Key Findings of CDC's LAHDRA Project: Public Exposures from the Trinity Test

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Photo by Jack Aeby

Testing of the Implosion-Assembled Plutonium Bomb Judged Necessary

During World War II, two atomic weapon concepts were carried through to production at Los Alamos. The implosion-assembled plutonium-based design was by far the more complicated. A test of that device was considered necessary because of the "enormous step" from theory and experiments to production of a combat weapon and realization that, if the device failed over enemy territory, "the surprise factor would be lost and the enemy would be presented with a large amount of active material in recoverable form" (Project Y, 1945). A "Fat Man" device was successfully tested at the Trinity Site near Socorro, New Mexico on 16 July 1945 and another was dropped over Japan 24 days later. Seen by some as one of the most significant events in world history, the Trinity test fell within the scope of the LAHDRA investigation.

The Trinity Test Site and Environs

Eight sites were considered for the Trinity test — four in New Mexico, two in California, one in Texas, and one in Colorado (Bainbridge 1976, USDOE 1994). The selected site was already part of the Alamogordo Bombing and Gunnery Range. As depicted in Figures 1 and 2, facilities at the test site included a shot tower placed at a location called "ground zero" (Figure 3). A Base Camp was built approximately 10 mi to the south-southwest and shelters were built 10,000 yd to the north, south, and west (Bainbridge, 1947, 1976).

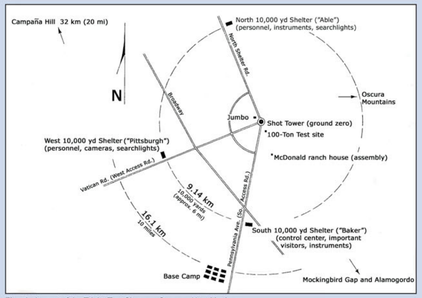

Fig. 1. Layout of the Trinity Test Site near Socorro, New Mexico

Based on analysis of maps issued in the early 1950s, there were approximately 63 ranches and three camps within 30 miles of ground zero, not including ranches that were taken over by the government in 1942 when the bombing range was established. The closest occupied residence at the time of the blast was approximately 12 miles north of ground zero. To preserve the secrecy of the atomic bomb mission, residents of New Mexico were not warned before the 16 July 1945 Trinity blast or informed of residual health hazards afterward, and no residents were evacuated.

The Trinity Blast and Conditions that Resulted

The Trinity device was placed atop a 100 ft steel tower that is shown in Figure 4 (Merlan, 1997). The device containing 6 kg of ^{239}Pu as its sole fissile material (USDOE, 2001) was detonated on 16 July 1945 at 5:29:15 a.m. (Bainbridge, 1976; Hacker, 1987). The published yield of the Trinity blast was 21 kt of trinitrotoluene equivalent (USDOE, 2000).

Exposure rates on the day of the world's first nuclear explosion measured up to 15 or 20 roentgens per hour (R h^{-1}) in public areas northeast of ground zero at distances around 20 miles, near Hoot Owl Canyon (Hempelmann, 1947; Hoffman, 1946; Hoffman, 1947; NTA, 1946). The areas of highest measured exposure rates are shown in Figure 2, including areas where terrain and air flow patterns caused the highest levels of fallout to occur in and around what became known to MED and Army personnel as "Hot Canyon" and on Chupadera Mesa. The Ratliff Ranch was in Hot Canyon (see Figures 5 and 6). That ranch, and another ranch near by were in areas where the highest exposure rates were measured on the day following the test, were unknown to monitoring teams and were not visited on 16 July 1945, so exposure rates there on test day could have been even higher. Ranchers reported that fallout "snowed down" for days after the blast. A rancher whose house was 20 mi northeast of Trinity, reported that "for four or five days after [the blast], a white substance like flour settled on everything" (Calloway, 1995).

Maximum recorded gamma exposure rates in some public areas were as follows:

- Bingham Area: 1.7 R h^{-1}
- Searchlight Station L-8: 2 R h^{-1}
- "Hot Canyon" Area: ~20 R h^{-1}
- White Store Area: 3.3 R h^{-1}

Because local ground water was not palatable to humans, many local residents collected rain water off their metal roofs into cisterns and used it for drinking water (see Figure 7). It rained the night after the test, so fresh fallout was likely consumed in collected water. Livestock were raised in the area, with most ranches having one or more dairy cows and a ranch near Hot Canyon maintaining a herd of 200 goats.

Fig. 7. System for collection of water off the roof of a residence on the Black Hills Ranch, formerly the Nalda Ranch, east-northeast of the Trinity Site. The cistern to the left, which was damaged by the Trinity blast and then repaired, is still in use today.

Fig. 3. An early wooden sign that marked the location of ground zero for the Trinity test of 16 July 1945 (foreground) and the obelisk that marks the location today (background)

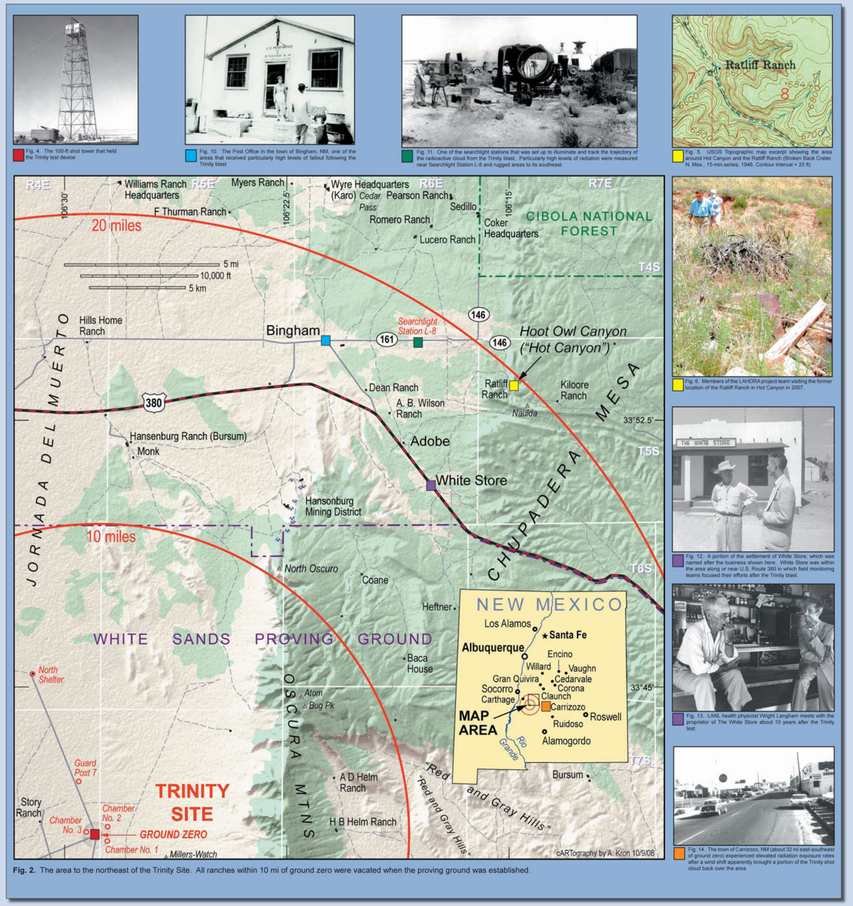

Fig. 2. The area to the northeast of the Trinity Site. All ranches within 10 mi of ground zero were vacated when the proving ground was established.

Fig. 8. Recovery team and radiation monitoring crew members after the Trinity blast

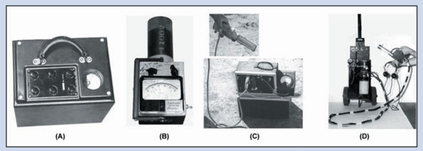

Fig. 9. Instruments used most commonly by field monitoring teams after the Trinity blast. A = Victoreen Model 247 ionization chamber; B = "Watts' Meter" ionization chamber; C = Hallicrafters G-M count rate meter; D = "Supersnoop" alpha counter.

Fig. 4. The 100-ft shot tower that held the Trinity test device

Fig. 10. The Post Office in the town of Bingham, NM, one of the areas that received particularly high levels of fallout following the Trinity blast

Fig. 11. One of the searchlight stations that was set up to illuminate and track the trajectory of the radioactive cloud from the Trinity blast. Particularly high levels of radiation were measured near Searchlight Station L-8 and rugged areas to its southeast.

Fig. 5. USGS Topographic map excerpt showing the area around Hot Canyon and the Ratliff Ranch (Broken Back Crater N. Mex., 15-min series, 1948. Contour interval = 25 ft)

Fig. 6. Members of the LAHDRA project team visiting the former location of the Ratliff Ranch in Hot Canyon in 2007

Fig. 12. A portion of the settlement of White Store, which was named after the business shown here. White Store was within the area along or near U.S. Route 380 in which field monitoring teams focused their efforts after the Trinity blast.

Fig. 13. LANL health physicist Wright Langham meets with the proprietor of The White Store about 10 years after the Trinity test.

Fig. 14. The town of Carrizozo, NM (about 32 mi east-southeast of ground zero) experienced elevated radiation exposure rates after a wind shift apparently brought a portion of the Trinity shot cloud back over the area.

Field Monitoring Team Measurements

Radiation levels after the Trinity blast were measured by field monitoring teams (Figure 8) using instruments that were crude, ill suited to field use, and incapable of effectively measuring alpha contamination from about 4.8 kg of unfissioned plutonium that was dispersed. The main instruments that were used are shown in Figure 9. Based on team records reviewed by LAHDRA team members, vehicle shielding and contamination were recognized but not corrected for.

The monitoring teams measured particularly high radiation exposure rates near Hot Canyon, the town of Bingham (Figure 10), Searchlight Station L-8 (Figure 11), and the town of White Store (Figures 12 and 13). Evacuation of members of the public was considered following measurement of elevated exposure rates near Bingham and Carrizozo, 32 miles to the east-southeast (Figure 14), but it was judged by Manhattan Project medical staff that radiation doses were not high enough to warrant such action.

Dose Evaluations Published for Trinity Test Fallout

All evaluations of public exposures from the Trinity blast that have been published to date have been incomplete in that they have not reflected the internal doses that were received by residents from intakes of airborne radioactivity and contaminated water and foods. Some unique characteristics of the Trinity event amplified the significance of those omissions. Because the "Fat Man" device was detonated so close to the ground, members of the public lived less than 20 mi downwind and were not relocated, terrain features and wind patterns caused "hot spots" of radioactive fallout, and lifestyles of local ranchers led to intakes of radioactivity via consumption of water, milk, and homegrown vegetables, it appears that internal radiation doses could have posed significant health risks for individuals exposed after the blast.

Protective Action Decision Making

The young health physics community had never faced the challenge of monitoring such an extensive environmental release of fission products, activation products, and unfissioned plutonium, and wartime pressure s to maintain secrecy and minimize legal claims led to decisions that would not likely have been made in later tests. Different standards of safety were applied to informed project workers than to uninformed members of the public.

Project workers knew enough to evacuate areas when high exposure rates were measured, to wear respirators, to close their windows and breathe through a slice of bread, and to bury their contaminated food rather than eat it. But members of the public did not realize that changes in their behavior were prudent, and project staff did not call for evacuations or protective measures even though predetermined tolerances for exposure rate and projected total exposure had been exceeded.

Even though exposure rates, total exposures, and alpha count rates exceeding pre-established limits were measured and projected; a "cover story" was in place that would have provided an avenue for relatively inconspicuous evacuation of selected residents; and evacuation personnel, vehicles, shelters, and supplies were on standby, no evacuations of members of the public were conducted.

Conclusions

Too much remains undetermined about exposures from the Trinity test to put the event in perspective as a source of public radiation exposure or to defensibly address the extent to which people were harmed. Beyond omission of internal doses, all assessments released to date are based on monitoring data that have not been subjected to the processes used in modern dose reconstruction studies that include quality checking, cross-checking against other data sources, application of appropriate adjustments or corrections, and uncertainty analysis.

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