X. RADIOCARBON ANALYSIS

Twenty radiocarbon samples were submittted for analysis from Lums Pond, 6 from feature fill and 14 from general stratigraphic proveniences. Fifteen of the samples were of sufficient size for standard counting procedures, although 3 required extended counting time to reduce the margin of error in the reported dates. Five samples required AMS dating. The dates returned from the assays are detailed in Table 36. The results are reported in both uncalibrated radiocarbon years (BP) and calibrated calendar years (BC/AD).

Methods: Collection and Processing

Radiocarbon samples were recovered from a variety of proveniences across the site. These included charcoal from concentrations within features; dispersed charcoal from arbitrary levels within features; dispersed charcoal from arbitrary stratigraphic levels not associated with features; and bulk soil samples from stratigraphic levels. All charcoal and humic acid samples were collected in sterile conditions which were maintained throughout the course of processing.

Charcoal samples were sorted and cleaned before transmittal to Beta Analytic, in Miami, for radiocarbon assay. There the samples were further cleaned and pretreated. Cleaning consisted of examination for rootlets and other non-carbonized organic material. The samples were then washed in hot acid to eliminate carbonates, rinsed to neutrality and washed in hot alkalai to remove humic acids, rinsed to neutrality, and washed in hot acid and rinsed a second time. The samples then underwent normal benzene synthesis and counting. Three small samples were given extended counting time (four times normal) to increase estimation precision. Preprocessing for the AMS samples consisted of the collection of carbon dioxides from combustion in a closed system. These were purified and reacted with hydrogen on cobalt catalysts to produce graphite and applied to a copper target. The AMS measurements were made in triplicate at either the Lawrence Livermore National Labortory (CAMS) or the Eidgenössische Technische Hochschule (ETH) in Zürich (Tamers 1995, 1996a, 1996b, 1996c, 1996d, 1996e).

Sample Types

The optimum material for radiometric dating is charcoal from a sealed feature, since this is the easiest situation in which to demonstrate good association between the material dated and the behavioral event in question. Moreover this type of context bears the least chance of contamination from postdepositional agents, whether natural or cultural. Alternatively, samples may be taken from dispersed charcoal contained in a depositional layer. The general lack of control over the amount of the material that is actually associated chronologically with the original depositional event make the results less reliable. This may be of particular concern if the deposit is unsealed or not quickly buried. The soil column is exposed to a large number of natural transformations as well as cultural disturbances, the latter including *post hoc* excavation through the deposit and introduction of later material (Wood and Johnson 1978; Schiffer 1987).

A third type of radiometric sample consists the actual soil from a sealed depositional layer. While soil sediments are typically considered the least reliable sources of radiometric data, they may serve a bracketing function in temporal assessment in the absence of other more suitable chronological data. Soil organic matter is derived from a variety of sources including humic acid and organic residues (Martin and Johnson 1995; Wang *et al.* 1996). In light of this, the date returned from a bulk soil assay could as likely be indicative of soil formation processes as cultural depositon. Nonetheless, such a date would provide a *terminus ante quem*, a date before which the cultural material associated with it was deposited. The result may often be younger than the cultural material, since the humic acids in particular are part of the process of soil development, overprinting the cultural deposit over a period of time, yet the date can function in combination with other data as part of the temporal framework of the site occupation. Assuming that the deposit is sealed, the organics contained within it should be less likely to be contaminated by cultural processes and so would provide a secure context from which to argue a *terminus ante quem*.

As in all matters of archaeological interpretation, the results of radiometric analyses must be weighed in view of several factors. The laboratory data returned from radiometric assays provide relatively clear seeming information on which to base the exposition of the chronological setting at a site. Yet the derivation of the samples is critical to the validity of the cultural interpretations. The type of sample and the level of reliability expected from it are an important factor discussed above. Additionally, and of perhaps overriding concern, are depositional contexts. The examination and assessment of the processes of site formation, detailing the original depositional patterning at the site and the degree and form of disturbance and transformation to the original deposition, are crucial to determining how sound the radiometric samples actually may be. Each of these factors these must be considered in turn prior to the confident development of final conclusions about site chronology.

Data Analysis

Radiocarbon dates are estimated measurements based on the known rate of radioactive decay of the C^{14} isotope. The decay occurs at random time intervals about a mean value, and dates are reported not as single points but as estimates of precision, or the probability that a date will fall within a specific distribution. Therefore simple presentation of the results of radiocarbon assays is misleading. Some form of central tendency measure is needed (Ottaway 1987:136), the most basic being the standard deviation, or sigma (σ), representing the precision of the measurement. This may merely involve the reporting of the sigma ranges, as in Table 36, or the use of a graphic display of the ranges. To assess the comparability of a series of dates, other analytical manipulations of the data based on the statistical nature of the probability distributions may be used. Yet prior to appraising the range of occupation implied by a set of date ranges, it is necessary to assess the validity of the dates within that range (Buck et al. 1994:231). This is the problem of outliers or aberrant determinations, and much of the analysis involves archaeological rather than statistical decisions — e.g., how secure the stratigraphic context, how valid the spatial associations.

Area 2

Eight radiocarbon dates were returned from Area2, six from feature proveniences, one from Block D, and one from basal gravels in the southern part of the area.

The two dates from non-feature proveniences varied widely providing bracketing dates for the main period of occupation in Area 2. An assay from the sub-plow zone layer in Block D returned a date of 810±60 BP, later than expected based on artifact data in the overlying deposit. The sample that was dated consisted of a low-carbon soil sample, and the resulting date appeared to be associated with soil formation processes which occurred after the artifacts in the layer were deposited and buried. A second sample consisted of organic material extracted from a gravel matrix located at the base of the soil profile, immediately overlying the Columbia Formation gravelly sand on the southern edge of Area 2. The date returned from the sample was 10,710±80 BP, and indicated the presence of a thin post-Pleistocene sedimentary veneer resulting from erosion on the midslope portion of the site.

Sample #	Provenience	Radiocarbon Age (1-Sigma)	Calibrated (2-Sigma)	Material	Analysis
AREA 2					
88100	Feature 2	2670±90 BP	1000-760 BC 670-550 BC	charcoal	standard
88101	Feature 10	1150±90 BP	AD 680-1035	charcoal	standard
88102	Feature 14	2660±100 BP	1005-525 BC	charcoal	standard
88103	Feature 16	2780±60 BP	1045-815 BC	charcoal	standard
88104	Feature 19	2720±90 BP	780-1045 BC	charcoal	standard
88105	Feature 23	2960±60 BP	1330-990 BC 1380-1335 BC	charcoal	extended count
88111	Blk D, B2	810±60 BP	AD 1055-1090 AD 1150-1295	sediment	extended count
92103	Area2 85-90cm	10710±80 BP		organic sediment	standard
AREA 3					
88106	Blk A, C1	400±50 BP	AD 1425-1640	charcoal	AMS (ETH)
92101	BlkA, C1	330±80 BP		sediment	standard
88107	BlkA, D1-2	640±50 BP	AD 1280-1415	charcoal	AMS (ETH)
88108	BlkA, D3-4	6350±60 BP	5415-5215 BC	charcoal	AMS (ETH)
92099	BlkA, 153-160cm	4310±60 BP	3045-2870 BC 2795-2770 BC	organic sediment	AMS (CAMS)
88109	Blk B, C1	700±80 BP	AD 1205-1415	charcoal	standard
92102	BlkB, C1	380±60 BP		sediment	standard
91398	BlkB, D1	3440±90 BP	1955-1515 BC	charcoal	standard
88110	Blk B, D2	3320±70 BP	1750-1430 BC	charcoal	standard
91399	BlkB, D3	3240±90 BP	1705-1305 BC	charcoal	extended count
92100	BlkB, 159-164cm	2400±50 BP	760-635 BP 560-380 BP	organic sediment	AMS (CAMS)
83166	N220/E237	230±50 BP	n/a	organic sediment	standard

Table 36. Lums Pond Radiocarbon Assay Results Reported in Radicarbon Years with 1-Sigma Precision and Calibrated Calendar Years with 2-Sigma Precision

Assays were run on radiocarbon samples from six features. One sample was from Feature 10, run on dispersed charcoal from a level provenience within the feature. The date returned was 1150±90 BP. There were relatively few artifacts recovered from the feature, none of which were chronologically diagnostic, and little chronological evidence from surrounding deposits. Thus there was no corroborating evidence for the radiocarbon date, and no objective means of determining whether or not it was valid.

The remaining five assays were from the cluster of features exposed in the eastern portion of Area 2. The dates ranged from 2660±100 BP to 2960±60 BP, the middle portion of the Woodland I period. The assay results were similar enough to suggest the possibility of contemporaneity. Pairwise significance tests for contemporaneity were run on the assays from the features (Thomas 1976:249-50). The statistic calculated for the test is the t-ratio. With the rejection region at $\alpha = .05$ and df = ∞, the table value of $t_{.05}$ = 1.96. The results of the tests are presented in Table 37. Statistically significant comparisons, suggesting contemporaneity, are highlighted.

F-14	2660±100	0.00				
F-2	2670±90	**0.07**	0.00			
F-19	2720±90	**0.45**	**0.39**	0.00		
F-16	2780±60	**1.03**	**1.02**	**0.83**	0.00	
F-23	2960±60	2.57	2.68	2.22	2.12	0.00
		F-14	F-2	F-19	F-16	F-23

Table 37. Pairwise Comparison for Contemporaneity of Radiocarbon Assays from Selected Features in Area 2

The results of the tests indicated that the distributions returned from Features 2, 14, 16, and 19 showed no statistically significant differences, while the distribution from Feature 23 was different from each of the others.

To further assess the dates from the features in terms of their implications for continuity and contemporaneity of site occupation, a form of aggregation analysis developed by Kintigh (1991) was employed. As noted earlier, radiocarbon dates are not single points in time but are in fact probability distributions. Using this information, aggregation analysis calculates the probability that the date returned for a specific radiocarbon assay will fall within a specified time interval based on the combined probabilities of all of the dates from the provenience. The shape of the resulting probability curve can provide an indication as to the continuity of occupation represented by the dates. Assuming that the dates are representative of the temporal range of site activity, a unimodal distribution might imply a single episode of occupation, while a more complex curve might imply one or more breaks in activity.

Figure 87 illustrates the results of an aggregation analysis performed on the data from the Area 2 features. The chart displays the expected frequency of dates on a 50-year interval. The distribution appears essentially unimodal, yet there is a small, secondary peak at 2950 BP, to the left of the main peak at 2650 BP, corresponding to the data represented in the distribution by Feature 23.

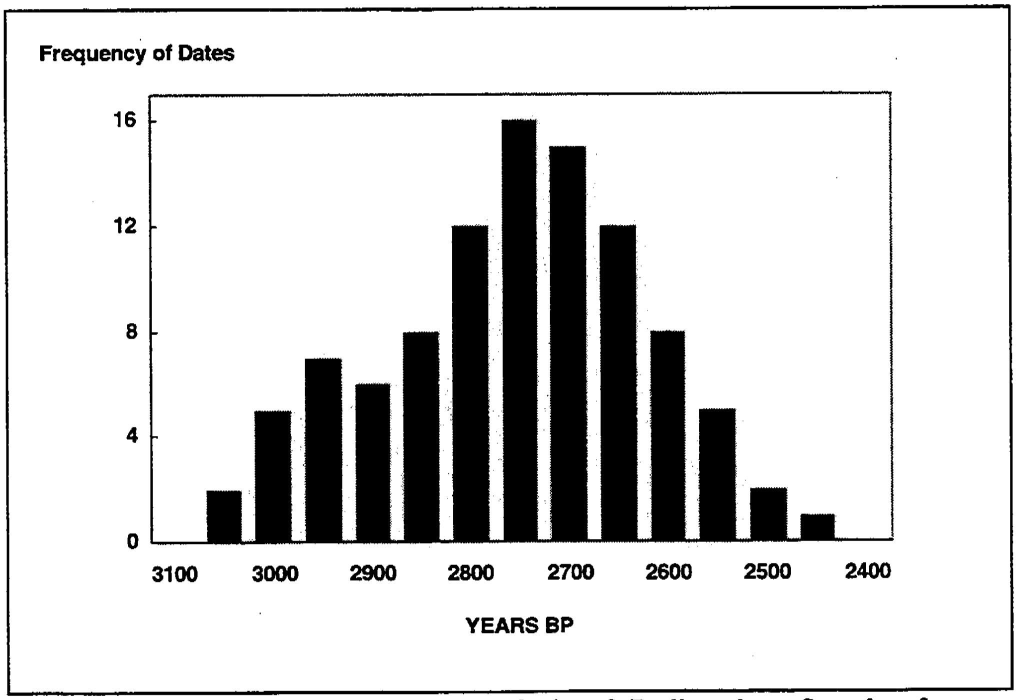

Figure 87. Graph of Aggregation Analysis of Radiocarbon Samples from Features in Area 2, Showing Continuity of Activity as Probability Percentages on a 50-Year Interval

As a final alternative, the 2-sigma ranges (95 percent confidence interval) of the distributions were graphed (Figure 88). The region in which the probabilities correlated has been indicated by shading. As figure 88 illustrates, the analysis implied a potential for temporal overlap among all of the features.

On the basis of these analyses, it was concluded that the features were contemporary. Given the uncertainty of depositional processes, the potential for contamination in collection and processing (in spite of efforts to control adulteration), and the probabilistic nature of the assay results, it is arguable that the dates of features were indeed comparable. Further, contemporaneity is assumed for the remaining features in the cluster, judging from their mutual proximity (within a radius of 4 m or less), a general lack of physical overlap (such as would indicate serial use), their approximate regularity of morphology, and the general uniformity of their contents.

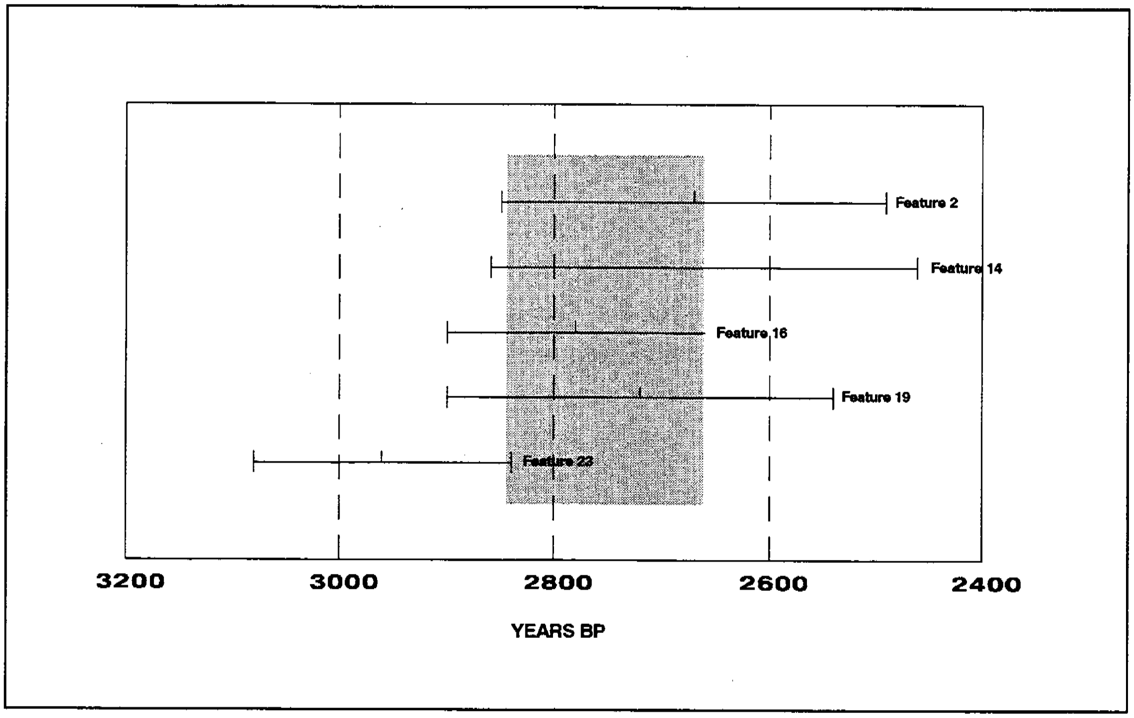

Figure 88. Radiocarbon Assay Results from Area 2 Feature Dates Displayed with 2-Sigma Range, Shaded Region Indicates Potential Overlap

This being said, an average date for the feature cluster was determined following calculations presented in Long and Rippeteau (1974:209). All five dates were used in the calculation. Because the sigmas associated with the dates were dissimilar, a form of weighted average was employed. Weighting factors used in the calculation are relative, based on the ratios of the sigmas and inversely proportional to the precision of the measurement (Long and Rippeteau 1974:Table 2). The sigmas themselves were averaged as follows:

$$\bar{\sigma} = \frac{1}{\sqrt{\frac{1}{\sigma_1^2} + \frac{1}{\sigma_2^2} + \frac{1}{\sigma_n^2}}}$$

The averaged date for the feature cluster was calculated as 2802±33 BP.

Area 3

Twelve dates were returned from Area 3, five from Block A, six from Block B, and one from the terrace edge south of Block A. Average dates were determined for two of the Area 3 proveniences, following calculations presented in Long and Rippeteau (1974:209).

Four dates from Stratum C — 330±80 BP, 380±60 BP, 400±50 BP, and 700±80 BP — provided an average of 431±32 BP, late in the Woodland II period. Stratum C was assumed to be a single, uniform buried A-horizon extending across Block A and Block B, and the dates used in calculating the average were from both block excavations. There was no evidence of stratification within the deposit in either block, leading to the assumption that each sample of charcoal from the stratum was as likely as the rest to be representative of the mean period of occupation. The calculation does weight the individual dates, but only according to the magnitude of the sigma. Hence the mean date of occupation for Stratum C is considered to be 431±32 BP.

A cluster of three dates was returned from successive levels of Stratum D in Block B — from Level 1, 3440±90 BP; from Level 2, 3320±70 BP; and from Level 3, 3240±90 BP, all three dates falling in the middle portion of the Woodland I period. The dates were not in chronological order with depth, yet they were close in terms of probability distributions as indicated by a pairwise significance tests for contemporaneity (Thomas 1976:249-50). The calculated statistic is the t-ratio. The table value of $t_{.05}$ = 1.96, with df = ∞. The results of the tests are presented in Table 38. Statistically significant comparisons, suggesting contemporaneity, are highlighted. In this case, all three distributions were considered similar.

	D1	D2	D3
D1 3440±90	0.00		
D2 3320±70	**1.05**	0.00	
D3 3240±90	**1.57**	**0.70**	0.00

Table 38. Pairwise Comparison for Contemporaneity of Radiocarbon Assays from Level Proveniences in Stratum D of Block B

As with the data from Stratum C, each sample from Stratum D appeared as likely as the rest to be representative of the mean period of occupation, and thus the dates were averaged. The mean date of occupation for Stratum D is considered to be 3331±47 BP (3378-3284 BC).

A final assay was returned on a sample of peat recovered from the base of a test unit on the southern edge of Area 3. The date returned was 230±50 BP, implying that the material had been deposited comparatively recently. This location represented the edge of the active stream during the historic period where it had cut into the earlier, prehistoric floodplain, filling in with water-borne debris.

There were four inconsistent dates from Area 3. Consideration of the validity of these dates involved archaeological decisions regarding stratigraphic contexts or spatial associations rather than statistical desicions.

- 640±50 BP from D1-2 Block A — this sample was combined from two proveniences, with most of the material (almost 80 percent) coming from Level 1, clearly raising the possibility of contamination from the overlying Stratum C; the date was disregarded
- 6350±60 BP from D3-4 Block A — this date appeared early compared with the dates from the same levels in Block B; yet there was no additional evidence from that part of the profile to suggest that the date was in fact invalid; the sample was from combined proveniences, possibly making it less reliable than more concentrated samples; the date was disregarded
- 2400±50 BP from a depth of 160 cm in Block B, the lower buried A-horizon, 3Ab — this date was later than three statistically consistent dates occurring in a contiguous unit considerably higher in the profile; the material dated was organic sediment; this date was assumed to be less reliable than other dates from the block
- 4310±60 BP from a depth of 160 cm in Block A, the lower buried A-horizon, 3Ab — if the 6350 date were assumed to be good, this date would fall well out of sequence in a similar manner to the 2400 date in Block B; were the 6350 date considered aberrant, this date may be acceptable; there was no additional data, radiometric or artifactual, to corroborate either assessment

The most secure dates, and those which we will use in Area 3, are those from Stratum C, which average 431±32 BP, and Stratum D, which average 3331±47 BP. The date of 4310±60 BP from the gravelly 3Ab horizon may be a bracketing date for the early end of the continuum. It appears acceptable although there is no corroborating evidence.

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