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ESKDALE MILL, BOOT, CUMBRIA
DENDROCHRONOLOGICAL ANALYSIS OF OAK TIMBERS

SCIENTIFIC DATING REPORT

Ian Tyers

INTERVENTION AND ANALYSIS

ENGLISH HERITAGE

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Ian Tyers

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SUMMARY
A tree-ring dating programme was commissioned on oak timbers from Eskdale Mill. This building is believed to be a Corn Mill mentioned in a survey of AD 1578, to which a second wheel was added *c* AD 1740. The results identified that the oak timbers from throughout the structural framing and in the machinery were not datable by tree-ring dating techniques. This report archives the dendrochronological sampling and analysis.

CONTRIBUTORS
Ian Tyers

ACKNOWLEDGEMENTS
The sampling and analysis of timbers at Eskdale Mill was funded by English Heritage (EH). Practical help and valuable discussions were provided by David King (miller, Eskdale Mill and Heritage Trust). Cathy Tyers, Scientific Dating Team (EH) discussed the results.

ARCHIVE LOCATION
Cumbria HER
Historic Environment Service
Environment Directorate
County Offices
Kendal
Cumbria LA9 4RQ

DATE OF INVESTIGATION
2008

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CONTENTS

INTRODUCTION

This document is a technical archive report on the tree-ring analysis of oak timbers from Eskdale Mill, Boot, Cumbria. It is beyond the dendrochronological brief to describe the building in detail or to undertake the production of detailed drawings. Elements of this report may be combined with detailed descriptions, drawings, and other technical reports at some point in the future to form either a comprehensive publication or an archive deposition on the building.

Eskdale runs roughly east-west between Hardknott Pass and Ravenglass in Cumbria. Boot is about 30km west of Windermere (Figs 1 and 2). Eskdale Mill stands slightly to the north of Boot alongside the Whillan Beck. The roughly T-shaped range of buildings, forming the mill itself, are on an uneven site and thus have a mixture of floor and roof heights. The building has two water-wheels along the east side, and contains a complex set of mill machinery with a plethora of timber beams, props, and supports (Fig 3). The buildings have probably undergone an accelerated repair programme due to the action of the water-wheels, whilst the machinery timbers have probably had innumerable *ad hoc* and more conventional programmes of enhancement and upgrade. At the time of sampling the building was Grade II* listed and due to submit a Heritage Lottery bid involving building works. This analysis was thus undertaken to inform listed building consent.

METHODOLOGY

Tree-ring dating employs the patterns of tree growth to determine the calendar dates for the period during which the sampled trees were alive. The amount of wood laid down in any one year by most trees is determined by the climate and other environmental factors. Trees over relatively wide geographical areas can exhibit similar patterns of growth, and this enables dendrochronologists to assign dates to some samples by matching the growth pattern with other ring-sequences that have already been linked together to form reference chronologies.

The building was visited in February 2008 in company with David King, the resident miller. An assessment of the dendrochronological potential of the timbers had been requested by Jane Sidell (at the time Assistant Scientific Dating Coordinator, EH) to identify whether oak timbers with sufficient numbers of rings for analysis existed in any part of the building. This assessment concluded that timbers throughout contained some suitable oak material, although the combination of the likely presence of multiple phases of activity, and the somewhat remote location were always likely to stretch the capabilities of tree-ring dating at this site. Thus it was noted that the overall dendrochronological potential was not high. However following careful discussion it was decided to proceed with sampling.

Sampling was undertaken in order to inform advice during the proposed refurbishment and enhance the understanding of this important building. The sampling took place over a period of days in April 2008, and the outcome of the study was released verbally by EH

following initial analysis. The selected timbers were sampled using a 15mm diameter corer attached to an electric drill. The cores were taken as closely as possible along the radius of the timbers so that the maximum number of rings could be obtained for subsequent analysis. The ring sequences in the cores were revealed by sanding.

This preparation revealed the width of each successive annual tree ring. Each prepared sample could then be accurately assessed for the number of rings it contained, and at this stage it was also possible to determine whether the sequence of ring widths within it could be reliably resolved. Dendrochronological samples need to be free of aberrant anatomical features, such as those caused by physical damage to the tree, which may prevent or significantly reduce the chances of successful dating.

Standard dendrochronological analysis methods (see eg English Heritage 1998) were applied to each suitable sample. The complete sequence of the annual growth rings in the suitable samples were measured to an accuracy of 0.01mm using a micro-computer based travelling stage. The sequence of ring widths were then plotted onto semi-log graph paper to enable visual comparisons to be made between sequences. In addition, cross-correlation algorithms (eg Baillie and Pilcher 1973) were employed to search for positions where the ring sequences were highly correlated. Highly correlated positions were checked using the graphs and, if any of these were satisfactory, new composite sequences were constructed from the synchronised sequences. Any *t*-values reported below were derived from the original CROS algorithm (Baillie and Pilcher 1973). A *t*-value of 3.5 or over is usually indicative of a good match, although this is with the proviso that high *t*-values at the same relative or absolute position need to have been obtained from a range of independent sequences, and that these positions were supported by satisfactory visual matching.

Not every tree can be correlated by the statistical tools or the visual examination of the graphs. There are thought to be a number of reasons for this: genetic variations; site-specific issues (for example a tree growing in a stream bed will be less responsive to rainfall); or some traumatic experience in the tree's lifetime, such as injury by pollarding, defoliation events by caterpillars, or similar. These could each produce a sequence dominated by a non-climatic signal. Experimental work with modern trees shows that 5–20% of all oak trees cannot be reliably cross-matched, even when enough rings are obtained.

Converting the date obtained for a tree-ring sequence into a useful date requires a record of the nature of the outermost rings of the sample. If bark or bark-edge survives, a felling date precise to the year or season can be obtained. If no sapwood survives, the date obtained from the sample gives a *terminus post quem* for its use. If some sapwood survives, an estimate for the number of missing rings can be applied to the end-date of the heartwood. This estimate is quite broad and varies by region. This report uses a minimum of 10 rings and a maximum of 46 rings as a sapwood estimate (see eg English Heritage 1998, 10–11).

Where bark-edge or bark survives, the season of felling can be determined by examining the completeness or otherwise of the terminal ring lying directly under the bark. Complete material can be divided into three major categories:

- 'early spring', where only the initial cells of the new growth have begun - this is equivalent to a period in March/April, when the oaks begin leaf-bud formation;
- 'later spring/summer' where the early wood is evidently complete but the late wood is evidently incomplete, which is equivalent to May-through-September of a normal year, and
- 'winter' where the latewood is evidently complete and this is roughly equivalent to September-to-March (of the following year) since the tree is dormant throughout this period and there is no additional growth put on the trunk.

These categories can overlap as, for example, not all oaks simultaneously initiate leaf-bud formation. It should also be noted that slow growing or compressed material cannot always be safely categorised.

Timber technology studies demonstrate that many of the tool marks recorded on ancient timbers can only have been done on green timber. There is little evidence for long-term storage of timber or of widespread use of seasoned, rather than green, timber in the medieval period (see eg English Heritage 1998, 11–12).

Reused timbers can only provide tree-ring dates for the original usage date, not their reuse. Identifying reused timbers requires careful timber recording which notes the presence of features which are not functional in the current structure. It is always possible that some timbers exhibit no evidence of earlier usage, and are thus 'hidden reused' timbers. The dendrochronological impact of this problem is particularly acute where only single timbers have been dated from a structure.

The analysis may highlight potential same-tree identifications if two or more tree-ring sequences are obtained that are exceptionally highly correlated. Such pairs, or sometimes more, are then used as a same-tree group and each can be given the interpreted date of the most complete of the samples. They are most useful where several timbers date but only one has any sapwood or where same-tree identifications yield linkages between different areas.

RESULTS

Thirty-seven timbers were cored at Eskdale Mill in 2008 and labelled 1–37 inclusively. Table 1, and Figures 4 and 5 show the distribution of the samples through the structure, which comprise the best available material within the structure and the machinery, although as noted above the entire assemblage of timber was of overall borderline suitability for dating purposes. In total 10 samples were obtained from the Exhibition

Room, 10 from the Upper Machinery Room, 11 from the Lower Machinery Room, two from the Peat Store, and four from the Peat Kiln.

Each sample was assessed for the wood type, the number of rings it contained, and whether the sequence of ring widths could be reliably resolved. This assessment confirmed that all the sampled timbers were oak (*Quercus* spp), that there was very good survival of sapwood in all timbers, but only 13 of the cores were suitable for dendrochronological analysis. The exceptions either had too few rings for analysis or had fragmented badly during sampling. The unsuitable cores comprised five of the Exhibition Room cores, nine of the Upper Machinery Room cores, seven of the Lower Machinery Room cores, and three of the Peat Kiln cores. Twelve of the suitable cores retained some sapwood, with eight retaining bark-edge. The details of the samples are provided in Table 1.

The 13 suitable oak samples from the building were prepared for analysis, measured, and the resultant ring series were initially compared with other material from the building. An interim composite grouping was made of two sample sequences (samples 15 and 16 both from the Peat Store joists, *t*-value 6.99) during this process. The interim composite and the individual sample series were compared with reference series of medieval and later oak tree-ring data from throughout Britain. These results were reviewed. Neither the composite sequence nor the 13 individual samples were found to exhibit good external cross-matching with the reference data. A summary of the individual samples is provided in Table 1.

The measurement data for all the measured samples are listed in Appendix 1

DISCUSSION

No dating information was obtained, which, since there are relatively few reference sequences from this part of the Lake District, was perhaps not an unexpected outcome. The poor internal cross-matching and low numbers of rings, with only four samples containing more than 80 rings, only exacerbated the problem. These samples are derived from various areas of the building and its machinery, and are probably derived from numerous phases of activity. The matching of the two joist timbers suggests that they were derived from a single tree. No other useful interpretative data was obtained. The data was re-checked against recently analysed sites prior to the production of this report.

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English Heritage, 1998 *Dendrochronology: guidelines on producing and interpreting dendrochronological dates*, English Heritage

FIGURES

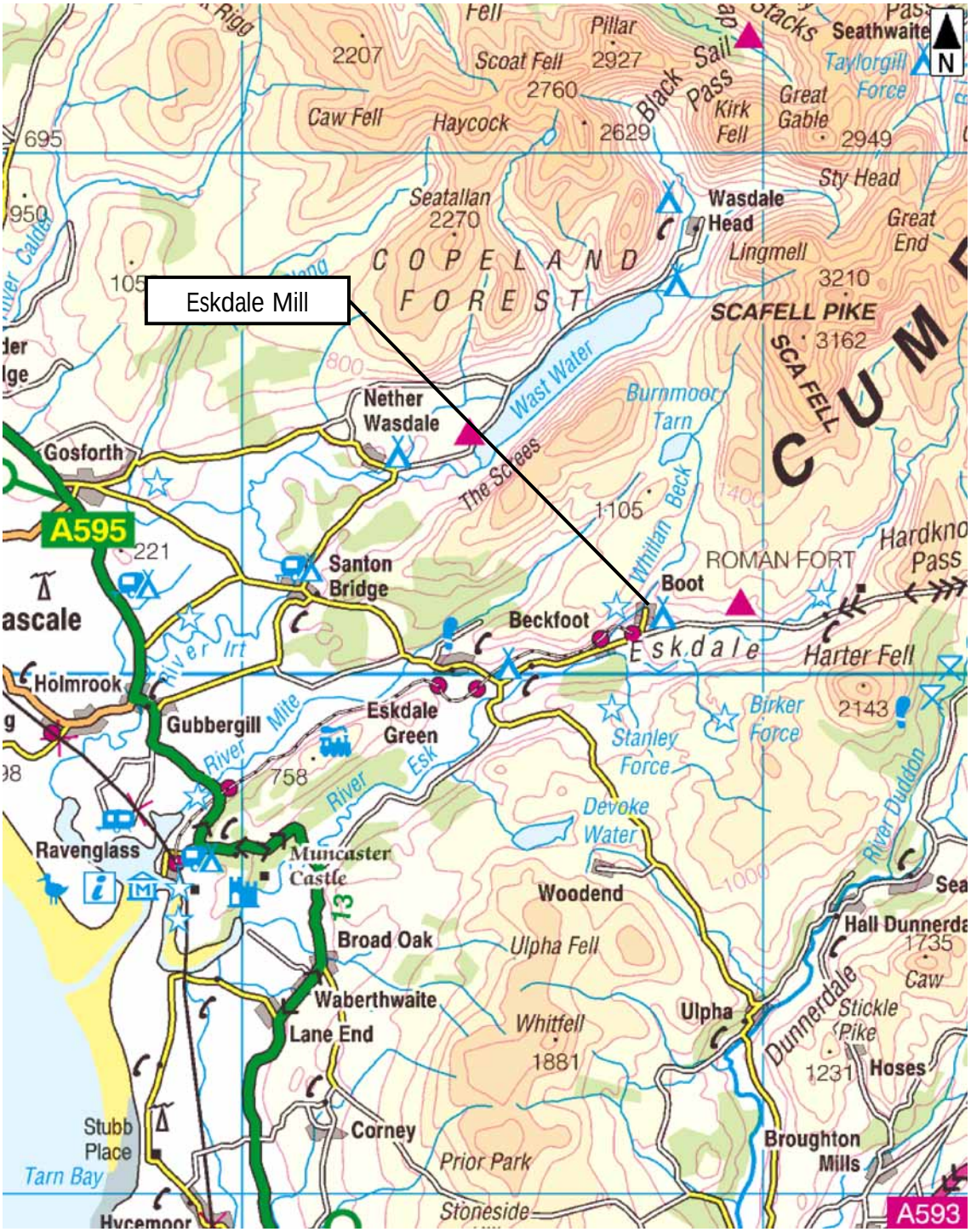

Figure 1: Location of Eskdale Mill, Boot. © Crown Copyright and database right 2014. All rights reserved. Ordnance Survey Licence number 100024900

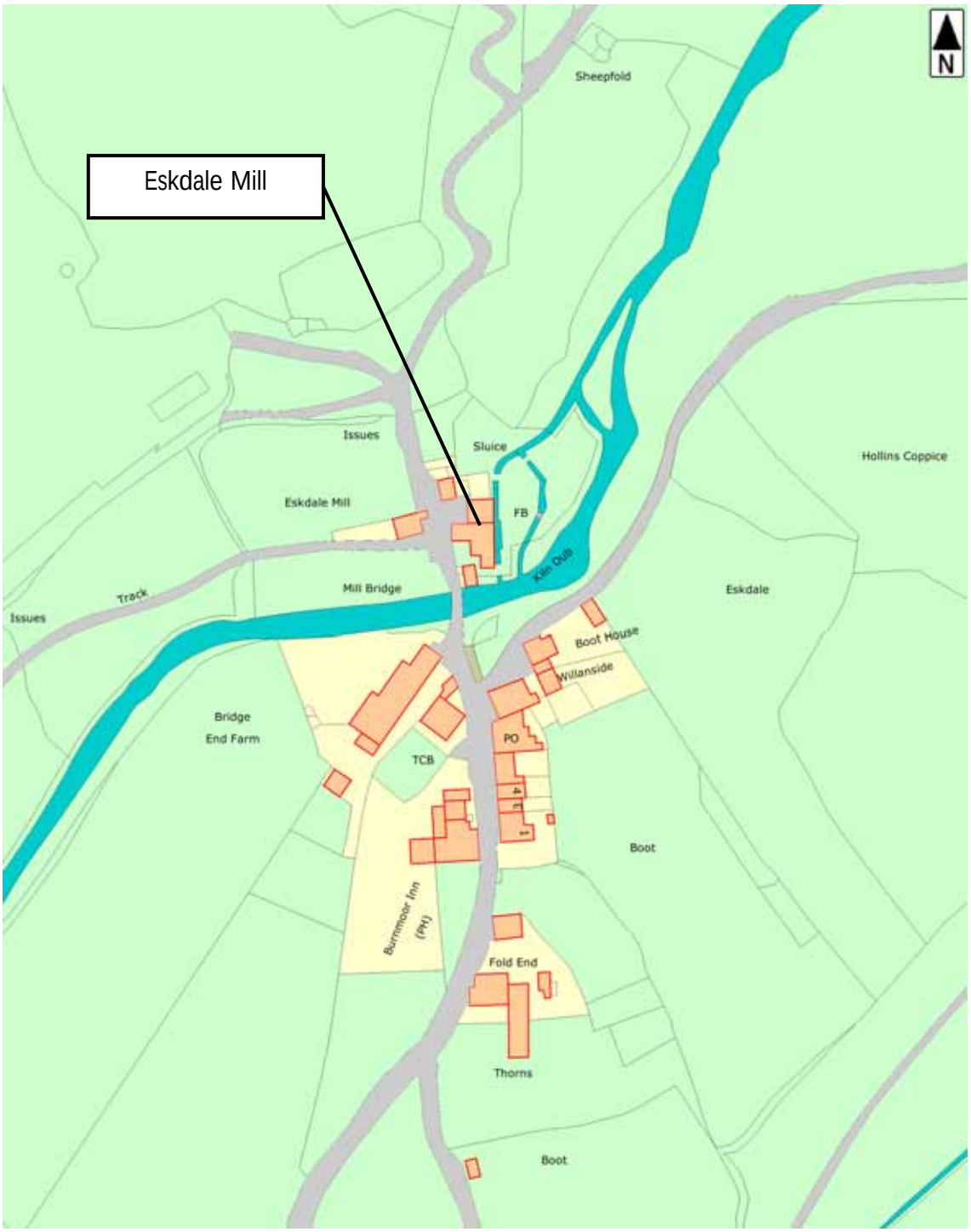

Figure 2: Location of Eskdale Mill, Boot. © Crown Copyright and database right 2014. All rights reserved. Ordnance Survey Licence number 100024900

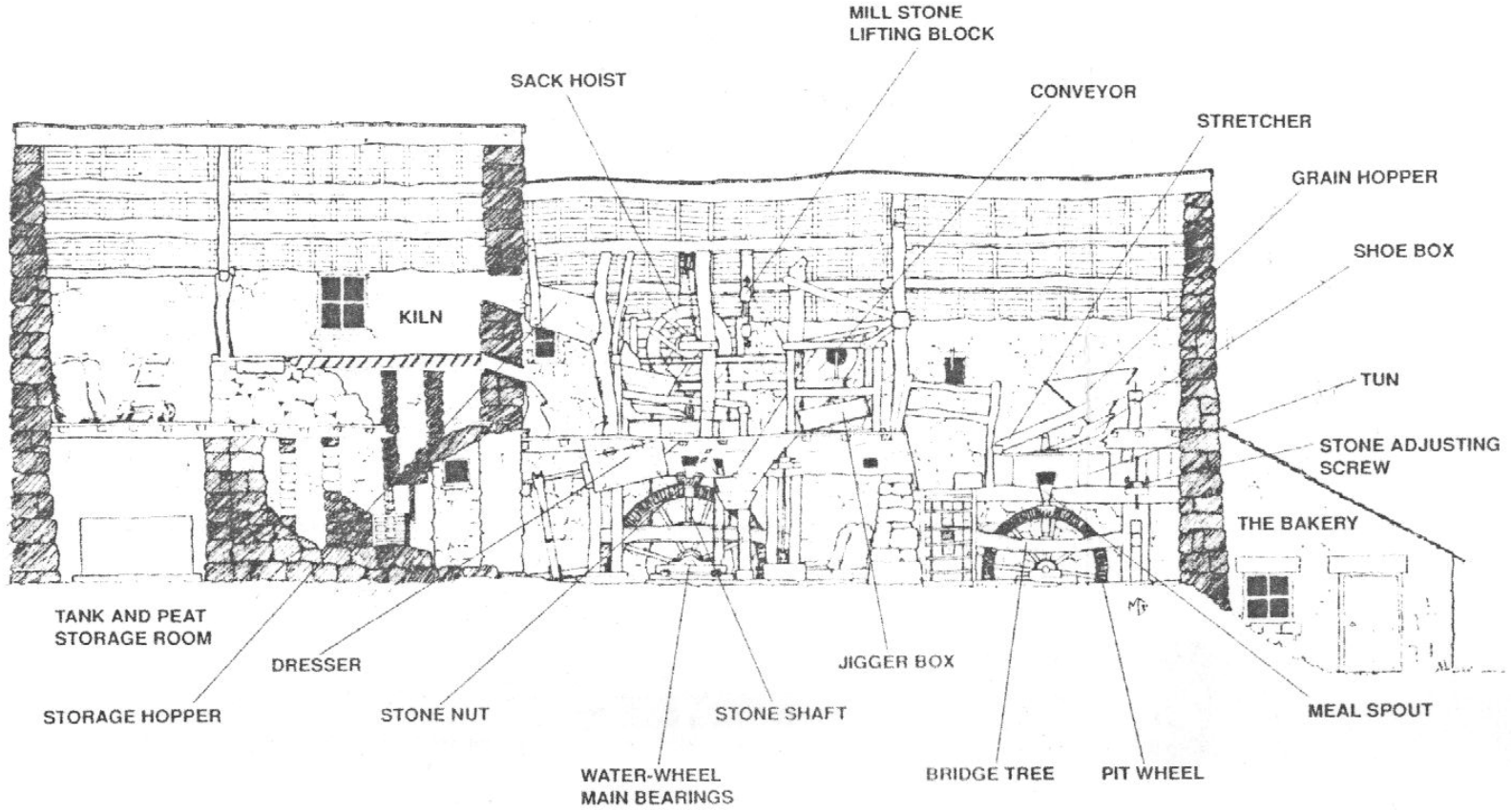

Figure 3: Eskdale Mill, Boot, sketch section looking east showing machinery nomenclature, floor heights, and roof detail. Drawing with permission from David King, Eskdale Mill and Heritage Trust

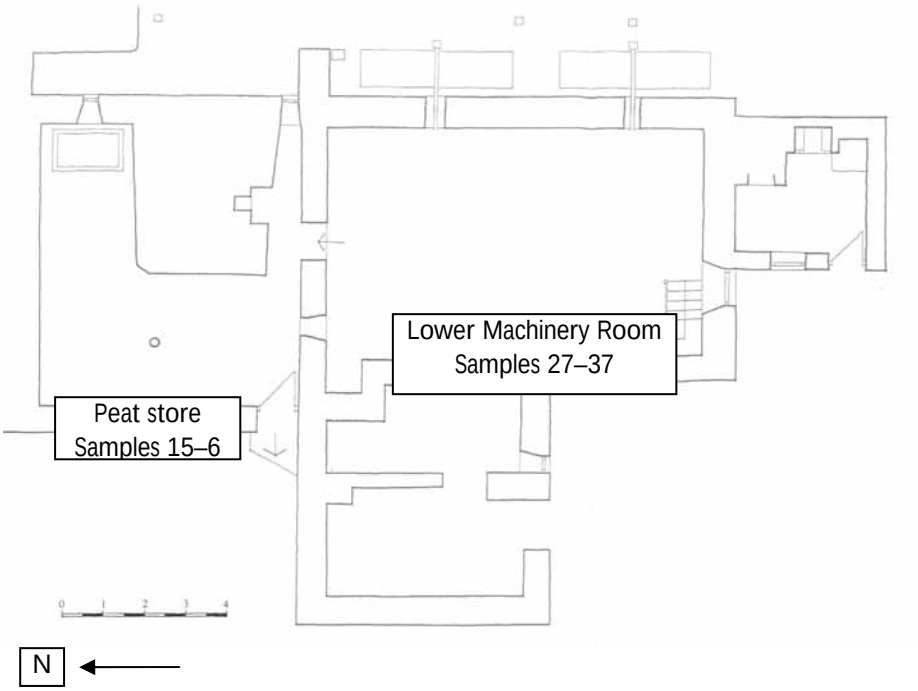

Figure 4: Eskdale Mill, Boot. Ground-floor plan. Drawing with permission from David King, Eskdale Mill and Heritage Trust

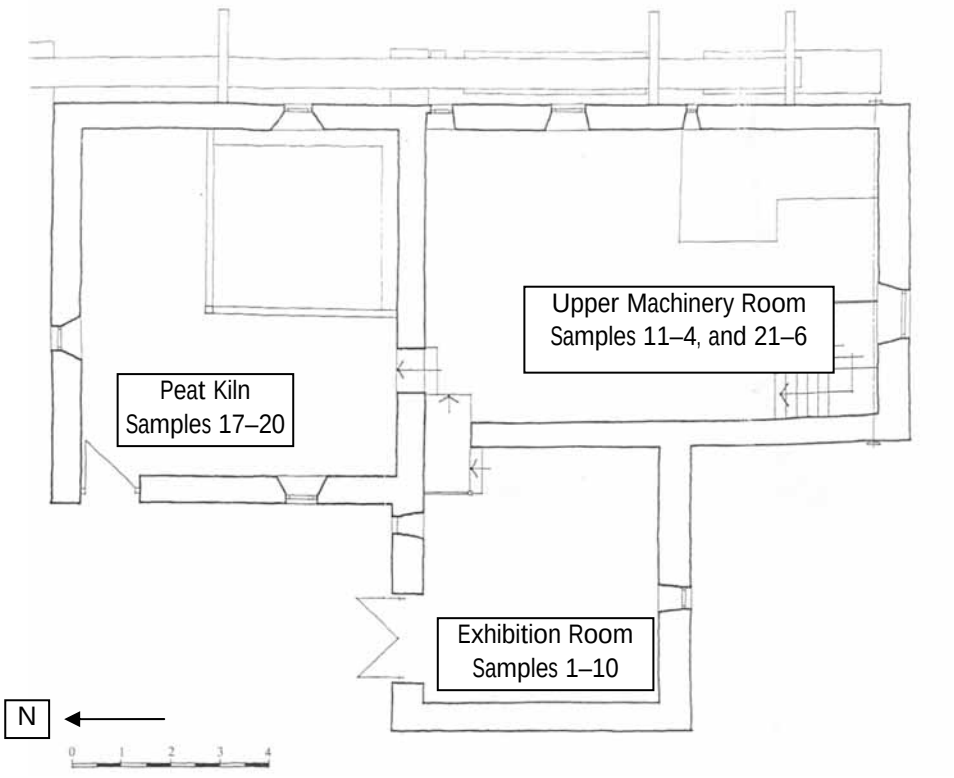

Figure 5: Eskdale Mill, Boot. First-floor plan. Drawing with permission from David King, Eskdale Mill and Heritage Trust

TABLE

Table 1: Details of the 37 oak core samples taken from timbers from Eskdale Mill, Boot

Sample	Location	Rings	Sapwood	Date of measured sequence	Interpreted result
1	ExR tiebeam	72	13+Bs	not dated	-
2	ExR north principal	-	-	not measured	-
3	ExR lower NW purlin	-	-	not measured	-
4	ExR upper NW purlin	91	27+?B	not dated	-
5	ExR SE purlin	-	-	not measured	-
6	ExR upper SW purlin	-	-	not measured	-
7	ExR NE purlin	105	33+sB	not dated	-
8	ExR S window lintel	-	-	not measured	-
9	ExR S wall plate	104	-	not dated	-
10	ExR W wall plate	53	17+Bw	not dated	-
11	UMR tiebeam	-	-	not measured	-
12	UMR west principal	-	-	not measured	-
13	UMR lower SW purlin	-	-	not measured	-
14	UMR EW tie	-	-	not measured	-
15	Peat Store joist 7E	80	27+Bw	not dated +	-
16	Peat Store joist 6E	59	4	not dated +	-
17	Peat Kiln west principal	61	16+Bw	not dated	-
18	Peat Kiln east principal	-	-	not measured	-
19	Peat Kiln tiebeam	-	-	not measured	-
20	Peat Kiln tie extension	-	-	not measured	-
21	UMR square jigger post	-	-	not measured	-
22	UMR rectang. jigger post	-	-	not measured	-
23	UMR lower NE purlin	-	-	not measured	-
24	UMR support NE purlin	58	23+Bw	not dated	-
25	UMR ridge 3	-	-	not measured	-
26	UMR pulley support	-	-	not measured	-
27	LMR S window N lintel	-	-	not measured	-
28	LMR S NS spine beam	64	11	not dated	-
29	LMR W door lintel	-	-	not measured	-
30	LMR N NS spine beam	-	-	not measured	-
31	LMR support NS spine	-	-	not measured	-
32	LMR cross hursting beam	-	-	not measured	-
33	LMR hursting joist	83	H/S	not dated	-
34	LMR hursting post	-	-	not measured	-
35	LMR bridge tree	73	4	not dated	-
36	LMR support jigger posts	-	-	not measured	-
37	LMR W floor beam	71	24+Bw	not dated	-

KEY ExR exhibition room, UMR upper machinery room, LMR lower machinery room. For locations see Figures 4 and 5. H/S is heartwood/sapwood edge. Bs summer felled bark-edge, sB spring felled bark edge in following year, Bw winter felled bark edge, ?B possible bark edge. + these series match each other.

APPENDIX 1

emb01

247	411	448	333	348	222	258	223	183	156
218	205	215	146	150	117	135	188	248	189
198	132	132	112	155	142	124	116	137	119
155	166	172	118	141	107	107	88	67	81
70	75	64	82	103	106	110	66	60	102
92	98	122	112	135	155	166	132	141	140
147	161	132	145	145	172	141	67	89	119
126	94								

emb04

223	227	75	130	210	146	235	254	142	172
146	148	238	260	231	183	187	183	225	376
381	353	161	207	152	126	161	218	269	299
293	106	64	64	68	53	93	60	53	81
100	108	64	66	113	129	178	153	193	162
71	57	52	128	129	131	123	121	121	153
163	148	174	252	176	133	176	166	40	45
43	40	40	35	54	38	32	45	46	38
45	46	48	44	47	83	79	55	51	67
81									

emb07

368	259	252	218	391	267	264	293	263	235
212	276	212	319	300	279	277	230	201	188
187	143	117	114	140	128	144	140	124	160
128	122	142	133	120	117	139	117	136	141
75	69	70	94	108	100	129	153	136	124
93	122	131	127	145	130	160	148	117	86
100	115	128	110	103	109	78	112	121	104
120	103	112	92	80	64	39	67	88	33
47	51	46	71	68	74	79	72	70	70
87	53	48	64	51	80	62	72	81	109
146	141	195	171	181					

emb09

161	91	95	83	137	75	74	110	149	142
142	180	162	111	76	94	101	121	107	76
106	111	123	96	80	84	90	98	78	87
148	124	154	168	142	93	129	117	98	103
129	101	129	81	99	139	103	102	58	75
122	100	121	114	89	58	71	89	87	94
89	99	87	121	152	116	143	120	104	115
102	79	59	79	99	101	135	170	54	43
33	31	39	43	42	48	70	57	79	58
80	87	84	78	67	76	55	49	47	51
63	66	70	81						

emb10

297	310	323	263	224	298	217	157	215	174
217	343	210	192	245	232	135	91	123	195
170	172	159	139	84	110	164	158	172	166
144	136	100	120	109	117	128	136	83	77
69	67	101	130	119	126	124	116	108	109
115	146	142							

emb15

285	257	250	348	236	227	210	182	136	129
168	146	198	270	266	279	376	278	220	221
176	109	149	187	197	215	211	184	138	134
230	176	171	171	122	155	170	149	211	138
170	123	119	89	75	101	60	128	189	129
116	90	108	120	123	167	185	130	258	103
101	94	88	104	115	104	106	96	145	127
146	131	113	117	102	103	110	138	95	103

emb16

453	369	312	363	283	255	290	238	215	130
135	201	260	335	370	348	342	249	215	243
170	135	168	159	225	219	269	254	196	193
327	245	194	257	182	189	240	264	260	192
201	165	161	121	101	146	96	171	162	119
112	111	130	135	134	155	181	167	256	

emb17

287	257	174	160	151	93	112	120	118	182
184	162	200	130	233	212	141	137	180	214
172	184	170	215	207	147	234	208	311	267
328	170	220	259	318	294	349	311	225	277
280	279	283	361	317	187	174	255	307	195
132	94	98	104	105	157	144	128	187	176
228									

emb24

179	153	113	100	91	84	87	129	126	108
129	114	165	191	247	197	119	160	162	159
222	195	188	147	151	140	155	137	103	163
139	133	94	128	156	148	160	79	103	98
146	127	134	173	171	154	113	75	77	90
81	86	67	99	124	154	118	94		

emb28

168	175	231	196	168	128	97	124	132	135
126	106	131	87	101	84	87	120	98	239
214	167	185	231	211	192	125	64	61	89
150	180	268	369	249	231	173	207	174	267
293	343	270	300	303	258	178	208	152	290
260	226	99	186	193	163	153	233	264	229
260	153	270	200						

emb33

227	214	201	172	201	189	131	98	143	140
153	123	126	126	143	97	103	97	100	114
119	90	63	79	83	89	100	105	125	118
139	130	72	74	115	123	119	103	127	85
100	77	88	89	77	84	106	58	121	78
115	105	94	103	122	118	141	88	78	137
115	149	158	187	195	190	169	146	155	128
152	167	119	160	128	176	145	135	109	109
124	108	110							

emb35

241	221	169	273	238	127	170	103	61	100
84	146	171	165	196	154	105	86	57	73
143	241	102	97	141	110	163	163	123	154
151	94	104	81	85	103	59	129	134	132
167	159	167	306	206	212	270	145	96	120
168	196	179	169	237	414	482	236	238	177
249	197	264	149	368	331	381	301	190	200
199	176	173							

emb37

144	140	118	89	88	71	65	49	43	91
74	109	89	110	141	274	310	310	237	225
199	243	255	168	227	170	204	175	249	185
160	158	184	165	177	214	147	103	101	68
65	46	32	51	85	79	107	160	121	121
118	115	146	143	121	93	105	86	75	106
104	109	131	143	106	111	122	110	99	87
88									

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