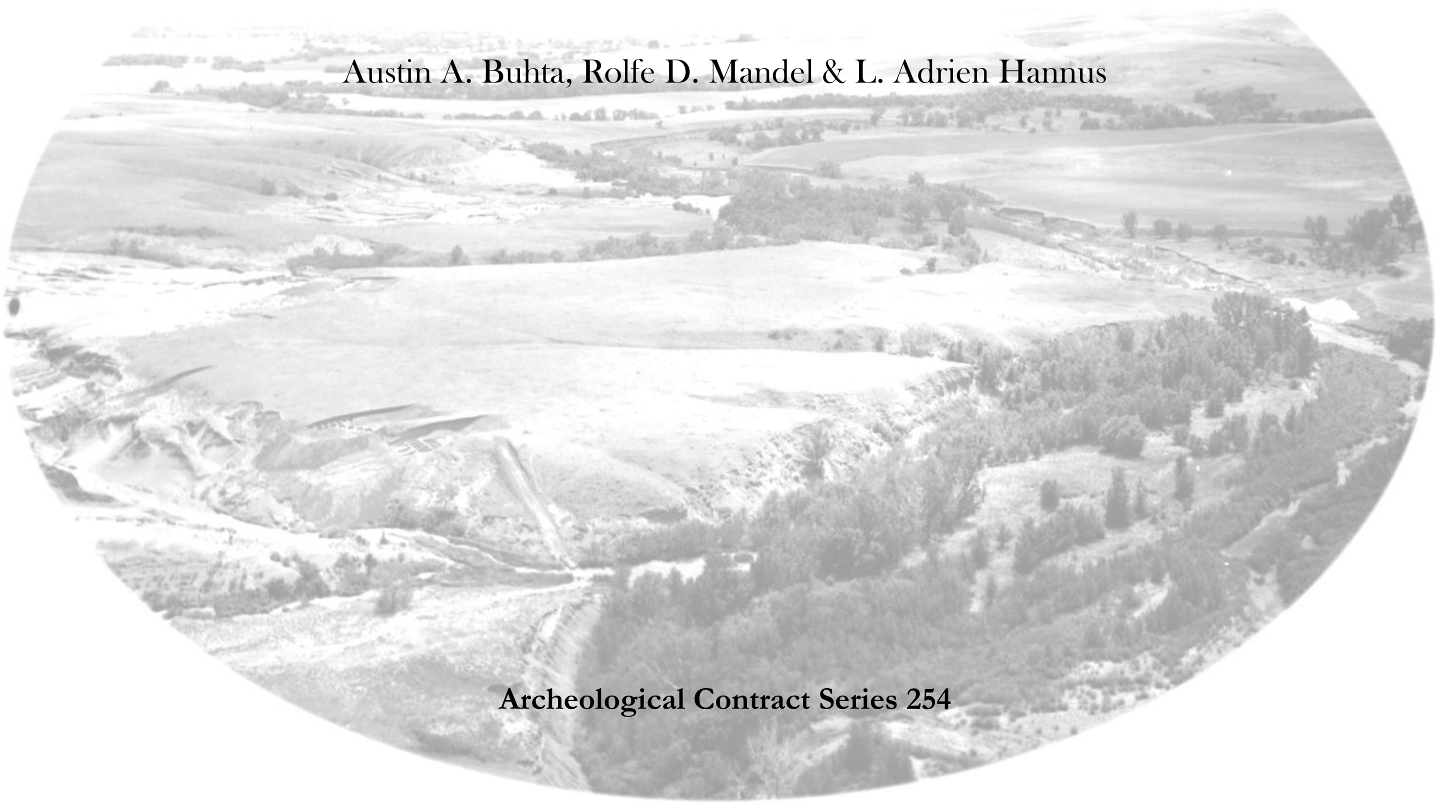
The Archeology, History, and Geomorphology of the Ray Long Site (39FA65), Angostura Reservoir, Fall River County, South Dakota

Manuscript II

Volume I
Cultural Resources Report



Austin A. Buhta, Rolfe D. Mandel & L. Adrien Hannus

Archeological Contract Series 254

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Prepared for:
U.S. Department of the Interior,
Bureau of Reclamation
Rapid City Field Office 515 9th Street, Room 101
Rapid City, South Dakota 57701

Prepared under Cooperative Agreement Nos. R09AC60006 and 09FC602369
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Cover Image: 1950 aerial photograph of the Ray Long site (39FA65) taken by Richard P. Wheeler. The original Smithsonian Institution bulldozer trenches at Area B are visible in the lower left corner of the image (Field Photograph No. W50-L15-8).

ABSTRACT

This manuscript represents the second of three reports detailing the results of historical, archeological, and geomorphological research conducted at the Ray Long site (39FA65), Angostura Reservoir, Fall River County, South Dakota. Due to an alluring combination of antiquity, preservation, and the presence of a poorly understood cultural technocomplex, the Ray Long site has been the subject of archeological scrutiny and intermittent investigations for over six decades. Ray Long is best known as the type-site for the Angostura complex, an enigmatic Paleoindian group that occupied the Plains around 9,000 years ago. However, archeological and radiocarbon evidence indicate that the site was inhabited by other groups who both predate and postdate the Angostura occupation. Manuscript II presents an overview of radiocarbon dates obtained from the site, the geology and geomorphology of the site, a review of site collections curated at the Smithsonian Institution, and a reevaluation of the 1948-1950 River Basin Survey excavations at the site. The final manuscript, Manuscript III, includes a detailed reevaluation of the Angostura cultural technocomplex, and an assessment of the science and management of the site to-date, as well as in the future.

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Overview and Analysis of Radiocarbon Dates Obtained from the Ray Long Site

Between 1949 and 2010, 24 organic samples collected from the Ray Long site were submitted for radiocarbon assay (Table 1; Figures 1 and 2).[1] Dates were obtained from three samples in 1949 and 1950 during the RBS investigations at the site, and ARC researchers collected and dated two additional samples in 1987. The remaining 19 dates were obtained from samples collected during fieldwork undertaken by ALAC between 1985 and 2010 (see Appendix E, Manuscript I). Eighteen dates were obtained from Area B, while six were obtained from Area A. No dates were obtained from Area C. Wheeler (1995:404) reports that during the 1948 RBS excavations at Area C, "Ten lots of finely divided charcoal and earth were obtained…," but he then notes that the samples "…have not yet been identified or submitted for carbon-14 analysis." All of the samples submitted for radiocarbon assay from Ray Long were either wood charcoal or bulk soil organic matter (SOM); no charred annuals were dated. The 14 most recently submitted samples (1 from 1993, 1 from 1994, 4 from 1995, 2 from 1996, 5 from 1998, and 1 from 2010) were dated with an accelerator mass spectrometer (AMS). The samples submitted by the RBS were processed during the infancy of radiocarbon dating and have extremely large standard deviations; the 1985 dates have large standard deviations as well. While those samples are reported here for the sake of being comprehensive, the limitations of their precision must certainly be considered. An overview of the radiocarbon dates from Ray Long is provided below.

Dates From the River Basin Survey Excavations

R. P. Wheeler collected three charcoal samples from the Ray Long site during the 1949 and 1950 Smithsonian Institution RBS excavations. Two samples collected from Trench 1 in Area B of the site were dated (Wheeler 1995:427) and a third, collected from Area A, was also dated (Wheeler 1995:440). The first Area B sample, collected in 1949 from a lens of dark soil and charcoal in unit N7 E4, yielded a date of 7715 ± 740 RCYBP (Arnold and Libby 1951). Wheeler does not assign a formal feature number to this burned area, and the report indicates that it was located at a maximum depth of 1.8 feet (ca. 0.55 m) below surface (Wheeler 1995:427). Additional notes suggest it was located at an absolute elevation of between 3,200.00 and 3,200.30 feet (975.36-975.45 m) amsl. The second sample from Area B, collected in 1950 from a heavily fired hearth (Feature 14) in unit N3 E3, yielded a date of 7073 ± 300 RCYBP (Libby 1951). Wheeler (1995:411) describes Feature 14 as an oval area of burned clay-shale and charcoal located at an absolute elevation of 3,197.82 feet (974.70 m) amsl. The vertical position of the samples collected for these dates, relative to each other, is approximately 0.7 m. It is noteworthy that the date from Feature 14 is more recent than the other Area B date despite the fact that Feature 14 is positioned stratigraphically below the charcoal deposit from the first sample. Wheeler (1995:427) hypothesizes that the older date may have been contaminated – a plausible suggestion given the extensive bioturbation documented at the site coupled with the fact that the sample did not come from a well-defined, intact cultural feature (such as a hearth). In a subsequent contradictory statement, Wheeler (1995:447) asserts that the older of the two Area B dates is likely more accurate, and that the Feature 14 date "…need not be considered further."

[1] Dates are reported here in two ways: as uncalibrated radiocarbon dates – labeled as *Radiocarbon Years Before Present*, or *RCYBP*; and as dates calibrated with the use of CALIB 6.0 and the IntCal09 calibration curve (Reimer et al. 2009) – labeled as *Calibrated Years Before Present*, or *cal B.P.* The term *Present* denotes the calendar year A.D. 1950.

Table 1. Calibrated Radiocarbon Dates from the Ray Long Site (39FA65).*

Sample No. (Year)	Uncalibrated Date in RCYBP	Uncalibrated Age Range (B.C.)	Calibrated Dates (cal B.P.) (1 sigma)	Calibrated Dates (cal B.P.) (2 sigma)	Provenience/Comments
Wheeler -A (1950)	9380 ± 500	6880-7880	9893-11,319 (1.000)	9432-12,162 (0.993) 12,182-12,217 (0.003) 12,288-12,313 (0.002) 12,352-12,374 (0.002)	Area A. SOM from 'cs' zone. 979.93-980.85 m amsl.
Wheeler - Cat#203 (1949)	7715 ± 740	4975-6455	7849-7909 (0.028) 7912-9465 (0.972)	7028-7055 (0.001) 7068-7079 (0.001) 7085-7111 (0.002) 7155-10,430 (0.995)	Area B. Trench 1, Unit N7 E4, 975.36-975.45 m amsl.
Wheeler - Cat #417 (1950)	7073 ± 300	4773-5373	7622-7644 (0.031) 7650-8177 (0.969)	7334-7353 (0.003) 7376-7382 (0.001) 7415-8460 (0.992) 8467-8477 (0.001) 8497-8512 (0.002)	Area B. Feature 14, Trench 1, Unit N3 E3, 974.70 m amsl.
I-14241 (1985)	11,000 ± 310	8690-9310	12,607-13,192 (1.000)	12,096-13,477 (1.000)	Area B. Trench F, F3. Stratigraphically just below F1.
I-14245 (1985)	10,400 ± 360	8040-8760	11,620-11,679 (0.044) 11,687-12,627 (0.956)	11,174-12,990 (0.991) 13,000-13,070 (0.009)	Area B. Trench F, F1. 977.31 m amsl. Strat. Unit 8.
I-14240 (1985)	9540 ± 540	7000-8080	10,182-11,755 (1.000)	9541-12,426 (0.995) 12,481-12,519 (0.005)	Area B. Trench F, F2. Stratigraphically just above F1.
I-14239 (1985)	8950 ± 140	6810-7090	9796-9804 (0.012) 9818-9846 (0.49) 9867-9874 (0.010) 9887-10,240 (0.928)	9599-10,305 (0.962) 10,311-10,400 (0.038)	Area B. Trench F, F4. 978.20 m amsl. Likely Strat. Unit 3. At transition between Wheeler's granular clay (*gc*) and sandy clay (*sc*) strat. units.
Beta-13077 (1985)	8130 ± 600	5530-6730	8340-9740 (1.000)	7761-7774 (0.001) 7785-10,521 (0.998) 10,534-10,550 (0.001)	Area B west of Trench 1. Precise depth and position unknown.
Beta 25361 (1987)	8650 ± 80	6570-6730	9534-9699 (1.000)	9498-9890 (1.000)	Area B. ARC SW¼ XU4. 977.86-977.91 m amsl.
Beta 25360 (1987)	8560 ± 80	6480-6640	9472-9601 (1.000)	9420-9737 (1.000)	Area B. ARC SE¼ XU4. 977.86-977.91 m amsl.
I-18881 (1993)	8545 ± 65	6480-6610	9481-9550 (1.000)	9436-9634 (0.979) 9642-9662 (0.021)	Area B. Trench M, F93-1. 975.11-975.18 m amsl. Strat. Unit coincides with Wheeler's "clay-shale zone."

*** Shaded samples are from Area A of the site; the remainder is from Area B.**

Table 1 (continued).

Sample No. (Year)	Uncalibrated Date in RCYBP	Uncalibrated Age Range (B.C.)	Calibrated Dates (cal B.P.) (1 sigma)	Calibrated Dates (cal B.P.) (2 sigma)	Comments
I-17779 (1994)	9150 ± 230	6920-7380	9931-9995 (0.070) 10,003-10,064 (0.064) 10,119-10,661 (0.866)	9629-9648 (0.004) 9652-10,874 (0.959) 10,945-11,075 (0.037)	Area B. F94-4, Unit 9N 4W. 977.38-977.44 m amsl. Strat. Unit 7.
I-18324 (1995)	9360 ± 180	7180-7540	10,271-10,782 (0.977) 11,038-11,056 (0.023)	10,226-11,156 (1.000)	Area B. F95-1. Non-cultural – charcoal redeposited. Strat. Unit 7.
I-18480 (1995)	8993 ± 87	6906-7080	9933-9994 (0.229) 10,005-10,029 (0.077) 10,036-10,064 (0.098) 10,120-10,241 (0.596)	9773-10,296 (0.996) 10,357-10,370 (0.004)	Area B. F95-2, Unit 10N 2W. 977.29-977.34 m amsl. Strat. Unit 8.
I-18879 (1995)	8285 ± 75	6210-6360	9138-9177 (0.152) 9203-9222 (0.070) 9239-9415 (0.778)	9033-9052 (0.020) 9083-9465 (0.980)	Area B. SOM from Unit 10N 3W. 977.64-977.74 m amsl. Strat. Unit 6.
I-18481 (1995)	7862 ± 88	5774-5950	8546-8779 (0.870) 8833-8861 (0.074) 8920-8934 (0.035) 8940-8950 (0.022)	8460-8467 (0.006) 8477-8496 (0.018) 8512-8990 (0.975)	Area B. F95-3, Unit 9N 2W. 977.29-977.34 m amsl. Strat. Unit 8.
I-18880 (1996)	9140 ± 80	7060-7220	10,229-10,403 (1.000)	10,184-10,514 (1.000)	Area B. Unit 9N 1W. 977.04-977.09 m amsl. Strat. Unit 10.
I-18883 (1996)	9100 ± 65	7035-7165	10,196-10,298 (0.854) 10,327-10,340 (0.058) 10,354-10,372 (0.087)	10,174-10,433 (0.978) 10,461-10,485 (0.022)	Area B. Unit 8N 2W. 977.04-977.09 m amsl. Strat. Unit 10.
GX-24608 (1998)	11,300 ± 80	9220-10,100	13,121-13,268 (1.000)	12,962-13,026 (0.032) 13,053-13,362 (0.968)	Area A. Trench 2A. 980.38 m amsl.
GX-24605 (1998)	9060 ± 50	7010-7110	10,197-10,245 (1.000)	9975-9976 (0.001) 10,157-10,299 (0.972) 10,319-10,343 (0.012) 10,351-10,375 (0.015)	Area A. Unit 2N 2E. 980.55 m amsl. Same elevation and in vicinity of RBS Feature 17.
GX-24607 (1998)	9040 ± 50	6990-7090	10,190-10,239 (1.000)	9943-9989 (0.030) 10,015-10,021 (0.002) 10,042-10,059 (0.009) 10,146-10,287 (0.958)	Area A. Trench 2A. 980.20 m amsl.
GX-24603 (1998)	8970 ± 50	6920-7020	9947-9989 (0.233) 10,013-10,022 (0.034) 10,041-10,060 (0.089) 10,146-10,226 (0.645)	9917-10,085 (0.450) 10,114-10,233 (0.550)	Area A. Unit 11N 1E. 980.63 m amsl. Same elevation and in vicinity of RBS Feature 19 and 3 cm above F98-1.

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Table 1 (continued).

Sample No. (Year)	Uncalibrated Date in RCYBP	Uncalibrated Age Range (B.C.)	Calibrated Dates (cal B.P.) (1 sigma)	Calibrated Dates (cal B.P.) (2 sigma)	Comments
GX-24604 (1998)	8880 ± 50	6830-6930	9913-9965 (0.229) 9984-10,153 (0.771)	9777-10,182 (1.000)	Area A. Unit 12N 0E. 980.56 m amsl. Same elevation and in vicinity of RBS Feature 19.
ISGS-A1695 (2010)	9150 ± 25	7175-7225	10,241-10,295 (0.914) 10,358-10,368 (0.086)	10,237-10,302 (0.691) 10,313-10,392 (0.309)	Area B. F10-1, Unit 9N 6W. 977.01-977.03 m amsl. Strat. Unit 10

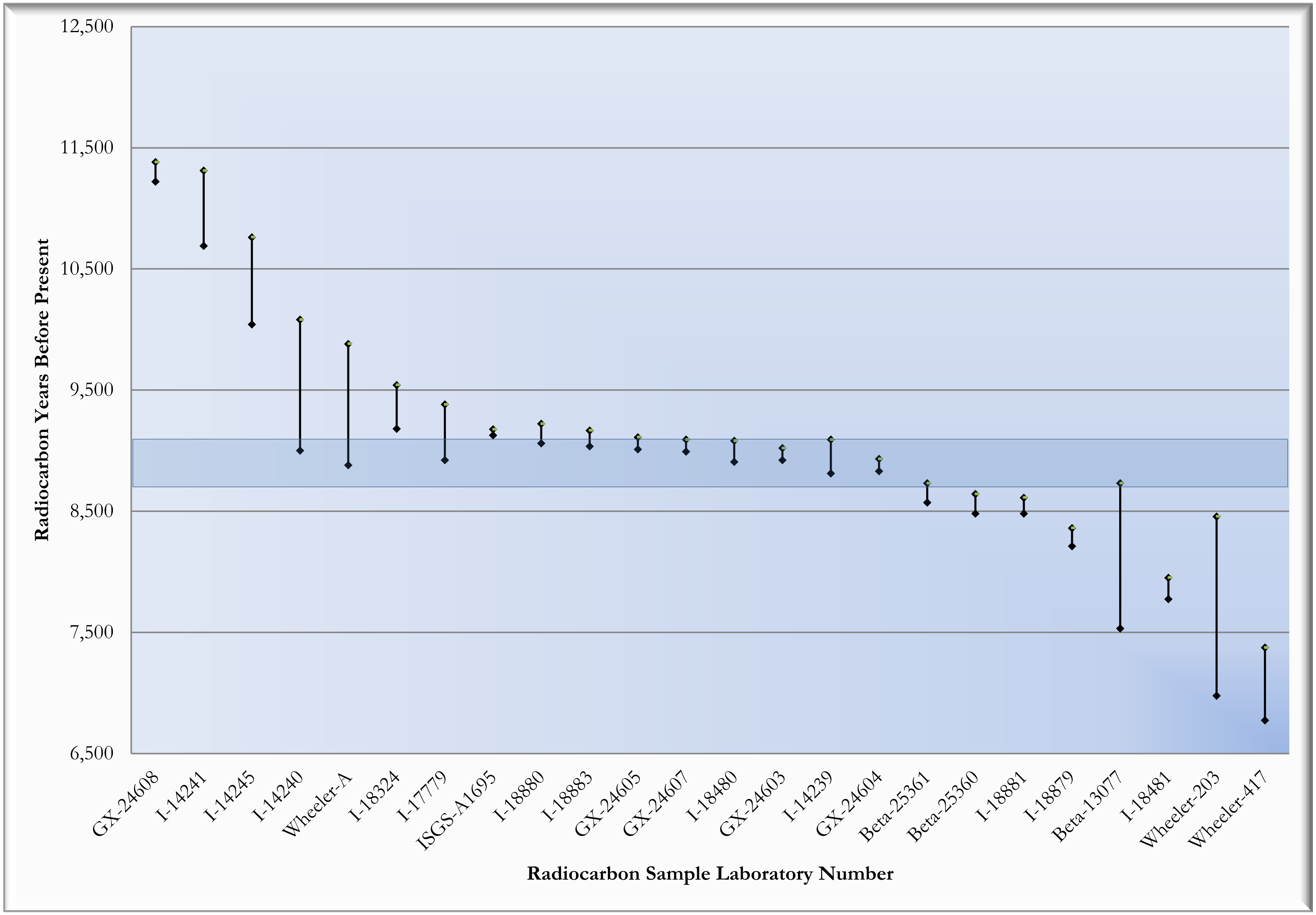

Figure 1. Uncalibrated radiocarbon date ranges (1 σ) by sample from the Ray Long site. The shaded area represents the approximate date range (8830-9110 RCYBP) associated with the Angostura occupation of the site based on the 1998 AMS dates from Area A.

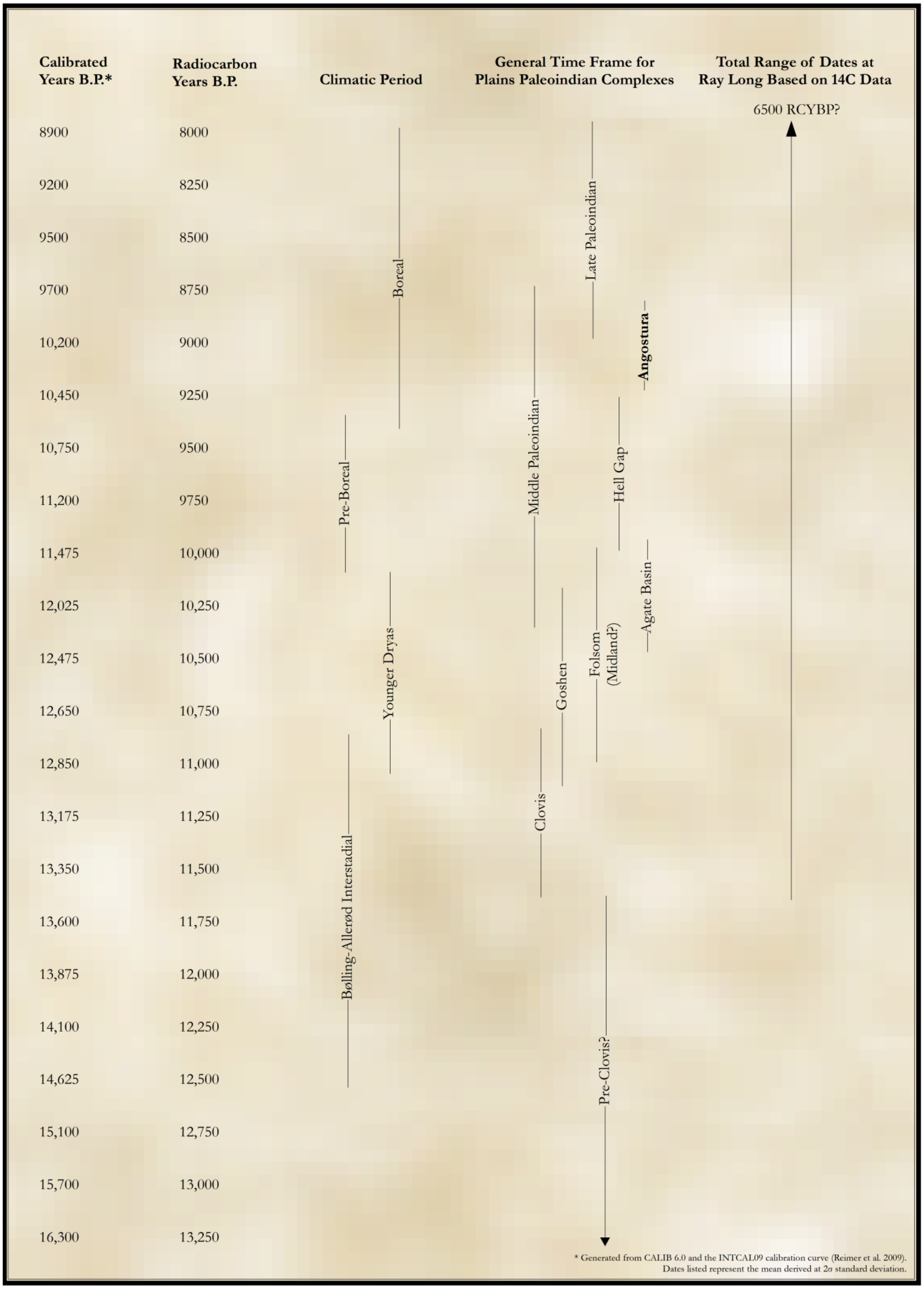

Figure 2. Radiocarbon calibration conversion chart detailing the Ray Long site and Angostura complex date ranges relative to those of other recognized Plains Paleoindian complexes.

The sample from Area A, a bulk soil and charcoal sample not associated with any particular cultural feature, was collected from the lower zone of weathered clay-shale that consisted of hundreds of tiny pieces of charcoal. This sample yielded a date of 9380 ± 500 RCYBP (Crane 1956). Wheeler (1995:384) identifies this clay-shale zone as "cs" in Figure 51 of his report. Because it was a composite bulk sample derived from a soil lens, no absolute elevation for the sample is provided; however, the approximate elevations for the clay-shale zone vary between 3,215 and 3,218 feet (979.93-980.85 m) amsl; its association with mapped site features from Area A is provided in Figure 51 (Wheeler 1995:384). All of the Angostura point specimens excavated in Area A came from areas adjacent to features documented within this zone.

Dates From the 1987 Archaeological Research Center Testing

In 1987, ARC personnel revisited Ray Long and excavated four 1-m-x-1-m test units (designated XUs 1-4) at Area B of the site (Haug 1987:2). No formal report detailing these test excavations was prepared; however, notes from the excavations, on file at ARC, have been used to reconstruct the results. The units were placed in a 2-m-x-2-m block adjacent to the north wall of Trench F and the east wall of Smithsonian Trench 2. A temporary datum was established at 1.77 m above the main site datum (R44R R.P.). Two solid carbon charcoal samples were collected from 'Charcoal Level 1' of XU4, which was located at a depth of between 50 and 55 cmbd, or 1.31-1.27 m *above* the main site datum (R44R R.P.) and between 977.91 and 977.86 m amsl. One of the samples was collected from the SE¼ of the unit and the other from the SW¼. These samples were submitted for radiocarbon assay on February 22, 1988. The samples (Beta-25360 and Beta-25361) yielded dates of 8560 ± 80 and 8650 ± 80 RCYBP, respectively (see Appendix E, Manuscript I). The two dated samples were collected from a large, amorphous charcoal-stained feature approximately 5 cm thick. No artifacts were documented in association with the feature and the notes do not indicate any evidence of oxidized or thermally altered soils in association with the stain. The soil matrix containing the stained area is described as light brownish gray-colored (10 YR 5/2) clay interspersed with a few small shale particles and sand grains. This soil stratigraphic unit corresponds with Wheeler's Area B sandy clay zone "sc" as depicted in Figure 46 of his report (Wheeler 1995:379).

Dates From the 1985-2010 Augustana College Excavations

Nineteen radiocarbon dates were obtained from samples collected at Ray Long between 1985 and 2010. Five of these dates came from samples collected in 1985, one was obtained from a sample collected in 1993, one was obtained from a sample collected in 1994, four came from samples collected in 1995, two were from samples collected in 1996, five came from samples collected in 1998, and one date was obtained from a sample collected during the 2010 field season.

1985 Samples

Samples from five features investigated in the 1985 field season were collected and dated. The first sample (Beta 13077) was actually collected by then State Archaeologist Robert Alex from a hearth feature eroding from a cutbank just west of Smithsonian Trench 1 in Area B. A sketch of the hearth, located in the ARC 39FA65 site file, depicts an approximately 8-9-cm-thick, 85-cm-long lens of dark soil and charcoal with abrupt edges that transitions into a bright orange-colored oxidized central zone with charcoal. The lens is depicted as being located about 25-35 cmbs;

however, no absolute elevational data is provided with the field illustration. The sample yielded a date of 8130 ± 600 RCYBP but any detailed, meaningful interpretation is precluded by the lack of elevational and soil-stratigraphic context for the feature. Without this context, it is impossible to understand how the feature fits into the broader site chronology. Unfortunately, the area containing this hearth has since fully eroded.

The four additional dates from ALAC's 1985 investigations were obtained from samples of solid wood charcoal collected from ephemeral hearth features discovered in Trench F, which is located immediately east of, and perpendicular to, Smithsonian Trench 2, and north of the Block B excavation grid, in Area B (Hannus 1986:24 [see Appendix B, Manuscript I]). Features 1, 2, and 3, from which samples I-14245, I-14240, and I-14241 were obtained (see Table 1), were all discovered at the bottom of the trench superimposed on one another (see Figure 2 in Hannus 1986:15). Feature 1 was documented at an absolute elevation of 977.31 m (3,206.56 feet) amsl, or 67.3 cm *above* the main site datum. The sample from this feature (No. I-14245) yielded a date of 10,400 ± 360 RCYBP. Feature 2, located stratigraphically just above Feature 1, yielded a date of 9540 ± 540 RCYBP (Sample No. I-14240). Feature 3, located stratigraphically just *below* Feature 1, yielded a date of 11,000 ± 310 RCYBP (Sample No. I-14241). The location of Feature 4 was further removed from the others. It was recorded approximately 6.75 m west of, and 88.7 cm *above*, Feature 1 at an absolute elevation of 978.20 m (3,209.32 feet) amsl (see Figure 2 in Hannus 1986:15). A charcoal sample collected from this feature, Sample No. I-14239, yielded a date of 8950 ± 140 RCYBP. The 1986 site report (Hannus 1986:14) describes the soil stratigraphic units in which the features were contained. Feature 4 derives from a "Dark silty clay band (Ab?). Mainly clay (70± %) with some shale particles (1 mm±) and siltstone grains (0.5 mm long)." Features 1-3 were located in a different stratigraphic unit below that containing Feature 4. It is described as: "Overbank clay, brownish gray with few coarse grain size siltstone particles – contains isolated lenses, 25-30 cm long and 2.5-4 cm thick that are composed of 'shale Particle' facies" (Hannus 1986:14).

1993 Sample

One sample of solid wood charcoal collected during the 1993 field season at the site was submitted for radiocarbon assay (see Hannus et al. 2012:25-26). The sample (No. I-18881) was collected from an ephemeral, oxidized, charcoal-rich feature located adjacent to Smithsonian Trench 1 in Area B of the site. It yielded an AMS date of 8545 ± 65 RCYBP. The reddish orange-colored stain was first noticed in the eastern wall of Trench M at an absolute elevation of between 975.11 and 975.18 m (3,199.17-3,199.40 feet) amsl. This elevation is only slightly below the depth from which the majority of Trench 1 features were originally recorded during the RBS excavations at the site (see Wheeler 1995:407). The soil stratigraphic unit containing the feature is described as being a dense grayish brown shaley clay soil – consistent with the "cs" zone identified by Wheeler (1995:378).

1994 Sample

One sample of solid wood charcoal collected during the 1994 field season at the site was submitted for radiocarbon assay (see Manuscript I:41-42). The sample (No. I-17779) was collected from a hearth feature (Feature 94-4) in Area B of the site. Feature 94-4 was documented in Level G of units 9N 3W and 9N 4W at an absolute elevation of between 977.38 and 977.44 m (3,206.63-3,206.82 feet) amsl, which is 74-80 cm *above* the main site datum and

221-224 cm below the 1992 rebar datum. It yielded an AMS date of 9150 ± 230 RCYBP. The feature was discovered near the base of soil stratigraphic unit 7, just above its transition with stratigraphic unit 8.

1995 Samples

In 1995, samples collected from three ephemeral hearth features (Features 95-2 – 95-4), one natural feature originally believed to be a hearth (Feature 95-1), and one charcoal-rich soil lens in Area B were submitted for AMS dating. The radiocarbon laboratory was unable to obtain a date from the Feature 95-4 sample because of some form of contamination. Feature 95-1 was documented in Level E of unit 9N 2W at an absolute elevation of between 977.49 and 977.54 m (3,206.99-3,207.15 feet) amsl, which is 85-90 cm *above* the main site datum and 210-215 cm below the 1995 datum. It is positioned stratigraphically within unit 7. The sample from this feature (No. I-18324) yielded a date of 9360 ± 180 RCYBP. However, the feature was found to be non-cultural and the charcoal fragments are believed to have been redeposited by fluvial processes (Albanese 2009:103 [see Appendix D, Manuscript I]), thereby calling into question the validity of the date relative to the context from which it was derived. Feature 95-2 was documented in Level I of Unit 10N 2W at an absolute elevation of between 977.29 and 977.34 m (3,206.33-3,206.50 feet) amsl, which is 65-70 cm *above* the main site datum and 230-235 cm below the 1995 datum. The sample from this feature (No. I-18480) yielded a date of 8993 ± 87 RCYBP. It is positioned stratigraphically near the base of unit 8. Feature 95-3 was documented in Level I of Unit 9N 2W at an absolute elevation of between 977.29 and 977.34 m (3,206.33-3,206.50 feet) amsl, which is 65-70 cm *above* the main site datum and 230-235 cm below the 1995 datum. It is positioned stratigraphically within unit 8. The sample from this feature (No. I-18481) yielded a date of 7862 ± 88 RCYBP. Despite the fact that this feature was from the same depth and stratigraphic position as Feature 95-2, the date is over a thousand years more recent. The feature was both diffuse and very poorly defined, and it is quite possible that the variance in dates is the result of a contaminated sample. The final date obtained from the 1995 field season was from a sample of SOM collected from a combination of Levels A and B in unit 10N 3W at an absolute elevation of between 977.64 and 977.74 m (3,207.48-3,207.81 feet) amsl, which is 100-110 cm *above* the main site datum and 190-200 cm below the 1995 datum. It is positioned stratigraphically within unit 6. The sample from this feature (No. I-18879) yielded a date of 8285 ± 75 RCYBP.

1996 Samples

Six solid carbon charcoal samples were collected from Area B of the site during the 1996 field season, including one sample from each of four ephemeral hearth features (Features 96-1 – 96-4) and two samples from a soil stratigraphic unit within excavation Level N. Of these, only the two samples collected from Level N were submitted for AMS dating. The samples from Level N (I-18883 and I-18880) were chosen for dating because they were collected from the deepest stratigraphic zone at the site to have yielded artifacts. Sample I-18883, which was collected from unit 8N 2W, yielded a date of 9100 ± 65 RCYBP. Sample I-18880, which was collected from unit 9N 1W, yielded a date of 9140 ± 80 RCYBP. Both samples were collected from an absolute elevation of between 977.04 and 977.09 m (3,205.51-3,205.68 feet) amsl, which is 40-45 cm *above* the main site datum and 255-260 cm below the 1995 datum. Both of these samples were collected from stratigraphic unit 10.

1998 Samples

Five solid carbon charcoal samples were collected during the 1998 field season and subsequently submitted for AMS dating. All five samples were collected from Area A of the site, including two from the north wall of Trench 2A and three from excavation units in the Area A grid. None of the samples was directly associated with a feature; however, all three samples from the grid area were recovered either immediately above a feature or from the same depth as, and adjacent to, a previously excavated feature. The samples from Trench 2A were collected from a portion of the trench that bisected the Area A grid at a position where 6N 0E transitions into 7N 0E (see Manuscript I:Figure 97). The first of these, sample GX-24607, was collected from an absolute elevation of 980.20 m (3,215.88 feet) amsl, which is 3.56 m *above* the main site datum and 1.73 m below the Area A datum. The sample came from a position just within the western edge of the grid and yielded a date of 9040 ± 50 RCYBP. The second sample, No. GX-24608, was collected from an absolute elevation of 980.38 m (3,216.47 feet) amsl, which is 3.74 m *above* the main site datum and 1.55 m below the Area A datum. It was positioned just outside of the western edge of the grid and yielded the oldest date obtained from the site: 11,300 ± 80 RCYBP. Both of these samples were collected from a stratigraphic unit that corresponds with the zone of massive weathered clay-shale (cs) originally identified by Wheeler (1995:384) and later identified by Albanese (2009:Figure 11) as massive shale particle facies.

Sample GX-24603 was collected from 3 cm above Feature 98-1 in excavation Unit 11N 1E. It was recovered from an absolute elevation of 980.63 m (3,217.29 feet) amsl, which is 3.99 m *above* the main site datum and 1.30 m below the Area A datum. It was located in the immediate vicinity of RBS Feature 19 (see Wheeler 1995:433). The sample yielded a date of 8970 ± 50 RCYBP. Sample GX-24604 was collected from excavation Unit 12N 0E at an absolute elevation of 980.56 m (3,217.06 feet) amsl, which is 3.92 m *above* the main site datum and 1.37 m below the Area A datum. It was located in the immediate vicinity of, and stratigraphically just below, RBS Feature 19 (see Wheeler 1995:433). The sample yielded a date of 8880 ± 50 RCYBP. Sample GX-24605 was collected from excavation Unit 2N 2E. It was recovered from an absolute elevation of 980.55 m (3,217.03 feet) amsl, which is 3.91 m *above* the main site datum and 1.38 m below the Area A datum. It was located in the immediate vicinity of, and stratigraphically just below, RBS Feature 17 (see Wheeler 1995:434). The sample yielded a date of 9060 ± 50 RCYBP. Each of these three samples was collected from a stratigraphic unit that corresponds with the zone of massive weathered clay-shale (cs) originally identified by Wheeler (1995:384).

2010 Sample

During the 2010 field season, one solid carbon charcoal sample was collected from the fill of an ephemeral hearth feature (Feature 10-1) at Area B of the site, and subsequently submitted for AMS dating. Feature 10-1 was documented in Level O of Unit 9N 6W at an absolute elevation of between 977.01 and 977.03 m (3,205.41-3,205.48 feet) amsl, which is 37-39 cm *above* the main site datum and 261-263 cm below the 1995 datum. The sample from this feature (No. ISGS-A1695) yielded a date of 9150 ± 25 RCYBP. The sample was collected from an area near the base of stratigraphic unit 10.

The Area A Chronology

Six radiocarbon dates have been obtained from Area A of the Ray Long site (Table 2); one by Wheeler in 1950 and five by ALAC in 1998. Wheeler also recovered seven Angostura point fragments (Features 3, 8, 9, 13, 15, 20, and 21) from in situ contexts in Area A associated with the same stratigraphic zone as RBS Hearth Feature 19 and Workshop Feature 17. Feature 19 is within the zone of weathered clay-shale that was dated in 1950 to 9380 ± 500 RCYBP, and Feature 17 is located just above the transition between the coarse granular clay zone and this weathered clay-shale zone. In 1998, three AMS dates were obtained from the same depth and vicinity of Features 17 (9060 ± 50 RCYBP) and 19 (8970 ± 50 and 8880 ± 50 RCYBP). Adjusting these last three dates by one standard deviation, the uncalibrated date range directly associated with the Angostura occupation zone is 9110-8830 RCYBP. Wheeler's date (9380 ± 500 RCYBP), which was obtained from charcoal distributed throughout the weathered clay-shale zone, produces an uncalibrated date range at one standard deviation of 9880-8880 RCYBP. The other two AMS-dated charcoal samples collected in 1998 yielded dates of 9040 ± 50 and 11,300 ± 80 RCYBP, and were from the same weathered clay-shale stratigraphic zone as the other dated samples.

Table 2. Radiocarbon Dates from Area A of the Ray Long Site.

Sample No. (Year)	Uncalibrated Date in RCYBP	Calibrated Date Range at 1σ in cal B.P.	Material Dated/Provenience
GX-24608 (1998)	11,300 ± 80	13,121-13,268 (1.000)	Charcoal/Trench 2A (980.38 m amsl). **Erroneous date – sample likely contaminated, see below**.
Wheeler – A (1950)	9380 ± 500	9893-11,319 (1.000)	SOM/weathered clay-shale zone (979.93-980.85 m amsl).
GX-24605 (1998)	9060 ± 50	10,197-10,245 (1.000)	Charcoal/Unit 2N 2E (980.55 m amsl). Same elevation and in vicinity of RBS Feature 17.
GX-24607 (1998)	9040 ± 50	10,190-10,239 (1.000)	Charcoal/Trench 2A (980.20 m amsl).
GX-24603 (1998)	8970 ± 50	9947-9989 (0.233) 10,013-10,022 (0.034) 10,041-10,060 (0.089) 10,146-10,226 (0.645)	Charcoal/Unit 11N 1E (980.63 m amsl). Same elevation and in vicinity of RBS Feature 19 and 3 cm above F98-1.
GX-24604 (1998)	8880 ± 50	9913-9965 (0.229) 9984-10,153 (0.771)	Charcoal/Unit 12N 0E (980.56 m amsl). Same elevation and in vicinity of RBS Feature 19.

The date obtained by Wheeler was from a bulk SOM sample. Given that the sample consisted of bulk sediments not associated with a defined feature and that it was dated shortly after the inception of the radiocarbon dating process, the very large standard deviation of 500 years is not surprising. Despite these issues, Wheeler's date actually fits well within the 1σ range of four of the five AMS dates obtained from Area A in 1998. Together, these dates provide a reliable timeframe of approximately 300 years (9110-8830 RCYBP) within which the Angostura occupation of Ray Long can be evaluated. Calibrated, this timeframe extends from approximately 10,300 to 9950 cal B.P.

One AMS date from Trench 2A in Area A is clearly anomalous. Sample GX-24608 yielded a date of 11,300 ± 80 RCYBP, making it the oldest date obtained from Ray Long. Taking standard deviation into account, GX-24608 yielded a date that is 2,130 years older than sample GX-24607, which was also collected from Trench 2A near position 6N 0E on the grid. However, sample GX-24607 was collected from a depth that was stratigraphically 18 cm *below* that of sample GX-24608. The evidence suggests that sample GX-24608 was, in some manner, contaminated and that the date yielded by this sample is erroneous.

THE AREA B CHRONOLOGY

Eighteen radiocarbon dates were obtained from Area B of the Ray Long site (Table 3). Samples from which these dates were obtained were collected between 1949 and 2010 by RBS, ALAC, and ARC personnel. One of the samples, I-18324, was collected from a feature (F95-1) that, as was later learned, was non-cultural and had formed from redeposited alluvial sediments (Albanese 2009:103 [see Appendix D, Manuscript I]). Because the charcoal from this sample was not collected from its original depositional context, this date should be disregarded. A second sample, Beta 13077, was collected from a hearth feature located just west of Smithsonian Trench 1; however, no more precise provenience data could be found in the ARC archive for this feature. Since it cannot be accurately evaluated within the larger site context, it also should be disregarded.

Wheeler (1995:378) identified a massive weathered clay-shale (cs) stratigraphic unit in Area B that contained several ephemeral hearth features. He believed that this unit was an extension of the same surface from which features and Angostura artifacts were recovered in Area A. However, the radiocarbon date he obtained from the hearth feature associated with the clay-shale zone in Area B produced a date of 7073 ± 300 RCYBP – substantially more recent than the dates associated with the Angostura occupation at Area A. The second date that Wheeler obtained from Area B, 7715 ± 740 RCYBP, came from a larger, amorphous burn area not attributed to a specific feature but still within the weathered clay-shale (cs) stratigraphic unit. This date is also much younger than those associated with the Area A Angostura occupation.

Similar inconsistencies were noted among the 14 additional dates obtained from Area B. In 1985, samples from hearth Features 1-3, which were superimposed, yielded dates of 11,000 ± 310, 10,400 ± 360, and 9540 ± 540 RCYBP. The large standard deviations associated with these dates are not entirely surprising considering that the samples were dated over 25 years ago and were not subjected to AMS methods. However, the investigators expected that, given the proximity of these features to one another, the standard deviations would all overlap; this clearly is not the case. These three samples were collected from a segment of Trench F just north of excavation unit 10N 3W in the block grid at a depth that corresponds with stratigraphic unit 8. Two additional samples from stratigraphic unit 8, obtained from hearth Features 95-2 and 95-3, yielded AMS dates of 8993 ± 87 and 7862 ± 88 RCYBP, respectively. Features 95-2 and 95-3 were both located at the same depth below datum and in adjacent excavation units; however, despite the much higher degree of precision, the standard deviations of these two dates also do not overlap. Taking into account this standard deviation, stratigraphic unit 8 (which is less than 15 cm thick) has produced five dates that range between approximately 7774 and 11,310 RCYBP. The 7862 ± 88 date is younger than all other Area B dates except those that Wheeler obtained, and it is positioned stratigraphically *below* at least four of these samples. The 11,000 ± 310 date is older than all other Area B dates and is positioned stratigraphically *above* at least three others that are roughly 2,000 years more recent.

Table 3. Radiocarbon Dates from Area B of the Ray Long Site.

Sample No. (Year)	Uncalibrated Date in RCYBP	Calibrated Date Range at 1σ in cal B.P.	Material Dated/Provenience
I-14241 (1985)	11,000 ± 310	12,607-13,192 (1.000)	Charcoal/Trench F, F3. Stratigraphically just below F1.
I-14245 (1985)	10,400 ± 360	11,620-11,679 (0.044) 11,687-12,627 (0.956)	Charcoal/Trench F, F1 (977.31 m amsl).
I-14240 (1985)	9540 ± 540	10,182-11,755 (1.000)	Charcoal/Trench F, F2. Stratigraphically just above F1.
I-18324 (1995)	9360 ± 180	10,271-10,782 (0.977) 11,038-11,056 (0.023)	Charcoal/F95-1. **Feature is non-cultural – charcoal redeposited**.
I-17779 (1994)	9150 ± 230	9931-9995 (0.070) 10,003-10,064 (0.064) 10,119-10,661 (0.866)	Charcoal/F94-4, Unit 9N 4W (977.38-977.44 m amsl).
ISGS-A1695 (2010)	9150 ± 25	10,241-10,295 (0.914) 10,358-10,368 (0.086)	Charcoal/F10-1, Unit 9N 6W (977.01-977.03 m amsl).
I-18880 (1996)	9140 ± 80	10,229-10,403 (1.000)	Charcoal/Unit 9N 1W (977.04-977.09 m amsl).
I-18883 (1996)	9100 ± 65	10,196-10,298 (0.854) 10,327-10,340 (0.058) 10,354-10,372 (0.087)	Charcoal/Unit 8N 2W (977.04-977.09 m amsl).
I-18480 (1995)	8993 ± 87	9933-9994 (0.229) 10,005-10,029 (0.077) 10,036-10,064 (0.098) 10,120-10,241 (0.596)	Charcoal/F95-2, Unit 10N 2W (977.29-977.34 m amsl).
I-14239 (1985)	8950 ± 140	9796-9804 (0.012) 9818-9846 (0.49) 9867-9874 (0.010) 9887-10,240 (0.928)	Charcoal/Trench F, F4 (978.20 m amsl).
Beta 25361 (1987)	8650 ± 80	9534-9699 (1.000)	Charcoal/ARC SW¼ XU4 (977.86-977.91 m amsl).
Beta 25360 (1987)	8560 ± 80	9472-9601 (1.000)	Charcoal/ARC SE¼ XU4 (977.86-977.91 m amsl).
I-18881 (1993)	8545 ± 65	9481-9550 (1.000)	Trench M, F93-1 (975.11-975.18 m amsl).
I-18879 (1995)	8285 ± 75	9138-9177 (0.152) 9203-9222 (0.070) 9239-9415 (0.778)	SOM/Unit 10N 3W (977.64-977.74 m amsl).
Beta-13077 (1985)	8130 ± 600	8340-9740 (1.000)	Charcoal/Hearth feature west of Trench 1 – **precise depth and position unknown**.
I-18481 (1995)	7862 ± 88	8546-8779 (0.870) 8833-8861 (0.074) 8920-8934 (0.035) 8940-8950 (0.022)	Charcoal/F95-3, Unit 9N 2W (977.29-977.34 m amsl).
Wheeler - Cat#203 (1949)	7715 ± 740	7849-7909 (0.028) 7912-9465 (0.972)	Charcoal/Trench 1, Unit N7 E4 (975.36-975.45 m amsl).
Wheeler - Cat #417 (1950)	7073 ± 300	7622-7644 (0.031) 7650-8177 (0.969)	Charcoal/Feature 14, Trench 1, Unit N3 E3 (974.70 m amsl).

Stratigraphic unit 7 produced two AMS dates. The first, 9360 ± 180 RCYBP, was from Feature 95-1, the same feature that was found to be non-cultural and consisted of redeposited charcoal fragments. The second date, 9150 ± 230 RCYBP, was felt to have more promise because it came from a more clearly defined hearth feature (Feature 94-4) that was documented in direct association with a mano, or grinding stone tool (see Hannus et al. 2012:46-49). However, the preciseness of this date is poor, particularly considering that it was AMS-dated, and the reasons for this are unclear.

The sample collected from the shallowest stratigraphic unit in the block B grid, unit 6, yielded an AMS date of 8285 ± 75 RCYBP. This is the only date obtained from stratigraphic unit 6. Although three other samples were collected from stratigraphic and absolute elevational contexts above this sample, all were recovered from west of the block grid adjacent to Smithsonian Trench 2 and either in, or adjacent to, ALAC Trench F. One of these three samples, collected in 1985 from hearth Feature 4 in Trench F, yielded a date of 8950 ± 140 RCYBP. The other two, collected by ARC in 1987 from XU4, yielded dates of 8650 ± 80 and 8560 ± 80 RCYBP. Descriptions of the soils from which the three more westerly samples were collected generally correspond with Wheeler's granular clay "gc" lens, and the elevational data suggest that their point of origin lies very close to the transition from the granular clay deposit to the sandy clay "sc" lens (see Wheeler 1995:379). In comparing these dates within a stratigraphic context, it immediately becomes apparent that they are 'upside down' relative to the law of superposition. In other words, the dates get progressively *younger* as they progress downward, not older as one would normally expect.

The lone sample collected in 1993 was also from west of the block B grid; however, this sample was collected from a feature located immediately adjacent to RBS Trench 1 and ALAC Trench M at a much lower absolute elevation. The elevational and soil stratigraphic data correlate well with Wheeler's (1995:378) weathered clay shale zone "cs" depicted in the Figure 45 Trench 1 profile. However, the date obtained from this sample, 8545 ± 65 RCYBP, is, after accounting for standard deviation, still over 1,100 years older than the date Wheeler obtained from Feature 14, located some 41 cm below it in this same stratigraphic unit.

Of all the dates obtained from Area B, the three collected from charcoal samples in stratigraphic unit 10 seem to be the most reliable. The two samples collected in 1996 yielded AMS dates of 9140 ± 80 and 9100 ± 65 RCYBP, and the sample collected in 2010 yielded an AMS date of 9150 ± 25 RCYBP. These dates are all precise and each corroborates the others from the unit well. Interestingly, the lithological composition of stratigraphic unit 10 is very similar to that of the Area A Angostura occupation surface (Rolfe D. Mandel, Project Geomorphologist, personal communication 2012).

Clearly, several issues associated with radiocarbon dates from the Ray Long site are in need of further exploration. First, none of the dated samples from Area B of the site was collected from contexts associated with artifacts or features that are diagnostic of the Angostura complex. Although two fragments of Angostura projectile points, including one base and one tip, were recovered in 1985 from the sloping surface immediately adjacent to Smithsonian Trenches 1 and 2, the original provenience of these pieces in unclear. We cannot tie these surface finds into a specific buried stratigraphic context. Therefore, the identification of buried land surfaces specifically attributable to an Angostura occupation of Area B would, in theory, only be possible through the correlation of soil stratigraphic units from Area B with those in Area A known to have contained Angostura cultural material, and then through a confirmation of the dates obtained from these strata. Unfortunately, due to geomorphological processes characteristic of the formation of alluvial fans, the soil stratigraphic units observed in Area A do not extend to Area B of the site (see Mandel, this report), so an Angostura occupation surface at Area B cannot be defined with certainty.

The second critical issue concerning the radiocarbon dates at Ray Long pertains to accuracy and relative soil stratigraphic context. Considering the number of dates obtained from Area B of the site, there is surprisingly little conformity among them in terms of stratigraphic positioning, and a substantial range of time is represented among the samples. This is most plainly illustrated in the approximately 3,500-year variance present among the five dates obtained from soil stratigraphic unit 8 (see above). Setting aside dating precision issues present among some of the earlier samples, two natural phenomena could well be responsible for the disparity evident among the Area B dates: bioturbation and fluvial sediment redeposition. The abundant rodent activity present in Area B of the Ray Long site has been well-documented throughout the course of field activities there (see for example Hannus et al. 2012: Figures 29, 31, 33, 37, 44, 61, and 63).

Rodent burrowing contributes to interpretive problems at many archeological sites, but perhaps more cogent to the Ray Long discussion are the results of fluvial sediment redeposition. No developed paleosols were documented at Area B (see Hannus et al. 1993:24-25), and many of the stratigraphic units mapped in Trenches A-G and elsewhere in Area B consist of laminated lenses of redeposited shale particles and overbank clay deposits – all of which are typically deposited episodically under high-flow fluvial regimes (Hannus et al. 1993:23). The sediment load comprising these strata, brought in from the east and northeast, formed from the Pierre shale that is exposed in numerous deflated areas immediately east and north of Area B. It is very difficult to obtain accurate radiocarbon dates on charcoal samples from these types of deposits. In addition to the problem of likely having been removed from its original depositional context, a significant proportion of bulk-sediment carbon is derived from ancient carbonate or carbonaceous rocks. Aquatic organisms incorporate carbon from dissolved carbonate rocks, limestones, and dolomites (the "hardwater effect"), and carbonaceous rocks, such as shales, often contribute a significant amount of carbon. The magnitude of this error is typically hundreds of years, and often thousands (Buhta et al. 2011:75).

A 1988 palynological study conducted on four soil samples collected from Trench F in Area B (Fredlund 1988 [see Appendix J]) provides an interesting correlation. Samples were collected from the same depth and stratigraphic context as the four features documented in the trench, as well as from a zone of more recent alluvial deposits (Fredlund 1988:10-12; Hannus 1986:15, 24). Of particular note is that pre-Quaternary pollen and spores were reported to be common in each of the four samples analyzed (Fredlund 1988:7). The presence of pre-Quaternary pollen and spores within Quaternary alluvial deposits suggests the occurrence of sediment redeposition. Fredlund (1988:13) concludes that: "The high frequencies of redeposited, pre-Quaternary organics in these sediments could significantly affect the apparent radiocarbon age of bulk sediment samples, causing them to assay several thousand years older than they actually are."

Such variance in the reported radiocarbon record would not, however, be expected from large, clean samples of dated charcoal fragments (Fredlund 1988:13), or from dated samples collected from intact cultural features, such as hearths.

If multiple Area B dates were, indeed, obtained from samples contaminated with redeposited, detrital charcoal, then the validity of the chronological sequence in this portion of the site is questionable. The almost complete absence of diagnostics from this area of the site only seems to underscore this confusion. The single diagnostic artifact documented in situ in Area B is the bi-fluted projectile point base recovered from what would represent the base of stratigraphic unit 8 (Hannus et al. 2012:60-61). There is some debate as to whether the projectile point specimen is attributable to the Clovis or the Folsom complex. Nevertheless, the specimen's provenience, stratigraphically *above* multiple ca. 9100 RCYBP dates and at the same depth as multiple pre-9000 RCYBP dates, suggests that it may also have been redeposited.

Oddly, of the few artifacts that were discovered in situ at Area B, it is the collection of lithic debitage that may prove most insightful to this discussion. The vast majority of Angostura projectile point fragments documented at Ray Long were produced from a distinctive, fine-grained quartzite that most commonly assumed a pinkish purple or light grayish brown color. At Ray Long, this material was clearly preferred by Angostura-period knappers in projectile point manufacture, though the sample size is admittedly small. Several pieces of debitage from this fine-grained quartzite were documented at the site, including 15 pieces from buried, in situ contexts at Area B. Of these pieces, two were collected from stratigraphic unit 6, two were collected from stratigraphic unit 8, and 11 were collected from stratigraphic unit 7. Interestingly, stratigraphic unit 7 also contained hearth feature 94-4, which was documented immediately adjacent to the complete mano and which yielded an AMS date of 9150 ± 230 RCYBP. The standard deviation of this date, while quite imprecise, is coeval with the Area A dates attributed to the Angostura occupation. The only other date from stratigraphic unit 7, 9360 ± 180 RCYBP, was obtained from Feature 95-1, which was found to have been redeposited and non-cultural.

Of all the dates obtained from Area B, the three AMS dates from stratigraphic unit 10 seem to be the most reliable and to correlate well. The standard deviations on each of these samples are very precise, and they are very consistent with one another. There are many lithological similarities between this unit and the Area A soil containing the Angostura occupation surface (Rolfe Mandel, Project Geomorphologist, personal communication 2012), and it is suggested that stratigraphic unit 10 may represent a more stable land surface that formed under conditions of lower energy deposition relative to many of the other stratigraphic units in Area B. If this is, indeed, the case, then stratigraphic unit 10 is, based on the dates yielded by samples I-18880, I-18883, and ISGS-A1695, largely coeval with the soil containing the Angostura occupation surface at Area A of the site.

Geoarcheology and Paleoenvironmental Context of the Ray Long Site

Rolfe D. Mandel, Ph.D.

Introduction

This chapter presents the results of the geoarcheological investigation conducted during the 2010 archeological excavations at the Ray Long site. The primary objectives of this investigation were to (1) provide a geomorphic, sedimentologic, and soil-stratigraphic context for interpreting the archeological record, (2) assess site formation processes, and (3) reconstruct past environments using $\delta^{13}C$ analysis of pedogenic organic matter. Understanding the paleoenvironmental context of the cultural deposits is crucial to understanding the relationships between landscape evolution, bio-climatic fluctuations, and human activities at the site.

In 1985, ALAC reinvestigated the Ray Long site to determine the integrity of the archeological deposits studied by Wheeler between 1948 and 1950. A major component of the 1985 investigation was the excavation of six backhoe trenches in the site area. John Albanese, the project geomorphologist, conducted an investigation of the site that included an inspection of these backhoe trenches. Albanese concluded that Areas A and B were intact zones of an alluvial fan, and that Area C had been eroded by wave action after Angostura Reservoir was created. Two of the trenches produced features (charcoal concentrations associated with unprepared hearths), and radiocarbon ages were determined on charcoal from four cultural features in one trench (Trench F). Those ages range from ca. 11,000 to 8950 RCYBP.

In 1992, ALAC resumed investigations at the Ray Long site, an endeavor that, with the exception of 1997 and 1999, was continued every year through 2000. John Albanese conducted geologic studies of the site in conjunction with the archeological investigations. The results of those studies were subsequently submitted to ALAC (see Appendix D, Manuscript I) and are summarized in the following discussion.

According to Albanese, buried cultural horizons at the Ray Long site lie within an "isolated prism" of Quaternary sediment that overlies Pierre shale bedrock. He noted that the "sediment pile" is the remnant of an alluvial fan on top of a strath (erosional) terrace (T3) cut across bedrock. According to Albanese, the fan began to aggrade around 14,000-13,000 years ago, with sediment being supplied to the fan by small feeder streams that flowed from the northeast to the southwest.

According to Albanese, the deposits of alluvium at the Ray Long site, unlike the deposits of alluvium comprising most of the fans in the area, are relatively free of gravel and coarse sand. He attributes the paucity of coarse sediment to (1) the sediment source, i.e., shale instead of sandstone (Figure 3), and (2) few debris flows at the site. Albanese noted that most of the sediment appears to have been deposited by sheet flows that spread out from numerous distributary channels on the alluvial fan. Coarse alluvium was documented at the site, but it is confined to channel fills. Albanese noted that approximately 3.2 m of the fine-grained alluvium accumulated between ca. 11,000 and 7000 RCYBP.

Figure 3. Pierre Shale exposed in the channel of an unnamed intermittent stream that delivers sediment to the alluvial fan at the Ray Long site. View is to the east.

Most of Albanese's 2009 report is devoted to describing the various alluvial facies that were identified in the walls of backhoe trenches. Six distinct alluvial facies were recognized at the site: coarse clast facies; shale particle facies; sand facies; clay-sand facies; clay facies; and sand-shale facies. Also, all channel fills were identified and described. The lithology of the alluvium comprising each channel fill was assessed in order to assign a facies to it, i.e., coarse clast facies, shale particle facies, etc.

Albanese did not place the archeological record and radiocarbon ages at the Ray Long site into a soil-stratigraphic context. Stratified Paleoindian and Early Archaic cultural deposits were recorded in the fan deposits, and there is a suite of 24 radiocarbon ages determined on charcoal from cultural features and bulk sediment samples taken from the site. However, the soil-stratigraphic context of the archeological deposits and radiocarbon ages is not discussed or illustrated. Consequently, it is impossible to interpret the temporal and spatial (vertical and horizontal) patterns of the archeological record, and it is difficult to assess site formation processes without the contextual information.

Albanese recorded buried soils within the alluvium, but only in Profile 1 and Profile 2 in Area B. In both profiles, the buried soil has A-C horizonation. Albanese (2009:18) noted "The organic rich soils which are superimposed on the Clovis and Folsom cultural horizons at many Paleoindian sites in the region are not present at the Ray Long site." He suggests that sedimentation on the fan was too rapid to allow organic-rich soils to form. Oddly, thick, organic-rich soils dating to ca. 11,000-10,000 RCYBP have been recorded in many alluvial fans throughout the central and western Great Plains (see Mandel 2008). The fan at Ray Long, however, is an exception.

Albanese (2009:6) suggested that the lower alluvial unit at the Ray Long site aggraded during a "climatic episode wetter than that of the present," and that the overlying sheet-wash deposits accumulated during the warm, dry Altithermal climatic event that lasted between ca. 7500 and 5000 RCYBP. Although no paleoenvironmental data are presented to support this hypothesis, other studies suggest that aggradation of alluvial fans in the central and western Plains was well underway by ca. 9000 RCYBP in response to the onset of early Holocene aridity (see Bettis and Mandel 2002; Mandel 1995, 2006, 2008).

BACKGROUND

Stable Carbon Isotopes

Stable carbon isotope analysis of organic carbon in soils has been successfully used in many paleoenvironmental studies (e.g., Ambrose and Sikes 1991; Dorale et al. 2010; Fredlund and Tieszen 1997; Guillet et al. 1988; Kelly et al. 1991, 1993; Krishnamurthy et al. 1982; Mandel 2006; Nordt 1993, 2001; Nordt et al. 1994, 2002; Schwartz 1988; Schwartz et al. 1986). To understand the theory behind this analytical technique, the ecology of C_3 and C_4 plants must be considered. During photosynthesis, C_4 plants discriminate less against $^{13}CO_2$ than C_3 plants (O'Leary 1981; Vogel 1980). This difference in carbon isotope fractionation results in a characteristic carbon isotope ratio in plant tissue that serves as an indicator for the occurrence of C_3 and C_4 photosynthesis (Nordt 1993:52). The $\delta^{13}C$ values, or the difference between the $^{13}C/^{12}C$ ratio and a known standard, are expressed in parts per thousand (‰). Boutton (1991a) demonstrated that the $\delta^{13}C$ values of C_3 plant species range from -32 to -20 ‰, with a mean of -27 ‰, whereas the $\delta^{13}C$ values of C_4 plant species range from -17 to -9 ‰, with a mean of -13 ‰. Values between -22 ‰ and -17 ‰ represent a mixed plant community of both C_3 and C4 grasses. Thus, C_3 and C_4 plant species have distinct, non-overlapping $\delta^{13}C$ values and differ from each other by approximately 14 ‰ (Boutton 1991b).

Nearly all trees, shrubs, forbs, and cool-season grasses are C_3 species. Hence forests and most other temperate plant communities are dominated by C_3 species. Plants with the C_4 photosynthetic pathway are common in warm, semiarid environments with high light intensity, such as grasslands, savannas, deserts, and salt marshes. Studies have shown that both the proportion of C_4 species and the proportion of C_4 biomass in a given plant community are strongly related to environmental temperature (Boutton et al. 1980; Terri and Stowe 1976; Tieszen et al. 1979). These relationships are invaluable in paleoecological studies when the relative proportions of C_3 vs. C_4 species can be reconstructed (Nordt et al. 1994).

There is little change in the carbon isotopic composition of plant litter as it decomposes and is incorporated into the soil organic matter (Melillo et al. 1989; Nadelhoffer and Fry 1988). Consequently, the isotopic composition of soil organic matter reflects the dominant species (C_3 vs. C_4) in the plant community that contributed the organic matter (Dzurec et al. 1985; Nadelhoffer and Fry 1988; Stout and Rafter 1978). The stable carbon isotopic composition of soil organic matter in surface and buried soils may, therefore, be used to infer vegetation change (Hendy et al. 1972; Krishnamurthy et al. 1982; Nordt et al. 1994). Going one step further, the stable carbon isotopic values may be used to reconstruct climate.

METHODS

Physical and chemical analyses were performed to characterize and confirm field descriptions of stratigraphic units and soils and to assist in interpretation of depositional processes and post-depositional weathering. Standard USDA procedures (Soil Survey Staff 1982, 1983) were used to collect bulk soil samples weighing approximately 1 kg from two profiles.

Bulk soil samples from the profiles were air-dried at the Kansas Geological Survey and mechanically split into equal halves. One split of samples was decalcified with 0.5 N HCL and submitted to the University of Kansas W. M. Keck Paleoenvironmental and Environmental Stable Isotope Laboratory (KPESIL) to determine organic carbon (C) content. Those samples were analyzed on a Costech ECS 4010 Elemental Analyzer in conjunction with a series of atropine standards (Costech Code 031042) of known %C. From the analyzed standards, the Costech EAS32 software generates a calibration curve measuring area (Vs) versus weight (mg C). Knowing the carbon content of the standard and noting individual sample weights along with measured voltages, the software is then able to generate relative %C content for each analyzed sample. Typical standard calibration R^2 values are better than 0.9998.

Next, raw $\delta^{13}C$ values were obtained via high-temperature combustion with a Costech ECS 4010 elemental combustion system in conjunction with a ThermoFinnigan MAT253 isotope ratio mass spectrometer at KPESIL. International standards used to calibrate $\delta^{13}C$ values were NIST USGS-24 (graphite) #8541, IAEA-600 (caffeine), and NIST ANU (sucrose) #8542. A pre-calibrated internal standard (DORM-2 dogfish muscle; National Research Council of Canada) was used in the $\delta^{13}C$ calibration curve, as well as for percent carbon (%C) determination. The precision of reported $\delta^{13}C$ values is based on a linear correction of observed values versus expected values of the standards. Typical standard calibration curves yield an R^2 of 0.9994 or greater.

The grain-size distribution of the samples was determined using a slightly modified version of the pipette method (Gee and Bauder 1986). The samples were dispersed in a sodium hexametaphosphate solution and shaken on a reciprocal shaker overnight. Silt and clay aliquots were drawn from the appropriate pipette depth based on particle-size settling velocity, oven-dried, and weighed to the nearest milligram. Wet sieving recovered the sand fraction. The results, presented as weight percentages, total to 100% of the < 2-mm mineral fraction. Loess standards were used for inter-run comparisons of grain-size data.

Sediment and soil samples collected from the profile described in the excavation block in Area B and in Trench I in Area A were processed for stable carbon isotope analysis at the Kansas Geological Survey. The samples were dried in an oven at 50ºC, and homogenized with a ceramic mortar and pestle. Samples were pretreated by adding 20 ml of 0.5 N hydrochloric acid solution to 1 g of soil to remove calcium carbonate. After the reaction was complete, 30 ml of distilled water were added to each sample and centrifuged at 4000 RPMs for five minutes and decanted. The process was repeated to ensure chlorine removal. Decalcified samples were dried at 50º C, pulverized using a synthetic ruby mortar and pestle, and transferred to vials.

Prepared isotope samples from the two profiles were analyzed at the KPESIL. Raw $\delta^{13}C$ values were obtained via high-temperature combustion with a Costech ECS 4010 elemental combustion system in conjunction with a ThermoFinnigan MAT253 isotope ratio mass spectrometer.

International standards used to calibrate $\delta^{13}C$ values were NIST USGS-24 (graphite) #8541, IAEA-600 (caffeine), and NIST ANU (sucrose) #8542. A pre-calibrated internal standard (DORM-2 dogfish muscle; National Research Council of Canada) was used in the $\delta^{13}C$ calibration curve, as well as for percent carbon (%C) determination. The precision of reported $\delta^{13}C$ values is based on a linear correction of observed values versus expected values of the standards. Typical standard calibration curves yield an R^2 of 0.9994 or greater.

Results of Investigations

Trench I, Area A

A portion of Trench I was reopened to a depth of 3.25 m on the upper midsection of the alluvial fan at the Ray Long site (Figure 4). The trench was widened in order to completely remove backfill and expose undisturbed fan deposits. A profile was described and sampled at the north end of the trench (Figure 5).

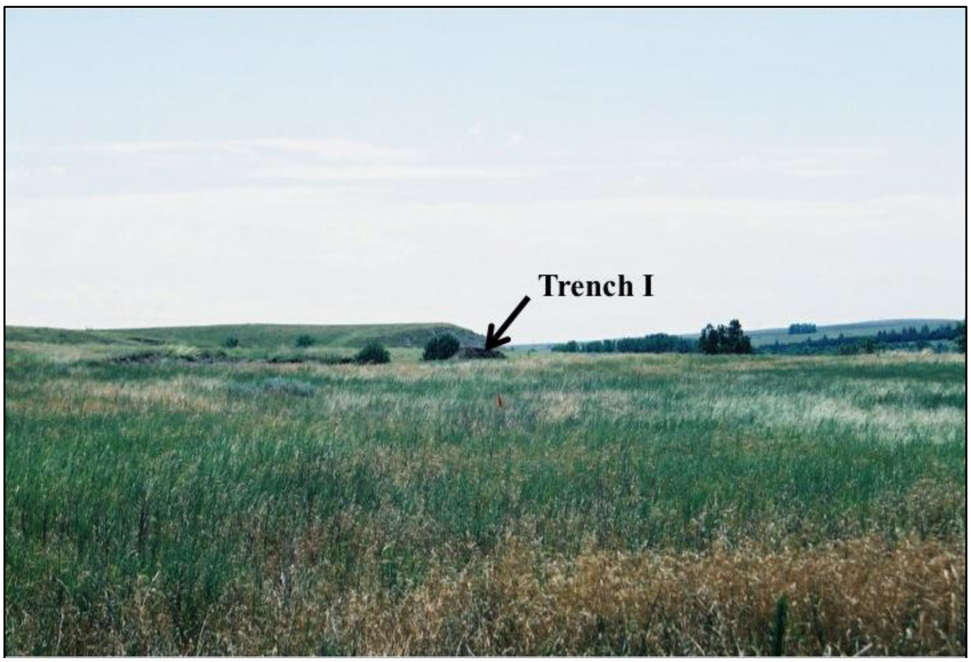

Figure 4. Trench I in Area A at the Ray Long site. View is to the south.

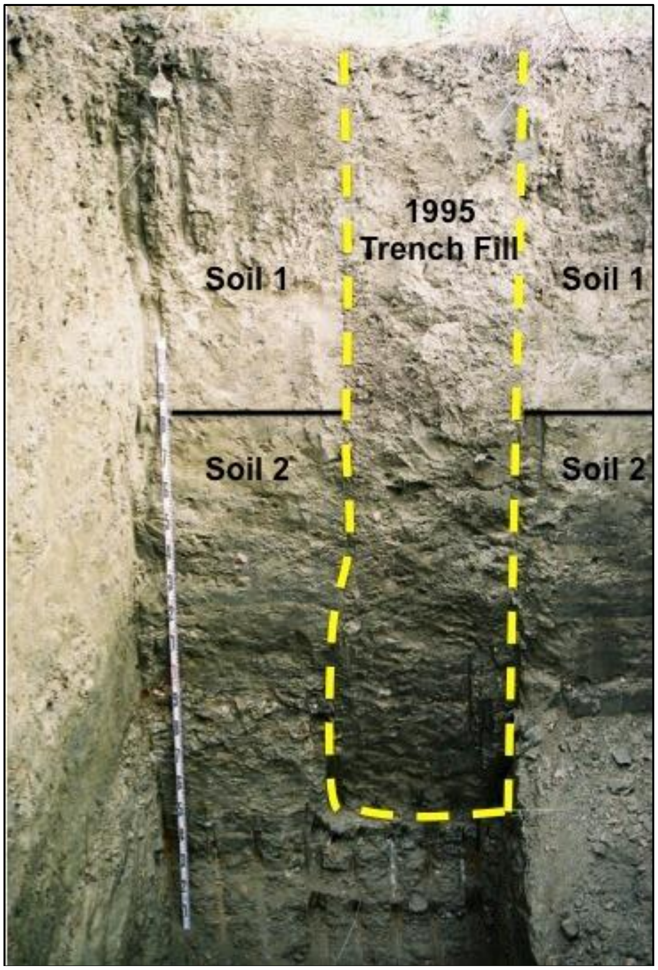

Figure 5. Photograph of the north wall profile of Trench I, Area A.

Three alluvial facies (cf. Albanese, this report [see Appendix D, Manuscript I]) were identified in the Trench I profile: clay facies at a depth of 0-71 cm, clay-sand facies at a depth of 71-153 cm, and coarse clast facies at a depth of 153-325 cm. The coarse clast facies comprise channel deposits (Figure 6), whereas the clay and clay-sand facies are products of sheet flow.

Two soils occur in the upper 96 cm of the fan: a surface soil (Soil 1) from 0-71 cm below surface, and a buried soil (Soil 2) from 71-96 cm below surface. The alluvium is stratified below a depth 96 cm. Soil 1 has a well-expressed A-Btkss profile (Figure 7; Table 4). The A horizon is 15 cm thick and consists of grayish brown (10YR 5/2, dry) clay. The Btkss1 and Btkss2 horizons consist of grayish brown (2.5Y 5/2, dry) clay and light olive brown (2.5Y 5/3, dry) clay, respectively. The Btkss3 horizon is a light olive brown (2.5Y 5/3, dry) clay loam. Clay content ranges from 38 to 49 percent in Soil 1 (Table 5), and a distinct clay peak occurs in the lower half of the Btkss1 horizon (see Figure 7). Slickensides are common throughout the Btkss horizons, indicating an abundance of expandable clay minerals, and carbonate morphology ranges from I+ to II.

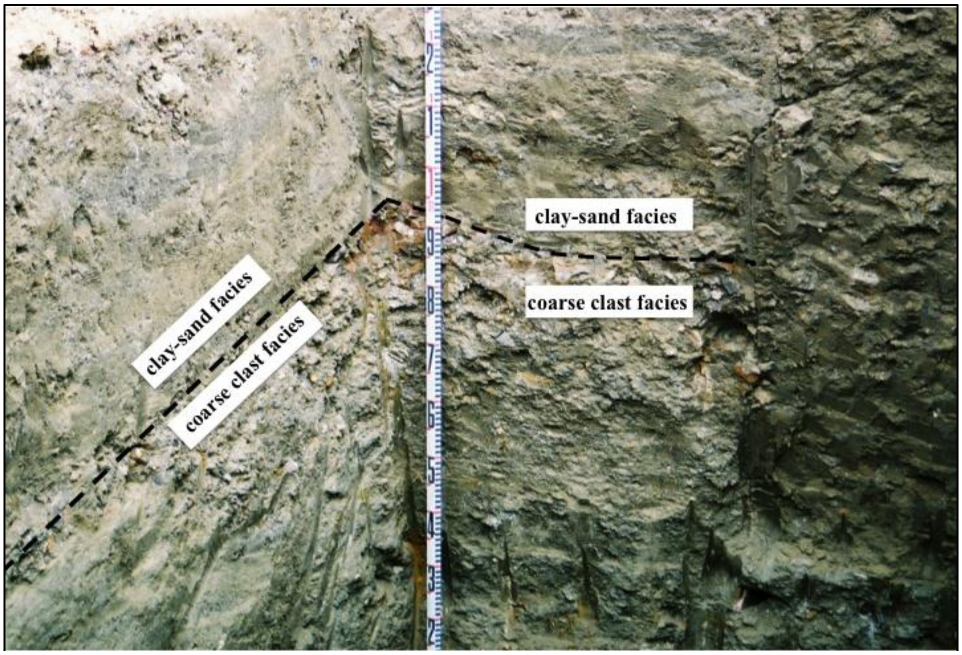

Figure 6. Photograph of the north and west walls of Trench I, showing clay-sand facies above coarse clast facies.

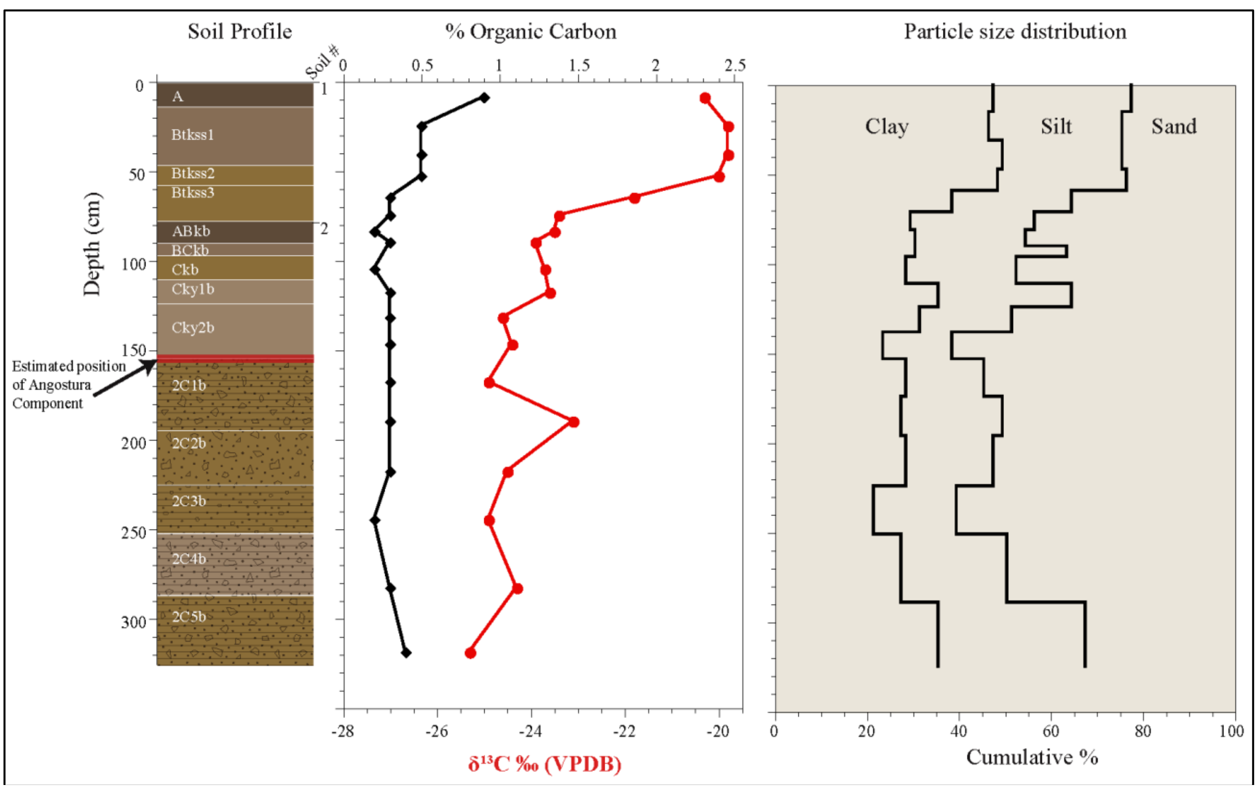

Figure 7. Diagram of the profile in Trench I showing soil stratigraphy, stable carbon isotope values, organic carbon content, and grain-size distribution.

Table 4. Description of the North Wall of Trench I, Area A, Site 39FA65.

Landform: Alluvial Fan
Slope: 1-2 percent
Drainage: Moderately well-drained
Described: August 3, 2010
Described by: Dr. Rolfe D. Mandel

Depth (cm)	Soil Horizon	Description
0-15	A	Grayish brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) moist; moderate medium and fine angular blocky structure; very hard, very firm; many fine and very fine roots; gradual smooth boundary.
15-47	Btkss1	Grayish brown (2.5Y 5/2) clay, dark grayish brown (2.5Y 4/2) moist; moderate medium angular blocky structure parting to moderate fine angular blocky; hard, firm; common distinct discontinuous dark grayish brown (10YR 4/2) clay films on ped faces; common fine soft and slightly hard masses of calcium carbonate; 5-10 percent continuous distinct intersecting slickensides throughout; common fine and very fine roots; gradual smooth boundary.
47-59	Btkss2	Light olive brown (2.5Y 5/3) clay, olive brown (2.5Y 4/3) moist; moderate medium angular blocky structure parting to moderate fine angular blocky; very hard, very firm; common distinct discontinuous dark grayish brown (10YR 4/2) clay films on ped faces; common films and thick encrusted threads of calcium carbonate; 5-10 percent continuous distinct intersecting slickensides throughout; common fine and very fine roots; gradual smooth boundary.
59-71	Btkss3	Light olive brown (2.5Y 5/3) clay loam, olive brown (2.5Y 4/3) moist; moderate medium angular blocky structure parting to moderate fine angular blocky; very hard, very firm; common distinct discontinuous dark grayish brown (10YR 4/2) clay films on ped faces; common films and thick encrusted threads of calcium carbonate; 5-10 percent continuous distinct intersecting slickensides throughout; few fine and very fine roots; clear smooth boundary.
71-90	ABkb	Grayish brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine subangular blocky structure; hard, friable; many films and thick encrusted threads of calcium carbonate; common fine and very fine roots; few open ant burrows; gradual smooth boundary.
90-96	BCkb	Grayish brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine subangular blocky structure; hard, friable; common films and thick encrusted threads of calcium carbonate; faint bedding (laminated); few fine and very fine roots; common open ant burrows; gradual smooth boundary.
96-111	Ckb	Laminated light olive brown (2.5Y 5/3) to light yellowish brown (2.5Y 6/3) sandy clay loam, olive brown (2.5Y 4/3) to dark olive brown (2.5Y 3/3) moist; interbedded with brown (10YR 4/3) and dark grayish brown (10YR 4/2) silt loam and silty clay loam, dark brown (10YR 3/3) and very dark grayish brown (10YR 3/2) moist; massive; soft, very friable; common fine encrusted threads of calcium carbonate; common fine roots; common open ant burrows; gradual smooth boundary.
111-124	Cky1b	Laminated light olive brown (2.5Y 5/3) to light yellowish brown (2.5Y 6/3) clay loam, olive brown (2.5Y 4/3) to dark olive brown (2.5Y 3/3) moist; interbedded with brown (10YR 4/3) and dark grayish brown (10YR 4/2) silt loam and silty clay loam, dark brown (10YR 3/3) and very dark grayish brown (10YR 3/2) moist; massive; soft, very friable; few fine encrusted threads of calcium carbonate; few fine concentrations of gypsum crystals; few fine roots; few open ant burrows; abrupt smooth boundary.
124-153	Cky2b	Grayish brown (2.5Y 5/2) sandy clay loam, dark grayish brown (2.5Y 4/2) moist; massive; very hard, very firm; few fine encrusted threads of calcium carbonate; few fine concentrations of gypsum crystals; few fine roots; few open ant burrows; abrupt smooth boundary.

Table 4 (continued).

Depth (cm)	Soil Horizon	Description
153-196	2C1b	Stratified olive gray (5Y 4/2) cobbly sandy clay loam, dark olive gray (5Y 3/2) and grayish brown (2.5Y 5/2) sandy clay loam, dark grayish brown (2.5Y 4/2) moist; interbedded with gravel and 1-3 cm-thick beds of brown (10YR 5/3) fine sand, brown (10YR 4/3) moist; massive; hard, firm; about 80% shale fragments and iron concretions; noneffervescent; abrupt wavy boundary.
196-224	2C2b	50% 5Y 5/2 olive gray cobbly sandy clay loam, olive gray (5Y 4/2) moist, 50% olive brown (2.5Y 4/3), dark olive brown (2.5Y 3/3) moist; massive; hard, firm; poorly sorted; about 75% shale fragments and iron concretions; noneffervescent; abrupt wavy boundary.
224-251	2C3b	Stratified light olive brown (2.5Y 5/3) sandy clay loam, olive brown (2.5Y 4/3) moist; interbedded with gravel; massive; hard, firm; about 25% shale fragments and iron concretions; noneffervescent; abrupt wavy boundary.
251-289	2C4b	Stratified grayish brown (2.5Y 5/2) cobbly sandy clay loam, dark grayish brown (2.5Y 4/2) moist; massive; hard, firm; about 50% shale fragments and iron concretions; noneffervescent; abrupt wavy boundary.
289-325	2C5b	Stratified olive gray (5Y 5/2) cobbly clay loam, olive gray (5Y 4/2) moist; massive; hard, firm; about 30% shale fragments and iron concretions; noneffervescent.

Table 5. Grain-size Data, Trench I, Area A.

Depth	Soil	Particle Size Distribution (percent)							
		Sand	Silt[1]				Clay[2]		
(cm)	Horizon	Total	C	M	F	Total	C	F	Total
0-15	A	**23**	10	10	10	**30**	27	20	**47**
15-31	Btkss1	**25**	8	11	10	**29**	23	23	**46**
31-47	Btkss1	**25**	7	9	10	**26**	23	26	**49**
47-59	Btkss2	**24**	8	10	10	**28**	22	26	**48**
59-71	Btkss3	**36**	7	10	9	**26**	22	16	**38**
71-81	ABkb	**44**	9	9	9	**27**	19	10	**29**
81-90	ABkb	**46**	8	8	8	**24**	20	10	**30**
90-96	BCkb	**37**	13	11	9	**33**	20	10	**30**
96-111	Ckb	**48**	9	8	7	**24**	18	10	**28**
111-124	Cky1b	**36**	11	8	10	**29**	22	13	**35**
124-138	Cky2b	**49**	4	8	8	**20**	21	10	**31**
138-153	Cky2b	**62**	3	6	6	**15**	15	8	**23**
153-174	2C1b	**55**	2	8	7	**17**	19	9	**28**
174-196	2C1b	**51**	6	8	8	**22**	18	9	**27**
196-224	2C2b	**53**	4	8	7	**19**	20	8	**28**
224-251	2C3b	**61**	5	6	7	**18**	15	6	**21**
251-289	2C4b	**50**	5	9	9	**23**	20	7	**27**
289-325	2C5b	**33**	8	12	12	**32**	26	9	**35**

[1] Silt fractions: C = Coarse (50-20µm); M = Medium (20-5µm); F = Fine (5-2µm)

[2] Clay fractions: C = Coarse (2-0.2µm); F = Fine (<0.2µm)

Soil 2 has an ABk-BCk profile with stage I-I+ carbonate morphology that is a product of post-burial diagenesis. It is likely that Soil 2 had an A-C profile prior to burial, but welding of the B horizon of Soil 1 onto Soil 2 transformed the A and C horizons into ABk and BCk horizons, respectively. The ABkb horizon is 19 cm thick and consists of grayish brown (2.5Y 5/2, dry) clay loam. Grayish brown (2.5Y 5/2, dry) clay loam comprising the BCkb horizon grades downward into laminated, light olive brown (2.5Y 5/3 dry) to light yellowish brown (2.5Y 6/3, dry) sandy clay loam (Ckb horizon). Stratified fine-grained alluvium (clay-sand facies) occurs to a depth of 153 cm, with a bed of laminated clay loam (Cky1b horizon) overlying a bed of sandy clay loam (Cky2b horizon). Fine concentrations of gypsum crystals (y) occur at a depth of 111-153 cm.

An abrupt change in lithology occurs at a depth of 153 cm, with fine-grained alluvium giving way to stratified cobbly alluvium (coarse clast facies). Based on the geometry of the cobble-rich deposits, they occupy former distributary channels that delivered sediment to the alluvial fan. With the exception of the 2C5b horizon, the sand content is high (61-50 percent) in the cobbly alluvium, and the coarse clasts are shale fragments and iron concretions.

During the 2010 investigation, cultural materials were not found in the walls of Trench I. However, Wheeler (1995) recorded an Angostura component at the top of a bed of coarse, clast-rich alluvium ca. 1.5 mbs in the nearby block excavation grid at Area A. Based on the depth of the component and lithology of the underlying alluvium, the Angostura cultural deposits probably rest on the 2C1b horizon, as shown in Figure 7.

Stable Carbon Isotope Values

The $\delta^{13}C$ values determined on organic carbon in samples from the Trench I profile range from -25.3 to -19.8 ‰ (Table 6; see Figure 7). The lightest value, -25.3 ‰, occurs in the 2C5b horizon of Soil 2, and the heaviest value, 19.8 ‰, occurs in the Btkss1 horizon of Soil 1. The difference between the maximum and minimum $\delta^{13}C$ value is -5.5 ‰.

Identifying the point at which changes in the $\delta^{13}C$ values reflect actual changes in vegetation composition (C_3 vs. C_4) is difficult (Cyr et al. 2011). According to Krull and Skjemstad (2003), changes between 1 and 3 ‰ are related to inherent soil processes, whereas differences exceeding 3 ‰ result from changes in the contribution of C_3 and C_4 vegetation. Ehleringer et al. (2000), however, noted

Table 6. Stable Carbon Isotope Ratios, Trench I, Area A.

Depth (cm)	Soil Horizon	$\delta^{13}C$ (‰)	OC[1] (percent)
0-15	A	-20.3	0.9
15-31	Btkss1	-19.8	0.5
31-47	Btkss1	-19.8	0.5
47-59	Btkss2	-20.0	0.5
59-71	Btkss3	-21.8	0.3
71-81	ABkb	-23.4	0.3
81-90	ABkb	-23.5	0.2
90-96	BCkb	-23.9	0.3
96-111	Ckb	-23.7	0.2
111-124	Cky1b	-23.6	0.3
124-138	Cky2b	-24.6	0.3
138-153	Cky2b	-24.4	0.3
153-174	2C1b	-24.9	0.3
174-196	2C1b	-23.1	0.3
196-224	2C2b	-24.5	0.3
224-251	2C3b	-24.9	0.2
251-289	2C4b	-24.3	0.3
289-325	2C5b	-25.3	0.4

[1] **OC = Organic Carbon**

that changes as slight as 1 ‰ may be caused by environmental stress. A 1 to 3 ‰ shift in the $\delta^{13}C$ values may reflect increased fractionation against ^{12}C by C_3 plants due to changes in respiration rates during drought, but may also represent small increases in C_4 plants within a C_3-dominated community.

The $\delta^{13}C$ values determined on organic matter from Soil 2 range from -25.3 to -23.1, indicating a vegetation community dominated by C_3 plants, i.e., woody species and/or cool-season grasses. A distinct $\delta^{13}C$ excursion occurs at 71 cm below surface, the boundary between Soils 1 and 2, with values becoming heavier upward through Soil 1 (see Figure 7). This excursion probably represents a shift to warmer and drier conditions sometime after the period of Angostura occupation (ca. 8830-9110 RCYBP). The $\delta^{13}C$ values from Soil 1 range from -21.8 to -19.8, indicating contributions of organic matter from a mixed C_3/C_4vegetation community similar to the modern community.

Excavation Block, Area B

The excavation block in Area B, on a distal segment of the alluvial fan, was reopened in 2010. The top two sedimentary units comprising approximately 1 m of the fan were completely stripped off the immediate area of the block excavation during previous excavations, leaving eleven units, numbered 3 to 11 from top to bottom, exposed in the north wall (Figures 8 and 9). The fan deposits exposed in the excavation block are strikingly different from the fan deposits exposed in Trench I. The profile in the north wall of the excavation block consists mostly of stratified fine-grained alluvium. Buried soils do not occur in the stratigraphic sequence, nor is there much variation in the lithology of the alluvium. The surface soil was stripped off the area when the excavation block was opened in 1994, so a description of that soil is not presented here.

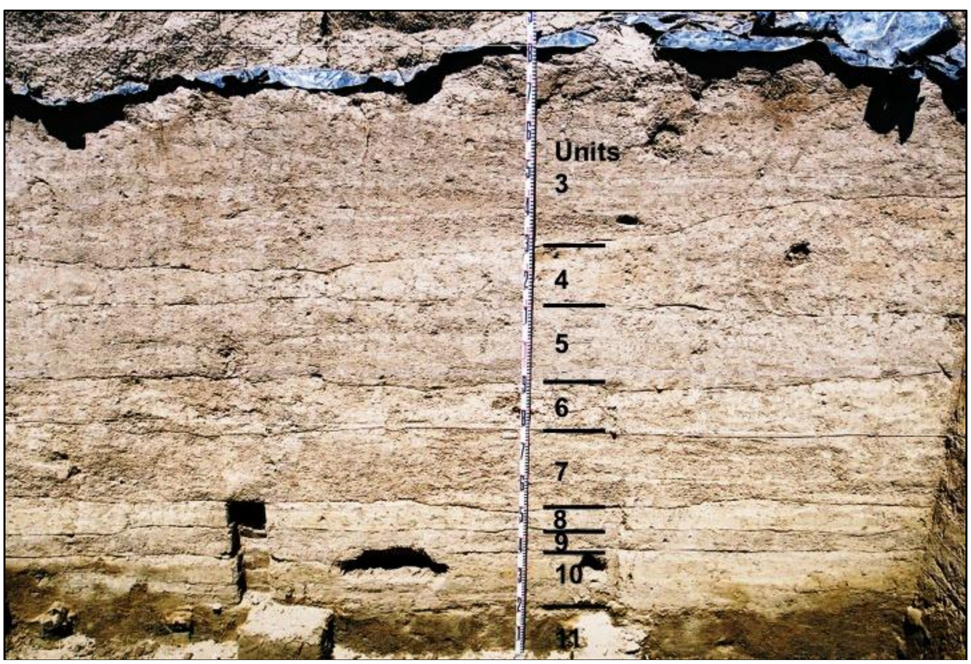

Figure 8. Photograph of the north wall of the 2010 excavation block in Area B, showing the stratigraphic units.

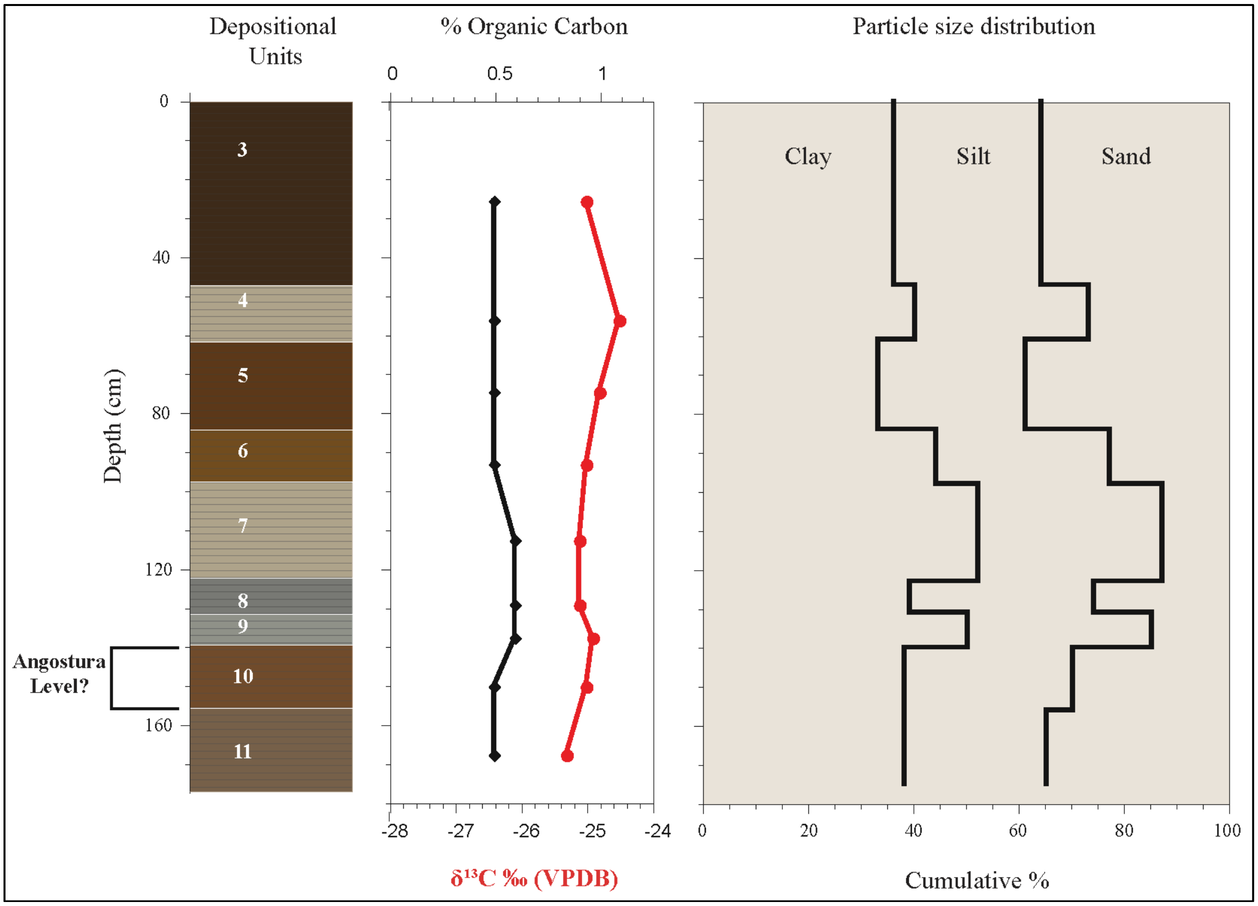

Figure 9. Diagram of the north-wall profile in the Area B block excavation showing soil stratigraphy, stable carbon isotope values, organic carbon content, and grain-size distribution.

The texture of the stratigraphic units in the Area B profile falls into two classes: clay and clay loam (Table 7). Clay content ranges from 52 to 33 percent, and sand content ranges from 39 to 13 percent (Table 8; see Figure 9). Alluvium comprising the units is laminated and free of cobble-size clasts. Lenses of fine gravel occur in units 5, 6, 8, and 10, but the fine-grained matrix of all units is free of gravel. The fine texture of the alluvium is attributed to the distal position of the fan segment in Area B. Sediment typically becomes finer-grained going from the proximal to the distal ends of alluvial fans.

During the 2010 field season, a charcoal sample was collected from the fill of an ephemeral hearth feature (Feature 10-1) at Area B of the site. The sample from this feature yielded an AMS age of 9150 ± 25 RCYBP (see Hannus et al. 2012:111-112). Although Feature 10-1 was not immediately adjacent to the north wall of the excavation block, based on its elevation, the hearth almost certainly lies in Unit 10.

Unit 10 consists of laminated brown (10YR 5/3, dry) clay loam with few lenses of fine gravel (see Table 7). A few fine threads of calcium carbonate occur in the unit, and few to common gypsum crystals were observed in macro-pores. Otherwise, there is no visible evidence of diagenesis.

Table 7. Description of the North Wall of Excavation Block, Area B, Site 39FA65.

Landform: Alluvial fan
Slope: 2-3 percent
Drainage: Well-drained
Described: August 4, 2010
Described by: Rolfe D. Mandel

Depth (cm)	Depositional Unit	Description
0-47	3	Laminated brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; massive; hard, firm; common thin beds of dark gray (10YR 4/1) very fine shale fragments; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
47-61	4	Laminated pale brown (10YR 6/3) clay, brown (10YR 4/3) moist; massive; hard, firm; few thin beds of dark gray (10YR 4/1) very fine shale fragments; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
61-84	5	Laminated brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; massive; hard, firm; common thin beds of dark gray (10YR 4/1) very fine shale fragments; few lenses of fine gravel mostly consisting of iron concretions; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
84-98	6	Laminated brown (10YR 5/3) to pale brown (10YR 6/3) clay, brown (10YR 4/3) to dark brown (10YR 3/3) moist; massive; hard, firm; few thin beds of dark gray (10YR 4/1) very fine shale fragments; few lenses of fine gravel mostly consisting of iron concretions; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
98-123	7	Laminated pale brown (10YR 6/3) and grayish brown (10YR 5/2) clay, brown (10YR 4/3) and dark grayish brown (10YR 4/2) moist; massive; hard, firm; few thin beds of dark gray (10YR 4/1) very fine shale fragments; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
123-131	8	Laminated gray (10YR 5/1) clay loam, dark gray (10YR 4/1) moist; many thin beds of dark gray (10YR 4/1) fine and very fine shale fragments; few lenses of fine gravel consisting of iron concretions and shale fragments; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
131-140	9	Laminated pale brown (10YR 6/3) and grayish brown (10YR 5/2) clay, brown (10YR 4/3) and dark grayish brown (10YR 4/2) moist; massive; hard, firm; few thin beds of dark gray (10YR 4/1) very fine shale fragments; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
140-156	10	Laminated brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; massive; hard, firm; few lenses of fine gravel consisting of iron concretions and shale fragments; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores; abrupt wavy boundary.
156-175	11	Laminated grayish brown (2.5Y 5/2) clay loam, dark grayish brown (2.5Y4/2) moist; massive; hard, firm; common iron concretions scattered through the matrix; few fine threads of calcium carbonate; few to common gypsum crystals in macro-pores.

Table 8. Grain-size Data, Excavation Block, Area B.

Depth (cm)	Unit	Sand Total	Silt[1] C	Silt[1] M	Silt[1] F	Silt[1] Total	Clay[2] C	Clay[2] F	Clay[2] Total
0-47	3	**36**	10	7	11	**28**	27	9	**36**
47-61	4	**27**	11	9	13	**33**	29	11	**40**
61-84	5	**39**	11	7	10	**28**	24	9	**33**
84-98	6	**23**	10	11	12	**33**	33	11	**44**
98-123	7	**13**	9	13	13	**35**	39	13	**52**
123-131	8	**26**	15	9	11	**35**	29	10	**39**
131-140	9	**15**	10	12	13	**35**	38	12	**50**
140-156	10	**30**	15	6	11	**32**	27	11	**38**
156-175	11	**35**	11	5	11	**27**	29	9	**38**

Particle Size Distribution (percent)

[1] Silt fractions: C = Coarse (50-20µm); M = Medium (20-5µm); F = Fine (5-2µm)

[2] Clay fractions: C = Coarse (2-0.2µm); F = Fine (<0.2µm)

Bounding radiocarbon ages are not available for the sequence of deposits exposed in the north wall of the excavation block. However, based on the radiocarbon age determined on charcoal from Feature 10-1, sediment comprising the upper ~1.5 m of the profile accumulated after ca. 9150 RCYBP. Wheeler (1995) reported a radiocarbon age of 7073 ± 300 RCYBP determined on charcoal collected at a depth of 70 cm below the surface of the fan in Area B, so sedimentation on the fan continued into the mid-Holocene. Alluviation was rapid and uninterrupted by soil development until the fan finally stabilized sometime after ca. 7000 RCYBP.

Stable Carbon Isotope Values

The $\delta^{13}C$ values determined on organic carbon in samples from the north wall of the excavation block range from -25.3 to -24.5‰ (Table 9; see Figure 9). These values indicate that C_3 plants (trees and/or cool season grasses) contributed most of the organic matter for the period of record preserved in the north wall. The lightest value, -25.3‰, occurs in Unit 11, and the heaviest value, -24.5‰, occurs in Unit 4. The difference between the maximum and minimum $\delta^{13}C$ value is -0.8‰. Hence, the C_3-dominated vegetation community appears to have been stable. However, the upper 1 m of the profile is missing, so the excursion in

Table 9. Stable Carbon Isotope Ratios, Excavation Block, Area B.

Depth (cm)	Unit	$\delta^{13}C$ (‰)	OC[1] (percent)
0-47	3	-25.0	0.5
47-61	4	-24.5	0.5
61-84	5	-24.8	0.5
84-98	6	-25.0	0.5
98-123	7	-25.1	0.6
123-131	8	-25.1	0.6
131-140	9	-24.9	0.6
140-156	10	-25.0	0.5
156-175	11	-25.3	0.5

[1] OC = Organic Carbon

$\delta^{13}C$ values recorded at 71 cm below the surface in Area A may not be detectable in the excavation block at Area B.

CONCLUSIONS

Site Formation Processes

At the Ray Long site, archeological materials, including the Angostura component, are sealed in alluvial fan deposits. Area A is on the upper midsection of the fan, and Area B is on a distal segment. Based on the results of the 2010 investigation, the Angostura component identified by Wheeler (1995) in Area A rests on coarse-grained channel deposits (high-energy depositional environment) overlain by fine-grained alluvium (low-energy depositional environment). The absence of a soil in the channel fill indicates that it was not exposed at the surface for a long period, i.e., burial was rapid. Also, the alluvium that encased the Angostura component has been only slightly modified by development. Soil 2, which is immediately above the Angostura level, has a weakly expressed ABk-BCk profile. Hence, it is unlikely that soil-mixing processes, such as bioturbation, have greatly affected the Angostura cultural deposits in this portion of the site.

In Area B of the site, fan sedimentation appears to have been rapid for most, if not all, of the period of record. However, unlike Area A, no channel deposits were observed in the block excavation. Instead, this portion of the fan mostly consists of stratified fine-grained alluvium that was deposited by low-energy sheet flows; thin lenses of fine gravel only occur in four sedimentary units. Sedimentation on the fan was not interrupted by soil development until the fan stabilized sometime after ca. 7000 RCYBP. Hence, the Angostura people occupied an unstable, aggrading geomorphic surface, and their material remains were rapidly buried. Although some biogenic features, such as krotovina and worm burrows, were observed in the walls of the excavation block, the cultural deposits have been spared the effects of soil development.

Environmental Change

Stable carbon isotopes analysis of organic carbon in soils and sediments in the Trench I profile at Area A and the north wall profile at Area B indicate that a cool-season C_3-dominated vegetation community existed at the site during the period of Angostura occupation. However, in the Trench I profile, a distinct shift towards heavier $\delta^{13}C$ values above the boundary between Soils 1 and 2 (71 cmbs) indicates that sometime after ca. 9000 RCYBP a mixed C_3/C_4 vegetation community replaced the C_3-dominated vegetation community. This vegetation change probably was in response to climatic warming and drying during the early Holocene, a pattern recorded elsewhere in the region (see Mandel 2008; Murphy and Mandel 2012).

An Examination and Summary of Ray Long Site Collections Curated at the Smithsonian Institution

Overview

The Smithsonian Institution's Museum Support Center (MSC) in Suitland, Maryland curates the artifact collection and paper archive generated from the 1948-1950 RBS excavations at the Ray Long site (Figure 10). The collection includes, among other items, lithic and faunal artifacts, charcoal and soil samples from the features and excavation units, black-and-white photographic prints and negatives, maps, illustrations, and field notes from the site excavations. From March 19-26, 1995, ALAC personnel L. Adrien Hannus and R. Peter Winham, and archeologist Kerry Lippincott, traveled to the MSC to examine and evaluate the curated Ray Long site materials (Figure 11). The objectives of the venture were fourfold. First, field notes and the paper and photographic archive from the RBS excavations at Angostura, Boysen, and Keyhole reservoirs, South Dakota and Wyoming, were to be reviewed; pertinent material was to be copied for possible inclusion in a forthcoming series of J & L Reprints of these projects (Wheeler 1995, 1996, 1997). Second, researchers proposed to identify the exact contents of the Ray Long site archive and artifact collection, and to obtain an accurate catalog for inclusion in the current report (see Appendix K). Third, researchers intended to photograph and conduct a detailed examination of all Angostura projectile point specimens in the collection as part of the broader reevaluation of the Angostura technocomplex. Finally, it was hoped that several charcoal samples, originally obtained during the RBS excavations at the site, could be identified in the collections and submitted for AMS dating.

Figure 10. 1995 view of the Smithsonian Institution Museum Support Center, Suitland, Maryland.

Findings

The first objective was completed successfully and the results of Wheeler's work at Angostura, Boysen, and Keyhole reservoirs were ultimately published between 1995 and 1997 as a three-part series (Volumes 46, 47, and 49) in the larger series of J & L Reprints in Anthropology (see Wheeler 1995, 1996, 1997).

The second objective was also accomplished as researchers were able to obtain copies of the RBS artifact catalog from the 1948-1950 excavations at the Ray Long site. The catalogs were segregated by site area (Areas A, B, and C) and "surface finds" and have been appended to this report for reference (see Appendix K).

The third objective met with only a modicum of success. During the visit, multiple artifacts from Ray Long were examined and photographed, including three of the Angostura projectile point specimens originally collected by Wheeler. On September 18, 1995, ALAC submitted a formal loan request letter for the latter items and four additional specimens from the site collection (Figure 12; Table 10). The one-year request was submitted to the Smithsonian Institution Sampling Committee with the intent of producing four sets of scientific casts and using the artifacts in a microwear analysis study of lithic tools from the Ray Long site. The Sampling Committee denied ALAC's request; however, personnel from the Smithsonian Institution subsequently submitted these seven artifacts to the Lithic Casting Lab, Troy, Illinois for casting. A set of the casts was then provided to ALAC.

Figure 11. One of the many aisles within the MSC housing the Smithsonian's archeological site collections.

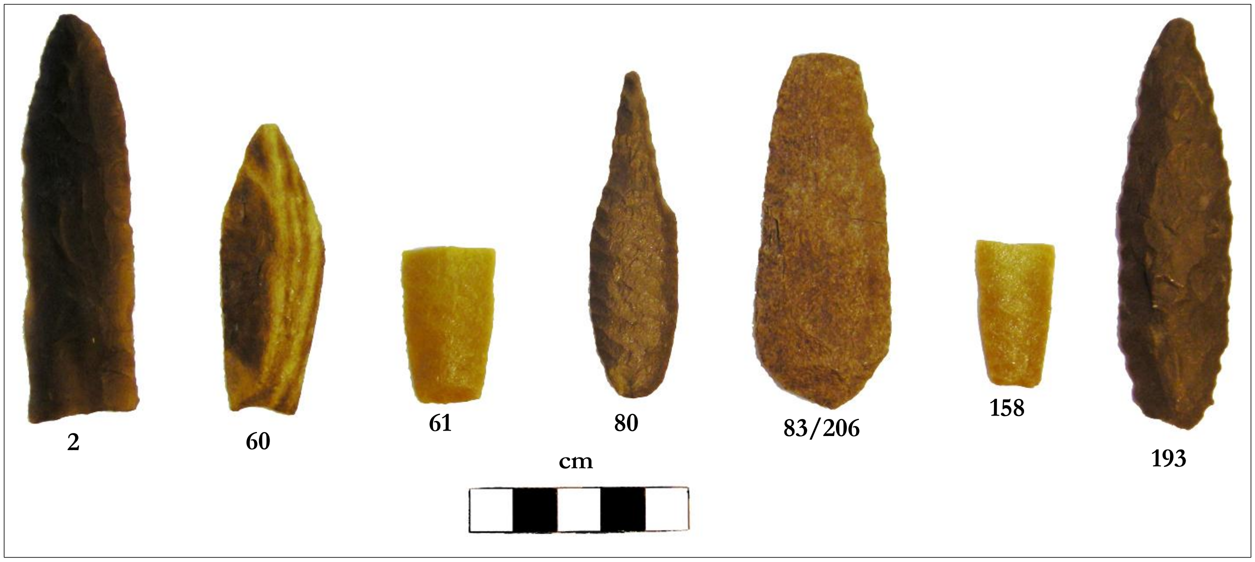

Figure 12. The seven Ray Long site specimens cast by the Lithic Casting Lab (labeled by old catalog no.). [1]

ALAC also obtained a set of three casts of Ray Long artifacts that the Smithsonian Institution had produced many years earlier. One of the specimens in this set, Catalog No. 158, was also reproduced in the more recent set of casts; it is depicted in Figure 12. The other two specimens, Catalog Nos. 1 and 141, are depicted in Figure 13, below.

[1] The Smithsonian Institution employed two different series of catalog numbers for the Ray Long site collection. One appears to have been assigned early-on and correlates with the original field numbers assigned to items during the RBS excavations. No correlation has been identified between the early catalog series and the more recently assigned numbers. As a result, the older series is referenced herein except in instances where both sets of numbers are available for a given artifact.

Table 10. Smithsonian Institution Ray Long Site Lithic Artifact Specimens from which Scientific Casts were Produced.

New SI Catalog No.	Old SI Catalog No.	Specimen Description	General Provenience
427515	2	Large projectile point/knife	Surface (unknown locality)
427522	60	Reworked projectile point	Area B, Surface
427523	61	Projectile point base	Area B, Surface
427532	80	Drill	Area C, Surface
427533	83/206	Preform blank refit	Area C, Surface
427545	158	Projectile point base	Area A, Unit L2-B2, Feature 8
427556	193	Preform blank	Area B, Surface – near N7-E2

Figure 13. Early casts of specimens collected from the Ray Long site (labeled by old catalog no.).

Unfortunately, it was discovered during the visit that a number of artifacts from the site, including at least 12 specimens classified as projectile points/point fragments of the Angostura type, were missing from the MSC facility (Table 11). Also missing from the facility was a photographic archive that included both prints and negatives of these and other specimens in the collection. Catalog numbers had previously been assigned to the missing specimens but records suggested that they were neither in an exhibit nor on loan; they had not been deaccessioned. The Smithsonian had, however, produced casts of two of the missing specimens prior to their disappearance. The casts remain in the site collection at the MSC; copies of these casts were also produced for ALAC (see Figure 13, above).

Table 11. Angostura Projectile Point Specimens Missing from the Smithsonian Institution Ray Long Site Collection.

SI Accession No.	Old SI Catalog No.	Specimen Description	General Provenience
00232741	1	Reworked projectile point (drill)	Surface (unknown locality)
00232741	3	Projectile point midsection	Surface (unknown locality)
00232741	4	Projectile point base	Surface (unknown locality)
00232741	55	Projectile point base	Area A, Unit B2 L3, 4.4 ft. bs
00232741	62	Projectile point base	Surface, Area B
00232741	63	Projectile point tip	Surface, Area B
00232741	141	Projectile point tip	Area A, Unit R5 B2, 3.5 ft below stake L3
00232741	166	Projectile point preform	Surface, Area B
00232741	275	Projectile point tip	Area A, Unit BFR 6, Feature 15, 3,217.82 ft amsl
00232741	276	Projectile point base	Area A, Unit BFR 6, Feature 19
00232741	277	Projectile point base	Area A, Unit BFR 6, Feature 19
00232741	280	Projectile point tip	Area A, Unit BFL 1, Feature 13, 3,217.48 ft amsl

Following the visit to the Smithsonian Institution, L. Adrien Hannus telephoned the daughter of Richard Wheeler, Ms. Valerie Wheeler, concerning the whereabouts of the missing artifacts and photographs from the Ray Long site collection. Ms. Wheeler was not aware of any such material among her father's belongings, but, nonetheless, agreed to search through her father's documents for any pertinent information. Approximately two months after the telephone conversation, Ms. Wheeler mailed a package to ALAC that contained a set of seven black-and-white photographic prints and accompanying negatives. The photographs depict a variety of artifacts from the Ray Long site, several of which are specimens noted to have been missing from the MSC site collection (Figures 14-20). Among the missing artifacts depicted in the photographs are all of the 12 projectile point specimens attributed to the Angostura technocomplex (see Figures 14 and 15 and Table 11). Unfortunately, Ms. Wheeler was unable to locate any of the missing artifacts among her father's belongings. Their whereabouts remain unknown at this time.

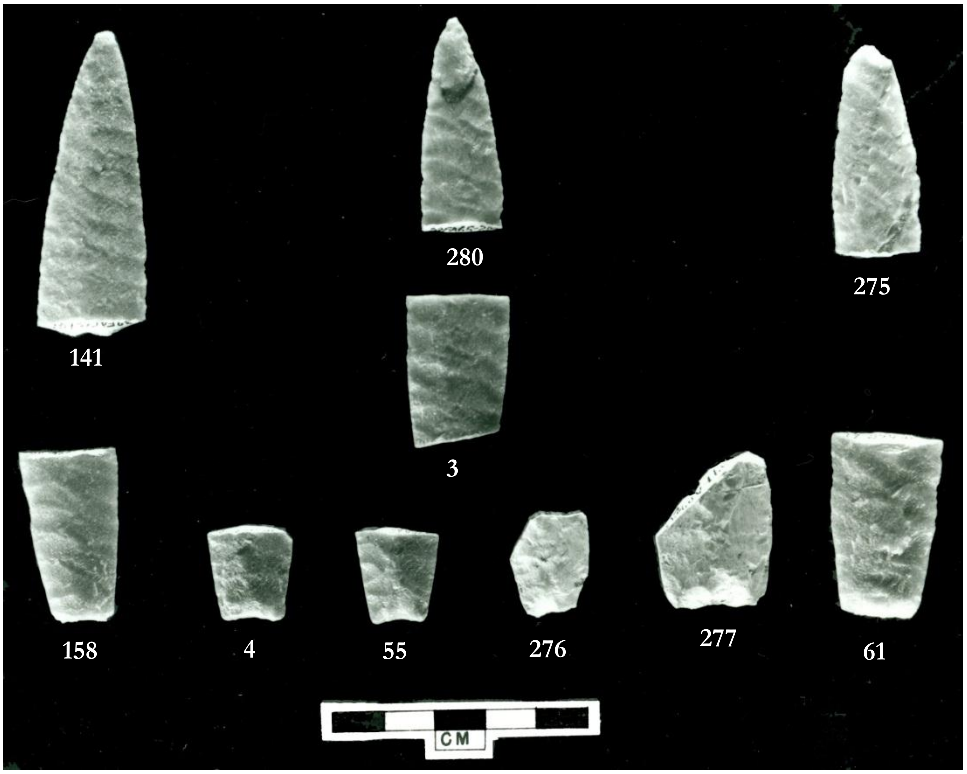

Figure 14. Wheeler Plate 1 – Angostura point fragments from the Ray Long site (old catalog nos. added).

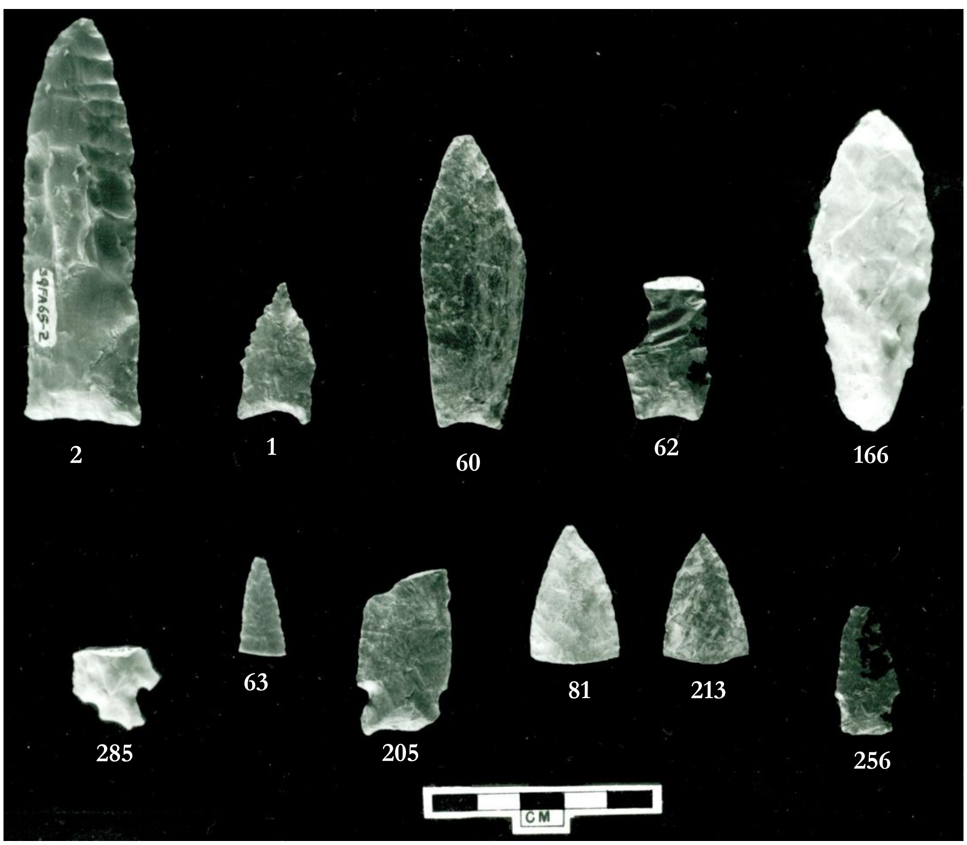

Figure 15. Wheeler Plate 2 – miscellaneous points/point fragments from Ray Long (old catalog nos. added).

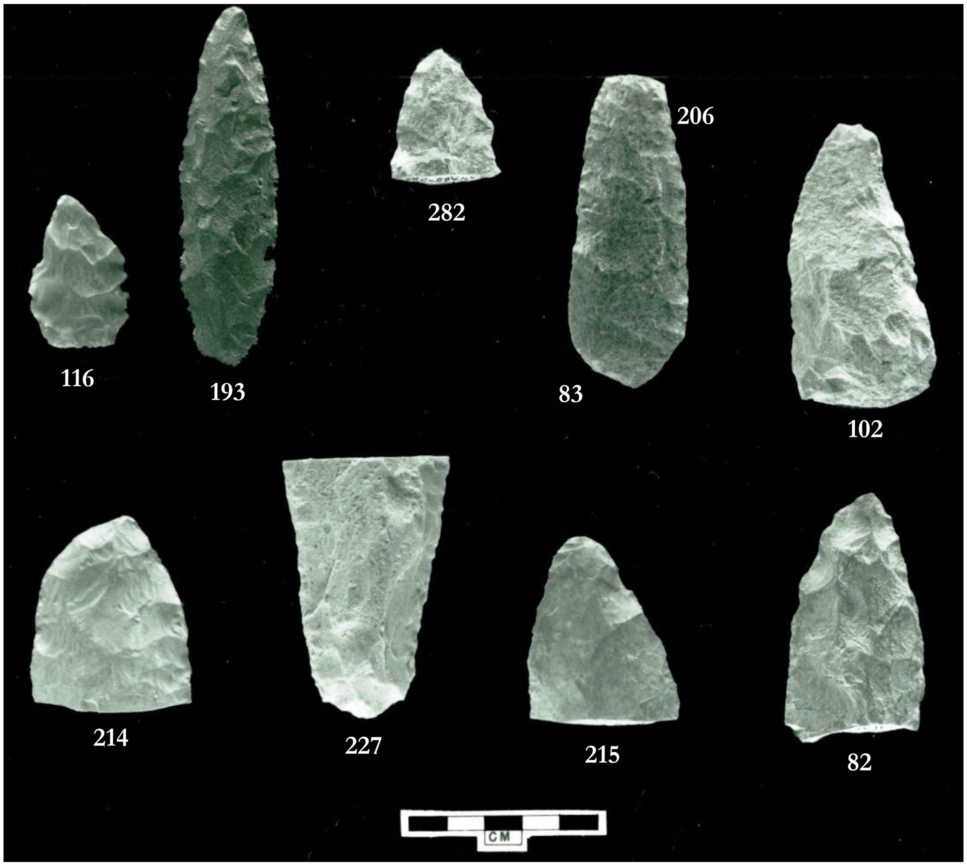

Figure 16. Wheeler Plate 3 – miscellaneous blades/blade fragments from Ray Long (old catalog nos. added).

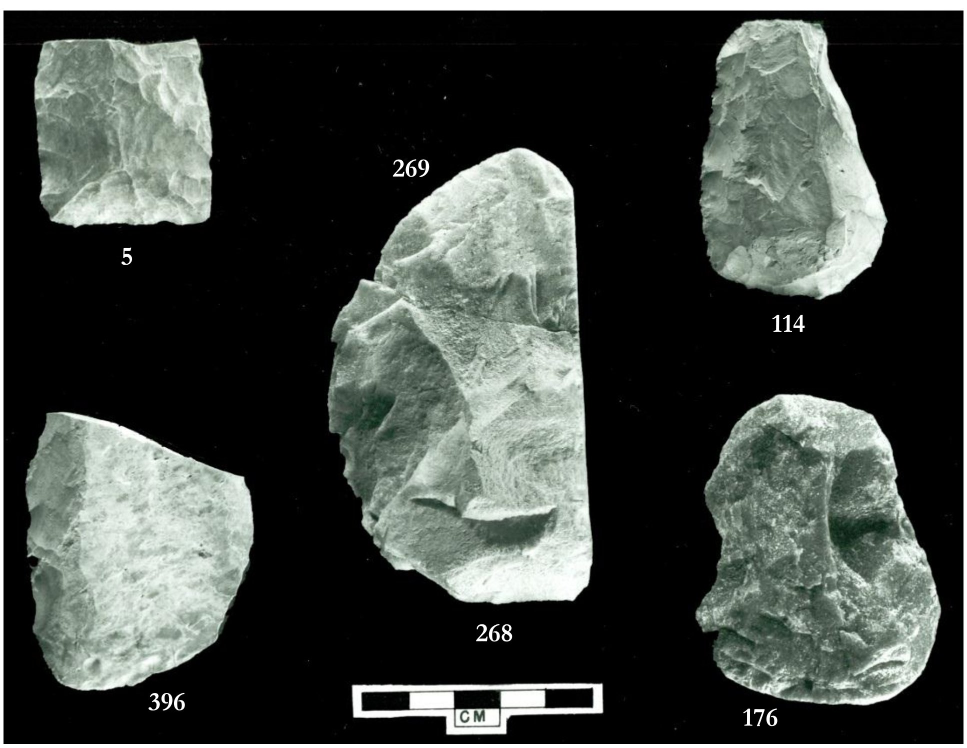

Figure 17. Wheeler Plate 4 – celts and chopping tools from the Ray Long site (old catalog nos. added).

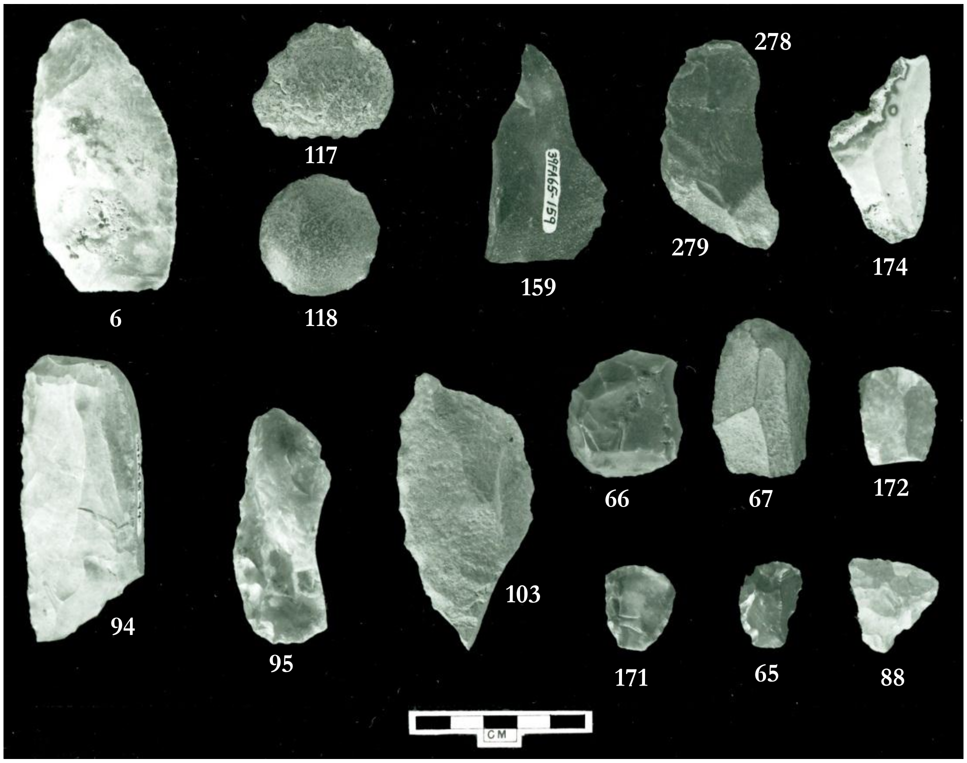

Figure 18. Wheeler Plate 5 – selection of scrapers from the Ray Long site (old catalog nos. added).

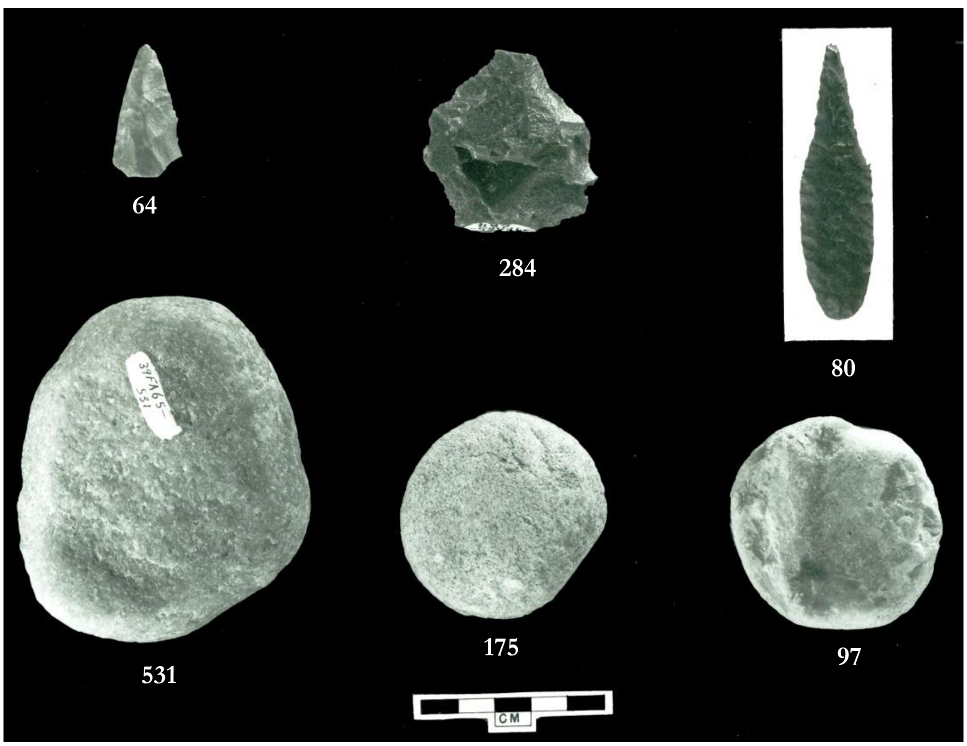

Figure 19. Wheeler Plate 6 – perforators and hammers from the Ray Long site (old catalog nos. added).

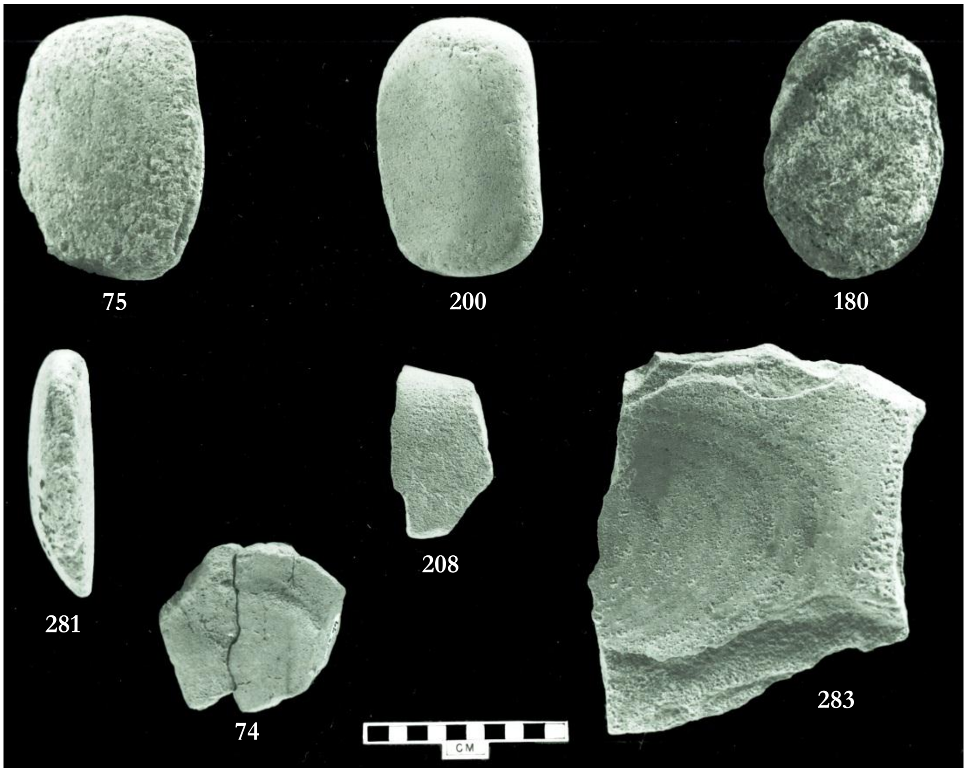

Figure 20. Wheeler Plate 7 – selection of grinding stone tools from the Ray Long site (old catalog nos. added).

The fourth and final objective of ALAC's visit to the Smithsonian Institution's MSC proved unsuccessful. ALAC had initially identified nine charcoal samples in the MSC Ray Long site collection that were considered good candidates for AMS dating (Table 12). These samples, including one from Area A of the site and eight from Area B, were originally collected from multiple depths and features at the site and would have provided a good control for testing the precision and accuracy of the site's earlier dates obtained by Wheeler, ALAC, and ARC. With the intention of submitting a portion of these samples for AMS dating, a formal letter of request for use of the samples was submitted on September 18, 1995 to the Smithsonian Institution Sampling Committee. The request was denied.

Table 12. Charcoal Samples from the Ray Long Site that ALAC Requested Permission to Date.

SI Old Catalog No.	Ray Long Site Area	General Provenience
204	B	Trench 1, Unit N7 E4 (one of two samples collected – first was previously dated)
381	A	Upper Zone
507	B	Feature 11
510	B	Upper Zone
511	B	Lower Zone
559	B	Upper Zone
560	B	Lower Zone
561	B	Trench 2, "Occupation Level"
562	B	Trench 2, "Occupation Level"

A Reevaluation of Fieldwork Conducted by the Smithsonian Institution at the Ray Long Site: 1948-1950

Overview

Initial archeological investigations at the Ray Long site were carried out between 1948 and 1950 by the Smithsonian Institution as part of the RBS program. The work conducted at Ray Long provided archeologists with a glimpse of a previously unidentified prehistoric cultural complex. At the time, it was the oldest site with intact archeological deposits to have been excavated in South Dakota. Indeed, it represented one of the few Paleoindian sites with subsurface deposits to have been discovered in the Northern Plains. The projectile points recovered at the site, subsequently classified as "Angostura," were of a style that had not previously been recognized by the professional archeological community. Organic samples collected from the site were some of the first to be assayed using the then-new method of radiocarbon dating.

In the 62 years since the conclusion of these initial excavations at Ray Long, the archeological database has grown and scientific techniques have been refined. A number of additional excavations have been undertaken at the site, allowing for an increased understanding of the occupants of this locale and the environment in which they lived. Technological advances in absolute dating have greatly improved both the accuracy and precision of radiocarbon dating, thereby providing a greater understanding of when the inhabitants of the site may have occupied the landscape. Additionally, archeological data obtained from the Plains and across North America since the 1950s provide a clearer picture of the context within which we may now view the site, its place in prehistory, and more importantly, its inhabitants.

Because the RBS program was established for the purpose of salvaging archeological sites prior to reservoir inundation, massive amounts of data were collected from a cadre of sites within the Missouri trench and other proposed reservoirs along its tributaries. The foremost objective of the program was the retrieval of as much data as possible from each site prior to its potential destruction. In this respect, the RBS program was quite successful. Although many of these datasets were never collated and published, Wheeler's work at Angostura Reservoir, including the Ray Long site excavations, was published as part of the J & L Reprints in Anthropology series (Wheeler 1995). A summary of the 1948-1950 excavations and findings that is derived primarily from Wheeler (1995) is provided below. More detailed accounts of the RBS work conducted at Ray Long are available in the aforementioned publication. The summation of this early work is followed by an evaluation of Wheeler's findings as viewed through the lens of the present. The chapter concludes with a brief discussion of unanswered questions and the available means of addressing them.

RBS Field Methodology

During the three field seasons at Ray Long, RBS archeologists, under the direction of Richard P. Wheeler, conducted salvage excavations in three separate localities at the site. Wheeler designated these localities, roughly from east to west across the site, Area A, Area B, and Area C, respectively (Figure 21). Wheeler describes Area B as being "…about 630 feet northwest of Area A…" and Area C as being "…about 830 feet northwest of Area A and across a deep gully from, and west of, Area B" (Wheeler 1995:395). Excavations focused, primarily, on Areas A and B of the site because Angostura projectile point specimens and charcoal were documented on the surface of these localities and they exhibited a greater potential for containing intact, subsurface deposits than Area C (Wheeler 1995:372-373).

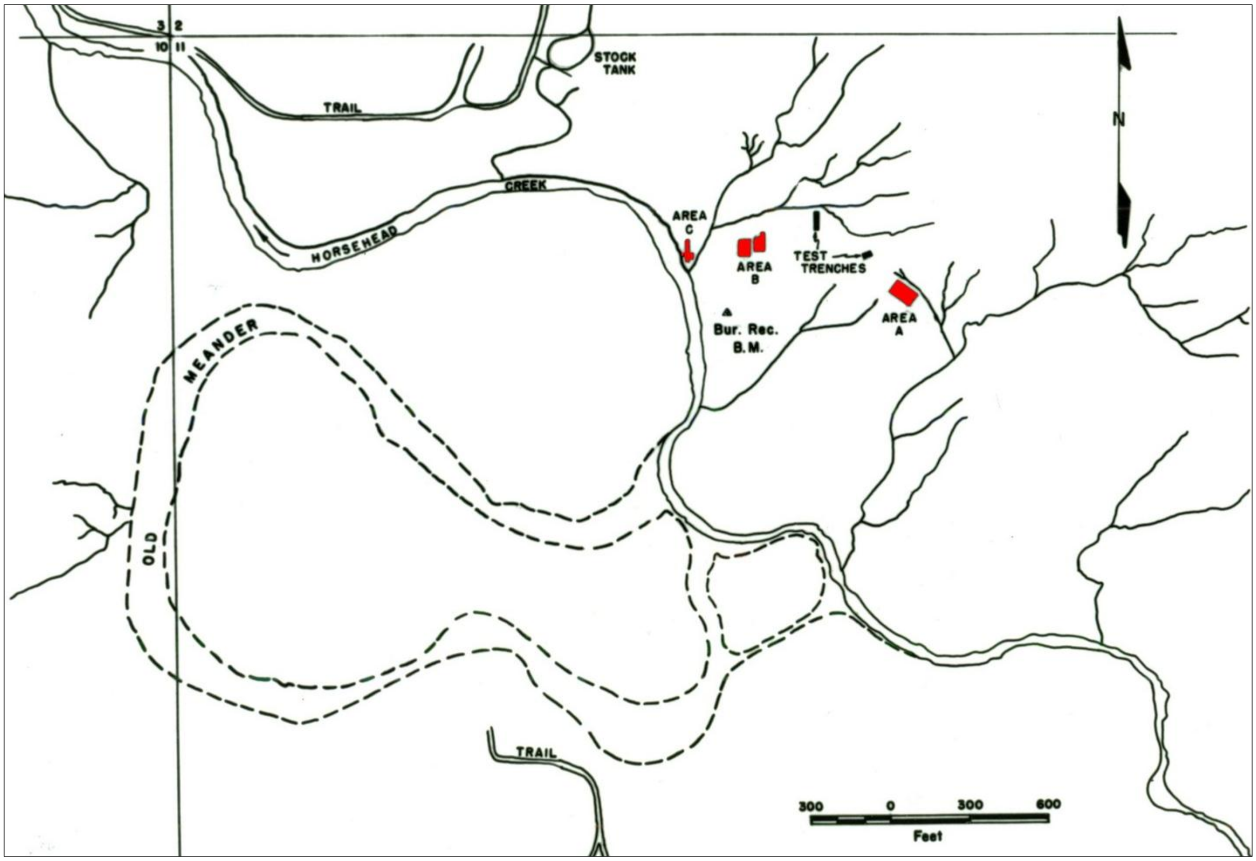

Figure 21. Wheeler's sketch map of the Ray Long site depicting the location of the Area A, B, and C excavations in red (adapted from Wheeler 1995:Figure 40).

Area A Investigations

Excavations in Area A were conducted from August 23 to September 11, 1948, from August 16 to September 8, 1949, and from July 3 to 18, 1950. In total, 46 full and 8 partial 5-ft-x-5-ft (ca. 1.5-m-x-1.5-m) units were excavated in Area A (Figure 22). The units were excavated to depths between 0.88 and 7.0 ft (0.27-2.13 m) below surface (Wheeler 1995:428-430). Excavations resulted in the discovery of 13 settlement features. Features identified include 10 unprepared hearths and 3 lithic workshop loci. The workshop loci, designated Features 1, 5, and 17, were small areas consisting, primarily, of concentrations of small-to-minute-sized flaking debris (Wheeler 1995:434). The hearths were classified as either lightly fired (n=5) or heavily fired (n=5). Of the lightly fired hearths, designated Features 4, 6, 7, 11, and 14, Features 4 and 14 were documented in direct association with artifacts. Both were documented in direct association with Angostura projectile point fragments and Feature 14 was also in close proximity to five flakes (Wheeler 1995:432). Of the heavily fired hearths, designated Features 2, 12, 16, 18, and 19, all except Feature 18 were documented in association with cultural material. Features 2 and 19 were documented in close proximity to Angostura projectile point fragments (Wheeler 1995:432-433).

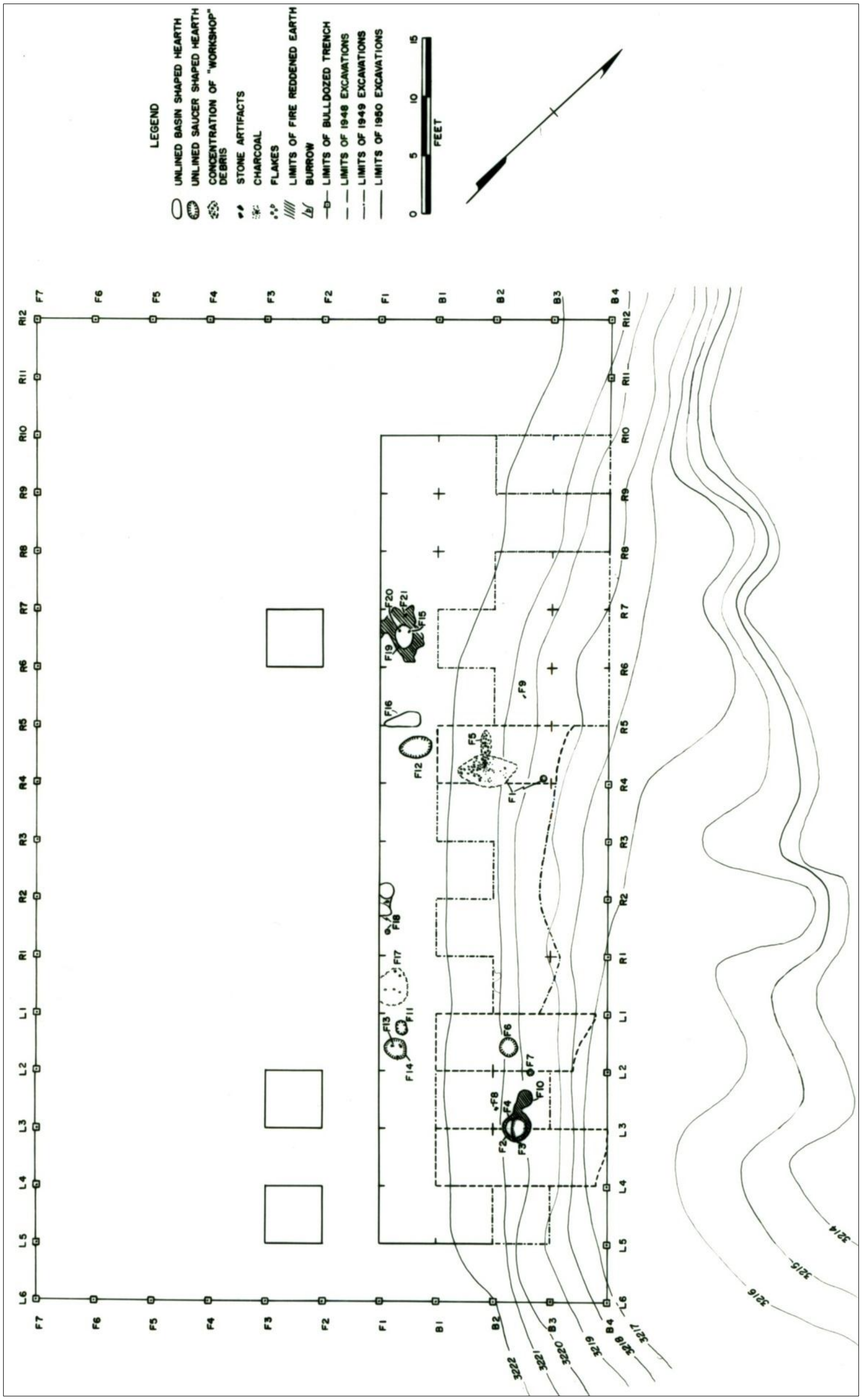

Figure 22. Wheeler's plan view map of Area A of the Ray Long site (from Wheeler 1995:Figure 50).

Artifacts recovered from Area A include 29 complete and fragmentary tools, 1,097 pieces of lithic debitage, and 1 lot of unidentifiable burned bone fragments retrieved from the Feature 19 hearth fill (Wheeler 1995:434-439). The assemblage of lithic reduction material consists, almost exclusively, of small and minute waste flakes. A total of 1,066 inventoried flakes are of various colors of fine-grained and very fine-grained quartzite, which is the raw material that the majority of identified Angostura points at the site are produced from (Wheeler 1995:434).

The tool assemblage from Area A is comprised of nine incomplete Angostura projectile points, two bifacial knives, one drill produced from an Angostura projectile point, nine scrapers, three utilized flakes, two choppers, one hammerstone, one engraver, and one palette fragment (Wheeler 1995:435-439). Also collected from Area A were 42 charcoal samples, including one from the talus screening, 39 from hearth fill and other subsurface localities excavated during 1948 and 1949, and two from bulk samples taken in 1950 from the two primary soil stratigraphic units within which the deposits were located. The bulk sample from the lower soil stratigraphic unit was radiocarbon dated to 9380 ± 500 RCYBP (Wheeler 1995:440). Seven of the nine Angostura point fragments from Area A were recovered in situ from subsurface contexts. These specimens were located either within or atop the soil stratigraphic unit from which the lone radiocarbon date for this area was obtained.

Area B Investigations

RBS crews spent portions of two field seasons working in Area B. Excavations were conducted there from September 8 to 17 in 1949, and from June 5 to July 3, and again between July 17 and 18, in 1950. In total, 18 full, 30 nearly complete, and 6 partial 5-ft-x-5-ft (ca. 1.5-m-x-1.5-m) units were excavated in two adjacent bulldozer trenches (Trenches 1 and 2) within Area B (Figure 23). The units were excavated to depths between 0.1 and 5.0 ft (0.03-1.52 m) below surface (Wheeler 1995:405, 407). Excavations resulted in the discovery of 12 settlement features. Features identified include 11 unprepared hearths and 1 large, amorphous burned area. The large area of burned clay shale, designated Feature 11, was fire-reddened and contained numerous fragments of charcoal. The feature was described as being at least 5 ft (1.52 m) across and as reaching a maximum depth of 0.15 ft (0.05 m) (Wheeler 1995:411). A mano fragment was discovered immediately above this feature. Wheeler presumed that this feature represented the remnants of a hearth that was disturbed prior to being buried. The hearths were classified as either lightly fired (n=7) or heavily fired (n=4). Of the lightly fired hearths, designated Features 9, 12, 13, 15, 16, 17, and 19, none was documented in direct association with artifacts (Wheeler 1995:409-410). Of the heavily fired hearths, designated Features 2, 10, 14, and 20, only Feature 14 was documented in direct association with cultural material; a single chalcedony flake and a small piece of burned sandstone were discovered in the fill of this feature (Wheeler 1995:411).

Artifacts recovered from Area B include 45 complete and fragmentary tools, 161 pieces of lithic debitage, 5 small cores, and 3 fragments and several tiny pieces of unidentifiable bone (Wheeler 1995:411-426). The assemblage of lithic reduction material consists exclusively of small and minute waste flakes. A total of 128 inventoried flakes are of various colors of fine-grained and very fine-grained quartzite, the material that the majority of identified Angostura points at the site are produced from (Wheeler 1995:411).

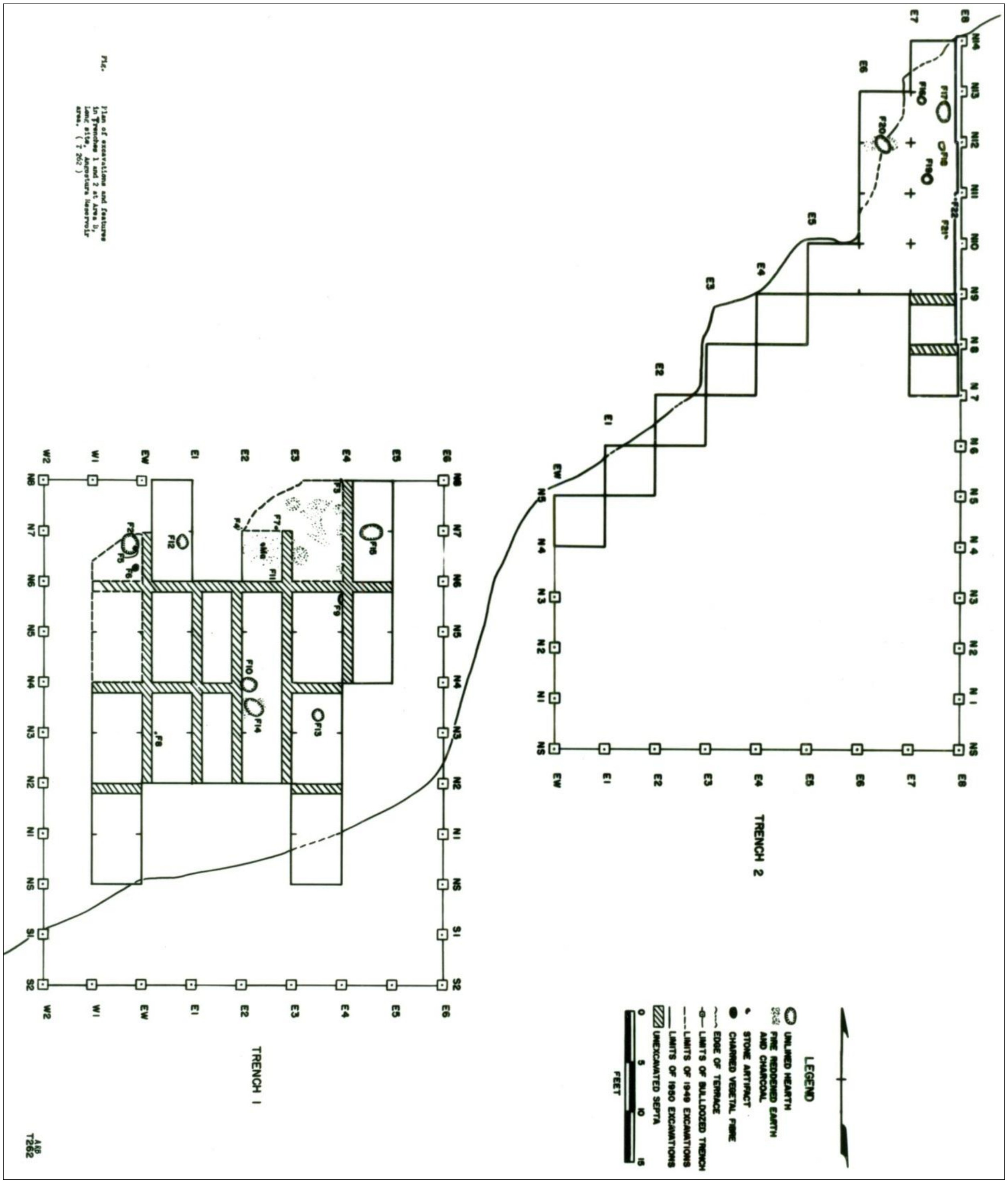

Figure 23. Wheeler's plan view map of Area B of the Ray Long site (from Wheeler 1995:Figure 44).

The tool assemblage from Area B is comprised of three incomplete Angostura projectile points, three biface preforms (which Wheeler interprets to be Angostura projectile point preforms), three bifacial knives, two distal drill tips, one hand drill, 12 scrapers, seven utilized flakes, three choppers, one hammerstone, two palette fragments, three metate fragments, and five manos

(Wheeler 1995:412-426). Also collected from Area B were 18 lots of charcoal and a mass of charred vegetal material consisting of small branches and grass stems. Two of the charcoal samples collected were submitted for radiocarbon dating. The first sample was collected from a 4-inch-thick (ca. 10.2 cm) lens of charcoal in unit N7 E4 of Trench 1 at a depth of 1.8 ft (0.55 m) below surface. It yielded a date of 7715 ± 740 RCYBP (Wheeler 1995:427). The second sample was collected from the fill of hearth Feature 14 in unit N3 E3 of Trench 1, approximately 20 ft (ca. 6.1 m) southwest of the provenience of dated charcoal sample 1. This sample yielded a date of 7073 ± 300 RCYBP (Wheeler 1995:427).

Area C Investigations

Of the three site areas investigated by Wheeler at Ray Long, Area C had been subjected to the greatest degree of disturbance from sheet wash and wind erosion. Prior to conducting excavations there, the area was succinctly described as "…extensively eroded and sparsely grassed" (Wheeler 1995:395). Surface cultural manifestations documented at Area C consisted of a sparse distribution of both complete and broken chipped and abraded lithic tools and debitage. Among the tools originally identified on the surface at Area C was a hand drill that had been reworked from an Angostura projectile point. The implications of this find alone likely served as the primary justification for expanded subsurface exploration of the largely deflated area.

Area C was the least intensively excavated at Ray Long and produced the least evidence of occupation. In total, 14 5-ft-x-5-ft (ca. 1.5-m-x-1.5-m) units were excavated at Area C between August 10 and 18, 1949 (Figure 24). The units were excavated to depths below surface that varied between 2.2 and 5.4 ft (0.67-1.65 m). Excavations resulted in the discovery of only one feature. This feature, designated Feature 1, is described as an unprepared hearth containing fire-reddened earth mixed with charcoal. It was uncovered at a shallow depth of only 0.1 ft (0.03 m) below surface (Wheeler 1995:398). Other lots of charcoal, 10 in total, were documented in subsurface contexts during excavations at Area C; however, none of these was confined to particular basin-shaped loci or observed in association with ash or burned earth. Wheeler attributed these ephemeral scatters of charcoal to additional hearths in the area that the limited excavations failed to uncover. He also suggested the probability that other such hearths have since been destroyed in the area as a result of landform erosion (Wheeler 1995:398). The Smithsonian Institution artifact catalog from Ray Long lists 10 lots of charcoal and two lots of finely divided charcoal and earth as being collected from Area C (see Appendix K). One of these charcoal samples, Catalog No. 267, was collected from unit N6 where Feature 1 was documented. Despite the collection of these samples, no radiocarbon dates were obtained from Area C of the site.

Artifacts recovered from Area C include 42 complete and fragmentary tools and 188 pieces of lithic reduction detritus. The assemblage of lithic reduction material consists of 185 flakes and three cores. The vast majority of the identified flake material was categorized as small waste flakes. Of the inventoried flakes, 119 are of the light red-to-purple-colored fine-grained quartzite that the majority of identified Angostura points at the site are produced from.

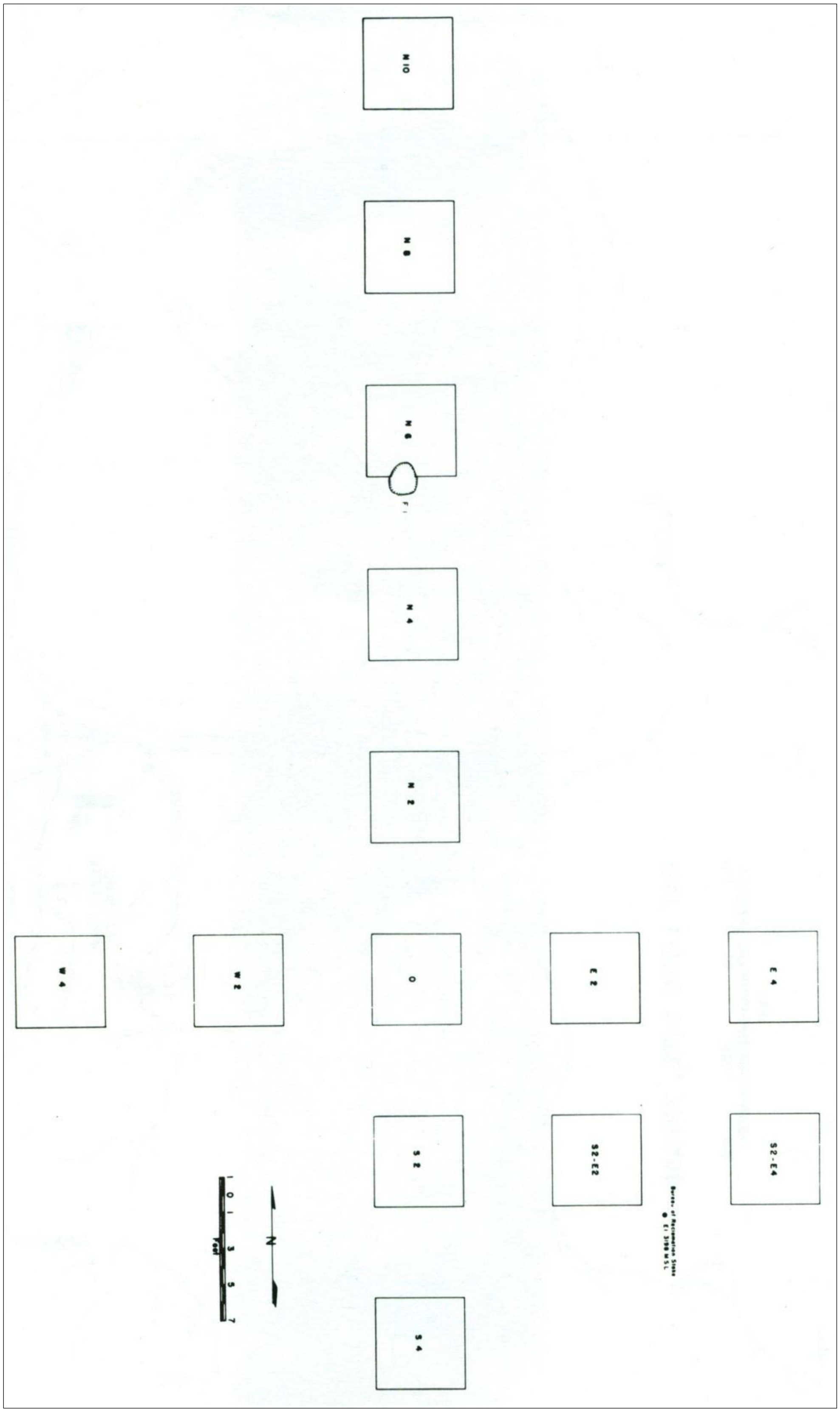

Figure 24. Wheeler's plan view map of Area C of the Ray Long site (from Wheeler 1995:Figure 41).

The tool assemblage from Area C is comprised of four incomplete projectile points, 14 bifacial knives, one drill produced from an Angostura projectile point (mentioned above), nine scrapers, two utilized flakes, four choppers, four hammerstones, one mano fragment, one metate fragment, and two palette fragments. Of particular interest are the projectile points and the drill. Clearly, the drill specimen is suggestive of an Angostura presence at Area C; however, two of the projectile points documented imply a more recent cultural presence in the area. These specimens, including a large stemmed point and a small stemmed specimen identified by Wheeler (1954) as "Duncan," are characteristic of later, Archaic-period groups.

REVISITING THE FINDINGS

Wheeler (1995:446-447) finds a definitive cultural correlation between Areas A and B at Ray Long. This cultural relationship is based on a series of traits identified by Wheeler which, taken together, are present at both Areas A and B of the site while being absent from Area C and all other identified sites in the Angostura Reservoir area and beyond. The traits identified by Wheeler are:

> …unprepared, small and medium-size, circular, subcircular or oval, lightly fired hearths; unprepared, medium-size, subcircular or oval, heavily fired hearths; narrow lanceolate, diagonally ripple flaked dart-points with narrow and slightly concave or straight base and ground lateral edges, of Angostura type; knives (curiously few in number; of indeterminate size and shape in Component B; large narrow lanceolate with straight base and small ovate with straight base in Component C); drill points (?); and medium-size and small flake-scrapers; utilized flakes; medium-size trapezoidal core-biface scrapers (cf. "Clear Fork gouges," etc.); small ovate (?) core-biface choppers; small subtriangular core-uniface scrapers; small hand-hammers (oval in Component B; flat, subtriangular in Component C); small unifacial palettes; small and minute, tissue paper-thin, waste flakes; and very fragmentary, unidentifiable animal bones [Wheeler 1995:446-447].

Wheeler (1995:448) interpreted Area C as being entirely unrelated to Areas A and B of the site and, for the most part, his argument does appear credible. The presence of two stemmed projectile points supports this interpretation, but more noteworthy is the documented disposition of the subsurface cultural material from Area C as compared to that from the other two areas of the site. The Area C material is described as "superficial," and the soil descriptions from the site indicate that the Area C deposits were confined to a different soil stratigraphic unit than that which Wheeler describes as containing the Angostura deposits from Areas A and B (Wheeler 1995:448).

One issue arises within Wheeler's argument that the presence of "unprepared" hearths is a notable trait that distinguishes Areas A and B of the site from other sites in the Angostura Reservoir area, including Area C of Ray Long (Wheeler 1995:446). One of these unprepared hearth features *was* also excavated at Area C. Unfortunately, the lack of absolute dates from Area C makes it impossible to positively confirm or refute Wheeler's interpretations about it relative to the other two areas of the site.

In a similar vein, there appears to be a lack of definitive evidence in the argument for cultural continuity between the Area A and Area B site occupations. Clearly, the presence of multiple Angostura projectile point fragments at both localities suggests an Angostura presence in both areas. The question is one of a secure timeframe. Unfortunately, the only Angostura projectile point specimens documented at Area B were identified surficially; none was discovered in situ in buried contexts that were associated with dated occupational features (Wheeler 1995:413-414).

The second issue concerns the dates themselves. Only one date, collected from a bulk soil organic matter (SOM) sample, was obtained from Area A of the site, and only two dates were obtained from Area B. As Wheeler (1995:447) points out, there is a 1,665-year time-gap between the two occupation areas at the site. When adjusted to one standard deviation such that the Area A date is corrected to be more recent (8880 RCYBP) and the Area B dates older (7373 and 8455 RCYBP), there still exists a 425-year discrepancy between the two localities. It must be remembered that when this site was first investigated, the science of radiocarbon dating was in its infancy. Today, with the use of accelerator mass spectrometers and some six decades worth of additional trials and practice in the field, labs can generate radiocarbon dates that are more precise and more accurate while using only a fraction of the organic material that was originally required. Other issues of potential sample contamination at this site were raised earlier (see Overview and Analysis of Radiocarbon Dates Chapter, this report; see also Appendix J).

AVENUES OF FURTHER EXPLORATION

Timing is everything. The ability to clearly visualize not only the spatial relationships between artifacts, camps, and activity areas at Ray Long, but also their distribution through time, is critical to the site interpretation process. Unfortunately, given what is now understood about both the site and the science of radiocarbon dating, the precision and accuracy of the dates obtained during the RBS investigations must be viewed with an ample degree of caution.

The most effective way to resolve this issue would be to obtain additional radiocarbon dates from the site, utilizing modern dating methods, and then use the new dates as a litmus test of sorts for the original dates. To a certain degree, this has been accomplished. Since the RBS excavations, an additional 21 radiocarbon dates have been obtained from Areas A and B of the site (see Table 1, this report). In Area A, Wheeler's date appears to have been largely validated; however, the same cannot be said about Areas B and C. No dates exist for Area C, and this locality was inundated and destroyed by wave-action from the reservoir subsequent to the RBS work at the site. In Area B, the additional dates obtained were from a trench and block grid located east of, and up slope from, Wheeler's two trenches; no dates were obtained from features in direct proximity to the samples Wheeler dated.

Though the science of radiocarbon dating was cutting-edge technology at the time, Wheeler clearly understood that advancements in technology and scientific methodology were unremitting. Because of this foresight, numerous organic samples were collected by the RBS, most in the form of charcoal lots, from each area investigated at the site. These samples were not dated at the time and are presently curated at the Smithsonian's Museum Support Center in Suitland, Maryland (see preceding chapter, this report; see also Appendix K).

Curated samples from Area A include lots of charcoal from the upper soil stratigraphic unit (Catalog No. 381) and from the fill of Feature 2 (Catalog No. 127) in this locality. The lone date Wheeler obtained from Area A was from a sample of organics in the lower soil stratigraphic unit. The date returned from this sample was 9380 ± 500 RCYBP. A date from the upper unit could provide a bounded timeframe within which the Area A occupation could be studied. A date from the Feature 2 fill would tighten this chronology even further. These dates would also serve to further test the accuracy of Wheeler's original date from this locality.

Curated samples from Area B include lots of charcoal from the fill of Feature 11 (Catalog No. 507), the charcoal lens in Trench 1, unit N7 E4 (Catalog No. 204), which Wheeler previously dated to 7715 ± 740 RCYBP, the Trench 2 occupation level (Catalog Nos. 561 and 562), and general SOM samples of the upper (Catalog Nos. 510 and 559) and lower (Catalog Nos. 511 and 560) soil stratigraphic units of the area. As with Area A, dates obtained from these samples, particularly the one associated with Feature 11, would greatly enhance our understanding of the occupational chronology of this locality, both independently and with respect to the other two occupation areas at the site.

Also among the curated samples is one from Feature 1 of Area C (Catalog No. 267). Processing of this sample would provide a valuable (the only) date for the occupation of this area of the site. This date could greatly clarify the temporal relationship between Area C and the two other site areas.

ALAC previously attempted to obtain these samples for dating but the request was denied by the Smithsonian's Sampling Committee (see preceding chapter, this report). However, ALAC recently contacted SI Department of Anthropology personnel about the possibility of obtaining these samples, or a portion thereof, for AMS dating. The preliminary response is encouraging. It was indicated that a written request to the Chair of the SI Department of Anthropology would likely result in permission to obtain these samples (Dennis J. Stanford, Curator of North American Archaeology, Smithsonian Institution, personal communication to L. Adrien Hannus 2012). Acquiring AMS dates from the above-listed organic samples would be the most valuable avenue to further explore with respect to the original RBS investigations at the Ray Long site. Such a suite of dates would help alleviate certain concerns about the precision and accuracy among the earliest dates published while concurrently tightening the occupational chronology for each of the three areas.

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