Blue Ribbon Panel Committee Action Report
On Radioactive Contamination in Guam Between 1946-1958

From the offices of Senator Angel L. G. Santos & Senator Mark Forbes

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Introduction

This action report outlines the research project on nuclear contamination commissioned by the 26th Guam Legislature, and requested by the offices of Senator Mark Forbes and Senator Angel Santos co-chairs of the Blue Ribbon Panel Committee. The concern of this research is to focus on the time periods from the mid-forties to the late fifties in regards to both direct atmospheric fallout and decontamination runoff from military ships and aircraft. This project represents the first paper written for the express purpose of discerning *if* radioactive fallout came to Guam. No other committee, group, or organization has ever compiled a report of this nature, so the findings of this report are unique in that the historical and scientific information has never been shown in reference to Guam specifically, except for the Celestial Report that was presented to congress in concert with the Brookhaven Institute and the Livermore Labs, thanks to the efforts of Congressman Robert Underwood and Robert Celestial in 2001. The evidence in this action report consists of corresponding data from various people, groups and organizations both private and government related. This preliminary research paper will show the direct responsibility of the Federal Government to the local military and civilian population of Guam. The actions taken by the (AEC) Atomic Energy Commission, the United States Navy and Air Force put the population of Guam in harms way knowingly and with total disregard for there well being. The post World War II governments of the world gave various islands in this region over as a protectorate so that they could develop in to healthy societies after the damage done by WWII. What was perpetrated against this region was the largest ecological disaster in human history. This disaster was no less than the detonation of over 108,000 kilotons of nuclear explosive directly up jet stream of Guam. The amount of contamination was 42 times the approximately 150 million curies released as a result of testing in the United States of America. The AEC ejected between 6.3 billion and 17 billion curies of radioactive contamination over a twelve year period, this inundated the region and other surrounding regions with various radioactive isotopes such as Cerium-140, Iodine-131, Xenon-131, Strontium-90, Yittrium-90, Cesium-137, Barium-137, Potassium-40, Cesium-40, Argon-40, Magnesium-24, Hydrogen-3, and Helium-3, all of these are products of nuclear tests with a half-life of from four days to thirty years, enough time to reach Guam according to the data provided by and collected in this report. Another finding in this report is the potential time that the radioactive debris was suspended in the air, some readings put fallout beginning in 1946 and ending as late as 1974. All of these isotopes cause various different types of genetic damage to biological organisms, the longer the debris was suspended in our environment the more damage that the island would have sustained. The type of damage done to the cellular structure varies by the type of particle that interacts with it, and how long the particle is in contact with the cell. This report also gives an overview of what other citizens of the United States have done to combat these problems and what we can do to emulate there success. Using the Radiation Exposure Compensation Act as a guide set up by the Federal Government in 1998, this paper will show that Guam more than qualifies for compensation as outlined in the RECA document. To follow through with the research and compensation requests this paper describes in the policy development the creation of the BRAVO Commission (**B**ureau of **R**adiation contamination **A**nd the office of **V**ictims **O**verseas) to give an office for the research to be focused out of. This commission would centralize an information database that would be accessible to the personnel tasked with the question of compensation for Guam's people.

This paper has been broken in to two interdependent parts. The first section is an ***issue analysis***; this will give an overview of the events, the people involved, the impact on our island, and the social issues that will come with it as a reaction to this information being released. The second part of this paper will outline the steps for ***policy development*** that could be implemented to fully prepare the issue for discussion by this committee and other parties related to this issue. The number of people affected in this case encompasses all the inhabitance of Guam, military and civilian residence present from 1946-1974. The final year of contamination will not be known until readings are made to ascertain who all had the potential of being impacted by the events in question.

Part 1: Issue Analysis

Step 1: Identify issues that may influence Guam in regards to the Nuclear Testing in the Marshall Islands and any other environmentally impacting operations between the years of 1946 to 1958.

The issues that this committee has been tasked to research consist of, but are not limited to the fallout that followed atomic activity in the Marshall Islands, and its impact on the people of Guam. *Fallout* is the process of phenomenon of the decent to the earth's surface of particles contaminated with radioactive material from the radioactive cloud produced by above ground detonation of a fission device. The term is also applied in a collective sense to the contaminated particulate matter itself. The early (or local) fallout is defined, somewhat arbitrary, as those particles, which reach the earth within 24 hours after a nuclear explosion. The delayed (or worldwide) fallout consists of the smaller particles, which ascend into the upper troposphere and into the stratosphere and are carried by winds to all parts of the earth. The delayed fallout is brought to earth, mainly by rain and snow, over extended periods ranging from months to years; this process is called the scavenging effect. (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy) It is this delayed fallout and scavenging effect that will most concern the issue at hand. It is the contention of this paper that Guam was directly in the path of the global fallout and all the factors that come with the phenomenon of nuclear fission, these are explained in detail in Appendix 2.

The facts that support our preliminary findings of nuclear contamination on Guam are as follows. First, Guam is approximately 1200 miles directly West of the Marshall Islands. Second, the Atomic Energy Commission detonated 66 nuclear devices with a total yield of 108,492.2 kilotons, in and around the Marshall Islands (Nuclear Testing in the Marshall Islands: A Brief History. Majuro: Micronitor News and Printing Company, August 1996). Third, there are ten detonations that had the yield necessary (1 megaton) to project material from the center of the explosion to the height of between 12 to 55 miles, and in to the jet stream (University of Washington Radio ecological Studies in the Marshal Islands, 1946-1977) (Appendix II Figure 2.16**.** Approximate values of stabilized cloud height and radius as a function of explosion yield for land surface or low airbursts). Fourth, the jet stream travels from the Marshall Islands and carried the radioactive material as fine dust particles; these particles collected ice at high altitudes and fell to earth condensing in to clouds, this is known as the scavenging effect (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy). Fifth, the material drops in the form of rain and enters the food and water supply of the local population (Testimony of Charles Bert Schrieber). Sixth, reports from the Navy indicated that they had full knowledge and did not warn or help the local population, this behavior compromises the integrity of the military forces that were put here to protect the very people that they were harming (Nuclear Agency Report on the Bravo Test Describing the Blast and Subsequent Fallout, and Testimony of Charles Bert Schreiber). Seventh, ships present during the nuclear testing were decontaminated in Guam harbors with acidic detergents and the runoff from these operations went directly in to our local fishing and reef environments (Operation Crossroads, 1946 United States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review). Eighth, the U.S. Navy preformed radio ecological studies on the surface water in and around Guam and found a major peak of radioactive contamination in 1959. (University of Washington's Radioecological Studies in the Marshall Islands, 1946-1977 Lauren R. Donaldson, Allyn H. Seymour, and Ahmad E. Nevissi) All of these findings are explained in greater detail, it is important to note that the information taken as a whole paints a picture of a catastrophic environmental abuse on Guam and the surrounding region.

<u>Step</u> 2: <u>The Characteristics of the events in question are as follow.</u>

First, The United States Government detonated 66 nuclear devices in the Marshall Islands between 1946 and 1958 (Appendix IV). Second, the Bikini and Enewetak Atoll set the geographical location for the nuclear tests. Their global position is 11.62 North Latitude and 165.48 East Longitude; Guam's global position is 13.48 North Latitude and 144.45 West longitudes. Third, the geographical location of the island of Guam is directly down jet stream to the west 1200 miles. The jet stream travels in a body of high altitude air known as the *stratosphere* that is independent of any low level warmer air (Appendix III). The stratosphere is characterized by a slight temperature increase with altitude and the absence of clouds. The stratosphere extends between 11 and 31 miles (17 to 50 kilometers) above the earth's surface. The earth's ozone layer is located in the stratosphere. Ozone, a form of oxygen, is crucial to our survival because this layer absorbs a lot of ultraviolet solar energy. Only the highest clouds (cirrus, cirrostratus, and cirrocumulus) are in the lower stratosphere. (National Weather Service)

The radioactive particles traveled in to this body of air collecting ice. As the particles gained in mass the weight of the particles would increase there by creating a larger gravitational effect and then descend to the levels that rain clouds form. The radioactive particles would then condense in the warmer air and become clouds. Shown in Appendix II, Fig2.12 the height that the detonated cloud traveled was at a minimum of 12 miles high for a one-megaton device (the Bravo device had a yield of 15 megatons) this puts the radioactive debris in a direct route to Guam. With the detonation of the Bravo device the cloud traveled a great deal higher and would therefore travel a great deal farther into our region. The importance of theses events and their relationship to Guam can be seen and researched through the local populations on island medical records, and health trends. The Marshall Island populations exhibit a greater degree of cancer and brain neurological diseases that our also found on Guam (Nuclear Testing in the Marshall Islands: A Brief History. Majuro: Micronitor News and Printing Company, August 1996). It can be proven that these events in question contributed to the harm of the citizens of Guam, and a case can be made for impact compensation.

The potential cellular damage done to the general population was caused by radioactive particles as mentioned above. This type of energy is called ionizing radiation defined as the separation of a normally electrically neutral atom or molecule in to electrically charged components. The term is also employed to describe the degree of extent to which this separation occurs. This is best described as the removal of an electron (negative charge) from the atom or molecule, either directly or indirectly, leaving a positively charged ion. The separated electron and ion are referred to as an ion pair this is the particle that is launched from the unstable atom and reacts with other material within its range. As these particles leave the unstable atom they shoot out and react with other matter changing the structure, in regards to organic mater the particles change the structure of the cell there by altering its function creating cancers and different types of cellular diseases. It is this resulting damage that the Blue ribbon Panel, Guam Legislature and medical groups will be most concerned with. (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy)

Knowing what the half-life of these radioactive particles may help deduct how much radiation is still in the environment. For example, Hydrogen-3 have a half-life of 12.3 years would mean that one sixteenth of the original amount of Hydrogen-3 released in is still here on Guam. It also fallows that Strontium-90 and Cesium-137 with a half-life of 28.9 and 30 years, respectively, would be a little over one quarter its original levels now than what they were in the early fifties. These extrapolations may act as a guide when tests are done on the soil to see exactly how much damage can be contributed to radioactive fallout in our region.

Table 2-1. Radioactive Decay

Isotope	Half-Life	Radiations Emitted	Decay Product	Half-Life
a. Fissionable Material				
Uranium-235	7.1×10^8 yr	α, γ	Thorium-231*	25.2 hr
Uranium-238	4.5×10^9 yr	α, γ	Thorium-234*	24 days
Plutonium-239	2.4×10^4 yr	α, γ	Uranium-235*	7.1×10^8 yr
b. Fission Products				
Lanthanum-140	40 hr	β^-, γ	Cerium-140	Stable
Iodine-131	8 days	β^-, γ	Xenon-131m	11.9 days
Strontium-90	28.9 yr	β^-	Yttrium-90	64 hr
Cesium-137	30.0 yr	β^-, γ	Barium-137m	2.5 min
c. Other Radioisotopes				
Radon-222	3.8 days	α, γ	Plononium-218*	3 min
Potassium-40	1.3×10^9 yr	β^-, β^+, γ	Cesium-40	Stable
			or Argon-40	Stable
Sodium-24	15 hr	β^-, γ	Magnesium-24	Stable
Hydrogen-3 (Tritium)	12.3 yr	β^-	Helium-3	Stable

* Includes other daughter radionuclides.

Each one of these ionizing radioactive isotopes is a byproduct of nuclear fission. Ionizing radiation interacts with matter in one of two ways. It is either scattered or absorbed. Both result in deposition of energy in the target system. Transfer of energy from an incident photon or particle to the atoms of an absorbing target material may occur by two mechanisms. The first type of ionizing radiation is called *Excitation.* This process involves the addition of energy to an atomic or molecular system, thereby transferring it from its ground or stable state to an excited or unstable state. Depending upon the type of interaction, either the atomic nucleus or one of its orbital electrons may absorb the excitation energy.

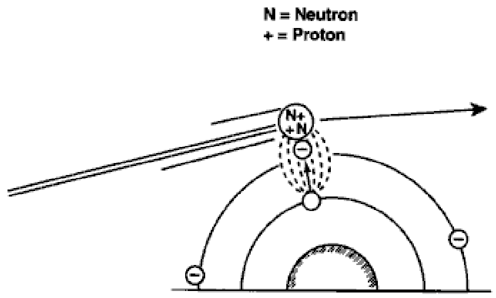


Figure 2-XII. Excitation of an Electron

The second type of radiation is called Ionizing radiation. As indicated previously, ionization is any process, which results in the removal of an electron (negative charge) from an atom or molecule thereby leaving the atom or molecule with a net positive charge. Ionization occurs if alpha or beta particles, or gamma photons transfer sufficient energy to dislodge one of the electrons from the outer orbital shells of the target atom. Each ionization event produces an ion pair consisting of a free electron and the positively charged remainder of the atom.

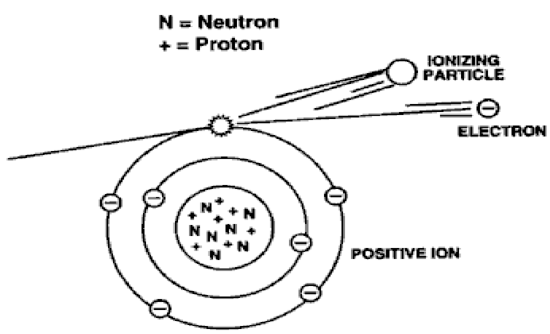


Figure 2-XIII. Electron Removal by Ionization

The penetrating ability of radiation depends on the rate at which the radiation deposits energy along its path. The term specific ionization, which is defined as the average number of ion pairs generated per unit length of path, is used to describe the ionizing capability of ionizing radiations. Generally speaking, the ion density along the path of a low-energy particle is greater than that along the path of a high-energy particle of the same mass and charge. This is because the low-energy particle is moving slower and has more time to interact. Its total pathway is shorter, however, and the total number of interactions may well be less. Likewise, the ion density towards the end of the path of a particle is greater than at the beginning, because its velocity is less and the probability of interaction is increased accordingly. Alpha particles are capable of producing the highest specific ionization followed in order by beta particles and the secondary electrons produced by gamma-photon interactions. The more common basis for comparing the various types of radiations is known as *Linear Energy Transfer* (LET), and represents the average energy released (or lost) per unit track length in ionization and excitation interactions. LET is usually expressed in units of KeV (thousands of electron volts) per micron of path length. To a considerable extent, the *Relative Biological Effectiveness* (RBE) of various radiations depends on the rate of energy loss (LET) along the paths of the individual ionizing particles or photons. Radiations with low LET such as X- or gamma rays produce diffuse ionizations throughout the medium. In contrast, the LET associated with neutrons or alpha particles is so high that the passage of a single track will, in all probability, put enough ionizations into a traversed cell to produce death. (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy)

Table 2-II. Specific Ionization of Radiation

Radiation	Range in air	Speeds	Specific ionization
Alpha	5 - 7 cm	3,200 - 32,000 km/sec	20,000 - 50,000 ion pairs/cm
Beta	200 - 800 cm	25 - 99% speed of light	50 - 500 ion pairs/cm
Gamma	Use of half-thickness	Speed of light 300,000 km/sec	5 - 8 ion pairs/cm

High-speed electrons in the form of beta radiation lose most of their energy after penetrating only a few millimeters of tissue. If the beta emitting material is on the surface of the skin, the resulting beta irradiation causes damage to the basal stratum of the skin. The lesion is similar to a superficial thermal burn. However, if the beta material is incorporated internally, the beta radiation can cause much more significant damage. The damage will be in spheres of tissue around each fragment or source of radioactive material. The total damage is a function of the number of sources and their distribution in the body. The distribution is determined by the chemical nature of the material. (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy)

Table 5-II. Tissue Dose Rate at Various Distances Around a 37 KBq (1μCi) Particle of Various Beta Emitting Materials (Range in Tissue 1-10 mm)

Distance	Dose rate		
	^{14}C	^{90}SR - ^{90}Y	^{32}P
10μm	2,000,000	766,400	380,000
100μm -0.1 mm	1,500	7,380	3,700
200μm - 0.2 mm	40	1,705	930
400μm - 0.4 mm	0.03	340	230
600μm -0.6 mm	0	130	100
1,000μm -1.0 mm	0	34	30
10,000μm -10.0 mm	0	0.02	0
Max. beta energy (MeV)	0.156	0.546-2.27	1.71

Table 5-II lists the critical ranges of radiation exposure in tissue for beta emitters of various energies. These ranges are considerably greater than those for alpha particles. In addition to a difference in range when compared with alpha radiation, there is also a significant difference in the pattern of energy deposition. The density of energy deposited is much less for beta irradiation than for alpha, and as a result, the target cells may be damaged rather than killed outright. Damaged cells may be of greater significance to the total organism than killed cells, particularly if they go on to become malignant or otherwise malfunction. Killed cells are replaced quickly in most tissues with any degree of reserve capacity and do not cause significant overall clinical effects unless the cells involved are highly critical or the fraction of cells killed in a given organ is large.

Table 5-III. Tissue Dose Rate at Various Distances from a 37 KBq (1μCi) Alpha Emitter

Distance (μm)	Dose rate at distance (cGy/hr)
10	1.7×10^{8}
20	5.2×10^{7}
30	0

Its very important to understand how the different types of ionizing radiation works so that a better idea can be formed as to how much and what kind of damage is being done to the local population. The characteristic of the Beta radiation is the most important due to the way the human body deals with the isotope. As it is explained later in this paper the Beta particles produced by strontium-90 is stored as calcium in the bones and teeth once it has been ingested via food or water. As shown in table 5-II the penetration of the beta particles through the air is 200-800cm when these particles are placed in human bone the effect that was mentioned earlier the ionization of bone marrow and other soft tissues in the body would take place. As it is also mentioned this type of ionizing radiation tends to damage as opposed to kill the host cell. It is this property of

Beta particles that is most concerning to the local population. If the ionizing radiation does not kill the cell then the cell goes on operating as if it were normal but is not, this could lead us to accounting for the various rare diseases that surface in such a small population as Guam. (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy)

When radiation interacts with target atoms, energy is deposited, resulting in ionization or electron excitation. This ionization or excitation must involve certain critical molecules or structures in a cell such as DNA; the damage caused by radiation may follow consistent patterns. It has been theorized that this localization of absorbed energy in critical molecules could be either a direct or an indirect action, i.e., the energy deposited by the radiation may involve particular sensitive chemical bonds directly, or it may be deposited elsewhere first and transferred to the sensitive bonds by means of an appropriate energy transfer system. The former mechanism implies that the radiation quite precisely hits particular target atoms, whereas the latter implies that there is a method for preferentially directing randomly deposited energy to sensitive sites.

The exact radiochemical mechanism involved in mammalian systems subjected to whole-body doses of penetrating radiation is not fully understood. However, the most reasonable hypothesis at the present time is that water, both intracellular and extra-cellular, is the primary site of radiation energy deposition and that the energy deposited in the water would be transferred to and affect sensitive molecules indirectly of cells. Non-lethal changes in cellular function can occur as a result of lower radiation doses. Due to the distance and the gradual increase of radiation that Guam received the low level peculating exposure is more likely. These include delays in certain phases of the mitotic cycle, disrupted cell growth, permeability changes, and changes in motility.

Table 5-IV. Relative Radiosensitivity of Various Organs Based on Parenchymal Hypoplasia

Organs	Relative radiosensitivity	Chief mechanism of parenchymal hypoplasia
Lymphoid organs; bone marrow; testes & ovaries; small intestines	High*	Destruction of parenchymal cells, especially the vegetative or differentiating cells
Skin; cornea & lens of eyes; gastrointestinal organs: cavity, esophagus, stomach, rectum	Fairly high	Destruction of vegetable and differentiating cells of the stratified epithelium
Growing cartilage; the vasculature; growing bones	Medium	Destruction of proliferating chondroblasts or osteoblasts; damage to the endothelium; destruction of connective tissue cells & chondroblasts or osteoblasts
Mature cartilage or bone; lungs; kidneys; liver; pancreas; adrenal gland; pituitary gland	Fairly low	Hypoplasia secondary damage to the fine vasculature and connective tissue elements
Muscle; brain; spinal cord	Low	Hypoplasia secondary damage to the fine vasculature and connective tissue elements, with little contribution by the direct effects on parenchymal tissues

*Embryonic tissue is also highly radiosensitive.

Mitosis may be delayed or inhibited following radiation exposure. Dose dependent inhibition of mitosis is particularly common in actively proliferating cell systems, such as the ingestion of radioactive water. This inhibition occurs approximately 40 minutes before prophase in the mitotic cycle, at a time when the chromosomes are discrete, but prior to the breakdown of the nuclear membrane. Subsequent irradiation after this radiation transition point does not delay mitosis. Delays in mitosis can cause profound alterations in cell kinetic patterns resulting in depletions of all populations. This is the basic kinetic pattern resulting in depletions of all populations. This is the basic mechanism underlying the later clinical changes seen in the hematopoietic and gastrointestinal syndromes of whole-body irradiation. Cell growth may also be retarded, usually after a latent period. This may be due to progressive formation of inhibitory metabolic products and/or alterations in the cell microenvironment. Irradiated cells may show both increased and decreased permeability. Radiation changes within the lipid bilayers of the membrane may alter ionic pumps. This may be due to changes in the viscosity of intracellular fluids associated with disruptions in the ratio of bound to unbound water. Such changes would result in an impairment of the ability of the cell to maintain metabolic equilibrium and could be very damaging even if the shift in equilibrium were quite small. The motility of a cell may be decreased following irradiation.

However, the presence of normal motility does not imply the absence of radiation injury. Irradiated spermatozoa, for example, may retain their motility and be capable of fertilization while carrying radiation-induced genetic changes which may alter subsequent embryogenesis. This potential problem would propose that any person of a lineage from Guam during this time could conceivably be carrying these genetic changes to future generations. The importance of this is in regards to the baud spectrum of compensation that the island population would be privy to. (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J. Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy)

Once a cell has been altered due to radioactive contamination it begins to affect the organ that the cells make up. Different types of organs have various resistances to these types of radiation, depending on what types of cells that the organ is made up of. The relative sensitivity of an organ to direct radiation injury depends upon its component tissue sensitivities. The following chart gives various organs in decreasing order of radiosensitivity on the basis of a relatively direct radiation effect, parenchymal hypoplasia.

Cell nuclei contain chromosomes, which in turn contain the genes controlling cellular somatic and reproductive activity. These chromosomes are composed of deoxyribonucleic acid (DNA), the macromolecule containing the genetic information. This is a large, tightly coiled, double-stranded molecule and is sensitive to radiation damage. Radiation effects range from complete breaks of the nucleotide chains of DNA, to point mutations, which are essentially radiationinduced chemical changes in the nucleotides, which may not affect the integrity of the basic structure. Intermediate effects, such as abnormal bonding between adjacent molecules and alterations in viscosity, have also been observed.

After irradiation, chromosomes may appear to be "sticky" with formation of temporary or permanent interchromosomal bridges preventing normal chromosome separation during mitosis and transcription of genetic information. Unequal division of nuclear chromosome material between daughter cells with production of nonviable abnormal nuclei may result. This resulting condition could lead to various stillbirths, Down syndrome or any number of neurological problems, under developed organs. (The Effects of Nuclear Weapons Complied and edited by Samuel Glasstone and Philip J.

Dolan, Third Edition, Prepared and Published by the United States Department of Defense and the United States Department of Energy)

All of these medical conditions have been recorded on Guam, it will be up to the BRAVO Commission to find a direct correlation between the fallout and the symptoms, in an effort to further understand the nature of problems facing Guam this paper will outline three major types of radioactive isotopes. These are Strontium-90, Iodine-131, and Cesium-137. All of these isotopes had the necessary longevity to reach Guam via the jet stream and then enter the environment.

Strontium-90

Strontium-90 (Sr-90) in not a naturally accruing substance; its presence in the environment as a result of human activities, such as the prior testing of nuclear bombs in the open at the Bikini Atoll and Enewetak Atoll. Radioactive decay is the only way for decreasing the concentration of Sr-90. Eventually, all Sr-90 will be converted to stable zirconium. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Most of the Sr-90 in water is dissolved. Sr-90 in water comes from the settling of Sr-90 dust out of the air. Some Sr-90 is suspended in water, as in muddy water. The EPA for exposure levels in water established health advisories. The limit for a 22-pound child is 25 mg/L no matter how long or how often the exposure occurs it should never exceed that dose for one life time, this amount according to readings made by the U. S. Energy Research and Development Administration put levels in water catch systems as high as 3.0 Ci/Liter dose (U. S. Energy Research and Development Administration) each time that the population would drink from there water system, this means that a child in this environment for twelve years (1946-1958) would receive doses well beyond the limits for safety set down by the federal government's EPA. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Although strontium, as a molecular surrogate for calcium, it can be distributed through the body, its main target is the skeleton. Excess strontium ingestion has been implicated as a contributing factor to the high prevalence in rickets among children living in the Sivas, Turkey. Exposure to radioactive strontium becomes harmful when the amount of radiation damage exceeds the capacity of natural cellular repair mechanisms. External exposure to radioactive strontium resulted in dermal and ocular effects in humans and animals. *Since absorbed raidostrontium is preferentially retained in bone, and therefore has a long biological half-life, all internal exposures, of whatever duration, will lead to chronic internal exposure to ionizing radiation.* Consequently, the most significant effects of exposure to absorbed radioactive strontium are necrosis and cancers of the bone and tissues adjacent to bone. At lower levels of exposure chronic suppression of immune function has been observed in humans and animals. In animal studies, inhalation of insoluble particles of radioactive strontium led to retention in the lung and resulted in pulmonary necrosis and cancer. The young are more susceptible to adverse effects of absorbed radioactive strontium because of their higher rates of gastrointestinal absorption and of strontium retention in the immature skeleton. High prenatal exposure levels may cause major developmental anomalies in the skeleton and adjacent areas if critical tissues are destroyed. In addition, since children have a higher proportion of mitotic cells than adults, they are susceptible to higher rates of cancer because genetic lesions become fixed mutations when mitosis occurs before genetic damage is repaired. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

The Minimal Risk Levels (MRL) of radioactive strontium is very difficult to identify due to the fact that no human tests have been done to observe the effects that the isotope would have on biological systems. In all applications such as inhalation, and oral contact with strontium the subjects were also exposed to various other types of radiation so no independent contamination took place, so deriving the resulting effects of strontium in a population is imposable due to the various isotopes that the populations came in contact with. No studies have ever been done in regards to death by inhalation of strontium with humans, so no reliable data exists to compare the state of our islands population with other population that were similarly effected. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

There are two theoretical ways in which the fetus might be exposed to radiation from the decay of radioactive strontium: from transfers of strontium across the placenta or from proximity to radiation emitted from the material body (about 200cm-800cm). Placental transfer of radioactive strontium to the fetus has been demonstrated in humans and animals. Animal studies demonstrated that the developmental consequences in pregnant females with radioactive strontium are qualitatively different depending on the gestational day of administration. This is partly related to temporal differences in the onset of osteogenic activity and calcification of the skeletal structure. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Groups of people that our unusually susceptible to Sr-90 will exhibit different or enhanced responses to various levels of Sr-90 in there cellular system, how each persons body deals with the isotope determines the nature of the manifestation the illness will take. The following is a list of disorders related to Sr-90 exposure. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Protein Deficiency and Ethanol Consumption. Protein deficient diets may increase the adverse effects of exposure to excess stable strontium or to radioactive strontium, by reducing clearance and increasing incorporation into bone. A metabolic experiment in adult male Wister rat showed that consumption of a protein deficient diet increased the intestinal absorption of dietary strontium and its incorporation into bone, while reducing fecal and urinary excretion of strontium. When rats were given ethanol in addition to the protein-deficient diet, incorporation of strontium into bone was significantly enhanced, although ethanol given with a protein-normal diet tended to reduce strontium incorporation through its diuretic effects. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001) The status of dietary habits and environmental conditions should be looked at further to see if the general population of Guam had a low protein diet, if this is the case the protein deficient diet could lead to a better understanding of the level of contamination the people of Guam were subjected too.

Renal Disorders. Patients with chronic kidney failure may be more susceptible to excess strontium than the general population, because of a reduced ability to excrete strontium and retain calcium. In such patients, plasma levels of strontium were found to be 60% higher compared to controls. In a variety of studies, uremic patients on dialysis were found to have significantly higher levels of strontium in serum, muscle and brain tissue compared to normal undialized controls. Although the high level of strontium in serum is uremic patients was correlated with the high level of strontium in the local tap water, it is also possible that uremic patients may have reduced rates of strontium excretion. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Paget's Disease (osteitis deformans). Patients with Paget's disease had a higher than normal retention rate following administration of strontium. Part-body retention measurements demonstrated that disease bone had a relatively higher uptake of strontium compared to undiseased bone. Pagetic bone contains a higher proportion of small mineral crystals with greater surface area, which accounts for its increased ability to accumulate strontium. Reflecting the high degree of osteoclast activity in Paget's disease, diseased had an increased turnover of strontium, compared to undiseased bone in the same patient. Since bone metabolism is locally accelerated in persons with this disease, they are likely to develop higher body burdens of radioactive strontium than healthy adults. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Rheumatoid Arthritis or Seronegative Spondarthrits. Patients with active rheumatoid arthritis or seronegative spondarthrits were found to have significantly higher levels of strontium and calcium in their granulocytes. The strontium was thought to be linked to the degree of inflammation and was positively related to serum levels of the acute-phase protein haptoglobin; coricosteroid therapy differentially reduced the strontium content of granulocytes compared to calcium. It would seem that persons with active disease would be especially vulnerable to radiation damage if they were exposed to radioactive strontium, since some of the radionuclide would preferentially sequester in granulocytes, thereby exacerbating the adverse hematological effects caused by radionuclide bound to bone. (Toxicological Profile for Strontium by the Department of

Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Diabetes. Persons with diabetes may be more vulnerable to adverse effects from dermally-appleid radioactive strontium. Thinning of the sclera developed in a diabetic patient who had been treated for pterygium with a single dose of Sr-90. The reaction was not observed in 170 other eyes treated at that dose level; however, the authors did not state whether other diabetics were in the group unaffected. Conversely, in rats made diabetic by injection of streptozotocin, the absorption of strontium in the duodenum was significantly reduced, which would appear to be protective. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Genetic Polymorphism. Polymorphisms in genes that may affect rates of strontium absorption and bone mineralization are currently under investigation. In a study of postmenopausal women with osteoporosis, polymorphisms of vitamin D receptor gene apparently caused a 40% variation in the rate of strontium absorption. However, other studies found no effect of vitamin D receptor polymorphism on bone mineral density. Other candidate genes vitamin D receptor polymorphisms on bone mineral density. Other candidate genes that may affect bone mineralization include the parathyroid hormone receptor 1, the estradiol receptor, collagen type I alpha 1, transforming growth factor-beta 1, interleukin-6, calcitonin receptor, alpha2-HS-glycoprotein, osteocalcin, calcium-sensing receptor, interleukin-1 receptor antagonist, beta-3-adrenergic receptor, apolipoprotiein E, insulin-like growth factor-I, glucocortoid receptor, and epidermal growth factor. The relative contribution of these factors on bone mineralization has yet to be clarified and whether any polymorphism increase susceptibility to adverse effects of strontium remains to be determined. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

All of these disorders react to the introduction of strontium-90 in different ways it will be the objective of the medical experts to use this and other medical information that found in the Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001. This document has listed the various ways that the human body can be tested and what areas of medical science need to be elaborated on in order to understand the ideas and concepts involved with the interaction of strontium-90 and the human body. (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Iodine-131

The health effects of exposure to radioiodine derive from the emission of beta and gamma radiation. Radioiodine that is absorbed in to the body quickly distributes to the thyroid gland and, as a result, the tissues that receive the highest radiation doses are the thyroid gland and surrounding tissues (e.g. parathyroid gland). Tissues other than the thyroid gland can accumulate radioiodine, including salivary glands, gastric mucosa, choroids plexus, mammary gland, placenta, and sweat gland. Although these tissues may also receive a radiation dose from internal radioiodine, the thyroid gland receives a higher radiation dose. The radiation dose to the thyroid gland from absorbed radioiodine varies with the type of isotope. In this case iodine-131, 94% percent of the radiation produced is beat radiation, the effective half-life in the thyroid is 177 hours, the mean range of the beta particles in the thyroid tissue is .4 mm, and a total dose of 5.627 RAD from one mCi in the thyroid. These are the physical characteristics of iodine-131. (Toxicological Profile for Iodine by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry February 22, 2002)

The AEC ejected approximately 17, 401,500,000 Ci of iodine-131 in the region up jet stream from Guam. If you compare this to the 148,500,000 Ci released in the United States the view of the AEC is painfully clear in there total disregard for the safety of the people in this region. With the release of this quantity of iodine-131 in our environment the effects on the people would have been adverse, the following is an over view of what we should expect to find as symptoms of iodine poisoning. (Toxicological Profile for Iodine by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry February 22, 2002)

Radiation doses to the thyroid gland (external and Internal) in the most highly exposed individuals after the Marshall Island BRAVO test is estimated to have ranged from 30-2000 RAD. External radiation is estimated to have contributed approximately 4-16% or 10-50% of the total thyroid dose, depending on the location of the individual with respect to the blast and wind direction. Thyroid gland outcomes have been assessed periodically since the BRAVO test in 1954. Cases of thyroid gland disorders began to be detected in the exposed population in 1964, 10 years after the BRAVO test, particularly in exposed children; these include cases of apparent growth retardation, myxedema (typical of hypothroidism), and thyroid gland neoplasms. Collectively, the various health assessments and studies of the so-called BRAVO cohort have revealed dose-related abnormally high elevations in serum concentrations of TSH, characteristics of hypothyroidism. Among exposed children who were 1-year-old at the time of the BRAVO test and who received an estimated thyroid radiation dose exceeding 1,500 RAD, 83% had serum concentrations of TSH > 5 mU/L; thyroid nodularity was found in 67%-81% of the most highly exposed group, and thyroid cancer was discovered in 6% of the most an apparent highly exposed group. (Toxicological Profile for Iodine by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry February 22, 2002)

Neurological effects of iodine-131 impact populations depending on what stage of biological development they are at the time of contamination. Exposure to excess iodine-131 has been shown to produce subclinical hypothyroidism, which in certain sensitive individuals may take the form of hypothyroidism. Sensitive populations include fetuses, newborn infants, and individuals who have thyroid or Graves' disease, many of whom have abnormal autoimmune disorders. Of these iodine-induced forms of hypothyroidism, that occurred in the fetus or newborn infant has the greatest potential for producing neurological effects. This is because thyroid hormones are essential to the development of the neuromuscular system and brain. An iodine-induced hypothyroid state can result in delayed or deficient brain and neuromuscular development of the newborn. Patients who develop thyrotoxicosis may experience neuromuscular disorders, including myopathy, periodic paralysis, myasthenia gravis, peripheral neuropathy, tremor, and chorea. (Toxicological Profile for Iodine by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry February 22, 2002)

Congenital hypothyroidism secondary to thyroid ablation has been reported subsequent to maternal exposure to ablative doses of iodien-131. In one case, an infant became hypothyroid after his mother received 99 mCi of iodine-131 during her sixth week of pregnancy. Growth retardation was also observed in some children who were exposed to radioiodine in the Marshall Island BRAVO cohort, early after the bomb test. Studies are suggestive of possible extra-thyroid development effects of radioiodine following maternal exposure to ablative doses of iodine-131 received 2-10 years prior to pregnancy. Observed outcomes that may or may not be related to the iodine-131 exposure includes low birth weight with subsequent normal growth patterns, tetrology of Fallout (pulmonic stenosis, atrial septal defect, and right ventricular hypertrophy), hypoparathyroidism, Down's syndrome, and cardiac anomalies. The maternal exposure ranged from 20-460 mCi. (Toxicological Profile for Iodine by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry February 22, 2002)

Exposure to iodine-131 may cause disruption of the reproductive functions, secondary to thyroid gland dysfunction. Hypothyroidism can produce changes in the menstrual cycle in humans including menorrhagia (excessive uterine bleeding) and anovulation (no ovulation). Spontaneous abortions, stillbirths, and premature births have also been associated with hypothyroidism. Reproductive impairments associated with hyperthyroidism include amenorrhea and alterations in gonadotropin release and sex hormone-binding globulin, and associated changes in the levels and metabolism of steroid hormones in both female and male. (Toxicological Profile for Iodine by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry February 22, 2002)

CESIUM-137

High levels of cesium-137 were released as a by-product in to the environment as a result of the surface testing of nuclear weapons. Energy released by the radioactive isotopes can result in significant damage to living cells. Both cesium-137 emit beta particles and gamma rays, which may ionize molecules within cells penetrated by these emissions and result in tissue damage and disruption of cellular function. The most important exposure routs for radioisotopes of cesium are external exposure to the radiation released by the radioisotopes and ingestion of radioactive cesium-contaminated food sources. Inhalation and dermal exposure routs may also present a health hazard. (Toxicological Profile for Cesium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Radiation absorbed doses are expressed in terms of the amount of energy absorbed per unit mass, in units called RAD. Generally, acute radiation doses below 15 RAD do not result in observable adverse health effects. At doses in the range of 15-50 RAD, subclinical responses such as chromosomal breaks and transient changes in formed elements of the blood may be seen in sensitive individuals. Symptoms of acute radiation syndrome are observed at radiation doses above 50 RAD, characterized by transient hematopoietic manifestations, nausea and vomiting, and moderate leukopenia at doses near 100 RAD, processing through more serious hematopoietic systems, clinical signs, and gastrointestinal symptoms with increasing dose (100-800 RAD), and usually death in persons receiving total doses ≥1000 RAD. Other health effects from acute or continued exposure to ionizing radiation may include reproductive, developmental, and latent cancer effects. (Toxicological Profile for Cesium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Signs and symptoms of acute toxicity from external and internal exposure to high levels of radiation from cesium-137 are typical of those observed in cases of high exposure to ionizing radiation in general. Depending on the radiation dose, symptoms may include those typical of acute radiation syndrome, skin lesions, neurological signs, chromosomal abnormalities, compromised immune function, and death. (Toxicological Profile for Cesium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Acute or repeated exposure of humans or animals to ionizing radiation may result in reduced male fertility, abnormal neurological development following exposure during critical stages of fetal development, and genotoxic effects such as increased frequencies of chromosomal aberrations, T-lymphocyte point mutations, dominant lethal mutations, and reciprocal translocations. (Toxicological Profile for Cesium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Do to the ionizing properties of radionuclide such as cesium-137, increased cancer risk would be expected among exposed individuals. However, studies of increased cancer risk specifically associated with exposure of humans to radioactive cesium do not exist. The closest source of information would be the Chernobyl reactor accident in the Ukraine. Long-term cancer studies on exposed individuals have not been completed to date. (Toxicological Profile for Cesium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Reproductive effects of cesium-137 in males may result in reduced fertility as evidenced by reduced concentrations of spermatozoa in men who had been exposed externally and internally to cesium-137 approximately 1 month prior to testing. The developmental effects such as reduced post-natal body weight, impaired motor activity, morphological changes in the brain, reduced head size, and retarded odontogenesis and palatal closure have been reported in rats that have been exposed to radioactive cesium. Reported developmental effects in similarly exposed mice included significantly decreased brain weight and increased aggressive behavior. (Toxicological Profile for Cesium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Due to the effects of ionizing radiation, radioactive cesium when it comes in to contact with cellular organisms will damage the cells chromosomal make up and cause other damage indicative of radioactive contamination. The lack of information regarding the specific effects of radioactive cesium is due to the lack of opportunity of long-term studies and populations exposed to only cesium-137, in most regional nuclear fallout contamination cases the regions are contaminated with many different types radioactive isotopes. (Toxicological Profile for Cesium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

Step 3: The key figures in this research project are Guam Insurance companies, the Government of Guam and its initiation of this research through the Blue Panel and other cooperating government institutions.

The office of Senator Angel Santos coordinates the initiation of this project; Senator Mark Forbs both have contributed greatly in the logistical areas of this report such as the initial funding. Other interested parties consist of effected citizens and their relatives; when asked they will provide the needed data in regards to patient history and what treatments were used in the correction of health problems. They will also provide needed samples from there loved ones for use in determining the amount of fallout they came in contact with, this will most likely take the form of baby teeth for the "Guam Tooth Fairy Project" (GTFP) (*Strontium-90 in baby teeth as a factor in early childhood cancer: Jay M. Gould, Ernest J. Sternglass, Janette D. Sherman, Jerry Brown, William McDonnell, Joseph J. Mangano International Journal of Health Services*). This information will be focused in one office so that a database can be compiled. This in turn would give us an idea of the financial impact these debilitating diseases had on the local families.

Organizations such as the Down winders thanks to Robert N. Celestial Co-author of this paper have contributed to national efforts in researching the steps already taken to correct fallout damage to social groups and communities in the United States such as the a for mentioned Jew Jersey Tooth Fairy Project. The healthcare industry can give us up to date national averages of different kinds of cancer and the commonality that their presence indicates. This is important because these companies live on probability of disease occurrence. Any abnormally high occurrence of cancer would directly impact on that company's ability to turn a profit, there fore compromising the company's future.

The different departments inside of Gov. Guam will also lend to the data collection once this project is fully funded focusing on such information as neurological problems with development on an education and social level. Department of Education will give this project information on educational budget impact in dealing with the integration of large groups of special needs students to mainstream student populations for education purposes. This could lead to an impact report for special education funding to compensate for the burden applied to the system at large. Public Health and GMH will provide information in much the same respect as the Health Care Industry simply because they are both part of the same health care infrastructure.

The importance of a second source for health care data for the population should not be underestimated. We can look for Strontium-90 in bones or teeth from people living on Guam in 1946 to the present time due to the potentially long duration that the radioactive particles can remain suspended in the atmosphere. This has been done in New Jersey to great effect. They called it the "Tooth Fairy Project" and it will be explained further in this document (*Strontium-90 in baby teeth as a factor in early childhood cancer: Jay M. Gould, Ernest J. Sternglass, Janette D. Sherman, Jerry Brown, William McDonnell, Joseph J. Mangano International Journal of Health Services*). With cooperating data from two sources can lead to a greater accumulation of supporting health trend information and health care that has been subsidized by the people of Guam. All of these organizations have expressed help in regards to financial burdens and equipment and personnel shortages. If it could be shown in a court of law that the Federal Government is at *fault*, then the possibility of support for them would be considerably more likely while in legal negotiations.

Step 4: To determine the possible impact on our population the activity in the Marshall's had, we will start with the people that were on Guam at that time.

It will likely be in the generation of citizens that were on Guam from Operation Ivy MIKE detonated 10/31/52 with a yield of 10400 Kilotons to Operation Hardtack I Poplar detonated 7/12/58 due to the possible personal contact with radioactive material as listed below (*University of Washington Radio ecological Studies in the Marshal Islands, 1946-1977*) (Appendix IV). Of this group of people the impact will be most apparent in the birth rate of the woman and any offspring that they produce. The reason for this is that woman are born with all the eggs that they will have for there entire life (Web MD.com), so it follows that any damage that would be caused by radioactive contamination known as cellular ionization spoken in more detail earlier in this report effect the offspring that would come as a result of a growing post war population. In the twelve years that the Federal Government detonated high yield nuclear devices the island was inundated with radioactive dust at least ten times. (A Defense Nuclear Agency Report on the Bravo Test Describing the Blast and Subsequent Fallout) Each reoccurring radioactive contact could have potentially caused a great deal of damage to the regions population. (University of Washington Radio ecological Studies in the Marshall Islands, 1946-1977) Health problems such as Cancer, Leukemia, and Multiple myeloma cost a great deal to treat through expensive chemotherapy and laser surgery, these costs would have direct impact on the well beings of those affected. The health insurance industry will also have been directly affected by a contamination of the general populations. Any condition brought about by radioactive fallout would raise the probability of health risk and there fore affect the overall standing of any insurance company of Guam.

Operation	Date	Yield
MIKE	**10/31/52**	**10400**
BRAVO	**2/28/54**	**15000**
ROMEO	**3/26/54**	**11000**
UNION	**4/25/54**	**6900**
YANKEE	**5/4/54**	**13500**
CHEROKEE	**5/20/56**	**3800**
NAVAJO	**7/10/56**	**4500**
TEWA	**7/20/56**	**5000**
OAK	**6/28/58**	**8900**
POPLAR	**7/12/58**	**9300**

These detonations are the ten worst nuclear bombs that the AEC ever tested in any of its nuclear test operations. They all have the needed explosive energy of 1 megaton to eject debris in to the upper atmosphere (12 to 55 miles high) and enter the jet stream. The six-year period from November 2 1952 to July 16 1958 would be the peek years that the radioactive fallout came to Guam. The dates are delayed by four days to account for the time it would take the radioactive cloud to reach Guam as is explained in reference to the Schreiber Report later in this paper. Any children born between these years should be examined in detail. What is expected in this sample of the population is an increase of cancers and other cellular diseases that are associated with radioactive fallout.

Step 5: Next we determine how other groups on the island and in the United States will react to the findings of this report.

The groups that will be paramount in the pursuit of a resolution to this issue are local families, education, healthcare organizations, the not for profit groups, and local environmental organizations. The groups that will be negative towards this issue will be the military (non-personnel), federal government, Department of Energy and some of the educational institutions that use federal money for research. These entities are connected to the status quo and any deviation from the defined norm will directly impact them in an adverse way.

The political implications of this issue will be very positive for the local officials; they will gain recognition for developing a new relationship with the federal government. They will also gain in the solving of problems that have plagued Guam for many years, such as the mentioned health care and elderly compensation issues for wartime activities. The voting behavior of the population will be more inclined with the members of the

Government that back such an initiative and create new potential growth for Guam jobs and its infrastructure.

The financial power is somewhat one sided when looking at the resources the Federal Government can bring to the negotiation's table. The Federal Government has a history of arguing the opposition's side of matters concerning fault and liability as they did in the case of the Marshall Islands (*University of Washington's Radio ecological Studies in the Marshall Islands, 1946-1977 Lauren R. Donaldson, Allyn H. Seymour, and Ahmad E. Nevissi*). The Marshal Islands filed a case against the Federal Government through the judicial branch in 1980 and by 1982 they had negotiated a status with the United States Federal Government. In the years since the initial settlement the Marshall Islands have received over one hundred million dollars in compensation. In late 2000, the Marshall Islands government filed a petition with the U.S. Congress seeking more than $1 billion in nuclear test clean-up compensation, damages and personal injury claims. In additions, it is seeking an additional $2.3 billion in health care funding for Marshall Islanders over the next 50 years. (Attorney optimistic about Marshall's claims, Guam Variety News and Views- Monday- April 15, 2002)

The island of Guam on the other hand has an over taxed judicial system and no resources to put forward to the end goal of compensation. It will be up to the elected officials to find a way to bring this subject to the courts. Why the judicial branch? History has shown us that relying on the congressional committee (Legislative branch) or the Presidential Committee (Executive branch) has taken the past forty years to lead us to this point. The Judicial branch is all that is left to us, without equal representation in the other two branches we will never get a hearing. The courts will give us a forum on which we can do a great deal of good for the island and its people. The judicial branch will also create the record needed to force fallout impact compensation legislation through congress so that we could have a forum of discussion for the compensation to take form.

Step 6: Alternative responses by the Federal Government could vary in the degree of their understanding.

They could agree with us and begin a federally funded impact report to find out how extensive the damage to the island was and propose some solution to deal with the defined impact. They could on the other hand take the subject and slowly develop a plan of action in the courts; this will have two effects on Guam. One will be the postponement of needed help; two Gov. Guam will be bled of badly needed resources till we cannot afford to move froward with the case. Either of these will be devastating to the island goal of compensation for the local population harmed by the events in question.

In the past the Congress has passed laws to help military personnel and workers of the state such as uranium minors and personnel related to that industry. The Federal Government set up a very narrow standard that the workers could be compensated. To date each states has had to form legislation to encompass each regions specific issues and populations. New Mexico lawmakers urged a Senate panel to include uranium miners and mill workers from their state in legislation to compensate victims exposed to radiation from the nation's nuclear testing program. Residents of Nevada, Utah and Arizona from 1947 to 1971 were eligible for compensation in the bill. New legislation by Rep. Bill Redmond, R-N.M., and Sen. Jeff Bingaman, D-N.M., would not only add residents of New Mexico but also expand the time of eligibility from 1942 to 1990 and increase compensation up to $200,000. Sen. Orrin Hatch, R-Utah, the panel's chairman, Sen. Edward Kennedy, D-Mass., have been advocates for American citizens gaining compensation. These would be some of the members of the Senate that the island could rally support from when the case for Guam's "down wind" status is resolved.

Step 7: The mission statement for this resolution of this issue is as follows.

It is the charge of the Blue Ribbon Panel to examine all material evidence (literature, audio, video, pictures, etc) and to conduct additional interviews and hearings in order that a comprehensive report replete with findings and recommendations may be forwarded for review and consideration by the Twenty-Sixth Guam Legislature as it relates to possible exposure to radiation by Chamorus and other Guamanians as a result of nuclear testing in the Western Pacific and other related activities from 1946-1958.

Step 8: This is a ranking of questions that we need to answer if any action can be taken.

Did radioactive particles reach Guam?

Yes, it can be shown that radiation traveled from the Bikini Island to Guam, and that Guam came in to contact with radioactive debris from a nuclear agency report, We also have documents that show the island had corresponding bouts of radiation from the detonation, and that the time that the radioactive cloud took to come here is directly related to detonations made in the Marshall Islands.

The following testimony is from a nuclear fallout specialist stationed on Guam in the early fifties, his duties were to maintain equipment for radiation monitoring, and was also responsible for coordination of military personal incase of nuclear attack.

> "On or about November 3, 1952 I was making my monthly check sitting at the desk in that office that was about 5 feet from the window screens that covered the wall all the way down to about a couple of inches from the floor. I took out the metal calibration rod (about as big as a normal soda straw and about 6 inches long) stored in the instrument that has a small radioactive source on its end.
>
> I put the counter on the low setting (it has three; low, medium, and high) and was ready to place the rod near the detection windows (two of them), but the dial needle was way over on the scale and the audible signal was clicking like mad, or almost a continuous sound; sounds like constant static on a radio.
>
> I raised it up and put it near the screen window, the dial needle swung even further over and the sound increased still further. I then put it close to the screen near the floor and the needle went of the scale (as far as it could swing right). I knew it was not the counter, but that there was some radioactivity outside.
>
> I ran outside with the counter (now on the medium range setting) and when I put it near the ground, especially where the rainwater that had fallen off the "roof" of the BOQ, the readings

> were very large. In spite of the readings, the total was not an immediate life-threat, but you wouldn't want to get any of that dirt on you body or especially in your lungs if you could help it.
>
> I did not stop to inform the Commanding Officer of the Headquarters Command whose office I passed on the way. I went immediately to the reception area (bypassing my immediate superior) and spoke to the Flag Lieutenant (top aide of the admiral), Lt. Cmdr. G. E. A. Holland, USN. I informed him of my findings and what they could mean and what the results were if something was not done etc. He told me to go wait in the corridor outside the office. A few minutes later the Flag Lieutenant came out and told me to leave. I then knew something was very, very wrong.
>
> The Guamainians, for the large part, had only rainwater for drinking, especially out in the "boonies" or jungle. They were drinking highly contaminated radioactive rainwater and I could not tell them to stop. The Navy, which had control over all the COMNAVMARINAS region of about 1.5 million square miles of the Pacific Ocean area, did not provide any information to the military personnel, civilians or the natives about how to protect themselves. Much construction was going on raising a lot of dust that included this fallout. Construction was not halted or even or even instructions given to wear a simple dust mask issued.
>
> I knew that many of the Guamainians and the other natives in that fallout area would eventually die horribly from cancer, leukemia, subtle birth defects, and too many other such afflictions to even list. (*Testimony of Charles Bert Schreiber July 30, 2001*)"

The dates that Lt. Schreiber inadvertently took the radioactivity readings coincide with operation Ivy-Mike; this device had a yield of 10,400 kilotons (see Appendix IV). This puts the radioactive cloud as high as 40 miles. We can use this as a measuring stick to determine a few previously unknown factors in how long it took the fallout to get here. Lt. Schreiber took the measurements on November 3 and the detonation was carried out on October 31 in the morning. With Guam at a distance of 1200 miles and the debris taking 4 days or approximately 96 hours to reach our region. This would give the radioactive cloud a speed of 12.5 miles per hour. This corresponds with the 10-20 MPH that the jet stream is reported to travel. The fact that it only took four days for the radioactive cloud is important because it opens the island up to various radioactive isotopes that have a considerably shorter half-life than Strontium-90. Iodine –131 has a half-life of eight days, this isotope has a serious effect on the body's thyroid and has been connected to many debilitating diseases. With the exposure of these and other isotopes the level of damage that the Schreiber testimony hints at is considerable (Institute for Social Ecology Chapter 6: RADIATON AND HUMAN HEALTH).

The Institute for Social Ecology compiled the following document and out lines what was observed in the northern hemisphere in regards to the fallout that occurred from the open air testing in the United States. What should be noted is the total yield of the open air testing in the United States was just over one megaton; this regions total yield was equal to one hundred and eight megatons. The information is pertinent to Guam because the behavior of the fallout should hold to the same level and more so due to the fact that the detonations that were preformed in this region were of a higher yield than the devices used in the North American continent. This section also deals with the level of disinformation that the Department of Energy perpetrated on the general population and the reaction to this information and how it compromised the integrity of that department. This goes to the credibility of the Federal Government and to what mind set they have put the general population.

The examples given with the "milk" issue does not directly impact Guam but if you consider the nature of that fallout and how the radioactive material traveled down the different trophic levels, then it could be extrapolated that when radio active debris came to Guam the different biota in that area would be affected. An example of this would be the radioactive particles fell in to the reef and was inadvertently consumed by various small animal and plant organisms. Then the reef fish feed on those contaminated smaller life forms and over time due to the number of contaminated organisms the level of strontium-80, strontium-90, cesium-137, and iodine-133 would build in these fish, then they in-turn were consumed by the local population. This could directly affect the people in this region and future generation of islanders.

> Until recently, the layman was given a highly misleading picture of the hazards created by nuclear weapons tests. This picture was largely created by the Atomic Energy Commission, the official agency that had been made chiefly responsible for furnishing the public with information in the field of nuclear energy. For many years the A.E.C. consistently minimized the danger posed by radioactive fallout produced by nuclear weapons tests. For example, it completely ignored the extent to which food had been contaminated with strontium-90 until scientists who were critical of the agency's public information policies raised the problem. "In the 13th Semiannual Report of the AEC, published in 1953" notes Berry Commoner, of Washington Univ. , "the AEC stated that the only possible hazard to humans from strontium-90 would arise from 'the ingestion of bone splinters which might be intermingled with muscle tissue during butchering and cutting of the meat.' No mention of milk was made"- or for that matter, of vegetables and cereals. Spokesman for the AEC predicted that fallout would be uniformly distributed over the earth, so that no areas need fear concentrations of debris from nuclear weapons tests. The public was assured that the greater part of the debris sent into the stratosphere would remain aloft for a period of five years. As fallout occurs very slowly, it was said, the radioactivity of short-lived radioisotopes would be almost entirely dissipated in the stratosphere.
>
> Actually, the radioactive debris that soars in to the stratosphere stays there, on an average, less than five years. According to General Herbert B. Loper, of the Department of Defense, half the stratospheric debris produced by nuclear explosion returns to the earth within two years. Fallout occurs three and one half times faster that Willard F. Liby, former commissioner of the AEC had estimated. A model of stratospheric air circulation developed by A. W. Brewer and G. M. B. Dodson indicates that the heaviest fallout in the northern Hemisphere occurs in the temperate zone, reaching a peak between 40 and 50 degrees north latitude-or roughly between Madrid and London in Europe and nuclear weapons test moratorium indicated that the hazard from fallout in these latitudes is substantially greater that the world wide average. (Let us grant that the AEC had made an honest error, but how did the agency handle the facts when it becomes evident from classified data that its predictions were wrong? A chronological account prepared by the joint committee on Atomic Energy indicates that a restudy by the AEC, released early 1959, "makes no mention of the Defense Department study" and " maintains the position of a residence time of 5 to 10 years, selecting 6 years as the mean residence time of stratospheric fallout. Results of another AEC analysis, Project Ash Can, which indicated a residence of 3 years, were discounted as being doubtful. No mention was made that the Department of Defense conclusions of residence half life of 2 years tended to support results of Project Ash Can."
>
> The rapidity with which radioactive debris descends to the earth places the danger presented by short-lived, supposedly harmless radioactive elements in a new perspective. Cesium-144 and strontium-80 have half-lives of only 290 and 56 days, respectively, but nuclear explosions produced these radioactive elements in such relatively large quantities that, if fallout is rapid, they become a serious hazard to public health. Cesium-144, like long-lived cesium-137 (another component of fallout), is an emitter of beta rays. When taken into the body, both cesium isotopes are handled metabolically like potassium; they migrate to all the soft tissues, including the reproductive organs. Strontium-89 possesses the characteristics of strontium-90; it, too, emits beta rays and tends to lodge in bone matter. Although a short-lived bone seeker like strontium-89 might seem to be relatively harmless, it should not be underestimated as a hazard to public health. "Since strontium-89 is produced more abundantly in fission than strontium-90…," the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy reported in 1959, "it is

possible that comparable doses to the body from the two materials could occur." The subcommittee added that ": it would require100 times more initial activity of strontium-89, whose half life is 56 days, to deliver the same dose to tissue that would be created by 1 unit of strontium-90. It is considered significant that transient levels of strontium-89 with approximately this ratio to strontium-90 have been observed in milk."

Fore a few weeks after a nuclear explosion, the wind-borne debris in the lower part of the atmosphere may contain appreciable amounts of iodine-131. Iodine-131 has a half-life of eight days. At the 1959 hearings of the Special Subcommittee on Radiation, E. B. Lewis, of the California Institute of Technology, observed, "the radioiodines in fallout are a significant fraction of the fresh fission products released by nuclear weapons explosion. Grazing cattle ingest and inhale those radioiodines in fallout and then concentrate it in their milk. Infants and children are expected to ingest more of the of the isotopes than will adults since fresh cows milk in the principal source of fallout radioiodine in the human diet and young people obviously drink milk more than do adults. As has long been known, iodine isotopes, natural and radioactive, concentrate in the thyroid gland. Moreover, for the same amount of radioiodine orally ingested, the infant thyroid receives some 15 to 20 times the dose that the adult thyroid receives. (Briefly, this is because more radioiodineis taken up by the infant than by the adult thyroid; as a result many more of the short-range iodine-131 beta rays will be generated in a gram of infant than in a gram of adult thyroid tissue.) Finally, in spite of its small size, the infant thyroid may be more susceptible tan the adults thyroid to cancer induction by ionizing radiation"(Institute for Social Ecology Chapter 6: RADIATON AND HUMAN HEALTH)

Different Laboratory's did various studies and measurements on Guam to see what the effect the radiation has on the population. This next quote gives an idea of the type of findings that they had found. This was a study of the biota (plankton and small marine animals) in the surface water of the ocean. What is important to note is that the only way that enough radioactive material could affect water in and around Guam would be through rainfall, and the decontamination of military boats in our region. Any injection of radioactive material in a primary trophic level would carry its self through to other animals such as fish then in to the local population. With the Schreiber testimony and this report the evidence that radioactive contaminated rain did come to Guam is reasonable to deduct.

"There were two ocean surveys in 1956, and three in 1958. Four of these surveys were Laboratory programs and the other (in 1958) was a joint effort of three teams; of which the Laboratory was one. Ships from the U.S. Navy supported all of these surveys. The general objectives for study of the fallout "foot print" remained the same, and, in a sense. The later surveys were considered to be sequels to preceding surveys. Principal findings are as follows:

2. The rate of advance of radioactivity in the surface waters was estimated to be approximately 13-18km (7-10 miles) per day and was reasonably close to previous predictions.
6. To indirectly monitor the arrival of fallout radionuclides "down stream" from the test sites, collection of plankton, fish, invertebrates and algae were obtained from Guam, Palau and the Gulf of Siam from July 1958 to October 1959. Their distances from the test sites were approximately 2,200 3,600, and 7,900 km (1,200, 1,950, and 4,250 miles), respectively. Guam and Palau and in the North Pacific Equatorial Current System, the Gulf of Siam is not. In terms of gross beta activity of the plankton samples, the Guam samples were very much greater than the Gulf of Siam. Radioactivity of the Gulf Siam samples was no greater than would be expected from naturally occurring radioisotopes. *There was a major peak at Guam in January 1959 and a minor peak at Palau in August 1958.* Conclusion: the feasibility of using biota for this indirect measure of identifying the presence of fallout radionuclides transported; however, a reliable prediction of the date of radionuclide origin (the date of nuclear detonation) cannot be made from the available data. (*University of Washington's Radio ecological Studies in the Marshall Islands, 1946-1977 Lauren R. Donaldson, Allyn H. Seymour, and Ahmad E. Nevissi*)"

Other documents have surfaced that lead us to the conclusion that rain was not the only way that the radioactive isotopes reached Guam. This document is part of a radiation safe protocol that was put in to action and used on Guam to decontaminate ships that were at the test sights. It says that the radioactive dust was washed in to harbors; this directly puts the local food supply at risk and is a perfect example of direct dust contamination of Guam, not by rain but by Government policy. These policies were setup after the fact and were only put in to place to protect the military personal from radioactive contamination.

> After further study, the task force radsafe and safety advisors decided the precautions set forth in the letter of 19 August were inadequate to protect personnel from alpha emitters associated with the detected radiation. Moreover, considerable cleaning would be required to eliminate radioactivity and the cleaning itself and the wastes created would pose yet another problem. After a conference with the safety advisors, the ComServPac on 29 August issued special precautions to be applied to all vessels that had spent more than 10 days in Bikini Lagoon after 25 July (Reference C.9.185, p. 21). In summery, the precautions were as follows:
>
> 1. Avoid dry-docking until further notice.
> 2. Avoid opening saltwater pluming.
> 3. Avoid exposing the external surface of the hull below the water line.
> 4. Avoid exposing personnel to fumes or dust from welding, cutting, or other work on contaminated saltwater surfaces.
>
> Disposal of Acid used in Decontamination
>
> Cleaning ships' hulls using wet sandblasting and cleaning saltwater piping using various acid solutions began early in the effort to decontaminate non-target CROSSROADS vessels. Until 4 December 1946, the sand and acid solution used to decontamination was segregated and disposed of at sea.
>
> The problem of disposal was discussed at the Washington BuShips conference on 27 November. The conferees concluded that (Reference C.9.187, pp. 108 and 109):
>
> 1. Special disposal of sand used in sandblasting underwater bodies of radioactively contaminated non-target ships in not required, provided marine growth is removed first and disposed of.
> 2. Solutions used in removal of radioactivity from saltwater systems of non-target ships may be discharged into harbors preferably at a slow rate or after dilution, without security or health hazard.
> 3. Acid and other decontaminating solutions used in cleaning saltwater systems may be discharged in to the harbor. Solutions should be discharged at slow rate or by providing a flow of water along with the discharge so as to dilute the solution by about one-forth. Discharge should be made will clear of docks and shorelines during ebb tides.
>
> (*Operation Crossroads, 1946 united States Atmospheric Nuclear Weapons Tests Nuclear Test Personnel Review*)

The following document represents data collected from a local researcher and consultant on this paper. It describes the level of fallout that the island endured. It also talks about radiation exposure compensation for populations in fallout areas. The U.S. Environmental Protection Agency nuclear exposure standard is 15 millirems this was exceeded many times over in the fallout from the Marshall Islands. Accurate comparison to the fallout received in the United States verses the amount of fallout in our region. Citizens of the main land have received compensation for various types of fallout related problems and we the people of Guam were subjected to forty two times the amount of fallout then it would follow that we should be considered for compensation. Any and all people that were living or stationed here on Guam would fall under this umbrella of radioactive debris.

> More than six billion curies of I-131 was released to the atmosphere as a result of the testing in the Marshal Islands. The amount is 42 times the approximately 150 million curies released as a result of testing at the Nevada test site.
>
> President Clinton signed into law the Exposure to Radiation Act in July 2000. Prior to that he signed an Executive Order in 1994 to form the Advisory Committee to research Human Radiation Experiments. The Advisory Committee declassified records from these Agencies: CIA, FBI, DOE, and DNA. In there findings they mentioned in the final report that it was worse than the Nuremburg era.
>
> Radiation Exposure Compensation Act Amendments of 2000 January 24, 2000.
> S. 1515 Amendment Sec. 2 Findings
> Congress finds that-
>
> 1. The Radiation Exposure Compensation Act (42 U.S.C. 2210 note) recognize the responsibility of the Federal Government to compensate individuals who were harmed by the mining of radioactive materials or fallout from nuclear arms testing.
>
> 6. It should be the responsibility of the federal Government in partnership with the State and local governments and appropriate healthcare organizations, to initiate and support programs designed for the early detection, prevention and education on radiogenic diseases in approved States to aid the thousands of individuals adversely affected by the mining of uranium and the testing of nuclear weapons for the Nations weapons arsenal.

(*Radiation fallout Guam by Robert N. Celestial Atomic Veteran, SGT, Retired U.S. Army)*

In a Defense Nuclear Agency Report it states that ships between 110 deg. And 155 deg. were contaminated down wind from the test sight this puts a radioactive cloud that starts half way between Guam and the Marshall Islands (although it is safe to assume that the clouds point of origin would have been the Marshall Islands), it ends on the coast of Vietnam. All U.S. Navy boats in this area on that date would have gone through radiation decontamination. This is also important because it confirms the travel speed, distance of the radioactive cloud, and will allow for us to take a closer look at the exact times that the cloud could of reached Guam.

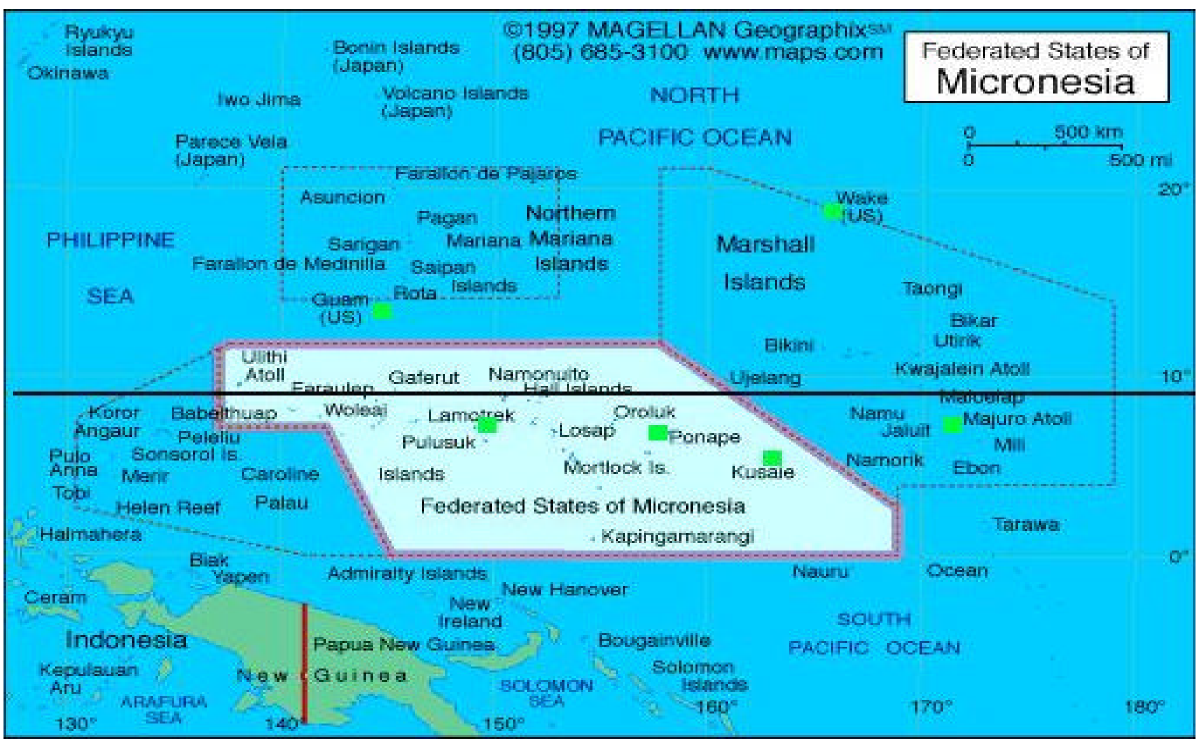
> "Meanwhile, at those fleet units arrayed in a sector bounded by 110deg. and 155deg. bearings from ground zero about 1300 and Continued into the evening. It reached maximum at 1800 and had ceased by 2400. This fallout appeared to be composed of much smaller particles that had taken considerably longer to fall from the great heights to which they had been carried than the large particles from the morning fallout. Again wash down systems were turned on. A TG 7.1 radsafe representative on the Bairoko advised that all nonessential personnel remain below decks to minimize the Possibility of inhaling the small particles."

(A Defense Nuclear Agency Report on the Bravo Test Describing the Blast and Subsequent Fallout)

Did the particles enter in to the food and water supply of the population?

The process by which radioactive particles are pulled out of the atmosphere is called the *Scavenging effect* this is the selective removal of material from the radioactive cloud from a nuclear explosion by inert substances, such as earth or water, introduced into the fireball. The term is also applied to the process of removal of fallout particles from the atmosphere by precipitation. This process acts as a filter peculating the radioactive debris out of the upper atmosphere and dumps it on regions that the rain happens to land on. This creates hot spots or a region in a contaminated area in which the level of radioactive contamination is somewhat greater than in neighboring regions in the area. It has been shown through the Schreiber report that the rain on Guam was directly contaminated by radioactive isotopes, this next exert shows that years later the residue of what the original exposure level was on Guam.

Beginning in 1968 and ending in 1974 the Lawrence Livermore Laboratory tested the water of Guam for strontium 90; as mentioned earlier in this paper strontium-90 is a byproduct of open air testing of fission nuclear weapons. This research was preformed for the U.S. Energy Research & Development Administration. Its purpose was to determine the range that the radioactive cloud traveled and to what level that contamination was in the water supply. They did this so as to know how much radiation the different populations were receiving and how in the long term they would react to radioactive isotopes. The health and Safety reports were used to determine minimum safe distances in regards to both local and global fallout.



Shown on this table are the strontium 90 concentrations on rainfall at several Pacific islands between 1968 and 1974. When the six-year mean value are plotted as a function of latitude, the interpolated (to change by inserting new or foreign matter) mean quantity of fallout strontium 90 expected in rainwater at

the latitude of Bikini Atoll is only 0.1 pCi/Liter. The cisterns have, on the average, 15 times this concentration.
(Evaluation of the Radiological Quality of the Water on Bikini and Eneu Islands in 1975: Dose Assessment Based on Initial Sampling, written on January 21, 1977 by *V. E. Noshkin, W. L Robison, K. M. Wong, and R. J. Eagle*)

Strontium 90 in Yearly Rain Fall (pCi/Liter)

Island	1968	1969	1970	1971	1972	1973	1974	Six Year Mean
Wake	*0.35*	*0.47*	*0.44*	*0.35*	*0.28*	*0.07*	*0.25*	*0.320*
Johnston	*0.36*	*0.51*	*0.26*	*0.54*	*0.14*	*0.05*	*0.68*	*0.360*
Guam	**0.20**	**0.11**	**0.13**	**0.13**	**0.10**	**0.02**	**0.10**	**0.110**
Yap	0.12	0.07	0.11	0.07	0.05	.008	0.07	0.071
Truk	0.08	0.08	0.10	0.08	0.03	.003	0.06	0.061
Koror	.095	0.04	0.07	0.07	0.05	.003	0.06	0.055
Majuro	0.11	0.09	0.14	0.09	0.03	.006	0.06	0.075
Ponap	0.08	0.07	0.09	0.10	0.03	.008	0.05	0.061

(Fallout Program Quarterly Summary Report, Appendix, U. S. Energy Research and Development Administration, Health and Safety Lab Report 1975)

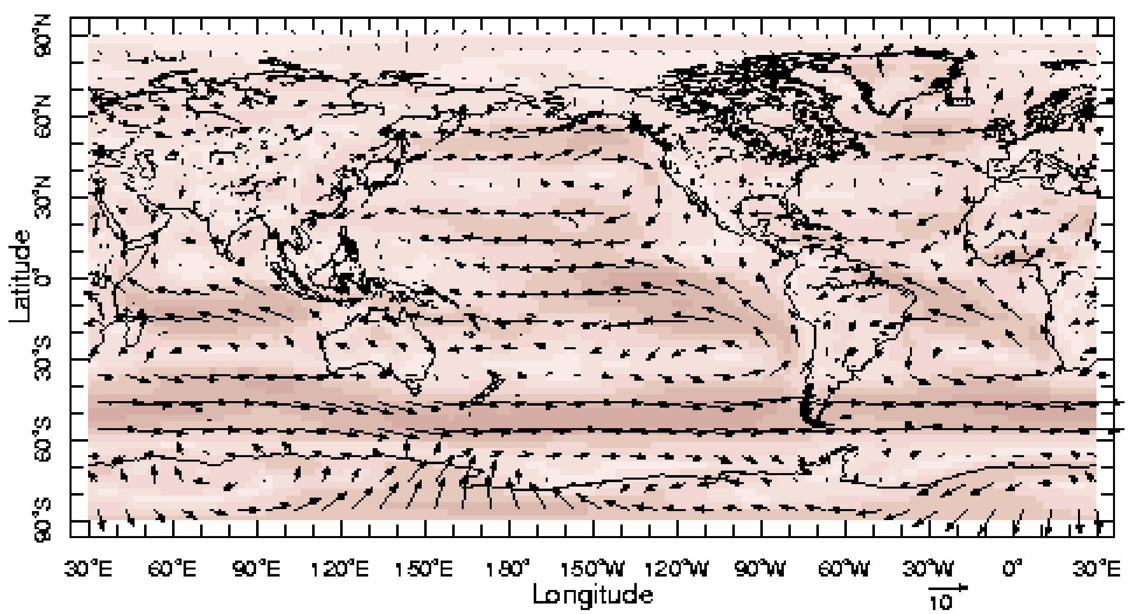
This Map depicts the different locations that were tested in this region. The islands that are located below the black line have significantly less strontium 90 in its water than those islands that are located above the line. This indicates that the majority of the radioactive fallout was carried by the trade winds and deposited on those areas that it passed over.

With the concentrations being higher in the water cache systems due to evaporation that puts the level of contamination at 3.0 strontium 90 pCi/Litre in 1968, ten years after the last open air detonation in the region. If these levels were present years after those detonations then it could be argued that the levels of strontium 90 were a great deal higher between 1946 and 1958 when the U.S. Government was actively inundating the island with radioactive particles. Another point that this report brings out is the fact that after ten years the radioactive particles were still suspended in the air years after the last bomb was detonated. This information has the potential to expand the initial age bracket for contamination. If this information is taken in to consideration any person born from May 1946 to August 1958 would have been affected, but if the particles stayed suspended for twenty or thirty years after detonation as this report indicates then the final date for the exposure could be in to the nineteen eighties. If this is the case then a very large segment of the population has been affected and compensation could be considerably larger.

The amount of Strontium-90 that has been measured in drinking water in different parts of the United States by the EPA is generally less than one tenth of a Ci for every Liter of water. In the tests above the readings in 1968 were twice those numbers. Indicating a much higher level of contamination than that of the continental United

States. Due to the water catch systems bringing those readings as high as thirty times that of the US, the EPA states that the 0.1 pCi is a safe level to have but the DOE has established derived air concentrations for workplace exposure at DOE facilities at 0.000000002 Ci/mL of air for less than 100 days retention in the lungs, Guam's levels exceeded that by many times ten years after the last nuclear detonation was carried out. According to the Fallout Program Quarterly Summary Report, Appendix, U. S. Energy Research and Development Administration, Health and Safety Lab Report 1975 Guam had a Strontium-90 level reading of 0.2 pCi/Liter ten years after the last detonation, this gives rise to questions of safety for the population of this island and the surrounding islands. The people of this island were subjected to these levels for over twelve years (Toxicological Profile for Strontium by the Department of Health & Human Services Public Health Service Agency for Toxic Substances and Disease Registry October 31, 2001)

The following image depicts the course that the jet stream travels on average for wind direction. Guam lies at 13.48N Latitude and 144.45W Longitude, the Marshall Islands Lie due East at 11.62 North Latitude and 165.48 east Longitude. The jet stream moves directly West of the Marshall Islands and in to our area. This is important because the jet stream is one of the pathways for the contamination took to reach Guam. It also explains why Guam has a higher level of contamination than some islands located in a more southerly direction. This image also indicates the direction globally that an fine panicles of matter would have traveled and in what sovereign countries this radioactive debris would have contaminated. The Bravo device had a radioactive cloud potentially over five thousand miles long, probably longer and this cloud could have



925 mb Sep-Nov 1961

The rain that Guam received in the years between 1946-1958 would have traveled down in to every level of food and water supply in significant amounts. For example taking a look at the detonation of the Ivy-Mike; this device had a yield of 10400 kilotons. As mentioned earlier in this paper in the testimony of Charles Schreiber, we know that the fallout on Guam corresponds with the date of that detonation. This radioactively contaminated water then entered the local populations drinking system via the local practice of catching water in containers for consumption purposes. Due to the remote geographical location there was a great deal of agriculture being practiced to support the local population. This too would have been heavily contaminated even with practiced sanitation through washing of all grown products. All un-distilled water on Guam comes from local precipitation this being the case the population that lived on Guam from 1946 to at least 1975 were contaminated through actions taken by the United States Government Department of Energy. (Fallout Program Quarterly Summary Report, Appendix, U. S. Energy Research and Development Administration, Health and Safety Lab Report 1975)

What impact did the contamination have on the population and the following generations of the Guam people?

The Federal Government has made a list of the various diseases known to be connected with radioactive fallout. This list was created for the Marshall Island people so as to determine the amount of compensation due to them. The amount of money given over to date has far exceeded these numbers but it does set a precedent for further compensation in respect for the diseases listed.

> "In June 1983, the United States and the Marshall Islands entered into a formal agreement in which the U.S. recognized the contributions and sacrifices made by the Marshallese as a result of the Nuclear Testing Program. The Marshall Islands Nuclear Claims Tribunal was established in 1988 to grant compensation for personal injury that deemed to have been caused by the testing.

As of December 31, 1997 $63,127,000 had been awarded to or on behalf of 1,549 people.

Marshall Islands Nuclear Claims Tribunal Summary of Presumed Medical Conditions Regulations

> Pursuant to 23(13) of the Marshall Islands Nuclear Claims Tribunal Act 1987, as amended, the Tribunal adopted regulations in August 1991 establishing a list of 25 medical conditions which are Irrefutably presumed to be the result of the Nuclear Testing Program. Those regulations were amended by the Tribunal and approved by the Cabinet of the Republic of the Marshall Islands in January 1944 to add two additional conditions (numbers 26 and 27 below) to the presumed list. Effective October 1, 1996, the regulations were again amended by the Tribunal and approved by

the Cabinet to include seven additional conditions (number 28-34 below).

For eligible claimants, the administratively presumed medical conditions and the amounts of compensation for each that will be paid in pro rata annual payments are as follows:

1. Leukemia (other than chronic lymphocytic leukemia)...……….$125,000

2. Cancer of the thyroid

a. if recurrent or requires multiple surgical and/or ablation..…………………………………$75,000

b. if non-recurrent or does not require multiple treatment.......................................………………………………..$50,000

3. Cancer of the breast

a. if recurrent or requires mastectomy.............……………………$100,000

b. if not recurrent or requires lumpectomy..........………………… $75,000

4. Cancer of the pharynx............................……………………….$100,000

5. Cancer of the esophagus...........................……………………..$125,000

6. Cancer of the stomach............................……………………..$125,000

7. Cancer of the small intestine.....................……………………$125,000

8. Cancer of the pancreas...........................……………………..$125,000

9. Multiple myeloma...................................……………………...$125,000

10. Lymphomas (except Hodgkins's disease)..............…………..$100,000

11. Cancer of the bile ducts..........................……………………$125,000

12. Cancer of the gall bladder........................…………………...$125,000

13. Cancer of the liver (except cirrhosis or hepatitis B is indicated)...................................…………………………………$125,000

14. Cancer of the colon................................……………………..$75,000

15. Cancer of the urinary bladder.......................………………….$75,000

16. Tumors of the salivary gland

a. if malignant....................................…………………………….$50,000

b. if benign and requiring surgery..................……………………..$37,500

c. if benign and not requiring surgery..............……………………$12,500

17. Non-malignant thyroid nodular disease (unless limited to occult nodules)

a. if requiring total thyroidectomy..................……………………..$50,000

b. if requiring partial thyroidectomy................…………………….$37,500

c. if not requiring thyroidectomy....................……………………..$12,500

18.Cancer of the ovary...............................……………………….$125,000

19.Unexplained hypothyroidism (unless thyroiditis indicated

....………………………………….$37,500

20.Severe growth retardation due to thyroid damage......………….$100,000

21.Unexplained bone marrow failure.....................……………….$125,000

22.Meningioma.......................................……………………….$100,000

23. Radiation sickness diagnosed between June 30, 1946 and August 18, 1958, inclusive..................…………………………………..$12,500

24. Beta burns diagnosed between June 20, 1946 and August 18, 1958, inclusive.......................……………………………………….$12,500

25.Severe mental retardation (provided born between May and September 1954, inclusive ,and mother was present on Rongelap or Utirik Atolls at any time in March 1954)........………………….$100,000

26.Unexplained hyperparathyroidism......................…………..$12,500

27. Tumors of the parathyroid gland

a.. ifmalignant...................................……………………….$50,000

b. if benign and requiring surgery....................…………………$37,500

c. if benign and not requiring surgery................……………….. $12,500

28. Bronchial cancer (including cancer of the lung and pulmonarysystem)...............................……………………….. $37,500

29.Cancer of the brain................................…………………... $125,000

30.Cancer of the central nervous system................…………… $125,000

31.Cancer of the kidney................................………………… $75,000

32.Cancer of the rectum................................………………… $75,000

33.Cancer of the cecum................................………………… $75,000

34. Non-melanoma skin cancer in individuals who were diagnosed as having suffered beta burns under number 24 above............................……………………………………… $37,000

> The regulations adopted by the Tribunal also provide a mechanism and set out applicable standards for (1) the consideration of non-presumed conditions for compensation in individual cases; (2) the periodic standards for (1) the consideration of non-presumed conditions for compensation in individual cases; (2) the periodic evaluation of possible modifications to the list of presumed conditions; (3) the assignment of compensation levels to non-presumed or future presumed medical conditions; and (4) adjustments to the amounts of compensation based on a claimant's age and prognosis. "
> (Source: Nuclear Claims Tribunal, Republic of the Marshall Islands)

With this established, a case could be made for compensation, the problem will be the subtle way that the radiation affected the Guam people. The people of the Marshall Islands were with in a 100 miles of the explosion we were 1200 miles down jet stream, this means that the symptoms that the islands population will exhibit will be different but related to those that were seen in the Marshall Islands.

As for the detection of radioactive particles other states in the U.S. have already gone the next step. They had their children's baby teeth tested for Strontium 90, this being a product of nuclear fallout. If we the people of Guam made a push to have our own "Tooth Fairy Project" then we could get data that would show that we were contaminated.

> "Programs focused on measuring Sr-90 in human bone and teeth because of the known biochemical actions and physical behavior of this radioisotope, along with the biochemical actions and physical behavior of the radioisotope,

> along with the feasibility of measuring Sr-90, years after it enters the human body due to its long physical half life of 28.7 years.
>
> The U.S. Government also participated in a study measuring Sr-90 concentrations in the baby teeth of about 60,000 children by the St. Louis-based Committee for Nuclear Information (CNI) began in 1958. The use of baby teeth made it simple to collect large samples, rather than relying on autopsy results. The baby tooth analysis" (*Strontium-90 in baby teeth as a factor in early childhood cancer: Jay M. Gould, Ernest J. Sternglass, Janette D. Sherman, Jerry Brown, William McDonnell, Joseph J. Mangano International Journal of Health Services*)

In an effort to seek information about the physical presence of radioactive isotopes on Guam, steps were taken to speak to field researchers at the University of Guam and discern if they had ever found any signs of the longer lasting byproducts of nuclear fallout. Research was done on Guam by the National Geological Research Center to determine at what rate the island of Guam was and is eroding. They use different mineral markers to determine what loose soil was moving and were. The geologists used a specific isotope as a marker in this research, the importance of this marker is that it is *not* naturally forming particle. The particle in question is Cesium-137; this isotope has a thirty-year half-life a proven fission byproduct of open-air nuclear detonations, and is expounded upon in greater detail earlier in this paper. That means that one quarter of the radioactive fallout in the fifties will be on Guam in 2010, eight years from the date of this report publication. The fact that the particle exists on Guam is enough at this phase of the project. Once adequate funding has been identified then more specific measurements can take place to evaluate the total level of radioactive contamination.

Another source of information on Strontium-90 levels in and around the island would be the coral reefs that make up much of our coastline. Coral reefs are communities of animals that extract calcium out of the ocean and use it to create a hard shell the use as a home, the creation of millions of these shells create the reefs. Because of the relation between Strontium and Calcium the coral animals could not tell if it was using the isotope or the calcium. Another important characteristic of coral life forms is the layer upon layer of these coral shells that make up the reef its self, much like a tree the coral reef has "rings" that show the age and trauma that the colony would have endured, but most importantly we would have level and date indicators on environmental interaction of Strontium-90. If this process of determination were implemented buy the BRAVO Commission then this being the first case that reef morphology would be used to determine the levels of radioactive isotopes in an environmental context.

Both the reefs and the geological survey are examples of areas that research that needs to be done in order to fully understand the total impact the radioactive fallout has had and will have on this and the surrounding islands in our region. Another proposed sight of geological information would be the Fena Valley Reservoir, the sediment strata would represent a geological time table that could provide the yet another source of in formation showing when and how much radioactive debris fell to Guam. As information develops and different sources of data become apparent this projects will grow in to an overall survey of the island and its relationship with the events in question.

What can be done to aid the Guam people if contamination is found?

The first aspect that must be looked at is in what direction the island wishes to take in any kind of tort litigation. The Federal Government has litigation broken down in to four main branches. Litigation against the Federal Government is under the general supervision of the Civil Division's Torts Branch. The Torts Branch has four different litigation offices or staffs, each of which specializes in a different area.

The ***Aviation and Admiralty*** Staff handles claims arising out of the government's role as aircraft or ship owner and as regulator of both air traffic and the nation's coastal and inland waterways. The Aviation and Admiralty staff represents the government in its role as owner of ships and regulator of the nation's coastal waters and inland waterways. Admiralty litigation may involve suits under statutes such as the Suits in Admiralty Act, the Public Vessels Act, and the Contract Disputes Act. Issues in admiralty may involve cargo damage, ship collision, contracts, and *pollution in navigable waters*. Aviation litigation arises from private and *military* air carrier operations and from the government's ownership and operation of both civil and military aircraft. The government's role in air traffic control, aircraft and airport certification, and dissemination of weather information is often involved in these cases.

The Admiralty staff of the Torts Branch specializes, on the defensive side, in cases involving collisions at sea, groundings, seamen's injuries, search and rescue and other actions relating to the government's regulation of the nation's waterways. On the affirmative side, the cases include mortgage foreclosure, oil pollution and damage to government property. The admiralty staff also handles cases filed in district courts involving maritime contracts, both defensive and affirmative. The Admiralty staff generally retains primary responsibility for the defense of admiralty litigation, including preparation and trial. In any admiralty case handled primarily by an Assistant United States Attorney, there should be close cooperation with the Admiralty staff.

The Aviation staff specializes in the defense of aviation cases arising primarily out of the activities of the FAA, NWS, NOAA and the military services. The Aviation staff generally retains primary responsibility for the defense of aviation litigation, including preparation and trial, particularly if questions of broad national import with particular presidential significance are involved, or if the litigation will raise questions concerning the use of air traffic control services or dissemination of weather and in-flight information to operators of commercial and private aircraft. In any aviation case handled primarily by an Assistant United States Attorney, there should be close cooperation with the Aviation Staff.

Two field offices handle the bulk of New York and West Coast maritime cases, because of the number of cases arising in these port areas and the active presence of major client agencies there. Maritime cases involving New York or nearby environs are generally handled in the New York Field Office located in New York City. Case brought in West Coast states, as well as in Alaska, Hawaii and *Guam are generally handled in the West Coast Field Office in San Francisco.*

The ***Constitutional and Specialized Torts*** Staff represents federal employees sued in their individual capacities for actions taken within the scope of their employment and handles matters arising out of claims under the Vaccine and Radiation Exposure compensation programs. The Constitutional and Specialized Torts staff represents current and former Government officials who are personally sued for monetary damages as a result of actions taken in the course of their official duties. An exception to this is that all cases relating to the delivery or failure to deliver medical care to prisoners, including Bivens actions, should be sent to the FTCA staff. This staff also represents the government in claims brought against the Secretary of Health and Human Services under the National Vaccine Injury Compensation Program. Cases under the Program are litigated in the U.S. Court of Federal Claims and involve allegations of injuries and death attributable to the receipt of certain childhood vaccines. Further, this section is responsible for reviewing claims and compensating victims of radiation exposure from atmospheric nuclear testing and uranium mining under the Radiation Exposure Compensation Act.

The Constitutional Torts staff defends present and former government officials in suits seeking damages against them in their official and individual capacities based upon official conduct. Pursuant to 28 U.S.C. §§ 516 to 519, the Attorney General and the Department of Justice are responsible for attending to the interests of the United States in litigation which includes providing representation to present and former government employees who are sued for actions taken within the scope of their employment. Policy guidelines for Department of Justice representation are published at 28 C.F.R. §§ 50.15 and 50.16. The Constitutional Tort staff processes the majority of representation requests in suits against individual federal employees, and questions regarding representation requests should be directed to that staff.

Personal damages claims against individuals raise special concerns that are critical to their defense and with which the government attorney must be able to deal effectively. These are discussed briefly in subsequent sections.

The Constitutional Torts staff defends present and former government officials in suits seeking damages against them in their official and individual capacities based upon official conduct. Pursuant to 28 U.S.C. §§ 516 to 519, the Attorney General and the Department of Justice are responsible for attending to the interests of the United States in litigation which includes providing representation to present and former government employees who are sued for actions taken within the scope of their employment. Policy guidelines for Department of Justice representation are published at 28 C.F.R. §§ 50.15 and 50.16. The Constitutional Tort staff processes the majority of representation requests in suits against individual federal employees, and questions regarding representation requests should be directed to that staff.

Personal representation of government employees is necessary only when they are sued in an individual capacity for damages. When a government employee is sued in an official capacity, the real defendant is the United States. Should relief be awarded, it would be against the resources of the United States. The Department of Justice represents federal officials sued in their official capacities for declaratory, injunctive or other forms of relief. No formal request for representation is necessary in such cases.

When an employee (present or former) is sued in his or her individual capacity, he or she is the personal target of the lawsuit. The plaintiff seeks recovery from the personal assets of the employee as opposed to the assets of the United States. Additionally, it is noted that in most instances a federal employee providing testimony (i.e. deposition), and who is not a party to the action, does not need personal representation and Department of Justice representation will not be authorized. In any case in which there is doubt as to whether an employee is sued in his individual capacity for constitutional or federal statutory violations, authority to represent the official individually should be secured from the Department pursuant to 28 C.F.R. § 50.15.

The employee's actions giving rise to the suit must reasonably appear to have been performed within the scope of his/her federal employment. . It must also be in the interest of the United States to provide the requested representation. 28 C.F.R. § 50.15(a). The Department of Justice is ultimately responsible for making the "scope" and "interest" determinations after benefiting from the agency recommendation. Because the Executive Branch is responsible for determining the interests of the United States in litigation, decisions of this nature are precluded from Judicial Branch scrutiny by the doctrine of separation of powers. *Falkowski v. Equal Employment Opportunity Commission*, 764 F.2d 907 (D.C. Cir. 1985), *reh'g denied*, 783 F.2d 252 (D.C.Cir.), *cert. denied*, 478 U.S. 1013 (1986).

The current immunity doctrines not only are designed to protect officials from liability but from the burdens of litigation as well. *Harlow v. Fitzgerald*, 457 U.S. 800 (1982). Accordingly, an order denying an absolute immunity defense is immediately appeal able, to the extent that it turns on an issue of law. *Mitchell v. Forsyth*, 472 U.S. 511, 530 (1985). In *Johnson v. Jones*, 515 U.S. 304, 115 S.Ct. 2151 (1995), the Supreme Court held that a pretrial order denying qualified immunity is not immediately appeal able to the extent that the order "determines whether or not the pretrial record sets forth a 'genuine' issue of fact for trial." 515 U.S. at 319. Nevertheless, appellate jurisdiction will still exist over the district court's determination that a violation of clearly established law has been shown on a given set of facts, or that a factual dispute is material to the issue of qualified immunity. *See Behrens v. Pelletier*, ___ U.S. ___, 11 6 S.Ct. 834, 842 (1996). Regarding any possible appeal of a denial of immunity, very close contact should be maintained with the Torts Branch and Appellate Staff. *See* 28 C.F.R. § 50.15(a)(11).

The ***Environmental Torts*** (formerly Environmental and Occupational Disease Litigation) Staff handles property and personal injury cases involving toxic substances in the environment, the workplace, and government-owned housing. The Environmental Torts (ET) staff defends the United States in cases arising from allegations of personal injuries and property damage due to exposure to toxic materials resulting from federal activities. Ongoing litigation addresses complaints of injuries caused by air, surface-water, or groundwater contamination; housing and facility construction/renovation programs; and radiation experimentation. These cases include exposure to substances such as TCE, PCBs and dioxins, asbestos, lead-based paint, Agent Orange, Legionnella bacteria, radiation, electric magnetic fields and biological agents. Tort cases alleging toxic injury to persons or property in the course of EPA's clean-up activities are the responsibility of ET.

On October 15, 1990, Congress passed the Radiation Exposure Compensation Act (the "Act"), 42 U.S.C. § 2210 note (Supp. 1995), which provides for compassionate payments to, or on behalf of, individuals who contracted certain cancers and other serious diseases following exposure to radiation that was released during above-ground nuclear weapons tests or as a result of their exposure to radiation during employment in uranium mines.

The Radiation Exposure Compensation Program (the "Radiation Program"), part of the Torts Branch, Civil Division, is responsible for administering the Act. The procedures established in the implementing regulations are designed to utilize existing records so that claims can be quickly resolved in a reliable, objective, nonadversarial manner with little administrative cost to the United States or to the person filing the claim. Part 79 of Title 28, Code of Federal Regulations.

There are three categories of claims: uranium miners, down winders, and onsite participants. There are two major eligibility criteria for each category of claims: exposure to radiation and subsequent development of a compensable disease.

The uranium miner provisions of the Act provide a payment of $100,000 to, or on behalf of, underground uranium miners who worked in Arizona, Colorado, New Mexico, Wyoming or Utah during the years 1947 to 1971. The miner must have been exposed to certain threshold levels of radiation measured by working level months of radiation ("WLMs") during the course of his underground uranium mining activities. The miner also must have subsequently developed primary cancer of the lung or one of the following non-malignant respiratory diseases: pulmonary fibrosis, fibrosis of the lung, cor pulmonale related to fibrosis of the lung, and moderate or severe silicosis and pneumoconiosis. § 5(b)(3), 42 U.S.C. § 2210, 28 CFR §§ 79.31(h), (i).

The down winder provisions of the Act provide a payment of $50,000 to, or on behalf of, individuals who lived or worked downwind of atmospheric nuclear tests in certain geographical areas in Utah, Nevada and Arizona for at least 24 months (cumulative or consecutive) during the time period of January 21, 1951, and ending on October 31, 1958, or the entire period from June 30, 1962, to July 31, 1962. In order to receive compensation under the "downwinder" provisions of the Act it must also be demonstrated that, after the requisite length of exposure, one of the following specified compensable diseases was developed: leukemia (but not chronic lymphocytic leukemia), lymphoma (but not Hodgkin's disease), multiple myeloma, or primary cancer of the thyroid, female breast, esophagus, stomach, pharynx, small intestine, pancreas, bile duct, gall bladder, or liver. § 4(b)(2), 42 U.S.C. § 2210, 28 CFR § 79.21(d). Each disease has its own additional requirements such as age at first exposure, latency period, and absence of heavy smoking and drinking. 28 CFR § 79.22(b).

The onsite participant provisions of the Act provide a payment of $75,000 to, or on behalf of, individuals who contracted a compensable disease after being present onsite, as a participant, during a period of atmospheric nuclear testing between July 16, 1945 and December 31, 1962. The test site locations where atmospheric nuclear testing occurred are: (1) the Nevada Test Site; (2) the Pacific Test Sites; (3) the Trinity Test Site; and (4) the South Atlantic Test Site. § 4(a)(2)(C), 42 U.S.C. § 2210, 28 CFR §§ 79.42(a), (b). The onsite participant also must have developed one of the 13 cancers identified under the down winder provisions.

The Environmental Torts staff (formerly Environmental and Occupational Disease Litigation (EODL) staff) defends the United States in FTCA and other toxic tort actions arising from contamination of the environment or exposure in the workplace and elsewhere to chemicals or substances. Some of the most visible examples of the litigation over the past few years have been those cases dealing with groundwater contamination, radiation experimentation on human subjects, and exposure to asbestos. Other ongoing litigation addresses complaints of injuries allegedly caused by PCBs and dioxins, lead-based paint, Agent Orange, Legionnella bacteria and other "sick building" toxins, electric magnetic fields and biological agents. Many of these cases arise out of activities of the military, but may stem from other agencies' activities, as well.

Toxic tort litigation involves direct personal injury and/or property damage actions and third-party claims by manufacturers and suppliers for contribution and indemnity. Claims are filed under the Federal Tort Claims Act, the Suits in Admiralty and Public Vessels Acts, the Little Tucker Act, and against individual government employees seeking monetary damages. The ET staff litigates in the district courts and the U.S. Court of Federal Claims. Tort cases alleging negligence in the course of EPA'S Clean-Up Activities are the responsibility of ET. Vessel-caused pollution and clean-up cost recovery cases are handled by the Aviation & Admiralty staff.

Inquiries regarding toxic tort and asbestos litigation may be made by calling 202-616-4200 or writing to the Environmental Torts section at Post Office Box 340, Benjamin Franklin Station, Washington, D.C. 20044. Federal Express deliveries should be mailed to EODL, Torts Branch, 1331 Pennsylvania Avenue, N.W., Suite 800 South, Washington, D.C. 20004.

Environmental and related product liability tort actions, whether involving mass numbers of parties or only a few, pose special case management problems and thus are generally designated as "primary" to be handled by Department of Justice attorneys. Given long latency periods, the litigation often is not filed until decades after exposure. The cases can require massive and prolonged discovery involving millions of documents and the analysis of convoluted and complex fact situations. For example, in the asbestos litigation, fact issues have spanned a period since prior to World War II. All asbestos cases are designated for primary handling by ET and as a general rule will not be assigned to United States Attorneys.

Environmental tort litigation also requires familiarity with specialized scientific and medical issues. The source of contamination in any particular case may be chronic and latent, as with asbestos exposure or progressive groundwater contamination, or may be readily apparent, as with chemical or industrial spills. Disease or injury often manifests itself only following cumulative or repeated exposure, and in many instances, the effects of exposure have not been definitively scientifically or medically documented. Like the asbestos cases, fact issues can span decades, some spanning periods before World War I.

United States Attorneys confronted with environmental and related product liability tort claims against the United States should contact ET as early as possible, preferably before suit. ET is prepared to assume "primary" responsibility for toxic tort litigation as described within USAM 4-5.510.

It should be noted that tort suits alleging breaches of duty arising directly from *regulatory* activities of the government generally are within the purview of the Federal Tort Claims Act staff, and should be directed to that staff. *See* USAM 4-5.600. Matters involving clean-up activities of the Environmental Protection Agency, however, should immediately be brought to the attention of ET. Such cases should be handled jointly with the Environment and Natural Resources Division. Also, matters involving the Oil Pollution Act of 1990 should be referred to the Aviation and Admiralty staff.

ET's expertise developed in the asbestos litigation has led to the assignment of certain contract (Little Tucker Act and Tucker Act) cases to ET. Cases asserting implied warranties or indemnities arising out of contracts for government purchase of products made in conformity with government specifications where said products' alleged toxicity caused personal injuries should be referred to ET. *See, e.g., Hercules v. United States*, 516 U.S. 417, 116 S.Ct. 981 (1996) (Agent Orange); *Lopez v. A.C. & S.*, 858 F.2d 712 (Fed. Cir. 1988), *cert. denied*, 491 U.S. 904 (1989) (asbestos). In addition, cases where government contractors seek to invoke indemnity provisions to be held harmless from environmental regulatory claims and tort claims should be referred to ET.

The ***Federal Tort Claims Act Staff*** handles all other tort claims, including traditional actions against the government for personal injury and property damage. The Federal Tort Claims Act Staff defends the government against tort suits including, for example, such areas as medical malpractice; personal injuries attributed to the actions of government employees, and Governmental Regulatory activities. This staff is also responsible for affirmative tort claims not encompassed within another staff's responsibilities. Any tort suit not within the responsibility of the other three staffs is the responsibility of the FTCA Staff.

Cases brought under the Federal Tort Claims Act may be the responsibility of any one of the four staffs, depending upon the subject matter. Although different categories of tort cases are the responsibility of the different staffs of the Torts Branch, many aspects of defending a federal tort lawsuit are common to all, or several, categories of tort cases. For example, many of the defenses available under the Federal Tort Claims Act may be equally applicable in aviation cases, general tort cases, and cases involving exposure to hazardous substances. Similarly, it is not uncommon for a single case to present alternative causes of action which cross the boundary between particular categories. For example, a single case will often include both a constitutional tort claim against individuals and a general tort claim against the government. In addition, as will be discussed, infra, some related contract issues may be handled by the Torts Branch, and, in some circumstances, cases may be the joint responsibility of the Torts Branch and other components of the Civil Division or other Divisions of the Department.

The Assistant United States Attorney assigned to a tort suit is expected to assume full responsibility for preparation of an aggressive, professional defense to the suit, unless the suit is one assigned to be handled directly by a component of the Torts Branch. The initial letter from the Torts Branch will request the agency to forward a litigation report to the Assistant United States Attorney. This litigation report will be the starting point for development of the facts and legal position to be taken in the litigation. However, the Assistant United States Attorney is responsible for ensuring that each reasonable legal and factual defense is pursued regardless of whether the agency litigation report identifies the defense. The Torts Branch Monographs and, particularly the FTCA Staff's Monograph "Checklist of FTCA Defenses," provide assistance.

The Assistant United States Attorney should obtain approval from the appropriate Torts Branch Staff prior to raising the "discretionary function exception" defense in any case and may well desire to consult with the Branch when a difficult issue pertaining to any of the exceptions or exclusions to the Federal Tort Claims Act arises. If the case is designated as a monitored case, Assistant United States Attorney may seek assistance from the Torts Branch attorney or reviewer designated in the initial letter from the Torts Branch to the agency requesting a litigation report. If the case is designated as a delegated case, the author of the appropriate Monograph, if any, should be contacted or calling the responsible Director's office may make inquiry.

The FTCA is the exclusive remedy for common law torts committed by federal employees acting in the scope of employment. United States Attorneys are authorized to make the certification required by law (28 U.S.C. § 2679(d)(1)) in order to substitute the United States for a federal employee against whom a common law tort suit is brought. *See* 28 C.F.R. § 15.3.

United States Attorneys responsible for the defense of FTCA or other tort litigation (e.g., Suits in Admiralty Act or Vessels Act) are currently delegated $1,000,000 in settlement authority, subject to the limitations set forth in Civil Division Directive No. 14-95, 28 C.F.R. Part O, Subpart y, App. If a United States Attorney seeks to settle for an amount in excess of the delegated authority, a detailed justification for the settlement must be forwarded to the Torts Branch. The responsible Director will then make a recommendation to the Assistant Attorney General (or if the proposed amount is in excess of $2,000,000 to the Associate Attorney General). Although the Torts Branch endeavors to expedite consideration of settlement proposals, opposing counsel and, if necessary, the court should be informed that immediate action couldn't be guaranteed on any settlement proposal. It is customary to consult with the Torts Branch during settlement negotiations when any concern arises regarding the advisability of settlement or of the amount of the settlement. Although authority to settle a case can be obtained in exceptional cases prior to submission of an authorized offer from the other party(ies) to the case, this procedure is highly disfavored and should not be used unless special justification for its use is provided. However, the Torts Branch will provide counsel as to what amount it will recommend to the Assistant Attorney General in advance of initiation or completion of settlement negotiations.

The procedures for payment of an FTCA settlement should not be initiated until after all required approvals are obtained. Most FTCA settlements are paid by means of a Treasury check issued upon making a request to the Department of the Treasury. Forms for use in transmitting a request for payment to the Treasury Department are included in the Civil Resource Manual at 224 *et seq.*

Structured settlement agreements require careful attention to the terms and provisions of the agreement. The Torts Branch is available to be consulted regarding the particular terms of a structured settlement. Copies of the final settlement papers should be forwarded to the Torts Branch for retention. In the event that a reversionary trust provision is included in a structured settlement, the trust should include a requirement that the reversionary interest be paid to the United States Treasury in care of the Torts Branch pursuant to the terms of the agreement. Further information on the format and provisions for structured settlements is included in the Torts Branch Handbook entitled "Damages Under the FTCA."

Sections 2651 to 2653 of Title 42 authorize the recovery of the reasonable value of hospital, medical, surgical, or dental care and treatment (including prostheses and medical appliances) which the United States is authorized or required by law to furnish or has furnished to a person who is injured or suffers a disease under circumstances creating tort liability upon the part of a third party.

Administrative agencies are bound by regulations promulgated by the Attorney General (28 C.F.R. §§ 43.1 to 43.4) and generally will prevail upon the insured person to assert the government's claim in his/her own name for the use and benefit of the United States. 42 U.S.C. § 2651(b)(1) authorizes the government to intervene in the insured person's tort suit as of absolute right. If intervention is necessary, the injured person can normally be counted on to establish the defendant's basic tort liability. Intervention should be utilized as a measure of last resort only if private counsels do not cooperate with the agency to protect our right to participate in agency recovery.

The Marshall Islands renegotiated their relationship with the U. S. Federal Government, and got a new status they also have free transportation to and from the military hospitals in Hawaii. We could do the same; the options are wide in scope. Forms of payment may come as individual payments or a civil reinvestment in infrastructures that will help the over all well being of the general population. Examples of this would be reinvestment in our education, utility infrastructure and healthcare system. Healthcare is one of the areas that will be focused on in the coming years by interested professionals seeking knowledge of the effects that the radiation has had on the indigenous and transient populations of Guam.

Medical treatment of the local population will be a complex matter that holds little hope of ever being completed. Radioactive material must be eliminated from the body to remove its hazardous effects. Detoxification, which is effective against materials, which are chemical hazards, will not be effective since radioactivity is not modified by chemical changes. The methods of elimination include renal excretion for most soluble materials, elimination in the feces for materials which are retained in the gut or which can be secreted in the bile, and exhalation for volatile materials and gases. Chelating agents, e.g., calcium or zinc DTPA (diethylenetriamine pentaacetic acid), if administered soon after exposure, they are effective in enhancing the elimination of certain radioisotopes. These materials are not very effective for radioisotopes, which have been incorporated and fixed in organs and tissues, e.g., bone. Under conditions of nuclear war, chelation therapy is very unlikely to be used.

The rate at which a material is eliminated is usually expressed as the biological half-life. This is the time it takes for one-half of a given amount of material to be excreted or eliminated. During each successive half-life, an additional one-half is removed from the body. It is analogous, therefore, to the physical half-life. Not all materials follow a simple exponential elimination process, but this method of expression is sufficiently accurate to be applicable to most soluble isotopes. An exception, which must be noted, is the retention of insoluble heavy metals such as plutonium in the lungs and in bone. The rates of loss under these circumstances are not exponential and are very slow.

The biological half-life may be variable. A prime example of this is body water, the turnover of which can be as short as 4 days to as long as 18 days depending upon the state of hydration, volume of intake, and renal function. If tritiated water is incorporated into the body, the biological half-life is the factor determining the hazard since it is so much shorter than the physical half-life of about 12 years. Reduction of the biological half-life to a minimum by over hydration and the administration of diuretics have obvious value and is the recommended therapy in cases of exposures to tritium. Other isotopes cannot be cleared from the body as rapidly, and there is no adequate treatment available at present for increasing the rate of removal of a mixture of isotopes which would be incorporated into the body as a result of ingesting fallout contaminated food and water.

The overall hazard of materials, which are eliminated exponentially, will be a function of their physical and biological half-lives considered together. Whichever is shorter will become the primary factor. The effective half-life is usually determined and expressed by the following formula:

$$\text{Effective half-life} = \frac{\text{Biological half-life} \times \text{Radiological half-life}}{\text{Biological half-life} + \text{Radiological half-life}}$$

The uptake by the body of radioisotopes can be blocked in some cases. For example, potassium iodide or iodate if given prior to or soon after an intake of radioiodine will reduce the uptake of radioiodine by the thyroid gland. Similarly, orally administered Prussian Blue will reduce the absorption of cesium from the gut and Alginate will reduce strontium absorption. No policy exists which would allow for NATO or US forces to stock and issue these substances. Seeing as these substances were not readily available to the general population at the time of radioactive fallout came to Guam the use of such options are limited and can not be used as a source of rehabilitation.

Groups are trying to come up with solutions as to the military personnel that were living on Guam at the time of the nuclear tests. This redress of rehabilitations in regards to the military personnel has a far-reaching effect; Anderson Air Force Base was one of the busiest air bases in the world between early to late sixties during the Korean and Vietnam war, this means that all of those personnel that were stationed on Guam would have been affected by the fallout.

> Fort Lauderdale, Fla. (UPI)
>
> Veterans in Florida are being asked to help in a study of whether servicemen stationed on the Pacific island of Guam during World War II have contracted neurological diseases. A nationwide survey of veterans of that period may help explain a high incidence of Parkinson's disease and amyotrophic lateral sclerosis, known as Lou Gehrig's disease, among Chamorro natives of the island.
> (*Fort Lauderdale sun-Sentinel reported*)
>
> A team of neuroscientists has identified a gene that when damaged may cause inherited form of amyotrophic lateral sclerosis (ALS), or Lou Gehrig's disease – a devastating, ultimately fatal neuro-degenerative disorder with no effective treatment. Taken together with previous research findings related to ALS, McNamara asserts, the new evidence suggests that mutations in the gene cause the inherited form of the disorder. From studies of families with multiple members affected by the disorder, researchers estimate that between 5 and 10 percent of ALS canes has a genetic cause. In the mid-1980s, some scientists began to suspect that the nerve-cell death in ALS arises from mutations impairing the cells' ability to properly use glutamate, one of the chemicals that transfer messages between nerve cells.

(Science News, January 2, 1993, Vol. 143, No. 1 Closing in on the Lou Gehrig's Disease Gene)

These reports show a pattern of concern and focus on the events that occurred in the Marshall Islands, as more information about the human g-nome and how it is affected by radiation comes to light the body of evidence will grow and become more profound and indisputable.

Other cases haven been brought before the courts in the pursuit of compensation. In 1996 twelve people were unwittingly exposed to radioactive ash and were given a $400,000 dollar settlement. The most important aspect of this case is an admission of guilt on the part of the U.S. Department of Energy. (Families of Radiation Victims To Get Settlement, Karen McPherson, Scripps Howard Service in the Chronicle Journal Thunder Bay October 26, 1996)

In a November 19, press relies by the Associated Press announced on November 19 1996 that a 4.8 million dollar settlement was achieved by family members of patients that were injected with plutonium in the 1940. The settlement indicates the willingness of the Federal Government to take care of unfinished business in regards to people contaminated by the different methods used by the Department of Energy. (U.S. Reaches 4.8 Million Settlement With Radiation Victims, By Melissa B. Robinson Associated Press Writer November 19, 1996)

The states of Utah and Nevada have been actively lobbying for a resolution to the RECA issues as related to their states. As mentioned in *Radiation fallout Guam by Robert N. Celestial Atomic Veteran, SGT, Retired U.S. Army* Guam was in contact with a great deal more radiation than these respective states. The island of Guam will be able to use any and all headway made by these states as foundation for political resolution to the issue of compensation.

Part 2: Policy Development for the Government of Guam

Step 1: Review the analysis of the issue.

All of this information will be given over to the Blue Panel and used by them to make an educated assessment of the data. They will each bring an area of expertise in a certain field and apply it to the project. These areas consist but are not limited to the following. The medical field will show what if any harm has taken place on a biological level. The legal field will plot a course that would best suit the information that the panel has reviewed. The legal aspect of this project will be very telling in its direction as to how the impact compensation will manifest its self. A great deal of work on the domestic front will need to taken in regards to the information assimilation process. The job of these members is to create an environment in the public eye that will educate and direct any social energy that will be generated by the personal impact this will have on the general populations. The negative impact of information of this nature can be very profound and will be the largest hurdle that will present its self to the public relation related members.

Step 2: State the issue in neutral language, not in question form that suggests there should be either a right or wrong answer.

The issues brought to the attention of this panel have been expressed in a form that states all the information in a mater of fact or a proof format. This document can be looked at by both sides of the issue and due to the fact that all the information gathered are from military and federal web sights the opposition should be able to agree with these findings. This document will also act as a foundation for further extrapolation of the data and could lead to greater insight of the topic matter. Each different field of study will contribute to the total information of this document.

Step 3: Determine how involved the Government of Guam should become in the issue.

In 1994 the United States Senate implemented a special investigative hearing on the radiation effects on American citizens. This report was so damaging that the Senate refused to release the final document and stipulated that only by request of a congressional representative would the document be released. The Senate did not notify Guam's Congressional Representative when given the findings of this action report the notification seemed to be warranted. It was not till the Celestial Report published in 2001 that our Congressional Representative was notified and then could take action. The attention brought to the issue of radiation, thanks to Congressman Underwood and Robert Celestial, the Legislature formed the committee that with this action report supplemental data takes this issue to the next logical step.

Once the data has taken shape the Legislative Committee must look at the issue and decide how involved it should be. This is when the relationship between the Federal Government and Guam comes to the table. There are many degrees of involvement that the Government of Guam can take. By the creation of the committee Government Officials have set a foundational level of involvement. The next stratum is the matter of compensation request. This point will take many intrinsic levels of cooperation. The first of which will be in the courtroom, this means that a level of court should be decided. It also should be noted that this matter could lead to the Supreme Court and what it could mean to the island. The only other population out side of the continental United States to gain compensation is the Marshall Islands. In 1981 the Bikinians file a class action lawsuit against the U.S. government in U.S. courts seeking $450 million in compensation. Attorneys for the Marshall Islands Atomic Testing Litigation Project file lawsuits on behalf of several thousand Marshall Islanders seeking about $4 billion in compensation from the United States for personal injuries from the nuclear testing. In 1982 The U.S. establishes a second trust fund of $20 million for the Bikini people. Later, it will increase this with an additional $90 million appropriation in the late 1980s. In 1983 Compact of Free Association is approved in a plebiscite by about 60 percent of Marshal Islands voters. The Compact includes a Section 177 trust fund of $150 million that is to provide $270 million in compensation payments over the 15-year life of the Compact. (Bikini $75 million; Enewetak $48; Rongelap $37 million; Utrik $22 million;

Nuclear Claims Tribunal $45 million; $2 million annually for medical care for the "four atolls" 53 million for a nationwide radiological survey; etc.). (S*ource: Nuclear Claims Tribunal, Republic of the Marshall Islands*)

<u>Step</u> 4: <u>Assess the political and social risks of choosing a positive or negative position on this issue.</u>

A positive position in this subject mater will by its necessity be the search for compensation for the people of Guam. Negative positions will in-tail the curbing of such an initiative. It would be in the best interest for Guam to focus on the positive position, the needs of the people on this island. As was stated in the Schreiber testimony the military leaders on this island had full knowledge of the fallout that was coming to Guam and they did nothing to curtail the impact of the contamination (*Testimony of Charles Bert Schreiber July 30, 2001*)

This positive approach for compensation could take many different forms. First it would concentrate on the troubled areas that are directly effected by the fallout, such as in education due to neurological diseases and healthcare. Both of these segments in our community are in turmoil and need some relief if they are ever to get a hold on the issues of this island. With Education Grants and Subsidized Medical funds the island could revitalize our most basic needs, giving the Government of Guam an opportunity to use its limited resources to solve problems in other areas. This would lead to a total over hall of the basic operations in the Government. One possible trade in the negotiations with the Federal Government is to have an on island auditor to coordinate the distribution and spending of these impact funds that would be injected in to the Government of Guam, and other select sectors of the island private companies. With this type of check and balance the Government of Guam would only be compromising on some of the basic accountability and would save more money on not needing an entire office to coordinate with all of the families and organizations, the logistic savings would be considerable. The compensation will for the most part be focused on some of the more expensive parts of the Gov. Guam budget. Two thirds of the current budget is spent on education. The Federal subsidies will take the burden off of the on island budget so that the Government can focus on issues like power and other forms of infrastructure. This also creates an environment of job creation that will intern raise the income tax input that the Government of Guam relies on for general operations.

<u>Step</u> 5: <u>Assess all resources available to the Government of Guam to influence the issue in the direction that has been determined by our elected officials.</u>

The resources directed to this project are limited in this early stage, but it is the hope of the preliminary research team to generate funds through private donation of time and money, so that an office can be set up to fallow through the many processes that this project will take. The designation of this bureau will be BRAVO or the **B**ureau of **R**adiation contamination **A**nd the office of **V**ictims **O**verseas. The procurement of grants from organizations and the Department of Energy in the Federal Government will be fundamentally important if this project is to be successful and BRAVO commission would be tasked with the procurement of funding. All funds would be applied to the hiring of personnel as mentioned below. We will also be seeking education grants for students that work on this project such as students working on graduate papers and projects for degree programs. The reason for the wide verity of revenue is the fact that never in the history of Guam has any one taken the questions that are proposed by this project and done any comprehensive publishable research focused on Guam. The Federal Government has a great deal of information relating to Guam, but no group has every put a document together with Guam in mind. This project has the benefit of never being done before. These benefits give rise too a great deal of untapped money.

INPUT

People Power: This Project will focus but not limit itself to the recruitment of student and academic personnel for the research work. The group will not exceed five personnel unless instructed by the Research Administrator.

The Researcher and the Administrator description of duties are as follows.

BRAVO COMMISION PROJECT RESEARCHER

Location: The offices of Honorable Angel L.G. Santos

Salary Range: $7.50 per hour/ 8 hours a day at 5 days a week

Character of Duties: The Researcher serves as a connection between and among the various internal and external offices and constituencies which provide the request information, data analysis, and projections regarding the Special Investigation Committee on Nuclear Testing and Radiation Exposure in the Western Pacific, and factors which impact on it. The Researcher, in collaboration with executive administration, establishes official data conventions. The Researcher is the single source of official certified data such as and not limited to the topics covered by this investigation. The Researcher coordinates closely with the officials, organizations, and Federal groups as to facilitate an organized conclusion on the issues designated by the Special Investigative Committee.

Qualifications: *Required*: At least two years of research experience and a working knowledge of the subject matter, documented computer, and research skill. Experiences working with complex databases excellent verbal written and interpersonal skills. Minimum of three years combined in an organization that required these skills.

BRAVO COMMISION PROJECT ADMINISTRATOR

Location: The offices of Honorable Angel L.G. Santos

Salary Range: To be determined by budget

Character of Duties: The Administrator serves as a connection between and among the various internal and external offices and constituencies which provide the request information, data analysis, and projections regarding the Special Investigation Committee on Nuclear Testing and Radiation Exposure in the Western Pacific, and factors which impact on it. The Administrator, in collaboration with executive administration, establishes official data conventions. The Administrator is solely responsible for the coordination in the research group. The prioritizing of resources and the dissemination of information for public relations prepossess. The Administrator coordinates closely with the officials, organizations, and Federal groups as to facilitate an organized response to the issues designated by the Special Investigative Committee.

Qualifications: *Required*: At least two years of research experience, at least two years of committee work with organizations on Guam, a working knowledge of the subject matter, documented computer, and has sat on a public relations committee for at least a year. Experiences working with complex databases excellent verbal written and interpersonal skills. Minimum of three years combined in an organization that required these skills.

Facilities and Equipment: the Honorable Senator Angel Santos from his main head quarters will provide Offices. Computers with Internet will be available at the office site. The project staff will also utilize their own Computers and transmit over the Internet any finding for further analysis by the committee and any other personnel.

BRAVO OFFICE

This group of individuals would sit under a organizational name of **BRAVO**, this has both an historical reference to the largest nuclear device test that the Department of Energy ever conducted and is also an acronym for; **B**ureau of **R**adiation contamination **A**nd the office of **V**ictims **O**verseas. This bureau would be responsible for the coordination of information and research to better facilitate the factors contributing to compensation. The location of this office would be to the discretion of the policy support members in the Guam Legislature.

Policy Support and Authorization from:

Representative Members of the 26th Guam Legislature

Hon. Angel L.G. Santos
Co-Chairman

Hon. Mark Forbes
Co-Chairman

Hon. Kaleo Moylan
Member

Hon. Eddie Baza Calvo
Member

Hon. Ben Pangelinan
Member

Hon. Mark Charfaurus
Member

Hon. Lou Leon Guerrero
Member

Hon. Judith Won Pat
Member

Hon. Felix Camacho
Member

Hon. Frank Aguon Member

Members of the Blue Ribbon Panel

Dr. W. Chris Perez
Chair

Dr. Juan Fernandez
Vice Chair

Archbishop Anthony Apuron

Pastor Ron DeGuzman

Atty. Mike Phillips

Mr. Ray Tenorio, Lions Club

Mr. Bob Celestial, NFP Org.

Mr. Ed Chanco

Ms. Jan Furakawa

Mr. Joanquin Santos

Mr. Mark Benavente

Ms. Trinidad Torrez

Organizations

Guam Legislature

Office of the Governor of Guam

Office of the Governor, CNMI

APIL
University of Guam

Archiodecese of Hagatna

Guam Cancer Institute

Pacific Downwinders

Guam IFIL Lions Club

Guam Sunshine Lions Club

SPJ

ASPA(UOG)

PROCESSES

Training: The students and academics that are recruited will be for the express purpose of limiting project orientation time. The staff will already have working skills as researchers due to their current occupational student rating. It should fallow that they need only the criteria of subject matter, the plan of action with research strategy design and implementation to begin work immediately. The amount of data that the preliminary research has brought to light is not categorized or cross-referenced in any way; this will be there primary work in the beginning stages of this project. The team will set up and reference the information as part of their orientation; training and familiarization with said materials. This should do two things; first the personnel will understand the fundamentals of the research material second the group will be able to pull form the data and extrapolate any information from the various references.

Research Design: The staff will use all resources at their disposal including but not limited to the Internet, federal information banks; local information collected by the staff its self and other local and governmental groups. The dissemination and organization of this information that is collected will be an on going practice throughout this project and in the formulation of an over all picture of the situation. Once a data collection process has been established then the staff will begin the connecting of all sources and determine their relation to one another. The documentation will develop in to a body of correlated and cross-referenced data that will be ready to go before the Legislature for their approval and understanding.

Given the nature of the topic and it implications on the island, the research will look in to health and population studies. The relationships of disease on the island, and external influences that may have causal relationship with them should be a priority. The Group will also look at declassified documents that focus on this region. The research will use members of the Blue Ribbon Panel to move the work forward and as expert analyses of the information collected. The panel will also assist the staff in areas of here to unknown sources and elaborate on aspects that may be indigenous to the island. The staff will follow the "Part II: Policy Development" that was mentioned and described in detail earlier in this action plan.

Decision Making and Management Sys: The Research Administrator of the Special Investigative Committee in cooperation with the 26th Legislature will guide the project down a predetermined course, meeting all objectives outlined by the Representative Members of the Legislature, and the Blue Ribbon Panel.

Research Process: The project will be organized, and headquartered in offices, of the same building as the Special Investigative Committee Chairman Hon. Angel L.G. Sontos. The staff will meet on regularly scheduled intervals to be determined by the Research Administrator. These meetings will serve on various different levels. First each researcher is given a topic to study (ex. Weather patterns, health care data, and atomic test sight information) and bring that topic to the meeting. Second and exchange of information between the different areas of research so that it will limit the redundant research producing a more efficient project analyses team. Thirdly the Research Administrator will compile the information and create an overall picture of the research to date, and give the Representative Members of the Legislature in cooperation with the Blue Ribbon Panel an up to date progress report on the projects status. This will also facilitate a dialog of understanding on the issues by our elected officials, and better prepare them for media interviews and other events of that nature.

OUTPUT

Groups and Organization workshops: *The Following are organizations that have shown an interest in this subject mater and have asked what they can do for us.*

Guam Legislature

Office of the Governor of Guam

Office of the Governor, CNMI

APIL
University of Guam

Archiodecese of Hagatna
Guam Cancer Institute

Pacific Down Winders

Guam IFIL Lions Club

Guam Sunshine Lions Club

SPJ

ASPA(UOG)

The areas in research that the different groups can help use with, vary a great deal. The Guam Legislature has already helped this project by lending there support and seed money. The Office of the Governor could lend support in information exchange and any logistical administrative foundation work that may come up. The international and or regional governments (CNMI, Philippians, and Marshall Islands) can provide the statistical information that will help us calculate the different variables in a project such as this. The University of Guam can provide for this project in many of the personnel rolls (researchers) and has a great deal of scientific data and expert analyses on many of the complex details intrinsic to the subject matter. On a community level the Archiodecese of Hagatna has honored this project with its cooperation, and can bring to the front a great deal of data regarding subjects on family life (passing away of loved ones exc.) that could be very enlightening to this issue. Due to the personal nature of this information we would not request name only confirmation and supporting numbers, but any family who wishes to give the any information could do so through the Archdiocese and then a researcher could pick it up. This is just one example of many regarding the cooperation with Archdiocese of Hagatna. The Guam Cancer Institute and Pacific Down Winders can contribute to the research aspect of the project, and they could also give statistical data to correlate the historical and potential environmental events that could have affected Guam. The Lions Club has volunteered to help us in any capacity that they can, their organization has been on Guam for many years and the average age of the organization is in the fifties. The committee in interviews and other grass root research could utilize this fact. Given the time period is a space fifty-five years long and any first hand information would be useful.

Report Overview: It is the purpose of this report to determine "if" the welfare of the people of Guam has been affected in a harmful way by the actions of the Federal Government, and if so then what can be done to rectify the situation. It is the assertion that the United States Government detonated sixty-six atomic weapons approximately twelve hundred miles directly East of Guam. One of the concerns that this report has clarified is the relationship between the possible fallout from any of those sixty-six devices and the rate of cancer and reproductive problems that the island sees now. This report has shown that the explosion determines the range of fallout and its spread over an area, so those detonations that have the power to reach the jet stream could indeed reach Guam. This report has also shown through weather pattern data that the clouds that drop rain on Guam comes from the same region as those detonations. The Report has also shown that in the forties and fifties the people of Guam's water system was a "water catch system" this device catches the water as it falls in the form of rain, and did rendered the population totally exposed to the radioactive particles in there drinking water. To put it a step further there is information to suggest that the levels of radioactive fallout were on average fifteen times that of the rainfall do to the evaporations of water from the holding tanks. This report has proven that the radioactive contamination could explain the abnormally high rates of cancer that we see on the island today. The findings in this report have been objective and any and all other possibilities will also be covered in this report.

Dissemination Process: This report is for public discretion and can and will be viewed by all interested parties upon it completion. The media will be a good resource for public opinion and the measuring stick as to potential public backlash and other related issues.

Research and Gov. Policy Orientation: It is the hope of this report to provide the government bodies of Guam the information necessary to guide Guam through an eventual status in the US/Guam relationship.

Step 6: Establish a proposed organizational policy.

What ever the policy set down by the Blue Panel Committee the need for a localized office to handle the paper work filing and dissemination of information to the general public will be a necessary and natural development of the government. The BRAVO Commission as described earlier would be the center that all requests for compensation would be filed and then forwarded to the RECA Committee. The BRAVO office would also allow us to keep record of all filed cases and follow up so that an accurate picture of compensation can be monitored and coordinated. This office will also be tasked with the duty of applying for federal compensation on a community level, such as grants for education and special needs developed from students with neurological diseases that are caused by genetic damage from radioactive ionization.

Step 7: Assess the proposed policy to determine if it adequately addresses the concerns raised in the issue analysis

This project has focused on radioactive contamination and the health problems caused by internal consumption of radioactive isotopes in the drinking water. Due to the nature of such exposure the potential treatments are limited. The problem with direct treatment of the people directly affected by the fallout is that they most likely did not survive given the time period and the life shortening problems that come with contamination. Addressing the larger segments of the population through education and healthcare subsidies will be the most efficient, and all encompassing compensation that should be distributed to the island. With the resources gained in these two areas Guam will see marked improvement in education witch will in turn create an island population better prepared for the obstacles inherent in any damaged segment of Guam's population.

Summary

It is the opinion of this research that Guam meets the requirements of the Radiation Exposure Compensation Acts as set down by the federal government. The fault has been shown to be directly on the shoulders of Department of Energy and all of its previous manifestations such as the Atomic Energy Commission. The Island of

Guam was bombarded with radioactive isotopes in the years of 1946 through to the mid seventies. The material that was ejected in to the upper atmosphere can hang in the atmosphere for years at a time. Strontium-90 and Cesium-137 with a half-life of 28.9 and 30 years respectively would be a little over one quarter its original levels now than what they were in the early fifties. Due to the half-life of Hydrogen-3, that has a half-life of 12.3 years, one sixteenth of the original amount of Hydrogen-3 is still here on Guam This being the case the current population of Guam is at risk with current levels due to the poor infrastructure such as cracks in the piping and water lines, seepage in to the general water supply is still likely but at reduced levels. The prospect of Strontium-90 readings as late as 1974 gives rise to questions of how long after the initial tests did the radioactive particles fall to Guam through the process of the scavenging effect and if that process of scavenging is still in effect. Other processes that added to the levels of radiation on Guam were the runoff from the decontamination operation that the military practiced. The runoff was fed in to both our reef system and our water lens. All of these systems are integral to both the prosperity and health of the island population. It is the recommendation of this action report that Guam move forward with establishing an office and staff for the express purpose of furthering the research to build a case for compensation by the United States of America and develop the tools necessary to over come the damaging fallout that the population of Guam was exposed to. With direct impact on both our educational and medical systems the cost will be significant, the only possibility for aid in these departments as they stand to date will be financial injection of capital in to these ailing parts of our island. This research will need a base of operations in order to meet the goals that are apparent in the subject matter; the people of Guam will need to coordinate a social movement and the BRAVO Commission should be the vehicle to guide that movement.

Appendix I

CHRONOLOGICAL DEVELOPMENT OF AIR BURST

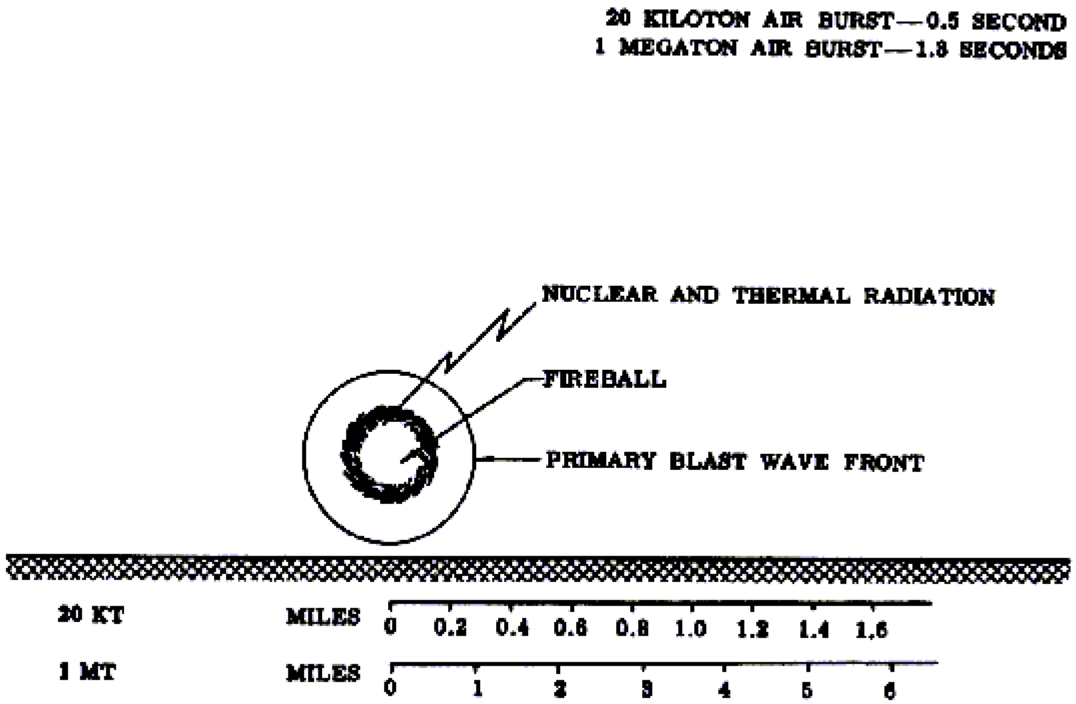


Figure 2.51a. Chronological development of an air burst; 0.5 second after 20-kiloton detonation; 1.8 seconds after 1-megaton detonation.

Immediately following the detonation of a nuclear weapon in the air, an intensely hot and luminous (gaseous) fireball is formed. Because of its extremely high temperature, it emits thermal (or heat) radiation capable of causing skin burns and starting fires in flammable material at a considerable distance. The nuclear processes that cause the explosion and the radioactive decay of the fission products are accompanied by harmful nuclear radiations (gamma rays and neutrons), which also have a long range in air. Very soon after the explosion, a destructive shock (or blast) wave develops in the air and moves rapidly away from the fireball.

At the times indicated, the fireball has almost attained its maximum size, as shown by the figures given below:

	<u>*Diameter of fireball*</u>	<u>*(feet)*</u>
	20 kilotons	*1 megaton*
At time indicated ----------------------	1,460	6,300
Maximum ----------------------------	1,550	7,200

The blast wave front in the air is seen to be well ahead of the fireball, about 800 feet for the 20-kiloton explosion and roughly half a mile for the 1-megaton detonation.

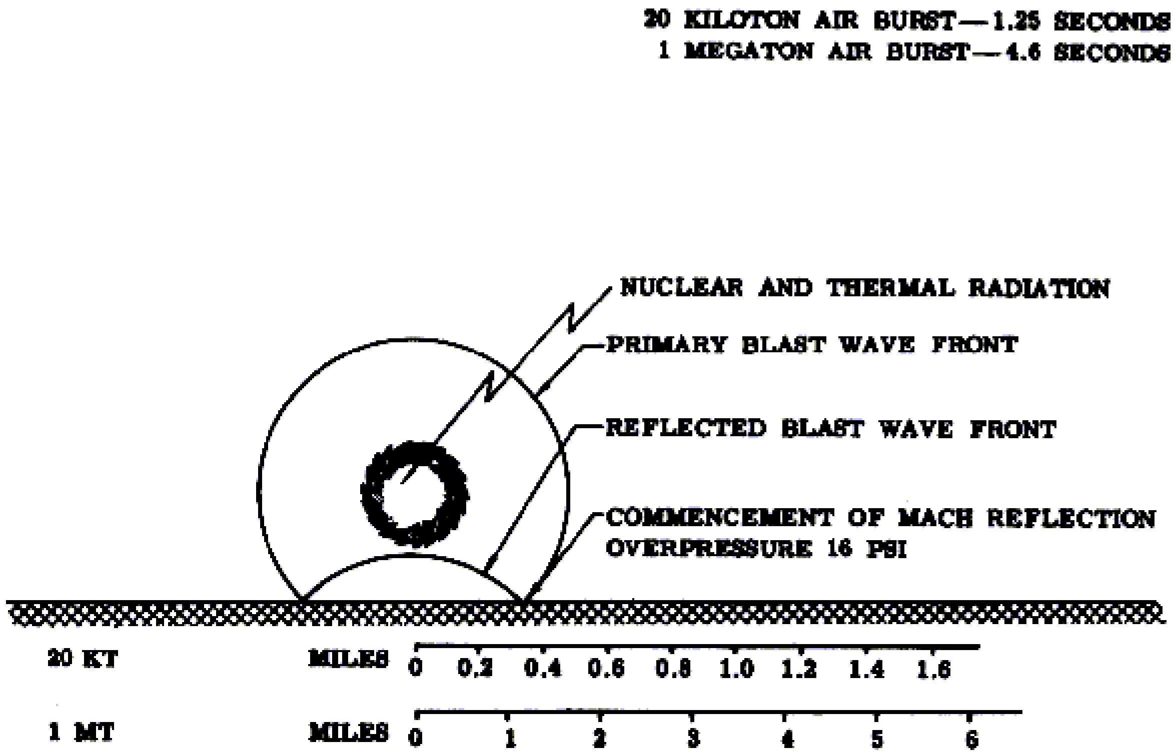


Figure 2.51b. Chronological development of an air burst; 1.25 seconds after 20-kiloton detonation; 4.6 seconds after 1-megaton detonation.

When the primary air blast wave from the explosion strikes the ground, another blast wave is produced by reflection. At a certain distance from ground zero, which depends upon the height of burst and the energy yield of the weapon, the primary and reflected wave fronts fuse near the ground to form a single, reinforced Mach front (or stem).

The time and distance at which the Mach effect commences for the air bursts at the given heights are as follows:

Explosion yield	*Height of burst (feet)*	*Time after detonation (seconds)*	*Distance from ground zero (miles)*
20 kilotons -----------------	1, 760	1.25	0.35
1 megaton -----------------	6,500	4.6	1.3

The overpressure at the earth's surface is then 16 pounds per square inch.

Significant quantities of thermal and nuclear radiations continue to be emitted from the fireball.

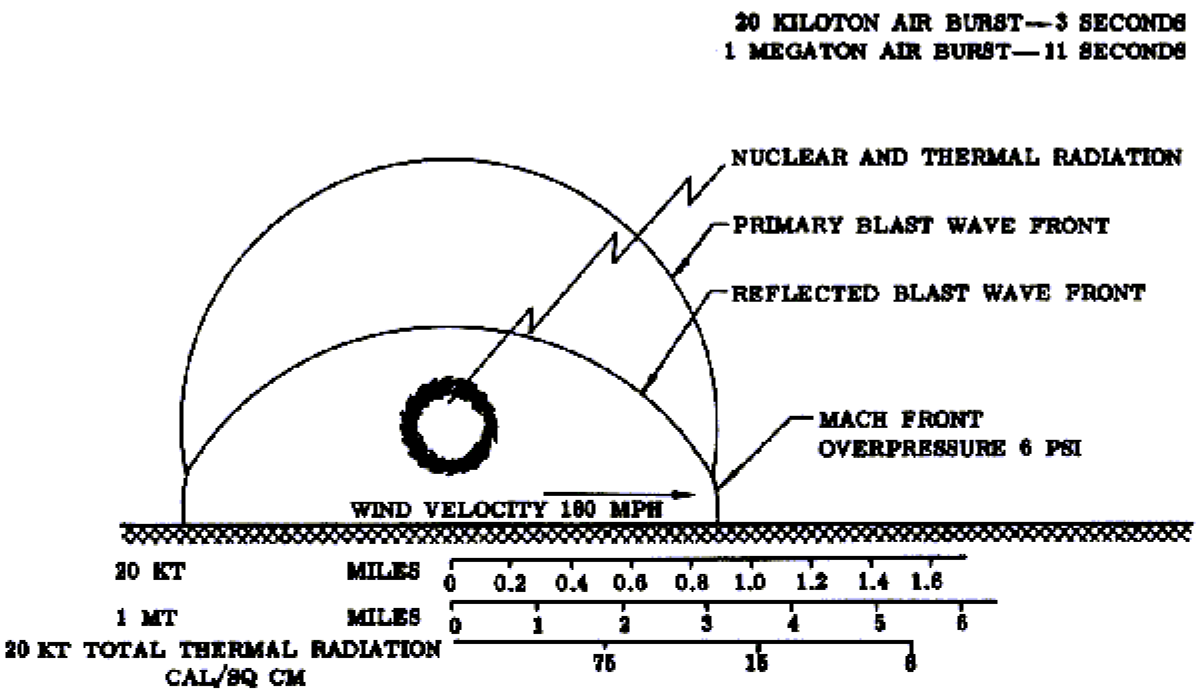


Figure 2.51c. Chronological development of an airburst; 3 seconds after 20-kiloton detonation; 11 seconds after 1-megaton detonation.

As time progresses, the Mach front (or stem) moves outward and increases in height. The distance from ground zero and the height of the stem at the times indicated are as follows:

Explosion yield	*Height of burst (feet)*	*Time after detonation (seconds)*	*Distance from ground zero (miles)*	*Height of stem (feet)*
20 kilotons ---------	1, 760	3	0.87	185
1 megaton ---------	6,500	11	3.2	680

The overpressure at the Mach front is 6 pounds per square inch and the blast wind velocity immediately behind the front is about 180 miles per hour.

Nuclear radiations from the weapon residues in the rising fireball continue to reach the ground. But after 3 seconds from the detonation of a 20-kiloton weapon, the fireball, although still very hot, has cooled to such an extent that the thermal radiation is no longer important. The total accumulated amounts of thermal radiation, expressed in calories per square centimeter, received at various distances from ground zero after a 20-kiloton air burst, at 1,760 feet, are shown on the scale at the bottom of the figure (for further details, see Chapter VII). Appreciable amounts of thermal radiation are still received from the fireball at 11 seconds after a 1-megaton explosion; the thermal radiation emission is spread over a longer time interval than for an explosion of lower energy yield.

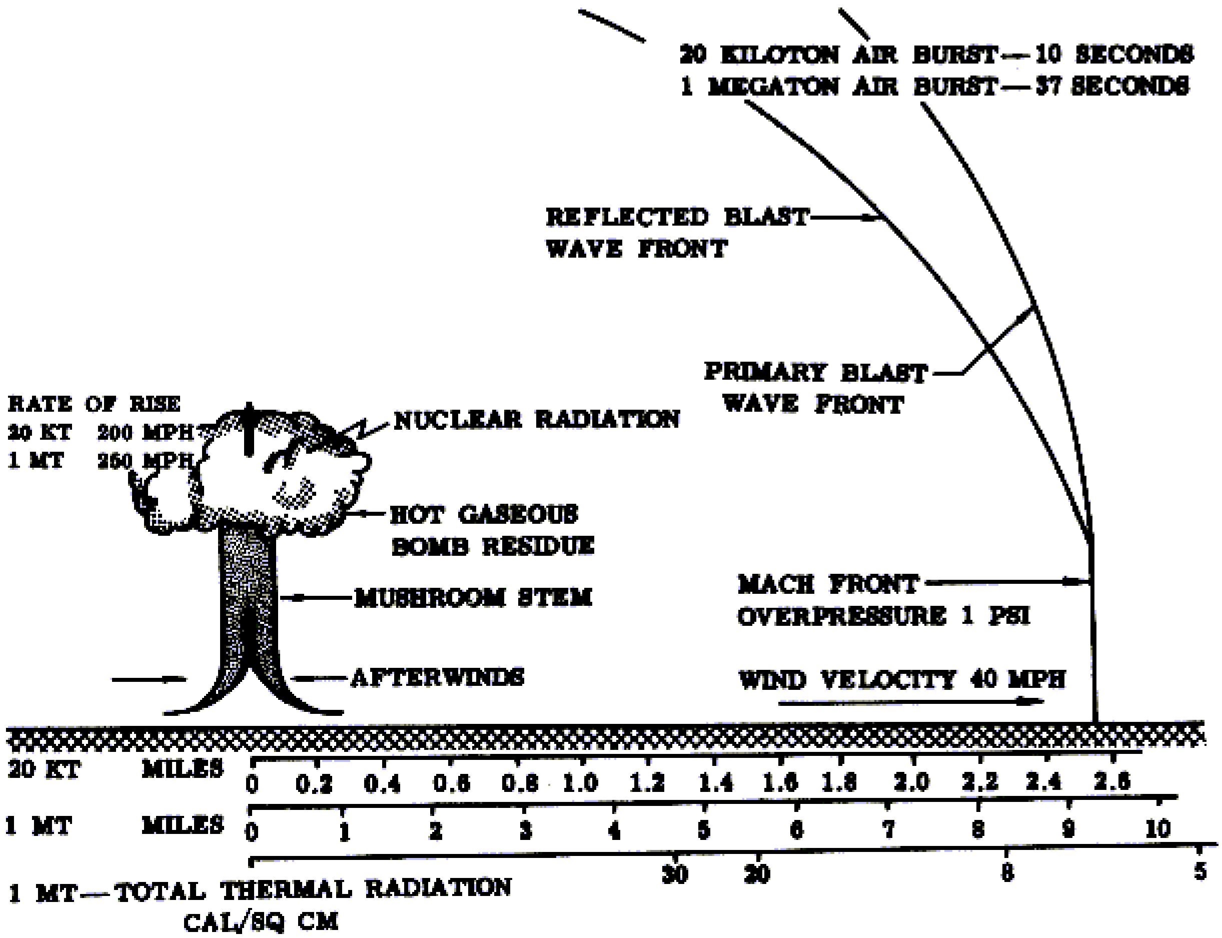


Figure 2.51d. Chronological development of an air **burst**; 10 seconds after 20-kiloton detonation; 37 seconds after 1-megaton detonation.

At 10 seconds after a 20-kiloton explosion at an altitude of 1,760 feet the Mach front is over 2 1/2 miles from ground zero, and 37 seconds after a 1-megaton detonation at 6,500 feet, it is nearly 9 1/2 miles from ground zero. The overpressure at the front is roughly 1 pound per square inch, in both cases, and the wind velocity behind the front is 40 miles per hour. There will be slight damage to many structures, including doors and window frames ripped off, roofs cracked, and plaster damaged. Glass will be broken at overpressures down to 1/2 pound per square inch. Thermal radiation is no longer important, even for the 1-megaton burst, the total accumulated amounts of this radiation, at various distances, being indicated on the scale at the bottom of the figure. Nuclear radiation, however, can still reach the ground to an appreciable extent; this consists mainly of gamma rays from the fission products.

The fireball is no longer luminous, but it is still very hot and it behaves like a hot-air balloon, rising at a rapid rate. As it ascends, it causes air to be drawn inward and upward, somewhat similar to the updraft of a chimney. This produces strong air currents, called after winds. For moderately low airbursts, these winds will raise dirt and debris from the earth's surface to form the stem of what will eventually be the characteristic mushroom cloud.

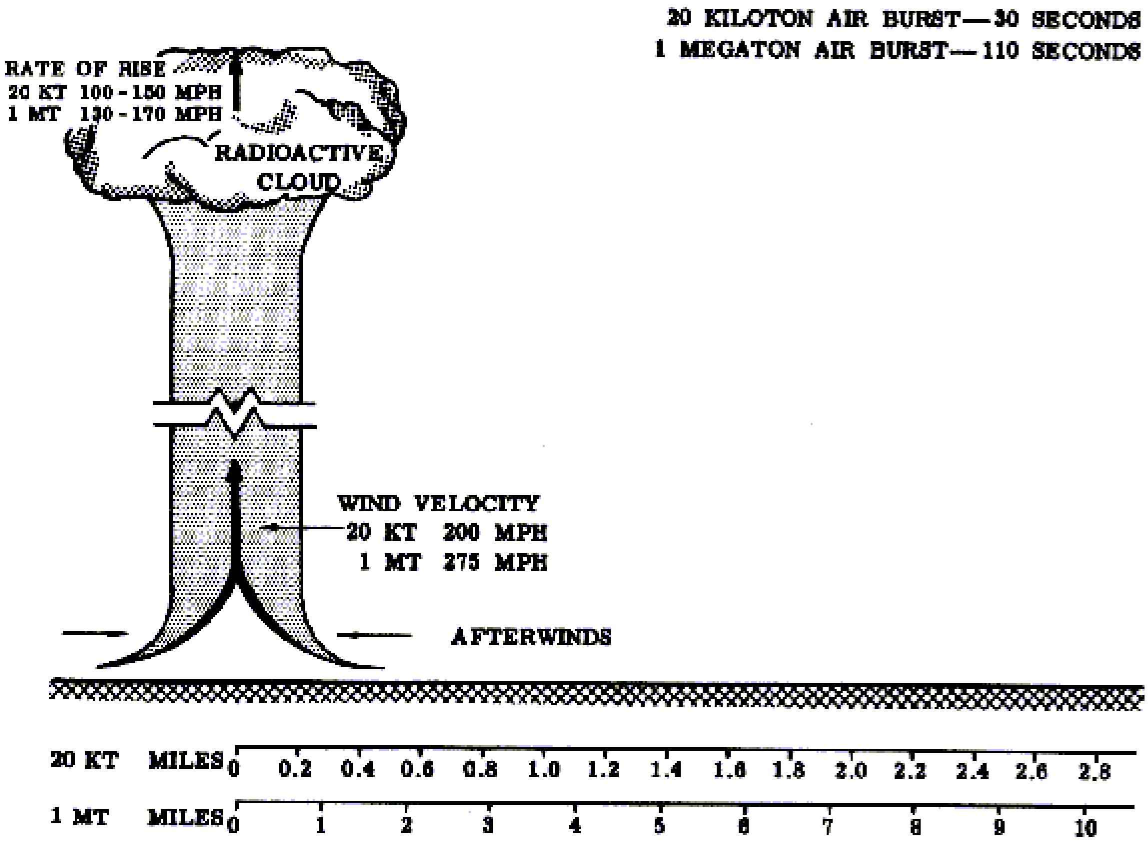


Figure 2.51e. Chronological development of an airburst; 30 seconds after 20-kiloton detonation; 110 seconds after 1-megaton detonation.

The hot residue of the weapon continues to rise and at the same time it expands and cools. As a result, the vaporized fission products and other weapon residues condense to form a cloud of highly radioactive particles. The after winds have velocities of 200 or more miles per hour, and for a sufficiently low burst they will continue to raise a column of dirt and debris which will later join with the radioactive cloud to form the characteristic mushroom shape. At the times indicated, the cloud from a 20-kiloton explosion will have risen about 1 1/2 miles and that from a 1-megaton explosion about 7 miles. After about 10 minutes, the maximum heights attained by the clouds will be about 7 miles and 14 miles, respectively. Ultimately, the particles in the cloud will be dispersed by the wind and, unless there is precipitation, there will usually be no early (or local) fallout. Only if the height of burst is less than about 600 feet for a 20-kiloton and 3,000 feet for a 1-megaton explosion would appreciable early fallout be expected.

Although the cloud is still highly radioactive, very little of the nuclear radiation reaches the ground. This is the case because of the increased distance of the cloud above the earth's surface and the decrease in the activity of the fission products due to natural radioactive decay.

From *The Effects of Nuclear Weapons*, Samuel Glasstone, ed., USAEC, Washington, DC, April 1962; Revised Edition reprinted February 1964.

Digital version by Gregory Walker, gwalker@netcom.com.
For more information see Trinity Atomic Web Site at
http://www.envirolink.org/issues/nuketesting/

Appendix II

DESCRIPTIONS OF NUCLEAR EXPLOSIONS

INTRODUCTION

A number of characteristic phenomena, some of which are visible whereas others are not directly apparent, are associated with nuclear explosions. Certain aspects of these phenomena will depend on the type of burst, i.e., air, high-altitude, surface, or subsurface, as indicated in Appendix I this research focuses on surface air burst. This dependence arises from direct and secondary interactions of the output of the exploding weapon with its environment, and leads to variations in the distribution of the energy released, particularly among blast, shock, and thermal radiation. In addition, the design of the weapon can also affect the energy distribution. Finally, meteorological conditions, such as temperature, humidity, wind (jet stream), precipitation, and atmospheric pressure, and even the nature of the terrain over which the explosion occurs, may influence some of the observed effects. Nevertheless, the gross phenomena associated with a particular type of nuclear explosion, namely, high-altitude, air, surface, underwater, or underground, remain unchanged. It is such phenomena that are described in this chapter.

The descriptions of explosions at very high altitudes as well as those in the air nearer to the ground refer mainly to nuclear devices with energies in the vicinity of 1-megaton TNT equivalent. For underwater bursts, the information is based on the detonations of a few weapons with roughly 20 to 30 kilotons of TNT energy in shallow and moderately deep, and deep water. Indications will be given of the results to be expected for explosions of other yields. As a general rule, however, the basic phenomena for a burst in a particular environment are not greatly dependent upon the energy of the explosion. In the following discussion it will be supposed, first, that a typical airburst takes place at such a height that the fireball, even at its maximum, is well above the surface of the earth. The modifications, as well as the special effects, resulting from a surface burst and for one at very high altitude will be included. In addition, some of the characteristic phenomena associated with underwater and underground nuclear explosions will be described.

DESCRIPTION OF AIR AND SURFACE BURSTS

THE FIREBALL

As already seen, the fission of uranium (or plutonium) or the fusion of the isotopes of hydrogen in a nuclear weapon leads to the liberation of a large amount of energy in a very small period of time within a limited quantity of matter. As a result, the fission products, bomb casing, and other weapon parts are raised to extremely high temperatures, similar to those in the center of the sun. The maximum temperature attained by the fission weapon residues is several tens of million degrees, which may be compared with a maximum of 5,000^{0}C (or 9,000^{0}F) in a conventional high-explosive weapon. Because of the great heat produced by the nuclear explosion, all the materials are converted into the gaseous form. Since the gases, at the instant of explosion, are restricted to the region occupied by the original constituents in the weapon, tremendous pressures will be produced. These pressures are probably over a million times the atmospheric pressure, i.e., of the order of many millions of pounds per square inch.

Within less than a millionth of a second of the detonation of the weapon, the extremely hot weapon residues radiate large amounts of energy, mainly as invisible X rays, which are absorbed within a few feet in the surrounding (sea-level) atmosphere. This leads to the formation of an extremely hot and highly luminous (incandescent) spherical mass of air and gaseous weapon residues, which is the fireball, referred to in a typical fireball accompanying an air burst is shown in Fig. 2.04. The surface brightness decreases with time, but after about a millisecond, the fireball from a 1-megaton nuclear weapon would appear to an observer 50 miles away to be many times more brilliant than the sun at noon. In several of the nuclear tests made in the atmosphere at low altitude at the Nevada Test Site, in all of which the energy yields were less than 100 kilotons, the glare in the sky, in the early hours of the dawn, was visible 400 (or more) miles away. This was not the result of direct (line-of-sight) transmission, but rather of scattering and diffraction, i.e., bending, of the light rays by particles of dust and possibly by moisture in the atmosphere. However, high-altitude bursts in the megaton range have been seen directly as far a 700 miles away.

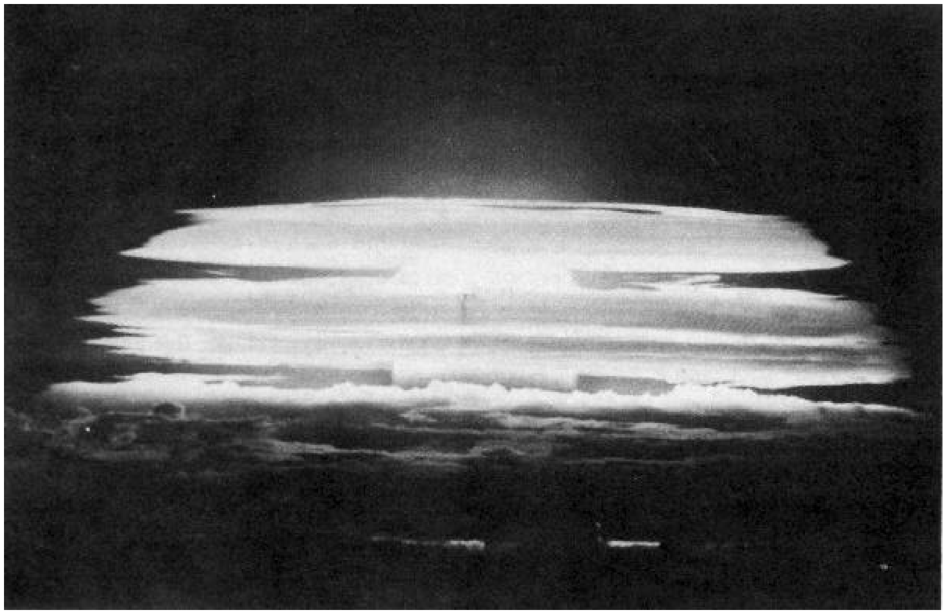


Figure 2.04 Fireball from an air burst in the megaton energy range, photographed from an altitude of 12,000 feet at a distance of about 50 miles. The fireball is partially surrounded by the condensation cloud.

The surface temperatures of the fireball, upon which the brightness (or luminance) depends, do not vary greatly with the total energy yield of the weapon. Consequently, the observed brightness of the fireball in an airburst is roughly the same, regardless of the amount of energy released in the explosion. Immediately after its formation the fireball begins to grow in size, engulfing the surrounding air. This growth is accompanied by a decrease in temperature because of the accompanying increase in mass. At the same time, the fireball rises, like a hot-air balloon. Within seven-tenths of a millisecond from the detonation, the fireball from a 1-megaton weapon is about 440 feet across, and this increases to a maximum value of about 5,700 feet in 10 seconds. It is then rising at a rate of 250 to 350 feet per second. After a minute, the fireball has cooled to such an extent that it no longer emits visible radiation. It has then risen roughly 4.5 miles from the point of burst.

THE RADIOACTIVE CLOUD

While the fireball is still luminous, the temperature, in the interior at least, is so high that all the weapon materials are in the form of vapor. This includes the radioactive fission products, uranium (or plutonium) that has escaped fission, and the weapon casing (and other) materials. As the fireball increases in size and cools, the vapors condense to form a cloud containing solid particles of the weapon debris, as well as many small drops of water derived from the air sucked into the rising fireball.

Quite early in the ascent of the fireball, cooling of the outside by radiation and the drag of the air through which it rises frequently bring about a change in shape. The roughly spherical form becomes a toroid (or doughnut), although this shape and its associated motion are often soon hidden by the radioactive cloud and debris. As it ascends, the toroid undergoes a violent, internal circulatory motion as shown in Fig. 2.07a. The formation of the torrid is usually observed in the lower part of the visible cloud, as may be seen in the lighter, i.e., more luminous, portion of Fig. 2.07b. The circulation entrains more air through the bottom of the toroid, thereby cooling the cloud and dissipating the energy contained in the fireball. As a result, the toroidal motion slows and may stop completely as the cloud rises toward its maximum height.

The color of the radioactive cloud is initially red or reddish brown, due to the presence of various colored compounds (nitrous acid and oxides of nitrogen) at the surface of the fireball. These result from chemical interaction of nitrogen, oxygen, and water vapor in the air at the existing high temperatures and under the influence of the nuclear radiation. As the fireball cools and condensation occurs, the color of the cloud changes to white, mainly due to the water droplets as in an ordinary cloud.

Depending on the height of burst of the nuclear weapon and the nature of the terrain below, a strong updraft with inflowing winds, called "after winds," is produced in the immediate vicinity. These after winds can cause varying amounts of dirt and debris to be sucked up from the earth's surface into the radioactive cloud.

In an air burst with a moderate (or small) amount of dirt and debris drawn up into the cloud, only a relatively small proportion of the dirt particles become contaminated with radioactivity. This is because the particles do not mix intimately with the weapon residues in the cloud at the time when the fission products are still vaporized and about to condense. For a burst near the land surface, however, large quantities of dirt and other debris are drawn into the cloud at early times. Good mixing then occurs during the initial phases of cloud formation and growth. Consequently, when the vaporized fission products condense they do so on the foreign matter, thus forming highly radioactive particles.

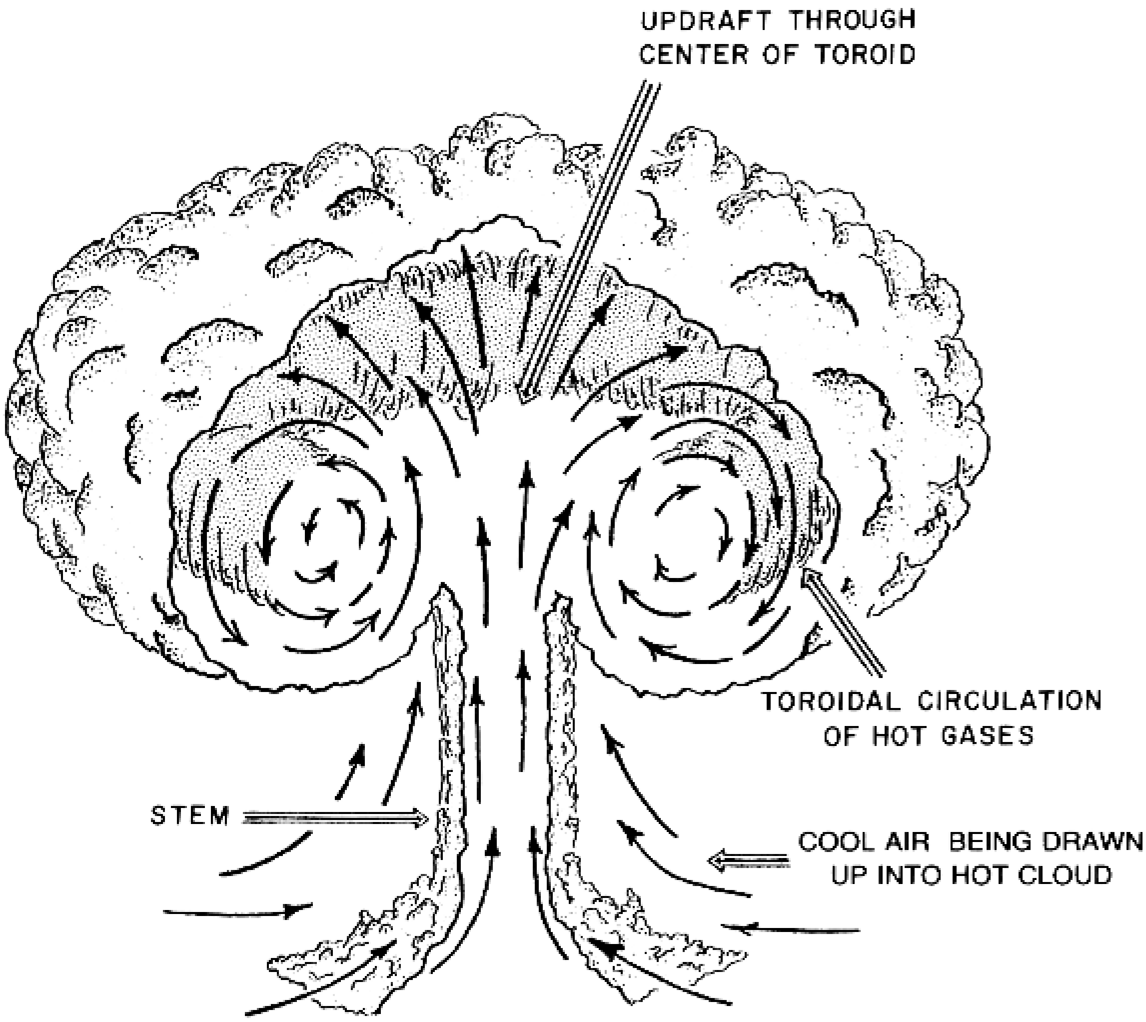


Figure 2.07a Cutaway showing artist's conception of toroidal circulation within the radioactive cloud from a nuclear explosion.

At first the rising mass of weapon residues carries the particles upward, but after a time they begin to fall slowly under the influence of gravity, at rates dependent upon their size. Consequently, a lengthening (and widening) column of cloud (or smoke) is produced. This cloud consists chiefly of very small particles of radioactive fission products and weapon residues, water droplets, and larger particles of dirt and debris carried up by the after-winds.

The speed with which the top of the radioactive cloud continues to ascend depends on the meteorological conditions as well as on the energy yield of the weapon. An approximate indication of the rate of rise of the cloud from a 1-megaton explosion is given by the results in Table 2.12 and the curve in Fig. 2.12. Thus, in general, the cloud will have attained a height of 3 miles in 30 seconds and 5 miles in about a minute. The average rate of rise during the first minute or so is nearly 300 miles per hour (440 feet per second). These values should be regarded as rough averages only, and large deviations may be expected in different circumstances (see also Figs. l0.158a, b, c).

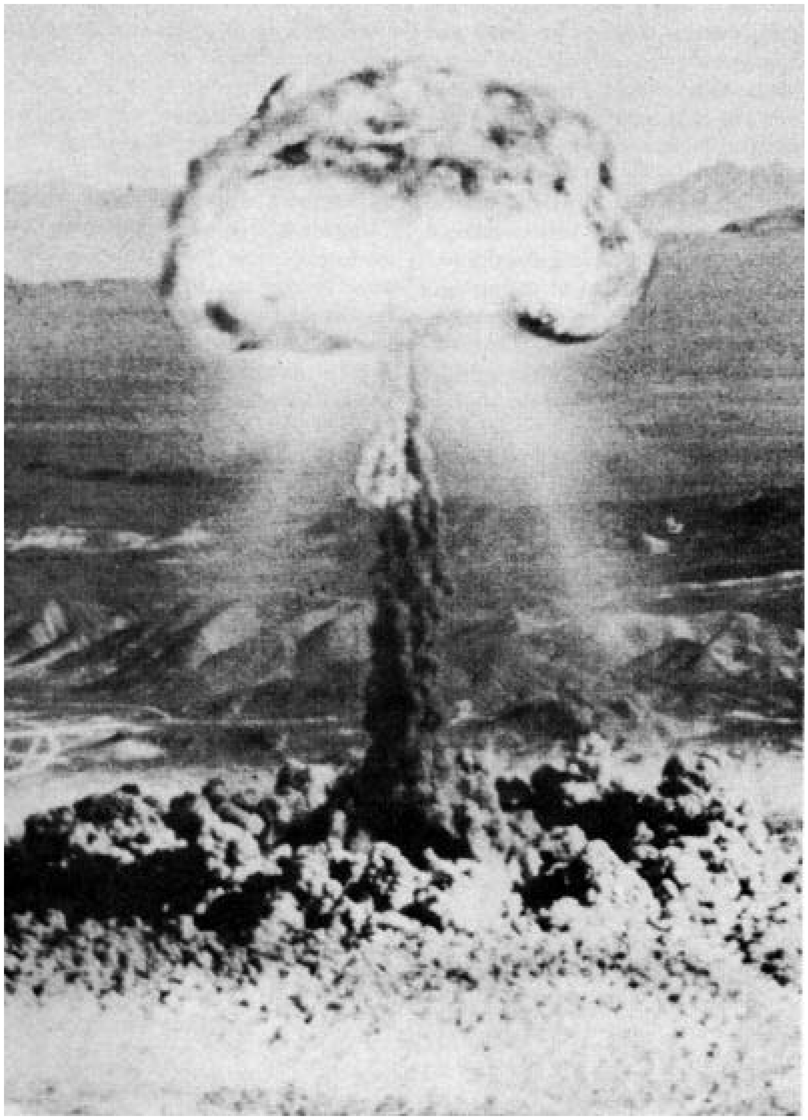


Figure 2.07b Low air burst showing toroidal fireball and dirt cloud

The eventual height reached by the radioactive cloud depends upon the heat energy of the weapon, and upon the atmospheric conditions, e.g., moisture content and stability. The greater the amount of heat generated the greater will be the upward thrust due to buoyancy and so the greater will be the distance the cloud ascends. The maximum height attained by the radioactive cloud is strongly influenced by the tropopause, i.e., the boundary between the troposphere below and the stratosphere above, assuming that the cloud attains the height of the troposphere.

When the cloud reaches the tropopause, there is a tendency for it to spread out laterally, i.e., sideways. But if sufficient energy remains in the radioactive cloud at this height, a portion of it will penetrate the tropopause and ascend into the more stable air of the stratosphere.

Table 2.12

RATE OF RISE OF RADIOACTIVE CLOUD

FROM A I-MEGATON AIRBURST

Height (miles)	Time (minutes)	Rate of Rise (mph)
2	0.3	330
4	0.7	270
6	1.1	220
10	2.5	140
12	3.8	27

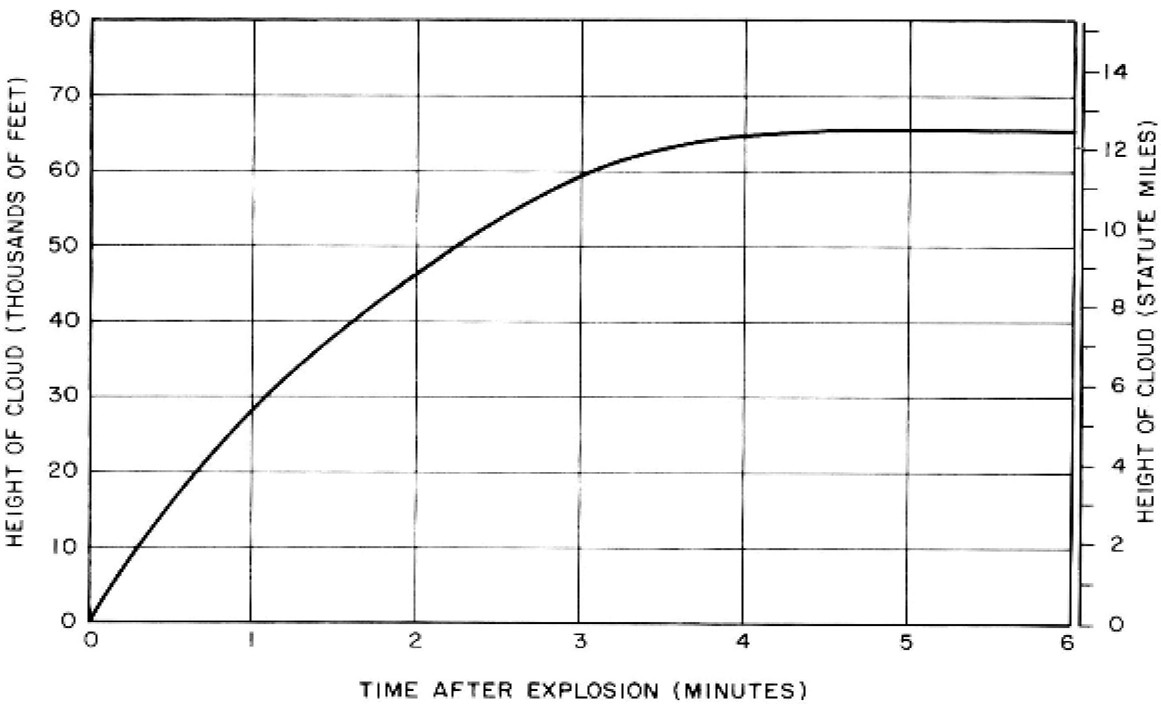


Figure 2.12. Height of cloud top above burst height at various times after a 1-megaton explosion for a moderately low air burst.

The cloud attains its maximum height after about 10 minutes and is then said to be "stabilized." It continues to grow laterally, however, to produce the characteristic mushroom shape (Fig. 2.15). The cloud may continue to be visible for about an hour or more before being dispersed by the winds into the surrounding atmosphere where it merges with natural clouds in the sky.

Figure 2.15. The mushroom cloud formed in a nuclear explosion in the megaton energy range, photographed from an altitude of 12,000 feet at a distance of about 50 miles.

The dimensions of the stabilized cloud formed in a nuclear explosion depend on the meteorological conditions, which vary with time and place. Approximate average values of cloud height and radius (at about 10 minutes after the explosion), attained in land surface or low air bursts, for conditions most likely to be encountered in the continental United States, are given in Fig. 2.16 as a function of the energy yield of the explosion. The flattening of the height curve in the range of about 20- to 100-kilotons TNT equivalent is due to the effect of the tropopause in slowing down the cloud rise. For yields below about 15 kilotons the heights indicated are distances above the burst point but for higher yields the values are above sea level. For land surface bursts, the maximum cloud height is somewhat less than given by Fig. 2.16 because of the mass of dirt and debris carried aloft by the explosion.

For yields below about 20 kilotons, the radius of the stem of the mushroom cloud is about half the cloud radius. With increasing yield, however, the ratio of these dimensions decreases, and for yields in the megaton range the stem may be only one-fifth to one-tenth as wide as the cloud. For clouds which do not penetrate the tropopause the base of the mushroom head is, very roughly, at about one-half the altitude of the top. For higher yields, the broad base will probably be in the vicinity of the tropopause. There is a change in cloud shape in going from the kiloton to the megaton range. A typical cloud from a 10-kiloton air burst would reach a height of 19,000 feet with the base at about 10,000 feet; the horizontal dimensions would also be roughly 10,000 feet. For an explosion in the megaton range, however, the horizontal dimensions are greater than the total height.

CHARACTERISTICS OF A SURFACE BURST

Since many of the phenomena and effects of a nuclear explosion occurring on or near the earth's surface are similar to those associated with an air burst, it is convenient before proceeding further to refer to some of the special characteristics of a surface burst. In such a burst, the fireball in its rapid initial growth, abuts (or touches) the surface of the earth (Fig. 2.18a). Because of the intense heat, some of the rock, soil, and other material in the area is vaporized and taken into the fireball. Additional material is melted, either completely or on its surface, and the strong after winds cause large amounts of dirt, dust, and other particles to be sucked up as the fireball rises (Fig. 2.18b).

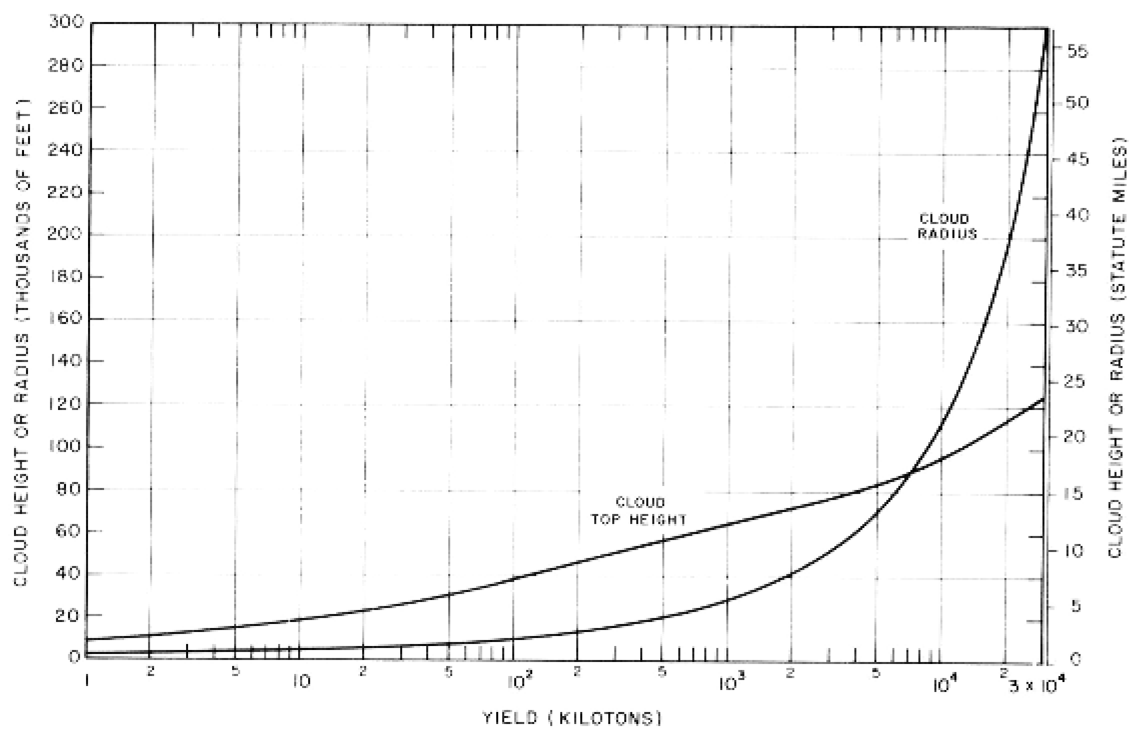


Figure 2.16. Approximate values of stabilized cloud height and radius as a function of explosion yield for land surface or low airbursts.

An important difference between a surface burst and an airburst is, consequently, that in the surface burst the radioactive cloud is much more heavily loaded with debris. This consists of particles ranging in size from the very small ones produced by condensation as the fireball cools to the much larger debris particles which have been raised by the after winds. The exact composition of the cloud will, of course, depend on the nature of the surface materials and the extent of their contact with the fireball.

For a surface burst associated with a moderate amount of debris, such as has been the case in several test explosions in which the weapons were detonated near the ground, the rate of rise of the cloud is much the same as given earlier for an air burst (Table 2.12). The radioactive cloud reaches a height of several miles before spreading out abruptly into a mushroom shape.

When the fireball touches the earth's surface, a crater is formed as a result of the vaporization of dirt and other material and the removal of soil, etc., by the blast wave and winds accompanying the explosion. The size of the crater will vary with the height above the surface at which the weapon is exploded and with the character of the soil, as well as with the energy of the explosion. It is believed that for a 1-megaton weapon there would be no appreciable crater formation unless detonation occurs at an altitude of 450 feet or less.

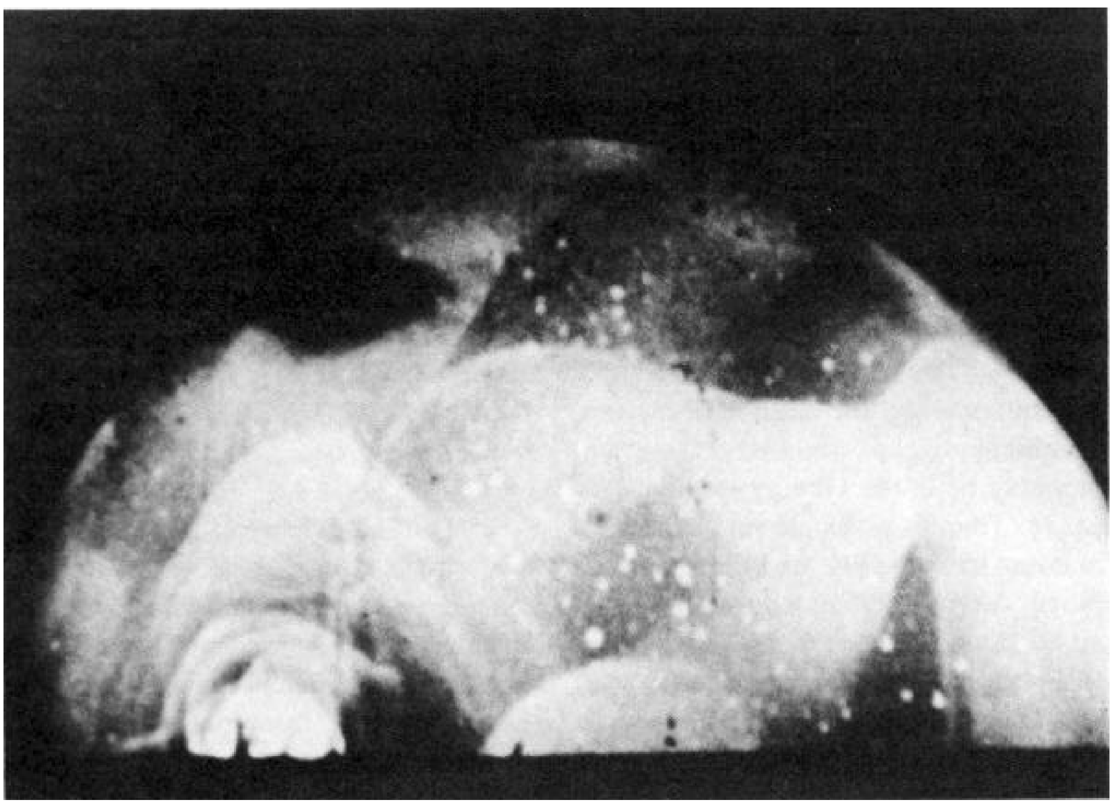


Figure 2.18a. Fireball formed by a nuclear explosion in the megaton energy range near the earth's surface. The maximum diameter of the fireball was 3 1/4 miles.

If a nuclear weapon is exploded near a water surface, large amounts of water are vaporized and carried up into the radioactive cloud. When the cloud reaches high altitudes the vapor condenses to form water droplets, similar to those in an ordinary atmospheric cloud.

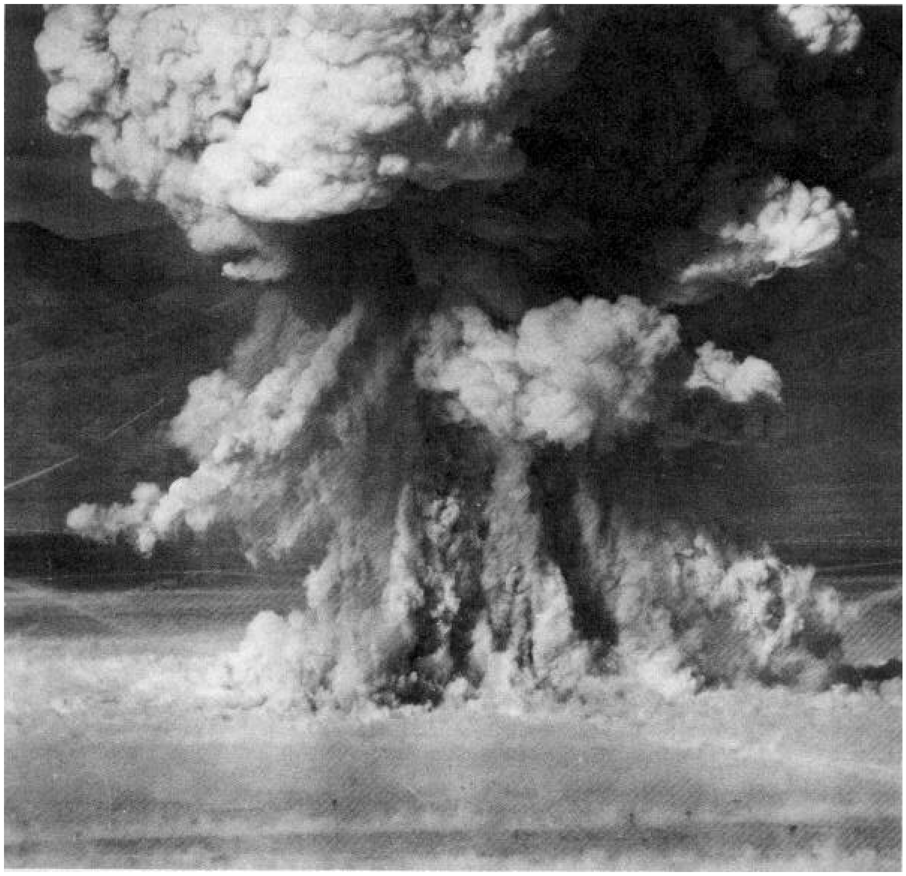


Figure 2.18b. Formation of dirt cloud in surface burst.

THE FALLOUT

In a surface burst, large quantities of earth or water enter the fireball at an early stage and are fused or vaporized. When sufficient cooling has occurred, the fission products and other radioactive residues become incorporated with the earth particles as a result of the condensation of vaporized fission products into fused particles of earth, etc. A small proportion of the solid particles formed upon further cooling are contaminated fairly uniformly throughout with the radioactive fission products and other weapon residues, but as a general rule the contamination is found mainly in a thin shell near the surface of the particles (§ 9.50). In water droplets, the small fission product particles occur at discrete points within the drops. As the violent disturbance due to the explosion subsides, the contaminated particles and droplets gradually descend to earth. This phenomenon is referred to as "fallout," and the same name is applied to the particles themselves when they reach the ground. It is the fallout, with its associated radioactivity, which decays over a long period of time, that is the main source of the residual nuclear radiation referred to in the preceding chapter.

The extent and nature of the fallout can range between wide extremes. The actual situation is determined by a combination of circumstances associated with the energy yield and design of the weapon, the height of the explosion, the nature of the surface beneath the point of burst, and the meteorological conditions. In an airburst, for example, occurring at an appreciable distance above the earth's surface, so that no large amounts of surface materials are sucked into the cloud, the contaminated particles become widely dispersed. The magnitude of the hazard from fallout will then be far less than if the explosion were a surface burst. Thus at Hiroshima (height of burst 1670 feet, yield about 12.5 kilotons) and Nagasaki (height of burst 1640 feet, yield about 22 kilotons) injuries due to fallout were completely absent.

On the other hand, a nuclear explosion occurring at or near the earth's surface can result in severe contamination by the radioactive fallout. From the 15-megaton thermonuclear device tested at Bikini Atoll on March 1, 1954—the BRAVO shot of Operation CASTLE—the fallout caused substantial contamination over an area of more than 7,000 square miles. The contaminated region was roughly cigar-shaped and extended more than 20 statute miles upwind and over 350 miles downwind. The width in the crosswind direction was variable, the maximum being over 60 miles (§ 9.104).

The meteorological conditions which determine the shape, extent, and location of the fallout pattern from a nuclear explosion are the height of the tropopause, atmospheric winds, and the occurrence of precipitation. For a given explosion energy yield, type of burst, and tropopause height, the fallout pattern is affected mainly by the directions and speeds of the winds over the fallout area, from the earth's surface to the top of the stabilized cloud, which may be as high as 100,000 feet. Furthermore, variations in the winds, from the time of burst until the particles reach the ground, perhaps several hours later, affect the fallout pattern following a nuclear explosion.

It should be understood that fallout is a gradual phenomenon extending over a period of time. In the BRAVO explosion, for example, about 10 hours elapsed before the contaminated particles began to fall at the extremities of the 7,000 square mile area. By that time, the radioactive cloud had thinned out to such an extent that it was no longer visible. This brings up the important fact that fallout can occur even when the cloud cannot be seen. Nevertheless, the area of contamination, which presents the most serious hazard generally, results from the fallout of visible particles. The sizes of these particles range from that of fine sand, i.e., approximately 100 micrometers in diameter, or smaller, in the more distant portions of the fallout area, to pieces about the size of a marble, i.e., roughly 1 cm (0.4 inch) in diameter, and even larger close to the burst point.

Particles in this size range arrive on the ground within one day after the explosion, and will not have traveled too far, e.g., up to a few hundred miles, from the region of the shot, depending on the wind. Thus, the fallout pattern from particles of visible size is established within about 24 hours after the burst. This is referred to as "early" fallout, also sometimes called "local" or "close-in" fallout. In addition, there is the deposition of very small particles which descend very slowly over large areas of the earth's surface. This is the "delayed" (or "worldwide") fallout, to which residues from nuclear explosions of various types—air, high-altitude, surface, and shallow subsurface—may contribute.

Although the test of March 1, 1954 produced the most extensive early fallout yet recorded, it should be pointed out that the phenomenon was not necessarily characteristic of (nor restricted to) thermonuclear explosions. It is very probable that if the same device had been detonated at an appreciable distance above the coral island, so that the large fireball did not touch the surface of the ground, the early fallout would have been of insignificant proportions.

The general term "scavenging" is used to describe various processes resulting in the removal of radioactivity from the cloud and its deposition on the earth. One of these processes arises from the entrainment in the cloud of quantities of dirt and debris sucked up in a surface (or near-surface) nuclear burst. The condensation of the fission-product and other radioactive vapors on the particles and their subsequent relatively rapid fall to earth leads to a certain degree of scavenging.

Another scavenging process, which can occur at any time in the history of the radioactive cloud, is that due to rain falling through the weapon debris and carrying contaminated particles down with it. This is one mechanism for the production of "hot spots," i.e., areas on the ground of much higher activity than the surroundings, in both early and delayed fallout patterns. Since rains (other than thundershowers) generally originate from atmospheric clouds whose tops are between about 10,000 and 30,000 feet altitude, it is only below this region that scavenging by rain is likely to take place. Another effect that rain may have if it occurs either during or after the deposition of the fallout is to wash radioactive debris over the surface of the ground. This may result in cleansing some areas and reducing their activity while causing hot spots in other (lower) areas.

THE BLAST WAVE

At a fraction of a second after a nuclear explosion, a high-pressure wave develops and moves outward from the fireball (Fig. 2.32). This is the shock wave or blast wave, mentioned in and to be considered subsequently in more detail, which is the cause of much destruction accompanying an air burst. The front of the blast wave, i.e., the shock front, travels rapidly away from the fireball, behaving like a moving wall of highly compressed air. After the lapse of 10 seconds, when the fireball of a 1-megaton nuclear weapon has attained its maximum size (5,700 feet across), the shock front is some 3 miles farther ahead. At 50 seconds after the explosion, when the fireball is no longer visible, the blast wave has traveled about 12 miles. It is then moving at about 1 ,150 feet per second, which is slightly faster than the speed of sound at sea level.

When the blast wave strikes the surface of the earth, it is reflected back, similar to a sound wave producing an echo. This reflected blast wave, like the original (or direct) wave, is also capable of causing material damage. At a certain region on the surface, the position of which depends chiefly on the height of the burst and the energy of the explosion, the direct and reflected wave fronts merge. This merging phenomenon is called the "Mach effect." The "overpressure," i.e., the pressure in excess of the normal atmospheric value, at the front of the Mach wave is generally about twice as great as that at the direct blast wave front.

For an airburst of a 1-megaton nuclear weapon at an altitude of 6,500 feet, the Mach effect will begin approximately 4.5 seconds after the explosion, in a rough circle at a radius of 1.3 miles from ground zero. The overpressure on the ground at the blast wave front at this time is about 20 pounds per square inch, so that the total air pressure is more than double the normal atmospheric pressure.

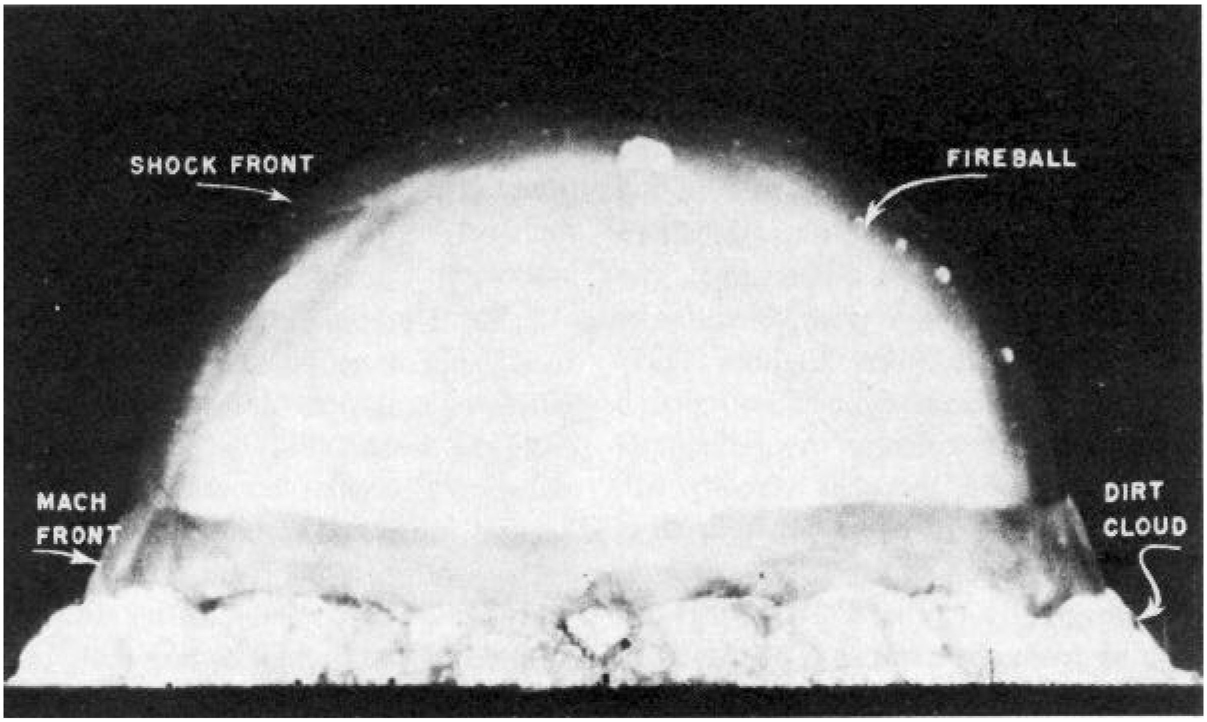


Figure 2.32. The faintly luminous shock front seen just ahead of the fireball soon after breakaway (see § 2.120).

At first the height of the Mach front is small, but as the blast wave front continues to move outward, the height increases steadily. At the same time, however, the overpressure, like that in the original (or direct) wave, decreases correspondingly because of the continuous loss of energy and the ever-increasing area of the advancing front. After the lapse of about 40 seconds, when the Mach front from a 1-megaton nuclear weapon is 10 miles from ground zero, the overpressure will have decreased to roughly 1 pound per square inch.

The distance from ground zero at which the Mach effect commences varies with the height of burst. Thus, as seen in Fig. 2.32, in the low-altitude (100 feet) detonation at the TRINITY (Alamogordo) test, the Mach front was apparent when the direct shock front had advanced a short distance from the fireball. At the other extreme, in a very high air burst there might be no detectable Mach effect. (The TRINITY test, conducted on July

16, 1945 near Alamogordo, New Mexico, was the first test of a nuclear (implosion) weapon; the yield was estimated to be about 19 kilotons.)

Strong transient winds are associated with the passage of the shock (and Mach) front. These blast winds (§ 3.07) are very much stronger than the ground wind (or after wind) due to the updraft caused by the rising fireball which occurs at a later time. The blast winds may have peak velocities of several hundred miles an hour fairly near to ground zero; even at more than 6 miles from the explosion of a 1-megaton nuclear weapon, the peak velocity will be greater than 70 miles per hour. It is evident that such strong winds can contribute greatly to the blast damage resulting from the explosion of a nuclear weapon.

THERMAL RADIATION FROM AN AIR BURST

Immediately after the explosion, the weapon residues emit the primary thermal radiation. Because of the very high temperature, much of this is in the form of X rays which are absorbed within a layer of a few feet of air; the energy is then re-emitted from the fireball as (secondary) thermal radiation of longer wavelength, consisting of ultraviolet, visible, and infrared rays. Because of certain phenomena occurring in the fireball (see § 2.106 *et seq.*), the surface temperature undergoes a curious change. The temperature of the interior falls steadily, but the apparent surface temperature of the fireball decreases more rapidly for a small fraction of a second. Then, the apparent surface temperature increases again for a somewhat longer time, after which it falls continuously (see Fig. 2.123). In other words, there are effectively two surface-temperature pulses; the first is of very short duration, whereas the second lasts for a much longer time. The behavior is quite general for air (and surface) bursts, although the duration times of the pulses increase with the energy yield of the explosion.

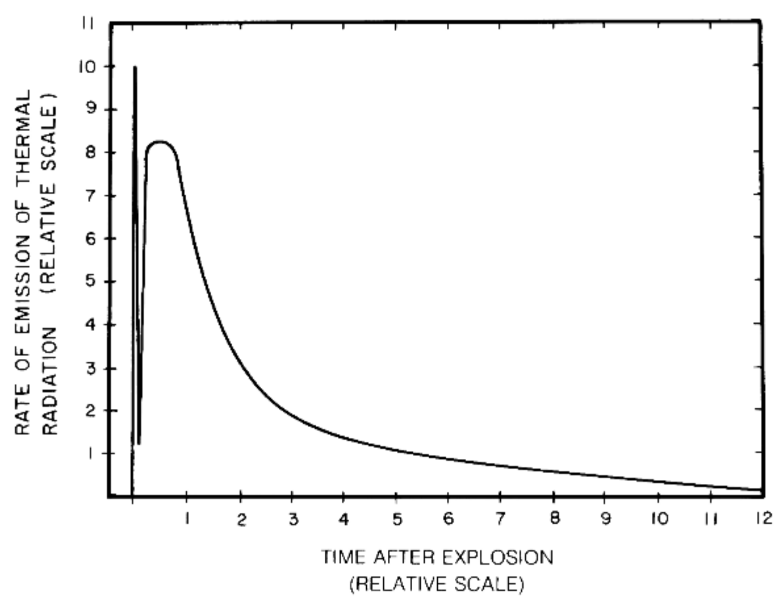


Figure 2.39. Emission of thermal radiation in two pulses in an air burst.

Corresponding to the two surface-temperature pulses, there are two pulses of emission of thermal radiation from the fireball (Fig. 2.39). In the first pulse, which lasts about a tenth of a second for a 1-megaton explosion, the surface temperatures are mostly very high. As a result, much of the radiation emitted by the fireball during this pulse is in the ultraviolet region. Although ultraviolet radiation can cause skin burns, in most circumstances following an ordinary air burst the first pulse of thermal radiation is not a significant hazard in this respect, for several reasons. In the first place, only about 1 percent of the thermal radiation appears in the initial pulse because of its short duration. Second, the ultraviolet rays are readily attenuated by the intervening air, so that the dose delivered at a distance from the explosion may be comparatively small. Furthermore, it appears that the ultraviolet radiation from the first pulse could cause significant effects on the human skin only within ranges at which other thermal radiation effects are much more serious. It should be mentioned, however, that although the first radiation pulse may be disregarded as a source of skin burns, it is capable of producing permanent or temporary effects on the eyes, especially of individuals who happen to be looking in the direction of the explosion.

In contrast to the first pulse, the second radiation pulse may last for several seconds, e.g., about 10 seconds for a 1-megaton explosion; it carries about 99 percent of the total thermal radiation energy. Since the temperatures are lower than in the first pulse, most of the rays reaching the earth consist of visible and infrared (invisible) light. It is this radiation, which is the main cause of skin burns of various degrees suffered by exposed individuals up to 12 miles or more, and of eye effects at even greater distances, from the explosion of a 1-megaton weapon. For weapons of higher energy, the effective damage range is greater, as will be explained in Chapter VII. The radiation from the second pulse can also cause fires to start under suitable conditions.

INITIAL NUCLEAR RADIATION FROM AN AIR BURST

The explosion of a nuclear weapon is associated with the emission of various nuclear radiations, consisting of neutrons, gamma rays, and alpha and beta particles. Essentially all the neutrons and part of the gamma rays are emitted in the actual fission process. These are referred to as the "prompt nuclear radiations" because they are produced simultaneously with the nuclear explosion. Some of the neutrons liberated in fission are immediately captured and others undergo "scattering collisions" with various nuclei present in the weapon. These processes are frequently accompanied by the instantaneous emission of gamma rays. In addition, many of the escaping neutrons undergo similar interactions with atomic nuclei of the air, thus forming an extended source of gamma rays around the burst point. The remainder of the gamma rays and the beta particles are liberated over a period of time as the fission products undergo radioactive decay. The alpha particles are expelled, in an analogous manner, as a result of the decay of the uranium (or plutonium), which has escaped fission in the weapon.

The initial nuclear radiation is generally defined as that emitted from both the fireball and the radioactive cloud within the first minute after the explosion. It includes neutrons and gamma rays given off almost instantaneously, as well as the gamma rays emitted by the fission products and other radioactive species in the rising cloud. It should be noted that the alpha and beta particles present in the initial radiation have not been considered. This is because they are so easily absorbed that they will not reach more than a few yards, at most, from the radioactive cloud.

The somewhat arbitrary time period of 1 minute for the duration of the initial nuclear radiations was originally based upon the following considerations. As a consequence of attenuation by the air, the effective range of the fission gamma rays and of those from the fission products from a 20-kiloton explosion is very roughly 2 miles. In other words, gamma rays originating from such a source at an altitude of over 2 miles can be ignored, as far as their effect at the earth's surface is concerned. Thus, when the radioactive cloud has reached a height of 2 miles, the effects of the initial nuclear radiations are no longer significant. Since it takes roughly a minute for the cloud to rise this distance, the initial nuclear radiation was defined as that emitted in the first minute after the explosion.

The foregoing arguments are based on the characteristics of a 20-kiloton nuclear weapon. For a detonation of higher energy, the maximum distance over which the gamma rays are effective will be larger than given above. However, at the same time, there is an increase in the rate at which the cloud rises. Similarly for a weapon of lower energy, the effective distance is less, but so also is the rate of ascent of the cloud. The period over which the initial nuclear radiation extends may consequently be taken to be approximately the same, namely, 1 minute, irrespective of the energy release of the explosion.

Neutrons are the only significant nuclear radiations produced directly in the thermonuclear reactions mentioned in. Alpha particles (helium nuclei) are also formed, but they do not travel very far from the explosion. Some of the neutrons will escape but others will be captured by the various nuclei present in the exploding weapon. Those neutrons absorbed by fissionable species may lead to the liberation of more neutrons as well as to the emission of gamma rays. In addition, the capture of neutrons in nonfission reactions is usually accompanied by gamma rays. It is seen, therefore, that the initial radiations from an explosion in which both fission and fusion (thermonuclear) processes occur consist essentially of neutrons and gamma rays. The relative proportions of these two radiations may be somewhat different than for a weapon in which all the energy release is due to fission, but for present purposes the difference may be disregarded.

THE ELECTROMAGNETIC PULSE

If a detonation occurs at or near the earth's surface produces intense electric and magnetic fields which may extend to distances up to several miles, depending on the weapon yield. The close-in region near the burst point is highly ionized and large electric currents flow in the air and the ground, producing a pulse of electromagnetic radiation. Beyond this close-in region the electromagnetic field strength, as measured on (or near) the ground, drops sharply and then more slowly with increasing distance from the explosion. The intense fields may damage unprotected electrical and electronic equipment at distances exceeding those at which significant air blast damage may occur, especially for weapons of low yield.

OTHER NUCLEAR EXPLOSION PHENOMENA

There are a number of interesting phenomena associated with a nuclear air burst that are worth mentioning although they have no connection with the destructive or other harmful effects of the explosion. Soon after the detonation, a violet-colored glow may be observed, particularly at night or in dim daylight, at some distance from the fireball. This glow may persist for an appreciable length of time, being distinctly visible near the head of the radioactive cloud. It is believed to be the ultimate result of a complex series of processes initiated by the action of the various radiations on the nitrogen and oxygen of the air.

Another early phenomenon following a nuclear explosion in certain circumstances is the formation of a "condensation cloud." This is sometimes called the Wilson cloud (or cloud-chamber effect) because it is the result of conditions analogous to those utilized by scientists in the Wilson cloud chamber. It will be seen in Chapter III that the passage of a high-pressure shock front in air is followed by a rarefaction (or suction) wave. During the compression (or blast) phase, the temperature of the air rises and during the decompression (or suction) phase it falls. For moderately low blast pressures, the temperature can drop below its original, preshock value, so that if the air contains a fair amount of water vapor, condensation accompanied by cloud formation will occur.

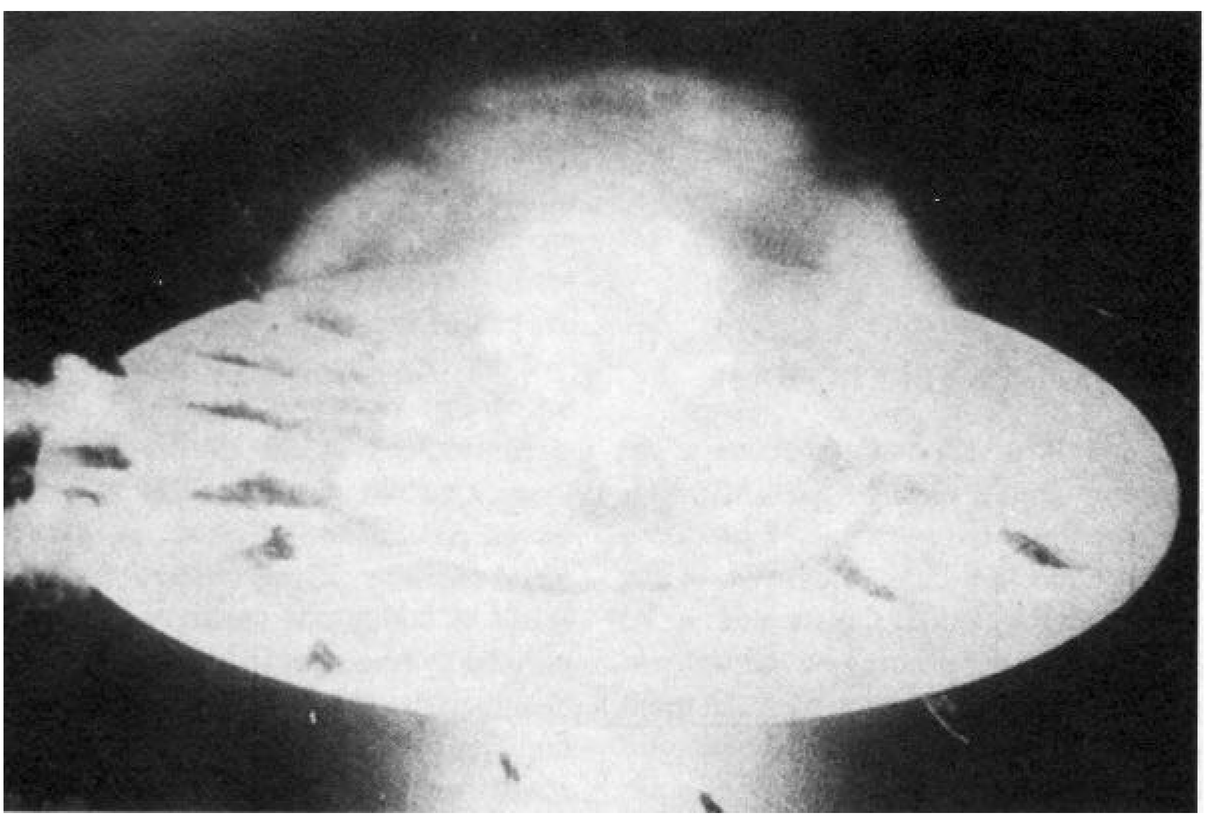


Figure 2.49. Condensation cloud formed in an air burst over water.

The condensation cloud which was observed in the ABLE Test at Bikini in 1946 is shown in Fig. 2.49. Since the device was detonated just above the surface of the lagoon, the air was nearly saturated with water vapor and the conditions were suitable for the production of a Wilson cloud. It can be seen from the photograph that the cloud formed some way ahead of the fireball. The reason is that the shock front must travel a considerable distance before the blast pressure has fallen sufficiently for a low temperature to be attained in the subsequent decompression phase. At the time the temperature has dropped to that required for condensation to occur, the blast wave front has moved still farther away, as is apparent in Fig. 2.49, where the disk-like formation on the surface of the water indicates the passage of the shock wave.

The relatively high humidity of the air makes the conditions for the formation of the condensation cloud most favorable in nuclear explosions occurring over (or under) water, as in the Bikini tests in 1946. The cloud commenced to form 1 to 2 seconds after the detonation, and it had dispersed completely within another second or so, as the air warmed up and the water droplets evaporated. The original dome-like cloud first changed to a ring shape, as seen in Fig. 2.50, and then disappeared.

Figure 2.50 Late stage of the condensation cloud in an air burst over water.

Since the Wilson condensation cloud forms after the fireball has emitted most of its thermal radiation, it has little influence on this radiation. It is true that fairly thick clouds, especially smoke clouds, can attenuate the thermal radiation reaching the earth from the fireball. However, apart from being formed at too late a stage, the condensation cloud is too tenuous to have any appreciable effect in this connection.

DESCRIPTION OF HIGH-ALTITUDE BURSTS

INTRODUCTION

Nuclear devices were exploded at high altitudes during the summer of 1958 as part of the HARDTACK test series in the Pacific Ocean and the ARGUS operation in the South Atlantic Ocean. Additional high-altitude nuclear tests were conducted during the FISHBOWL test series in 1962. In the HARDTACK series, two high-altitude bursts, with energy yields in the megaton range, were set off in the vicinity of Johnston Island, 700 miles southwest of Hawaii. The first device, named TEAK, was detonated on August 1, 1958 (Greenwich Civil Time) at an altitude of 252,000 feet, i.e., nearly 48 miles. The second, called ORANGE, was exploded at an altitude of 141,000 feet, i.e., nearly 27 miles, on August 12, 1958 (GCT). During the FISHBOWL series, a megaton and three submegaton devices were detonated at high altitudes in the vicinity of Johnston Island. The STARFISH PRIME device, with a yield of 1.4 megatons, was exploded at an altitude of about 248 miles on July 9, 1962 (GCT). The three submegaton devices, CHECKMATE, BLUEGILL TRIPLE PRIME, and KINGFISH, were detonated at altitudes of tens of miles on October 20, 1962, October 26, 1962, and November 1, 1962 (GCT), respectively.

The ARGUS operation was not intended as a test of nuclear weapons or their destructive effects. It was an experiment designed to provide information on the trapping of electrically charged particles in the earth's magnetic field (§ 2.145). The operation consisted of three high-altitude nuclear detonations, each having a yield from 1 to 2 kilotons TNT equivalent. The burst altitudes were from about 125 to 300 miles.

HIGH-ALTITUDE BURST PHENOMENA

If a burst occurs in the altitude regime of roughly 10 to 50 miles, the explosion energy radiated as X rays will be deposited in the burst region, although over a much larger volume of air than at lower altitudes. In this manner, the ORANGE shot created a large fireball almost spherical in shape. In general, the fireball behavior was in agreement with the expected interactions of the various radiations and kinetic energy of the expanding weapon debris with the ambient air.

The mechanism of fireball formation changes appreciably at still higher burst altitude, since the X-rays are able to penetrate to greater distances in the low-density air. Starting at an explosion altitude of about 50 miles, the interaction of the weapon debris energy with the atmosphere becomes the dominant mechanism for producing a fireball. Because the debris is highly ionized, the earth's magnetic field, i.e., the geomagnetic field, will influence the location and distribution of the late-time fireball from bursts above about 50 miles altitude.

A sharp and bright flash of light accompanied the TEAK explosion, which was visible above the horizon from Hawaii, over 700 miles away. Because of the long range of the X rays in the low-density atmosphere in the immediate vicinity of the burst, the fireball grew very rapidly in size. In 0.3 second, its diameter was already 11 miles and it increased to 18 miles in 3.5 seconds. The fireball also ascended with great rapidity, the initial rate of rise being about a mile per second. Surrounding the fireball was a very large red luminous spherical wave, arising apparently from electronically excited oxygen atoms produced by a shock wave passing through the low-density air (Fig. 2.56).

At about a minute or so after the detonation, the TEAK fireball had risen to a height of over 90 miles, and it was then directly (line-of-sight) visible from Hawaii. The rate of rise of the fireball was estimated to be some 3,300 feet per second and it was expanding horizontally at a rate of about 1,000) feet per second. The large red luminous sphere was observed for a few minutes; at roughly 6 minutes after the explosion it was nearly 600 miles in diameter.

Figure 2.56. Fireball and red luminous spherical wave formed after the TEAK high-altitude shot. (The photograph was taken from Hawaii, 780 miles from the explosion.)

The formation and growth of the fireball changes even more drastically as the explosion altitude increases above 65 miles. Because X rays can penetrate the low-density atmosphere to great distances before being absorbed, there is no local fireball. Below about 190 miles (depending on weapon yield), the energy initially appearing as the rapid outward motion of debris particles will still be deposited relatively locally, resulting in a highly heated and ionized region. The geomagnetic field plays an increasingly important role in controlling debris motion as the detonation altitude increases. Above about 200 miles, where the air density is very low, the geomagnetic field is the dominant factor in slowing the expansion of the ionized debris across the field lines. Upward and downward motion along the field lines, however, is not greatly affected. When the atmosphere, at about 75 miles altitude, stops the debris it may heat and ionize the air sufficiently to cause a visible region, which will subsequently rise and expand. Such a phenomenon was observed following the STARFISH PRIME event.

A special feature of explosions at altitudes between about 20 and 50 miles is the extreme brightness; of the fireball. It is visible at distances of several hundred miles and is capable of producing injury to the eyes over large areas.

Additional important effects that result from high-altitude bursts are the widespread ionization and other disturbances of the portion of the upper atmosphere known as the ionosphere. These disturbances affect the propagation of radio and radar waves, sometimes over extended areas. Following the TEAK event, propagation of high-frequency (HF) radio communications was degraded over a region of several thousand miles in diameter for a period lasting from shortly after midnight until sunrise. Some very-high-frequency (VHF) communications circuits in the Pacific area were unable to function for about 30 seconds after the STARFISH PRIME event.

Detonations above about 19 miles can produce EMP effects on the ground over large areas, increasing with the yield of the explosion and the height of burst. For fairly large yields and burst heights, the EMP fields may be significant at nearly all points within the line of sight, i.e., to the horizon, from the burst point. Although these fields are weaker than those in the close-in region surrounding a surface burst, they are of sufficient magnitude to damage some unprotected electrical and electronic equipment.

An interesting visible effect of high-altitude nuclear explosions is the creation of an "artificial aurora." Within a second or two after burst time of the TEAK shot a brilliant aurora appeared from the bottom of the fireball and purple streamers were seen to spread toward the north. Less than a second later, an aurora was observed at Apia, in the Samoan Islands, more than 2,000 miles from the point of burst, although at no time was the fireball in direct view. The formation of the aurora is attributed to the motion along the lines of the earth's magnetic field of beta particles (electrons), emitted by the radioactive fission fragments. Because of the natural cloud cover over Johnston Island at the time of burst, direct observation of the ORANGE fireball was not possible from the ground. However, such observations were made from aircraft flying above the low clouds. The auroras were less marked than from the TEAK shot, but an aurora lasting 17 minutes was again seen from Apia. Similar auroral effects were observed after the other high-altitude explosions.

FOOTNOTES

[1] A millisecond is a one-thousandth part of a second.

[2] The tropopause is the boundary between the troposphere and the relatively stable air of the stratosphere. It varies with season and latitude, ranging from 25,000 feet near the poles to about 55,000 feet in equatorial regions (§ 9.128).

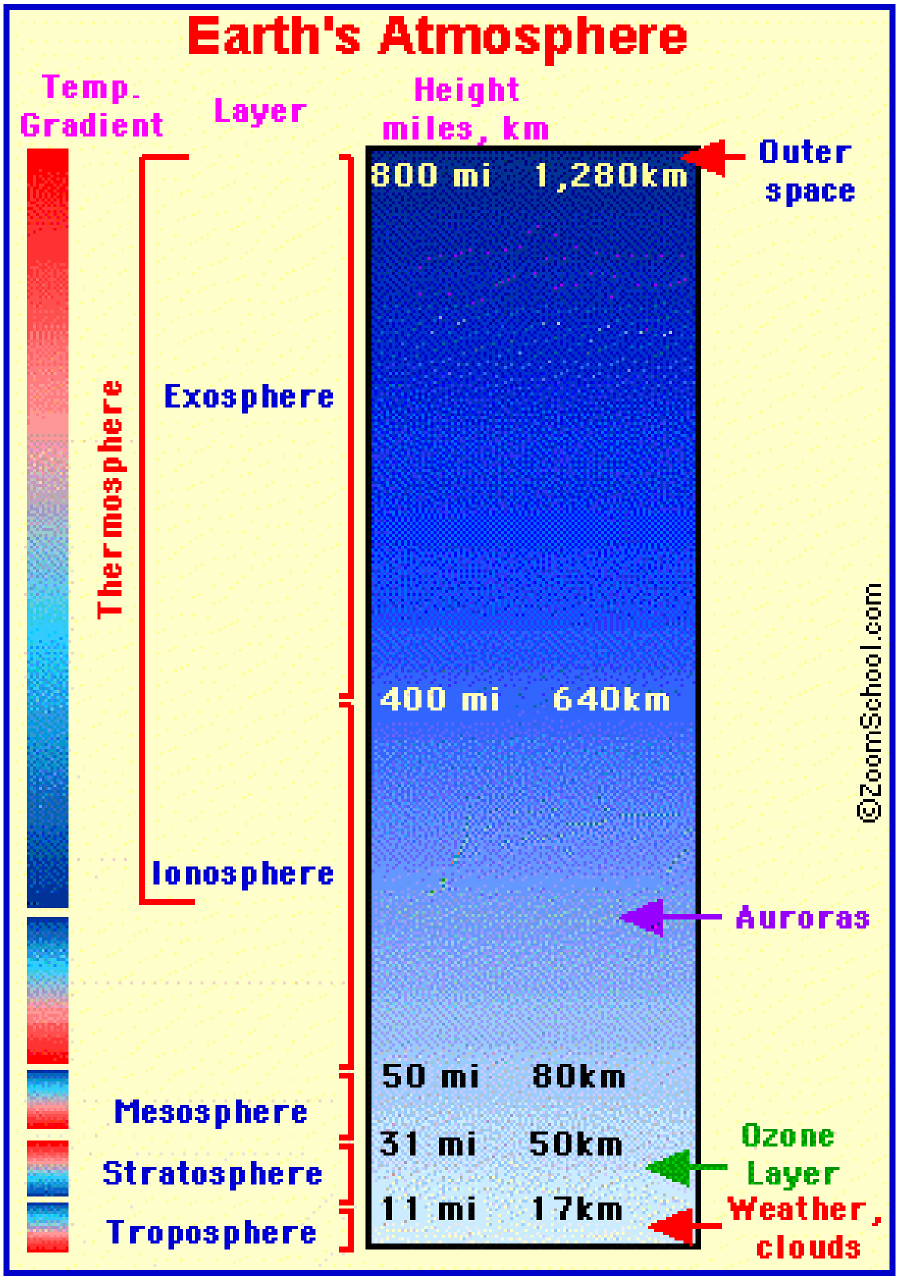
[3] These residues include radioactive species formed at the time of the explosion by neutron capture in various materials (§ 9.31).

[4] A micrometer (also called a micron) is a one-millionth part of a meter, i.e., 10^{-6} meter, or about 0.00004 (or 4×10^{-5}) inch

[5] The term "ground zero" refers to the point on the earth's surface immediately below (or above) the point of detonation. For a burst over (or under) water, the corresponding point is generally called "surface zero." The term "surface zero" or "surface ground zero" is also commonly used for ground surface and underground explosions. In some publications, ground (or surface) zero is called the "hypocenter" of the explosion.

[6] The normal atmospheric pressure at sea level is 14.7 pounds per square inch.

Appendix III


Earth's Atmosphere
Temp. Gradient
Layer
Height miles, km
Thermosphere
Exosphere
Ionosphere
Mesosphere
Stratosphere
Troposphere
800 mi 1,280km
400 mi 640km
50 mi 80km
31 mi 50km
11 mi 17km
Outer space
Auroras
Ozone Layer
Weather, clouds
©ZoomSchool.com

Appendix IV
Summery of Problematic Atomic Test
For Micronesia

Shot Name	Operation	Date	Time	Yield in kt	Local
ABLE	Crossroads	6/30/46	1000	21	Bikini Atoll
BAKER	Crossroads	7/24/46	935	21	Bikini Atoll
X-RAY	Sandstone	4/14/48	617	37	Enewetak
YOKE	Sandstone	4/30/48	609	49	Enewetak
ZEBRA	Sandstone	5/14/48	604	18	Enewetak
DOG	Greenhouse	4/7/51	634	81	Enewetak
EASY	Greenhouse	4/20/51	627	47	Enewetak
GEORGE	Greenhouse	5/8/51	930	225	Enewetak
ITEM	Greenhouse	5/24/51	617	45.5	Enewetak
MIKE	**Ivy**	**10/31/52**	**715**	**10400**	**Enewetak**
KING	Ivy	11/15/52	1130	500	Enewetak
BRAVO	**Castle**	**2/28/54**	**645**	**15000**	**Bikini Atoll**
ROMEO	**Castle**	**3/26/54**	**630**	**11000**	**Bikini Atoll**
KOON	Castle	4/6/54	620	110	Bikini Atoll
UNION	**Castle**	**4/25/54**	**605**	**6900**	**Bikini Atoll**
YANKEE	**Castle**	**5/4/54**	**610**	**13500**	**Bikini Atoll**
NECTAR	**Castle**	**5/13/54**	**620**	**1690**	**Enewetak**
LACROSSE	Redwing	5/4/56	625	40	Enewetak
CHEROKEE	**Redwing**	**5/20/56**	**551**	**3800**	**Bikini Atoll**
ZUNI	**Redwing**	**5/27/56**	**556**	**3500**	**Bikini Atoll**
YUMA	Redwing	5/27/56	756	0.19	Enewetak
ERIE	Redwing	5/30/56	615	14.9	Enewetak
SEMINOLE	Redwing	6/6/56	1255	13.7	Enewetak
FLATHEAD	Redwing	6/11/56	626	365	Bikini Atoll
BLACKFOOT	Redwing	6/11/56	626	8	Enewetak
KICKAPOO	Redwing	6/13/56	1126	1.49	Enewetak
OSAGE	Redwing	6/16/56	1314	1.7	Enewetak
INCA	Redwing	6/21/56	956	15.2	Enewetak
DAKOTA	**Redwing**	**6/25/56**	**606**	**1100**	**Bikini Atoll**
MOHAWK	Redwing	7/2/56	606	360	Enewetak
APACHE	**Redwing**	**7/8/56**	**606**	**1850**	**Enewetak**
NAVAJO	**Redwing**	**7/10/56**	**556**	**4500**	**Bikini Atoll**
TEWA	**Redwing**	**7/20/56**	**546**	**5000**	**Bikini Atoll**
HURON	Redwing	7/21/56	616	250	Enewetak
YUCCA	Hardtack I	4/28/58	1440	1.7	97km W Bikini
CACTUS	Hardtack I	5/5/58	615	18	Enewetak
FIR	**Hardtack I**	**5/11/58**	**550**	**1360**	**Bikini Atoll**
BUTTERNUT	Hardtack I	5/11/58	615	81	Enewetak
KOA	**Hardtack I**	**5/12/58**	**630**	**1370**	**Enewetak**
WAHOO	Hardtack I	5/16/58	1330	9	Enewetak
HOLLY	Hardtack I	5/20/58	630	5.9	Enewetak
NUTMEG	Hardtack I	5/21/58	920	25.1	Bikini Atoll
YELLOWWOOD	Hardtack I	5/26/58	1400	330	Enewetak
MAGNOLIA	Hardtack I	5/26/58	600	57	Enewetak
TOBACCO	Hardtack I	5/30/58	1415	11.6	Enewetak
SYCAMORE	Hardtack I	5/31/58	1500	92	Bikini Atoll
ROSE	Hardtack I	6/2/58	645	15	Enewetak
UMBRELLA	Hardtack I	6/8/58	1115	8	Enewetak
MAPLE	Hardtack I	6/10/58	530	213	Bikini Atoll
ASPEN	Hardtack I	6/14/58	530	319	Bikini Atoll
WALNUT	**Hardtack I**	**6/14/58**	**630**	**1450**	**Enewetak**
LINDEN	Hardtack I	6/18/58	1600	11	Enewetak

REDWOOD	Hardtack I	6/27/58	530	412	Bikini Atoll
ELDER	Hardtack I	6/27/58	630	880	Enewetak
OAK	**Hardtack I**	**6/28/58**	**730**	**8900**	**Enewetak**
HICKORY	Hardtack I	6/29/58	1200	14	Bikini Atoll
SEQUOIA	Hardtack I	7/1/58	630	5.2	Enewetak
CEDAR	Hardtack I	7/2/58	530	220	Bikini Atoll
DOGWOOD	Hardtack I	7/5/58	630	397	Enewetak
POPLAR	**Hardtack I**	**7/12/58**	**1530**	**9300**	**Bikini Atoll**
SCAEVOLA	Hardtack I	7/14/58	1600	0(safety test)	Enewetak
PISONIA	Hardtack I	7/17/58	1100	255	Enewetak
JUNIPER	Hardtack I	7/22/58	1620	65	Bikini Atoll
OLIVE	Hardtack I	7/22/58	830	202	Enewetak
PINE	**Hardtack I**	**7/26/58**	**830**	**2000**	**Enewetak**
QUINCE	Hardtack I	8/6/58	1415	0	Enewetak
FIG	Hardtack I	8/18/58	1600	0.02	Enewetak

Total Tests by Location

Island	TOTAL # OF TESTS	MIN. YIELD	MAX. YIELD	TOTAL YEILD
Bikini Atoll	24	1.7 kt.	15000.0 kt	76838.8 Kt
Enewetak	42	0.0 kt	10400.0 kt	31653.4 Kt
			Total Regional Yield	***108,492.2 Kt***

Note: *The underlined detonations represent the tests most likely to have the yield necessary to reach the jet stream there by entering Guam's region.*

Glossary

Absorbed Dose- The amount of energy imparted by nuclear (or ionizing) radiation to unit mass of absorbed material. The unit is the rad.

Absorption- The irreversible conversion of the energy of an electromagnetic wave into another form of energy as a result of its interaction with matter. As applied to gamma (or X) rays it is the process (or processes) resulting in the transfer of energy by the radiation absorbing material through which it passes. In this sense, absorption involves the photoelectric effect and pair production, but only of the Compton effect.

Afterwinds- Wind currents set up in the vicinity of a nuclear explosion directed towards the burst center, resulting from the updraft accompanying the rise of the fireball.

Air Burst- The explosion of a nuclear weapon at such a height that the expanding fireball does not touch the earth's surface when the luminosity is a maximum (in the second pulse).

Alpha Particle- A particle emitted spontaneously from the nuclei of some radioactive elements. It is identical with a helium nucleus, having a mass of four units and an electric charge of two positive units.

Atom- The smallest (or ultimate) particle of an element that still retains the characteristics of that element. As a basis of reference, the atomic weight of the common isotope of carbon (carbon-12) is taken to be exactly 12; the atomic weight of hydrogen (the lightest element) is then 1.008. Hence, the atomic weight of any element is approximately the mass of an atom of that element relative to the mass of hydrogen atom.

Background Radiation- Nuclear (or ionizing) radiations arising from within the body and from the surroundings to which individuals are always exposed. The main sources of the natural background radiation are potassium-40 in the body, potassium-40 and thorium, uranium, and their decay products (including radium) present in rocks and soil, and cosmic rays.

Base Surge- A cloud, which rolls outward from the bottom of the column produced by subsurface explosion. For underwater bursts the visible surge is, in effect, a cloud of liquid (water) droplets with the property of flowing almost as it it was a homogeneous fluid. After the water evaporates, an invisible base surge of small radioactive particles may persist.

Beta Particle- A charged particle of very small mass emitted spontaneously from the nuclei of certain radioactive elements. Most (if not all) of the direct fission products emit (negative) beta particles. Physically, the beta particle is identical with an electron moving at high velocity.

Biological Half-Life- The time required for the amount of a specified element which has entered the body (or a particular organ) to be decreased to half it initial value as a result of natural, biological elimination processes.

Blast Wave- A pulse of air in which the pressure increases sharply at the front, accompanied by winds, propagated from an explosion.

Blast Yield- That portion of the total energy of a nuclear explosion that manifests itself as a blast (or shock) wave.

Breakway- The onset of a condition in which the shock front (in the air), moves away from the exterior of the expanding fireball produced by the explosion of a nuclear weapon.

Cloud Column- The visible column of weapon debris (and possible dust and water droplets) extending upwards from the point of burst of a nuclear weapon.

Condensation Cloud- A mist or fog of minute water droplets which temporarily surrounds the fireball following a nuclear detonation in a comparatively humid atmosphere. The expansion of the air in the negative phase of the blast wave from the explosion results in a lowering of the temperature, so that condensation of water vapor presenting the air accurse and a cloud forms. The cloud is soon dispelled when the pressure returns to normal and the air warmsup again. The phenomenon is similar to that used by physicists in the Wilson cloud chamber and is sometimes called the cloud chamber effect.

Contamination- The deposit of radioactive material in the surface of structures, areas, objects, or personnel, following a nuclear explosion. This material generally consists of fallout in which fission products and other weapon debris has become incorporated with particles of dirt, etc. Contamination can also arise from radioactivity induced in certain substances by the action of neutrons from a nuclear explosion.

Crater- The pit, depression, or cavity formed in the surface of the earth by a surface or underground explosion. Crater formation can occur by vaporization of the surface material, by the scouring effect of air blast, by throw out of disturbed material, or by subsidence. In general, the major mechanism changes from one to the next with increasing depth of burst. The apparent crater is the depression which is seen after the burst; is is smaller than the true crater (i.e., the cavity actually formed by the explosion), because it is covered with a layer of loose earth, rock, etc.

Critical Mass- The minimum mass of a fissionable material that will just maintain a fission chain reaction under precisely specified condition, such as the nature of the material and its purity, the nature and thickness of the tamper (or neutron reflector), the density (or compression) and the physical shape (or geometry). For an explosion to occur, the system must be supercritical (i.e., the mass of material must exceed the critical mass under the existing conditions).

Curie- A unit of radioactivity; it is the activity of a quantity of any radioactive species in which 3.700X10 to the tenth power nuclear disintegrations occur per second. The gamma curie is sometimes defined correspondingly as the activity of material in which this number of gamma-ray photons is emitted per second.

Decay (or Radioactive Decay)- The decrease in activity of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, sometimes accompanied by gamma radiation.

Decontamination- The reduction or removal of contaminating radioactive material from a structure, area, object, or person. Decontamination may be accomplished by (1) treating the surfaces as to remove or decrease the contamination; (2) letting the material stand so that the radioactivity is decreased as a result of natural decay; (3) covering the contamination os as to attenuate the radiation emitted. Radioactive material removed in process (1) must be disposed of by burial on land or at sea, or in other suitable ways.

Dose- A (total or accumulated) quantity of ionizing 9or nuclear) radiation. *The absorbed dose* in rads represents the amount of energy absorbed from the radiation per gram of specified absorbing material. In soft body tissue the absorbed dose in rads is essentially equal to the exposure in roentgens. The biological dose (also called the RBE dose) in rems is a measure of biological effectiveness of the absorbed radiation.

Dose Equivalent- In radiation protection associated with peacetime nuclear activities, the dose equivalent in rems is a measure of the biological effectiveness of absorbed ionizing radiation. It is similar to the biological dose, which is used in connection with the large radiation exposures that might accompany a nuclear explosion.

Dose Rate- As a general rule, the amount of ionizing (or nuclear) radiation which an individual or material would receive per unit of time. It is usually expressed as rads (or rems) per hour or in multiples or submultiples of these units, such as milliards per hour. The dose rate is commonly used to indicate the level of radioactivity in a contaminated area.

Electron- A particle of very small mass that carries a unit negative or positive charge. Negative electrons, surrounding the nucleus, (i.e., orbital electrons), are present in all atoms; there number is equal to the number of positive charges (or protons) in the particular nucleus. The term electron, where used alone, commonly refersto negative electrons. A positive electron is usually called a positron, and a negative electron is sometimes called a negatron.

Element- One of the distinct, basic varieties of matter occurring in nature which, individually or in combination, composed substances of all kinds. Approximately ninety different elements are known to exist in nature and several others, including plutonium, have been obtained as a result of nuclear reaction with these elements.

Exposure- A measure expressed in roentgens of the ionizing produced by gamma (or X) rays in air. The exposure rate is the exposure per unit time(e.g., roentgens per hour).

Fallout- The process of phenomenon of the decent to the earth's surface of particles contaminated with radioactive material from the radioactive cloud. The term is also applied in a collective sense to the contaminated particulate matter itself. The early (or local) fallout is defined, somewhat arbitrary, as those particles, which reach the earth within 24 hours after a nuclear explosion. The delayed (or worldwide) fallout consists of the smaller particles, which ascend into the upper troposphere and into the stratosphere and are carried by winds to all parts of the earth. The delayed fallout is brought to earth, mainly by rain and snow, over extended periods ranging from months to years

Fireball- The luminous sphere of hot gases which forms a few millionths of a second after a nuclear explosion as the result of the absorption by the surrounding medium of the thermal X rays emitted by the extremely hot (several tens of million degrees) weapon residues. The exterior of the fireball in air is initially sharply defined by the luminous shock front and later by the limits of the hot gases themselves.

Fission- The process whereby the nucleus of a particular heavy element splits into (generally) two nuclei of lighter elements, with the release of substantial amounts of energy. The most important fissionable material is uranium-235 and plutonium-239; fission is caused by the absorption of neutrons.

Fission Products- A general term for complex mixture of substances produced as a result of nuclear fission. A distinction should be made between these and the direct fission products, or fission fragments which, are formed by the actual splitting of the heavy-element nuclei. Something like 80 different fission fragments result from roughly 40 different modes of fission of a given nuclear species (e.g., uranium-235 of plutonium-239). The fission fragments, being radioactive, immediately begin to decay, forming additional (daughter) products, with the result that the complex mixture of fission products so formed contains over 300 different isotopes.

Fusion- The process whereby the nuclei of light elements, especially those of the isotopes of hydrogen, namely, deuterium and tritium, combine to form the nucleus of a heavier element with the released of substantial amounts of energy.

Gamma Rays- Electromagnetic radiations of high photon energy originating in atomic nuclei, and accompanying many nuclear reactions (e.g., fission, radioactivity, and neutron capture). Physically, gamma rays are identical with X rays of high energy, the only essential difference being that X rays do not originate from atomic nuclei, but are produced in other ways (e.g., by slowing down (fast) electrons of high energy).

Genetic Effect- The effect of various agents (including nuclear radiation) in producing changes (mutations) in the hereditary components (genes) of the germ cells present in the reproductive organs (gonads). A mutant gene causes changes in the nest generation, which may or may not be apparent.

Ground Zero- The point on the surface of land vertically below or above the center of a burst of a nuclear weapon; frequently abbreviated to GZ. For a burst over or under water the corresponding term is surface zero (SZ). Surface zero is also commonly used for ground surface and underground bursts.

Half-Life- The term required for the activity of a given radioactive species to decrease to half of its initial value due to the radioactive decay. The half-life is a characteristic property of each radioactive species and is independent of its amount or condition. The effective half-life of a given isotopes the time in which the quantity in the body (or an organ) will decrease to half as a result of both radioactive decay and biological elimination.

Half-Residence Time- As applied to delayed fallout, it is the time required for the amount of weapon debris deposited in a particular part of the atmosphere (e.g., stratosphere or troposphere) to decrease to half of its initial value.

Hot Spot- Region in a contaminated area in which the level of radioactive contamination is somewhat greater than in neighboring regions in the area.

Hydrogen Bomb- A term sometimes applied to nuclear weapons in which part of the explosive energy is obtained from nuclear fusion (or thermonuclear) reactions.

Implosion Weapon- A device in which a quantity of fissionable material, less than a critical mass, has its volume suddenly decreased by compression, so that it becomes supercritical and explosion can take place. The compression is achieved by means of a spherical arrangement of specially fabricated shapes of ordinary high explosive, which produce an inwardly directed implosion wave, the fissionable material being at the center of the sphere.

Induced Radioactivity- Radioactivity produced in a certain materials as a result of nuclear reactions, particularly the capture of neutrons, which are accompanied by the formation of unstable (radioactivity) nuclei. In a nuclear explosion, neutrons can induce radioactivity in the weapon materials, as well as in the surrounding (e.g., by interaction with nitrogen in the air and with sodium, manganese, aluminum, and silicon in soil and sea water).

Intensity- The amount or energy of any radiation incident upon (or flowing through) unit area, perpendicular to the radiation beam, in unit time. The intensity of thermal radiation is generally expressed in calories per square centimeter per second falling on a given surface at any specified instant. As applied to nuclear radiation, the term intensity is sometimes used, rather loosely, to express the exposure (or dose) rate at a given location.

Internal Radiation- Nuclear radiation (alpha and beta particles and gamma radiation) resulting from radioactive substances in the body. Important sources are iodine-131 in the thyroid gland, and strontium-90 and plutonium-239 in bone.

Ionization- The separation of a normally electrically neutral atom or molecule in to electrically charged components. The term is also employed to describe the degree of extent to which this separation occurs. In the sense used to the removal of an electron (negative charge) from the atom or molecule, either directly or indirectly, leaving a positively charged ion. The separated electron and ion are referred to as an ion pair.

Ionosphere - The region of the atmosphere, extending from roughly 40 to 250 miles altitude, in which where is an appreciable ionization. The presence of charged particles in this region profoundly affects the propagation of long-wavelength electromagnetic radiation.

Isotope - Forms of the same element having identical chemical properties but different in their atomic masses (due to different numbers of neutrons in their respective nuclei) and in their nuclear properties (e.g., radioactivity, fission, etc.). For example, hydrogen has three isotopes with masses of 1 (hydrogen), 2 (deuterium), and 3 (tritium) units, respectively. The first two of these are stable (non-radioactive), but the third (tritium) is a radioactive isotope. Both of the common isotopes of uranium, with masses of 235and 238 unit, respectively, are radioactive, emitting alpha particles, but their half-lives are different. Furthermore, uranium-235 is fissionable by neutrons of all energies, but uranium-238 will under go fission only with neutrons of high energy.

Kiloton Energy- Defined strictly as 10 to the 12 power calories (or 4.2X10 to the 19 power ergs). This is approximately the amount of energy that would be released by the explosion of 1 kiloton (1000 tons) of TNT.

Megaton Energy- Defined strictly as 10 to the 15 power calories (or 4.2X10 to the 22 ergs). This is approximately the amount of energy that would be released by the explosion of 1000 kilotons (1000000 tons) of TNT.

Neutron- A neutral particle (i.e., with no electrical charge) of approximately unit mass, present in all atomic nuclei, except those ordinary (light) hydrogen. Neutrons are required to initiate the fission process, and large numbers of neutrons are produced by both fission and fusion reactions in nuclear explosions.

Nuclear Radiation- Particulate and electromagnetic radiation emitted from atomic nuclei in various processes. The important nuclear from a weapons stand point, are alpha and beta particles, gamma rays, and neutrons. All nuclear radiations are ionizing radiations, but they are not nuclear radiations since they do not originate from atomic nuclei.

Nuclear Tests- Tests carried out to supply information required for the design and improvement of nuclear weapons and to study the phenomena and effects associated with nuclear explosions.

Nuclear Weapon- A general name given to any weapon in which the explosion results from the energy released by reactions involving atomic nuclei, either fission or fusion or both. Thus, the A-bomb and H-bomb are both nuclear weapons. It would be equally true to call them atomic weapons, since it is the energy of the atomic nuclei that is involved in each case.

Nucleus- The small, central, positively charged rgion of an atom, which carries essentially all the mass. Except for the nucleus of ordinary (light) hydrogen, which is a single proton, all atomic nuclei contain both protons and neutrons. The number of protons determines the total positive charge, or atomic number; this is the same for all the atomic nuclei of a given chemical element. The total number of neutrons and protons, called the mass number, is closely related to the mass (or weight) of the atom. The nuclei of isotopes of a given element contain the same number of protons, but different numbers of neutrons. They thus have the same atomic number, and so, are the same element, but they have different mass numbers (and masses). The nuclear properties (e.g., radioactivity, fission, neutron capture, etc.) of an isotope of a given element are determined by both the number of the neutrons and the number of protons.

Nuclide- An atomic species distinguished by the composite of its nucleus (i.e., by the number of protons and the number of neutrons). In isometric nuclides the nuclei have the same composition but are in different energy states.

Proton- A particle of mass (approximately) unit carrying a unit positive charge; it is identical physically with the nucleus of the ordinary (light) hydrogen atom. All atomic nuclei contain protons.

Rad- A unit of absorbed dose of radiation; is represents the absorption of 100 ergs of nuclear (or ionizing) radiation per gram of absorbing material, such as body tissue.

Radioactive Cloud- An All inclusive term for the cloud of hot gasses, smoke, dust and other particulate matter from the weapon itself and from the environment, which is carried aloft in conjunction what the rising fireball produced by the detonation of a nuclear weapon.

Radioactivity- The spontaneous emission of radiation, generally alpha, beta particles, often accompanied by gamma ray, from the nuclei of an unstable isotope. As a result of this emission the radioactive isotope of a different (daughter) element, which may or may not also be radioactive. Ultimately, as a result of one or more stages of radioactive decay, a stable or non-radioactive end product is formed.

Rainout- The removal of radioactive particles from a nuclear cloud by precipitation when this cloud is within a rain cloud.

RBE (Relative Biological Effect)- The ratio of the number of rads of gamma radiation of a certain energy which will produce a specified biological effect to the number of rads, of another radiation required to produce the same effect is the RBE of the latter radiation.

Rem- A unit of biological dose of radiation; the name is derived from the initial letters of the term "roentgen equivalent mammal". The number of rems of radiation is equal to the number of rads absorbed multiplied by the RBE of the given radiation (for a specified effect). The rem is also the unit of dose equivalent, which is equal to the product of the number of rads absorbed and the "quality factor" of the radiation.

Roentgen- A unit of exposure to gamma radiation. It is defined precisely as the quantity of gamma rays that will produce electrons (in ion pairs) with a total charge of 2.58X10 to the –4 power coulomb in 1 kilogram of dry air. An exposure of 1 roentgen results in the deposition of about 94 ergs of energy in 1 gram of body tissue. Hence, an exposure of 1 roentgen is approximately equivalent to an absorbed dose of 1 rad in soft tissue.

Scavenging - The selective removal of material from the radioactive cloud from a nuclear explosion by inert substances, such as earth or water, introduced into the fireball. The term is also applied to the process of removal of fallout particles from the atmosphere by precipitation.

Stratosphere - A relatively stable layer of he atmosphere between the tropopause and a height of about 30 miles in which temperature changes very little (in polar and temperate zones) or increases (in the tropics) with increasing altitude. In the stratosphere clouds of water never from and there is practically no convection.

Supercritical- A term used to describe the state of a given fission system when the quantity of fissionable material is greater than the critical mass under the existing condition. A highly supercritical system is essential for the production of energy at a very rapid rate so that an explosion may occur.

Surface Burst- The explosion of a nuclear weapon at the surface of the land or water as a height above the surface less than the radius of the fireball at a maximum luminosity (in the second thermal pulse). An explosion in which the weapon is detonated actually on the surface (or within 5 W to the 0.3 power, where W is the explosion yield in kilotons, above or below the surface) is called a contact surface burst or a true surface burst.

Syndrome, Radiation- The complex of symptoms characterizing the disease known as radiation injury, resulting from excessive exposure of the whole (or a large part) of the body to ionizing radiation. The earliest of these symptoms are nausea, vomiting, and diarrhea, which may be followed by loss of hair (epilation), hemorrhage, inflammation of the mouth and throat, and general loss of energy. In severe cases, where the radiation exposure has been relatively large, death may occur within 2 to 4 weeks. Those who survive 6 weeks after the receipt of a single dose of radiation may generally be expected to recover.

Tritium- A radioactive isotope of hydrogen, having a mass of 3 units; it is produced in nuclear reactors by the action of neutrons on lithium nuclei.

Tropopause- The imaginary boundary layer dividing the stratosphere from the lower part of the atmosphere, the troposphere. The tropopause normally occurs at an altitude of about 25,000 to 45,000 feet in polar and temperate zone, and at 55,000 feet in the tropics.

Troposphere - The region of the atmosphere, immediately above the earth's surface and up to the tropopause, in which the temperature falls fairly regularly with increasing altitude, clouds form, and convection is active, and mixing is continuous and more or less complete.

Washout - The removal of radioactive particles from a nuclear cloud by precipitation when this cloud is below a rain cloud.

Weapon Debris - The highly radioactive material, consisting of fission products, various products of neutron capture, and uranium and plutonium that have escaped the fission process.

Weapon Residue - The extremely hot, compressed gaseous residues formed at the instant of the explosion of a nuclear weapon. The temperature is several tens of millions degrees (Kelvin) and the pressure is many millions of atmospheres.

Yield- The total effective energy released in a nuclear explosion. It is usually expressed in terms of the equivalent tonnage of TNT required to produce the same energy release in an explosion. The total energy yield is manifested as nuclear radiation, thermal radiation, and shock energy, the actual distribution being dependent upon the medium in which the explosion occurs and also upon the type of weapon and the time after detonation.

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