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Part 3

ADDITIONAL METEOROLOGICAL ANALYSES OF SHOT SMOKY, PLUMBBOB TEST SERIES

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INTRODUCTION

An in-depth meteorological analysis of Shot Smoky (August 31, 1957) was started during 1966 in the Plumbbob Test series. Results of the work completed prior to March, 1967 were reported in the last annual report.[1] In summary, it was shown that meteorological data provided as a special support for Shot Smoky contained errors. When included in the stream function analysis, these errors resulted in a trajectory pattern not consistent with other measured parameters. Deletion of these data resulted in a realistic stream function analysis, and the derived trajectory analysis provided a cloud travel path in spatial and temporal agreement with an aircraft observation to within a time period of 20 min at a distance of 770 km.

Research on Shot Smoky this year was directed toward the following objectives:

- To attempt further isentropic trajectory verification
- To correlate meteorological observations of precipitation with cloud passage
- To compare the results of the DELFIC program[2] representation of close-in fallout on Shot Smoky with manual calculations and the observed fallout pattern.

DISCUSSION

The 1966 annual report[1] showed that isentropic trajectory calculations were confirmed at 770 km to within a time of 20 min by correlation with an aircraft observation. Further confirmation of this technique to depict the temporal displacement of a debris cloud is now available. Cedar City, Utah is approximately 310 km from ground zero along the cloud path. The portion of the cloud following the 330° θ surface was computed to have arrived at this location at 3.5 hr after shot time. A U.S. Weather Bureau observer reported the nuclear debris cloud overhead on the 1558 Z August 31 meteorological surface observation. At the same time, an observer at Delta, Utah reported a nuclear cloud to the south coinciding with the computed arrival time of the 340° θ trajectory shown in Figure 1.

Measurements of the radioactive fallout material in the vicinity of Rock Springs, Wyoming[3] were higher than those of the surrounding area by a factor of five, i.e., a hot spot in the pattern. This finding can be attributed to depletion of the nuclear cloud material and subsequent ground deposition by scavenging mechanisms associated with precipitation. It has

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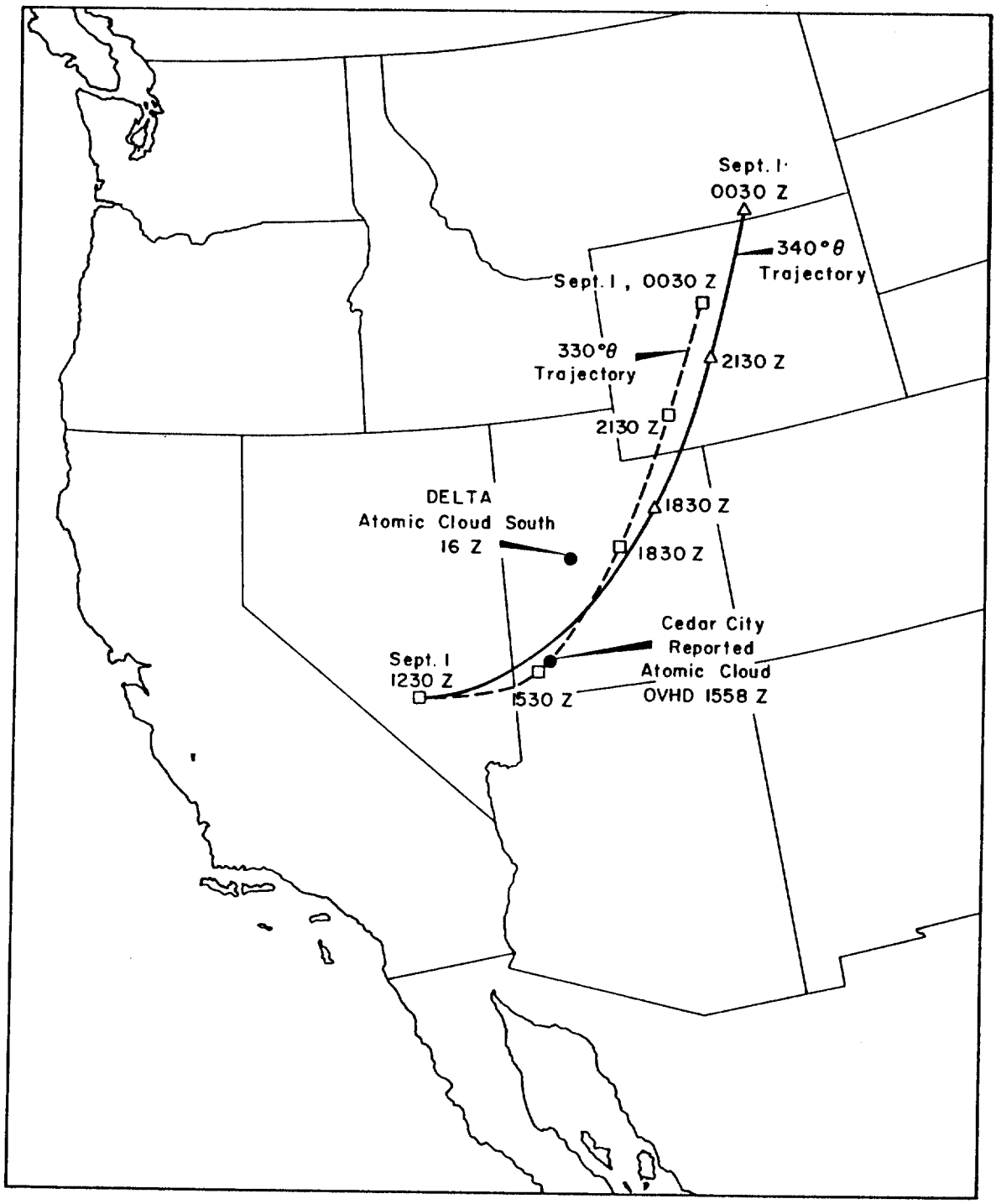

FIGURE 1. Isentropic Trajectories for Shot Smoky. Aug. 31, 1230Z to Sept. 1, 0030Z, 1957 θ = 330° dashed line
θ = 340° solid line
Time of arrival is noted along the paths.

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long been hypothesized and supported by experimental programs,[4,5,6,7,8] that when a particulate cloud coincides in space and time with a precipitating cloud then the particulates will be depleted from the atmosphere and deposited on the ground. Isentropic trajectory analyses for Shot Smoky showed that the debris cloud, travelling along the 320° θ surface, would arrive at Rock Springs, Wyoming at 13 to 14 hr after shot time, as shown by Figure 2. Meteorological observations from the U.S. Weather Bureau station at Rock Springs, Wyoming, as officially recorded, indicated precipitation at that time. Although specific in-cloud and below-cloud observations of radioactivity are not available, the coincidence of events provides an explanation for the "hot spot." However, the possibility that this high radiation measurement could have been deposited by previous shots cannot be entirely discounted.[4]

One other area where the computed cloud path coincided with a precipitation area was in North Central Wyoming. The upper air sounding at Lander, Wyoming during nuclear cloud passage indicated that the unstable conditions could have permitted precipitation scavenging up to about the 330° θ surface as shown by Figure 3. However, the lack of radioactivity measurements in this area precludes corroborative evidence of the washout mechanism.

A time consuming manual computation of the surface deposition pattern was performed for this study. A typical procedure fully defining a fallout pattern and the size separation was developed to include the required computations of mean vector winds for many layers in the atmosphere. These data were then averaged with respect to time and applied successively to the various particle size fractions, assumed to fall at constant velocities as a function of particle size until intersection with the ground. The Defense Land Fallout Interpretive Code (DELFIC) computational model[2] was developed to perform these functions. This DELFIC program was modified for use in the Univac 1108 and employed to define fallout pattern out to 170 km (manual methods were used for greater distances). The one condition necessary for use of the DELFIC model, i.e., intersection of the ground surface by the fireball, was satisfied by Shot Smoky.[4]

Meteorological input data as measured at Yucca Flat approximately 26 km south of ground zero were used as initial conditions (Figure 4). These vertical profiles of temperature and wind defined an initially stabilized cloud adjusted for wind deformation. The model computed the cloud top to be 12,290 m above sea level, whereas the one available observation placed the top at 11,500 m as shown in the following tabulation.

	Cloud Top	Cloud Bottom	Cloud Radius
Smoky[3]	11,500 m	~6,100 m	Not observed
DASA	12,290 m	7,983 m	4,000 m

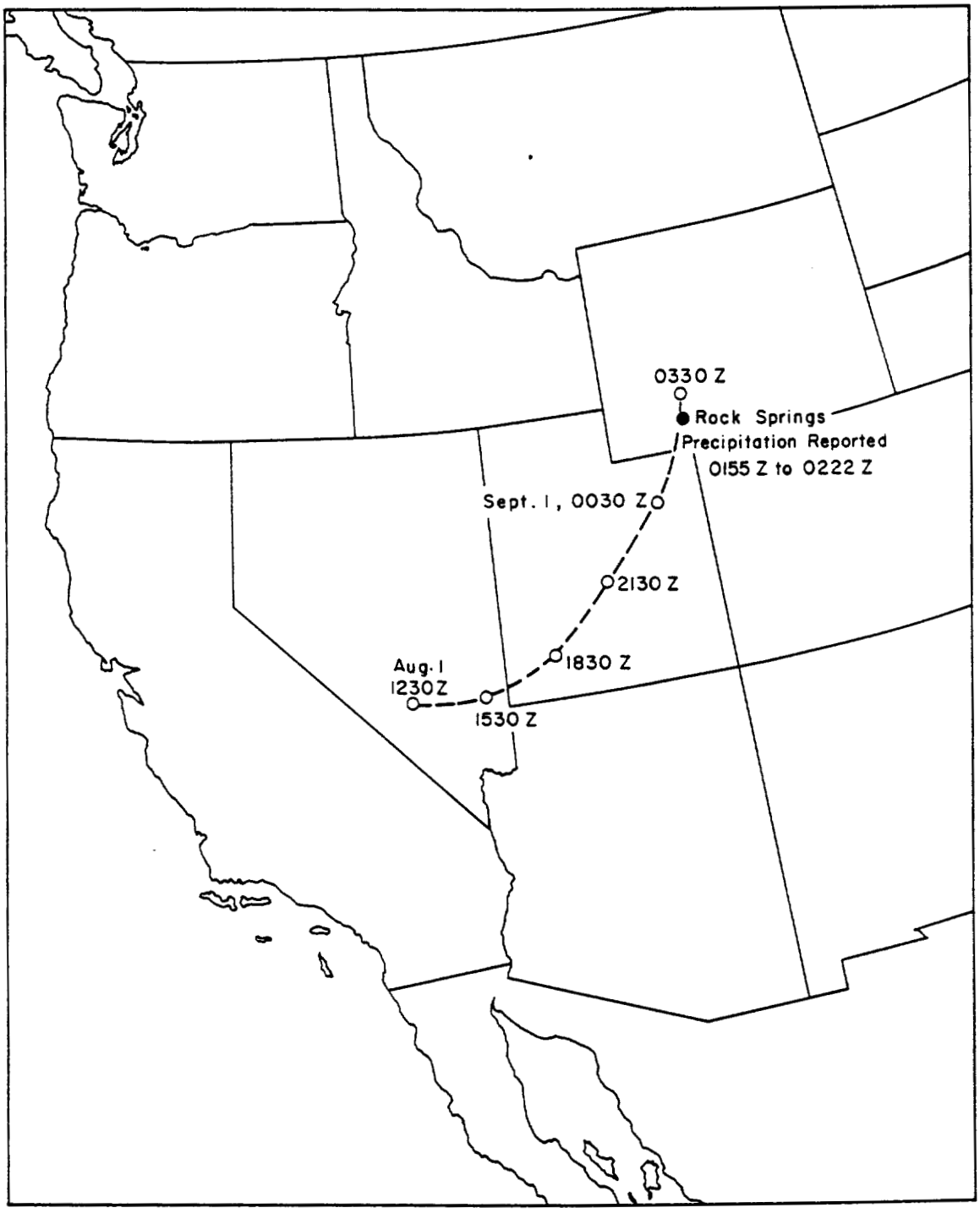

FIGURE 2. Isentropic Trajectory for Shot Smoky. Aug. 31, 1230Z to Sept. 1, 0030Z, 1957 θ = 320°

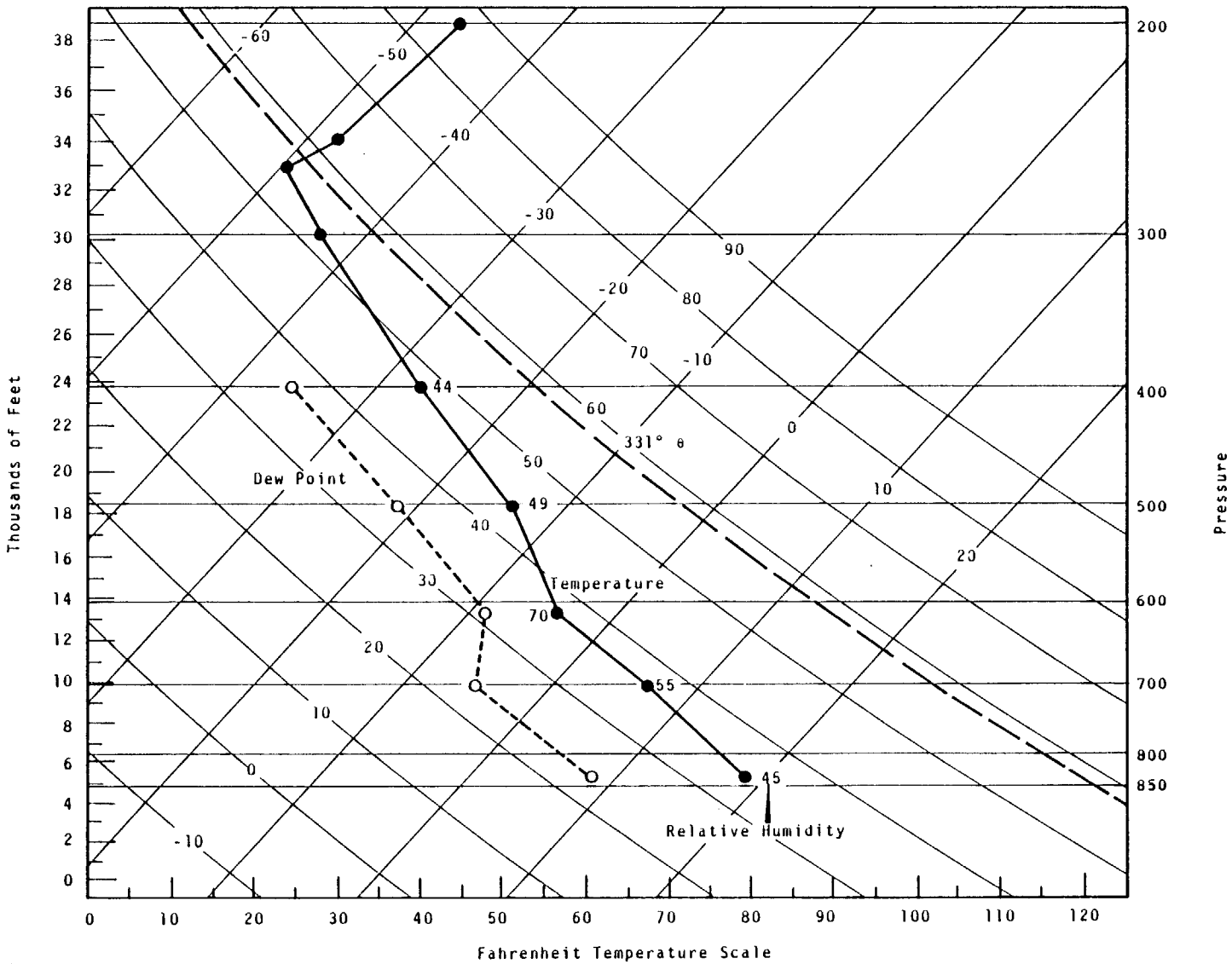

FIGURE 3. Plot of Radiosonde Report of Pressure, Temperature, Dew Point and Relative Humidity for Lander, Wyoming, Sept. 1, 00Z, 1957

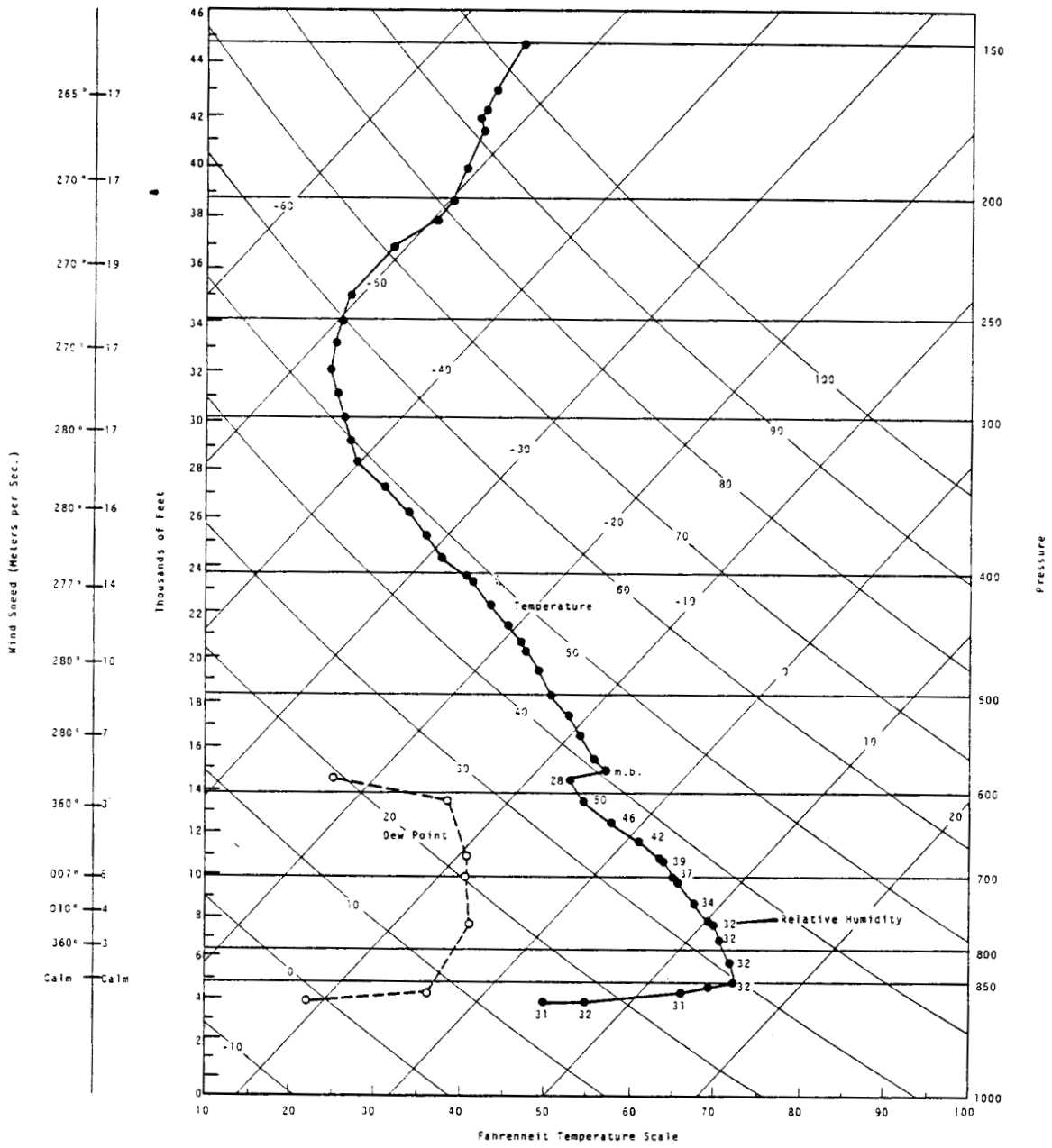

FIGURE 4. Plot of Radiosonde Report of Pressure, Temperature, Dew Point and Relative Humidity plus Upper Air Wind Report for Yucca, Nevada, Aug. 31, 1230Z, 1957

In practice, the DELFIC computations considered the wind field defined by the 10 data points nearest the cloud. These were processed and combined as inputs to the transport module, with the particle population as defined by the model. The cloud was moved in accordance to these data until new wind data were entered. This process was continued until the particles were calculated to have intersected the ground or the particles had passed through the boundary of the model.

The transport model also has a capability to consider local circulation cells. In the Shot Smoky analysis this option caused the program to cycle and resulted in an excessive use of computer time without producing usable results. The option was then removed and a deposition pattern was produced. The deposition patterns produced by the DELFIC[2] computations were compared with the measured values.[3] The following results were obtained:

- An anomalous low value near Sheep Mountain coincided with the measured value reported by K. H. Larson, et al.[3] As yet, which factors in the DELFIC model calculation are responsible for this result is not known.
- The computed mid-line coincided with the measured mid-line out to 90 km. Beyond 90 km, the computed mid-line was defined as being <5 km south of the measured mid-line.
- Computed and measured arrival times are in good agreement out to H + 3 hours. However, beyond that point and away from the centerline, disagreements of as much as 2 hr are noted.

Consideration of the vertical wind profile (Figure 4) indicated need for a north-south separation of particle sizes in the pattern as a result of the shear in the wind direction profile at 5 km above mean sea level. This is evident in the skewed distribution of the observed time of arrival to the south of the measured mid-line shown in Figure 5.[3]

Previously unpublished patterns[5] of observed particle sizes <44 μ, 44-88 μ, 88-105 μ, and 105-125 μ in diameter (Figures 6, 7, 8, and 9) were compared to the DELFIC prediction.

The computed and measured mid-lines were in good agreement for the 88-105 μ and 105-125 μ-size fractions out to 50 km from ground zero. From 50 km to 90 km, the computed mid-line diverged to a position about 5 km to the north of the observed mid-line at 90 km from ground zero.

Manual and DELFIC model calculations indicate that the <44 μ and 44-88 μ-size fractions should have been deposited along the southern part of the pattern (Figure 10). In fact, however, the measurements[3] indicate that the mid-line deposition for these particle sizes occurred along the mid-line prediction for the 100 μ to 350 μ-size particles as shown in Figures 6, 7, and 10. One possible explanation for this disagreement between predicted and observed deposition patterns for the

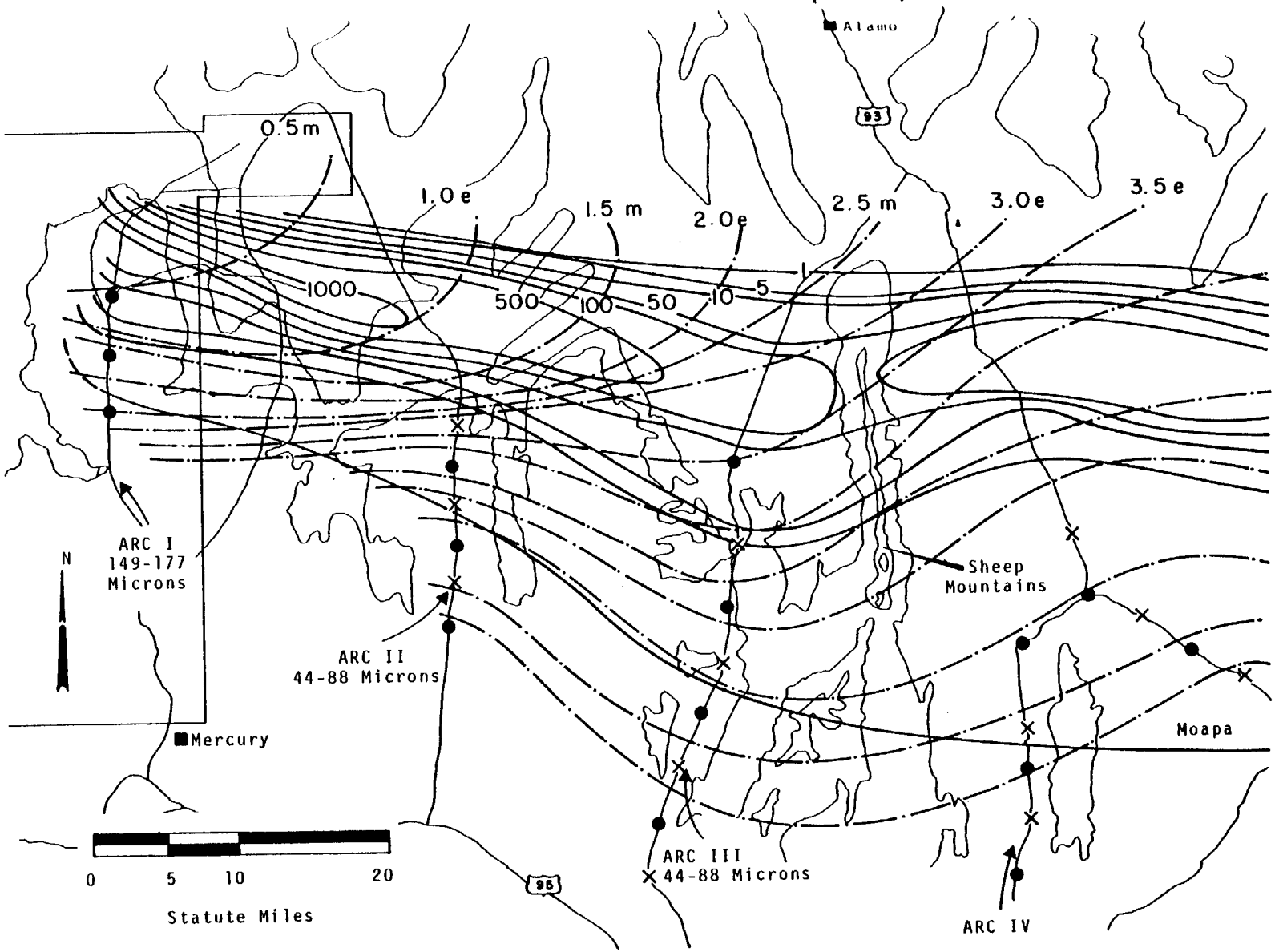

FIGURE 5. Smoky Fallout Pattern. Dose Rate Contours (solid line) MR/hr at H + 12 hr. Time of Arrival (H + hours) Shown by Dashed-Dot Lines

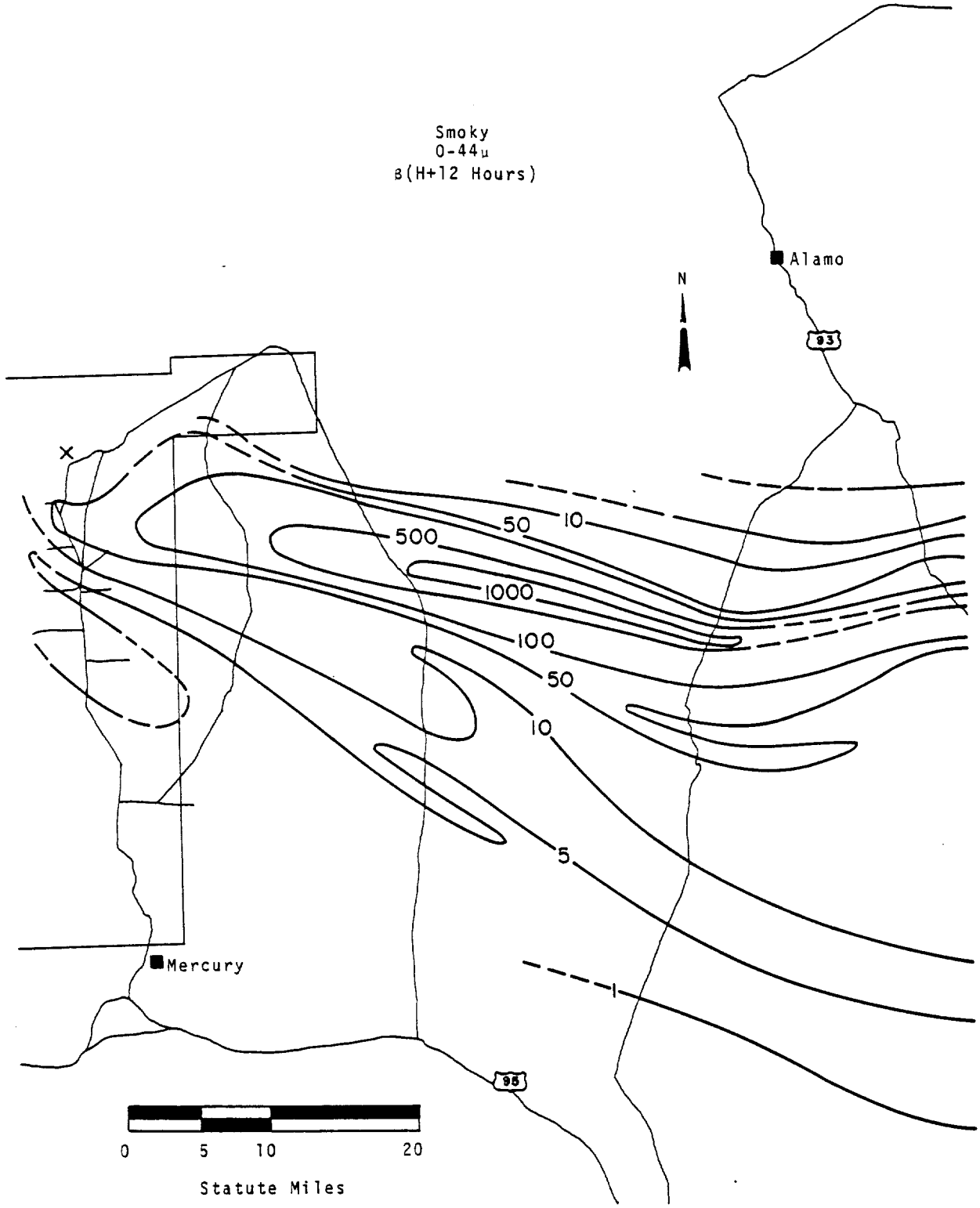

FIGURE 6. Smoky Fallout Pattern for <44 μ Diameter Particle. β(μc/ft²) at H + 12 hr

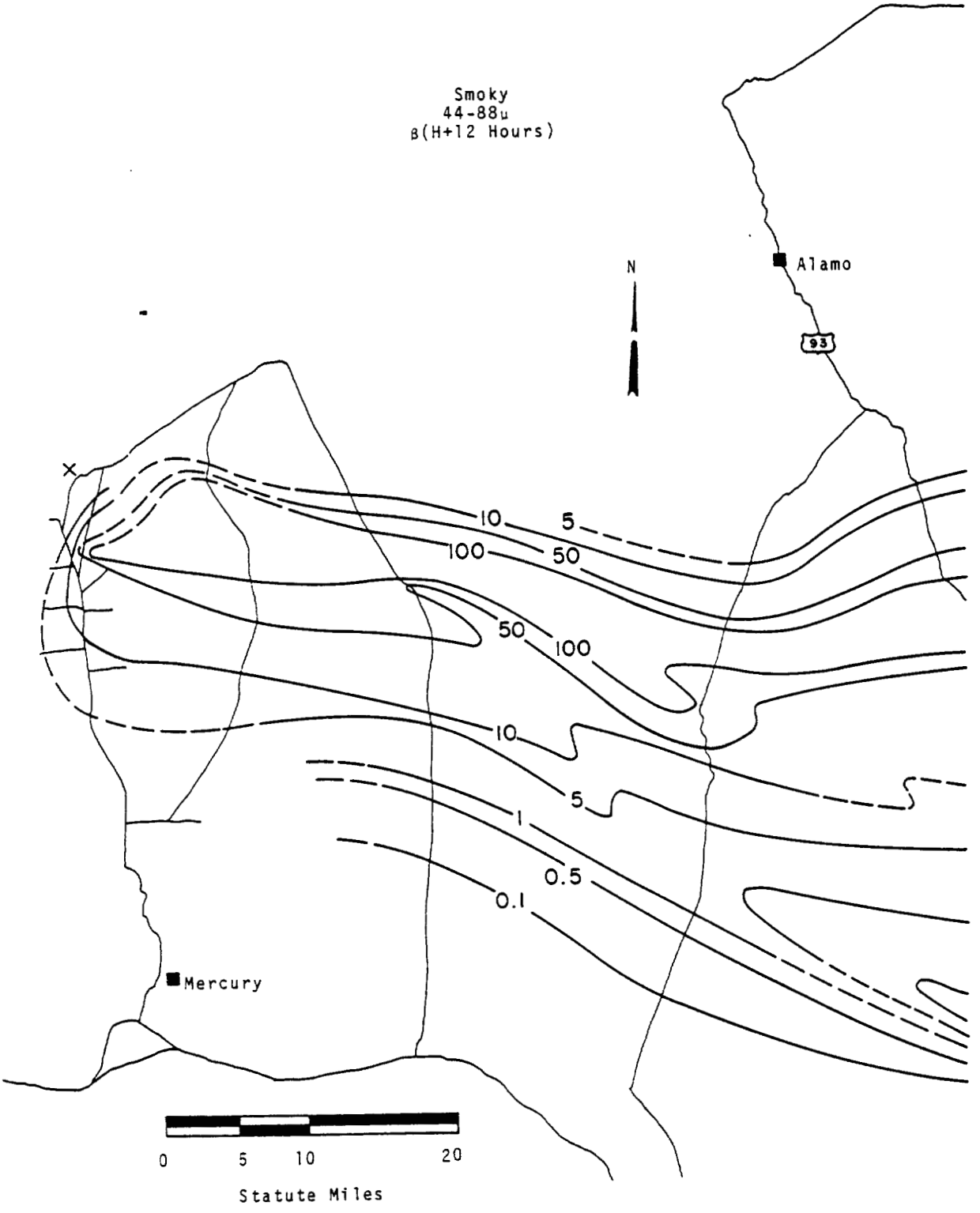

FIGURE 7. Smoky Fallout Pattern for 44 μ to 88 μ Diameter Particle. β(μc/ft²) at H + 12 hr

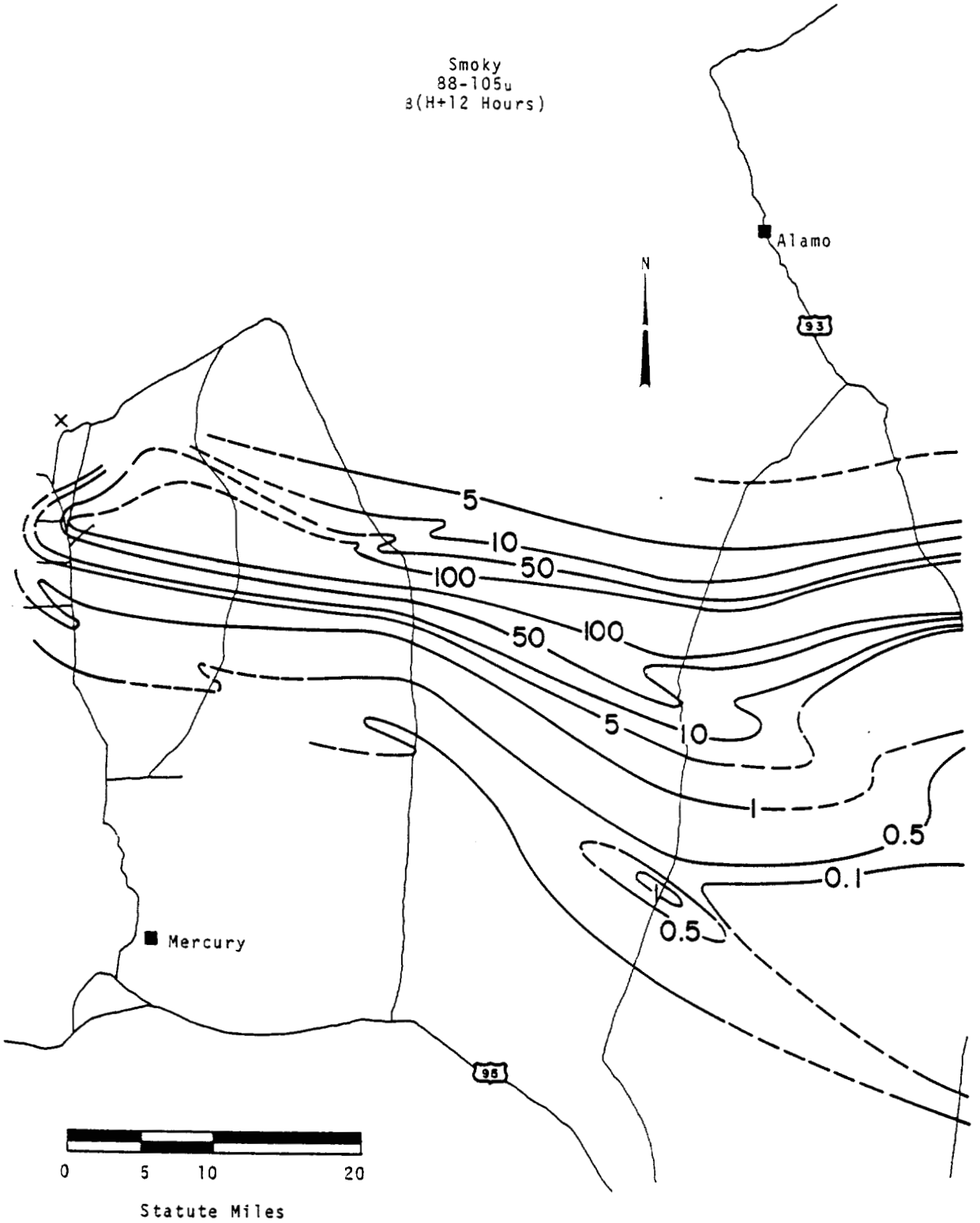

FIGURE 8. Smoky Fallout Pattern for 88 μ to 105 μ Diameter Particle. β(μc/ft²) at H + 12 hr

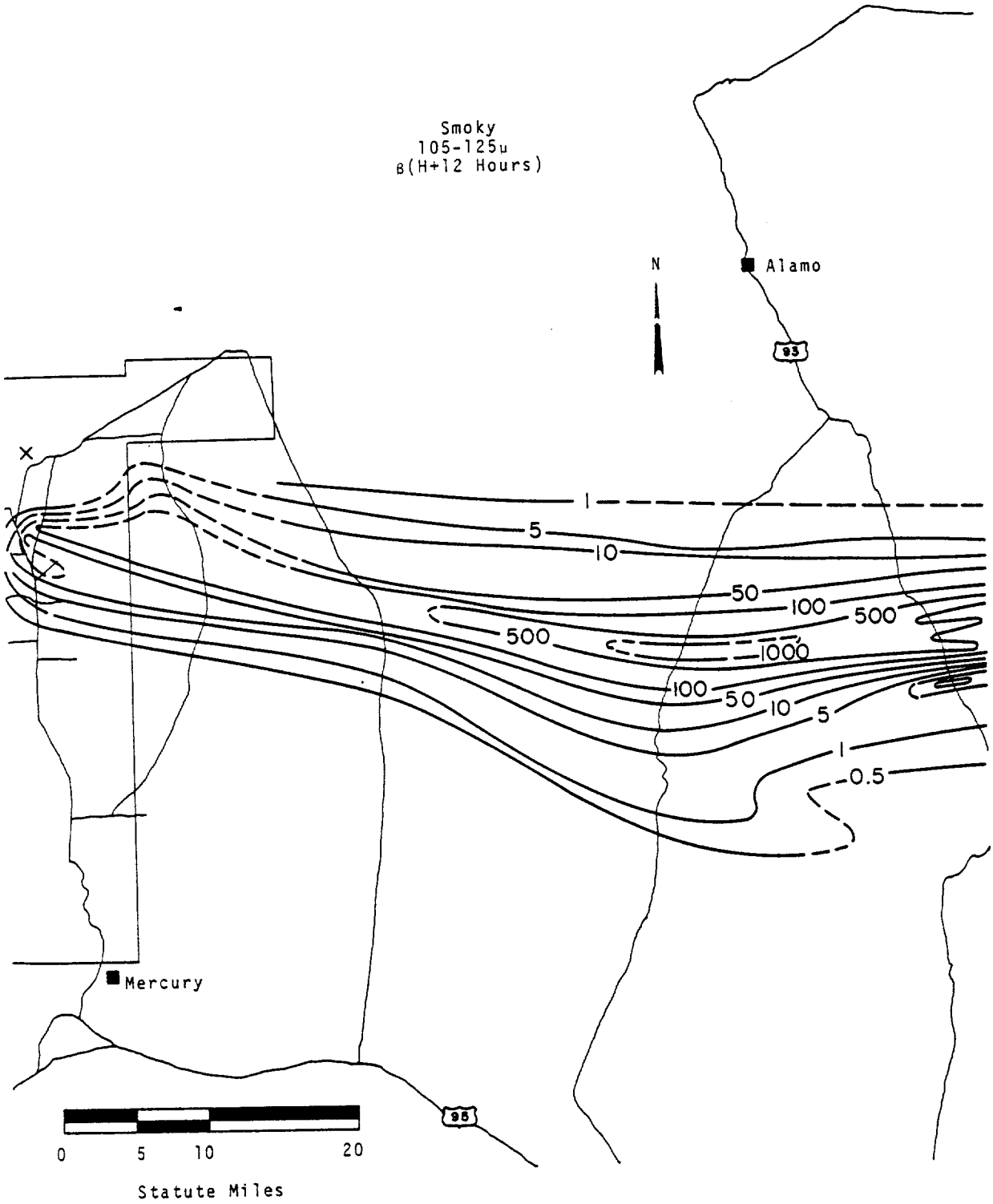

FIGURE 9. Smoky Fallout Pattern for 105 μ to 125 μ Diameter Particle. β(μc/ft²) at H + 12 hr

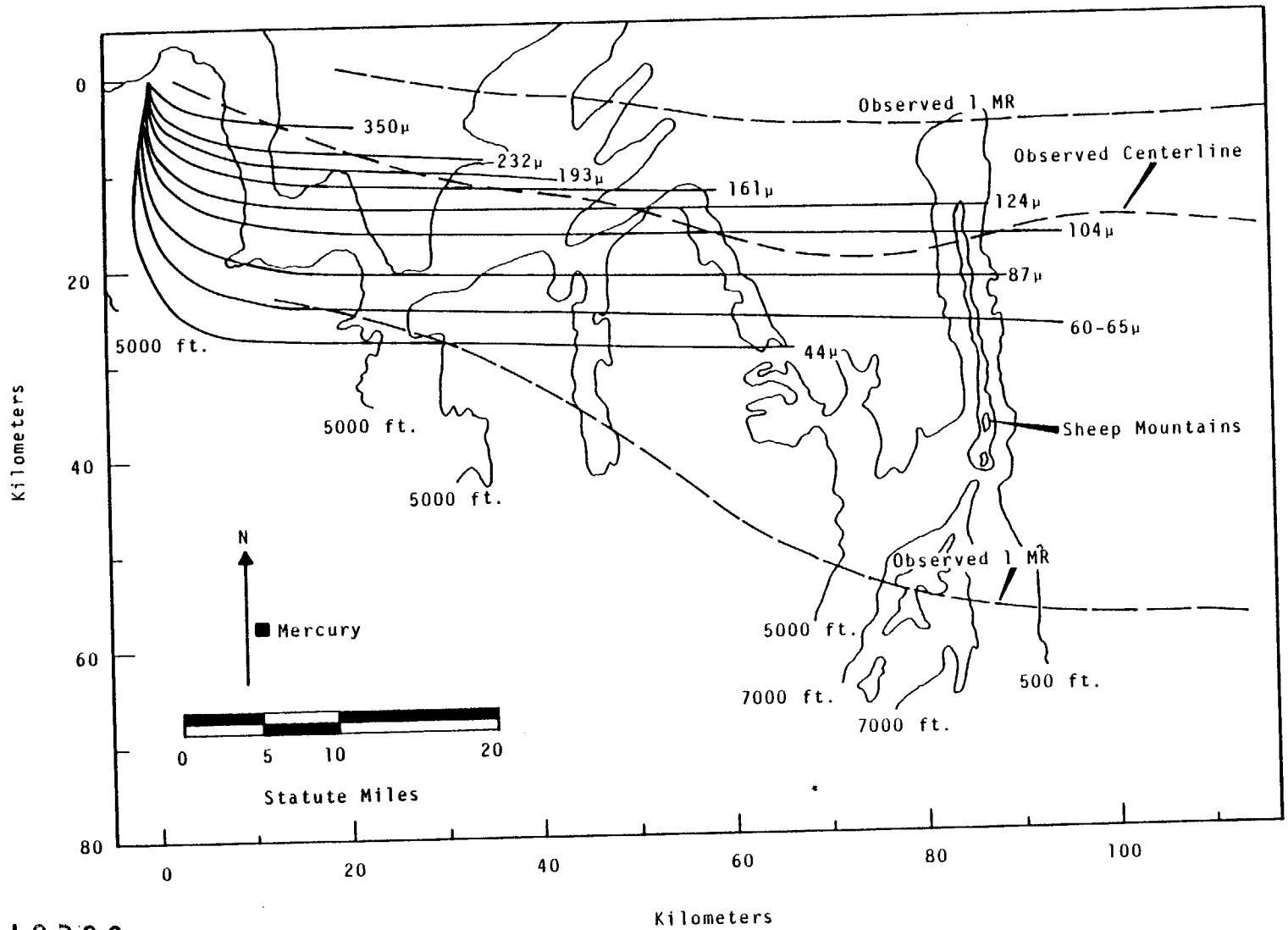

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FIGURE 10. Deposition Centerlines for Shot Smoky for 44 μ to 350 μ Diameter Particles as Predicted by Manual and DELFIC Calculations