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EXPOSURES PRIOR TO 1960 ✓

REPORT OF TEST MANAGER'S COMMITTEE TO ESTABLISH
FALLOUT DOSES TO COMMUNITIES NEAR THE NEVADA TEST SITE
APRIL 1959

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REPORT OF TEST MANAGER'S COMMITTEE TO ESTABLISH
FALLOUT DOSES TO COMMUNITIES NEAR THE NEVADA TEST SITE

APRIL 1959

The tabulation of estimated dose to approximately 300 communities in the area surrounding the Nevada Test Site covers the time period from the commencement of weapons testing in 1951 through the test series in the fall of 1958. The figures summarizing the dose accumulated from all series as given in the attached list are the estimated doses in roentgens applicable to persons living in these communities since 1951. The tabulation provides dosage figures for all series prior to Operation Plumbbob, for Plumbbob, and for the Hardtack II series.

Estimation of the gamma radiation doses most probably received by people involves different and sometimes conflicting sources of data, certain assumptions and several uncertainties. Following the Plumbbob test series, preliminary estimates for Plumbbob and for all tests through Plumbbob based on the early analysis of the monitoring data were prepared by the Off-Site Radiological Safety Group of the Nevada Test Site Organization and published in the Twenty-third Semiannual Report of the Atomic Energy Commission (January, 1958).

A revised list of estimated doses for all tests through Plumbbob was prepared by the Test Manager's Committee to Establish Fallout Doses and was published by the Nevada Test Site Organization in September, 1958, in the pamphlet entitled Background Information on Nevada Nuclear Tests.

Through Operation Plumbbob the attached and final list is substantially the same as the September, 1958, list. The small additional doses contributed by Operation Hardtack II have been included separately and in the total for all operations.

Estimation of Pre-Plumbbob Doses

In the fall of 1956, a committee was established by the Nevada Planning Board with William R. Kennedy of LASL as Chairman, to determine as well as possible what total doses the populations in a number of communities would receive as a result of the Nevada tests before and including Teapot. Several groups prepared estimates of these doses, and in a meeting on October 26, 1956, the committee considered all of the estimates and agreed on the most probable dose to each of 119 communities. These doses were published by the AEC in March, 1957, in the booklet entitled Atomic Tests in Nevada.

The data used for estimating the doses to communities were primarily the dose-rate monitoring reports of the Off-Site Radiological Safety groups, since those groups were essentially concerned with populated areas; also the dose-rate monitoring by the UCLA group (presently designated Program 37,

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CNEG) was used in analyzing the fallout patterns from various bursts. Where available, film badge results were considered in making the estimates.

In converting dose rates from the time of measurement to other times and in computing the infinite doses, the $t^{-1.2}$ decay law was used. The actual dose assigned to communities was the "one year effective biological dose." This unit, defined by Dr. Gordon Durning, Division of Biology and Medicine, U.S. A.E.C. is an estimate of the dose that people would receive considering (1) the normal shielding effect of buildings in which people live and work, (2) the weathering of the fallout which tends to reduce the radiation that people receive, and (3) the effects of biological repair. The one-year effective biological dose (EBD) was not considered significantly different from the lifetime dose in light of the many uncertainties involved. The EBD was computed from the infinite dose and the arrival time and ranges from 60 percent of the infinite dose for arrival times of 0.5 to 0.8 hours to 50 percent for arrival times of about 8 or 9 hours and 45 percent for arrival times of 21-24 hours.

The most detailed documentation of the fallout prior to Plumbbob is in the Weather Bureau publication, "The Distribution of Significant Fallout from Nevada Tests," dated October, 1956. That report contains an analysis of the 12-hour dose rate pattern and arrival times for each burst which had significant off-site fallout. The analyses were based on all available dose-rate monitoring data and on the wind analyses. The report and a supplement dated October 9, 1956, contain the estimates of the doses from each of the bursts considered on each of the 119 communities.

Based on the doses for the 119 locations, a map was prepared showing the EBD contours throughout the test site region. This map and appropriate maps and data from individual detonations were used to estimate the dosages for additional communities subsequently included.

Estimation of Plumbbob Doses

Preliminary Estimates. The preliminary estimates of doses to communities were prepared shortly after each burst using the observed dose rate in each community, the observed or estimated time of arrival of the fallout, and the $t^{-1.2}$ decay law to get the infinite dose. The unit of probable dose to man used was the estimated dose (ED) defined in the AEC publication, "Radiological Safety Criteria During Nuclear Weapons Testing at the Nevada Test Site," dated April, 1957. This unit is almost identical to the effective biological dose but does not reduce the dose on account of biological repair. Weathering is considered to increase the decay rate to $t^{-1.3}$ for the second week and to $t^{-1.4}$ thereafter, and normal shielding is assumed to reduce the dose by 25 percent. For the following selection of arrival times, the percent of the infinite dose yielding the estimated dose is given.

| <u>Arrival Time (hours)</u> | <u>Percent of Infinite Dose</u> |
|-----------------------------|---------------------------------|
| 0.1 - 1.3 | 61 |
| 3.3 - 4.2 | 55 |
| 12.1-16.0 | 50 |
| 16.1-40.0 | 49 |

In general only the monitoring data of the Off-Site Radiological Safety Group were used. The reasons for considering these estimates as preliminary are as follows:

1. They were made before careful wind analysis could be made to provide better estimates of arrival times in cases where the fallout arrival was not observed.
2. They were made before detailed analysis could be made of all monitoring data. In particular, the additional monitoring information collected by Program 37 of the Civil Effect Test Group was not available for use in delineating the fallout patterns at the early times when these estimates were made.
3. The prompt calculations did not allow adequate time for considering the residual radiation from previous bursts.
4. Film badge results were in general not available in making the estimates.

For the above reasons, the preliminary estimated doses for some communities were subject to error.

Estimates prepared by the Test Manager's Committee. The estimates of doses to communities resulting from the work of the Test Manager's Committee, headed by Dr. A. V. Shelton of Lawrence Radiation Laboratory, are given in the list prepared by the Special Projects Section of the U. S. Weather Bureau for the Test Manager, entitled "Cumulative Estimated Dose in Milliroentgens for all Nevada Tests through Operation Plumbbob," along with an explanation of the procedures used in estimating the dose. This list was included as a part of the minutes of the meeting of the Planning Board for the Nevada Test Site held shortly before the Hardtack II series. Further information pertinent to these doses is contained in the report entitled "Fallout Patterns, Operation Plumbbob," dated April 1, 1958, also prepared by Dr. Shelton's committee.

In brief, these estimates resulted primarily from the analyses based on dose-rate monitoring which appear in the April 1, 1958, report. The analyses for the bursts monitored by Program 37, which included most of the bursts with relatively heavy fallout, were prepared by that group using primarily the monitoring data collected by that group but also considering much of the dose-rate monitoring of the Off-Site Radiological Safety Group, and also, for the Diablo and Shasta tests, the patterns monitored by the Army-sponsored Project 50.8.

The remaining bursts were analyzed by the Weather Bureau Special Projects Section using the off-site group's monitoring information and, for the Kepler shot, some additional information provided by Project 50.8. Careful consideration of the winds was required for many of these bursts in an attempt to determine what was residual radiation from some of the earlier tower bursts.

Based on the average gamma decay rate of fallout from seven of the more important bursts, as reported by the Program 37 group, a "Plumbbob gamma decay rate" was determined and used. In the important period from 6 to about 100 hours after burst, this decay was slower than that indicated by the $t^{-1.2}$ law and from 180 out to 3,000 hours, was somewhat faster than the conventional decay. After 3,000 hours the $t^{-1.2}$ law was assumed, although data now available out to 10,500 hours indicate a faster decay than $t^{-1.2}$ after 3,000 hours. Figure 1 shows the cumulative dose given by the $t^{-1.2}$ law and by the decay rates assumed for Plumbbob. An initial dose rate of 100 mr/hr arriving at H + 6 hours was assumed. It can be seen that the Plumbbob decay indicated a total dose about 50 percent higher than did the $t^{-1.2}$ law.

Another consideration in the analysis was an instrument correction whereby any reading made on an MX-5 Geiger counter was multiplied by 1.3 to make it comparable to the reading from the AN/PDR-39 (ionization chamber). Only lower dose rates were changed by this correction, since the more significant fallout was always measured with AN/PDR-39 instruments.

The Weather Bureau computed the estimated dose from each burst for each community. In the case of bursts analyzed by Program 37, the off-site monitoring reports for communities were given considerable weight in estimating the dose.

Estimated doses prepared from the dose-rate monitoring information were compared to the results of the area film badge data of the Off-Site Radiological Safety Group. In order to get the estimated dose from a film badge reading, the indicated dose was multiplied by 1.3 to approximate the infinite dose and then divided by two to approximate the estimated dose. When the resulting estimated dose was greater than that computed from dose-rate monitoring (which occurred in only about 20 communities), the film-badge value was generally the one assigned to that community.

Estimation of Hardtack II Doses

The doses contributed to communities by the Hardtack II series were in all cases small. The off-site dose-rate monitoring data and the wind analyses were used to prepare patterns of the estimated dose for each burst, and these patterns were summed to indicate the cumulative dose from the series. In the absence of specific decay information for the many bursts of this series, the $t^{-1.2}$ decay law was used.

The area film-badge data of the Off-Site Monitoring Group provided another source of information on doses to communities. The film badges for the most part were exposed before the series and collected a few days after the end of the series. With possibly a few exceptions, they were exposed to more than half of the infinite dose from the Hardtack II series. Since the estimated dose is also roughly half of the infinite dose, the film badge dose as reported was used as a measure of the estimated dose. The

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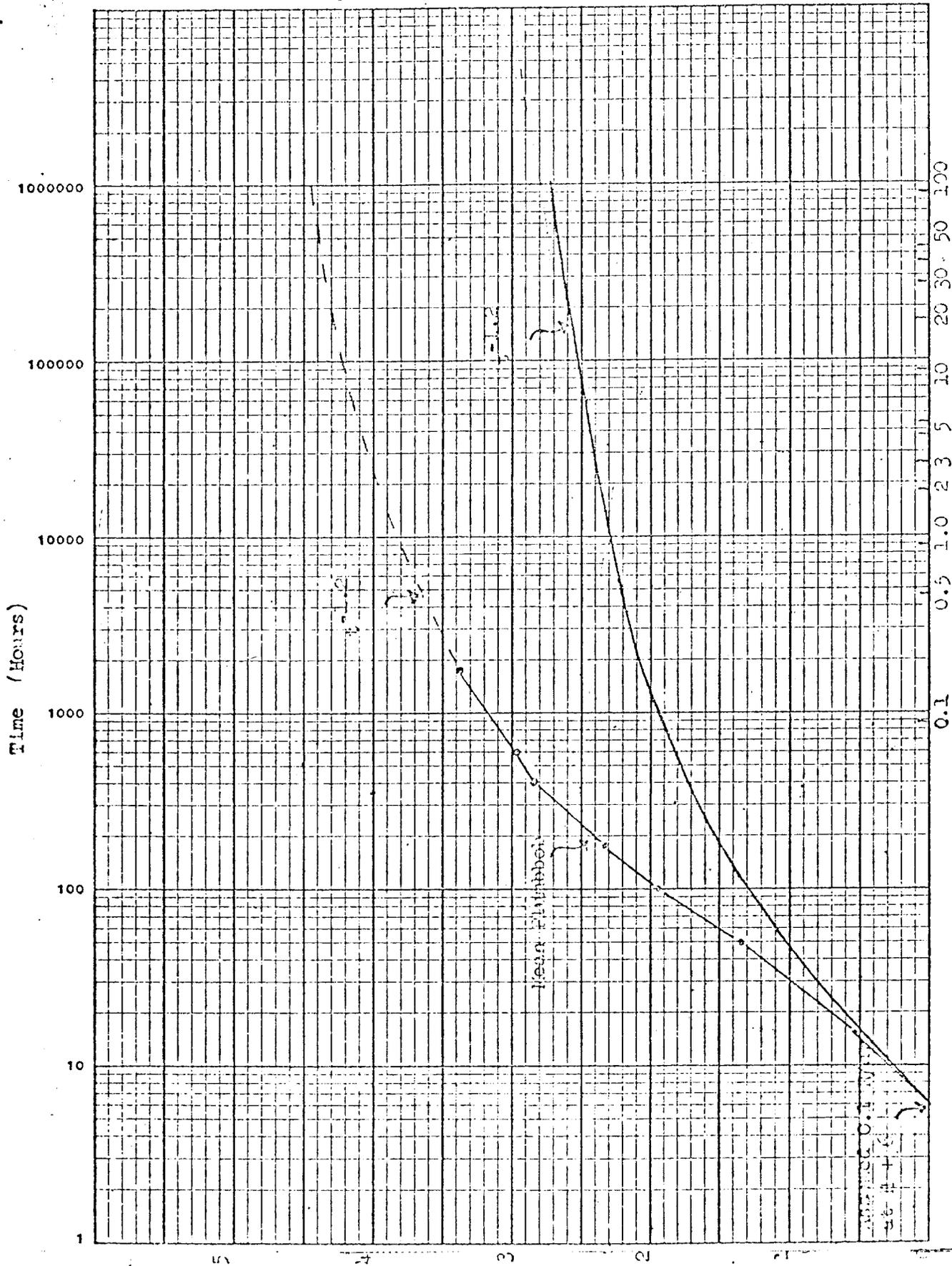


Figure 1. Comparison of Decay Rates

Equivalent Dose (Röntgens)

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pattern of estimated dose based on the film-badge results was similar in shape to that prepared from the dose-rate monitoring information, but in general indicated higher doses. The explanation probably lies in the errors inherent in the monitoring of very low dose rates and in the relatively high fraction of the dose contributed by airborne radioactivity while it drifted past some of the film badges.

The doses estimated for the various communities were primarily based on the analysis of the film-badge results, but no attempt was made to tabulate estimated doses of less than 0.05 roentgens.

Cumulative Doses Through Operation Hardtack II

The pre-Plumbbob effective biological dose was added to the Plumbbob and Hardtack II estimated doses to give the cumulative dose for all tests through Hardtack II since quantitatively these two definitions of the dose to communities are very similar.

Uncertainties in Estimating Fallout Doses

A number of the uncertainties involved in estimating doses to communities are summarized below:

Fission product decay rate. One of the more important uncertainties in estimating doses to communities is the gamma decay rate. There is evidence based on many samples from Operation Plumbbob that dosages calculated using the $t^{-1.2}$ decay rate for gamma radiation can be in error by as much as 50 percent. It is estimated that the total doses are uncertain by a factor of ± 0.3 because of the decay variations alone.

Instrument uncertainties. Although different types of instruments may be calibrated against a standard radiation source, their responses may differ for radiation from mixed fission products, and a correction may be required to make them compatible. Since higher values of dose rate are less subject to inaccuracies of instrument reading and were given more consideration by the individuals monitoring fallout, the following uncertainty factors as a function of total estimated-dose range in Roentgens (R) are considered applicable:

| | | | |
|----------------------------|-----------|------------|-----------|
| <u>Dose Range:</u> | < 0.1 R | 0.1 - 1.0R | > 1.0R |
| <u>Uncertainty Factor:</u> | ± 0.7 | ± 0.5 | ± 0.2 |

Film badge data use. The uncertainty factor resulting from the use of film-badge data in arriving at the estimated dose is ± 0.1 .

Analysis. Occasionally there was no monitoring in a community but the winds or the monitoring results from other areas indicated that there had been fallout there. The analysis of the fallout pattern is subject to error. Also, the arrival of the fallout is often not observed and

the arrival time must then be estimated from the wind field or from observed arrival times elsewhere. Particularly for early arrival times, an error of an hour or two can make a significant error in the cumulative dose. Another uncertainty stems from the fact that the fallout sometimes continues for an appreciable period of time. Thus, there is no single arrival time. What is desired is the effective arrival time which would give the proper integrated dose. Total doses are estimated to be uncertain by a factor of ± 0.1 because of analysis and arrival time errors.

Uneven deposition of material. Because of terrain, wind, ground cover, and the effects of buildings and paved areas, there is an unevenness of deposition of fallout material in a community. The uncertainty factors for unevenness of deposition of fallout material in assigning dose to communities are:

| | | | |
|----------------------------|-----------|------------|----------|
| <u>Dose Range:</u> | <0.1 R | 0.1 - 1.0R | >1.0R |
| <u>Uncertainty Factor:</u> | ± 0.4 | +0.2 - 0.4 | +0.1-0.3 |

Summary of Uncertainties. By taking the square root of the sum of the squares of the various uncertainty factors, it is possible to estimate the cumulative uncertainty factors believed applicable for various ranges of doses to communities, as given below.

| | For ED <u><0.1R</u> | For ED <u>0.1-1.0R</u> | For ED <u>>1.0R</u> |
|----------------------------------|---------------------------|---------------------------|---------------------------|
| Decay Rate | ± 0.3 | ± 0.3 | ± 0.3 |
| Instrument Errors | ± 0.7 | ± 0.5 | ± 0.2 |
| Film Badge Data Use | ± 0.1 | ± 0.1 | ± 0.1 |
| Analysis | ± 0.1 | ± 0.1 | ± 0.1 |
| Uneven Deposition | ± 0.4 | +0.2,-0.4 | + 0.1, -0.3 |
| Cumulative Uncertainty Factor | ± 0.86 | +0.63,-0.72 | + 0.4, -0.49 |

After careful deliberation the Committee agreed that the differences in the plus or minus uncertainties were not significant and to round the numbers to one significant figure. The numbers to be used with the total dose assigned to a community are:

± 0.8 for <0.1R ED
 ± 0.6 for 0.1 - 1.0R ED
 ± 0.4 for >1.0R ED

Tabulation of Doses

The tabulation presents the cumulative dose which an individual could have received had he lived and worked in a community continuously since 1951. However, people move about. It is impractical to assign a dose to those individuals who for example live in one community and work in another, or who move from one community to another. Therefore, caution must be used if one considers this dose to communities as applying to an individual.

In listing the estimated doses, a dash is used when the dose-rate monitoring, film-badge data, and fallout analysis indicated that there was no fallout or that the fallout was of such low levels that it could not reliably be distinguished from background radiation. In the Hardtack II data, doses of less than 0.05 Roentgens are included in this background category. In earlier series the attempt was often made, somewhat unrealistically, to estimate doses lower than 0.05 Roentgens.

All populated localities close to the Nevada Test Site are included in the list, together with all major and most small communities at greater distances within the fallout region. They are given alphabetically by states. The populations are naturally variable, but have been approximated as well as possible for Operation Plumbbob. Where significant variations are known, appropriate comments have been added to the tabulation.

Prepared April 2, 1959 in Washington, D. C.
by the following members of the Test
Manager's Committee to Establish Fallout
Doses: "

A. Vey Shelton, Chairman
Roscoe H. Goeke
William R. Kennedy
Kernit H. Larson
Kenneth M. Nagler
Oliver R. Placak

ARIZONA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|-----------------------------|-------------------|---|--|---|---|
| Beaver Dam | 5 | 2.00 | 0.30 | -* | 2.30 |
| Big Bend Ranch | 5 | (2.00) [#] | 0.19 | - | 2.19 |
| Bullhead | 500 | - | 0.02 | - | 0.02 |
| Catherine Ranger Station | x | - | - | - | - |
| Chloride | 160 | - | 0.02 | - | 0.02 |
| Davis Dam | 15 | - | - | - | - |
| Grasshopper Junction | 2 | - | 0.03 | - | 0.03 |
| Hackberry | 100 | - | 0.01 | - | 0.01 |
| Hughes Ranch | Transient | (2.00) | 0.30 | - | 2.30 |
| Kingman | 5,500 | 0.03 | 0.01 | - | 0.04 |
| Lake Mohave | 2 ^{1/2} | - | 0.02 | - | 0.02 |
| Littlefield | 44 | 1.60 | 0.32 | - | 1.92 |
| Mount Trumbull | 100 | 0.16 | - | - | 0.16 |
| Oatm | 40 | - | - | - | - |
| Peach Spring | 600 | - | - | - | - |
| Short Creek | 90 | 1.60 | - | - | 1.60 |
| Topock | 80 | - | - | - | - |
| Truxton | 26 | - | - | - | - |
| Valentine | 50 | - | 0.01 | - | 0.01 |
| Walapai | 15 | - | - | - | - |
| Warm Springs | x | - | - | - | - |
| Willow Beach | 5 | - | - | - | - |
| Wolf Hole | 5 | 1.30 | - | - | 1.30 |
| Yucca | 150 | - | - | - | - |

*As explained in the text, a dash implies no fallout or fallout not readily distinguishable from background radiation.

[#]Parentheses indicate that the community was not included in the October, 1956, list of Pre-Plumbbob doses.

*Population figures not available.

NOTE: Footnotes concerning populations of communities are on page 20.

CALIFORNIA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|------------------------------------|-------------------|---|--|---|---|
| Amboy | 1,004 | - | - | - | - |
| Baker | 726 | - | 0.03 | - | 0.03 |
| Barstow | 10,017 | - | 0.01 | - | 0.01 |
| Benton Station | 300 | - | 0.07 | - | 0.07 |
| Big Pine | 556 | - | 0.03 | - | 0.03 |
| Bishop | 2,891 | - | 0.06 | - | 0.06 |
| Boron | 592 | - | - | - | - |
| Camp Irwin | Variable | - | - | - | - |
| Cantil | 100 | - | - | - | - |
| Cartago | 126 | - | 0.03 | - | 0.03 |
| Chalfante | 25 | - | 0.10 | - | 0.10 |
| China Lake | 10,000 | - | - | - | - |
| Crest View | 25 | - | - | - | - |
| Daguerre | 525 | - | - | - | - |
| Death Valley Junction | 20 | - | - | 0.15 | 0.15 |
| Deep Springs | 100 | - | 0.03 | - | 0.03 |
| Emigrant Springs Ranger Station | 2 | - | 0.01 | 0.08 | 0.00 |
| Essex | 75 | - | 0.02 | - | 0.02 |
| Four Corners | x | - | - | - | - |
| Furnace Creek | 50 | - | - | 0.15 | 0.15 |
| Hinkley | 780 | - | - | - | - |
| Independence | 875 | - | 0.02 | - | 0.02 |
| Inyokern | 600 | - | - | - | - |
| Johannesburg | 300 | - | 0.03 | - | 0.03 |
| Kelso | 271 | - | 0.03 | - | 0.03 |
| Laws | 72 | - | 0.07 | - | 0.07 |
| Lenwood | 2,600 | - | 0.01 | - | 0.01 |
| Littlelake | 32 | - | - | - | - |
| Lone Pine | 1,415 | - | 0.03 | 0.05 | 0.03 |

CALIFORNIA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|-----------------|-------------------|---|--|---|---|
| Ludlow | 250 | - | - | - | - |
| Manix | 10 | - | - | - | - |
| Mojave | 2,055 | - | - | - | - |
| Mountain Pass | 10 | - | - | - | - |
| Needles | 5,480 | - | - | - | - |
| Newberry | 700 | - | - | - | - |
| Oasis | 12 | - | 0.10 | - | 0.10 |
| Olancha | 275 | - | 0.03 | - | 0.03, |
| Randsburg | 281 | - | - | - | - |
| Red Mountain | 320 | - | 0.03 | - | 0.03 |
| Ridgecrest | 4,000 | - | 0.02 | - | 0.02 |
| Ryan Mine | 1 | - | 0.06 | 0.15 | 0.21 |
| Shoshone | 100 | - | - | - | - |
| Silv Lake | 10 | - | 0.05 | - | 0.05 |
| South Haiwee | 25 | - | - | - | - |
| Stovepipe Wells | 2 | - | 0.01 | 0.05 | 0.06 |
| Tecopa | 25 | - | - | - | - |
| Tom's Place | Variable | - | 0.02 | - | 0.02 |
| Trona | 3,500 | - | - | - | - |
| Wheaten Springs | x | - | - | - | - |
| Yermo | 700 | - | 0.01 | - | 0.01 |
| ZZZZ Springs | 40 | - | - | - | - |

NEVADA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|------------------------|------------------------|---|--|---|---|
| A2B Mine | 4 - 12 | (0.50) | 2.90 | - | 3.40 |
| Acama | 10 | 3.00 | - | - | 3.00 |
| Adam's Ranch | x | (1.00) | 0.37 | 0.80 | 2.17 |
| Alamo | 250 | 1.30 | 0.04 | 0.05 | 1.39 |
| Apex | 50 ^{2/} | 0.10 | 0.03 | - | 0.13 |
| Ash Meadows | 8 | 0.05 | 0.01 | 0.15 | 0.21 |
| Ash Springs | 5 | 0.60 | 0.06 | - | 0.66 |
| Atlanta | 2 | (0.30) | 0.26 | - | 0.56 |
| Austin | 520 | 0.05 | 0.15 | - | 0.20 |
| Babbitt | 2,464 | - | 0.23 | 0.05 | 0.28 |
| Baker | 60 | 0.80 | 0.25 | - | 1.05 |
| Barclay | 10 | 2.00 | 0.04 | - | 2.04 |
| Barlow Ranch | 13 ^{1/} | (1.70) | 0.26 | 0.08 | 2.04 |
| Basalt | 8 | - | 0.15 | 0.05 | 0.20 |
| Beatty | 550 | 0.05 | 0.11 | 0.05 | 0.21 |
| Bolew Ranch | 3 | (1.19) | 0.47 | 0.08 | 1.74 |
| Belmont | 6 | (0.10) | 1.10 | 0.05 | 1.25 |
| Blue Diamond | 400 | (0.05) | - | - | 0.05 |
| Blue Eagle School | 11 | (1.04) | 0.46 | 0.05 | 1.55 |
| Bonanza Boy Scout Camp | Variable ^{4/} | (0.12) | - | - | 0.12 |
| Bond Ranch | x | (0.05) | 0.70 | - | 0.75 |
| Boulder City | 4,000 | 0.08 | - | - | 0.08 |
| Boyd | Variable ^{5/} | (1.50) | 0.04 | - | 1.54 |
| Bristol Silver Mine | 25 - 50 | (0.64) | 0.06 | 0.08 | 0.78 |
| Buckhorn Ranch(US 93) | 12 | 0.90 | 0.08 | - | 0.98 |
| Bunkerville | 250 | (4.30) | 0.17 | 0.05 | (4.52) |
| Butler Ranch | 26 ^{1/} | ((8.40)) | (6.60) | - | (15.00) |

NEVADA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|-------------------------------------|------------------------|---|--|---|---|
| Cactus Springs | 18 | 0.03 | 0.05 | - | 0.08 |
| Caliente | 970 | 0.70 | 0.01 | 0.05 | 0.76 |
| Carp | 25 | 3.60 | 0.30 | - | 3.90 |
| Castleton Mine | 40 - 147 | (0.70) | 0.02 | - | 0.72 |
| Charleston Lodge | 60 | 0.15 | - | - | 0.15 |
| Cherry Creek | 112 | (0.26) | 0.24 | - | 0.50 |
| Clark's Station | 0- 5 | 0.80 | 0.81 | - | 1.61 |
| Cloud | Variable ^{5/} | (3.00) | 0.65 | - | 3.65 |
| Coaldale | 25 | - | 0.88 | 0.10 | 0.98 |
| Cole & Dolan Ranch | 3 | (0.50) | 0.26 | 0.05 | 0.81 |
| Corn Creek | 11 | (0.40) | - | - | 0.40 |
| Cove | 20 | (0.55) | 0.30 | - | 0.85 |
| Crestline | 22 | 0.70 | - | - | 0.70 |
| Crye 1 | 5 ^{7/} | 4.00 | 0.06 | - | 4.06 |
| Currant | 75 | 0.50 | 0.33 | - | 0.83 |
| Delmic | 7 | (0.60) | 0.01 | - | 0.61 |
| Desert Rock | Variable ^{8/} | 0.05 | 0.02 | 0.08 | 0.15 |
| Dodge Construction Camp | 175 ^{9/} | (8.00) | 2.70 | 0.10 | 10.80 |
| Donahue Ranch | 4 | (0.25) | 0.05 | 0.05 | 0.35 |
| Dry Lake | 20 | 1.00 | 0.03 | - | 1.03 |
| Duckwater | 50 | 0.80 | 0.21 | - | 1.01 |
| D-X Ranch | x | (0.85) | 0.20 | - | 1.05 |
| Dyer | 35 | - | 0.13 | 0.05 | 0.18 |
| East Ely | 1,000 | 0.60 | 0.55 | 0.05 | 1.20 |
| El Dorado | 3 | (0.45) | 0.60 | - | 1.05 |
| Eldridge Ranch (N. of Eureka) | 4 | (0.20) | 0.34 | - | 0.54 |
| Eldridge Ranch (Mt. Wheeler Inn) | x | (0.85) | 0.13 | - | 0.93 |
| Elgin | 30 | 3.50 | 0.06 | - | 3.56 |
| Ely | 3,558 | 0.60 | 0.55 | 0.05 | 1.20 |

NEVADA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|-------------------------------|------------------------|---|--|---|---|
| Etna | Variable ^{5/} | (0.80) | 0.02 | - | 0.82 |
| Eureka | 500 | 0.20 | 0.60 | 0.05 | 0.85 |
| Fallini Ranch | 15 | 0.80 | 1.10 | 0.08 | 1.98 |
| Fallon | 2,400 | - | 0.14 | - | 0.14 |
| Fish Creek Ranch | x | (0.50) | 0.60 | 0.05 | 1.15 |
| Gabbs | 625 | - | 0.38 | - | 0.38 |
| Galt | Variable ^{5/} | (6.00) | 4.90 | - | 10.90 |
| Garnet | Variable ^{5/} | (0.85) | 0.05 | - | 0.90 |
| Geyser Maintenance Station | 10 | (1.00) | 0.42 | - | 1.42 |
| Geyser Ranch | 5 | (1.05) | 0.50 | - | 1.55 |
| Glendale | 75 | 0.70 | 0.10 | 0.05 | 0.85 |
| Goldfield | 220 | 0 | 1.10 | 0.10 | 1.20 |
| Goldpoint | 10 | (0.90) | 0.30 | 0.10 | 1.30 |
| Goodsprings | 160 | - | - | - | - |
| Groom Mine | 0 ^{10/} | 2.00 | 2.80 | 0.10 | 4.90 |
| Gubler Ranch | x | (0.90) | 0.44 | 0.05 | 1.39 |
| Hawthorne | 1,861 | - | 0.23 | 0.05 | 0.28 |
| Henderson | 14,000 | 0.02 | - | - | 0.02 |
| Hiko | 55 | 1.00 | 0.08 | - | 1.08 |
| Hollinger's Ranch | 1 | (0.30) | 0.02 | 0.05 | 0.37 |
| Hoover Dam | x | 0.05 | - | - | 0.05 |
| Hoya | Variable ^{5/} | (3.70) | 2.20 | - | 5.90 |
| Indian Creek Ranch | x | (0.80) | 0.18 | - | 0.98 |
| Indian Springs | 2,650 ^{11/} | 0.05 | 0.10 | - | 0.15 |
| Ione | 40 | - | 0.24 | - | 0.24 |
| Johnnie | 5 | 0 | - | - | - |
| Kimberly | 120 | 0.50 | 0.37 | 0.05 | 0.92 |
| Kyle | Variable ^{5/} | (3.20) | 0.26 | - | 3.46 |

NEVADA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|--------------------------|-------------------------|---|--|---|---|
| Laboard Ranch | x | (0.06) | 0.39 | - | 0.45 |
| Lake Mead Base | 5 | 0.05 | 0.04 | - | 0.09 |
| Lane City | 40 | (0.55) | 0.38 | 0.05 | 0.98 |
| Las Vegas | 47,000 | 0.20 | 0.01 | - | 0.21 |
| Isthrop Wells | 9 - 15 | 0.05 | 0.03 | 0.08 | 0.16 |
| Lehman Caves | variable ^{12/} | (0.95) | 0.25 | - | 1.20 |
| Leith | variable ^{5/} | (3.00) | 0.32 | - | 3.32 |
| Lida | 25 | (0.50) | 0.32 | 0.05 | 0.87 |
| Lida Junction | 3 | (0.40) | 0.78 | 0.10 | 1.28 |
| Lincoln Mine | 100-500 | 4.00 | 1.90 | 0.05 | 5.95 |
| Lockes | 4 | 1.30 | 0.31 | - | 1.61 |
| Logandale | 300 | 0.40 | 0.16 | - | 0.56 |
| Lund | 250 | 0.80 | 0.44 | 0.05 | 1.29 |
| Lunf | 50 | - | 0.44 | 0.05 | 0.49 |
| M&M Mine | 2 | (0.50) | 2.90 | - | 3.40 |
| Manhattan | 42 | (0.08) | 0.26 | 0.05 | 0.39 |
| McGill | 2,297 | 0.40 | 0.32 | 0.05 | 0.77 |
| Mercury | 300-3,500 | 0.10 | 0.02 | 0.10 | 0.22 |
| Mesquite | 590 | 1.80 | 0.24 | 0.05 | 2.09 |
| Millett | 5 | (0.04) | 0.40 | - | 0.44 |
| Mina | 450 | - | 0.50 | 0.08 | 0.58 |
| Moapa | 52 | 0.80 | 0.10 | 0.05 | 0.95 |
| Moapa Indian Reservation | 100- 150 | (0.80) | 0.17 | - | 0.97 |
| Moon River Ranch | 3 | (1.48) | 0.52 | 0.08 | 2.08 |
| Mounts Ranch | x | (0.85) | (0.24) | - | 1.09 |
| Nellis Air Force Base | 8,000 | 0.05 | - | - | 0.05 |
| Nelson | 100 | - | - | - | - |
| Nivloc | 250 | - | 0.35 | 0.08 | 0.43 |
| North Las Vegas | 13,000 | 0.20 | - | - | 0.20 |

NEVADA

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|------------------------------------|------------------------|---|--|---|---|
| Nyala | 6 | 1.70 | 0.28 | 0.08 | 2.06 |
| Overton | 750 | 0.35 | 0.08 | - | 0.43 |
| Pahrump | 89 | 0.20 | - | - | 0.20 |
| Pahrump Mining Co. | x | (0.09) | 0.01 | - | 0.10 |
| Panaca | 500 | 0.65 | 0.01 | - | 0.66 |
| Parmon's Ranch | 6- 8 | (0.10) | 0.25 | 0.10 | 0.45 |
| Pioche | 1,392 | 0.70 | 0.04 | - | 0.74 |
| Pittman | x | (0.10) | - | - | 0.10 |
| Pony Springs | x | (0.65) | 0.45 | 0.08 | 1.18 |
| Pop's Oasis | x | - | - | - | - |
| Potts | 17 | (0.20) | 0.19 | - | 0.39 |
| Preston | 60 | 0.70 | 0.48 | 0.05 | 1.23 |
| Rattlesnake Maintenance Station | 4 | (0.75) | 0.80 | 0.10 | 1.65 |
| Reed | 0 ^{13/} | 4.00 | 2.66 | 0.08 | 6.74 |
| Reveille Mill | 6 ^{14/} | (0.70) | 4.70 | 0.10 | 5.50 |
| Riverside | 0 ^{15/} | 7.80 | 0.10 | 0.05 | 7.95 |
| Rhyblite | 7 | - | 0.06 | 0.05 | 0.11 |
| Rogers Ranch | 10 | (0.76) | 0.21 | 0.05 | 1.02 |
| Rose Valley | 10 | (0.65) | - | - | 0.65 |
| Round Mountain | 200 | 0.05 | 0.36 | 0.08 | 0.49 |
| Rox | Variable ^{5/} | 3.00 | 0.30 | - | 3.30 |
| Ruby Hill Mine | 50 | (0.18) | 0.65 | 0.05 | 0.88 |
| Ruth | 1,244 | 0.50 | 0.40 | 0.05 | 0.95 |
| Sarcobatus | 3 | (0.10) | 0.08 | 0.05 | 0.23 |
| Schurz | 100 | - | 0.22 | - | 0.22 |
| Searchlight | 150 | - | 0.08 | - | 0.08 |
| Searls Ranch | 16 | (0.70) | 0.23 | 0.05 | 0.98 |
| Seven L Ranch | 1 | (0.40) | 0.02 | - | 0.42 |

NEVADA

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|------------------------|------------------------|---|--|---|---|
| Sharps (Adaven) | 25 | 1.20 | 0.41 | 0.08 | 1.69 |
| Shoshone | 250 | 0.70 | 0.24 | - | 6.94 |
| Silver Peak | 7 | - | 0.65 | 0.10 | 0.75 |
| South Paw Mine | 3 | (1.00) | 0.79 | 0.05 | 1.84 |
| Springdale | 15 | 0.02 | 0.04 | 0.05 | 0.11 |
| State Line | 90 | - | - | - | - |
| Steward, R. Ranch | 6 | (0.70) | 0.52 | 0.08 | 1.30 |
| Stine | Variable ^{5/} | (1.10) | 0.06 | - | 1.16 |
| Stowe Cabin Ranch | 8 | (0.60) | 0.37 | 0.05 | 1.02 |
| Sunnyside | 26 | 1.20 | 0.48 | 0.05 | 1.73 |
| Swallow Ranch | x | (0.80) | 0.22 | - | 1.02 |
| Tonopah | 1,375 | 0.70 | 0.98 | 0.10 | 1.08 |
| Tonopah Airport | 4 | - | 0.70 | 0.10 | 0.80 |
| Uhaldi Ranch | 5 - 8 | (1.33) | 0.47 | 0.08 | 1.88 |
| Urretias Ranch | x | (1.10) | 0.63 | 0.05 | 1.78 |
| Ursine | 25 | 0.60 | 0.01 | - | 0.61 |
| Vigo | Variable ^{5/} | (3.00) | 0.52 | - | 3.52 |
| Walch Pine Creek Ranch | 4 - 6 | (2.25) | 0.45 | 0.08 | 2.78 |
| Warm Springs | 55 | 0.50 | 0.35 | 0.08 | 0.93 |
| Warm Springs Ranch | 58 ^{16/} | 1.00 | 0.23 | - | 1.23 |
| Watertown | 300 ^{17/} | (2.40) | (1.30) | 0.10 | 3.80 |
| Whipple Ranch | 10 | (1.00) | 0.10 | - | 1.10 |
| Whitney | 78 | 00 | - | - | - |

UTAH

| <u>Location</u> | <u>Population</u> | <u>Pre-Plumbbob Effective Biological Dose (Roentgens)</u> | <u>Plumbbob Estimated Dose (Roentgens)</u> | <u>Hardtack II Estimated Dose (Roentgens)</u> | <u>All Nevada Tests Cumulative Estimated Dose (Roentgens)</u> |
|--------------------------------------|-------------------------|---|--|---|---|
| Adamsville | 98 | (0.23) | - | - | 0.23 |
| Alton | 154 | 0.80 | 0.03 | - | 0.83 |
| Anderson Junction | 17 | 1.20 | 0.68 | - | 1.88 |
| Bear Valley Junction | 10 | 0.40 | 0.55 | - | 0.95 |
| Beaver | 1,685 | 0.25 | - | - | 0.25 |
| Beryl | 15 | 0.50 | 0.03 | - | 0.53 |
| Beryl Junction | 8 | 1.00 | 0.05 | - | 1.05 |
| Black Rock | 9 | (0.05) | - | - | 0.05 |
| Bryce Canyon | Variable ^{18/} | (0.55) | 0.01 | - | 0.56 |
| Cedar City | 6,106 | 0.40 | 0.24 | - | 0.64 |
| Central | 49 | (1.50) | 0.41 | - | 1.91 |
| Cove Fort | 8 | 0.07 | - | - | 0.07 |
| Desert Range Experimental Station | 5 | (0.10) | - | - | 0.10 |
| Duck Creek Forest Camp | x | (0.90) | 0.17 | - | 1.07 |
| Enoch | 250 | (0.50) | 0.04 | - | 0.54 |
| Enterprise | 800 | 0.70 | 0.09 | - | 0.79 |
| Garrison | 125 | 0.70 | 0.18 | - | 0.88 |
| Glendale | 275 | (0.24) | - | - | 0.24 |
| Greenville | 173 | (0.24) | - | - | 0.24 |
| Gunlock | 127 | 2.60 | 0.52 | - | 3.12 |
| Hamilton Fort | 26 | 0.60 | 0.20 | - | 0.80 |
| Hamlin Valley | Variable | (0.50) | 0.01 | - | 0.51 |
| Hatch | 24 | (0.50) | 0.14 | - | 0.54 |
| Hilldale | 10 | (0.30) | 0.14 | - | 0.44 |
| Hurricane | 1,375 | 4.20 | 0.15 | - | 4.35 |
| Kanab | 1,900 | 1.60 | 0.02 | - | 1.62 |
| Kanarrville | 263 | 1.20 | 0.73 | - | 1.93 |
| Kanosh | 476 | (0.05) | - | - | 0.05 |
| La Verkin | 387 | (3.50) | 0.16 | - | 3.66 |
| Lead | 215 | 3.00 | 0.70 | - | 3.70 |

UTAH

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|------------------------------|-------------------|---|--|---|---|
| Long Valley Junction | 10 | 0.80 | 0.07 | - | 0.87 |
| Lund | 75 | 0.50 | - | - | 0.50 |
| Manderfield | 62 | (0.20) | 0.03 | - | 0.23 |
| Milford | 1,673 | 0.10 | - | - | 0.10 |
| Minersville | 593 | 0.20 | - | - | 0.20 |
| Modena | 100 | 0.50 | 0.04 | - | 0.54 |
| Mount Carmel | 125 | 0.85 | 0.09 | - | 0.94 |
| Mount Carmel Junction | 10 | (0.80) | 0.05 | - | 0.85 |
| New Castle | 115 | 0.60 | 0.05 | - | 0.65 |
| New Harmony | 126 | 1.20 | 0.68 | - | 1.88 |
| Ogdenville | 371 | 1.50 | 0.10 | - | 1.60 |
| Paiute Indian Reservation | 95 | (0.30) | - | - | 0.30 |
| Panatch | 1,500 | 0.20 | 0.50 | - | 0.70 |
| Paragonah | 404 | 0.40 | 0.02 | - | 0.42 |
| Parowan | 1,455 | 0.40 | 0.02 | - | 0.42 |
| Pintura | 50 | 1.20 | 1.00 | - | 2.20 |
| Rockville | 125 | 3.00 | 0.10 | - | 3.10 |
| Saint George | 5,000 | 3.00 | 0.70 | - | 3.70 |
| Santa Clara | 319 | 3.50 | 0.77 | - | 4.27 |
| Shivwits | 95 | 2.80 | 0.80 | - | 3.60 |
| Springdale | 209 | 2.60 | 0.09 | - | 2.69 |
| Summit | 146 | (0.50) | 0.02 | - | 0.52 |
| Toquerville | 219 | 2.00 | 0.33 | - | 2.33 |
| Uvada | 15 | (0.70) | - | - | 0.70 |
| Veyo | 100 | 2.00 | 0.82 | - | 2.82 |
| Vic's Place | 3 | (1.20) | 0.68 | - | 1.88 |
| Vic's Service Station | 2 | (3.00) | 0.90 | - | 3.90 |
| Virgin | 147 | 1.50 | 0.12 | - | 1.62 |

UTAH

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|-----------------|-------------------------|---|--|---|--|
| Washington | .435 | 3.00 | 0.30 | - | 3.30 |
| Zane | 25 | 0.30 | - | - | 0.30 |
| Zion Lodge | Variable ^{18/} | (1.00) | 0.16 | - | 1.66 |

Footnotes concerning populations of communities

1. Lake Mohave - also some transients.
2. Apex - about 50 day workers; generally only a watchman at night.
3. Bardoli Ranch - population only 1 after Plumbbob.
4. Bannock Boy Scout Camp - variable population, summer months only.
5. Railroad maintenance stations (Boyd, Cloud, Etna, Galt, Garnet, Hoya, Kyle, Leith, Fox, Stine, Vigo)-population variable from 0 to about 15.
6. Butler Ranch - Mrs. Butler was absent during the important fallout in Plumbbob, (from the Smoky burst) and Mr. Butler was evacuated for a few hours shortly after the fallout arrived. Personnel film badges indicated that Mrs. Butler received less than 2 Roentgens and that Mr. Butler received less than 5 Roentgens.
7. Crystal - unpopulated after Plumbbob.
8. Desert Rock - unpopulated except during major test series.
9. Eagle Construction Camp - unpopulated except Plumbbob series.
10. Gloom Mine - population variable 2-10 prior to Plumbbob, intermittent during Plumbbob but only trivial doses indicated by personnel film badges during Plumbbob.
11. Indian Springs - population variable, about 250 plus 2400 on military post during Plumbbob.
12. Lohman Caves - tourists during summer season.
13. Reed - population 3 during the Teapot series only, and these were evacuated for 7-10 days during the highest fallout activity.
14. Reveille Mill - unpopulated prior to Plumbbob.
15. Riverside - population 2-14 through Upshot-Knothole, 2 during Teapot and 0 after Teapot.
16. Warm Springs Ranch - up to 500 people on weekends during the summer.
17. Watertown - population 0 prior to Plumbbob; about 300 during first month of Plumbbob, and 2 thereafter.
18. Bryce Canyon and Zion Lodge - many tourists during summer.