 150 90 148 146 198 175 139 188  
181 178 127 135 165 149 91 126 122 116 79 60 100 105 92 93 119 111 85 50  
68 96 136 113 72 76 132 79 60 76 72 139 113 100 68 75 45 42 46 64  
53 37 47 110 66 47 63 77 83 79 100 72 62 50 84 73 66 86 77 96  
70 93 86 118 110 64 102 112 79 109 152 117 75 128 128 205 121 185 96 99  
80 109 118 186 118 192 183 73 75 107 98 125 97 95 111 88 72 86 55 69  
77 62 66 74 66 64 86

CBM-M10B 187

220 169 140 211 216 143 293 268 278 296 195 362 341 427 428 334 422 490 408 439  
370 409 347 258 191 238 267 319 209 351 410 334 274 275 351 314 338 313 323 350  
329 348 338 330 397 442 316 188 230 280 265 274 233 258 324 356 289 262 228 326  
251 319 214 250 177 95 111 124 148 183 229 140 148 97 144 152 197 180 128 183  
166 196 116 125 180 152 87 122 136 120 61 67 95 120 77 90 112 124 80 57  
53 106 142 111 77 76 123 85 62 140 82 148 114 101 63 70 46 38 44 63  
56 50 45 99 65 51 57 85 79 76 97 77 51 54 82 66 74 81 76 95  
78 84 79 120 101 75 112 112 61 114 141 127 81 126 123 215 117 186 92 82  
87 97 117 200 134 181 169 90 77 99 92 130 97 96 104 91 75 82 56 56  
65 85 65 72 74 60 83

CBM-M11A 112

618 754 711 402 456 429 445 425 574 485 402 355 340 449 372 345 348 429 343 318  
334 323 408 421 259 226 392 484 404 291 338 352 400 309 329 308 343 351 287 321  
245 165 172 202 321 391 337 185 343 403 329 251 357 401 622 491 524 375 442 342  
286 353 450 394 429 340 286 356 444 418 340 601 444 281 240 362 299 324 395 381  
498 312 437 376 481 393 368 591 700 432 427 552 536 376 401 353 294 361 321 393  
404 491 377 297 375 417 350 296 409 356 462 412

CBM-M11B 112

617 763 704 407 447 436 445 441 540 485 390 357 341 431 353 342 358 424 351 332  
333 322 409 414 268 224 453 398 410 293 341 350 397 315 312 312 335 358 295 301  
247 164 157 212 299 404 327 211 282 426 334 273 376 374 635 486 512 371 430 343  
306 356 437 369 417 369 300 352 431 439 355 594 479 281 246 349 340 314 397 388  
481 296 443 311 495 489 270 556 727 441 381 505 466 396 387 356 277 347 331 379  
391 485 372 286 385 400 325 310 435 350 463 471

CBM-M12A 145

384 408 330 445 404 431 515 570 634 664 440 487 537 482 418 441 424 605 490 555  
442 359 345 257 473 413 431 276 397 247 293 312 353 321 284 367 287 439 380 329  
232 354 280 325 194 158 260 196 187 196 226 186 245 180 176 211 305 111 110 138  
199 171 142 212 203 205 136 138 91 190 242 200 170 131 130 153 203 247 326 233  
229 194 194 177 178 228 250 261 185 216 110 129 147 161 126 143 117 145 85 120  
120 105 145 156 177 178 136 73 98 109 130 138 150 133 122 150 133 135 91 152  
185 213 170 121 189 237 154 126 130 179 180 102 105 99 108 93 123 117 142 106  
115 118 156 241 209

CBM-M12B 145

400 405 321 455 401 417 534 574 597 661 431 493 523 476 410 438 420 616 483 519  
439 359 342 252 475 405 444 277 395 247 259 295 337 334 289 370 274 443 379 327

236 332 285 335 193 183 209 222 190 172 247 204 232 173 177 214 287 108 118 142  
185 168 130 222 208 206 145 148 91 220 249 158 181 157 131 139 189 250 319 229  
229 201 185 199 143 243 233 265 185 192 141 136 132 162 148 129 115 152 97 119  
163 114 114 140 209 149 127 82 118 100 123 140 150 131 129 151 122 112 104 137  
181 209 167 140 182 231 147 140 131 152 114 101 113 98 170 93 143 116 119 140  
115 108 142 243 224

CBM-M13A 95

130 130 93 155 123 180 144 92 79 175 117 136 121 94 112 102 129 95 112 136  
98 96 143 136 55 59 105 150 177 213 83 62 156 216 182 254 207 273 278 388  
334 378 305 325 290 316 269 310 229 295 417 376 379 333 321 203 293 201 192 218  
203 181 222 365 327 343 239 249 272 196 334 341 191 219 285 309 332 294 282 200  
216 149 73 100 107 149 124 100 90 180 227 201 138 128 149

CBM-M13B 95

146 129 83 155 124 188 151 86 85 169 114 140 117 137 84 113 100 92 127 138  
95 104 151 136 50 73 114 148 188 208 75 68 164 213 187 253 208 277 282 381  
345 379 315 324 301 327 272 320 221 298 423 350 373 335 316 211 290 188 188 230  
209 212 196 384 333 340 236 259 262 224 391 343 183 222 290 315 324 352 244 193  
212 132 122 117 110 144 124 88 106 179 227 185 145 127 144

CBM-M14A 89

411 339 456 331 316 550 429 256 451 624 469 492 354 407 272 362 335 280 328 369  
285 229 324 568 376 396 271 289 301 388 407 561 331 320 214 238 254 250 265 303  
301 273 268 295 480 454 488 316 330 367 368 298 433 290 293 251 294 350 312 382  
385 314 266 360 406 475 636 504 505 467 371 475 339 448 446 285 375 356 340 500  
406 261 319 580 462 533 555 743 600

CBM-M14B 89

359 334 441 361 331 541 418 278 446 622 457 493 354 420 284 349 317 279 308 381  
279 227 337 581 371 392 281 292 287 379 394 573 320 325 202 238 261 242 255 324  
322 254 290 288 470 478 467 316 356 340 345 308 433 297 311 251 286 348 314 374  
372 317 256 381 402 456 641 516 490 479 368 486 336 551 314 313 384 347 371 597  
425 257 333 531 477 574 560 715 678

CBM-M15A 128

308 432 413 436 326 275 128 278 332 450 340 577 350 129 209 114 157 146 226 140  
205 112 161 121 138 170 106 119 145 172 94 82 82 200 127 112 128 93 99 105  
69 57 109 72 113 64 95 56 52 102 97 84 83 124 101 69 130 138 118 114  
129 205 100 47 63 93 120 214 113 225 119 90 102 81 115 186 241 134 132 106  
139 101 61 88 104 141 130 168 135 133 114 268 356 135 380 223 499 175 404 197  
351 194 273 270 290 215 407 405 385 260 233 345 200 246 294 266 432 312 433 264  
161 179 308 277 311 257 240 134

CBM-M15B 128

302 456 405 396 320 285 125 286 342 439 320 596 352 137 204 113 156 149 230 132  
205 111 168 120 132 170 112 109 162 180 85 92 80 192 128 125 109 93 96 106  
98 53 121 61 123 56 105 55 50 96 108 87 76 128 96 72 135 128 107 131  
130 199 102 47 63 97 104 220 120 222 119 95 96 83 121 179 248 122 140 96  
131 96 63 95 99 144 121 178 145 122 121 266 374 132 371 211 506 179 404 192  
349 203 263 272 288 224 393 419 381 266 258 339 206 227 281 266 454 303 432 258  
195 162 315 280 288 272 240 190

CBM-M16A 57

104 142 77 94 165 74 45 95 116 106 100 75 54 130 91 90 97 131 108 138  
172 133 79 83 97 156 198 105 137 128 98 130 125 145 224 127 190 263 212 183  
191 282 185 259 270 264 238 310 210 165 191 196 189 294 301 348 189

CBM-M16B 57

96 147 78 91 156 73 54 87 117 114 102 68 61 123 86 94 103 128 109 134  
177 131 71 85 100 167 189 102 137 137 85 112 145 125 237 131 194 256 211 181  
210 274 187 262 271 274 244 299 172 189 205 208 208 273 310 347 174

CBM-M17A 71

214 298 324 289 244 199 143 149 197 209 238 231 110 209 202 209 176 172 191 193  
205 256 185 176 165 211 201 230 166 175 207 158 134 63 111 125 127 78 101 201  
187 131 139 159 155 203 166 153 169 132 111 153 159 89 123 129 74 91 85 105  
123 96 84 103 95 67 63 102 70 63 70

CBM-M17B 71

239 266 341 294 232 200 129 151 202 211 235 238 103 211 187 221 173 177 191 185  
204 228 195 180 155 223 206 220 170 163 195 140 156 64 105 120 98 110 120 184  
182 150 128 152 149 220 158 156 154 134 126 159 148 81 131 119 79 81 98 95  
124 122 75 100 74 82 58 95 79 59 63

CBM-M18A 121

161 233 312 279 345 284 194 213 255 397 333 415 210 270 233 348 163 343 214 215  
248 261 293 231 228 244 321 250 284 227 237 219 215 212 182 300 347 281 217 190  
135 118 119 155 160 212 256 360 250 379 363 174 200 264 380 315 164 241 301 286  
326 192 309 276 203 328 227 230 290 398 288 264 243 235 236 165 256 263 360 317  
357 265 309 226 432 361 200 281 271 452 325 397 231 138 162 150 333 388 220 325  
339 354 306 390 386 284 278 234 237 223 221 225 218 116 155 211 282 284 222 253  
243

CBM-M18B 121

142 242 322 258 375 254 200 207 256 389 344 387 217 262 249 333 189 333 209 213  
245 275 288 238 226 248 317 254 272 226 233 226 210 212 179 304 346 283 209 191  
139 120 120 153 159 211 250 367 242 386 371 177 194 262 384 309 175 230 291 292  
310 183 325 283 217 353 219 216 281 395 285 254 242 229 232 175 287 255 369 335  
335 277 304 236 397 381 239 249 290 456 322 409 227 147 170 137 339 367 213 335  
383 342 296 406 392 265 294 241 223 232 214 250 193 136 162 219 269 300 204 241  
238

CBM-M19A 139

457 626 465 556 381 376 635 653 604 523 344 666 574 446 485 293 285 157 105 79  
77 123 168 162 109 127 219 289 308 355 245 335 263 383 303 321 474 223 219 299  
286 305 227 271 315 298 301 299 238 288 284 193 164 340 260 266 247 241 277 309  
231 228 210 183 117 58 56 55 53 48 38 66 87 42 34 52 61 61 57 89  
114 142 99 124 81 90 158 245 169 168 118 182 119 101 187 165 198 227 230 125  
177 148 222 219 193 226 222 321 293 289 90 173 149 226 294 322 244 363 470 379  
313 345 283 228 162 211 219 186 211 276 160 155 198 404 347 268 250 229 225

CBM-M19B 139

449 621 465 553 385 414 625 628 612 527 348 663 558 451 474 301 271 165 115 73  
78 126 166 144 108 136 220 298 323 323 244 332 264 377 316 285 459 234 214 299  
293 293 220 250 343 304 300 287 259 272 286 193 156 339 288 254 240 241 262 318  
239 222 208 183 118 63 62 47 57 38 38 68 92 34 38 45 71 67 50 93  
109 154 105 121 78 90 154 250 173 165 112 188 117 111 175 164 200 222 227 126  
152 134 228 216 200 211 231 319 287 285 96 155 156 236 301 317 243 374 461 376  
319 334 296 233 158 217 210 195 215 277 141 150 209 415 330 266 296 219 213

CBM-M20A 188

430 96 167 179 122 153 240 228 247 15 16 20 34 51 64 57 141 210 325 247  
294 325 349 340 286 264 518 568 525 385 441 558 600 683 595 546 534 311 234 602  
693 572 441 503 630 489 316 512 358 587 406 368 352 247 299 282 235 353 435 440  
220 205 307 340 479 687 665 655 762 814 750 612 444 749 618 727 566 715 488 251



496 627 685 528 617 450 310 248 546 655 598 594 439 514 659 614 313 493 567 489  
463 656 638 367 315 476 573 460 476 403 351 577 450 284 302 348 469 601 421 602  
331 381 367 292 257 394 363 202 329 459 353 188 231 345 360 309 201 291 235 268  
270 428 346 341 280 473 272 293 299 370 336 343 235 266 267 256 330 377 398 428  
527 361 269 166 469 524 326 335 305 357 332 376 160 340 280 228 321 373 283 522  
321 414 240 274 301 169 142 157

CBM-M20B 188

431 69 159 180 138 152 218 247 253 14 10 18 35 59 47 70 138 220 322 233  
305 314 344 341 306 271 499 570 520 442 438 557 573 653 592 559 518 299 227 594  
687 590 419 493 603 520 341 484 354 578 445 354 344 267 284 288 239 311 486 421  
192 209 299 340 476 699 680 617 784 786 743 612 470 734 616 760 576 677 496 250  
438 653 700 515 611 447 295 266 549 660 605 582 417 489 665 642 323 489 580 502  
433 642 642 345 321 508 552 465 484 416 331 571 479 282 307 329 464 572 430 595  
326 367 365 311 216 345 362 205 345 460 360 183 240 359 381 300 200 265 227 282  
282 409 342 338 296 481 266 284 303 387 308 330 238 307 273 266 305 342 370 427  
516 393 332 172 408 494 341 347 304 338 343 390 164 340 261 245 312 364 259 487  
308 439 275 313 349 174 141 149

of widths of this site sequence is stored on the computer. The reason for creating site sequences is that it is usually easier to date an average sequence of ring widths with a master sequence than it is to date the individual component sample sequences separately.

The straightforward method of cross-matching several sample sequences with each other one at a time is called the 'maximal *t*-value' method. The actual method of cross-matching a group of sequences of ring-widths used in the Laboratory involves grouping and averaging the ring-width sequences and is called the 'Litton-Zainodin Grouping Procedure'. It is a modification of the straight forward method and was successfully developed and tested in the Laboratory and has been published (Litton and Zainodin 1991; Laxton *et al* 1988).

4. ***Estimating the Felling Date.*** As mentioned above, if the bark is present on a sample, then the date of its last ring is the date of the felling of its tree. Actually it could be the year after if it had been felled in the first three months before any new growth had started, but this is not too important a consideration in most cases. The actual bark may not be present on a timber in a building, though the dendrochronologist who is sampling can often see from its surface that only the bark is missing. In these cases the date of the last ring is still the date of felling.

Quite often some, though not all, of the original outer rings are missing on a timber. The outer rings on an oak, called *sapwood* rings, are usually lighter than the inner rings, the *heartwood*, and so are relatively easy to identify. For example, sapwood can be seen in the corner of the rafter and at the outer end of the core in Figure 2, both indicated by arrows. More importantly for dendrochronology, the sapwood is relatively soft and so liable to insect attack and wear and tear. The builder, therefore, may remove some of the sapwood for precisely these reasons. Nevertheless, if at least some of the sapwood rings are left on a sample, we will know that not too many rings have been lost since felling so that the date of the last ring on the sample is only a few years before the date of the original last ring on the tree, and so to the date of felling.

Various estimates have been made and used for the average number of sapwood rings in mature oak trees (English Heritage 1998). A fairly conservative range is between 15 and 50 and that this holds for 95% of mature oaks. This means, of course, that in a small number of cases there could be fewer than 15 and more than 50 sapwood rings. For example, the core CRO-A06 has only 9 sapwood rings and some have obviously been lost over time – either they were removed originally by the carpenter and/or they rotted away in the building and/or they were lost in the coring. It is not known exactly how many sapwood rings are missing, but using the above range the Laboratory would estimate between a minimum of 6 (=15-9) and a maximum of 41 (=50-9). If the last ring of CRO-A06 has been dated to 1500, say, then the estimated felling-date range for the tree from which it came originally would be between 1506 and 1541. The Laboratory uses this estimate for sapwood in areas of England where it has no prior information. It also uses it when dealing with samples with very many rings, about 120 to the last heartwood ring. But in other areas of England where the Laboratory has accumulated a number of samples with complete sapwood, that is, no sapwood lost since felling, other estimates in place of the conservative range of 15 to 50 are used. In the East Midlands (Laxton *et al* 2001) and the east to the south down to Kent (Pearson 1995) where it has sampled extensively in the past, the Laboratory uses the shorter estimate of 15 to 35 sapwood rings in 95% of mature oaks growing in these parts. Since the sample CRO-A06 comes from a house in Cropwell Bishop in the East Midlands, a better estimate of sapwood rings lost since felling is between a minimum of 6 (=15-9) and 26 (=35-9) and the felling would be estimated to have taken place between 1506 and 1526, a shorter period than before. (Oak boards quite often come from the Baltic and in these cases the 95% confidence limits for sapwood are 9 to 36 (Howard *et al* 1992, 56)).

Even more precise estimates of the felling date and range can often be obtained using knowledge of a particular case and information gathered at the time of sampling. For example, at the time of sampling the dendrochronologist may have noted that the timber from which the core of Figure 2 was taken still had complete sapwood but that none of the soft sapwood rings were lost in coring. By measuring into the timber the depth of sapwood lost, say 2 cm, a reasonable estimate can be made of the number of sapwood rings lost, say 12 to 15 rings in this case. By adding on 12 to 15 years to the date of the last ring on the sample a good tight estimate for the range of the felling date can be obtained, which is often better than the 15 to 35 years later we would have estimated without this observation. In the example, the felling is now estimated to

*t*-value/offset Matrix

	C45	C08	C05	C04
C45		+20	+37	+47
C08	5.6		+17	+27
C05	5.2	10.4		+10
C04	5.9	3.7	5.1	

## Bar Diagram

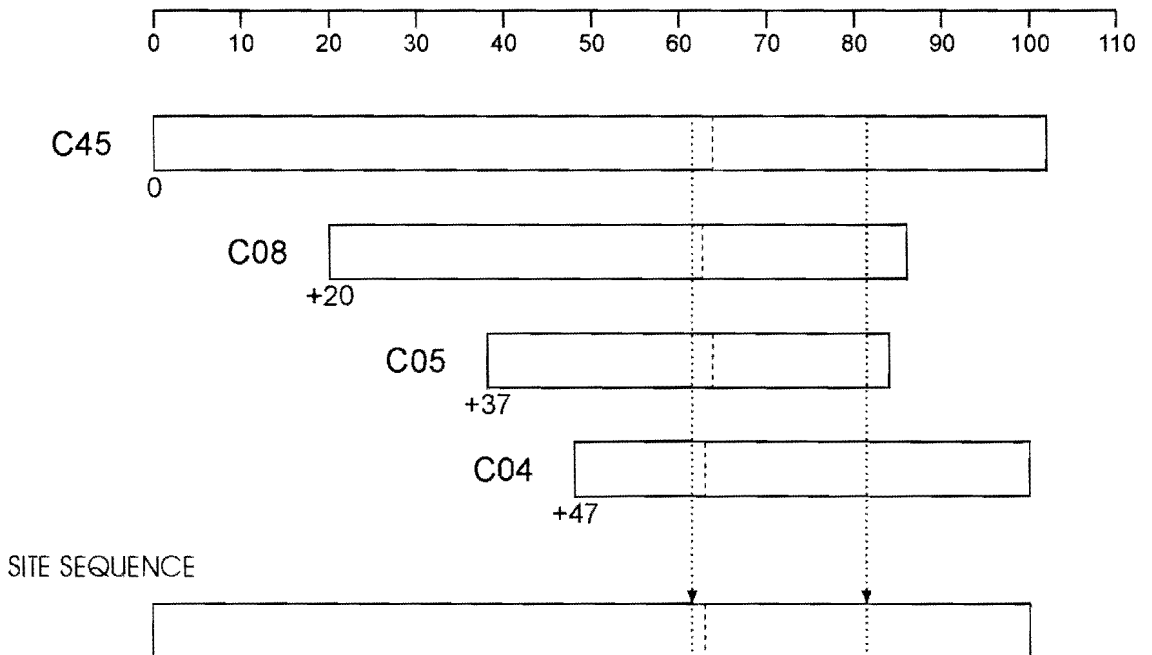


Fig 5. Cross-matching of four sequences from a Lincoln Cathedral roof and the formation of a site sequence from them.

The *bar diagram* represents these sequences without the rings themselves. The length of the bar is proportional to the number of rings in the sequence. Here the four sequences are set at relative positions (*offsets*) to each other at which they have maximum correlation as measured by the *t*-values.

The *t*-value/offset matrix contains the maximum *t*-values below the diagonal and the offsets above it. Thus, the maximum *t*-value between C08 and C45 occurs at the offset of +20 rings and the *t*-value is then 5.6.

The *site sequence* is composed of the average of the corresponding widths, as illustrated with one width.

have taken place between AD 1512 and 1515, which is much more precise than without this extra information.

Even if all the sapwood rings are missing on a sample, but none of the heartwood rings are, then an estimate of the felling-date range is possible by adding on the full compliment of, say, 15 to 35 years to the date of the last heartwood ring (called the heartwood/sapwood boundary or transition ring and denoted H/S). Fortunately it is often easy for a trained dendrochronologist to identify this boundary on a timber. If a timber does not have its heartwood/sapwood boundary, then only a *post quem* date for felling is possible.

5. ***Estimating the Date of Construction.*** There is a considerable body of evidence collected by dendrochronologists over the years that oak timbers used in buildings were not seasoned in medieval or early modern times (English Heritage 1998 and Miles 1997, 50-55). Hence provided all the samples in a building have estimated felling-date ranges broadly in agreement with each other, so that they appear to have been felled as a group, then this should give an accurate estimate of the period when the structure was built, or soon after (Laxton *et al* 2001, figure 8 and pages 34-5 where 'associated groups of fellings' are discussed in detail). However, if there is any evidence of storing before use or if there is evidence the oak came from abroad (eg Baltic boards), then some allowance has to be made for this.
6. ***Master Chronological Sequences.*** Ultimately, to date a sequence of ring widths, or a site sequence, we need a master sequence of dated ring widths with which to cross-match it, a Master Chronology. To construct such a sequence we have to start with a sequence of widths whose dates are known and this means beginning with a sequence from an oak tree whose date of felling is known. In Fig 6 such a sequence is SHE-T, which came from a tree in Sherwood Forest which was blown down in a recent gale. After this other sequences which cross-match with it are added and gradually the sequence is 'pushed back in time' as far as the age of samples will allow. This process is illustrated in Fig 6. We have a master chronological sequence of widths for Nottinghamshire and East Midlands oak for each year from AD 882 to 1981. It is described in great detail in Laxton and Litton (1988), but the components it contains are shown here in the form of a bar diagram. As can be seen, it is well replicated in that for each year in this period there are several sample sequences having widths for that year. The master is the average of these. This master can now be used to date oak from this area and from the surrounding areas where the climate is very similar to that in the East Midlands. The Laboratory has also constructed a master for Kent (Laxton and Litton 1989). The method the Laboratory uses to construct a master sequence, such as the East Midlands and Kent, is completely objective and uses the Litton-Zainodin grouping procedure (Laxton *et al* 1988). Other laboratories and individuals have constructed masters for other areas and have made them available. As well as these masters, local (dated) site chronologies can be used to date other buildings from nearby. The Laboratory has hundreds of these site sequences from many parts of England and Wales covering many short periods.
7. ***Ring-width Indices.*** Tree-ring dating can be done by cross-matching the ring widths themselves, as described above. However, it is advantageous to modify the widths first. Because different trees grow at different rates and because a young oak grows in a different way from an older oak, irrespective of the climate, the widths are first standardized before any matching between them is attempted. These standard widths are known as ring-width indices and were first used in dendrochronology by Baillie and Pilcher (1973). The exact form they take is explained in this paper and in the appendix of Laxton and Litton (1988) and is illustrated in the graphs in Fig 7. Here ring-widths are plotted vertically, one for each year of growth. In the upper sequence of (a), the generally large early growth after 1810 is very apparent as is the smaller later growth from about 1900 onwards when the tree is maturing. A similar phenomena can be observed in the lower sequence of (a) starting in 1835. In both the widths are also changing rapidly from year to year. The peaks are the wide rings and the troughs are the narrow rings corresponding to good and poor growing seasons, respectively. The two corresponding sequence of Baillie-Pilcher indices are plotted in (b) where the differences in the immature and mature growths have been removed and only the rapidly changing peaks and troughs remain, that are associated with the common climatic signal. This makes cross-matching easier.

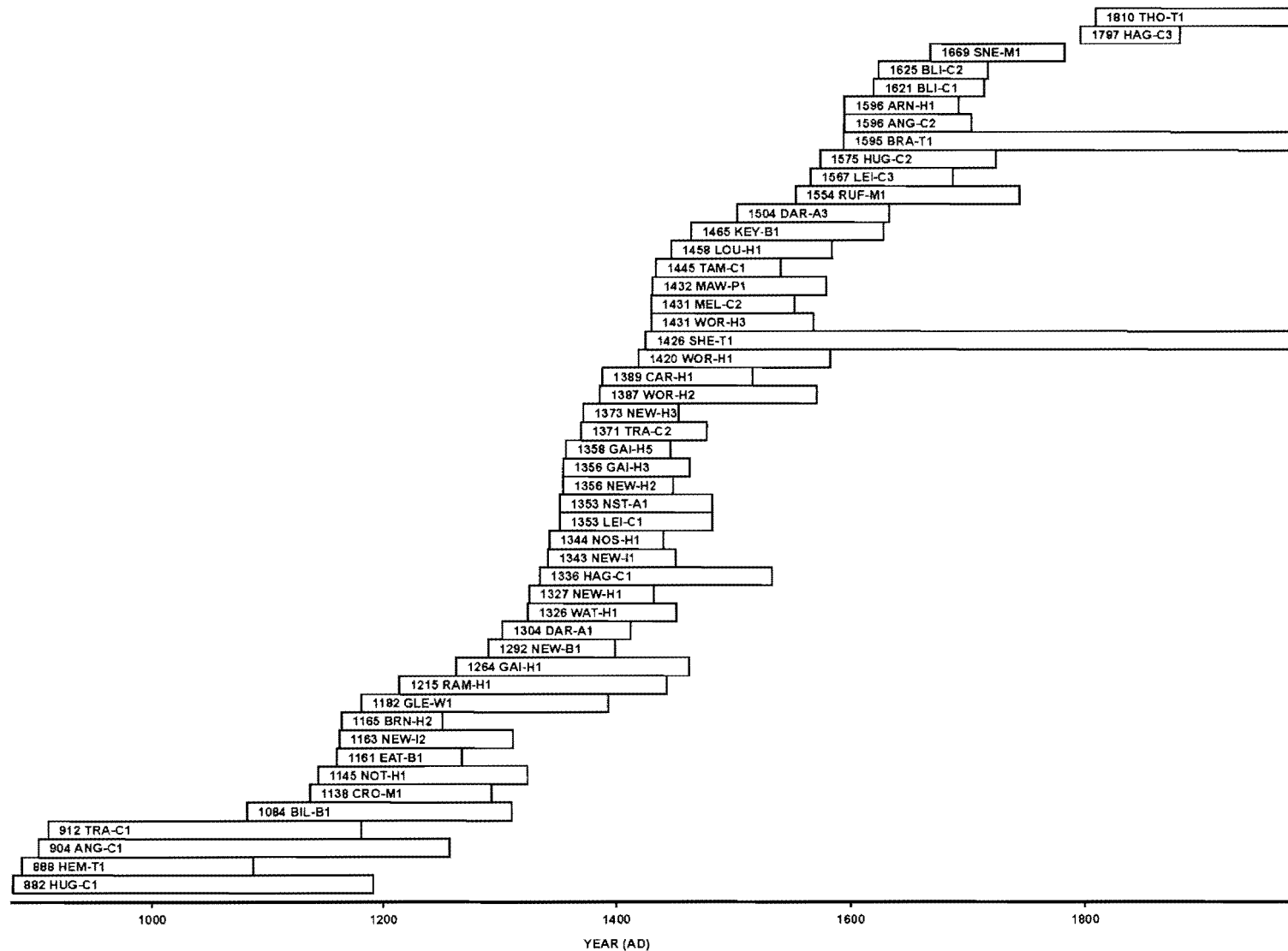
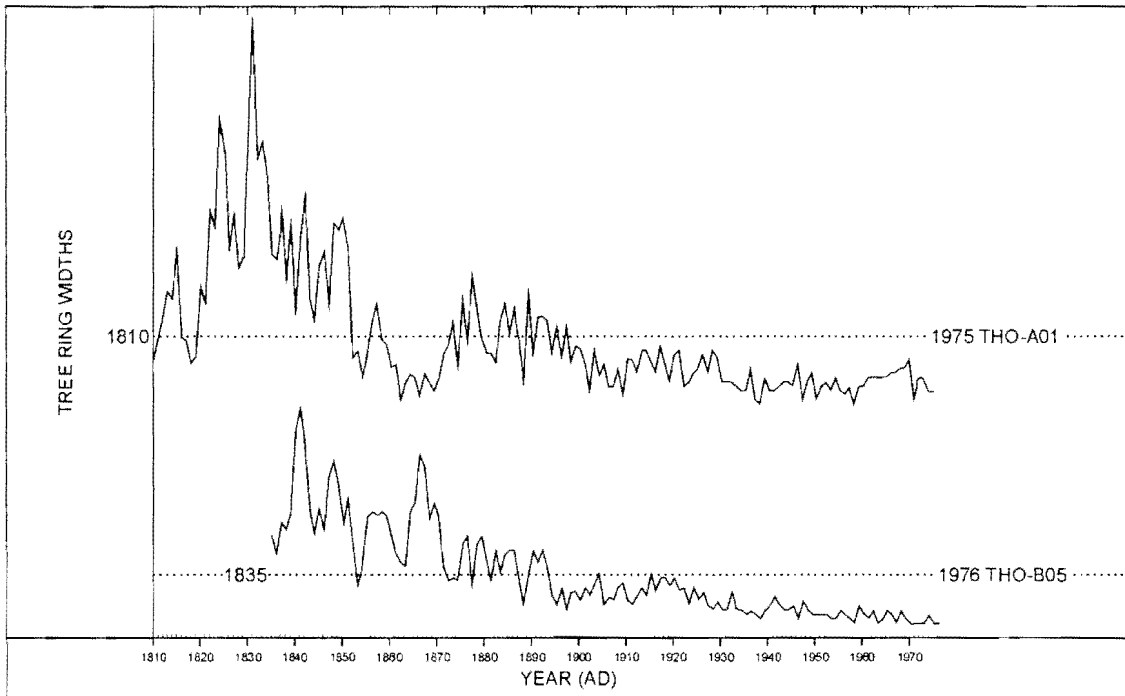


Fig. 6 Bar diagram showing the relative positions and dates of the first rings of the component site sequences in the East Midlands Master Dendrochronological Sequence, EM08/87

(a)



(b)

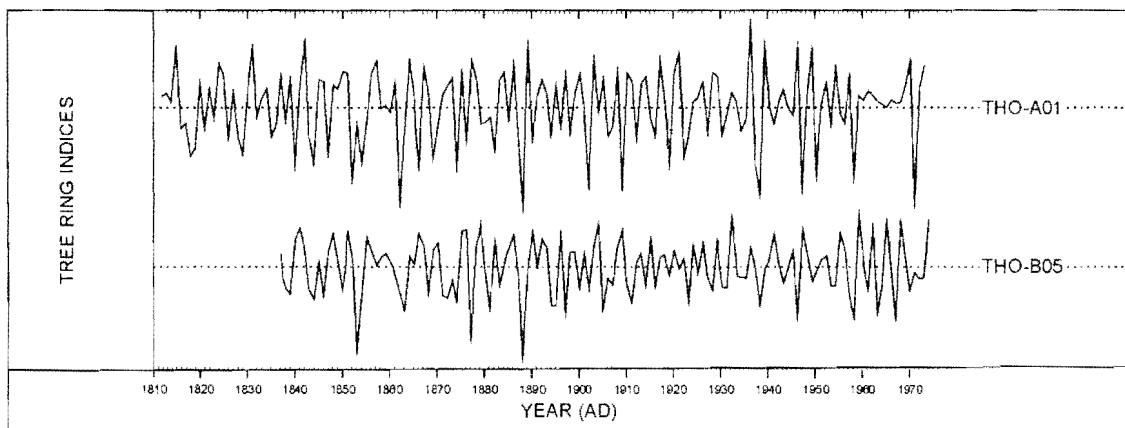


Fig 7. (a) The raw ring-widths of two samples, THO-A01 and THO-B05, whose felling dates are known. Here the ring widths are plotted vertically, one for each year, so that peaks represent wide rings and troughs narrow ones. Notice the growth-trends in each; on average the earlier rings of the young tree are wider than the later ones of the older tree in both sequences.

Fig 7. (b) The *Baillie-Pilcher* indices of the above widths. The growth-trends have been removed completely.

## REFERENCES

- Baillie, M G L, and Pilcher, J R, 1973, A simple cross-dating program for tree-ring research, *Tree-Ring Bulletin*, **33**, 7-14
- English Heritage, 1998 *Dendrochronology: Guidelines on Producing and Interpreting Dendrochronological Dates*, London
- Hillam, J, Morgan, R A, and Tyers, I, 1987, Sapwood estimates and the dating of short ring sequences, *Applications of tree-ring studies*, BAR Int Ser, **3**, 165-85
- Howard, R E, Laxton, R R, Litton, C D, and Simpson, W G, 1984-95, Nottingham University Tree-Ring Dating Laboratory Results, *Vernacular Architecture*, **15-26**
- Hughes, M K, Milson, S J, and Legett, P A, 1981 Sapwood estimates in the interpretation of tree-ring dates, *J Archaeol Sci*, **8**, 381-90
- Laxon, R R, Litton, C D, and Zainodin, H J, 1988 An objective method for forming a master ring-width sequence, *P A C T*, **22**, 25-35
- Laxton, R R, and Litton, C D, 1988 *An East Midlands Master Chronology and its use for dating vernacular buildings*, University of Nottingham, Department of Archaeology Publication, Monograph Series III
- Laxton, R R, and Litton, C D, 1989 Construction of a Kent Master Dendrochronological Sequence for Oak, AD 1158 to 1540, *Medieval Archaeol*, **33**, 90-8
- Laxon, R R, Litton, C D, and Howard, R E, 2001 *Timber; Dendrochronology of Roof Timbers at Lincoln Cathedral*, English Heritage Research Transactions, **7**
- Litton, C D, and Zainodin, H J, 1991 Statistical models of Dendrochronology, *J Archaeol Sci*, **18**, 29-40
- Miles, D W H, 1997 The interpretation, presentation and use of tree-ring dates, *Vernacular Architecture*, **28**, 40-56
- Pearson, S, 1995 *The Medieval Houses of Kent, An Historical Analysis*, London
- Rackham, O, 1976 *Trees and Woodland in the British Landscape*, London