APPENDIX D
HUMAN HEALTH

D.1 PUBLIC HEALTH CONSEQUENCES: PRIMER AND RECENT STUDIES NEAR LANL

In this appendix, supplemental information is presented on the effects on human health of radioactive and chemical exposures. The information is presented in two sections: that addressing our general knowledge and understanding (section D.1.1) and that presenting in more detail the findings of the recent studies of public health in the community of Los Alamos, and New Mexico and U.S. studies (including Native Americans in New Mexico, Hispanic white and nonhispanic white populations throughout the U.S. (section D.1.2). The presentation in section D.1.1 is useful to the reader as a primer on human health effects of exposures to radioactivity or to chemicals. The summaries presented in section D.1.2 are the results of descriptive epidemiology studies. That is, they are analyses of disease incidence rates and causes of death using statistical analytical methodologies.

Exposure to toxic chemicals is regulated by other agencies, and DOE subscribes to and applies those regulations without change to its own activities. The Occupational Safety and Health Administration (OSHA) promulgates and enforces regulations for the protection of workers, and EPA regulates exposures to the public. Chapter 7 provides a detailed review of the regulatory requirements for the operation of LANL.

D.1.1 Primer on Human Health Consequences of Radiological and Chemical Exposures

Table D.1.1–1 summarizes the differences in consequences between exposures to radioactive materials and exposures to chemicals. More detailed information on the modes of exposure and potential effects of these exposures are given in the sections below.

D.1.1.1 *About Radiation and Radioactivity*

In the simplest sense, radiation is defined as energy propagated through space (NBS 1952). This definition covers a broad range, including visible light, radio and television transmissions, microwaves, and emissions from atomic and nuclear reactions and interactions. The method by which radiation interacts with matter is by transferring its energy to the atoms of the matter. The amount of energy transferred determines the effect that it will have on matter. The broad spectrum of radiation can be subdivided into two groups, ionizing and nonionizing. Ionization occurs when the radiation transfers enough energy to strip one or more electrons from the interacting atom. When ionization takes place in the body, it can cause chemical and physical changes that are of concern to human health. Radiation that does not have enough energy to strip electrons is called “nonionizing” (discussed further in appendix D, section D.2.2.2).

Ionizing radiation is used in a variety of ways, many of which are familiar to us in our everyday lives. The machines used by doctors to diagnose and treat medical patients typically use x-rays, which is one form of ionizing radiation. The process by which a television displays a picture is by ionizing coatings on the inside of the screen with electrons. Most home smoke detectors use a small source of ionizing radiation to detect smoke particles in the room’s air.

TABLE D.1.1–1.—*Comparison of Consequences of Radioactivity and Toxic Chemicals*

	RADIOACTIVE MATERIALS	TOXIC CHEMICALS
Threshold for effects?	Assume no threshold (stochastic effects).	Yes, and different thresholds for different effects.
Accumulative effects?	Assumed exposures accumulate over a lifetime, with no repair.	Typically, the body repairs itself between exposures; may build sensitive allergic reaction or interact with cells.
Sensory perception?	We do not feel, smell, or otherwise sense ionizing radiation.	Very low concentrations not sensed. Often an annoying odor and irritating effects at low concentrations. Some gases are visible when in high concentrations.
Carcinogenic?	All ionizing radiation is regulated as carcinogenic.	Only some chemicals are confirmed human carcinogens. Some others are suspected, and some are animal (mammal, or closer to human, primate) carcinogens.
Effects-exposure relationship?	Usually treated as linear at low doses, although this is a conservative simplification (BEIR V 1990).	Typically nonlinear and nonadditive. Thresholds exist. For some chemicals, effects can be treated as linear with exposures, but only over small ranges. Synergisms among chemicals are not understood.
Acute effects?	Acute deterministic effects are soon observed, but occur only above a threshold of about 50 rem (less for the eye).	Effects may be immediately observed for levels of exposures above the thresholds.
Entry paths of particulates into the body?	Radionuclides enter through inhalation, ingestion, and wounds. A few are absorbed through the skin.	Same routes, except a greater percentage of chemicals than of radionuclides are absorbed through the skin.
Target organs?	The chemistry of the radionuclide determines its residence time and location in the body.	Same as for radionuclides. Except, the body also metabolizes chemicals, sometimes into more toxic chemicals.
Penetrating?	Alpha and beta radiation do not penetrate skin. In contrast, dense materials are needed to shield against gamma and x-ray radiation.	About 20% of OSHA-regulated chemicals have skin as an import route of entry. Only corrosive chemicals penetrate protective gear rapidly.

Ionizing radiation is generated through many mechanisms. The two most common mechanisms are the electrical acceleration of atomic particles such as electrons, as in x-ray machines, and the emission of energy from nuclear reactions in atoms. This second process is termed "radioactive decay." Atoms are made up of various combinations of particles called protons, neutrons, and electrons. In most cases, the numbers of neutrons and protons are balanced such that the atom will stay together forever. An atom formed with too many of either the neutrons or protons will attempt to change itself into a more stable form. To do this, the atom will emit an atomic particle, such as an electron, normally called a beta particle, or a "packet" of energy called a photon. This is the process of radioactive decay. The time that it takes for the atom to decay is characterized by a value called the half-life. This is the time it takes for a quantity of radioactive material to decay to one-half its original amount. In general, radioactive materials are identified by their half-lives and the type and energy of their emissions. In some cases, atoms may emit a highly energetic, ionized, helium atom, called an alpha particle. The energy carried away by these emissions is normally capable of creating a large number of ionizations in matter.

Besides ionization, other particles can often be emitted during interactions between radiation and matter, depending upon the type and energy of the interaction. Neutrons, protons, and some other more exotic particles are often emitted during various processes. Nuclear reactors use neutrons to break apart, or fission, particular isotopes of uranium and plutonium in order to release heat and more neutrons to continue the reaction. Large machines, often called "atom smashers," cause atoms at high energies to collide and break apart, releasing particles in order to study their nuclear structure. However, due to the design and operation of these types of facilities, it would be highly unlikely for these types of radiations to reach the public outside the boundaries of the facility.

When an individual is in the presence of an unshielded radiation source, this is referred to as being exposed. The amount of ionizing radiation that the individual receives during the exposure is referred to as dose. The measurement of radiation dose is called radiation dosimetry, and is done by a variety of methods depending upon the characteristics of the incident radiation. The units of measure for radiation doses are normally rads and rem. (Note that the term millirem [mrem] is also used often. A millirem is one one-thousandth of a rem.) The rad is a measure of the energy deposited in the body by the radiation, regardless of the type of emission. The rem is a measure of the biological effect, by including the effectiveness of the particular type and energy of the incident radiation for causing biological effects. This is due to the fact that some heavier or higher energy radiations, such as alpha particles or neutrons, can deposit their energy into much smaller volumes, and consequently, cause more intense damage through localized, chemical changes.

When an individual is exposed to an unshielded radiation source, this is called external radiation. If radioactive material is incorporated into the body and consequently decays, it is called internal radiation. The external radiation is measured as a value called the deep dose equivalent (DDE). Internal radiation is measured in terms of the committed effective dose equivalent (CEDE). More information about the CEDE is presented in the discussion about the processes by which radioactive material enters the body. The sum of the two contributions (DDE and CEDE) provides the total dose to the individual, called the total effective dose equivalent (TEDE). Often the radiation dose to a selected group or population is of interest, and is referred to as the collective dose equivalent, with the measurement units of person-rem.

D.1.1.2 *About Radiation and the Human Body*

Ionizing radiation affects the body through two basic mechanisms. The ionization of atoms can generate chemical changes in body fluids and cellular material. Also, in some cases the amount of energy transferred can be sufficient to actually knock an atom out of its chemical bonds, again resulting in chemical changes. These chemical changes can lead to alteration or disruption of the normal function of the affected area. At low levels of exposure, such as the levels experienced in occupational or environmental settings, these chemical changes are very small and ineffective. The body has a wide variety of mechanisms that repair the damage induced. However, occasionally, these changes can cause irreparable damage that could ultimately lead to initiation of a cancer, or changes to genetic material that could be passed to the next generation. The probability for the occurrence of health effects of this nature depends upon the type and amount of radiation received, and the sensitivity of the part of the body receiving the dose.

At much higher levels of exposure, at least 10 to 20 times higher than the legal limits for occupational exposures, the body is unable to recover from the large amount of chemical changes occurring during the exposure. At these levels, damage is much more immediate, direct, and observable. Health effects range from reversible changes in the blood to vomiting, loss of hair, temporary or permanent sterility, and other changes leading ultimately to death at exposures above about 100 times the regulatory limits. In these cases, the severity of the health effect is dependent upon the amount and type of radiation received. Exposures to radiation at these levels are quite rare, and, outside of intentional medical procedures for cancer therapy, are always due to accidental circumstances.

For low levels of radiation exposure, the probabilities for induction of various cancers or genetic effects have been extensively studied by both national and international expert groups. The problem is that the potential for health effects at low levels is extremely difficult to determine without extremely large, well-characterized exposed populations. Therefore, only particular groups with fairly high exposures, such as atomic bomb survivors, radiation accident victims, and some groups receiving large medical exposures, can be studied to evaluate the probabilities. Unfortunately, the levels and rates of exposures, and the conditions under which they occurred, are very different from those in which the normal population is exposed to background radiation or to normal operational releases from nuclear operations. Therefore, expert groups must make significant approximations and assumptions in order to apply the study results to the lower levels of exposure. This is done in a manner that attempts to ensure that the resulting risk factors are conservative estimates of the actual probabilities. In other words, it is unlikely that the actual risks are greater than the estimates, while it is fairly likely that the actual risk is smaller than the estimate.

There is another type of study, referred to as an epidemiology study, that attempts to estimate the risk factors in populations with much lower doses than mentioned above. These studies are even more difficult to perform. There are two types of epidemiology studies: descriptive (based on statistical analyses of death and disease incidences) and analytical (case studies and observational analysis within a community or work force). The studies summarized in chapter 4, section 4.6.1.2, and appendix D, section D.1.2, are descriptive. The risk factors for radiation-induced cancer at low levels of exposure are very small, and it is extremely important to account for the many nonradiation related mechanisms for cancer induction, such as smoking, diet, lifestyle, and chemical exposures. These multiple factors also make it difficult to establish cause-and-effect relationships that could attribute high or low cancer rates to specific initiators. As a consequence, the results of such studies have not been generally accepted within the scientific community and are not currently used as the primary basis for establishing the risk factors.

Risk factors are estimated for a large number of fatal and nonfatal cancers, for hereditary effects, and a few other identified radiation-induced health effects. Table D.1.1.2–1 lists the fatal cancer risk factors used in this SWEIS, which are based upon the recommendations of a recognized authoritative international expert group, the International Commission on Radiological Protection (ICRP). The other, smaller risk factor in the table for nonfatal cancer and hereditary effects may be similarly applied by interested readers.

In keeping with the previous discussion of the difficulties in determining the risk factors used in this document, it is worthwhile to discuss the level of confidence that is associated with those factors. The ICRP, in the recommendation that established the risk factors used here, stated that, "The nominal values of fatal cancer risk, which form the basis of the detriment following radiation exposure, are not to be regarded as precise and immutable. They are, unfortunately, at this time still subject to many uncertainties and to many assumptions involving factors which may be subject to change. ...It is hoped, and indeed expected, that these uncertainties will diminish in the future as the accumulated experience in exposed populations such as the Japanese survivors increases and as more information develops from a broader variety of human experiences" (ICRP 1991). The Committee on the Biological Effects of Ionizing Radiations (BEIR), which developed the risk factors that the ICRP recommends, also discussed the uncertainty of the factors: "Finally, it must be recognized that derivation of risk estimates for low doses and dose rates through the use of any type of model involves assumptions that remain to be validated. ...Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the millisievert (1 millisievert = 100 millirem) dose range. Thus the background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero" (BEIR V 1990).

Given these concerns, the reader should recognize that these risk factors are intended to provide a conservative estimate of the potential impacts to be used in the decision-making process, and are not necessarily an accurate representation of actual anticipated fatalities. In other words, one could expect that the stated

TABLE D.1.1.2–1.—*Risk Factors for Cancer Induction and Heritable Genetic Effects from Exposure to Ionizing Radiation*

EXPOSED POPULATION[a]	FATAL CANCER[b]	NONFATAL CANCER	HEREDITARY EFFECTS (SEVERE)[d]	TOTAL DETRIMENT
Adult Workers	0.0004[c]	0.00008	0.00008	0.00056
Whole Population	0.0005[c]	0.0001	0.00013	0.00073

[a] The distinction between the worker risk and the general public risk is attributable to the fact that sensitivities vary with age, general health, and other factors that contribute more to the general population than to the worker population.

[b] When applied to an individual, units are lifetime probability of excess cancer fatalities per rem of radiation dose. When applied to a population of individuals, units are excess numbers of fatal cancers per person-rem of radiation dose.

c This is the source of the 4 x 10^{-4} worker and 5 x 10^{-4} public risk factors used in this SWEIS.

[d] Heritable genetic effects as used here apply to populations, not individuals. For the other columns, the units would change accordingly, in terms of number of effects per unit dose.

Source: ICRP 1991

impacts from an activity or accident form an envelope around the situation, and that actual consequences could be less, but probably would not be worse.

When considering the risks from exposure to ionizing radiation, it is important to remember that we are always being exposed to the radiation in the environment around us. Natural background radiation is the collective term for all of the sources that occur naturally, such as cosmic radiation and naturally occurring radioactive materials, such as potassium, uranium, thorium, radium, and others. These sources contribute an average of 0.3 rem per year to each individual. Manufactured radiation sources contribute another 0.06 rem per year on the average, with the majority coming from medical procedures. Fallout from the atmospheric testing of nuclear weapons currently contributes less than 0.001 rem per year to our doses (NCRP 1987).

D.1.1.3 *About Radioactive Material Within the Body*

Typically, radioactive material that is released into the environment is in the form of very fine particulates, gases, or liquids. That is usually because these forms are the hardest to contain in a facility. This material is easily carried into and spread around the air, soil, and water. As these materials move through the environment, it is possible for them to be taken into the body, through breathing, eating, or drinking. During normal operations of a facility, every effort is made to minimize these releases to levels well below natural background. During accidents, it is possible that higher levels may be released; but, the facilities are designed and operated to control these releases as much as possible.

Radioactive material normally enters the body through one of three mechanisms. When the material is in the air, it is inhaled into the lungs, where a fraction will be trapped, depending upon the size of the particles. When it is ingested by eating or drinking, or by clearing of the respiratory tract, it passes through the stomach and into the gastrointestinal tract. Under the right conditions, it can also be absorbed through the skin or enter through open wounds.

Once in the body, the fate of the material is determined by its chemical behavior. Some material will be dissolved into bodily fluids and transferred into various organs of the body. Remaining material may either be retained at its point of entry, such as in the lungs, or pass through the body rapidly, as in the gastrointestinal tract. The effect of material in the body is characterized by the type of radiation it delivers and the organs in which it tends to collect. The rate at which the material is removed from the body is represented by a value called effective biological half-life (the time it takes for the activity in the body to be reduced to one-half as a consequence of radioactive decay and biological turnover of the radionuclide).

When radioactive material is in the body, it irradiates the living tissue around it. Some radiation types, like beta and alpha particles, are much more effective at causing changes when inside the body than when outside. This is because these types of radiation cannot effectively penetrate the dead layer of the skin from an external source. As mentioned above, the radiation dose from material inside the body is called the CEDE. Remember that the dose from an external source stops when you walk away or are shielded from it. But you cannot walk away from an internal source. Therefore, the CEDE is designed to determine the risk commitment from the intake. It is the dose that will be received over the next 50 years from the material in the body. Because of the assumptions that doses are cumulative and their effects are not repaired, this means that the lifetime risk from an internal source in rem CEDE can be directly compared to the risk from an external source in rem DDE.

D.1.1.4 *About the Material of Interest at LANL*

LANL has a large involvement in nuclear science and applications. Therefore, there are many types of radioactive material and radiation sources in use. However, many of the uses require only very small amounts of material. Note that all radioactive materials are considered in this SWEIS; but, there are three types that tend to dominate the human health effects and DOE accident scenarios. This is due to either their particular radioactive and biological characteristics, the quantities of material being used, or the potential for dispersion in an accident. These materials are plutonium, uranium, and tritium.

Plutonium is a man-made element that has several applications in weapons, nuclear reactors, and space exploration. There are several types of plutonium atoms, called isotopes, which are distinguished by the different numbers of neutrons in their nucleus. (Note that isotopes of a particular atom all behave the same chemically.) In most cases, the isotopes of plutonium of interest here decay by alpha particle emission with radioactive half-lives ranging from tens to thousands of years. There is nothing unique about plutonium as a health risk compared to other radioactive materials. It is only that once incorporated into the body, it tends to stay for a very long time and deposits a lot of localized energy due to its alpha particles.

Uranium is a naturally occurring radioactive element. The discovery that an atom of uranium could be fissioned with neutrons was the starting point of the Nuclear Age. Uranium-235 is one of several fissile materials that fission with the release of energy.

Various applications require the use of different isotopes of uranium. Because isotopes cannot be chemically separated, processes have been developed to enrich uranium to various isotopic ratios. Enriched uranium is uranium that is enhanced in the isotope uranium-235 above its natural ratio of 0.72 percent. Highly enriched uranium (HEU) is where the uranium-235 content is 20 percent or greater. Depleted uranium (DU) is where the content of uranium-235 is below its natural value. Obviously, natural uranium is where the material is in its natural isotopic ratios.

Most uranium isotopes of interest here have very long half-lives and are alpha emitters. Their half-lives are much longer than the plutonium isotopes, and as a result uranium is generally of lower radiological concern than plutonium. However, its actual radiological concern varies with its enrichment. As a heavy metal, uranium also can be chemically toxic to the kidneys. Depending upon the enrichment and chemical form, either chemical or radiological considerations will dominate.

Tritium is a radioactive isotope of hydrogen. It is generated at low levels in the environment by interactions of cosmic radiation with the upper atmosphere, but for practical applications it is normally produced in a nuclear reactor. Tritium has a half-life of around 12 years and decays by emitting a low energy beta particle. Because tritium is an isotope of hydrogen, it can be incorporated into the water molecule, forming tritiated water. In the environment, tritium is most often found either in its elementary form as a gas, or as water. Tritiated water is a significant concern to the human body because the body is composed mostly of water. This actually is a mixed blessing. Tritiated water will easily and rapidly enter the body and irradiate it rather uniformly; however, it also is removed from the body rather quickly, being easily displaced with regular water and with a biological half-life of about 12 days under normal conditions.

D.1.1.5 *How DOE Regulates Radiation and Radioactive Material*

Radiation doses to workers and the public and the release of radioactive materials are regulated by DOE for its contractor facilities. Under the conditions of the *Atomic Energy Act* (as amended by the *Price-Anderson Amendments Act of 1988)*, DOE is authorized to establish federal rules controlling radiological activities at DOE sites. The act also authorizes DOE to impose civil and criminal penalties for violations of these requirements. Some activities are also regulated through a DOE Directives System that uses contractual means to regulate the contractor activities.

Occupational radiation protection is regulated by the *Occupational Radiation Protection Rule*, Title 10 of the Code of Federal Regulations, Part 835 (10 CFR 835). Environmental radiation protection is currently regulated contractually with DOE Order 5400.5, which is in the process of being converted to a rule. There is a process by which these regulations are developed. The EPA, working with other agencies such as DOE and the NRC, develops a federal guidance document that is signed by the President (52 *Federal Register* [FR] 2822–2834). This document is based upon the recommendations of the National Council on Radiation Protection and Measurements (NCRP), and considers recommendations of international expert groups such as the ICRP. This federal guidance then becomes the basis for all federal regulations for radiation protection, including DOE's and also U.S. Nuclear Regulatory Commission (NRC) rules. This process ensures a common, scientifically based approach to all radiation protection in the U.S.

D.1.1.6 *About Chemicals and Human Health*

The characteristics and consequences of exposures to chemicals are quite different from those of exposure to ionizing radiation. Table D.1.1–1 summarizes the differences.

For noncarcinogens, there are threshold concentrations that must be exceeded for observable adverse effects to happen; whereas, for ionizing radiation it is assumed that the integrated (accumulated) exposure determines the likelihood of observable effects.

The threshold values for effects from toxic chemicals vary somewhat among individuals, but values can be determined that represent most of the more vulnerable people among the general population. The several different effects from a chemical each have different thresholds. For instance, there may be different concentrations that produce odor, irritation, effects that last only a short time, permanent effects, and death. Older and ill people, and those with a particular sensitivity such as respiratory problems, are more vulnerable and will have lower thresholds for effects.

Using human inhalation of chlorine in illustration, 0.2 to 0.4 parts per million (parts of chlorine per million parts of air) is the odor threshold; 1 to 3 parts per million for periods less than an hour produce burning eyes, scratchy or irritated throat, and headache; 15 parts per million is the lowest concentration observed to cause respiratory distress; no deaths were observed in any animals exposed to 50 parts per million for 30 minutes; and 210 parts per million has been estimated to be the 30-minute LC50 for humans, although 50 parts per million might cause death in some vulnerable individuals. (The 30-minute LC50 is defined as the concentration that produces 50 percent fatalities among individuals exposed for 30 minutes.)

The ability to resist a potential effect and to recover from that effect clearly depends upon a person's health and age. For the population of workers, presumed to have few individuals who are especially vulnerable, regulatory agencies set permissible exposure limits and average concentrations for the 8-hour and 10-hour work day. Lower values than these would be appropriate to public exposures; whereas, higher values are deemed acceptable for military personnel under military exigencies.

Again using inhalation of chlorine gas in illustration, the OSHA permissible exposure limit is a time-weighted average (TWA) over the 8-hour work day of 0.5 parts per million[1]. There also is an OSHA short-term exposure limit of a 1-part-per-million 15-minute TWA that should not be exceeded at any time during the work day. The immediately dangerous to life and health (IDLH) value is 30 parts per million; this is the concentration from which a worker could escape within 30 minutes without a respirator and without escape-impairing or irreversible effects.

This SWEIS analysis uses the TWA as a convenient measure for screening the chemical inventory at LANL, and then uses Emergency Response Planning Guidelines (ERPGs) or their surrogate Temporary Emergency Exposure Limits (TEELs) for bounding the consequences to persons exposed to a release to the atmosphere. ERPGs are provided by the American Industrial Hygiene Association (AIHA) for planning for emergencies, rather than for determining consequences. ERPG–1, ERPG–2, and ERPG–3 are defined and described in detail in appendix G, Accident Analysis. They are intended to provide protection for most members of the public, and so their exposure time (up to one hour) and their concentrations are directly related to effects (no safety factor of ten was applied).

1. The definition of the TWA is the sum of all the instantaneous air concentrations over the 8 hours, averaged by dividing by the 8 hours.

Again using chlorine in illustration, the ERPG–2 is 3 parts per million, the concentration at which nearly all individuals could be exposed without irreversible or other serious health effects or impairment of ability to take protective actions. The ERPG–3 is 20 parts per million, below which nearly all individuals could be exposed without life-threatening effects.

Only for some chemicals and only for a limited extent, effects are directly related to the product of the concentration and length of exposure ("Haber's Law"). Chlorine is not such a chemical. When attempting to apply an existing guideline to a different exposure period than for which the guideline applies, toxicologists must be consulted, and they will consider actual effects data.

D.1.1.7 *How Toxic Chemicals Affect the Body*

Some toxic chemicals can have direct effects upon the eyes and the skin through contact and can enter the body by absorption through the skin. These are considered in the derivation of guides and limits for airborne concentration. Toxic chemicals also can enter the body via ingestion (eating and drinking). All the LANL accidents considered in the SWEIS that pose significant risk to the public produce their exposure through airborne releases, and so airborne concentrations guides and limits are used in the screening and consequence analyses.

After intake, the chemical may follow primarily one or more routes within the body, involving the respiratory system and digestive system, the blood circulatory system, and the urinary tract. The route and residence time before excretion is strongly determined by the chemical's solubility, and if particulate, by its particle size. The chemical may be metabolized, usually in the liver, into other chemicals that are either more or less toxic. For carcinogens, the principal target organs (i.e., where the effects primarily occur) are the respiratory tract, urinary bladder, and to a lesser extent the bone marrow, gastrointestinal tract, and liver.

D.1.1.8 *About Chemical Carcinogens*

Some chemicals are regulated as carcinogens because they or their metabolites may cause cancer. There are limited data on chemical carcinogens for humans, and there are problems with applying the results of animal studies to humans. Therefore, these chemicals are classified as known human carcinogens, potential or suspected carcinogens, and chemicals that cause cancer in animals. Exposure to chemical carcinogens is treated in the same manner as cumulative exposure to ionizing radiation; that is, exposures are assumed to be additive in producing cancer.

Some chemicals are carcinogenic at concentrations that do not produce observable effects from acute (short-term) exposures. For these, the airborne exposure limits and guidelines are based on their carcinogenicity. Some chemicals may produce an irreversible change to cells (tumor initiation), which then may be submitted to chemicals that are promoters of cancer. Such promoters must be given repeatedly to be effective. For this reason, chemical carcinogens are regarded as additive to one another, and individual chemicals are regulated at 1/100 of the exposure level regarded as hazardous, perhaps to account for the conservative possibility of having 100 such chemicals in one's environment.

The carcinogenic effects of certain chemicals are similar to those of ionizing radiation and have been noted in virtually every organ, depending on the chemical, the species, and conditions of exposure. The cancers induced by chemicals and by ionizing radiation cannot be distinguished from cancers induced by other causes. Therefore, the effects of chemicals and ionizing radiation are inferred only on a statistical basis, and must inferred from exposures at higher doses and dose rates. The choice of model has a large influence on the estimated excess cancer risk. The extrapolation is made by assuming an uncertain and controversial no-threshold, linear mathematical relationship between dose and resultant effects. This model is usually thought likely to overestimate the risk at low doses, and so is often said to estimate the "upper limit" of risk (NCRP 1989).

Chemicals vary widely in their capacity to induce cancer. There are even fewer data on the carcinogenic effects for chemicals than for radiation. With most chemicals, assessment of risks for humans must be based on extrapolation from laboratory animals or other experimental systems. Hence, the risk assessment for chemicals has even more uncertainty than risk assessment for ionizing radiation (NCRP 1989). Ultimately, the desired certainty in risk assessment at low-level exposures to chemicals and radiation will require better understanding of their effects at all stages of carcinogenesis.

The EPA, in setting standards for compliance with the *Clean Air Act*, is required by judicial decision and the *Clean Air Act* to determine a "safe" level with an "ample margin of safety to protect public health" without consideration as to cost or technology feasibility (Bork 1987). After that level is determined, costs and feasibility can be considered in setting the standard. Although this decision applied specifically to vinyl chloride and the *Clean Air Act*, it aids in understanding the EPA challenge faced in determining what is "safe," "adequate," or "acceptable" when setting standards for protection of workers, public, and environment. In the attempt to provide an objective context for evaluating the risks posed by LANL operations, the SWEIS authors have searched for authoritative statement on acceptable risk levels. A few such statements and inferences can be found in ICRP, NCRP, EPA, and OSHA documents.

EPA regulations provide goals for environmental remediation (cleanup). The EPA goals "for acceptable exposure levels to known or suspected carcinogens are generally concentration levels that represent an excess upper bound lifetime cancer risk between 10^{-4} and 10^{-6}. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals" when existing and relevant requirements are not available or sufficiently protective because there are multiple contaminants or pathways. When the combined risk from multiple contaminants exceed 10^{-4}, then factors such as detection limits and uncertainties may be considered in determining the cleanup level to be attained (40 CFR 300.430). Note that this is the lifetime risk to an undetermined public population group.

OSHA (OSHA 1997) expressed that its proposed worker permissible exposure limit for methylene chloride of 25 parts per million (average for 8 hours per day) would entail an employment lifetime risk of 3.62×10^{-3}, and that this was "clearly well above any plausible upper boundary of the significant risk range defined by the Supreme Court and used by OSHA in its prior rulemaking." OSHA noted that typical lifetime occupational risk for all manufacturing industries is 1.98×10^{-3}, and that the risk in occupations of relatively low risk, like retail trade, is 8.2×10^{-4}. Note that worker risk is generally accepted at a higher level than public dose because it is an accepted risk of employment. This is compatible with the EPA upper bound lifetime public cancer risk of between 10^{-4} and 10^{-6}.

D.1.1.9 *Radionuclides and Chemicals of Interest at LANL*

Radionuclides of interest at LANL are discussed with their respective emission facilities in appendix B, section B.1. Chemicals of interest are presented in appendix B, section B.2. LANL has used, uses, and will use a wide variety of chemicals because of its research mission. LANL has a chemical database that tracks the quantity and location of chemicals on site. About 51 of the chemicals tracked in the database are carcinogenic. A large number of the chemicals tracked in the database are toxic; that is, they are able to produce harm to humans. The analysis of the consequences to the public from chemical emissions under normal operations of LANL is provided in chapter 5, sections 5.2.4 and 5.2.6. Methodology is provided in section 5.1.4 and 5.1.6. Those of risk to the public, should they be accidentally released to the atmosphere, were determined by screening the entire database. Details on the accidental release screening and its results are presented in appendix G, Accident Analysis.

D.1.2 Supplemental Information on Public Health: U.S., New Mexico, and the Local LANL Community

The information presented below is supplemental to the information presented in chapter 4, section 4.6. It is presented to provide the context of the human health analysis provided in chapter 5, which estimates potential consequence to public health.

The population of Los Alamos County has grown primarily by immigration. The average annual fertility rate has remained at approximately 48/1,000 women across all races (DOC 1990 and Athas and Key 1993), which would produce annual growth of only 2.4 percent if there were no deaths. However, the growth rate has been approximately 25 percent between 1950 and 1960, more than 16 percent between 1960 and 1970 as well as between 1970 and 1980, and approximately 3 percent between 1980 and 1990.

Several studies have been conducted in the community due to concerns expressed within the community concerning the rates of some cancers. While these are summarized in section

4.6 of the SWEIS, additional information is presented here in order to meet the request of many during the scoping meetings for presentation of these results in the SWEIS.

These studies are largely descriptive; that is, they use statistical analyses to identify patterns of disease or death in a community. The thyroid cancer study (Athas 1996) reported below is a mixture of descriptive and analytical approaches (based on case studies and observational analyses). All epidemiological studies are subject to limitations in attempting to determine cause and effect relationships. Some of these limitations are:

- Small population sizes in the community to be studied
- Relatively few total numbers of cases of the specific disease or cancer to be studied
- High mobility in the population to be studied (if a large portion of the community has been in the community for shorter periods of time than that necessary to detect chronic disease, results are inconclusive)
- Disease etiology—one may have received the causative exposure decades before its diagnosis; households in the U.S. move on average every 3 years; in Los Alamos County in 1980, 45 percent of residents had been in the same home for 5 years; earlier census data showed lesser periods of time in the same residence
- Comparability—for instance, the makeup of Los Alamos County is quite dissimilar from its surrounding counties in ethnic distribution and in socioeconomic and occupational conditions
- Natural variability in disease incidence within the human population from any and all sources
- Increased technology efficiency used in disease detection, therefore, causing apparent increases in rates of incidence of the better-detected disease
- More than one causal agent suspected or known to cause the disease being studied, including lifestyle choices such as smoking and dietary patterns
- Disease cause from multiple sources in the same community
- Methodology limitations such as multiple comparison across differing time periods, across studies made for different purposes, consideration of all combinations across the study time frame, etc.

D.1.2.1 *Public Health: United States*

Heart disease remains the leading cause of death in the U.S. (Table D.1.2.1–1). There has been a significant decrease in mortality in the U.S. attributable to heart disease and cerebrovascular disease over the last 20 years. Cancer remains the second leading cause of death.

Table D.1.2.1–2 identifies the lifetime risk of dying from cancer for men and women by cancer type. Over all cancer types, the lifetime risk of dying from cancer is approximately 24 percent for men and 21 percent for women.

TABLE D.1.2.1–1.—*Leading Causes of Death in U.S.: Percent of All Causes of Death (1973 Versus 1993)*

CAUSE OF DEATH	PERCENT OF ALL CAUSES (1973)	PERCENT OF ALL CAUSES (1993)
Heart Disease	38.4	32.8
Cerebrovascular	10.9	6.6
Cancer	17.1	23.4
Pneumonia and Influenza	3.2	3.7
Chronic Lung Disease	1.5	1.2
Accidents	5.9	4.0
All Other Causes	22.5	28.4

Source: Ries et al. 1996

TABLE D.1.2.1–2.—*Lifetime Risk (Expressed as Percent) of Dying from Cancer: SEER[a] Areas (1973 Through 1993), All Races*

TYPE OF CANCER	MEN	WOMEN
All Types	23.77	20.66
Oral and Pharynx	0.45	0.24
Esophagus	0.65	0.23
Stomach	0.81	0.53
Colon and Rectum	2.54	2.54
Liver and Bile Duct	0.52	0.33
Pancreas	1.11	1.21
Larynx	0.25	0.07
Lung and Bronchus	7.11	4.35
Melanomas of Skin	0.31	0.20
Breast	0.03	3.54
Cervix Uteri	—	0.27
Corpus and Uterus	—	0.53
Ovary	—	1.12
Prostate	3.62	—
Testis	0.02	—
Urinary Bladder	0.69	0.34
Kidney and Renal Pelvis	0.49	0.33
Brain and Other Nervous	0.51	0.41
Thyroid	0.04	0.07
Hodgkin's Disease	0.06	0.05
Non-Hodgkin's Lymphoma	0.90	0.85
Multiple Myeloma	0.47	0.43
Leukemias	0.93	0.74

[a] SEER is the NIH/NCI Surveillance, Epidemiology, and End Results Program.
Source: Ries et al. 1996

Cancer incidence and mortality trends have changed over the last 20 years (Table D.1.2.1–3). Melanoma of the skin, for example, has increased in both incidence and mortality rate, as has brain and other nervous system cancers. Leukemia incidence and mortality rates have decreased.

D.1.2.2 *Comparison of Cancer Mortalities Between the U.S. and New Mexico*

A comparison of cancer mortality rates between the U.S. as a whole and New Mexico is given in Table D.1.2.2–1. These comparisons were made for 1989 through 1993 based on the National Institute of Health/National Cancer Institute (NIH/NCI) Surveillance, Epidemiology, and End Results (SEER) Program (Ries et al. 1996). For most cancers, differences were insignificant.

However, New Mexico had significantly higher mortality from thyroid cancer. (The reader is referred also to Athas 1996 for the local Los Alamos County study of thyroid cancer presented below.) New Mexico deaths due to thyroid cancers ranked 4th among the states. Thyroid cancers are associated with some types of radiological processes and research applications, principally those that could result in emitted radio-iodine. LANL has historically not used more than research amounts of radio-iodine. Radio-iodine emissions from LANL have been measured and have continually been very low (chapter 4, section 4.4 and the tables of emissions estimated for key LANL facilities, in chapter 3, section 3.6 discuss this further).

New Mexico had statistically lower rates of cancer mortalities for several cancers (Table D.1.2.2–1) relevant to the Los Alamos cancer studies, specifically, brain and other nervous system cancers and breast cancer.

TABLE D.1.2.1–3.—*Trends in Cancer Incidence and Mortality for Selected Cancers (1973 Through 1993), All Races, Both Sexes*

DECREASING INCIDENCE; DECREASING MORTALITY	INCREASING INCIDENCE; DECREASING MORTALITY	INCREASING INCIDENCE; INCREASING MORTALITY
Oral Cavity and Pharynx	Ovary	Total Cancers
Stomach	Testis	Esophagus
Colon and Rectum	Urinary Bladder	Liver and Bile Duct
Pancreas	Thyroid	Lung and Bronchus
Larynx		Melanoma of Skin
Cervix Uteri		Breast
Corpus and Uterus		Prostate
Hodgkin’s Disease		Kidney and Renal Pelvis
Leukemia		Brain and Other Nervous
		Non-Hodgkin’s Lymphoma
		Multiple Myeloma

Source: Ries et al. 1996

TABLE D.1.2.2–1.—*Comparison of Cancer Mortality Rates for the United States and New Mexico (1989 Through 1993), All Races, Both Sexes (Rate per 100,000 Population, Age Adjusted to 1970 U.S. Standard Population)*

TYPE OF CANCER	U.S. RATE	NEW MEXICO RATE	RANKING (AMONG STATES)	COMPARISON U.S. VS. NEW MEXICO
Breast	26.8	23.4	49th	NM < U.S.
Colon and Rectum	18.4	14.2	50th	NM < U.S.
Esophagus	3.5	2.4	49th	NM < U.S.
Hodgkin's Disease	0.6	0.6	25th	NSD
Larynx	1.4	1.2	34th	NSD
Leukemia	6.4	6.1	40th	NSD
Liver and Bile Duct	3.0	3.2	15th	NSD
Lung and Bronchus	49.9	35.0	49th	NM < U.S.
Melanomas of Skin	2.2	2.1	49th	NSD
Non-Hodgkin's Lymphoma	6.4	5.6	46th	NSD
Brain and Nervous	4.2	3.5	48th	NM < U.S.
Stomach	4.6	5.0	12th	NSD
Testis	0.3	0.2	43rd	NM < U.S.
Urinary Bladder	3.3	2.7	47th	NM < U.S.
Oral/Pharynx	2.9	2.6	32nd	NSD
Pancreas	8.4	8.1	40th	NSD
Thyroid	0.3	0.4	4th	NM > U.S.
Prostate	26.4	23.2	49th	NM < U.S.
Ovary	7.8	6.7	47th	NSD
Kidney and Renal Pelvis	3.5	3.4	36th	NSD
Multiple Myeloma	3.0	3.0	30th	NSD
Corpus and Uterus	3.4	3.0	43rd	NSD
Cervix Uteri	2.9	2.7	33rd	NSD

Sources: SEER Database and Ries et al. 1996
NSD = No significant difference

D.1.2.3 *Cancer Incidence and Mortality Among Ethnic Groups Relevant to the LANL Area*

While the Native American population within Los Alamos County remains less than 3 percent (DOC 1990), the populations down gradient (with respect to air emissions and water flow) in the adjacent Santa Fe County Area are dominantly Native American (San Ildefonso Pueblo).

Table D.1.2.3–1 summarizes the findings regarding the top five cancers (both incidence and mortality) among nonhispanic whites (U.S.), Hispanic whites (U.S.), and Native Americans (New Mexico). The Native American cancer incidence and cancer mortality rates are lower than either of the other examined populations for both men and women. This is the case for all cancer types, not just the top five cancers with respect to incidence and mortality rate.

Among men, lung and prostate cancer dominate incidence and mortality. Among women, breast and lung cancer dominate cancer incidence and mortality. A fairly rare cancer, gall bladder, is the leading cause of cancer mortality among New Mexican Native American women. However, because there were so few cases, and the uncertainty level thus associated with the observation is so high, it is inappropriate to draw conclusions even regarding gall bladder cancer incidence in this population of women.

D.1.2.4 *Supplemental Information on Recent Studies of Los Alamos County Cancer*

Objectives

The primary objective of the study was to review Los Alamos County incidence rates for brain and nervous system cancer and other major cancers during the 21-year time period 1970 to 1990 (Athas and Key 1993). Secondary objectives were to review mortality rate data for select cancers of concern and to review Los Alamos County mortality data relating to benign brain and nervous system tumors.

Specific aims developed for incidence study were as follows:

- To calculate age-adjusted cancer incidence rates for Los Alamos County and a New Mexico state reference population using data of the New Mexico Tumor Registry (NMTR)
- To compare Los Alamos County cancer incidence rates to (1) incidence rates calculated for a New Mexico state reference population, and (2) national rates obtained from the SEER Program of the National Cancer Institute
- To determine if any of the Los Alamos County cancer incidence rates were elevated in comparison to rates observed in the reference population

The study protocol specified that statistical tests would be used to determine whether any of the Los Alamos County rates were elevated in comparison to the reference populations. Early in the course of the study, however, it became apparent that the small number of cases for virtually all of the Los Alamos County cancers reviewed would make the finding of statistical significance unlikely for small to modest elevations in a rate. Consequently, the analysis of the Los Alamos County incidence data was expanded to include not only statistical considerations but other types of information such as temporal patterns of cancer occurrence, prevalence of established risk factors, case characteristics, and tumor cell types. Cancers of concern were: oral cavity and pharynx, digestive system, respiratory system, melanoma of the skin, female breast, female genital system, urinary system, male genital system, lymphoreticular system, childhood cancers

TABLE D.1.2.3–1.—*The Five Most Frequently Diagnosed Cancer and the Five Most Common Types of Cancer Death (1988 Through 1992) Among White Non-Hispanics (all U.S.), White Hispanics (all U.S.), Native Americans (New Mexico)*

POPULATION GROUP	CANCER INCIDENCE[a]		CANCER MORTALITY[a]	
	CANCER TYPE (RATES/100,000 POPULATION, AGE ADJUSTED TO 1970 U.S. STANDARD)			
	MEN	WOMEN	MEN	WOMEN
White, Non-Hispanic	Prostate (137.9)	Breast (115.7)	Lung (74.2)	Lung (32.9)
	Lung (79.0)	Lung (43.7)	Prostate (24.4)	Breast (27.7)
	Colon/Rectum (57.6)	Colon/Rectum (39.2)	Colon/Rectum (23.4)	Colon/Rectum (15.6)
	Bladder (33.1)	Corpus Uteri (23.0)	Pancreas (9.8)	Ovary (8.2)
	Non-Hodgkin's Lymphoma (19.1)	Ovary (16.2)	Leukemia (8.6)	Pancreas (7.0)
White, Hispanic	Prostate (92.8)	Breast (73.5)	Lung (33.6)	Breast (15.7)
	Lung (44.0)	Colon/Rectum (25.9)	Prostate (15.9)	Lung (11.2)
	Colon/Rectum (40.2)	Lung (20.4)	Colon/Rectum (13.4)	Colon/Rectum (8.6)
	Bladder (16.7)	Cervix (17.1)	Stomach (8.8)	Pancreas (5.4)
	Stomach (16.2)	Corpus Uteri (14.5)	Pancreas (7.4)	Ovary (5.1)
Native American, NM	Prostate (52.5)	Breast (31.6)	Prostate (16.2)	Gallbladder (8.9)[b]
	Colon/Rectum (18.6)	Ovary (17.5)	Stomach (11.2)[b]	Breast (8.7)[b]
	Kidney (15.6)	Colon/Rectum (15.3)	Liver (11.2)[b]	Cervix (8.0)[b]
	Lung (14.4)	Gallbladder (13.2)	Lung (10.4)[b]	Pancreas (7.4)[b]
	Liver (13.1)[b]	Corpus Uteri (10.7)	Colon/rectum (8.5)[b]	Ovary (7.3)[b]

[a] NIH/NCI SEER Program statistics from several regions around the U.S.
[b] Statistics calculated with extremely high uncertainty because they are based on fewer than 25 cases. Other rates (not footnoted) were calculated from larger total numbers of cases and, therefore, have less uncertainty associated with them.
Source: Miller et al. 1996

(ages 0 to 19 years) thyroid, and brain and nervous system cancers.

Following a review of tabulated incidence rate data for 23 major cancers, nine were selected for additional review and evaluation: liver and intrahepatic bile duct cancer, non-Hodgkin's lymphoma, leukemia, melanoma of skin, ovarian cancer, breast cancer, childhood cancers, thyroid cancer, and brain and nervous system cancer. The majority of these cancers were chosen on the basis of incidence rates, which were higher in Los Alamos County in comparison to the reference populations. Childhood cancer was chose for further review based on mortality rate data showing an apparent excess of childhood cancer deaths in Los Alamos County. Leukemia and liver cancer where chosen as cancers of concern specifically to examine tumor cell types. Cancers not chosen for further review included major sites in the respiratory, digestive, and urinary systems.

Incidence Data: Data Sources

Information regarding newly diagnosed cancers among Los Alamos County residents and New Mexico non-Hispanic Whites was compiled from records collected since 1969 by the NMTR at the University of New Mexico Cancer Center. Cancer is a reportable disease in New Mexico by regulation of the New Mexico Department of Health (NMDOH). Since the late 1960's, NMTR has been the repository of the confidential medical record abstracts and computerized masterfile for cancer in New Mexico. NMTR has been a part of the SEER Program since that program began in 1973.

Cancer Incidence Findings (1970 to 1990)

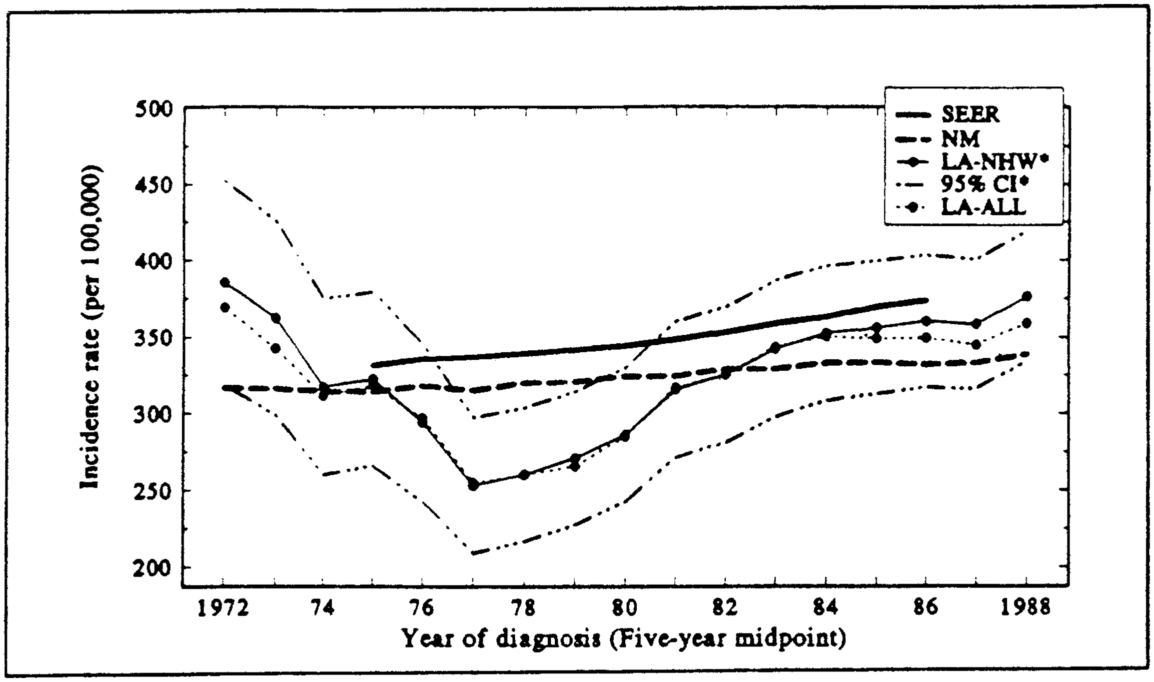
All Cancers. Figure D.1.2.4–1 shows that the Los Alamos County incidence rates for "all cancers" fluctuated considerably; but the rates generally were comparable to or lower than rates observed in the state and national reference populations.

Liver and Intra-Hepatic Duct Cancer. Seven cases of primary liver and intra-hepatic bile duct cancer occurred in Los Alamos County. Four of the seven cases (57 percent) were diagnosed between 1981 and 1982. Los Alamos County incidence rates were highly variable as a result of the small number of cases and the clustered temporal distribution of cases. No cases were reported up until the early 1980's, at which time the four cases diagnosed in 1981 to 1982 caused a marked elevation in the Los Alamos County rates in comparison to the state and national reference rates (Figure D.1.2.4–2). Los Alamos County rates subsequently diminished to a level consistent with the reference rates.

Non-Hodgkin's Lymphoma. Los Alamos County consistently experienced a small to modest elevation in incidence compared to the reference populations (Figure D.1.2.4–3). The magnitude of the elevated Los Alamos County incidence varied widely up to a two-fold higher than expected level. None of the Los Alamos County lower confidence limits excluded the reference rates. Incidence in the Los Alamos County non-Hispanic White population was consistently higher than that observed in the total county population. All Los Alamos County rates were based on 14 or fewer cases. For the most recent five-year time period (1986 to 1990), the rate for non-Hispanic Whites in Los Alamos County was 57 percent greater than the state reference rate.

Leukemia. The incidence of leukemia in Los Alamos County generally was the same or lower than that observed in the reference populations (Figure D.1.2.4.–4). Wide fluctuations in the Los Alamos County rates occurred as a result of low case numbers. All Los Alamos County rates were based on nine or fewer cases. For the most recent 5-year time period (1986 to 1990), the Los Alamos County rate equalled the state reference rate.

Melanoma. The incidence of melanoma consistently was around 50 percent higher in New Mexico non-Hispanic Whites compared



SOURCE: Athas and Key 1993

FIGURE D.1.2.4–1.—*5-Year Average Annual Incidence of All Cancer Sites, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

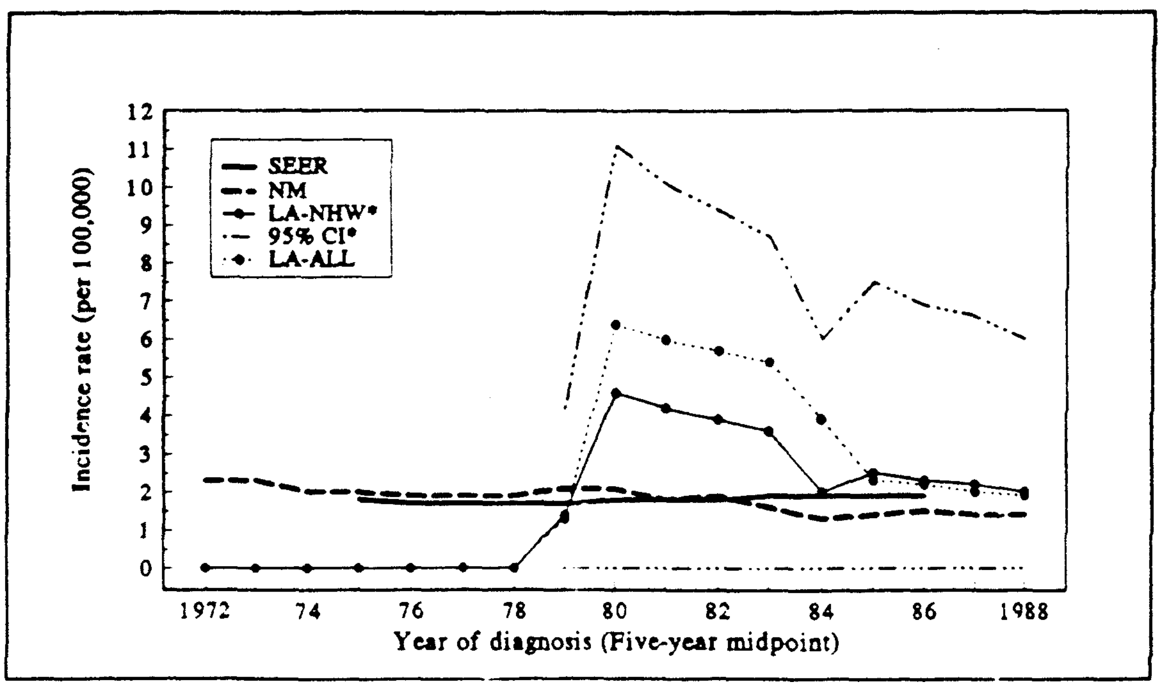


FIGURE D.1.2.4–2.—*5-Year Average Annual Incidence of Liver and Intra-Hepatic Bile Duct Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

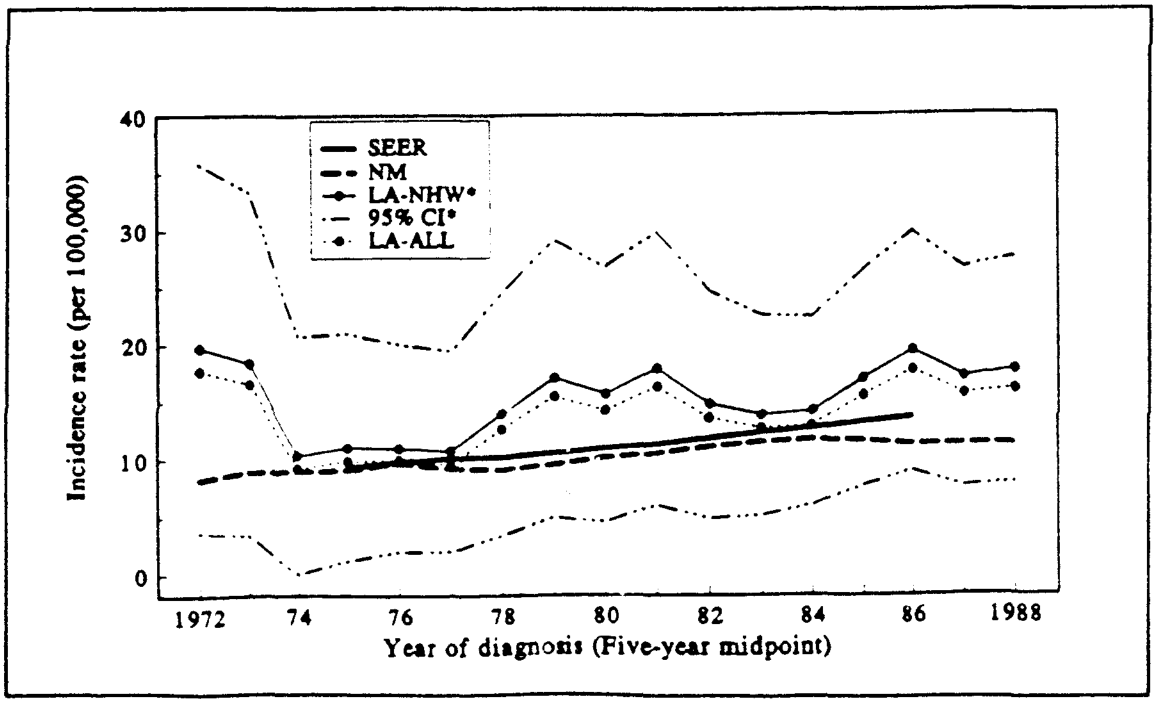


FIGURE D.1.2.4–3.—*5-Year Average Annual Incidence of Non-Hodgkin's Lymphoma, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

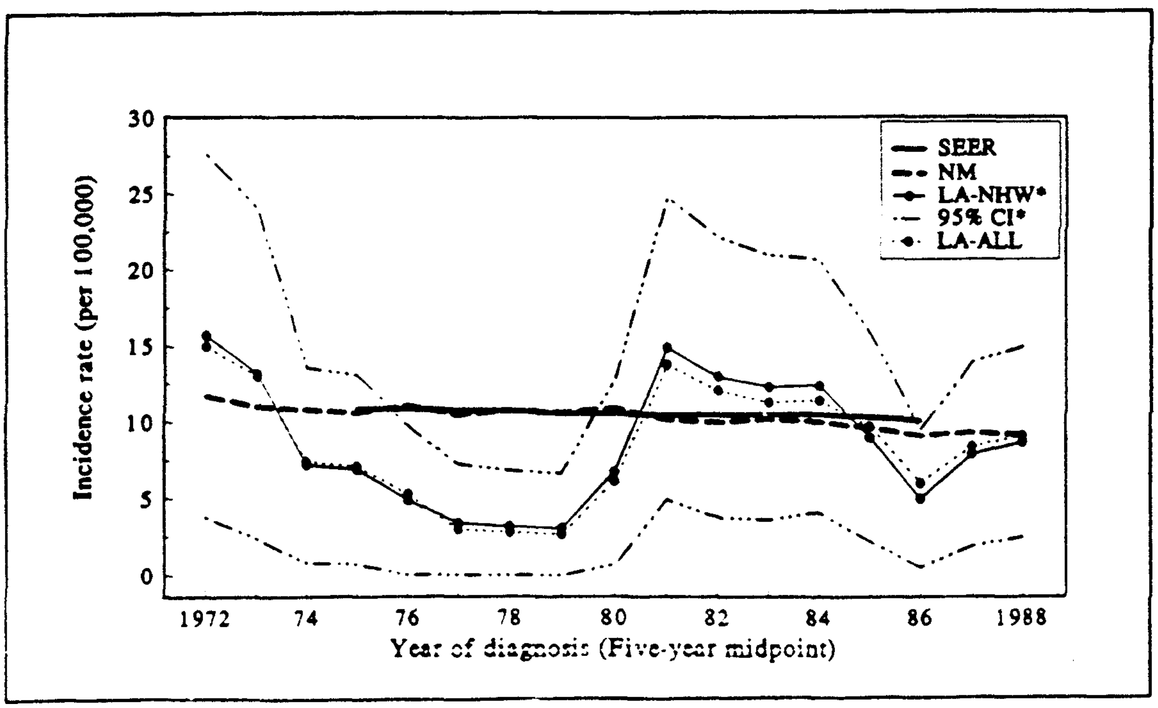


FIGURE D.1.2.4–4.—*5-Year Average Annual Incidence of Leukemia, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

with SEER Whites. Melanoma incidence steadily increased in both reference populations. Incidence rates in Los Alamos County were higher than the state reference rates over most of the 21-year study time period (Figure D.1.2.4–5). Early time periods were characterized by a small elevation in the Los Alamos County incidence; whereas, a more pronounced excess of melanoma in Los Alamos County began to appear in the mid 1980's. Beginning with the 1982 to 1986 period, and for all subsequent periods, the lower confidence limit of the Los Alamos County rate excluded the state reference rates. During these later periods, the incidence of melanoma in Los Alamos County increased roughly two-fold over that observed statewide.

Ovarian. Los Alamos County rates steadily rose by three-fold during 1970 to 1990, while both the sate and national reference rates remained essentially constant (Figure D.1.2.4–6). Initially lower than the reference rates, Los Alamos County incidence climbed to a statistically significant three-fold excess level during the 1982 to 1986 period. Half of all the Los Alamos County cases (15 out of 30) were diagnosed during these 5 years. Los Alamos County ovarian cancer incidence was two-fold higher than that observed in the state during the most recent 5-year period (1986 to 1990).

Breast. Breast cancer incidence in Los Alamos County women varied little over time; whereas, both reference populations displayed increasing incidence over time (Figure D.1.2.4–7). Los Alamos County incidence rates were 10 percent to 50 percent higher than the state and national reference rates over the entire study period. The lower confidence limits for the Los Alamos County rates consistently were near the reference rates, but excluded the reference rates in only several instances.

Childhood Cancers. Los Alamos County childhood cancer rates fluctuated around the more stable state and national reference population rates (Figure D.1.2.4–8). Following an initial two-fold elevation during the earliest

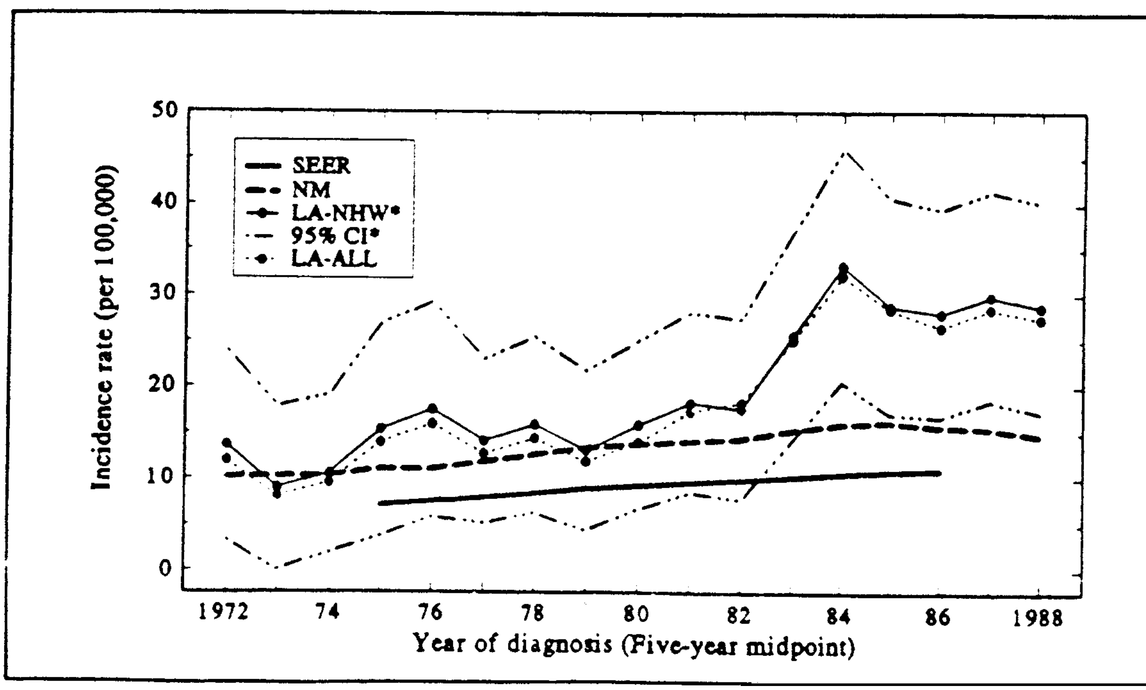


FIGURE D.1.2.4–5.—*5-Year Average Annual Incidence of Melanoma of Skin, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

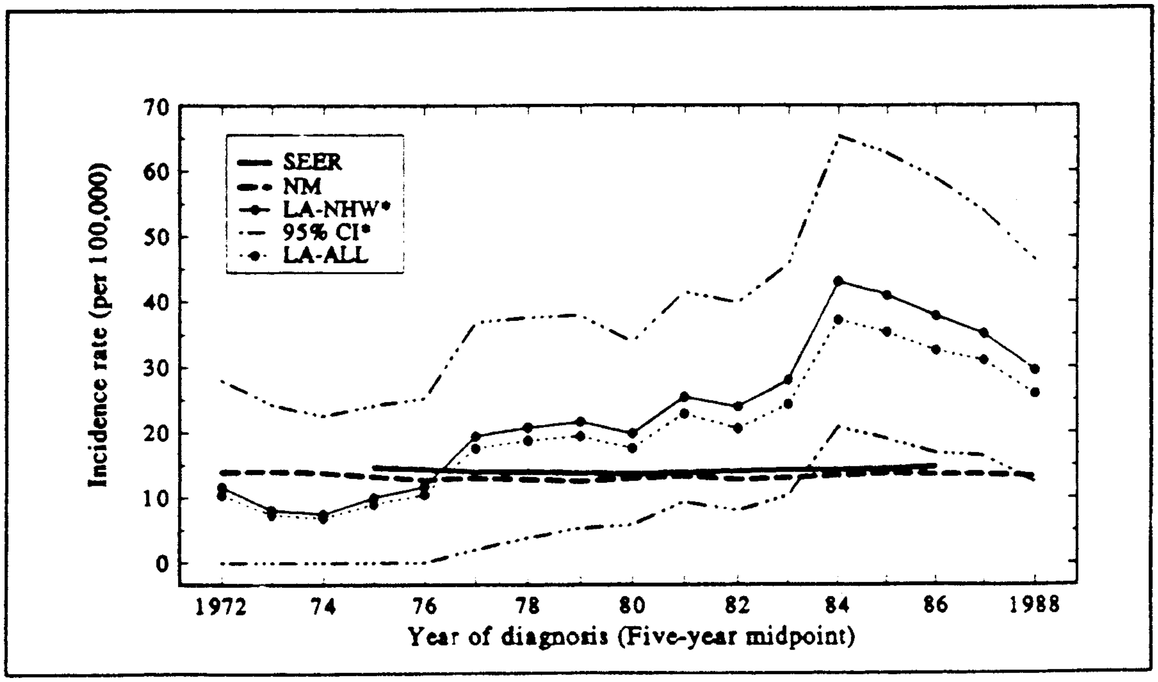


FIGURE D.1.2.4–6.—*5-Year Average Annual Incidence of Ovarian Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

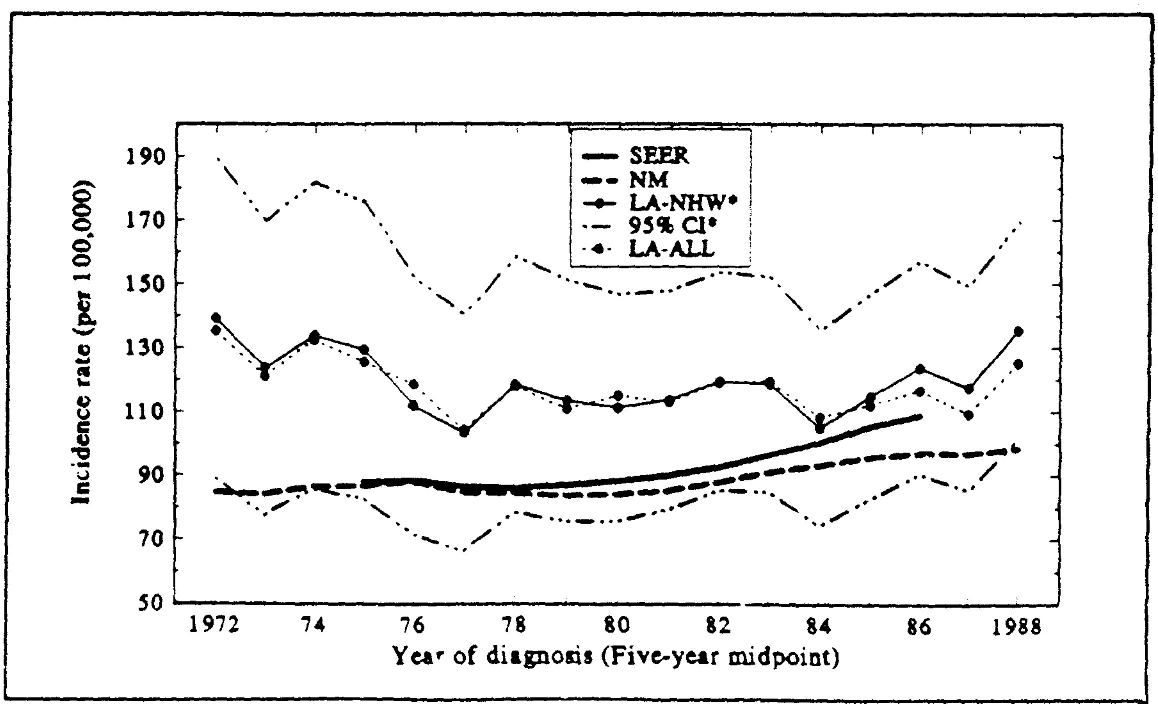


FIGURE D.1.2.4–7.—*5-Year Average Annual Incidence of Female Breast Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

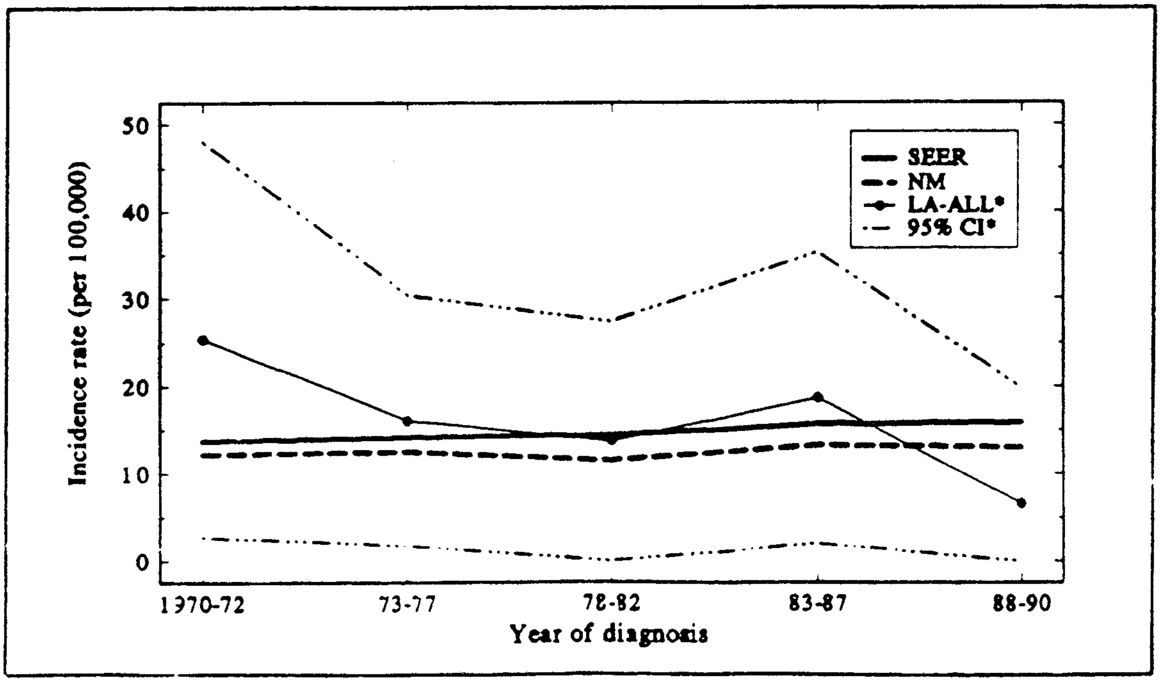


FIGURE D.1.2.4–8.—*Average Annual Incidence of Childhood Cancer (0 to 19 Years), Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.[a]*

[a] Incidence rate data based on independent time periods and not 5-year moving averages.

period (1970 to 1972), subsequent periods were characterized by incidence rates that were slightly higher than or lower than the reference incidence rates. Two childhood brain cancer cases not in the original childhood cancer data set were discovered through a supplemental review of childhood cancer mortality statistics. The two additional cases, diagnosed in 1978 and 1980, would raise the original 1978 to 1982 Los Alamos County rate (13.7 per 100,000) by about 50 percent to 20.3 cases per 100,000. For the latest period (1988 to 1990), the incidence of childhood cancers in Los Alamos County was roughly 50 percent lower than that seen in the state reference population; however, the Los Alamos County rate was based on only one case.

Thyroid. The incidence of thyroid cancer in Los Alamos County prior to the mid 1980's was roughly stationary and less than two-fold higher than that seen in the reference populations (Figure D.1.2.4–9). Los Alamos County incidence rates began to rise during the mid 1980's and continued to climb up until the latest time interval (1986 to 1990). The incidence of thyroid cancer in Los Alamos County during 1986 to 1990 was nearly four- fold higher than that observed in the state reference population. The near four-fold elevation for Los Alamos County was statically significant. Roughly half (17 out of 37) of all thyroid cancer cases that occurred in Los Alamos County between 1970 and 1990 were diagnosed during the 1986 to 1990 interval.

Brain and Nervous System. The incidence of brain cancer in Los Alamos County increased over time (Figure D.1.2.4–10). Los Alamos County incidence rates were lower than or comparable to the reference rates up until the mid 1980's. Increases in Los Alamos County brain cancer incidence became apparent during the mid to late 1980's. Los Alamos County incidence rates (all races) during this period were 60 to 80 percent higher than rates for the state and national reference populations. Diagnosed in 1978 and 1980, two additional

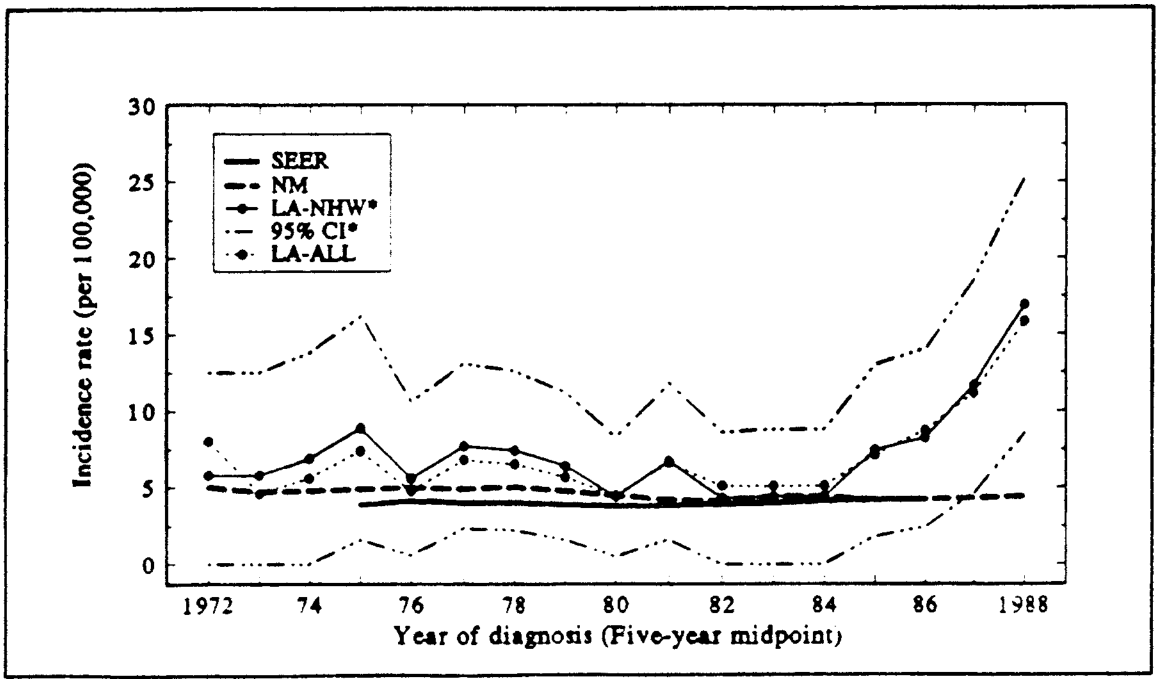


FIGURE D.1.2.4–9.—*5-Year Average Annual Incidence of Thyroid Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

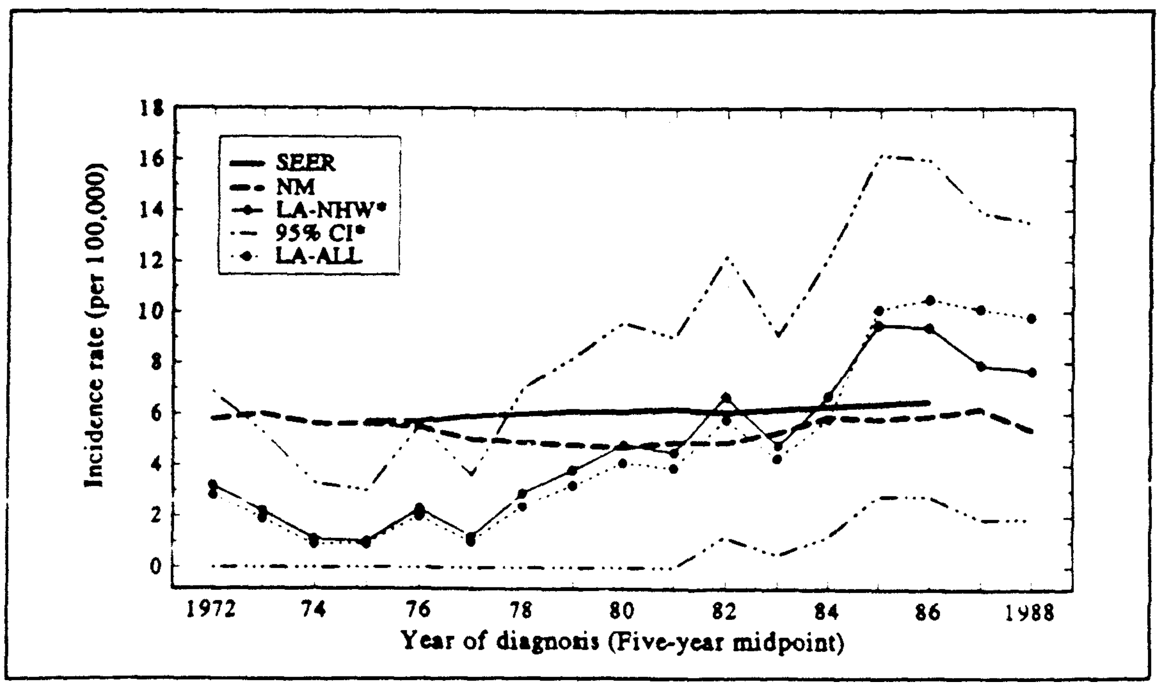


FIGURE D.1.2.4–10.—*5-Year Average Annual Incidence of Brain and Nervous System Cancer, Los Alamos County, New Mexico NHW, SEER Whites, 1970 to 1990.*

cases raised the central portion of the incidence rate curve to a range more comparable with the reference rates, but had no effect on the rates observed during the period of elevated incidence.

Mortality

Mortality rates for Los Alamos County and the U.S. were obtained as age-adjusted average annual mortality rates from the National Center for Health Statistics (NCHS) and the National Cancer Institute. All rates were standardized to the 1970 U.S. standard population and were race-specific for Whites. Site-specific Los Alamos County mortality rates were available for the periods 1969 to 1972, 1973 to 1977, 1978 to 1982, and 1983 to 1987. U.S. rates were available for the time period 1968 to 1972. For some cancers, both Los Alamos County and U.S. rates were available for the period 1968 to 1972. The confidence intervals that accompany the mortality rates were calculated as described for the incidence rates. Table D.1.2.4–1 summarizes the mortality rates by cancer type for Los Alamos County. Nationwide rates are also reported for comparison.

Subcounty Cancer Incidence

Table D.1.2.4–2 describes the cancer incidence for the five census tracts within Los Alamos County for all races, 1980 to 1990. The New Mexico non-Hispanic White population rates are provided also.

TABLE D.1.2.4–1.—*Average Annual Age-Adjusted Mortality Rates by Cancer Type for Los Alamos County and U.S. Whites (1969 to 1987)*

CANCER TYPE	LOCATION	MORTALITY RATE[a]			
		1969 TO 1972	1973 TO 1977	1978 TO 1982	1983 TO1987
Liver and Bile	Los Alamos	14.6 (2)[b]	0 (0)	5.4 (3)	7.1 (4)
	U.S.	—	2.1	2.1	2.3
Non-Hodgkin's Lymphoma	Los Alamos	13.5 (2)	5.8 (2)	12.0 (6)	2.3 (2)
	U.S.	NA[c]	4.9	5.2	5.9
Leukemia	Los Alamos	1.2 (1)	11.2 (6)	1.3 (1)	4.5 (4)
	U.S.	NA	6.8	6.7	6.5
Melanoma	Los Alamos	0 (0)	6.5 (3)	2.9 (2)	1.0 (1)
	U.S.	1.7	1.9	2.2	2.3
Ovarian	Los Alamos	19.7 (3)	5.7 (1)	8.9 (3)	3.8 (2)
	U.S.	NA	8.6	8.1	7.9
Breast	Los Alamos	39.6 (8)	17.4 (7)	60.7 (20)	29.7 (12)
	U.S.	26.9	26.9	26.6	27.2
Childhood Cancer	Los Alamos	3.6 (1)	12.3 (4)	16.1 (5)	10.6 (3)
	U.S.	6.6	5.4	4.6	4.0
Brain and Nervous System	Los Alamos	0 (0)	6.3 (4)	5.8 (5)	5.8 (5)
	U.S.	NA	4.0	4.1	4.3
Thyroid	Los Alamos	0 (0)	0 (0)	0 (0)	0 (0)
	U.S.	NR[d]	NR	NR	NR

[a] Rates per 100,000 and are age-adjusted to the 1970 U.S. standard population.
[b] Number of deaths given in parentheses.
[c] NA = Not available
[d] NR = Not reported

TABLE D.1.2.4–2.—*Average Annual Age-Adjusted Cancer Incidence Rates for Sub-County Regions of Los Alamos County, All Races (1980 to 1990)*[a]

SITE	CENSUS TRACT[b]					CDP[c]		LOS ALAMOS COUNTY	NEW MEXICO NHW[d]
	1	2	3	4	5	LOS ALAMOS	WHITE ROCK		
Non-Hodgkin's Lymphoma	18.9 (2)	4.5 (2)	20.4 (5)	11.1 (5)	16.7 (10)	12.6 (14)	16.7 (10)	14.3 (24)	11.0
	{0.0 to 45.6}	{0.0 to 11.0}	{2.2 to 38.7}	{1.2 to 21.0}	{6.1 to 27.2}	{5.8 to 19.3}	{6.1 to 27.2}	{8.5 to 20.1}	
Leukemia	1.9 (1)	10.3 (4)	17.5 (2)	5.5 (3)	11.8 (7)	7.1 (10)	11.8 (7)	8.5 (17)	9.5
	{0.0 to 5.7}	{0.0 to 20.6}	{0.0 to 42.2}	{0.0 to 11.8}	{2.9 to 20.7}	{2.6 to 11.6}	{2.9 to 20.7}	{4.4 to 12.6}	
Melanoma[e]	33.8 (10)	22.0 (10)	35.8 (7)	13.5 (6)	21.7 (11)	23.2 (32)	21.7 (11)	22.0 (43)	14.5
	{12.4 to 55.2}	{8.1 to 35.9}	{8.7 to 62.9}	{1.5 to 24.5}	{8.6 to 34.8}	{15.0 to 31.4}	{8.6 to 34.8}	{15.3 to 28.7}	
Ovary (Female)	76.7 (9)	19.4 (4)	19.5 (2)	14.0 (3)	12.7 (4)	27.4 (18)	12.7 (4)	23.0 (22)	12.8
	{25.6 to 127.8}	{0.0 to 38.8}	{0.0 to 47.0}	{0.0 to 30.2}	{0.0 to 25.4}	{14.5 to 40.3}	{0.0 to 25.4}	{13.2 to 32.8}	
Breast (Female)	145.3 (28)	120.5 (21)	159.2 (16)	85.3 (21)	116.0 (41)	119.8 (86)	116.0 (41)	119.0 (127)	92.2
	{90.4 to 200.2}	{67.9 to 173.1}	{79.6 to 238.9}	{48.1 to 122.5}	{79.8 to 152.3}	{93.9 to 145.6}	{79.8 to 152.3}	{97.9 to 140.1}	
Childhood (< 20 years)	21.9 (2)	6.7 (1)	0.0 (0)	24.5 (2)	16.9 (4)	14.2 (5)	16.9 (4)	15.2 (9)	14.8
	{0.0 to 52.8}	{0.0 to 20.2}	{ - }	{0.0 to 59.2}	{0.0 to 33.9}	{1.5 to 26.9}	{0.0 to 33.9}	{5.1 to 25.3}	
Thyroid	16.0 (6)	3.8 (2)	5.8 (1)	8.7 (4)	9.3 (9)	9.0 (13)	9.3 (9)	9.8 (22)	4.3
	{2.9 to 29.1}	{0.0 to 9.1}	{0.0 to 17.5}	{0.0 to 17.4}	{3.1 to 15.4}	{4.0 to 14.0}	{3.1 to 15.4}	{5.6 to 14.0}	
Brain	7.3 (2)	5.7 (3)	14.2 (3)	7.4 (2)	8.2 (7)	7.4 (10)	8.2 (7)	7.9 (17)	5.1
	{0.0 to 17.5}	{0.0 to 12.4}	{0.0 to 30.6}	{0.0 to 18.0}	{2.0 to 14.3}	{2.7 to 12.1}	{2.0 to 14.3}	{4.1 to 11.7}	

[a] Rates are for residence at diagnosis for all races per 100,000, age-adjusted to U.S. 1970 standard population; number of cases in parentheses ( ); 95% confidence limits in brackets { }, truncated at zero.
[b] Census Tract Designations: (1) North/Barranca Mesa; (2) North Community; (3) Western Area; (4) Eastern Area; (5) White Rock.
[c] Los Alamos Census Designated Place (CDP) comprises census tracts 1 through 4, White Rock CDP comprises census tract 5.
[d] Non-Hispanic Whites
[e] Excludes two cases with unknown residence at diagnosis.
Source: New Mexico Tumor Registry

D.2 METHODS USED FOR THE ESTIMATION OF HUMAN HEALTH CONSEQUENCES OF CONTINUED LANL OPERATIONS

The consequences of continued operations of LANL to public health and to LANL workers are evaluated in this SWEIS. The consequence analysis is based on several exposure scenarios that are conservatively defined in order to estimate potential maximum doses and risks (e.g., excess latent cancer fatality [LCF]) to the public and workers under normal operations in each of the four alternatives examined. (The consequences of credible and less than credible accidents on workers and the public are detailed in appendix G.)

D.2.1 Methods Used to Evaluate Public Health Consequences from Routine Operations

Public health consequences of continued LANL operations were based on several exposure scenarios, including exposure to external radiation, inhalation of airborne radioactivity and chemical emissions, ingestion of water and foodstuffs and inadvertent ingestion of sediments and soils, and dose received due to incident-free transportation to or from LANL. The methodology used to estimate dose to the public from external radiation and airborne radioactive and chemical emissions is given in appendix B. The methodology used to estimate dose from transportation to or from LANL is given in appendix F. The methods used to estimate dose, hazard, and cancer risk from radioactive and chemical intakes (inhalation and ingestion) are detailed below.

The estimation of potential dose and risk used in the public health consequence analysis was directed at estimating total risk. That is, the risks posed by all sources, including LANL, other anthropogenic sources, fallout and regional depositions such as through rainfall, and naturally occurring radionuclides and chemicals, were evaluated. For those radionuclides and chemicals shown to have risk probabilities greater than 1 in 1 million (1×10^{-6}) per year, the relative contribution of LANL operations versus other sources of risk was examined.

D.2.1.1 *Methods for Evaluation for External Radiation Risk and Inhalation Dose/Risk from Airborne Radionuclides and Chemicals*

The exposure pathways for members of the public were estimated for specific exposure scenarios and are "hypothetical" (that is, a person hypothesized to be present for a portion of the time or all the time that is conservatively located rather than by using actual location, such as assuming that a person is resident at the fenceline of a facility) members of the public. These include ingestion exposure scenarios for Los Alamos County residents, non-Los Alamos County residents, nonresident recreational users of canyons, resident recreational users of canyons, and people who could be exposed via special pathways. Special pathway exposures are through culturally associated lifestyle patterns such as increased use of herbal teas made from local vegetation, use of locally collected herbal smoking materials, working with clays, or increased consumption of local foodstuffs including game species resident/ migrating through the LANL reservation.

External Radiation and Airborne Radioactivity

For radioactive emissions from LANL facilities, population consequences were estimated to a radial distance of 50 miles (80 kilometers). Both point-source and diffuse source emissions were included in the analysis. Using the model CAP–88 (EPA 1992), the direct exposures (the sum of external radiation and inhalation and ingestion of airborne emissions) were estimated for each of the four alternatives for continued operations of LANL. The maximally exposed individual (MEI) was determined to be near the Los Alamos Neutron Science Center (LANSCE) (appendix B).

For individuals, the risk of excess LCFs was estimated for each alternative based on the recommendations of the International Commission on Radiological Protection (ICRP 1991), which provide the conversion of 0.0005 excess LCFs per rem of exposure (Table D.1.1.2–1).

Toxic Chemicals

Inhalation of airborne chemicals was evaluated on a TA-specific basis in the nonradiological air quality analysis presented in appendix B. The chemicals identified in this screening for public health consequence analysis were reviewed as described in section B.2.3.1.

First, a qualitative evaluation was made of the chemical's reference dose, toxicity, potential carcinogenicity, and chemical form(s) likely in the LANL area (both as released and upon deposition onto soils, waters, and sediments). Several chemicals identified in the very conservative nonradiological air screening process were eliminated from subsequent public health consequence analysis using these qualitative evaluations.

For the remaining chemicals, quantitative evaluation was made based on the modeled predicted concentrations at the nearest location where a member of the public could be exposed. The modeling methods are described in appendix B, as are the results for the modeled chemicals at specific TAs.

The factors used for quantitative analysis are those given in the *EPA Exposures Factors Handbook* (EPA 1997a). The exposure scenario assumed that a member of the public could be exposed to the average and 95^{th} percentile concentrations of the chemical at that nearest location to the source. Average and worst-case (95^{th} percentile) uptakes were calculated as milligram per kilogram-day for a standard adult human male.

Average and worst-case hazard indices were calculated (EPA 1997a): milligram per kilogram-day estimated per milligram per kilogram-day reference dose for the chemical. In some cases, no reference dose has been provided by EPA's IRIS (EPA 1997b). In instances where carcinogens or suspected carcinogens had no hazard index available, if unit risk factors were available, they were used to estimate potential risk to the MEI.

D.2.1.2 *Methods for Estimation of Ingestion Risks from Radionuclides and Chemicals*

Concentrations of radionuclides and chemicals in environmental media were used in dose/risk analysis. The data used were those from LANL's Environmental Surveillance Reports 1991 to 1996 (appendix C). The 95^{th} percentile upper confidence level (95 percent UCL) values were used in order to provide a conservative analysis (calculated using only measurements above zero or the detection threshold).

Data from specific contaminated sites were used to provide insight to potential additional but short-term exposures that could contribute to dose/risk. These datasets are also provided in appendix C.

Table D.2.1.2–1 presents the specific exposure pathways evaluated for the five exposure scenarios: residents (both Los Alamos and non-Los Alamos County), recreational users (residents and nonresidents), and special pathways. These exposure scenarios are defined below.

TABLE D.2.1.2–1.—*Ingestion and Hypothetical Receptors Used to Evaluate Radiological Dose and Potential Public Health Consequence*

EXPOSURE PATHWAY	RECEPTOR[a]				
	OFF-SITE RESIDENT LOS ALAMOS COUNTY	OFF-SITE RESIDENT NON-LOS ALAMOS COUNTY	NONRESIDENT RECREATIONAL USER[b]	RESIDENT RECREATIONAL USER[b]	SPECIAL PATHWAYS RECEPTORS[c]
Produce:					
Fruit	ESD	ESD	NA	NA	NA
Vegetables	ESD	ESD	NA	NA	NA
Meat (Cattle: Free-Ranging Steer)	NA	ESD	NA	NA	NA
Milk	ESD	ESD	NA	NA	NA
Fish	NA	ESD	NA	NA	ESD
Honey	ESD	ESD	NA	NA	NA
Elk	ESD[d]	ESD[d]	NA	NA	ESD[e]
Deer	ESD	ESD	NA	NA	TBD
Pinyon Nuts	NA	ESD	NA	NA	NA
Indian Tea (Cota)	NA	NA	NA	NA	ESD
Groundwater	ESD	ESD	NA	NA	NA
Surface Water:					
Creeks	NA	NA	ESD	ESD	NA
NPDES Discharge	NA	NA	ESD	ESD	NA
Soils	ESD	ESD	ESD	ESD	NA
Sediments	ESD	ESD	ESD	ESD	NA

[a] Receptor is a hypothetical person who is conservatively estimated to have intake of the 95th upper confidence limit (UCL) concentration of a contaminant in the specific medium evaluated for ingestion.
[b] The resident recreational user lives in Los Alamos County or a neighboring county and is in the Los Alamos canyons 24 visits per year, approximately 8 hours per visit. The nonresident recreational user lives outside the region of influence of LANL but hikes into the canyons 12 visits per year, approximately 6 hours per visit.
[c] Special pathways receptors are those who have traditional Native American or Hispanic lifestyles.
[d] Elk muscle.
[e] Elk heart and liver.
ESD = Environmental Surveillance Data
NA = Not applicable

The doses/risks from ingestion pathways were examined as total ingestion risk, resulting from all contributors to the concentrations of radionuclides and chemicals in foodstuffs, water, and soils/sediments. The concentrations include naturally occurring radionuclides and chemicals, residual contamination from worldwide fallout and earlier LANL operations, and small quantities of contamination from more recent operations. Because it is difficult to differentiate among these sources for most materials, this SWEIS analysis calculates the total risk from all these sources. (If this analysis demonstrated elevated risks from a particular contributor, then it would be investigated to determine its possible sources.)

The exposures through ingestion were calculated using the 95 percent upper confidence limit (UCL) concentrations. In calculating the UCL, all samples of zero or negative value or less than the detection limit were rejected. This significantly increases the average value and the UCL, and especially so when a large fraction of the samples show no detectable contamination. Based on the projected emissions and effluents under the four alternatives (section 3.6), there are no incremental differences in dose/risk from operations continuing at LANL for the next 10 years. Therefore, the ingestion dose/risk analysis was provided only in the No Action Alternative.

The consumption rates used for estimating dose/risks at both 50th and 95th percentile were taken from the *EPA Exposure Factors Handbook* (EPA 1997a, except where only available in 1989 edition). In each dose/risk ingestion analysis provided, the specific data used were identified as well as the intake rates and any conversion factors. Because these differ among radionuclides and chemicals analyzed, they are only provided in the dose/risk analysis detailed tables (section D.3.3).

Off-Site Resident

Two different types of off-site resident were analyzed: one of these represents Los Alamos County residents; the other represents non-Los Alamos County residents and was located near the Otowi Bridge (outside Los Alamos County) in an agricultural area.

Los Alamos County Off-Site Resident. Because there is no meat or milk production from Los Alamos County, there are no viable meat or milk ingestion pathways for any doses to residents in Los Alamos County. The Los Alamos County resident was assumed to have a garden at his or her home, and it was conservatively assumed that a portion of the resident's produce (fruit and vegetables) was obtained from this garden. The resident in Los Alamos County would use water from the Los Alamos County water supply.

Thus, the pathways for the off-site resident in Los Alamos County would include ingestion of produce, fish, honey, game animals, pinyon nuts, groundwater, and inadvertent ingestion of sediments and soil. Doses for ingestion pathways were primarily determined using the concentrations in the various media measured in LANL environmental surveillance programs (LANL 1992, LANL 1993, LANL 1994, LANL 1995, LANL 1996a, and LANL 1996b). These consumption rates are provided in Table D.2.1.2–2.

Non-Los Alamos County Off-Site Resident. The exposure pathways that are applicable to this off-site resident are the same as those for the Los Alamos County off-site resident, with the following exceptions. Two additional pathways were evaluated for non-Los Alamos County residents: ingestion of meat and ingestion of milk from sources outside of Los Alamos County but within the LANL region of influence (based on current LANL surveillance data, 1991 to 1996).

TABLE D.2.1.2–2.—*Consumption Rates Used for Public Health Consequence Analysis*

INGESTION PATHWAY	INGESTION RATE PER YEAR	
	AVERAGE VALUE (50%)	WORST-CASE VALUE (95%)
Produce	202 kg	587 kg
Milk Products	210 liters	778 liters
Meat	55 kg	134 kg
Fish	7 kg	7 kg
Honey	1.4 kg	5.0 kg
Pinyon Nuts	1.5 kg	none given
Water	550 liters	891 liters (90th percentile)
Soil and Sediments	0.036 kg	0.146 kg
Homegrown Fraction: Vegetables[a]	25%	40%
Homegrown Fraction: Fruit[a]	20%	30%

[a] EPA 1989

Recreational Users

The nonresident recreational user was defined in this analysis as a person who occupies on-site canyons during 12 visits per year, for 6 hours per visit. The resident recreational user was hypothesized to be resident in Los Alamos or neighboring counties and to spend an average of 2 visits per month, 8 hours per visit, in the canyons as an avid local outdoor enthusiast.

Special Pathways

Special pathways were also evaluated to assess potential impacts to Native American, Hispanic, and other traditional lifestyle receptors that might not be bounded by the hypothetical MEIs of residents and recreational users. The following exposure pathways were evaluated:

- Ingestion of game animals from the LANL area
- Ingestion of fish from the Cochiti reservoir
- Ingestion of native vegetation through the use of herbal teas
- Dermal absorption of sediments during craft or ceremonial use of clays
- Inhalation of local herbaceous plant materials via smoking
- Ingestion of surface waters from LANL
- Ingestion of soils and sediments from LANL
- Ingestion of locally grown produce

After investigations via interviews, it was determined that potential dermal absorption of contaminants from use of native clays for pottery is not a viable pathway. Clays are taken from specific areas and at depths that are not subject to appreciable contamination. Also, it was determined that potential uptakes via bathing or ceremonial uses of springs is not a viable pathway at LANL because there are no known permanent springs of sufficient size for such use. Finally, smoking use of herbs was not evaluated as a pathway because these are used in concert with tobaccos and do not significantly differ in risk than the risk posed by commercial tobacco use.

D.2.2 Worker Health

The methods used to estimate potential consequences to the health of workers from continued operations of LANL are given below.

These methods address: ionizing and nonionizing radiation, chemical exposures, and physical safety hazards during normal operations in LANL. The methods and consequences of accidents are addressed in appendix G.

D.2.2.1 *Radiological Consequences to Workers*

The worker radiation dose projected for this SWEIS is the total effective dose equivalent incurred by workers as a result of routine operations. The dose is the sum of the external whole body dose as monitored by personnel dosimeters, including dose from both photons and neutrons, and internal dose, as required by 10 CFR 835. The internal dose is the 50-year CEDE. However, the internal dose being projected is that for tritium, and does not include dose from incidents with plutonium or other nuclides. The internal dose from inhalation of plutonium occurs almost entirely from a breakdown of control or equipment, and is not predictable. Past plutonium exposures, such as the examples described in chapter 4 of volume I (Table 4.6.2.1.–1), are reported to DOE and have been included in the 1993 to 1995 baseline. Note that in 1996, plutonium produced measurable dose in two workers, contributing 4.8 person-rem to the worker collective dose. These incidental exposures are small compared to the total collective dose, which runs about 200 person-rem.

The collective doses for each LANL group and contractor, as monitored by the LANL Radiation Protection Program, were collected for 1993, 1994, and 1995 (LANL 1995, LANL 1996a, and LANL 1996b). The collective doses for the 3 years were summed for each group, and the groups were ranked by their total collective doses. Because of a major LANL reorganization in 1993 and 1994, many groups that were operating in 1993 and 1994 disappeared in 1995. Their functions were typically assumed by another group. This did not affect the major groups receiving radiation doses at LANL, which are listed in Table D.2.2.1–1 except for some groups at LANSCE (then called the Los Alamos Meson Physics Facility [LAMPF]). For these exceptions, the old groups were tracked to their new LANSCE counterparts through interviews with LANSCE personnel.

The 12 groups with the greatest total collective doses from 1993 through 1995 comprised more than 80 percent of the total collective dose for all LANL workers during that period. In addition to these 12 groups, groups that contributed more than 1 percent of the total LANL collective dose during this timeframe were interviewed to determine whether they would become major contributors to the collective dose in the future.

This process resulted in the identification of 15 groups that combined to contribute more than 84 percent of the collective LANL worker dose from 1993 to 1995 (Table D.2.2.1–1). These groups are included in the detailed radiation dose projections and analyses under each of the four SWEIS alternatives, based on the alternative descriptions and on historical exposure information. The following data were obtained for each of these groups:

- The group collective dose under each SWEIS alternative
- The group total collective dose from all programs for each alternative
- The number of workers with nonzero doses for each of the alternatives, as defined by LANL (Workers with measurable doses are referred to as nonzero dose workers.)

In order to obtain the total number of workers with nonzero dose for the entire laboratory, the index data were used to calculate a ratio of the number of workers with nonzero doses to the total number of workers monitored for radiation doses for the entire laboratory. Approximately 51 percent of the workers receiving a nonzero dose belong to the 12 groups that received the

TABLE D.2.2.1–1.—*Groups Used in the Projection of the Worker Doses*

RANK	GROUP	PERCENT OF LANL COLLECTIVE DOSE (1993 TO 1995)	CUMULATIVE PERCENT OF LANL COLLECTIVE DOSE (1993 TO 1995)[a]	KEY FACILITY
1	Operational Health Physics	17	17	LANL-wide
2	Actinide Ceramics and Fabrication	14	30	TA–55
3	Nuclear Materials Management	11	41	TA–55
4	LANL Craft Subcontractor	8.9	50	LANL-wide
5	Actinide Process Chemistry	8.7	59	TA–55
6	Weapons Component Technology[b]	8.2	67	TA–55
7	Particle Physics Studies	4.0	71	LANSCE
8	Weapons Component Technology[b]	2.9	74	TA–55
9	Target Area Maintenance	2.6	76	LANSCE
10	Facility Management Operations	1.9	78	TA–55
11	Actinide Research and Development	1.6	80	TA–55
12	Beam Alignment and Maintenance	1.5	81	LANSCE
13	Advanced Nuclear Technology	1.3	83	TA–18
14	Weapons Neutron Research/Manuel Lujan Center Experimenters	1.0	84	LANSCE
15	LANSCE Experimenters[c]	0.7	84.4	LANSCE

[a] Numbers may not total exactly due to rounding.
[b] These groups were combined in 1996.
[c] Refers to a group of workers and not to the entire key facility known as LANSCE.

largest dose from 1993 to 1995, and 49 percent belong to the rest of the laboratory.

Once the above group data were collected, the following steps were taken to determine the worker collective dose, the average nonzero worker dose, and the cancer risk associated with these doses:

- For each alternative, the dose projections for the groups listed in Table D.2.2.1–1 were totaled. The sum was then divided by 0.844 (the fraction of the total laboratory dose comprised by these groups from 1993 to 1995) to estimate the total collective dose for LANL.
- The total collective dose was then divided by the fraction of workers projected to have nonzero doses to obtain the average nonzero worker dose for the entire laboratory.
- A dose-to-risk conversion factor of 4 x 10^{-4} excess LCF per person-rem (Table D.1.1.2–1) was used to determine the risks associated with the above doses in Table D.2.2.1–2.

It should be noted that actual doses received by workers will vary to some degree based on the actual work assignments made at LANL. For example, the Particle Physics Studies group may again become involved in activities at LANSCE and may again incur some worker dose. Other groups may incur more or less dose than is projected using this methodology. The approach taken in this analysis is considered conservative (in particular, use of the 0.844 normalization factor changes the entire LANL

TABLE D.2.2.1–2.—*Worker Dose for Baseline and Alternatives*

ALTERNATIVE	COLLECTIVE DOSE (PERSON-REM/ YEAR)	COLLECTIVE EXCESS LCF RISK (LCF/YEAR)	AVERAGE DOSE (MILLIREM/ YEAR)	INDIVIDUAL EXCESS LCF RISK (LCF/YEAR)
Baseline (1993 to 1995)	208	0.083	0.097	3.9×10^{-5}
No Action	446	0.178	0.135	5.4×10^{-5}
Expanded Operations	833	0.333	0.235	9.4×10^{-5}
Reduced Operations	170	0.068	0.083	3.3×10^{-5}
Greener	472	0.189	0.141	5.6×10^{-5}

collective worker dose in a manner proportional to the changes incurred by the 15 groups with the greatest doses).

The collective and average measurable dose for the No Action Alternative are larger than those for the baseline. This is because the No Action Alternative includes projects that are not now being performed and that were not performed in 1993 to 1995. The average dose is expected to increase significantly in the Expanded Operations Alternative because the programs are expected to expand at a greater rate than is the number of radiation workers. As noted earlier, the dose projections include the doses from external radiation and tritium, but not from other radionuclides (such as plutonium). This is because past and present bioassay for radionuclides within the body are not sensitive to the low intakes typical of normal operations. A new method having significantly improved sensitivity for analyzing bioassay samples is now under development. This will not change the dominance of external radiation and tritium, however, but will permit a more accurate quantification of the internal doses from other radionuclides.

Despite the appearance in Table D.2.2.1–2 of the three significant digits that resulted from the process, the projected doses are, at best, only approximations. The parameters that affect the dose estimates have considerable variability, such as whether a program will be funded and at what level, what the final work practices will be, and mitigating factors such as shielding and controls that will be employed in implementing the as low as reasonably achievable (ALARA) process. Because of these uncertainties, an attempt was made to maximize the estimates given here by using the upper limit of the dose that could arise from a particular operation. This may have had an effect on the differences between the alternatives, but not likely upon their relative ranking as to worker dose. In any case, for all alternatives the average individual worker dose and the administrative control level for the individual are much lower than the standard of 5 rem per year.

DOE (10 CFR 835) requires that the ALARA process be applied to reduce worker exposure to ionizing radiation. The DOE also has set an administrative control level of 2 rem per year for an individual worker exposure, and LANL has set a level of 1 rem per year. These levels can be intentionally exceeded only with higher level management approvals.

Occasionally, however, individual radiation workers might be given permission to exceed this level if sufficient justification exists. It is not anticipated that any of the groups will request permission to exceed the DOE administrative control level (ACL) of 2 rem per year. Therefore, the maximum worker dose for any of the SWEIS alternatives was estimated to be approximately 1.95 rem per year for the purposes of this SWEIS. This maximum dose estimate would not vary across alternatives and would remain below 5 rem per year in the absence of accidental exposures.

D.2.2.2 *Nonionizing Radiation Consequences to Humans and Other Biota*

A review of the LANL OSHA 200 Logs (LANL 1990 to 1996) and of DOE's Occurrence Reporting and Processing System (ORPS) reports (LANL 1990 to 1995) was performed to identify any reported injuries to workers from nonionizing radiation. Because there are no incidences of nonionizing radiation injuries to workers, a hypothetical analysis of a worst-case exposure was hypothesized for the SWEIS.

In order to perform this analysis, a methodology was needed to relate a transmitter output to biological effect. The methodology developed was consistent with NCRP 67 (1981), NCRP 86 (1986) NCRP 119 (1993), Cember (1996), and Calder (1984). A spreadsheet was developed that allows the input of transmitter parameters (power, frequency, and antenna size), receptor parameters (exposure area, organism density, organism specific heat rate), and exposure parameters (distance and exposure time) to be used to determine the rise in receptor temperature due to an exposure. Additionally, the spreadsheet was used to determine the power densities at specific distances or the distance to a specific power density.

Four typical targets of interest were chosen for microwave radiation exposure at the TA–49 microwave transmitter: human, to represent both workers and the public at the nearest potential exposure point; zone-tailed hawk, to represent birds of all sizes in the Jemez Mountains; coyote, to represent middle-range animals; and elk, to represent large grazing animals. Exposure duration is governed by the operation of the microwave transmitter and is typically limited to short bursts. These give the range of potential effects of nonionizing radiation on higher order complex animals.

The area immediately around the transmitter(s) is secured. The closest that a member of the general public can get to a transmitter is approximately 1,640 feet (500 meters) to the southwest, along State Route 4. By procedure, all microwave experiments are directed east, away from State Route 4. Procedures do not permit directing the microwave beam above the horizontal plane. On site, the downrange microwave beam path is secured to a distance of 3,280 feet (1,000 meters). The receiving antenna(s) can be positioned anywhere along the beam path. Beyond 3,280 feet (1,000 meters), the beam path is uncontrolled other than by the remoteness of the facility.

The results are expressed as increased body temperature as a result of a short burst exposure. This estimate is conservative because even exposure to 1 second from the source is extremely unlikely. Results for potential microwave exposures for the targets of interest are given in Table D.2.2.2–1. Beyond the distances given in Table D.2.2.2–1, and more typical of the distances humans would be from the microwave source, body temperature increase would be less than that given in the table.

There is no increase in body temperature of humans or other animals evaluated for a 1-second exposure to microwaves. The negligible consequences resulting from body temperature rise of a target would not approach any critical metabolic temperature. However, body temperature changes could be greater if the person or animal were exposed for long periods, or were closer to the source, or if there were increased power output.

D.2.2.3 *Chemical Exposures Consequences to Workers*

There have been no fatal or disabling chemical exposures at LANL in the 1990's, and there is no reason to expect that this would change under any of the alternatives analyzed in this SWEIS.

TABLE D.2.2.2–1.—*Temperature Rise Due to Microwave Exposure (1-Second Exposure Duration)*

TARGET	DISTANCE IN FEET (METERS)	BODY TEMPERATURE RISE (°C)
Zone-Tailed Hawk	1,640 (500)	0.016
Coyote	3,280 (1,000)	0.0055
Elk	3,280 (1,000)	0.0036
Human	1,640 (500)	0.021
	3,280 (1,000)	0.0052

°C = degrees centigrade

It is anticipated that there would continue to be a few, less serious exposures annually, particularly exposures to: airborne asbestos, lead paint particulates, crystalline silica, fuming perchloric acid, hydrofluoric acid, or skin contact with acids or alkalis. These would be similar to those listed in Table 4.6.2.1–2.

Rates of such chemical exposures were projected by alternative on the basis of changes in the LANL worker population. During the recent years (1990 to 1996) reportable chemical exposures occurred at a rate of one to three incidents per year at LANL, and the worker population was approximately 9,000 individuals. Therefore, the current rate of injuries was used to estimate the number of injuries occurring during continuing operations of LANL, assuming the same rate is experienced in the projected workforce for each of the four alternatives. Although LANL has undertaken a chemical hygiene program that should reduce the rate of chemical exposures in the future, this methodology assumes no additional benefits from implementation of this program.

Beryllium

There is an ongoing beryllium worker monitoring program at LANL within the facility (Sigma) where beryllium is processed in quantities and chemical forms posing worker hazards.

The Chronic Beryllium Disease (CBD) Program Plan elements consist of conducting a baseline inventory and sampling, conducting hazard assessments, conducting exposure monitoring, reducing and minimizing exposures, conducting medical surveillance, providing training, keeping records, and providing performance feedback. Exposure reduction and minimization includes reducing airborne levels of beryllium as-low-as-practical, minimizing the number of current workers exposed and potentially increasing the number of early treatment options that may slow the progression of CBD and reduce health impacts and reduce mortality incidence. The disability associated with CBD is believed to be minimized by early detection of the disease. Workers sensitized to beryllium or with CBD are offered placement in positions without beryllium exposure to maintain employment, and are assured of secure benefits that provide medical care.

The presentation and progression of CBD are highly variable. A percentage of individuals with positive peripheral blood beryllium-induced lymphocyte proliferation test (Be-LPT) results go on to be diagnosed with CBD even though clinical signs and symptoms of CBD are not present at the time of the test.

The qualitative consequence analysis presented in chapter 5 was based on (1) engineering controls and the health and safety program to be implemented when the Beryllium Technology Center is opened in late 1998, and (2) industry standards and exposure limits under OSHA, as well as recommendations of American Conference of Governmental Industrial Hygienists (ACGIH) and National Institute for Occupational Safety and Health (NIOSH). These are summarized below.

OSHA Beryllium Exposure Limits

The OSHA General Industry Standard (20 CFR 1910.1000) establishes the following permissible exposure limits for beryllium:

- *8-Hour Time Weighted Average, 2 micrograms per cubic meter*—An employee's exposure to beryllium and its compounds in any 8-hour work shift of a 40-hour work week shall not exceed 2 micrograms per cubic meter.
- *Acceptable Ceiling Concentration, 5 micrograms per cubic meter*—An employee's exposure to beryllium and its compounds shall not exceed at any time during an 8-hour shift the 5 micrograms per cubic meter acceptable ceiling concentration limit.
- *Acceptable Maximum Peak Concentration, 25 micrograms per cubic meter*—An employee's exposure to beryllium and its compounds shall not exceed 25 micrograms per cubic meter, the acceptable maximum peak above the acceptable ceiling concentration, for a maximum duration of 30 minutes.

These exposure limits are repeated in 29 CFR 1926 for construction and were adopted from the American National Standards Institute (ANSI) standard, ANSI Z37.29–1970.

OSHA has specific beryllium requirements for welding and cutting on beryllium-containing base or filler metals in 29 CFR 1910.252(c)(8):

> Welding or cutting indoors, outdoors, or in confined spaces involving beryllium-containing base or filler metals shall be done using local exhaust ventilation and airline respirators unless atmospheric tests under the most adverse conditions have established that the workers' exposure is within the acceptable concentrations defined by 29 CFR 1910.1000. In all cases, workers in the immediate vicinity of the welding or cutting operations shall be protected as necessary by local exhaust ventilation or airline respirators.

These requirements are repeated in 29 CFR 1926 for construction activities. In addition, OSHA Technical Manual CPL 2-2.20B references beryllium in Chapter 1, "Personal Sampling for Air Contaminants," Appendix 1–E, "Sampling for Special Analyses," under "Samples Analyzed by Inductively Coupled Plasma" and in Chapter 2, "Sampling for Surface Contamination," which suggests swipe sampling of surfaces since accumulated toxic materials such as beryllium "may become suspended in air, and may contribute to airborne exposures. Bulk and wipe samples are used as aids in determining this possibility."

NIOSH Recommendation for Beryllium

The NIOSH Recommended Exposure Level (Ceiling) is 0.5 $\mu g/m^3$.

NIOSH also identifies beryllium as an occupational carcinogen.

American Conference of Governmental Industrial Hygienists Beryllium TLV

The ACGIH has established a threshold limit value (TLV) for beryllium and beryllium compounds. The TLV 8-hour TWA is 2 micrograms per cubic meter. The ACGIH lists beryllium and beryllium compounds as an A1 carcinogen, a confirmed human carcinogen. ACGIH explains this classification in their documentation of TLVs by indicating that the weight of evidence supports the view that beryllium is a confirmed human carcinogen but is of such low potency that only persons exposed to levels similar to those existing in the

Lorain and Reading plants in the 1940's would be at significant risk of developing lung cancer[1] (ACGIH 1997).

The ongoing medical surveillance program provides assurance that the processing level industrial hygiene monitoring measures are effective at detecting any beryllium exposure during beryllium operations. Worker exposure to beryllium from HE processing and testing would be the same as that experienced by the public and is discussed in section D.3.2.

D.2.2.4 *Worker Physical Safety Consequences*

Rates of accidents and injuries which are potentially within normal operations at LANL were projected by alternative on the basis of changes in the LANL worker population. Physical hazards include exposures to such hazards as slow leaks from compressed air cylinders of toxic gases such as acetylene, used in welding, or small "pony" bottles of specialized gases used in chemical processing or bench-scale research and development. Electrical hazards, industrial hazards associated with building maintenance and renovation, and ergonomic hazards are typical throughout LANL facilities and field sites. During 1995, reportable accidents and injuries occurred at a rate of 4.6 per 100 workers at LANL, and this rate was used in the SWEIS analyses to generate Table D.2.2.4–1. Although LANL has initiated a program to improve worker health and safety performance, no credit was taken for implementation of this program in the projections of accidents and injuries.

1. As an example, data for the Lorain plant found exposures ranging from 411 micrograms per cubic meter ($\mu g/m^3$) in the general area near a mix operation to 43,300 $\mu g/m^3$ in the breathing zone at an alloy operation.

TABLE D.2.2.4–1.—*Projected Recordable Cases per Alternative at LANL*

ALTERNATIVE	WORKER POPULATION	PROJECTED RECORDABLE CASES	PERCENT CHANGE FROM BASE CASE
Base Case	9,081	418	--
No Action	9,667	445	6.5
Expanded Operations	11,003	507	21.3
Reduced Operations	9,052	417	-0.2
Greener	9,656	445	6.5

D.3 ANALYSIS OF POTENTIAL PUBLIC HUMAN HEALTH CONSEQUENCES DUE TO THE CONTINUED OPERATION OF LANL

This section presents the detailed analyses performed with regard to the potential for the continued operation of LANL to affect public health.

D.3.1 Public Health Consequence Analysis

The analysis presented on human health consequences is extremely conservative. That is, DOE has used as a methodology to identify possible consequences based on maximum concentration estimates of radionuclides and chemicals in the environment, maximum exposure durations, and maximum estimates of ingestion or inhalation intake rates. The slope factors used to estimate carcinogenic risk and the reference doses used to estimate hazard indices, as well as the unit risk concentration used to evaluate outcomes were all established by EPA to be protective of human health, and therefore, include safety factors in order to avoid potential underestimation of impacts.

The conservatism is used in analysis of potential consequences because of the high degree of uncertainty associated with attempting to realistically estimate exposure, resulting dose, and resulting health effects. Therefore, the resulting values of risk (such as excess LCFs or hazard index) are believed to be worst-case consequences to a hypothetical receptor. The hypothetical receptor is not a person living in the community but an analytical construct representing a person who would be in the location of maximum concentrations of radionuclides or chemicals, take the maximum amounts of these contaminants into the person's body, and experience the worst outcome.

Uncertainties in public health consequence analysis include:

- Actual exposures to radionuclides and chemicals in each exposure pathway (inhalation, ingestion and immersion)
- Exposure durations to radionuclides and chemicals present in low concentrations in air, soils and sediments, water, and foodstuffs
- Variability among humans in reaction to exposure to radionuclides and chemicals
- Synergisms among chemicals/radionuclides in the exposed person, synergisms between chemical/radionuclides and natural phenomena (such as solar radiation and exposure to ultraviolet sources, as well as inhalation of radionuclides from LANL operations), and interactions between some chemicals/radionuclides and other stressors or behaviors such as smoking

D.3.1.1 *Inhalation Radiological Doses Estimated to the Public from LANL and Specific Key Facilities Under the Four Alternatives for Continued Operations*

The methods used to estimate the radiological dose from air emissions from specific facilities and from LANL as a site are summarized in sections 5.1.4 and 5.1.6 and are detailed in appendix B. The estimated doses to both the facility-specific and LANL-wide MEI are presented in Table D.3.1.1–1 for each of the four alternatives for continued operations. These values are also presented by alternative in sections 5.2.6.1 (No Action), 5.3.6.1 (Expanded Operations), 5.4.6.1 (Reduced Operations), and 5.5.6.1 (Greener). As detailed in section 5.1.6 and appendix D, section D.2, the ICRP methodologies for estimated cancer risk per rem dose received were applied to these estimates and are reported in chapter 5 in the referenced sections.

TABLE D.3.1.1–1.—*Facility-Specific and LANL-Wide MEI Doses and 50-Mile (80-Kilometer) Population Doses from LANL Continued Operations*[a]

FACILITY	MEI DISTANCE FT (M)[b]	MEI DIRECTION[b]	NO ACTION MREM/YR	EXPANDED OPERATIONS MREM/YR	REDUCED OPERATIONS MREM/YR	GREENER MREM/YR
CMR (TA–3–39)	3,576 (1,090)	N	0.43	1.32	0.36	0.35
Sigma (TA–3–66)	3,560 (1,085)	N	0.43	1.32	0.36	0.35
Machine Shops (TA–3–102)	3,379 (1,030)	N	0.34	1.02	0.29	0.28
HE Testing (TA–11)	4,298 (1,310)	S	0.31	0.73	0.31	0.31
HE Testing (TA–15 and TA–36)	7,415 (2,260)	NE	2.26	4.99	1.76	2.17
WETF (TA–16)	2,886 (880)	SSE	0.31	0.70	0.22	0.31
Pajarito Site (TA–18)	2,821 (860)	NE	1.73	4.39	1.51	1.93
TSTA/TSFF (TA–21)	1,050 (320)	N	1.41	2.55	1.22	1.54
Radiochemistry (TA–48)	2,920 (890)	NNE	1.66	3.67	1.08	1.64
LANSCE (TA–53)	2,625 (800)	NNE	3.11	5.44	1.88	4.52
Area G (TA–54)	1,197 (365) bndry	NE	0.75	1.81	0.68	0.79
	5,331 (1,625) WR	SW	0.43	1.07	0.39	0.45
Plutonium Facility (TA–55)	3,691 (1,125)	N	1.66	3.67	1.08	1.64
LANL-Wide MEI	2,625 (800)[c]	NNE	3.11	5.44	1.88	4.52
Regional Population Dose	50-mi (80-km) radius		13.59	33.09	10.83	13.79

[a] *Source*: Appendix B, sections B.1.1 and B.1.2.
[b] MEI direction and distance are from the stated facility.
[c] The LANL-wide MEI is the LANSCE MEI.
CMR = Chemistry and Metallurgy Research, HE = high explosives, WETF = Weapons Engineering Tritium Facility, TSTA = Tritium System Test Assembly, TSFF = Tritium Science and Fabrication Facility

D.3.1.2 *Public Radiological Doses from Ingestion for all Four Alternatives*

The methodology for estimating the public doses through ingestion is described in section D.2.1.2. Because there is no release that would increase existing concentrations in the environmental media comprising the ingestion pathways (food, soil, sediment, water), the projected doses are the same for the baseline and all four alternatives. These are given in Table 5.2.6.1–2 for an average (50^{th} percentile) intake of contaminated media, and in Table 5.2.6.1–3 for the worst-case (95^{th} percentile) consumption of contaminated media.

D.3.2 Analysis of Public Health Consequences from High Explosives Testing Site Chemical Emissions

In applying the nonradiological air quality methodology as presented in section 5.1.4.1, three chemicals (depleted uranium, beryllium, and lead) were identified from one or more of four TAs (TA–14, TA–15, TA–36 and TA–39) in which high explosives are tested as being of sufficient concentrations to require human health analysis. While a few other metals were identified using the screen (appendix B, section B.2), their reference doses (EPA 1997b) were high, potential concentrations in air were overestimated using the conservative screening methodologies applied, and have low toxicities and low probabilities of carcinogenicity. Therefore, they were not quantitatively evaluated for human health consequences. These metals were:

- Aluminum
- Copper
- Iron
- Tantalum
- Tungsten

The modeling used to estimate exposures to the public from HE chemical emissions under the No Action and Expanded Operations Alternatives is presented in section 5.1.4.1 and detailed in appendix B (sections B.2.3.2 and B.2.3.3). (The quantities of expended materials were the same for the Reduced Operations and Greener Alternatives as for No Action.)

Tables D.3.2–1 (No Action, Reduced Operations, and Greener) and D.3.2–2 (Expanded Operations) present the results of the modeling performed to estimate the concentration of specific chemicals at the MEI location for each TA. The chronic daily uptake was calculated as presented in appendix D.2.1 for both the average uptake and worst-case uptake, using EPA's *Exposure Factors Handbook* (EPA 1997a). The hazard index is presented for uranium and lead, based on the reference dose give in EPA's Integrated Risk Information System (EPA 1997b). A hazard index of 1 or greater than one is considered indicative of a potential health hazard to exposed individuals. EPA has not published a reference dose for inhalation of beryllium. Therefore, a hazard index could not be calculated for beryllium.

TABLE D.3.2–1.—*Analysis of Public Health Consequences from Specific Chemicals Emitted from the High Explosives Test Areas (TA–14, TA–15, TA–36, and TA–39) in the No Action, Reduced Operations, and Greener Alternatives*[a,c]

TECHNICAL AREA	CHEMICAL	ANNUAL RESPIRABLE EMISSION RATE (kg/yr)	MODELED HOURLY EMISSIONS RATE (g/sec)	CONCENTRATION AT MEI LOCATION (μg/m^3)	CHRONIC DAILY UPTAKE (mg/kg-day) AVERAGE	CHRONIC DAILY UPTAKE (mg/kg-day) WORST CASE	HAZARD INDEX AVERAGE	HAZARD INDEX WORST CASE
TA–14	Depleted Uranium	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	< 1.6E-6	< 3.0E-6
	Lead	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	< 4.9E-6	< 9.8E-6
TA–15	Beryllium	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	[b]	[b]
	Depleted Uranium	90	2.9E-3	1.5E-4	3.2E-9	6.2E-9	2.3E-6	4.5E-6
	Lead	5	1.7E-4	1.0E-5	2.1E-9	4.2E-9	4.9E-6	9.7E-6
TA–36	Beryllium	1.0	3.0E-5	< 1.0E-5	< 2.2E-9	< 4.2E-9	[b]	[b]
	Depleted Uranium	40	1.3E-5	1.3E-4	2.8E-8	5.4E-8	2.0E-5	3.9E-5
	Lead	1.0	3.0E-5	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 4.6E-6	< 9.8E-6
TA–39	Beryllium	1.0	3.0E-5	< 1.0E-5	< 2.1E-9	< 4.2E-9	[b]	[b]
	Lead	1.0	3.0E-5	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 4.9E-6	< 9.8E-6

Source: Appendix B, sections B.2.3.2 and B.2.3.3.

[a] Depleted uranium, beryllium, and lead were identified in the nonradiological air quality evaluation as requiring public health consequence analysis under the Expanded Operations Alternative. For the No Action, Reduced Operations, and Greener Alternatives, emissions were estimated as one-third that of the Expanded Operations emissions based on the annual expenditures of materials projected for these alternatives for continued HE testing.

[b] There is currently no reference dose for beryllium inhalation (EPA 1997b); therefore, no hazard index could be calculated. Based on the inhalation unit risk factor (EPA 1997b) of 2.4E-3 per μg/m^3, the maximum beryllium carcinogenic risk would be < 3.6E-8/year.

[c] Values rounded to 2 significant figures.

TABLE D.3.2–2.—*Analysis of Public Health Consequences from Specific Chemicals Emitted from the High Explosives Test Areas (TA–14, TA–15, TA–36, and TA–39) in the Expanded Operations Alternative (Values Rounded to 2 Significant Digits)*[a]

TECHNICAL AREA	CHEMICAL	ANNUAL RESPIRABLE EMISSION RATE (kg/yr)	MODELED HOURLY EMISSIONS RATE (g/sec)	CONCENTRATION AT MEI LOCATION (μg/m³)	CHRONIC DAILY UPTAKE (mg/kg-Day) AVERAGE	CHRONIC DAILY UPTAKE (mg/kg-Day) WORST CASE	HAZARD INDEX AVERAGE	HAZARD INDEX WORST CASE
TA–14	Depleted Uranium	3.1	1.0E-4	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 1.5E-6	< 3.0E-6
	Lead	3.1	1.0E-4	< 1.0E-5	< 2.1E-9	< 4.2E-9	< 4.9E-6	< 9.8E-6
TA–15	Beryllium	3.0	1.0E-4	1.0E-5	2.1E-9	4.2E-9	b	b
	Depleted Uranium	270	8.6E-3	4.3E-4	9.1E-8	1.8E-7	6.5E-5	1.3E-4
	Lead	15	5.0E-4	3.0E-5	6.4E-8	1.3E-8	1.5E-5	2.9E-5
TA–36	Beryllium	3.0	1.0E-4	1.0E-5	2.1E-9	4.2E-9	b	b
	Depleted Uranium	120	3.8E-3	3.9E-4	8.3E-8	1.6E-7	5.9E-5	1.2E-4
	Lead	3.0	1.0E-4	1.0E-5	2.2E-9	4.2E-9	4.9E-6	9.7E-6
TA–39	Beryllium	3.0	1.0E-4	1.0E-5	2.2E-9	4.2E-9	b	b
	Lead	3.0	1.0E-4	1.0E-5	2.2E-9	4.2E-9	4.91E-6	9.7E-6

Source: Appendix B, sections B.2.3.2 and B.2.3.3.

[a] Depleted uranium, beryllium, and lead were identified in the nonradiological air quality evaluation as requiring public health consequence analysis under the Expanded Operations Alternative.

[b] There is currently no reference dose for beryllium inhalation (EPA 1997b); therefore, no hazard index could be calculated. Based on the inhalation unit risk factor (EPA 1997b) of 2.4E-3 per μg/m³, the beryllium carcinogenic risk would be approximately 3.6E-8/year.

[c] Values rounded to 2 significant figures.

D.3.3 Estimates of Dose and Risk from Radiological and Metallic Contaminants Potentially Ingested by Residents, Recreational Users of LANL Lands, and via Special Pathways

The methodology for estimating dose and risk from contaminants that could be ingested as or with food and water is given in section 5.1.6 and detailed in appendix D, section D.2.1.2. The data on which the estimates of ingestion and risk were based were environmental surveillance data, which are presented in appendix D, section D.3.5.

Each table presented in this section (Tables D.3.3–1 through D.3.3–50, provided as an attachment to this appendix) contains the concentration data used for calculations. The 95 percent UCL was used for the concentrations. The 95 percent UCL was determined as the average value, plus twice the standard deviation. In calculating the UCL, all samples of zero or negative value or less than the detection limit were rejected. This significantly increases the UCL, and especially so when a large fraction of the samples show no detectable contamination. In other words, in this conservative approach, a few samples that show measurable contamination will receive disproportionate weighting in the distribution. Both the average intake and worst-case intake were estimated using EPA's *Exposures Factors Handbook* (EPA 1997a). All dose conversion factors are given in the tables.

These tables represent the risk estimated from all alternatives based on ingestion. The risk factors used are conservative and represent the upper bound of the risk. The risk is uncertain and could be much smaller, as discussed in section D.1.1.8. Note that for ingestion pathways, exposure limits for exposure by inhalation are not applicable. There are no estimated differences in contaminant levels that would result from implementation of any of the four alternatives for continued operations. There is a discussion of concentrations of radiological and metallic contaminants in media in the region of Los Alamos versus background concentrations of these in the region presented in section D.3.4. Total risks estimated for ingestion are presented in chapter 5, specifically in section 5.2.6.1 (No Action).

D.3.3.1 *Potential Exposures to Tritium via Los Alamos Canyon*

As a result of recent studies and concerns with regard to tritium in groundwater from recent and historical releases in and near Los Alamos Canyon, this section briefly summarizes the present status of knowledge found in the LANL annual environmental reports.

In the past, Los Alamos Canyon received treated and untreated industrial effluents containing some radionuclides. In the upper reach of Los Alamos Canyon there were releases of treated and untreated radioactive effluents during the earliest Manhattan Project operations at TA–1 (late 1940's) and some release of water and radionuclides from the research reactors at TA–2. Los Alamos Canyon also received discharges containing radionuclides from the sanitary sewage lagoon system at LANSCE (formerly Los Alamos Meson Physics Facility) (TA–53). The low-level radioactive waste stream was separated from the sanitary system at TA–53 in 1989 and directed into a total retention evaporation lagoon. An industrial liquid waste treatment plan that served the old plutonium processing facility at TA–21 discharged effluent containing radionuclides into DP Canyon, a tributary to Los Alamos Canyon, from 1952 to 1986.

The reach of Los Alamos Canyon within the LANL boundary currently carries flow from the Los Alamos Reservoir (west of LANL), as well as National Pollutant Discharge Elimination System (NPDES)-permitted effluents from TA–2, TA–53, and TA–21. Infiltration of NPDES-permitted effluents and natural runoff from the stream channel maintains a shallow body of groundwater in the alluvium of Los Alamos Canyon within the LANL boundary west of State Road 4. Groundwater levels are highest in late spring from snowmelt runoff and in late summer from thundershowers. Water levels decline during the winter and early summer when runoff is at a minimum. Depth to water is typically in the range of 4 feet to 15 feet (1.2 meters to 4.6 meters). Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on Pueblo of San Ildefonso lands. This alluvium is not continuous with the alluvium within LANL boundaries, and can be sampled utilizing wells installed by the Bureau of Indian Affairs.

The EPA primary drinking water standard and the New Mexico livestock watering standard are both 20,000 picocuries per liter. No tritium has been detected in surface or groundwater samples using the EPA-specified method with a detection limit of 700 picocuries per liter. LANL reported a sample of surface water with 200 picocuries per liter in 1995, and samples ranging from 78 to 428 picocuries per liter in 1994. Intermediate groundwater in 1994 and 1995 had a concentration of only 27 picocuries per liter. However, these values may be meaningless, in that the past detection limit may actually be 800 to as much as 2,000 picocuries per liter, as discussed in section 5 of the 1995 annual environmental surveillance report (LANL 1996b). In any event, the tritium concentrations are well below the standards for drinking water. Tritium content of sediments could not be measured due to insufficient moisture content.

Special study samples analyzed by Miami University with a detection limit of 0.3 picocuries per liter have demonstrated minimal recharge of the regional aquifer by surface waters. Details of special and routine measurements of tritium are found in the 1996 environmental surveillance report (LANL 1997).

D.3.3.2 *Mortandad Canyon*

Mortandad Canyon has a small drainage area that heads at TA–3. Its drainage area currently receives inflow from natural precipitation and a number of NPDES-permitted effluents, including one from the existing Radioactive Liquid Waste Treatment Facility at TA–50. The TA–50 facility began operations in 1963. In six cases during the period from 1993 through 1995, the derived concentration guide (DCG) was exceeded for: americium-241 in 1993; americium-241 and plutonium-238 in 1994; and plutonium-238, plutonium-239, plutonium-240, and americum-241 in 1995. For each of these years, the effluent nitrate concentrations exceeded the New Mexico groundwater standard of 10 milligrams per liter (nitrate as nitrogen). The groundwater standard applies because the TA–50 effluent infiltrates the alluvium in the canyon. In order to address these problems, LANL is working to upgrade the TA–50 treatment process. These effluents infiltrate the stream channel and maintain a saturated zone in the alluvium extending about 2.2 miles (3.5 kilometers) downstream from the TA–50 NPDES-permitted outfall. The easternmost extent of saturation is on site, about 1 mile (1.6 kilometers) west of the LANL boundary with the Pueblo of San Ildefonso. Surface flow in the drainage has not reached the Pueblo since observations began in the early 1960's.

Radioanalytical results for sediments collected from Mortandad Canyon in 1996 were modeled using the RESRAD model, version 5.61 (LANL 1997). The pathways evaluated are the external gamma pathway from radioactive material deposited in the sediments, the inhalation pathway from materials resuspended by winds, and the soil ingestion pathway. Because water in the canyon is not used for drinking water or irrigation, and there are no cattle grazing in the canyon or gardens in the canyon, the drinking water, meat ingestion, and fruit/vegetable ingestion pathways were not considered.

The RESRAD model was run for each sampled location and for the entire canyon system, with 10 to 14 samples per analyte collected throughout the canyon. For modeling purposes, it is assumed that the area of interest around each monitored location is 1,076 square feet (100 square meters). The site is part of an industrial complex where access to the monitored location is somewhat limited; thus, the amount of time a person spends in the canyon is limited to approximately 87 hours per year (Robinson and Thomas 1991), and there is no cover material over the site of interest that would reduce external exposure to radionuclides. The input parameters for the RESRAD model are summarized in LANL 1997. RESRAD calculates the daughter radionuclides based on the initial radionuclide concentration and time since placement of material.

The TEDE (i.e., the sum of the effective dose equivalents from the external gamma, and the inhalation and soil ingestion pathways) is presented in Table D.3.3.2–1. For comparison, the 1995 TEDE for each monitoring location is shown also. The TEDE, using the average concentration of all monitoring locations in Mortandad Canyon, is 6.0 millirem. The error term associated with this average value is extremely large, reflecting the high degree of variability in the concentrations throughout the canyon. In 1996, the average TEDE plus twice the error term (Table D.3.3.2–1) ranged from 0.19 millirem near the Chemistry and Metallurgy Research (CMR) Building to 27 millirem at the GS–1 sampling location.

TABLE D.3.3.2–1.—*Total Effective Dose Equivalent*[a] *for Mortandad Canyon (mrem)*

LOCATION	1996		1995	
Near CMR Building	0.16	(± 0.032)[b]	0.10	(± 0.14)[b]
West of GS–1	3.3	(± 0.60)[b]	0.17	(± 0.081)[b]
GS–1	24	(± 3.4)[b]	37	(± 5.9)[b]
MCO–5	21	(± 3.2)[b]	19	(± 3.3)[b]
MCO–7	8.8	(± 1.4)[b]	4.3	(± 0.95)[b]
MCO–9	0.78	(± 0.21)[b]	0.62	(± 0.20)[b]
MCO–13 (A–5)	0.65	(± 0.19)[b]	0.43	(± 1.1)[b]
A–6	0.41	(± 0.097)[b]	0.79	(± 1.2)[b]
A–7	0.36	(± 0.072)[b]	0.19	(± 0.10)[b]
A–8	—[c]		0.30	(± 0.15)[b]
SR–4 (A–9)	0.19	(± 0.057)[b]	0.17	(± 0.088)[b]
A–10	—[c]		0.061	(± 0.028)[b]
Rio Grande (A–11)	0.16	(± 0.12)[b]	0.10	(± 0.054)[b]
Average for Entire Mortandad Canyon	6.0	(± 22)[b]	6.8	(± 0.30)[b]

[a] Based on results from RESRAD (version 5.61) using three exposure pathways: ingestion, inhalation, and external.
[b] ±2 sigma in parenthesis
[c] No sample collected at these locations in 1996.

The maximum TEDE for monitoring sites surrounding the GS–1 site (i.e., west of GS–1, MCO–5, MCO–7, and MCO–9) increased in 1996 over the 1995 values. These five monitoring locations represent 96 percent of the 1996 maximum TEDE for the entire canyon system. The only radionuclide that contributed more than 5 percent to the TEDE at these locations is cesium-137 for each of the five sites. For the other monitoring locations (i.e., near the CMR Building, MCO–13 [A–5], A–6, A–7, A–9, and A–11), the naturally occurring radionuclides of uranium, and strontium-90 and cesium-137 from nuclear atmospheric testing contributed more than 5 percent to the TEDE at these monitoring locations. Averaged over the entire canyon system, cesium-137 and americium-241 contributed more than 5 percent to the canyon TEDE. The external pathway contributed more than 88 percent (with the cesium-137 contribution being more than 86 percent) to the total TEDE for the entire canyon system. Because there is a pathway approximately 10 feet (3 meters) from the stream channel and the external component falls off with distance from the source, the estimated TEDE is reduced to approximately 6 millirem in a year (i.e., 2.7 millirem from the external pathway and 3.3 millirem from all other pathways considered).

TABLE D.3.3–1.—*Ingestion of Radioactive Isotopes from LANL Supply Wells for an Off-Site Los Alamos County Resident (From ESR 1991–1996 Data, see Table D.3.5–2)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	9.31E-02	4.50E-06	2.30E-04	3.73E-04
Cesium-137[1]	2.30E+00	5.00E-08	6.33E-05	1.02E-04
Plutonium-238	2.40E-02	3.80E-06	5.02E-05	8.13E-05
Plutonium-239 and Plutonium-240	2.39E-01	4.30E-06	5.65E-04	9.16E-04
Strontium-90	4.48E+00	1.30E-07	3.20E-04	5.19E-04
Tritium	8.44E+02	6.30E-11	2.92E-05	4.74E-05
Uranium[2]	1.29E+00	2.60E-07	1.85E-04	2.99E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.44E-03	2.34E-03
Cancer Risk yr^{-1}			7.22E-07	1.17E-06
[1] Cesium-137 from ESR 1992–1996 data (see text). [2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).				
Average-Case Consumption				
5.50E+02 L/yr	=number of liters per year			
Worst-Case Consumption				
8.91E+02 L/yr	=number of liters per year			
1 yr	=exposure duration			
Uranium Conversion:		**U=**	**1.82**	**μg/L**
pCi U isotope / L water = μg total Uranium/L water X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/μg)			**RMA**	**SA**
U-238 =	6.05E-01 pCi/L		0.9928	3.35E+05
U-235 =	2.83E-02 pCi/L		0.0072	2.16E+06
U-234 =	6.59E-01 pCi/L		0.000058	6.24E+09
Total U Activity =	**1.29E+00 pCi/L**			

TABLE D.3.3–2.—*Ingestion of Metals in LANL Supply Wells to Off-Site Los Alamos County Residents (From ESR 1991–1996 Data, see Table D.3.5–2)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	8.20E+01	1.72E-03	2.79E-03	5.0E-03	-	3.44E-01	5.58E-01		
AL	2.97E+02	6.23E-03	1.01E-02	1.8E-01	-	3.46E-02	5.61E-02		
AS[1]	4.00E+01	8.39E-04	1.36E-03	3.0E-04	1.5E+00	2.80E+00	4.53E+00	1.26E-03	2.04E-03
B	2.01E+02	4.22E-03	6.83E-03	9.0E-02	-	4.69E-02	7.59E-02		
BA	8.35E+01	1.75E-03	2.84E-03	7.0E-02	-	2.50E-02	4.06E-02		
BE[2]	2.50E+00	5.25E-05	8.50E-05	5.0E-03	4.3E+00	1.05E-02	1.70E-02	2.26E-04	3.65E-04
CD	7.93E+00	1.66E-04	2.70E-04	5.0E-04	1.8E-03	3.33E-01	5.39E-01	3.00E-07	4.85E-07
CN *	1.00E+01	2.10E-04	3.40E-04	2.0E-02	-	1.05E-02	1.70E-02		
CO	2.46E+02	5.16E-03	8.36E-03	6.0E-02	-	8.60E-02	1.39E-01		
CR	1.87E+01	3.92E-04	6.36E-04	1.0E+00	-	3.92E-04	6.36E-04		
CU	3.33E+01	6.99E-04	1.13E-03	1.9E-02	-	3.68E-02	5.96E-02		
HG	2.70E-01	5.67E-06	9.18E-06	3.0E-04	-	1.89E-02	3.06E-02		
LI *	4.58E+01	9.61E-04	1.56E-03	2.0E-02	-	4.81E-02	7.79E-02		
MN	4.91E+01	1.03E-03	1.67E-03	1.4E-01	-	7.36E-03	1.19E-02		
MO	1.81E+01	3.80E-04	6.15E-04	5.0E-03	-	7.60E-02	1.23E-01		
NI	2.66E+01	5.58E-04	9.04E-04	2.0E-02	-	2.79E-02	4.52E-02		
NO3-N *	3.47E+03	7.28E-02	1.18E-01	1.6E+00	-	4.55E-02	7.37E-02		
PB[3]	6.40E+01	1.34E-03	2.18E-03	1.4E-03	no data	9.59E-01	1.55E+00		
SB	3.45E+00	7.24E-05	1.17E-04	4.0E-04	-	1.81E-01	2.93E-01		
SE	3.03E+00	6.36E-05	1.03E-04	5.0E-03	-	1.27E-02	2.06E-02		
SN	3.85E+01	8.08E-04	1.31E-03	6.0E-01	-	1.35E-03	2.18E-03		
SR	1.52E+02	3.19E-03	5.17E-03	6.0E-01	-	5.32E-03	8.61E-03		

TABLE D.3.3–2.—*Ingestion of Metals in LANL Supply Wells to Off-Site Los Alamos County Residents (From ESR 1991–1996 Data, see Table D.3.5–2)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
TI	1.00E+01	2.10E-04	3.40E-04	-					
TL[4]	2.64E+01	5.54E-04	8.98E-04	8.0E-05	-	6.93E+00	1.12E+01		
U	1.82E+00	3.82E-05	6.19E-05	3.0E-03	no data	1.27E-02	2.06E-02		
V	1.14E+02	2.39E-03	3.88E-03	9.0E-03	-	2.66E-01	4.31E-01		
ZN	4.93E+01	1.03E-03	1.68E-03	3.0E-01	-	3.45E-03	5.59E-03		

[1] Arsenic concentrations ranged from 2 to 48 µg/L in 33 of 56 samples analyzed with a mean of 12.4 µg/L for detected values.
[2] Beryllium concentrations ranged from 1 to 2 µg/L in 5 of 56 samples analyzed with a mean of 1.4 µg/L for detected values.
[3] Lead concentrations ranged from 1 to 95 µg/L in 17 of 59 samples with a mean of 14.6 µg/L for detected values
[4] Thallium concentrations ranged from 0.3 to 19 µg/L in 4 of 56 samples analyzed with a mean of 9.83 µg/L for detected values.
Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–2.—*Ingestion of Metals in LANL Supply Wells to Off-Site Los Alamos County Residents (From ESR 1991–1996 Data, see Table D.3.5–2)*-Continued

Groundwater Ingestion Factors

Intake (mg/kg-day) = (CW x IR x EF x ED x CF)/(BW x AT)

Note: modified from 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = LANL Supply Well concentration
1.51E+00	L/day	IR = **Average-Case** ingestion rate
365	days/yr	EF = **Average-Case** exposure frequency
2.44E+00	L/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 550 liters per year yields 1.51 liters per day for Average-Case.
Note: 891 liters per year yields 2.44 liters per day for Worst-Case.

TABLE D.3.3–3.—*Ingestion of Radioactive Isotopes from Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.37E-02	4.50E-06	8.34E-05	1.35E-04
Cesium-137[1]	1.70E+00	5.00E-08	4.68E-05	7.57E-05
Plutonium-238	6.49E-02	3.80E-06	1.36E-04	2.20E-04
Plutonium-239 and Plutonium-240	4.69E-02	4.30E-06	1.11E-04	1.80E-04
Strontium-90	8.44E-01	1.30E-07	6.03E-05	9.78E-05
Tritium	2.91E+02	6.30E-11	1.01E-05	1.63E-05
Uranium[2]	9.09E-01	2.60E-07	1.30E-04	2.11E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			5.77E-04	9.35E-04
Cancer Risk yr^{-1}			2.89E-07	4.67E-07

[1] Cesium-137 was detected in 1991 (LANL 1993) and 1993 (LANL 1995). However, due to concerns with the 1991 - 1992 data (see text), only the 1993 sample is used.
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).

Average-Case Consumption			
5.50E+02 L/yr	=number of liters per year		
Worst-Case Consumption			
8.91E+02 L/yr	=number of liters per year		
1 yr	=exposure duration		
Uranium Conversion:	**U=**	**1.28**	**µg/L**

pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF

RMA = relative mass abundance (g isotope per g total U)

SA = specific activity (pCi/g)

CF = conversion factor (1E-06 g/µg)

		RMA	SA
U-238 =	4.26E-01 pCi/L	0.9928	3.35E+05
U-235 =	1.99E-02 pCi/L	0.0072	2.16E+06
U-234 =	4.63E-01 pCi/L	0.000058	6.24E+09
Total U Activity =	**9.09E-01 pCi/L**		

TABLE D.3.3–4.—*Ingestion of Metals in Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AL	6.20E+01	1.30E-03	2.11E-03	1.8E-01	-	7.23E-03	1.17E-02		
AS[1]	3.82E+00	8.02E-05	1.30E-04	3.0E-04	1.5E+00	2.67E-01	4.33E-01	1.20E-04	1.95E-04
B	3.10E+01	6.51E-04	1.05E-03	9.0E-02	-	7.23E-03	1.17E-02		
BA	6.84E+01	1.44E-03	2.33E-03	7.0E-02	-	2.05E-02	3.32E-02		
BE	not detected			5.0E-03	4.3E+00				
CD	not detected			5.0E-04	1.8E-03				
CN *	not detected			2.0E-02	-				
CO	not detected			6.0E-02	-				
CR	3.58E+01	7.51E-04	1.22E-03	1.0E+00	-	7.51E-04	1.22E-03		
CU	not detected			1.9E-02	-				
F *	not detected			6.0E-02	-				
FE	8.50E+02	1.78E-02	2.89E-02	-	-				
HG	1.00E-01	2.10E-06	3.40E-06	3.0E-04	-	7.00E-03	1.13E-02		
LI *	not detected			2.0E-02	-				
MN	4.92E+01	1.03E-03	1.67E-03	1.4E-01	-	7.38E-03	1.19E-02		
MO	1.70E+00	3.57E-05	5.78E-05	5.0E-03	-	7.14E-03	1.16E-02		
NI	not detected			2.0E-02	-				
NO2-N *	not detected			1.0E-01	-				
NO3-N *	9.16E+02	1.92E-02	3.11E-02	1.6E+00	-	1.20E-02	1.95E-02		
PB	not detected			1.4E-03	no data				
SB	3.00E-01	6.30E-06	1.02E-05	4.0E-04	-	1.57E-02	2.55E-02		
SE	2.00E+00	4.20E-05	6.80E-05	5.0E-03	-	8.39E-03	1.36E-02		

TABLE D.3.3–4.—*Ingestion of Metals in Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
SN	1.00E+01	2.10E-04	3.40E-04	6.0E-01	-	3.50E-04	5.67E-04		
SR	2.62E+02	5.50E-03	8.91E-03	6.0E-01	-	9.16E-03	1.48E-02		
TL	4.00E-02	8.39E-07	1.36E-06	8.0E-05	-	1.05E-02	1.70E-02		
U	1.28E+00	2.69E-05	4.35E-05	3.0E-03	no data	8.95E-03	1.45E-02		
V	3.65E+01	7.66E-04	1.24E-03	9.0E-03	-	8.51E-02	1.38E-01		
ZN	1.61E+03	3.38E-02	5.47E-02	3.0E-01	-	1.13E-01	1.82E-01		
Chloroethane	1.30E+01	2.73E-04	4.42E-04	1.0E-01	-	2.73E-03	4.42E-03		

[1] Arsenic concentrations ranged from 2 to 3 µg/L in 3 of 4 samples analyzed with a mean of 2.67 µg/L for detected values.
Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–4.—*Ingestion of Metals in Supply Well LA-5 for an Off-Site Totavi Resident (From ESR 1991–1996 Data, see Table D.3.5–3)*-Continued

Groundwater Ingestion Factors

Intake (mg/kg-day) = (CW x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = LA-5 supply well concentration
1.51E+00	L/day	IR = **Average-Case** ingestion rate
365	days/yr	EF = **Average-Case** exposure frequency
2.44E+00	L/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 550 liters per year yields 1.51 liters per day for Average-Case.
Note: 891 liters per year yields 2.44 liters per day for Worst-Case.

TABLE D.3.3–5.—*Ingestion of Radioactive Isotopes from San Ildefonso Supply Wells for an Off-Site Non-Los Alamos County Resident (From ESR 1991–1996 Data, see Table C-6 but without LA-5 Well)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	6.10E-02	4.50E-06	1.51E-04	2.45E-04
Cesium-137[1]	3.56E+00	5.00E-08	9.79E-05	1.59E-04
Plutonium-238	8.69E-02	3.80E-06	1.82E-04	2.94E-04
Plutonium-239 and Plutonium-240	1.47E-01	4.30E-06	3.48E-04	5.63E-04
Strontium-90	3.84E+00	1.30E-07	2.75E-04	4.45E-04
Tritium	1.13E+03	6.30E-11	3.92E-05	6.34E-05
Uranium[2]	2.14E+01	2.60E-07	3.07E-03	4.97E-03
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			4.16E-03	6.74E-03
Cancer Risk yr^{-1}			2.08E-06	3.37E-06

[1] Cesium-137 from ESR 1992–1996 (see text).
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).

Average-Case Consumption				
5.50E+02 L/yr		=number of liters per year		
Worst-Case Consumption				
8.91E+02 L/yr		=number of liters per year		
1 yr		=exposure duration		
Uranium Conversion:		**U=**	**30.2**	**µg/L**
pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.00E+01 pCi/L		0.9928	3.35E+05
U-235 =	4.70E-01 pCi/L		0.0072	2.16E+06
U-234 =	1.09E+01 pCi/L		0.000058	6.24E+09
Total U Activity =	**2.14E+01 pCi/L**			

TABLE D.3.3–6.—*Ingestion of Metals in San Ildefonso Supply Wells for an Off-Site Non-Los Alamos County Resident (From ESR 1991–1996 Data, see Table C-6 But Without LA-5 Well)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	6.76E+01	1.42E-03	2.30E-03	5.0E-03	-	2.84E-01	4.60E-01		
AL	1.97E+02	4.13E-03	6.70E-03	1.8E-01	-	2.30E-02	3.72E-02		
AS[1]	2.18E+01	4.58E-04	7.41E-04	3.0E-04	1.5E+00	1.53E+00	2.47E+00	6.86E-04	1.11E-03
B	1.68E+03	3.53E-02	5.71E-02	9.0E-02	-	3.92E-01	6.35E-01		
BA	3.33E+01	6.99E-04	1.13E-03	7.0E-02	-	9.98E-03	1.62E-02		
BE[2]	2.04E+01	4.28E-04	6.94E-04	5.0E-03	4.3E+00	8.56E-02	1.39E-01	1.84E-03	2.98E-03
CD	5.49E+00	1.15E-04	1.87E-04	5.0E-04	1.8E-03	2.30E-01	3.73E-01	2.07E-07	3.36E-07
CN *	3.00E+01	6.30E-04	1.02E-03	2.0E-02	-	3.15E-02	5.10E-02		
CO	5.61E+01	1.18E-03	1.91E-03	6.0E-02	-	1.96E-02	3.18E-02		
CR	3.58E+01	7.51E-04	1.22E-03	1.0E+00	-	7.51E-04	1.22E-03		
CU	5.98E+01	1.26E-03	2.03E-03	1.9E-02	-	6.61E-02	1.07E-01		
HG	1.36E+00	2.85E-05	4.62E-05	3.0E-04	-	9.51E-02	1.54E-01		
LI *	2.80E+02	5.88E-03	9.52E-03	2.0E-02	-	2.94E-01	4.76E-01		
MN	1.62E+01	3.40E-04	5.51E-04	1.4E-01	-	2.43E-03	3.93E-03		
MO	4.50E+01	9.44E-04	1.53E-03	5.0E-03	-	1.89E-01	3.06E-01		
NI	4.47E+01	9.38E-04	1.52E-03	2.0E-02	-	4.69E-02	7.60E-02		
NO3-N *	1.15E+04	2.41E-01	3.91E-01	1.6E+00	-	1.51E-01	2.44E-01		
PB	5.78E+00	1.21E-04	1.97E-04	1.4E-03	no data	8.66E-02	1.40E-01		
SB	6.88E+00	1.44E-04	2.34E-04	4.0E-04	-	3.61E-01	5.85E-01		
SE	6.49E+00	1.36E-04	2.21E-04	5.0E-03	-	2.72E-02	4.41E-02		
SR	1.22E+03	2.56E-02	4.15E-02	6.0E-01	-	4.27E-02	6.91E-02		
TL	7.66E-01	1.61E-05	2.60E-05	8.0E-05	-	2.01E-01	3.26E-01		

TABLE D.3.3–6.—*Ingestion of Metals in San Ildefonso Supply Wells for an Off-Site Non-Los Alamos County Resident (From ESR 1991–1996 Data, see Table C-6 But Without LA-5 Well)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	3.02E+01	6.34E-04	1.03E-03	3.0E-03	no data	2.11E-01	3.42E-01		
V	3.94E+01	8.27E-04	1.34E-03	9.0E-03	-	9.19E-02	1.49E-01		
ZN	2.76E+02	5.79E-03	9.38E-03	3.0E-01	-	1.93E-02	3.13E-02		

[1] Arsenic concentrations ranged from 2 to 41 µg/L in 44 of 48 samples analyzed with a mean of 9.07 µg/L for detected values.
[2] Beryllium concentrations ranged from 1 to 17 µg/L in 6 of 48 samples analyzed with a mean of 7 µg/L for detected values.
Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Groundwater Ingestion Factors

Intake (mg/kg-day) = (CW x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = San Ildefonso supply well concentration
1.51E+00	L/day	IR = **Average-Case** ingestion rate
365	days/yr	EF = **Average-Case** exposure frequency
2.44E+00	L/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 550 liters per year yields 1.51 liters per day for Average-Case.
Note: 891 liters per year yields 2.44 liters per day for Worst-Case.

TABLE D.3.3–7.—*Ingestion of Radioactive Isotopes in Surface Water for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-2*)

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.20E+00	4.50E-06	2.88E-05	4.67E-05
Cesium-137[1]	2.49E+01	5.00E-08	6.64E-06	1.08E-05
Plutonium-238	1.10E+00	3.80E-06	2.23E-05	3.61E-05
Plutonium-239 and Plutonium-240	1.00E+01	4.30E-06	2.29E-04	3.72E-04
Strontium-90	2.40E+02	1.30E-07	1.66E-04	2.70E-04
Tritium	7.70E+00	6.30E-11	2.59E-09	4.19E-09
Uranium[2]	2.41E+00	2.60E-07	3.35E-06	5.42E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			4.57E-04	7.40E-04
Cancer Risk yr^{-1}			2.28E-07	3.70E-07

[1] Cesium-137 from ESR 1993–1996 data (see text).
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg 36 (see below).

Average-Case Consumption	
2.78E-02 L/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
5.33E+00 L/yr	=number of liters per year

Worst-Case Consumption	
4.50E-02 L/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
8.64E+00 L/yr	=number of liters per year
1 yr	=exposure duration

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

Uranium Conversion:		**U=**	**3.4**	**µg/L**
pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.13E+00 pCi/L		0.9928	3.35E+05
U-235 =	5.29E-02 pCi/L		0.0072	2.16E+06
U-234 =	1.23E+00 pCi/L		0.000058	6.24E+09
Total U Activity =	**2.41E+00 pCi/L**			

TABLE D.3.3–8.—*Ingestion of Metals in Surface Water to Resident Recreational User (From ESR 1991–1996 Data, see Table C-2)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	3.50E+02	7.12E-05	1.15E-04	5.0E-03	-	1.42E-02	2.31E-02		
AL	2.40E+04	4.88E-03	7.91E-03	1.8E-01	-	2.71E-02	4.40E-02		
AS	1.00E+01	2.04E-06	3.30E-06	3.0E-04	1.5E+00	6.78E-03	1.10E-02	3.05E-06	4.95E-06
B	2.50E+02	5.09E-05	8.24E-05	9.0E-02	-	5.65E-04	9.16E-04		
BA	4.70E+02	9.56E-05	1.55E-04	7.0E-02	-	1.37E-03	2.21E-03		
BE	8.40E+01	1.71E-05	2.77E-05	5.0E-03	4.3E+00	3.42E-03	5.54E-03	7.35E-05	1.19E-04
CD	1.30E+02	2.65E-05	4.29E-05	5.0E-04	1.8E-03	5.29E-02	8.57E-02	4.76E-08	7.71E-08
CN *	7.90E+01	1.61E-05	2.60E-05	2.0E-02	-	8.04E-04	1.30E-03		
CO	1.10E+02	2.24E-05	3.63E-05	6.0E-02	-	3.73E-04	6.04E-04		
CR	2.80E+02	5.70E-05	9.23E-05	1.0E+00	-	5.70E-05	9.23E-05		
CU	2.80E+02	5.70E-05	9.23E-05	1.9E-02	-	3.00E-03	4.86E-03		
F *	1.80E+03	3.66E-04	5.93E-04	6.0E-02	-	6.11E-03	9.89E-03		
FE	2.00E+04	4.07E-03	6.59E-03	-	-				
HG	7.40E-01	1.51E-07	2.44E-07	3.0E-04	-	5.02E-04	8.13E-04		
LI *	6.40E+01	1.30E-05	2.11E-05	2.0E-02	-	6.51E-04	1.05E-03		
MN	8.20E+02	1.67E-04	2.70E-04	1.4E-01	-	1.19E-03	1.93E-03		
MO	8.60E+02	1.75E-04	2.84E-04	5.0E-03	-	3.50E-02	5.67E-02		
NI	6.80E+02	1.38E-04	2.24E-04	2.0E-02	-	6.92E-03	1.12E-02		
NO2-N *	4.60E+02	9.36E-05	1.52E-04	1.0E-01	-	9.36E-04	1.52E-03		
NO3-N *	1.40E+04	2.85E-03	4.62E-03	1.6E+00	-	1.78E-03	2.88E-03		
PB	2.80E+01	5.70E-06	9.23E-06	1.4E-03	no data	4.07E-03	6.59E-03		
SB	2.50E+00	5.09E-07	8.24E-07	4.0E-04	-	1.27E-03	2.06E-03		

TABLE D.3.3–8.—*Ingestion of Metals in Surface Water to Resident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
SE	4.50E+02	9.16E-05	1.48E-04	5.0E-03	-	1.83E-02	2.97E-02		
SN	1.90E+02	3.87E-05	6.26E-05	6.0E-01	-	6.44E-05	1.04E-04		
SO4 *	9.30E+04	1.89E-02	3.07E-02		-				
SR	3.90E+02	7.94E-05	1.29E-04	6.0E-01	-	1.32E-04	2.14E-04		
TL	4.30E+00	8.75E-07	1.42E-06	8.0E-05	-	1.09E-02	1.77E-02		
U	3.40E+00	6.92E-07	1.12E-06	3.0E-03	no data	2.31E-04	3.74E-04		
V	6.00E+01	1.22E-05	1.98E-05	9.0E-03	-	1.36E-03	2.20E-03		
ZN	2.20E+02	4.48E-05	7.25E-05	3.0E-01	-	1.49E-04	2.42E-04		
Acetone	6.10E+01	1.24E-05	2.01E-05	1.0E-01	-	1.24E-04	2.01E-04		
Benzoic acid	1.10E+01	2.24E-06	3.63E-06	4.0E+00	-	5.60E-07	9.07E-07		
Bis(2-ethylhexyl) phthalate	1.90E+01	3.87E-06	6.26E-06	2.0E-02	1.4E-02	1.93E-04	3.13E-04	5.41E-08	8.77E-08
Di-n-butyl phthalate	1.80E+01	3.66E-06	5.93E-06	1.0E-01	-	3.66E-05	5.93E-05		
Di-n-octyl phthalate	8.00E+00	1.63E-06	2.64E-06	2.0E-02	-	8.14E-05	1.32E-04		
HMX	4.90E+00	9.97E-07	1.62E-06	5.0E-02	-	1.99E-05	3.23E-05		
RDX	7.60E-01	1.55E-07	2.51E-07	3.0E-03	1.1E-01	5.16E-05	8.35E-05	1.70E-08	2.76E-08

Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–8.—*Ingestion of Metals in Surface Water to Resident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

Surface Water Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–9.—*Ingestion of Radioactive Isotopes in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.20E+00	4.50E-06	1.08E-05	1.75E-05
Cesium-137[1]	2.49E+01	5.00E-08	2.49E-06	4.03E-06
Plutonium-238	1.10E+00	3.80E-06	8.36E-06	1.35E-05
Plutonium-239 and Plutonium-240	1.00E+01	4.30E-06	8.60E-05	1.39E-04
Strontium-90	2.40E+02	1.30E-07	6.24E-05	1.01E-04
Tritium	7.70E+00	6.30E-11	9.70E-10	1.57E-09
Uranium[2]	2.41E+00	2.60E-07	1.26E-06	2.03E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.71E-04	2.78E-04
Cancer Risk yr^{-1}			8.57E-08	1.39E-07

[1] Cesium-137 from ESR 1993–1996 data (see text).
[2] Uranium was converted using the formula from Fresquez et al. 1996, Appendix B, pg. 36 (see below).

Average-Case Consumption	
2.78E-02 L/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
2.00E+00 L/yr	=number of liters per year

Worst-Case Consumption	
4.50E-02 L/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
3.24E+00 L/yr	=number of liters per year
1 yr	=exposure duration

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

Uranium Conversion:		**U=**	**3.4**	**µg/L**
pCi U isotope / L water = µg total Uranium/L water X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.13E+00 pCi/L		0.9928	3.35E+05
U-235 =	5.29E-02 pCi/L		0.0072	2.16E+06
U-234 =	1.23E+00 pCi/L		0.000058	6.24E+09
Total U Activity =	**2.41E+00 pCi/L**			

TABLE D.3.3–10.—*Ingestion of Metals in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	3.50E+02	2.67E-05	4.33E-05	5.0E-03	-	5.34E-03	8.65E-03		
AL	2.40E+04	1.83E-03	2.97E-03	1.8E-01	-	1.02E-02	1.65E-02		
AS	1.00E+01	7.63E-07	1.24E-06	3.0E-04	1.5E+00	2.54E-03	4.12E-03	1.14E-06	1.85E-06
B	2.50E+02	1.91E-05	3.09E-05	9.0E-02	-	2.12E-04	3.43E-04		
BA	4.70E+02	3.59E-05	5.81E-05	7.0E-02	-	5.12E-04	8.30E-04		
BE	8.40E+01	6.41E-06	1.04E-05	5.0E-03	4.3E+00	1.28E-03	2.08E-03	2.76E-05	4.47E-05
CD	1.30E+02	9.92E-06	1.61E-05	5.0E-04	1.8E-03	1.98E-02	3.21E-02	1.79E-08	2.89E-08
CN *	7.90E+01	6.03E-06	9.77E-06	2.0E-02	-	3.01E-04	4.88E-04		
CO	1.10E+02	8.39E-06	1.36E-05	6.0E-02	-	1.40E-04	2.27E-04		
CR	2.80E+02	2.14E-05	3.46E-05	1.0E+00	-	2.14E-05	3.46E-05		
CU	2.80E+02	2.14E-05	3.46E-05	1.9E-02	-	1.12E-03	1.82E-03		
F *	1.80E+03	1.37E-04	2.23E-04	6.0E-02	-	2.29E-03	3.71E-03		
FE	2.00E+04	1.53E-03	2.47E-03	-	-				
HG	7.40E-01	5.65E-08	9.15E-08	3.0E-04	-	1.88E-04	3.05E-04		
LI *	6.40E+01	4.88E-06	7.91E-06	2.0E-02	-	2.44E-04	3.96E-04		
MN	8.20E+02	6.26E-05	1.01E-04	1.4E-01	-	4.47E-04	7.24E-04		
MO	8.60E+02	6.56E-05	1.06E-04	5.0E-03	-	1.31E-02	2.13E-02		
NI	6.80E+02	5.19E-05	8.41E-05	2.0E-02	-	2.59E-03	4.20E-03		
NO2-N *	4.60E+02	3.51E-05	5.69E-05	1.0E-01	-	3.51E-04	5.69E-04		
NO3-N *	1.40E+04	1.07E-03	1.73E-03	1.6E+00	-	6.68E-04	1.08E-03		
PB	2.80E+01	2.14E-06	3.46E-06	1.4E-03	no data	1.53E-03	2.47E-03		

TABLE D.3.3–10.—*Ingestion of Metals in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
SB	2.50E+00	1.91E-07	3.09E-07	4.0E-04	-	4.77E-04	7.73E-04		
SE	4.50E+02	3.43E-05	5.56E-05	5.0E-03	-	6.87E-03	1.11E-02		
SN	1.90E+02	1.45E-05	2.35E-05	6.0E-01	-	2.42E-05	3.91E-05		
SR	3.90E+02	2.98E-05	4.82E-05	6.0E-01	-	4.96E-05	8.04E-05		
TL	4.30E+00	3.28E-07	5.32E-07	8.0E-05	-	4.10E-03	6.65E-03		
U	3.40E+00	2.59E-07	4.20E-07	3.0E-03	no data	8.65E-05	1.40E-04		
V	6.00E+01	4.58E-06	7.42E-06	9.0E-03	-	5.09E-04	8.24E-04		
ZN	2.20E+02	1.68E-05	2.72E-05	3.0E-01	-	5.60E-05	9.07E-05		
Acetone	6.10E+01	4.66E-06	7.54E-06	1.0E-01	-	4.66E-05	7.54E-05		
Benzoic acid	1.10E+01	8.39E-07	1.36E-06	4.0E+00	-	2.10E-07	3.40E-07		
Bis(2-ethylhexyl) phthalate	1.90E+01	1.45E-06	2.35E-06	2.0E-02	1.4E-02	7.25E-05	1.17E-04	2.03E-08	3.29E-08
Di-n-butyl phthalate	1.80E+01	1.37E-06	2.23E-06	1.0E-01	-	1.37E-05	2.23E-05		
Di-n-octyl phthalate	8.00E+00	6.11E-07	9.89E-07	2.0E-02	-	3.05E-05	4.95E-05		
HMX	4.90E+00	3.74E-07	6.06E-07	5.0E-02	-	7.48E-06	1.21E-05		
RDX	7.60E-01	5.80E-08	9.40E-08	3.0E-03	1.1E-01	1.93E-05	3.13E-05	6.38E-09	1.03E-08

Note: gray shaded cells in UCL column have no 95% UCL - maximum value used.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–10.—*Ingestion of Metals in Surface Water for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-2)*-Continued

Surface Water Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	**Units**	**Parameter**
e.g., B3	µg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
365	d	AT = ED* 365 days

TABLE D.3.3–11.—*Ingestion of Radioactive Isotopes in NPDES Discharge Water for a Resident Recreational User (From NPDES Data, 1994–1996, see Table D.3.5–4)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Tritium	3.70E+04	6.30E-11	1.24E-05	2.01E-05
Radium-226 and Radium-228	7.30E+00	1.20E-06	4.67E-05	7.57E-05
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			5.92E-05	9.58E-05
Cancer Risk yr^{-1}			2.96E-08	4.79E-08
Average-Case Consumption				
2.78E-02 L/hr	=ingestion rate per hour			
8 hr/event	=number of hours per visit			
24 events/yr	=number of visits per year			
5.33E+00 L/yr	=number of liters per year			
Worst-Case Consumption				
4.50E-02 L/hr	=ingestion rate per hour			
8 hr/event	=number of hours per visit			
24 events/yr	=number of visits per year			
8.64E+00 L/yr	=number of liters per year			
1 yr	=exposure duration			

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

TABLE D.3.3–12.—*Ingestion of Metals in NPDES Discharge for a Resident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AL	7.50E+02	1.53E-04	2.47E-04	1.8E-01	-	8.48E-04	1.37E-03		
AS	2.60E+01	5.29E-06	8.57E-06	3.0E-04	1.5E+00	1.76E-02	2.86E-02	7.94E-06	1.29E-05
B	5.40E+02	1.10E-04	1.78E-04	9.0E-02	-	1.22E-03	1.98E-03		
CD	1.00E+01	2.04E-06	3.30E-06	5.0E-04	1.8E-03	4.07E-03	6.59E-03	3.66E-09	5.93E-09
CO	1.70E+01	3.46E-06	5.60E-06	6.0E-02	-	5.77E-05	9.34E-05		
CR	3.80E+01	7.73E-06	1.25E-05	1.0E+00	-	7.73E-06	1.25E-05		
CU	2.50E+02	5.09E-05	8.24E-05	1.9E-02	-	2.68E-03	4.34E-03		
HG	1.70E+00	3.46E-07	5.60E-07	3.0E-04		1.15E-03	1.87E-03		
PB	3.20E+01	6.51E-06	1.05E-05	1.4E-03	no data	4.65E-03	7.54E-03		
SE	4.60E+00	9.36E-07	1.52E-06	5.0E-03	-	1.87E-04	3.03E-04		
V	4.70E+01	9.56E-06	1.55E-05	9.0E-03	-	1.06E-03	1.72E-03		
ZN	3.40E+02	6.92E-05	1.12E-04	3.0E-01	-	2.31E-04	3.74E-04		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–12.—*Ingestion of Metals in NPDES Discharge for a Resident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*-Continued

NPDES Discharge Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–13.—*Ingestion of Radioactive Isotopes in NPDES Discharge Water for a Nonresident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Tritium	3.70E+04	6.30E-11	4.66E-06	7.55E-06
Radium-226 and Radium-228	7.30E+00	1.20E-06	1.75E-05	2.84E-05
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			2.22E-05	3.59E-05
Cancer Risk yr^{-1}			1.11E-08	1.80E-08
Average-Case Consumption				
2.78E-02 L/hr	=ingestion rate per hour			
6 hr/event	=number of hours per visit			
12 events/yr	=number of visits per year			
2.00E+00 L/yr	=number of liters per year			
Worst-Case Consumption				
4.50E-02 L/hr	=ingestion rate per hour			
6 hr/event	=number of hours per visit			
12 events/yr	=number of visits per year			
3.24E+00 L/yr	=number of liters per year			
1 yr	=exposure duration			

Note: 0.5 liters per day over 18 hrs yields 2.78E-02 L/hr for Average-Case.
Note: Average case increased by 1.62 yields 4.5E-02 L/hr for Worst-Case.

TABLE D.3.3–14.—*Ingestion of Metals in NPDES Discharge for a Nonresident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AL	7.50E+02	5.72E-05	9.27E-05	1.8E-01	-	3.18E-04	5.15E-04		
AS	2.60E+01	1.98E-06	3.21E-06	3.0E-04	1.5E+00	6.61E-03	1.07E-02	2.98E-06	4.82E-06
B	5.40E+02	4.12E-05	6.68E-05	9.0E-02	-	4.58E-04	7.42E-04		
CD	1.00E+01	7.63E-07	1.24E-06	5.0E-04	1.8E-03	1.53E-03	2.47E-03	1.37E-09	2.23E-09
CO	1.70E+01	1.30E-06	2.10E-06	6.0E-02	-	2.16E-05	3.50E-05		
CR	3.80E+01	2.90E-06	4.70E-06	1.0E+00	-	2.90E-06	4.70E-06		
CU	2.50E+02	1.91E-05	3.09E-05	1.9E-02	-	1.00E-03	1.63E-03		
HG	1.70E+00	1.30E-07	2.10E-07	3.0E-04		4.32E-04	7.01E-04		
PB	3.20E+01	2.44E-06	3.96E-06	1.4E-03	no data	1.74E-03	2.83E-03		
SE	4.60E+00	3.51E-07	5.69E-07	5.0E-03	-	7.02E-05	1.14E-04		
V	4.70E+01	3.59E-06	5.81E-06	9.0E-03	-	3.99E-04	6.46E-04		
ZN	3.40E+02	2.59E-05	4.20E-05	3.0E-01	-	8.65E-05	1.40E-04		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–14.—*Ingestion of Metals in NPDES Discharge for a Nonresident Recreational User (From NPDES 1994–1996 Data, see Table D.3.5–4)*-Continued

NPDES Discharge Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	µg/L	CW = On-site concentration
2.78E-02	L/hr	IR = **Average-Case** ingestion rate (0.5 L / 18 hours)
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
4.50E-02	L/hr	IR = **Worst-Case** ingestion rate (0.5 L * 1.62 / 18 hours)
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-03	mg/µg	CF = Conversion factor
71.8	kg	BW = Body weight
365	d	AT = ED* 365 days

TABLE D.3.3–15.—*Ingestion of Radioactive Isotopes in Perimeter Soil for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table D.3.5–5)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.70E-02	4.50E-06	6.08E-06	2.43E-05
Cesium-137	9.80E-01	5.00E-08	1.79E-06	7.15E-06
Plutonium-238	2.90E-02	3.80E-06	4.02E-06	1.61E-05
Plutonium-239 and Plutonium-240	2.13E-01	4.30E-06	3.34E-05	1.34E-04
Strontium-90	7.00E-01	1.30E-07	3.32E-06	1.33E-05
Tritium[1]	8.44E-02	6.30E-11	1.94E-10	7.77E-10
Uranium[2]	3.12E+00	2.60E-07	2.96E-05	1.19E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			7.83E-05	3.13E-04
Cancer Risk yr^{-1}			3.91E-08	1.57E-07

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
1.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
3.65E+01 g/yr	=number of grams per year

Worst-Case Consumption	
4.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
1.46E+02 g/yr	=number of grams per year
1 yr	=exposure duration

Tritium Conversion:	**H^3=**	**0.76**	**pCi/mL**

pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])

fraction soil moisture = 10%

soil moisture density = 1 g/mL

Tritium Activity (pCi/g) = 8.44E-02

TABLE D.3.3–15.—*Ingestion of Radioactive Isotopes in Perimeter Soil for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table D.3.5–5)*-Continued

Uranium Conversion:		**U=**	**4.4**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.46E+00 pCi/g		0.9928	3.35E+05
U-235 =	6.84E-02 pCi/g		0.0072	2.16E+06
U-234 =	1.59E+00 pCi/g		0.000058	6.24E+09
Total U Activity =	**3.12E+00 pCi/g**			

TABLE D.3.3–16.—*Ingestion of Metals in Perimeter Soil to an Off-Site Resident (Nonspecific County) (From ESR 1992–1996 Data, see Table D.3.5–5)*

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.40E+00	1.95E-06	7.80E-06	5.0E-03	-	3.90E-04	1.56E-03		
AL	3.50E+00	4.87E-06	1.95E-05	1.8E-01	-	2.71E-05	1.08E-04		
AS[1]	3.90E+00	5.43E-06	2.17E-05	3.0E-04	1.5E+00	1.81E-02	7.24E-02	8.15E-06	3.26E-05
B	1.40E+01	1.95E-05	7.80E-05	9.0E-02	-	2.17E-04	8.67E-04		
BA	1.60E+02	2.23E-04	8.91E-04	7.0E-02	-	3.18E-03	1.27E-02		
BE[2]	9.90E-01	1.38E-06	5.52E-06	5.0E-03	4.3E+00	2.76E-04	1.10E-03	5.93E-06	2.37E-05
CD	6.00E-01	8.36E-07	3.34E-06	5.0E-04	1.8E-03	1.67E-03	6.69E-03	1.50E-09	6.02E-09
CO	8.20E+00	1.14E-05	4.57E-05	6.0E-02	-	1.90E-04	7.61E-04		
CR	1.30E+01	1.81E-05	7.24E-05	1.0E+00	-	1.81E-05	7.24E-05		
CU	9.00E+00	1.25E-05	5.01E-05	1.9E-02	-	6.60E-04	2.64E-03		
HG	5.00E-02	6.96E-08	2.79E-07	3.0E-04	-	2.32E-04	9.29E-04		
MN	6.50E+02	9.05E-04	3.62E-03	1.4E-01	-	6.47E-03	2.59E-02		
MO	8.50E-01	1.18E-06	4.74E-06	5.0E-03	-	2.37E-04	9.47E-04		
NI	8.60E+00	1.20E-05	4.79E-05	2.0E-02	-	5.99E-04	2.40E-03		
PB	3.60E+01	5.01E-05	2.01E-04	1.4E-03	no data	3.58E-02	1.43E-01		
SB	1.70E-01	2.37E-07	9.47E-07	4.0E-04	-	5.92E-04	2.37E-03		
SE	6.40E-01	8.91E-07	3.57E-06	5.0E-03	-	1.78E-04	7.13E-04		
SN	1.00E+01	1.39E-05	5.57E-05	6.0E-01	-	2.32E-05	9.29E-05		
SR	3.60E+01	5.01E-05	2.01E-04	6.0E-01	-	8.36E-05	3.34E-04		
TL	1.70E+00	2.37E-06	9.47E-06	8.0E-05	-	2.96E-02	1.18E-01		

TABLE D.3.3–16.—*Ingestion of Metals in Perimeter Soil to an Off-Site Resident (Nonspecific County) (From ESR 1992–1996 Data, see Table D.3.5–5)*-Continued

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.40E+00	6.13E-06	2.45E-05	3.0E-03	no data				
V	2.90E+01	4.04E-05	1.62E-04	9.0E-03	-	4.49E-03	1.80E-02		
ZN	4.90E+01	6.82E-05	2.73E-04	3.0E-01	-	2.27E-04	9.10E-04		

[1] Detected values of Arsenic had a mean of 2.37 ± 1.53 µg/g (2 sigma).
[2] Detected values for Beryllium had a mean of 0.66 ± 0.33 µg/g (2 sigma).
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

Perimeter Soil Ingestion Factors

Intake (mg/kg-day) = (CS x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CS = perimeter soil concentration
1.00E+02	mg/day	IR = **Average-Case** ingestion rate
365	day/yr	EF = **Average-Case** exposure frequency
4.00E+02	mg/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–17.—*Ingestion of Radioactive Isotopes in Soil for a Resident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.90E-02	4.50E-06	9.12E-08	3.65E-07
Cesium-137	1.01E+00	5.00E-08	5.39E-08	2.15E-07
Plutonium-238	2.20E-02	3.80E-06	8.92E-08	3.57E-07
Plutonium-239 and Plutonium-240	4.03E-01	4.30E-06	1.85E-06	7.39E-06
Strontium-90	7.80E-01	1.30E-07	1.08E-07	4.33E-07
Tritium[1]	2.59E-01	6.30E-11	1.74E-11	6.96E-11
Uranium[2]	3.41E+00	2.60E-07	9.45E-07	3.78E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			3.14E-06	1.25E-05
Cancer Risk yr^{-1}			1.57E-09	6.27E-09

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
1.07E+00 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
4.27E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–17.—*Ingestion of Radioactive Isotopes in Soil for a Resident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*-Continued

Tritium Conversion:	**H^3=**	**2.33**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])			
Fraction soil moisture = 10%			
Soil moisture density = 1 g/mL			
Tritium Activity (pCi/g) =	**2.59E-01**		
Uranium Conversion:	**U=**	**4.8**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/µg)		**RMA**	**SA**
U-238 = 1.60E+00 pCi/g		0.9928	3.35E+05
U-235 = 7.46E-02 pCi/g		0.0072	2.16E+06
U-234 = 1.74E+00 pCi/g		0.000058	6.24E+09
Total U Activity = 3.41E+00 pCi/g			

TABLE D.3.3–18.—*Ingestion of Metals in Soil for a Resident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	2.30E+00	9.36E-08	3.74E-07	5.0E-03	-	1.87E-05	7.49E-05		
AL	4.30E+00	1.75E-07	7.00E-07	1.8E-01	-	9.72E-07	3.89E-06		
AS	3.70E+00	1.51E-07	6.02E-07	3.0E-04	1.5E+00	5.02E-04	2.01E-03	2.26E-07	9.04E-07
B	2.40E+01	9.77E-07	3.91E-06	9.0E-02	-	1.09E-05	4.34E-05		
BA	1.70E+02	6.92E-06	2.77E-05	7.0E-02	-	9.88E-05	3.95E-04		
BE	1.00E+00	4.07E-08	1.63E-07	5.0E-03	4.3E+00	8.14E-06	3.26E-05	1.75E-07	7.00E-07
CD	2.70E-01	1.10E-08	4.40E-08	5.0E-04	1.8E-03	2.20E-05	8.79E-05	1.98E-11	7.91E-11
CO	7.90E+00	3.22E-07	1.29E-06	6.0E-02	-	5.36E-06	2.14E-05		
CR	1.20E+01	4.88E-07	1.95E-06	1.0E+00	-	4.88E-07	1.95E-06		
CU	9.70E+00	3.95E-07	1.58E-06	1.9E-02	-	2.08E-05	8.31E-05		
FE	1.80E+00	7.33E-08	2.93E-07	-	-				
HG	4.00E-02	1.63E-09	6.51E-09	3.0E-04	-	5.43E-06	2.17E-05		
MN	6.10E+02	2.48E-05	9.93E-05	1.4E-01	-	1.77E-04	7.09E-04		
MO	9.30E-01	3.79E-08	1.51E-07	5.0E-03	-	7.57E-06	3.03E-05		
NI	9.70E+00	3.95E-07	1.58E-06	2.0E-02	-	1.97E-05	7.90E-05		
PB	3.00E+01	1.22E-06	4.88E-06	1.4E-03	no data	8.72E-04	3.49E-03		
SB	4.50E-01	1.83E-08	7.33E-08	4.0E-04	-	4.58E-05	1.83E-04		
SE	4.80E-01	1.95E-08	7.81E-08	5.0E-03	-	3.91E-06	1.56E-05		
SN	1.20E+01	4.88E-07	1.95E-06	6.0E-01	-	8.14E-07	3.26E-06		
SR	3.90E+01	1.59E-06	6.35E-06	6.0E-01	-	2.65E-06	1.06E-05		
TL	9.30E-01	3.79E-08	1.51E-07	8.0E-05	-	4.73E-04	1.89E-03		

TABLE D.3.3–18.—*Ingestion of Metals in Soil for a Resident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.80E+00	1.95E-07	7.81E-07	3.0E-03	no data	6.51E-05	2.60E-04		
V	3.00E+01	1.22E-06	4.88E-06	9.0E-03	-	1.36E-04	5.43E-04		
ZN	4.90E+01	1.99E-06	7.98E-06	3.0E-01	-	6.65E-06	2.66E-05		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

On-Site Soil Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–19.—*Ingestion of Radioactive Isotopes in Soil for a Nonresident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.90E-02	4.50E-06	3.42E-08	1.37E-07
Cesium-137	1.01E+00	5.00E-08	2.02E-08	8.08E-08
Plutonium-238	2.20E-02	3.80E-06	3.34E-08	1.34E-07
Plutonium-239 and Plutonium-240	4.03E-01	4.30E-06	6.93E-07	2.77E-06
Strontium-90	7.80E-01	1.30E-07	4.06E-08	1.62E-07
Tritium[1]	2.59E-01	6.30E-11	6.52E-12	2.61E-11
Uranium[2]	3.41E+00	2.60E-07	3.54E-07	1.42E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.18E-06	4.70E-06
Cancer Risk yr^{-1}			5.88E-10	2.35E-09

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
4.00E-01 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
1.60E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–19.—*Ingestion of Radioactive Isotopes in Soil for a Nonresident Recreational User (From ESR 1992–1996 Data, see Table D.3.5–5)*-Continued

Tritium Conversion:		**H^3=**	**2.33**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture /soil moisture density X [1-fraction soil moisture])				
fraction soil moisture = 10%				
soil moisture density = 1 g/mL				
Tritium Activity (pCi/g) =		**2.59E-01**		
Uranium Conversion:		**U=**	**4.8**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF				
RMA = relative mass abundance (g isotope per g total U)				
SA = specific activity (pCi/g)				
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**
U-238 =	1.60E+00 pCi/g		0.9928	3.35E+05
U-235 =	7.46E-02 pCi/g		0.0072	2.16E+06
U-234 =	1.74E+00 pCi/g		0.000058	6.24E+09
Total U Activity =	**3.41E+00 pCi/g**			

TABLE D.3.3–20.—*Ingestion of Metals in Soils to a Nonresident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	2.30E+00	3.51E-08	1.40E-07	5.0E-03	-	7.02E-06	2.81E-05		
AL	4.30E+00	6.56E-08	2.63E-07	1.8E-01	-	3.65E-07	1.46E-06		
AS	3.70E+00	5.65E-08	2.26E-07	3.0E-04	1.5E+00	1.88E-04	7.53E-04	8.47E-08	3.39E-07
B	2.40E+01	3.66E-07	1.47E-06	9.0E-02	-	4.07E-06	1.63E-05		
BA	1.70E+02	2.59E-06	1.04E-05	7.0E-02	-	3.71E-05	1.48E-04		
BE	1.00E+00	1.53E-08	6.11E-08	5.0E-03	4.3E+00	3.05E-06	1.22E-05	6.56E-08	2.63E-07
CD	2.70E-01	4.12E-09	1.65E-08	5.0E-04	1.8E-03	8.24E-06	3.30E-05	7.42E-12	2.97E-11
CO	7.90E+00	1.21E-07	4.82E-07	6.0E-02	-	2.01E-06	8.04E-06		
CR	1.20E+01	1.83E-07	7.33E-07	1.0E+00	-	1.83E-07	7.33E-07		
CU	9.70E+00	1.48E-07	5.92E-07	1.9E-02	-	7.79E-06	3.12E-05		
FE	1.80E+00	2.75E-08	1.10E-07	-	-				
HG	4.00E-02	6.11E-10	2.44E-09	3.0E-04	-	2.04E-06	8.14E-06		
MN	6.10E+02	9.31E-06	3.72E-05	1.4E-01	-	6.65E-05	2.66E-04		
MO	9.30E-01	1.42E-08	5.68E-08	5.0E-03	-	2.84E-06	1.14E-05		
NI	9.70E+00	1.48E-07	5.92E-07	2.0E-02	-	7.40E-06	2.96E-05		
PB	3.00E+01	4.58E-07	1.83E-06	1.4E-03	no data	3.27E-04	1.31E-03		
SB	4.50E-01	6.87E-09	2.75E-08	4.0E-04	-	1.72E-05	6.87E-05		
SE	4.80E-01	7.33E-09	2.93E-08	5.0E-03	-	1.47E-06	5.86E-06		
SN	1.20E+01	1.83E-07	7.33E-07	6.0E-01	-	3.05E-07	1.22E-06		
SR	3.90E+01	5.95E-07	2.38E-06	6.0E-01	-	9.92E-07	3.97E-06		
TL	9.30E-01	1.42E-08	5.68E-08	8.0E-05	-	1.77E-04	7.10E-04		

TABLE D.3.3–20.—*Ingestion of Metals in Soils to a Nonresident Recreational User (From ESR 1991–1996 Data, see Table D.3.5–5)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.80E+00	7.33E-08	2.93E-07	3.0E-03	no data	2.44E-05	9.77E-05		
V	3.00E+01	4.58E-07	1.83E-06	9.0E-03	-	5.09E-05	2.04E-04		
ZN	4.90E+01	7.48E-07	2.99E-06	3.0E-01	-	2.49E-06	9.97E-06		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

On-Site Soil Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–21.—*Ingestion of Radioactive Isotopes in Perimeter Sediment for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	2.20E-01	4.50E-06	3.61E-05	1.45E-04
Cesium-137	9.90E-01	5.00E-08	1.81E-06	7.23E-06
Plutonium-238	2.70E-02	3.80E-06	3.74E-06	1.50E-05
Plutonium-239 and Plutonium-240	3.70E+00	4.30E-06	5.81E-04	2.32E-03
Strontium-90	9.30E-01	1.30E-07	4.41E-06	1.77E-05
Tritium[1]	2.11E-01	6.30E-11	4.85E-10	1.94E-09
Uranium[2]	2.98E+00	2.60E-07	2.83E-05	1.13E-04
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			6.55E-04	2.62E-03
Cancer Risk yr^{-1}			3.28E-07	1.31E-06

[1] Tritium was converted from pCi/ml using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
1.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
3.65E+01 g/yr	=number of grams per year
Worst-Case Consumption	
4.00E+02 mg/day	=number of mg per day
365 days/yr	=number of days per year
1.46E+02 g/yr	=number of grams per year
1 yr	=exposure duration
Tritium Conversion:	**H^3= 1.9 pCi/mL**

pCi/g = pCi/ml X (fraction soil moisture /soil moisture density X [1-fraction soil moisture])

fraction soil moisture = 10%

soil moisture density = 1 g/ml

Tritium Activity (pCi/g) = 2.11E-01

TABLE D.3.3–21.—*Ingestion of Radioactive Isotopes in Perimeter Sediment for an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*-Continued

Uranium Conversion:	**U=**	**4.2**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/µg)		**RMA**	**SA**
U-238 =	1.40E+00 pCi/g	0.9928	3.35E+05
U-235 =	6.53E-02 pCi/g	0.0072	2.16E+06
U-234 =	1.52E+00 pCi/g	0.000058	6.24E+09
Total U Activity =	**2.98E+00 pCi/g**		

TABLE D.3.3–22.—*Ingestion of Metals in Perimeter Sediments to an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	2.10E+01	2.92E-05	1.17E-04	5.0E-03	-	5.85E-03	2.34E-02		
AL	1.20E+04	1.67E-02	6.69E-02	1.8E-01	-	9.29E-02	3.71E-01		
AS[1]	1.50E+01	2.09E-05	8.36E-05	3.0E-04	1.5E+00	6.96E-02	2.79E-01	3.13E-05	1.25E-04
B	1.60E+01	2.23E-05	8.91E-05	9.0E-02	-	2.48E-04	9.90E-04		
BA	2.40E+02	3.34E-04	1.34E-03	7.0E-02	-	4.78E-03	1.91E-02		
BE[2]	1.10E+00	1.53E-06	6.13E-06	5.0E-03	4.3E+00	3.06E-04	1.23E-03	6.59E-06	2.64E-05
CD	1.60E+00	2.23E-06	8.91E-06	5.0E-04	1.8E-03	4.46E-03	1.78E-02	4.01E-09	1.60E-08
CO	8.00E+00	1.11E-05	4.46E-05	6.0E-02	-	1.86E-04	7.43E-04		
CR	1.00E+01	1.39E-05	5.57E-05	1.0E+00	-	1.39E-05	5.57E-05		
CU	1.60E+01	2.23E-05	8.91E-05	1.9E-02	-	1.17E-03	4.69E-03		
HG	6.70E-02	9.33E-08	3.73E-07	3.0E-04	-	3.11E-04	1.24E-03		
MN	5.00E+02	6.96E-04	2.79E-03	1.4E-01	-	4.97E-03	1.99E-02		
MO	2.50E+00	3.48E-06	1.39E-05	5.0E-03	-	6.96E-04	2.79E-03		
NI	1.10E+01	1.53E-05	6.13E-05	2.0E-02	-	7.66E-04	3.06E-03		
PB	2.30E+01	3.20E-05	1.28E-04	1.4E-03	no data	2.29E-02	9.15E-02		
SB	9.70E-01	1.35E-06	5.40E-06	4.0E-04	-	3.38E-03	1.35E-02		
SE	2.40E+01	3.34E-05	1.34E-04	5.0E-03	-	6.69E-03	2.67E-02		
SN	2.30E+01	3.20E-05	1.28E-04	6.0E-01	-	5.34E-05	2.14E-04		
SR	3.70E+01	5.15E-05	2.06E-04	6.0E-01	-	8.59E-05	3.44E-04		
TL	4.30E+00	5.99E-06	2.40E-05	8.0E-05	-	7.49E-02	2.99E-01		

TABLE D.3.3–22.—*Ingestion of Metals in Perimeter Sediments to an Off-Site Resident (Nonspecific County) (From ESR 1991–1996 Data, see Table C-4)*-Continued

ANALYTES	95% UCL (mg/kg)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	4.20E+00	5.85E-06	2.34E-05	3.0E-03	no data	1.95E-03	7.80E-03		
V	2.40E+01	3.34E-05	1.34E-04	9.0E-03	-	3.71E-03	1.49E-02		
ZN	1.10E+02	1.53E-04	6.13E-04	3.0E-01	-	5.11E-04	2.04E-03		

[1] Detected values of Arsenic had a mean of 2.1 ± 12.9 µg/g (2 sigma).
[2] Detected values for Beryllium had a mean of 0.49 ± 0.51 µg/g (2 sigma).
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

Perimeter Sediment Ingestion Factors

Intake (mg/kg-day) = (CS x IR x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CS = perimeter sediment concentration
1.00E+02	mg/day	IR = **Average-Case** ingestion rate
365	day/yr	EF = **Average-Case** exposure frequency
4.00E+02	mg/day	IR = **Worst-Case** ingestion rate
365	days/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

TABLE D.3.3–23.—*Ingestion of Radioactive Isotopes in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.80E+00	4.50E-06	1.82E-05	7.30E-05
Cesium-137	1.80E+01	5.00E-08	9.60E-07	3.84E-06
Plutonium-238	1.70E+00	3.80E-06	6.89E-06	2.76E-05
Plutonium-239 and Plutonium-240	3.70E+00	4.30E-06	1.70E-05	6.79E-05
Strontium-90	1.60E+00	1.30E-07	2.22E-07	8.87E-07
Tritium[1]	3.11E+00	6.30E-11	2.09E-10	8.36E-10
Uranium[2]	2.70E+00	2.60E-07	7.48E-07	2.99E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			4.40E-05	1.76E-04
Cancer Risk yr^{-1}			2.20E-08	8.81E-08

[1] Tritium was converted from pCi/mL using the formulas from Fresquez et al. 1996, Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
1.07E+00 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
8 hr/event	=number of hours per visit
24 events/yr	=number of visits per year
4.27E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–23.—*Ingestion of Radioactive Isotopes in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

Tritium Conversion:	**H^3=**	**28**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])			
Fraction soil moisture = 10%			
Soil moisture density = 1 g/mL			
Tritium Activity (pCi/g) =	**3.11E+00**		
Uranium Conversion:	**U=**	**3.8**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/µg)		**RMA**	**SA**
U-238 = 1.26E+00 pCi/g		0.9928	3.35E+05
U-235 = 5.91E-02 pCi/g		0.0072	2.16E+06
U-234 = 1.38E+00 pCi/g		0.000058	6.24E+09
Total U Activity = 2.70E+00 pCi/g			

TABLE D.3.3–24.—*Ingestion of Metals in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.00E+01	4.07E-07	1.63E-06	5.0E-03	-	8.14E-05	3.26E-04		
AL	1.50E+04	6.11E-04	2.44E-03	1.8E-01	-	3.39E-03	1.36E-02		
AS	3.40E+00	1.38E-07	5.54E-07	3.0E-04	1.5E+00	4.61E-04	1.85E-03	2.08E-07	8.30E-07
B	3.90E+01	1.59E-06	6.35E-06	9.0E-02	-	1.76E-05	7.05E-05		
BA	2.90E+02	1.18E-05	4.72E-05	7.0E-02	-	1.69E-04	6.74E-04		
BE	1.70E+00	6.92E-08	2.77E-07	5.0E-03	4.3E+00	1.38E-05	5.54E-05	2.98E-07	1.19E-06
CD	1.50E+00	6.11E-08	2.44E-07	5.0E-04	1.8E-03	1.22E-04	4.88E-04	1.10E-10	4.40E-10
CO	8.40E+00	3.42E-07	1.37E-06	6.0E-02	-	5.70E-06	2.28E-05		
CR	1.80E+02	7.33E-06	2.93E-05	1.0E+00	-	7.33E-06	2.93E-05		
CU	1.20E+01	4.88E-07	1.95E-06	1.9E-02	-	2.57E-05	1.03E-04		
FE	1.50E+04	6.11E-04	2.44E-03	-	-				
HG	8.70E-02	3.54E-09	1.42E-08	3.0E-04	-	1.18E-05	4.72E-05		
LI	2.90E+01	1.18E-06	4.72E-06	2.0E-02	-	5.90E-05	2.36E-04		
MN	5.00E+02	2.04E-05	8.14E-05	1.4E-01	-	1.45E-04	5.81E-04		
MO	6.40E+00	2.60E-07	1.04E-06	5.0E-03	-	5.21E-05	2.08E-04		
NI	1.30E+01	5.29E-07	2.12E-06	2.0E-02	-	2.65E-05	1.06E-04		
PB	3.80E+01	1.55E-06	6.19E-06	1.4E-03	no data	1.10E-03	4.42E-03		
SB	9.80E+00	3.99E-07	1.60E-06	4.0E-04	-	9.97E-04	3.99E-03		
SE	6.00E-01	2.44E-08	9.77E-08	5.0E-03	-	4.88E-06	1.95E-05		
SN	7.30E+01	2.97E-06	1.19E-05	6.0E-01	-	4.95E-06	1.98E-05		
SR	1.80E+02	7.33E-06	2.93E-05	6.0E-01	-	1.22E-05	4.88E-05		
TL	1.00E+01	4.07E-07	1.63E-06	8.0E-05	-	5.09E-03	2.04E-02		

TABLE D.3.3–24.—*Ingestion of Metals in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	3.80E+00	1.55E-07	6.19E-07	3.0E-03	no data	5.16E-05	2.06E-04		
V	3.90E+01	1.59E-06	6.35E-06	9.0E-03	-	1.76E-04	7.05E-04		
ZN	1.60E+02	6.51E-06	2.60E-05	3.0E-01	-	2.17E-05	8.68E-05		
Bis(2-ethylhexyl) phthalate	3.50E+02	1.42E-05	5.70E-05	2.0E-02	1.4E-02	7.12E-04	2.85E-03	1.99E-07	7.98E-07
Di-n-butyl phthalate	9.90E+02	4.03E-05	1.61E-04	1.0E-01		4.03E-04	1.61E-03		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

TABLE D.3.3–24.—*Ingestion of Metals in Sediment for a Resident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

On-Site Sediment Ingestion Factors - Resident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
8	hr/event	ET = **Average-Case** exposure time
24	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
8	hr/event	ET = **Worst-Case** exposure time
24	events/yr	EF = **Worst-Case** exposure frequency
75	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
27375	d	AT = ED* 365 days

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–25.—*Ingestion of Radioactive Isotopes in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTE	95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	3.80E+00	4.50E-06	6.84E-06	2.74E-05
Cesium-137	1.80E+01	5.00E-08	3.60E-07	1.44E-06
Plutonium-238	1.70E+00	3.80E-06	2.58E-06	1.03E-05
Plutonium-239 and Plutonium-240	3.70E+00	4.30E-06	6.36E-06	2.55E-05
Strontium-90	1.60E+00	1.30E-07	8.32E-08	3.33E-07
Tritium[1]	3.11E+00	6.30E-11	7.84E-11	3.14E-10
Uranium[2]	2.70E+00	2.60E-07	2.81E-07	1.12E-06
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			1.65E-05	6.60E-05
Cancer Risk yr^{-1}			8.26E-09	3.30E-08

[1] Tritium was converted from pCi/mL using the formulas from Fresquez, 1996 et al. Appendix B, pg. 36 (see below).
[2] Uranium was similarly converted (see below).

Average-Case Consumption	
5.56E+00 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
4.00E-01 g/yr	=number of grams per year

Worst-Case Consumption	
2.22E+01 mg/hr	=ingestion rate per hour
6 hr/event	=number of hours per visit
12 events/yr	=number of visits per year
1.60E+00 g/yr	=number of grams per year
1 yr	=exposure duration

Note: 100 mg per day over 18 hrs yields 5.56 mg/hr for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg/hr for Worst-Case.

TABLE D.3.3–25.—*Ingestion of Radioactive Isotopes in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

Tritium Conversion:	**H^3=**	**28**	**pCi/mL**
pCi/g = pCi/mL X (fraction soil moisture/soil moisture density X [1-fraction soil moisture])			
Fraction soil moisture = 10%			
Soil moisture density = 1 g/mL			
Tritium Activity (pCi/g) =	**3.11E+00**		
Uranium Conversion:	**U=**	**3.8**	**µg/g**
pCi U isotope / g soil = µg total Uranium/g soil X RMA X SA X CF			
RMA = relative mass abundance (g isotope per g total U)			
SA = specific activity (pCi/g)			
CF = conversion factor (1E-06 g/µg)		**RMA**	**SA**
U-238 = 1.26E+00 pCi/g		0.9928	3.35E+05
U-235 = 5.91E-02 pCi/g		0.0072	2.16E+06
U-234 = 1.38E+00 pCi/g		0.000058	6.24E+09
Total U Activity = 2.70E+00 pCi/g			

TABLE D.3.3–26.—*Ingestion of Metals in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.00E+01	1.53E-07	6.11E-07	5.0E-03	-	3.05E-05	1.22E-04		
AL	1.50E+04	2.29E-04	9.16E-04	1.8E-01	-	1.27E-03	5.09E-03		
AS	3.40E+00	5.19E-08	2.08E-07	3.0E-04	1.5E+00	1.73E-04	6.92E-04	7.78E-08	3.11E-07
B	3.90E+01	5.95E-07	2.38E-06	9.0E-02	-	6.61E-06	2.65E-05		
BA	2.90E+02	4.43E-06	1.77E-05	7.0E-02	-	6.32E-05	2.53E-04		
BE	1.70E+00	2.59E-08	1.04E-07	5.0E-03	4.3E+00	5.19E-06	2.08E-05	1.12E-07	4.46E-07
CD	1.50E+00	2.29E-08	9.16E-08	5.0E-04	1.8E-03	4.58E-05	1.83E-04	4.12E-11	1.65E-10
CO	8.40E+00	1.28E-07	5.13E-07	6.0E-02	-	2.14E-06	8.55E-06		
CR	1.80E+02	2.75E-06	1.10E-05	1.0E+00	-	2.75E-06	1.10E-05		
CU	1.20E+01	1.83E-07	7.33E-07	1.9E-02	-	9.64E-06	3.86E-05		
FE	1.50E+04	2.29E-04	9.16E-04	-	-				
HG	8.70E-02	1.33E-09	5.31E-09	3.0E-04	-	4.43E-06	1.77E-05		
LI	2.90E+01	4.43E-07	1.77E-06	2.0E-02	-	2.21E-05	8.85E-05		
MN	5.00E+02	7.63E-06	3.05E-05	1.4E-01	-	5.45E-05	2.18E-04		
MO	6.40E+00	9.77E-08	3.91E-07	5.0E-03	-	1.95E-05	7.81E-05		
NI	1.30E+01	1.98E-07	7.94E-07	2.0E-02	-	9.92E-06	3.97E-05		
PB	3.80E+01	5.80E-07	2.32E-06	1.4E-03	no data	4.14E-04	1.66E-03		
SB	9.80E+00	1.50E-07	5.98E-07	4.0E-04	-	3.74E-04	1.50E-03		
SE	6.00E-01	9.16E-09	3.66E-08	5.0E-03	-	1.83E-06	7.33E-06		
SN	7.30E+01	1.11E-06	4.46E-06	6.0E-01	-	1.86E-06	7.43E-06		
SR	1.80E+02	2.75E-06	1.10E-05	6.0E-01	-	4.58E-06	1.83E-05		
TL	1.00E+01	1.53E-07	6.11E-07	8.0E-05	-	1.91E-03	7.63E-03		

TABLE D.3.3–26.—*Ingestion of Metals in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

ANALYTES	95% UCL (µg/L)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RFD mg/kg-day	ORAL SLOPE FACTOR per mg/kg/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
U	3.80E+00	5.80E-08	2.32E-07	3.0E-03	no data	1.93E-05	7.73E-05		
V	3.90E+01	5.95E-07	2.38E-06	9.0E-03	-	6.61E-05	2.65E-04		
ZN	1.60E+02	2.44E-06	9.77E-06	3.0E-01	-	8.14E-06	3.26E-05		
Bis(2-ethylhexyl) phthalate	3.50E+02	5.34E-06	2.14E-05	2.0E-02	1.4E-02	2.67E-04	1.07E-03	7.48E-08	2.99E-07
Di-n-butyl phthalate	9.90E+02	1.51E-05	6.04E-05	1.0E-01		1.51E-04	6.04E-04		

TABLE D.3.3–26.—*Ingestion of Metals in Sediment for a Nonresident Recreational User (From ESR 1991–1996 Data, see Table C-4)*-Continued

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human cancer risk.

On-Site Sediment Ingestion Factors - Nonresident Recreational User

Intake (mg/kg/day) = (CW x IR x ET x EF x ED x CF)/(BW x AT)

Note: modified from EPA 1989, exhibit 6-12, pg. 6-36.

Value	Units	Parameter
e.g., B3	mg/kg	CW = On-site concentration
5.56E+00	mg/hr	IR = **Average-Case** ingestion rate
6	hr/event	ET = **Average-Case** exposure time
12	events/yr	EF = **Average-Case** exposure frequency
2.22E+01	mg/hr	IR = **Worst-Case** ingestion rate
6	hr/event	ET = **Worst-Case** exposure time
12	events/yr	EF = **Worst-Case** exposure frequency
1	yr	ED = Exposure duration
1.00E-06	kg/mg	CF = Conversion factor
71.8	kg	BW = Body weight
365	d	AT = ED* 365 days

Note: 100 mg per day over 18 hrs yields 5.56 mg per hour for Average-Case.
Note: 400 mg per day over 18 hrs yields 22.2 mg per hour for Worst-Case.

TABLE D.3.3–27.—*Ingestion of Honey for Off-Site Residents (Note: Includes LANL 1990–1994 Los Alamos and White Rock County Data for Los Alamos County and San Ildefonso Data for Non-Los Alamos County Resident) (Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE		95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Los Alamos County Tritium[1]		4.64E+01	6.30E-11	7.37E-07	2.63E-06
Non-Los Alamos County Tritium		7.92E-01	6.30E-11	1.26E-08	4.49E-08
[1] 95% UCL concentration in % of food that is water					
		LOS ALAMOS COUNTY Average-Case	**LOS ALAMOS COUNTY** Worst-Case	**NON-LOS ALAMOS COUNTY** Average-Case	**NON-LOS ALAMOS COUNTY** Worst-Case
Total Dose (rem/yr)		7.37E-07	2.63E-06	1.26E-08	4.49E-08
Cancer Risk yr-1		3.69E-10	1.32E-09	6.29E-12	2.25E-11
Average-Case Consumption		(LANL 1997, Table 3-1)			
3.84 g/day		= number of grams of honey ingested per day			
0.69 g/day		= number of grams per day wet weight ingested			
Worst-Case Consumption		(LANL 1997, Table 3-1)			
13.7 g/day		= number of grams of honey ingested per day			
2.47 g/day		= number of grams per day wet weight ingested			
Moisture Content		(LANL 1997)			
0.18 unitless		= LANL fraction of honey that is water			
Exposure Duration					
365 days		= 1 yr exposure duration			
LAC Tritium Conversion		**H^3=**	**46.4**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	46.4	pCi/g			
Non-LAC Tritium Conversion		**H^3=**	**0.792**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	0.792	pCi/g			

TABLE D.3.3–28.—*Ingestion of Free-Range Steer for an Off-Site Non-Los Alamos County Resident (see Table D.3.5–7)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Americium-241	6.70E-05	4.50E-06	4.48E-06	1.09E-05	
Cesium-137	2.10E-02	5.00E-08	1.56E-05	3.79E-05	
Plutonium-238	3.00E-05	3.80E-06	1.69E-06	4.11E-06	
Plutonium-239	1.50E-04	4.30E-06	9.58E-06	2.33E-05	
Strontium-90	2.60E-02	1.30E-07	5.02E-05	1.22E-04	
Tritium	2.00E+02	6.30E-11	1.87E-04	4.55E-04	
Uranium	1.28E-03	2.60E-07	4.94E-06	1.20E-05	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			2.74E-04	6.65E-04	
Cancer Risk yr-1			1.37E-07	3.32E-07	
Average-Case Consumption		(EPA 1997a, 71.8 kg Man)			
2.10 g/kg-day		= number of grams per day ingested			
40.71 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, 71.8 kg Man)			
5.10 g/kg/day		= number of grams per day ingested			
98.87 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.27 unitless		= LANL dry/wet weight ratio			
Exposure Duration					
365 days		= 1 yr exposure duration			
Tritium Conversion		**H^3=**	**200**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	200	pCi/g			
Uranium Conversion		**U=**	**1.80E-03**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	5.99E-04	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.80E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	6.51E-04	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.28E-03**	**pCi/g**			

TABLE D.3.3–29.—*Ingestion of Elk for an Off-Site Los Alamos County Resident (Note: Includes LANL 1990–1994 Off-Site Road Kills (from Chama, Lindreth, and Tres Piedras, see Table D.3.5–6)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Cesium-137	6.26E-01	5.00E-08	7.57E-05	1.84E-04
Plutonium-238	0.00E+00	3.80E-06	0.00E+00	0.00E+00
Plutonium-239	0.00E+00	4.30E-06	0.00E+00	0.00E+00
Strontium-90	0.00E+00	1.30E-07	0.00E+00	0.00E+00
Tritium[1]	(not analyzed)	6.30E-11		
Uranium	2.49E-03	2.60E-07	1.57E-06	3.80E-06
[1] 95% UCL concentration in % of food that is water				
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			7.73E-05	1.87E-04
Cancer Risk yr-1			3.87E-08	9.37E-08
Average-Case Consumption		(EPA 1997a, General Population)		
26 g/day		= number of grams per day ingested		
6.63 g/day		= number of grams per day dry weight ingested		
Worst-Case Consumption		(EPA 1997a, General Population)		
63 g/day		= number of grams per day ingested		
16.065 g/day		= number of grams per day dry weight ingested		
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)		
0.255 unitless		= LANL dry/wet weight ratio		
Exposure Duration				
365 days		= 1 yr exposure duration		

Uranium Conversion		**U=**	**3.51E-03**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	1.17E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	5.46E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	1.27E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**2.49E-03**	**pCi/g**			

TABLE D.3.3–30.—*Ingestion of Elk for an Off-Site Non-Los Alamos (Note: includes LANL 1990–1994 On-Site Road Kills from TA–5, TA–16, TA–18, TA–46, and TA–49, see Table D.3.5–6)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Cesium-137	2.98E-01	5.00E-08	3.61E-05	8.74E-05	
Plutonium-238	2.00E-05	3.80E-06	1.84E-07	4.46E-07	
Plutonium-239	3.08E-04	4.30E-06	3.20E-06	7.77E-06	
Strontium-90	1.66E-02	1.30E-07	5.22E-06	1.27E-05	
Tritium[1]	6.86E+00	6.30E-11	3.06E-06	7.40E-06	
Uranium	7.67E-03	2.60E-07	4.83E-06	1.17E-05	
[1] 95% UCL concentration in % of food that is water					
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			5.25E-05	1.27E-04	
Cancer Risk yr-1			2.63E-08	6.37E-08	
Average-Case Consumption		(EPA 1997a, General Population)			
26 g/day		= number of grams per day ingested			
6.63 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, General Population)			
63 g/day		= number of grams per day ingested			
16.065 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.255 unitless		= LANL dry/wet weight ratio			
Exposure Duration					
365 days		= 1 yr exposure duration			
Tritium Conversion		**H^3=**	**6.86**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**6.86**	**pCi/g**			
Uranium Conversion		**U=**	**1.08E-02**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	3.59E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	1.68E-04	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	3.91E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**7.67E-03**	**pCi/g**			

TABLE D.3.3–31.—*Ingestion of Deer for an Off-Site Los Alamos County Resident (Note: Includes Off-Site Road Kills from Cuba and El Vado, LANL 1997, see Table D.3.5–8)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	0.00E+00	4.50E-06	0.00E+00	0.00E+00
Cesium-137	2.65E-02	5.00E-08	3.14E-06	7.62E-06
Plutonium-238	4.60E-05	3.80E-06	4.15E-07	1.00E-06
Plutonium-239	1.91E-04	4.30E-06	1.95E-06	4.72E-06
Strontium-90	3.83E-02	1.30E-07	1.18E-05	2.86E-05
Tritium[1]	8.60E-01	6.30E-11	1.29E-07	3.11E-07
Uranium	1.04E-03	2.60E-07	6.40E-07	1.55E-06

[1] 95% UCL concentration in % of food that is water

			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			1.81E-05	4.38E-05	
Cancer Risk yr-1			9.04E-09	2.19E-08	
Average-Case Consumption		(EPA 1997a, General Population)			
26 g/day		= number of grams per day ingested			
6.5 g/day		= number of grams per day dry weight ingested			
Worst-Case Ingestion		(EPA 1997a, General Population)			
63 g/day		= number of grams per day ingested			
15.75 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.25 unitless		= LANL dry/wet weight ratio			
Exposure Duration					
365 days		= 1 yr exposure duration			
Tritium Conversion		**H^3=**	**0.86**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**0.86**	**pCi/g**			
Uranium Conversion		**U=**	**1.46E-03**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	4.86E-04	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.27E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	5.28E-04	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity=	**1.04E-03**	**pCi/g**			

TABLE D.3.3–32.—*Ingestion of Deer for an Off-Site Non-Los Alamos County Resident (Note: Includes LANL Road Kills from TA–8, TA–16, TA–21, and TA–55, LANL 1997, see Table D.3.5–8)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	7.90E-05	4.50E-06	8.43E-07	2.04E-06
Cesium-137	5.00E-01	5.00E-08	5.93E-05	1.44E-04
Plutonium-238	5.00E-05	3.80E-06	4.51E-07	1.09E-06
Plutonium-239	5.60E-05	4.30E-06	5.71E-07	1.38E-06
Strontium-90	2.30E-02	1.30E-07	7.09E-06	1.72E-05
Tritium[1]	9.90E-01	6.30E-11	1.48E-07	3.59E-07
Uranium	4.97E-01	2.60E-07	3.07E-04	7.43E-04
[1] 95% UCL concentration in % of food that is water				
			Average-Case	**Worst-Case**
Total Dose (rem/yr)			3.75E-04	9.09E-04
Cancer Risk yr-1			1.88E-07	4.54E-07
Average-Case Consumption	(EPA 1997a, General Population)			
26 g/day	= number of grams per day ingested			
6.5 g/day	= number of grams per day dry weight ingested			
Worst-Case Ingestion	(EPA 1997a, General Population)			
63 g/day	= number of grams per day ingested			
15.75 g/day	= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)			
0.25 unitless	= LANL dry/wet weight ratio			
Exposure Duration				
365 days	= 1 yr exposure duration			

TABLE D.3.3–32.—*Ingestion of Deer for an Off-Site Non-Los Alamos County Resident (Note: Includes LANL Road Kills from TA–8, TA–16, TA–21, and TA–55, LANL 1997, see Table D.3.5–8)*-Continued

Tritium Conversion		**H^3=**	**0.99**	**pCi/mL**	
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**0.99**	**pCi/g**			
Uranium Conversion		**U=**	**7.00E-01**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	2.33E-01	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	1.09E-02	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	2.53E-01	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**4.97E-01**	**pCi/g**			

TABLE D.3.3–33.—*Ingestion of Fish for an Off-Site Non-Los Alamos County Resident (Note: Includes all Game and Nongame Fish from Abiquiu and Cochiti, Foodstuffs Database 1990–1994, see Table D.3.5–9)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Cesium-137	2.36E-01	5.00E-08	2.22E-05	6.95E-05	
Plutonium-238	8.22E-05	3.80E-06	5.87E-07	1.84E-06	
Plutonium-239	1.50E-04	4.30E-06	1.21E-06	3.80E-06	
Strontium-90	1.03E-01	1.30E-07	2.51E-05	7.88E-05	
Uranium	1.05E-02	2.60E-07	5.13E-06	1.61E-05	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			5.42E-05	1.70E-04	
Cancer Risk yr-1			2.71E-08	8.50E-08	
Average-Case Consumption		(EPA 1997a, General Population)			
20.1 g/day		= number of grams per day ingested			
5.1456 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, General Population)			
63 g/day		= number of grams per day ingested			
16.128 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.256 unitless		= LANL dry/wet weight ratio in fish 1990–1995			
Exposure Duration					
365 days		= 1 yr exposure duration			
Uranium Conversion		**U=**	**1.48E-02**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	4.92E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.30E-04	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	5.36E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.05E-02**	**pCi/g**			

TABLE D.3.3–34.—*Ingestion of Metals in Bottom-Feeding Fish for an Off-Site Non-Los Alamos County Resident (Note: Includes Abiquiu, Heron, and El Vado Data, which is higher than Cochiti Data, LANL 1997, Table D.3.5–10)*

ANALYTES	MEAN[1] (µg/g-wet)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.25E-01	3.50E-05	1.10E-04	5.0E-03	-	7.00E-03	2.19E-02		
AS	2.50E-01	7.00E-05	2.19E-04	3.0E-04	1.5E+00	2.33E-01	7.31E-01	1.05E-04	3.29E-04
BA	6.30E-02	1.76E-05	5.53E-05	7.0E-02	-	2.52E-04	7.90E-04		
BE	5.30E-02	1.48E-05	4.65E-05	5.0E-03	4.3E+00	2.97E-03	9.30E-03	6.38E-05	2.00E-04
CD	1.14E-01	3.19E-05	1.00E-04	5.0E-04	1.8E-03	6.38E-02	2.00E-01	5.74E-08	1.80E-07
CR	6.25E-01	1.75E-04	5.48E-04	1.0E+00	-	1.75E-04	5.48E-04		
CU	8.15E-01	2.28E-04	7.15E-04	1.9E-02		1.20E-02	3.76E-02		
HG	3.42E-01	9.57E-05	3.00E-04	3.0E-04	-	3.19E-01	1.00E+00		
NI	1.13E+00	3.15E-04	9.87E-04	2.0E-02	-	1.57E-02	4.94E-02		
PB	1.25E+00	3.50E-04	1.10E-03	1.4E-03	no data	2.50E-01	7.83E-01		
SB	1.25E+00	3.50E-04	1.10E-03	4.0E-04	-	8.75E-01	2.74E+00		
SE	2.75E-01	7.70E-05	2.41E-04	5.0E-03	-	1.54E-02	4.83E-02		
TL	1.25E+00	3.50E-04	1.10E-03	8.0E-05	-	4.37E+00	1.37E+01		
ZN	5.78E+00	1.62E-03	5.07E-03	3.0E-01		5.39E-03	1.69E-02		

[1] 95% UCL Values not available for all analytes, mean values used for consistency.
Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–34.—*Ingestion of Metals in Bottom-Feeding Fish for an Off-Site Non-Los Alamos County Resident (Note: Includes Abiquiu, Heron, and El Vado Data, which is higher than Cochiti Data, LANL 1997, Table D.3.5–10)*-Continued

Average-Case Ingestion	(EPA 1997a, General Population)	
20.1 g/day	= number of grams per day ingested	
5.1456 g/day	= number of grams per day dry weight ingested	
Worst-Case Ingestion	(EPA 1997a, General Population)	
63 g/day	= number of grams per day ingested	
16.128 g/day	= number of grams per day dry weight ingested	
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)	
0.256 unitless	= LANL dry/wet weight ratio in fish 1990-1995	
Unit Conversion Factor	1.00E-03 mg/µg	= number of milligrams per microgram
Average Man Weight	71.8 kg	= number of kg for an average man

TABLE D.3.3–35.—*Ingestion of Fruits and Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos and White Rock Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE	HOMEGROWN 95% UCL (pCi/g)	STORE-BOUGHT 95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
			FRUITS		
Cesium-137	4.87E-01	2.67E-01	5.00E-08	2.08E-04	8.12E-04
Plutonium-238	9.69E-04	4.15E-04	3.80E-06	2.67E-05	1.08E-04
Plutonium-239	9.87E-03	6.50E-04	4.30E-06	1.43E-04	7.16E-04
Strontium-90	1.22E-01	7.30E-02	1.30E-07	1.44E-04	5.56E-04
Tritium[1]	9.14E+00	9.34E-01	6.30E-11	1.23E-05	5.91E-05
Uranium	3.20E-02	2.88E-02	2.60E-07	1.02E-04	3.77E-04
			VEGETABLES		
Cesium-137	4.40E-01	3.47E-01	5.00E-08	3.13E-04	7.55E-04
Plutonium-238	6.46E-04	4.22E-04	3.80E-06	3.07E-05	7.64E-05
Plutonium-239	7.59E-03	1.17E-03	4.30E-06	2.02E-04	6.32E-04
Strontium-90	3.41E-01	1.06E-01	1.30E-07	3.62E-04	1.02E-03
Tritium[1]	1.13E+00	7.91E-01	6.30E-11	5.28E-06	1.30E-05
Uranium	8.02E-03	1.89E-02	2.60E-07	7.11E-05	1.49E-04

[1] 95% UCL concentration in % of food that is water

		Fruit Average-Case	Fruit Worst-Case	Vegetables Average-Case	Vegetables Worst-Case
Total Dose (rem/yr)		6.36E-04	2.63E-03	9.84E-04	2.65E-03
Cancer Risk yr-1		3.18E-07	1.31E-06	4.92E-07	1.32E-06

Average-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
3.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.20 fraction	= % homegrown (EPA 1989)
4.30 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
12.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.30 fraction	= % homegrown (EPA 1989)
10.00 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.40 fraction	= % homegrown (EPA 1989)

TABLE D.3.3–35.—*Ingestion of Fruits and Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos and White Rock Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Exposure Duration					
365 days		= 1 yr exposure duration			
(Note: Dry weight fractions are from Fresquez and Ferenbaugh 1998.)					
Fruit Tritium Conversion					
	HG	**SB**	**HG H^3=**	**9.14**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**9.34E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**9.14**	**0.934**	**pCi/g**		
Vegetable Tritium Conversion					
	HG	**SB**	**HG H^3=**	**1.13**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**7.91E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**1.13**	**0.791**	**pCi/g**		
Fruit Uranium Conversion			**HG U=**	**4.50E-02**	**µg/g**
			SB U=	**4.06E-02**	**µg/g**
pCi U isotope/g fruit = µg total uranium/g fruit X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	1.50E-02	1.35E-02	9.93E-01	3.35E+05	1.00E-06
U-235=	7.00E-04	6.31E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	1.63E-02	1.47E-02	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**3.20E-02**	**2.88E-02**	**pCi/g**		
Vegetable Uranium Conversion			**HG U=**	**1.13E-02**	**µg/g**
			SB U=	**2.66E-02**	**µg/g**
pCi U isotope/g vegetable = µg total uranium/g vegetable X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	3.76E-03	8.85E-03	9.93E-01	3.35E+05	1.00E-06
U-235=	1.76E-04	4.14E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	4.09E-03	9.63E-03	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**8.02E-03**	**1.89E-02**	**pCi/g**		

TABLE D.3.3–35.—*Ingestion of Fruits and Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos and White Rock Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Intermediate Step Calculation	(Assumes a body wt. of 71.8 kg)			
Fruit	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	6.51E-05	1.43E-04	3.56E-04	4.56E-04
Plutonium-238	9.84E-06	1.69E-05	5.38E-05	5.38E-05
Plutonium-239	1.13E-04	2.99E-05	6.21E-04	9.54E-05
Strontium-90	4.24E-05	1.01E-04	2.32E-04	3.24E-04
Tritium[1]	8.72E-06	3.57E-06	4.77E-05	1.14E-05
Uranium	2.22E-05	8.02E-05	1.21E-04	2.56E-04
Vegetables	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	9.30E-05	2.20E-04	3.46E-04	4.09E-04
Plutonium-238	1.04E-05	2.03E-05	3.86E-05	3.78E-05
Plutonium-239	1.38E-04	6.38E-05	5.13E-04	1.19E-04
Strontium-90	1.87E-04	1.75E-04	6.97E-04	3.25E-04
Tritium[1]	1.70E-06	3.58E-06	6.34E-06	6.66E-06
Uranium	8.82E-06	6.23E-05	3.28E-05	1.16E-04

TABLE D.3.3–36.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	5.40E-01	8.71E-05	3.24E-04	5.0E-03	-	1.74E-02	6.48E-02		
AS	1.00E-01	1.61E-05	6.00E-05	3.0E-04	1.5E+00	5.38E-02	2.00E-01	2.42E-05	9.00E-05
BA	2.50E+01	4.03E-03	1.50E-02	7.0E-02	-	5.76E-02	2.14E-01		
BE	6.00E-02	9.68E-06	3.60E-05	5.0E-03	4.3E+00	1.94E-03	7.20E-03	4.16E-05	1.55E-04
CD	1.20E-01	1.94E-05	7.20E-05	5.0E-04	1.8E-03	3.87E-02	1.44E-01	3.48E-08	1.30E-07
CR	2.50E+00	4.03E-04	1.50E-03	1.0E+00	-	4.03E-04	1.50E-03		
HG	5.00E-02	8.06E-06	3.00E-05	3.0E-04	-	2.69E-02	1.00E-01		
NI	1.70E+01	2.74E-03	1.02E-02	2.0E-02	-	1.37E-01	5.10E-01		
PB	3.90E+01	6.29E-03	2.34E-02	1.4E-03	no data	4.49E+00	1.67E+01		
SB	3.90E-01	6.29E-05	2.34E-04	4.0E-04	-	1.57E-01	5.85E-01		
SE	4.40E-01	7.10E-05	2.64E-04	5.0E-03	-	1.42E-02	5.28E-02		
TL	1.50E-01	2.42E-05	9.00E-05	8.0E-05	-	3.02E-01	1.13E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–36.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.4 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–37.—*Ingestion of Metals in Store Bought Vegetables for Off-Site Los Alamos and Non-Los Alamos County Residents (Note: Includes Española, Santa Fe, Jemez, Cochiti, Peña Blanca, Santo Domingo, LANL 1997, see Table D.3.5–11)*

ANALYTES	VEGETABLES (µg/g-dry) 95% UCL	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/ day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	4.70E-01	2.27E-04	4.23E-04	5.0E-03	-	4.55E-02	8.46E-02		
AS	7.30E-01	3.53E-04	6.57E-04	3.0E-04	1.5E+00	1.18E+00	2.19E+00	5.30E-04	9.86E-04
BA	1.70E+01	8.22E-03	1.53E-02	7.0E-02	-	1.17E-01	2.19E-01		
BE	6.00E-02	2.90E-05	5.40E-05	5.0E-03	4.3E+00	5.81E-03	1.08E-02	1.25E-04	2.32E-04
CD	2.50E-01	1.21E-04	2.25E-04	5.0E-04	1.8E-03	2.42E-01	4.50E-01	2.18E-07	4.05E-07
CR	4.00E+00	1.94E-03	3.60E-03	1.0E+00	-	1.94E-03	3.60E-03		
HG	8.20E-02	3.97E-05	7.38E-05	3.0E-04	-	1.32E-01	2.46E-01		
NI	2.50E+01	1.21E-02	2.25E-02	2.0E-02	-	6.05E-01	1.13E+00		
PB	2.80E+01	1.35E-02	2.52E-02	1.4E-03	no data	9.68E+00	1.80E+01		
SB	1.50E-01	7.26E-05	1.35E-04	4.0E-04	-	1.81E-01	3.38E-01		
SE	4.40E-01	2.13E-04	3.96E-04	5.0E-03	-	4.26E-02	7.92E-02		
TL	1.50E-01	7.26E-05	1.35E-04	8.0E-05	-	9.07E-01	1.69E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–37.—*Ingestion of Metals in Store Bought Vegetables for Off-Site Los Alamos and Non-Los Alamos County Residents (Note: Includes Española, Santa Fe, Jemez, Cochiti, Peña Blanca, Santo Domingo, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.75 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.6 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–38.—*Ingestion of Metals in Homegrown Fruit for Off-Site Los Alamos County Residents (Note: Includes Los Alamos Townsite Data, LANL 1997, see Table D.3.5–11)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	8.60E-01	8.77E-05	4.80E-04	5.0E-03	-	1.75E-02	9.60E-02		
AS	1.00E-01	1.02E-05	5.58E-05	3.0E-04	1.5E+00	3.40E-02	1.86E-01	1.53E-05	8.37E-05
BA	2.60E+00	2.65E-04	1.45E-03	7.0E-02	-	3.79E-03	2.07E-02		
BE	6.00E-02	6.12E-06	3.35E-05	5.0E-03	4.3E+00	1.22E-03	6.70E-03	2.63E-05	1.44E-04
CD	1.20E-01	1.22E-05	6.70E-05	5.0E-04	1.8E-03	2.45E-02	1.34E-01	2.20E-08	1.21E-07
CR	2.40E+00	2.45E-04	1.34E-03	1.0E+00	-	2.45E-04	1.34E-03		
HG	5.00E-02	5.10E-06	2.79E-05	3.0E-04	-	1.70E-02	9.30E-02		
NI	7.20E+00	7.34E-04	4.02E-03	2.0E-02	-	3.67E-02	2.01E-01		
PB	3.80E+00	3.88E-04	2.12E-03	1.4E-03	no data	2.77E-01	1.51E+00		
SB	1.50E-01	1.53E-05	8.37E-05	4.0E-04	-	3.83E-02	2.09E-01		
SE	1.00E-01	1.02E-05	5.58E-05	5.0E-03	-	2.04E-03	1.12E-02		
TL	1.50E-01	1.53E-05	8.37E-05	8.0E-05	-	1.91E-01	1.05E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–38.—*Ingestion of Metals in Homegrown Fruit for Off-Site Los Alamos County Residents (Note: Includes Los Alamos Townsite Data, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
3.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.2 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
12.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.3 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–39.—*Ingestion of Fruits and Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes San Ildefonso Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE	HOMEGROWN 95% UCL (pCi/g)	STORE-BOUGHT 95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
FRUITS					
Cesium-137	1.81E-01	2.67E-01	5.00E-08	1.67E-04	5.88E-04
Plutonium-238	2.12E-04	4.15E-04	3.80E-06	1.90E-05	6.56E-05
Plutonium-239	1.79E-03	6.50E-04	4.30E-06	5.05E-05	2.08E-04
Strontium-90	8.41E-02	7.30E-02	1.30E-07	1.31E-04	4.84E-04
Tritium[1]	7.57E-01	9.34E-01	6.30E-11	4.29E-06	1.53E-05
Uranium	5.52E-03	2.88E-02	2.60E-07	8.40E-05	2.77E-04
VEGETABLES					
Cesium-137	1.99E+00	3.47E-01	5.00E-08	6.40E-04	1.97E-03
Plutonium-238	2.80E-03	4.22E-04	3.80E-06	6.53E-05	2.05E-04
Plutonium-239	7.92E-04	1.17E-03	4.30E-06	7.82E-05	1.72E-04
Strontium-90	2.83E-01	1.06E-01	1.30E-07	3.30E-04	9.04E-04
Tritium[1]	1.14E+00	7.91E-01	6.30E-11	5.30E-06	1.31E-05
Uranium	1.41E-01	1.89E-02	2.60E-07	2.17E-04	6.91E-04

[1] 95% UCL concentration in % of food that is water

		Fruit Average-Case	Fruit Worst-Case	Vegetables Average-Case	Vegetables Worst-Case
Total Dose (rem/yr)		4.55E-04	1.64E-03	1.34E-03	3.96E-03
Cancer Risk yr-1		2.28E-07	8.19E-07	6.68E-07	1.98E-06

Average-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
3.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.20 fraction	= % homegrown (EPA 1989)
4.30 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Consumption	(EPA 1997a, Table 9-3; 9-4)
12.40 g/kg-day	= grams of **fruit** ingested per day per kg body wt.
0.15 fraction	= % of grams of **fruit** ingested per day as dry-wt.
0.30 fraction	= % homegrown (EPA 1989)
10.00 g/kg-day	= grams of **vegetables** ingested per day per kg body wt.
0.15 fraction	= % of grams of **vegetables** ingested per day as dry-wt.
0.40 fraction	= % homegrown (EPA 1989)

TABLE D.3.3–39.—*Ingestion of Fruits and Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes San Ildefonso Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Exposure Duration					
365 days		= 1 yr exposure duration			
(Note: Dry weight fractions are from Fresquez and Ferenbaugh 1998.)					
Fruit Tritium Conversion					
	HG	**SB**	**HG H^3=**	**7.57E-01**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**9.34E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**0.757**	**0.934**	**pCi/g**		
Vegetable Tritium Conversion					
	HG	**SB**	**HG H^3=**	**1.14**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water			**SB H^3=**	**7.91E-01**	**pCi/mL**
water density =	1	1	g/mL		
Tritium Activity =	**1.14**	**0.791**	**pCi/g**		
Fruit Uranium Conversion			**HG U=**	**7.78E-03**	**µg/g**
			SB U=	**4.06E-02**	**µg/g**
pCi U isotope/g fruit = µg total uranium/g fruit X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	2.59E-03	1.35E-02	9.93E-01	3.35E+05	1.00E-06
U-235=	1.21E-04	6.31E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	2.82E-03	1.47E-02	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**5.52E-03**	**2.88E-02**	**pCi/g**		
Vegetable Uranium Conversion			**HG U=**	**1.98E-01**	**µg/g**
			SB U=	**2.66E-02**	**µg/g**
pCi U isotope/g vegetable = µg total uranium/g vegetable X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Homegrown	**Store-Bought**	**RMA**	**SA**	**CF**
U-238=	6.59E-02	8.85E-03	9.93E-01	3.35E+05	1.00E-06
U-235=	3.08E-03	4.14E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	7.17E-02	9.63E-03	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.41E-01**	**1.89E-02**	**pCi/g**		

TABLE D.3.3–39.—*Ingestion of Fruits and Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes San Ildefonso Data for Homegrown and Regional Data for Store-Bought, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Intermediate Step Calculation	Body wt. kg = 71.8			
Fruit	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	2.42E-05	1.43E-04	1.32E-04	4.56E-04
Plutonium-238	2.15E-06	1.69E-05	1.18E-05	5.38E-05
Plutonium-239	2.06E-05	2.99E-05	1.13E-04	9.54E-05
Strontium-90	2.92E-05	1.01E-04	1.60E-04	3.24E-04
Tritium[1]	7.22E-07	3.57E-06	3.95E-06	1.14E-05
Uranium	3.84E-06	8.02E-05	2.10E-05	2.56E-04
Vegetables	**HG Average-Case Dose (rem/year)**	**SB Average-Case Dose (rem/year)**	**HG Worst-Case Dose (rem/year)**	**SB Worst-Case Dose (rem/year)**
Cesium-137	4.20E-04	2.20E-04	1.56E-03	4.09E-04
Plutonium-238	4.50E-05	2.03E-05	1.67E-04	3.78E-05
Plutonium-239	1.44E-05	6.38E-05	5.36E-05	1.19E-04
Strontium-90	1.55E-04	1.75E-04	5.78E-04	3.25E-04
Tritium[1]	1.72E-06	3.58E-06	6.40E-06	6.66E-06
Uranium	1.54E-04	6.23E-05	5.75E-04	1.16E-04

TABLE D.3.3–40.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.60E-01	2.58E-05	9.60E-05	5.0E-03	-	5.16E-03	1.92E-02		
AS	4.20E-01	6.77E-05	2.52E-04	3.0E-04	1.5E+00	2.26E-01	8.40E-01	1.02E-04	3.78E-04
BA	3.60E+01	5.81E-03	2.16E-02	7.0E-02	-	8.29E-02	3.09E-01		
BE	6.00E-02	9.68E-06	3.60E-05	5.0E-03	4.3E+00	1.94E-03	7.20E-03	4.16E-05	1.55E-04
CD	1.20E-01	1.94E-05	7.20E-05	5.0E-04	1.8E-03	3.87E-02	1.44E-01	3.48E-08	1.30E-07
CR	4.60E-01	7.42E-05	2.76E-04	1.0E+00	-	7.42E-05	2.76E-04		
HG	1.00E-01	1.61E-05	6.00E-05	3.0E-04	-	5.38E-02	2.00E-01		
NI	4.10E+00	6.61E-04	2.46E-03	2.0E-02	-	3.31E-02	1.23E-01		
PB	3.00E+01	4.84E-03	1.80E-02	1.4E-03	no data	3.46E+00	1.29E+01		
SB	1.50E-01	2.42E-05	9.00E-05	4.0E-04	-	6.05E-02	2.25E-01		
SE	7.80E-01	1.26E-04	4.68E-04	5.0E-03	-	2.52E-02	9.36E-02		
TL	1.50E-01	2.42E-05	9.00E-05	8.0E-05	-	3.02E-01	1.13E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–40.—*Ingestion of Metals in Homegrown Vegetables for Off-Site Non-Los Alamos County Residents (Note: Includes Los Alamos, White Rock, and Pajarito Acres, LANL 1997, see Table D.3.5–11)*-Continued

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.25 fraction	= % homegrown (EPA 1989)
Worst-Case Ingestion	(EPA 1997a Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
0.15 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)
0.4 fraction	= % homegrown (EPA 1989)
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–41.—*Ingestion of Milk for Off-Site Residents (Note: Includes Albuquerque Data for Los Alamos County and Nambe Data for Non-Los Alamos County Resident, Foodstuffs Database 1990–1994, see Table D.3.5–6)*

ANALYTE	MEAN[1] (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
LOS ALAMOS COUNTY				
Cesium-137	2.41E+00	5.00E-08	1.32E-05	3.52E-05
Iodine-131	1.00E+01	5.30E-08	5.80E-05	1.55E-04
Plutonium-238	0.00E+00	3.80E-06	0.00E+00	0.00E+00
Plutonium-239	0.00E+00	4.30E-06	0.00E+00	0.00E+00
Strontium-90	0.00E+00	1.30E-07	0.00E+00	0.00E+00
Tritium	0.00E+00	6.30E-11	0.00E+00	0.00E+00
Uranium	7.10E-02	2.60E-07	2.02E-06	5.39E-06
NON-LOS ALAMOS COUNTY				
Cesium-137	3.10E+00	5.00E-08	1.70E-05	4.53E-05
Iodine-131	4.70E+00	5.30E-08	2.73E-05	7.27E-05
Plutonium-238	3.00E-03	3.80E-06	1.25E-06	3.33E-06
Plutonium-239	0.00E+00	4.30E-06	0.00E+00	0.00E+00
Strontium-90	0.00E+00	1.30E-07	0.00E+00	0.00E+00
Tritium	1.00E+02	6.30E-11	6.90E-07	1.84E-06
Uranium	1.70E-01	2.60E-07	4.85E-06	1.29E-05

[1] 95% UCL concentration not available, value not converted from % moisture or dry/wet weight

	LOS ALAMOS COUNTY Average-Case	LOS ALAMOS COUNTY Worst-Case	NON- LOS ALAMOS COUNTY Average-Case	NON-LOS ALAMOS COUNTY Worst-Case
Total Dose (rem/yr)	7.33E-05	1.95E-04	5.10E-05	1.36E-04
Cancer Risk yr-1	3.66E-08	9.77E-08	2.55E-08	6.81E-08
Average-Case Consumption	(EPA 1997a, Table 3-26, pg. 3-23)			
0.30 L/day	= number of liters of milk ingested per day			
Worst-Case Consumption	(EPA 1997a, Table 3-26, pg. 3-23)			
0.80 L/day	= number of liters of milk ingested per day			
	(NOTE: assumes pregnant woman ingestion rate)			
Exposure Duration				
365 days	= 1 yr exposure duration			

TABLE D.3.3–41.—*Ingestion of Milk for Off-Site Residents (Note: Includes Albuquerque Data for Los Alamos County and Nambe Data for Non-Los Alamos County Resident, Foodstuffs Database 1990–1994, see Table D.3.5–6)*-Continued

Los Alamos County Uranium Conversion			**U=**	**1.00E-01**	**µg/L**
pCi U isotope/L milk = µg total uranium/L milk X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	3.33E-02	pCi/L	9.93E-01	3.35E+05	1.00E-06
U-235=	1.56E-03	pCi/L	7.20E-03	2.16E+06	1.00E-06
U-234=	3.62E-02	pCi/L	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**7.10E-02**	**pCi/L**			
Non-Los Alamos County Uranium Conversion			**U=**	**2.40E-01**	**µg/L**
pCi U isotope/L milk = µg total uranium/L milk X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	7.98E-02	pCi/L	9.93E-01	3.35E+05	1.00E-06
U-235=	3.73E-03	pCi/L	7.20E-03	2.16E+06	1.00E-06
U-234=	8.69E-02	pCi/L	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.70E-01**	**pCi/L**			

TABLE D.3.3–42.—*Ingestion of Fish for a Special Pathway Receptor (Note: Includes all Game and Nongame Fish from Abiquiu and Cochiti, Foodstuffs Database 1990–1994, see Table D.3.5–9)*

ANALYTE	95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Cesium-137	2.36E-01	5.00E-08	7.72E-05	1.87E-04	
Plutonium-238	8.22E-05	3.80E-06	2.04E-06	4.96E-06	
Plutonium-239	1.50E-04	4.30E-06	4.22E-06	1.02E-05	
Strontium-90	1.03E-01	1.30E-07	8.76E-05	2.13E-04	
Uranium	1.05E-02	2.60E-07	1.79E-05	4.34E-05	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			1.89E-04	4.59E-04	
Cancer Risk yr-1			9.44E-08	2.29E-07	
Average-Case Consumption		(EPA 1997a, Native American Subsistence)			
70 g/day		= number of grams per day ingested			
17.92 g/day		= number of grams per day dry weight ingested			
Worst-Case Consumption		(EPA 1997a, Native American Subsistence)			
170 g/day		= number of grams per day ingested			
43.52 g/day		= number of grams per day dry weight ingested			
Dry/Wet Weight Fraction		(Fresquez and Ferenbaugh 1998)			
0.256 unitless		= LANL dry/wet weight ratio in fish 1990–1995			
Exposure Duration					
365 days		= 1 yr exposure duration			
Uranium Conversion		**U=**	**1.48E-02**	**µg/g**	
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	4.92E-03	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	2.30E-04	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	5.36E-03	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**1.05E-02**	**pCi/g**			

TABLE D.3.3–43.—*Ingestion of Metals in Bottom-Feeding Fish for a Special Pathway Receptor (Note: Uses Regional Statistical Reference Level (RSRL) Data, LANL 1997, see Table D.3.5–12)*

ANALYTES	95% UCL (µg/g-wet)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.20E+00	1.17E-03	2.84E-03	5.0E-03	-	2.34E-01	5.68E-01		
AS	4.00E-01	3.90E-04	9.47E-04	3.0E-04	1.5E+00	1.30E+00	3.16E+00	5.85E-04	1.42E-03
BA	1.20E+00	1.17E-03	2.84E-03	7.0E-02	-	1.67E-02	4.06E-02		
BE	1.30E+00	1.27E-03	3.08E-03	5.0E-03	4.3E+00	2.53E-01	6.16E-01	5.45E-03	1.32E-02
CD	3.00E-01	2.92E-04	7.10E-04	5.0E-04	1.8E-03	5.85E-01	1.42E+00	5.26E-07	1.28E-06
CR	1.50E+00	1.46E-03	3.55E-03	1.0E+00	-	1.46E-03	3.55E-03		
CU	1.40E+00	1.36E-03	3.31E-03	1.9E-02		7.18E-02	1.74E-01		
HG	4.00E-01	3.90E-04	9.47E-04	3.0E-04	-	1.30E+00	3.16E+00		
NI	1.50E+00	1.46E-03	3.55E-03	2.0E-02	-	7.31E-02	1.78E-01		
PB	4.00E+00	3.90E-03	9.47E-03	1.4E-03	no data	2.79E+00	6.76E+00		
SB	2.10E+00	2.05E-03	4.97E-03	4.0E-04	-	5.12E+00	1.24E+01		
SE	4.00E-01	3.90E-04	9.47E-04	5.0E-03	-	7.80E-02	1.89E-01		
TL	2.10E+00	2.05E-03	4.97E-03	8.0E-05	-	2.56E+01	6.22E+01		
ZN	6.60E+00	6.43E-03	1.56E-02	3.0E-01		2.14E-02	5.21E-02		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

TABLE D.3.3–43.—*Ingestion of Metals in Bottom-Feeding Fish for a Special Pathway Receptor (Note: Uses Regional Statistical Reference Level (RSRL) Data, LANL 1997, see Table D.3.5–12)*-Continued

Average-Case Ingestion	(EPA 1997a, Native American Subsistence)
70 g/day	= number of grams per day ingested
17.92 g/day	= number of grams per day dry weight ingested
Worst-Case Ingestion	(EPA 1997a, Native American Subsistence)
170 g/day	= number of grams per day ingested
43.52 g/day	= number of grams per day dry weight ingested
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)
0.256 unitless	= LANL dry/wet weight ratio in fish 1990 to 1995
Unit Conversion Factor	
1.00E-03 mg/µg	= number of milligrams per microgram
Average Man Weight	
71.8 kg	= number of kg for an average man

TABLE D.3.3–44.—*Ingestion of Elk for a Special Pathway Receptor (Note: Includes Elk from Chama, Lindreth, and Tres Piedras, Fresquez et al. 1994, see Table D.3.5–13)*

ANALYTE	HEART 95% UCL (pCi/g) dry wt.	LIVER 95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	HEART AVERAGE-CASE DOSE (rem/year)	LIVER AVERAGE-CASE DOSE (rem/year)
Cesium-137	6.79E-02	5.96E-01	5.00E-08	1.48E-06	2.27E-05
Plutonium-238	0.00E+00	7.50E-05	3.80E-06	0.00E+00	2.17E-07
Plutonium-239	6.55E-04	9.50E-05	4.30E-06	1.23E-06	3.11E-07
Strontium-90	6.50E-03	8.20E-03	1.30E-07	3.68E-07	8.12E-07
Uranium	3.47E-02	1.60E-02	2.60E-07	3.93E-06	3.18E-06
				Heart Average-Case	**Liver Average-Case**
Total Dose (rem/yr)				7.01E-06	2.72E-05
Cancer Risk yr-1				3.51E-09	1.36E-08

Heart Average-Case Consumption	(Fresquez et al. 1994)
3.98 g/day	= number of grams per day ingested (at 3.2 lbs/yr)
1.194 g/day	= number of grams per day dry weight ingested
Liver Average-Case Consumption	(Fresquez et al. 1994)
6.96 g/day	= number of grams per day ingested (at 5.6 lbs/yr)
2.088 g/day	= number of grams per day dry weight ingested
Dry/Wet Weight Fraction	(Fresquez and Ferenbaugh 1998)
0.3 unitless	=LANL dry/wet weight ratio
Exposure Duration	
365 days	= 1 yr exposure duration

Uranium Conversion

Heart U=	**4.89E-02**	**µg/g**
Liver U=	**2.26E-02**	**µg/g**

pCi U isotope/g = µg total uranium/g X RMA X SA X CF

RMA = relative mass abundance (g isotope per g total U)

SA = specific activity (pCi/g)

CF = conversion factor (1E-06 g/µg)

	Heart	Liver	RMA	SA	CF
U-238=	1.63E-02	7.52E-03	9.93E-01	3.35E+05	1.00E-06
U-235=	7.60E-04	3.51E-04	7.20E-03	2.16E+06	1.00E-06
U-234=	1.77E-02	8.18E-03	5.80E-05	6.24E+09	1.00E-06
Total U Activity (pCi/g) =	**3.47E-02**	**1.60E-02**			

TABLE D.3.3–45.—*Ingestion of Herbal Tea (Cota) for Special Pathway Receptors (Note: Includes Data from San Ildefonso, LANL 1997, see Table D.3.5-14)*

ANALYTE	95% UCL (pCi/L)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)	
Americium-241	7.30E-02	4.50E-06	7.00E-05	2.43E-04	
Cesium-137	5.30E+01	5.00E-08	5.65E-04	1.96E-03	
Plutonium-238	2.80E-02	3.80E-06	2.27E-05	7.88E-05	
Plutonium-239	2.20E-02	4.30E-06	2.02E-05	7.01E-05	
Strontium-90	1.20E+00	1.30E-07	3.33E-05	1.16E-04	
Tritium	1.60E+02	6.30E-11	2.15E-06	7.47E-06	
Uranium	6.46E-01	2.60E-07	3.58E-05	1.24E-04	
			Average-Case	**Worst-Case**	
Total Dose (rem/yr)			7.49E-04	2.60E-03	
Cancer Risk yr-1			3.74E-07	1.30E-06	
Average-Case Consumption		(EPA 1997a, pg 3-16, Table 3-18)			
0.58 L/day		= mean number of liters per day ingested			
Worst-Case Ingestion		(EPA 1997a, pg 3-16, Table 3-18)			
2.03 L/day		= 99% number of liters per day ingested			
Exposure Duration					
365 days		= 1 yr exposure duration			
Uranium Conversion		U=	9.10E-01	µg/L	
pCi U isotope/L water = µg total uranium/L water X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)			**RMA**	**SA**	**CF**
U-238=	3.03E-01	pCi/L	9.93E-01	3.35E+05	1.00E-06
U-235=	1.42E-02	pCi/L	7.20E-03	2.16E+06	1.00E-06
U-234=	3.29E-01	pCi/L	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**6.46E-01**	**pCi/L**			

TABLE D.3.3–46.—*Ingestion of Radionuclides in Vegetables Grown in Contaminated Soil for Comparison Purposes (No Receptor Identified) (Note: On-Site Los Alamos Canyon Data for Pinto Beans, Sweet Corn, and Zucchini Squash, Fresquez et al. 1997, see Table D.3.5–15)*

ANALYTE	WEIGHTED[1] 95% UCL (pCi/g)	DOSE CONVERSION FACTOR (rem/pCi)	AVERAGE-CASE DOSE (rem/year)	WORST-CASE DOSE (rem/year)
Americium-241	1.68E-04	4.50E-06	8.50E-05	1.98E-04
Cesium-137	1.47E+00	5.00E-08	8.26E-03	1.92E-02
Plutonium-238	1.90E-04	3.80E-06	8.12E-05	1.89E-04
Plutonium-239	5.21E-05	4.30E-06	2.53E-05	5.88E-05
Strontium-90	4.52E+00	1.30E-07	6.63E-02	1.54E-01
Tritium[2]	1.10E+00	6.30E-11	7.79E-06	1.81E-05
Uranium	6.92E-04	2.60E-07	2.03E-05	4.72E-05

[1] Values represent the 95% UCL of the mean of the individual isotopic means for the three vegetable types, weighted by the appropriate dry weight fractions: Pinto Beans, 0.64; Sweet Corn, 0.26; and Zucchini Squash, 0.049 (Fresquez and Ferenbaugh 1998).
[2] 95% UCL concentration in % of food that is water, also corrected for the water fractions.

			Vegetables Average-Case	Vegetables Worst-Case
Total Dose (rem/yr)			7.48E-02	1.74E-01
Cancer Risk yr-1			3.74E-05	8.69E-05

Average-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)			
4.30	g/kg-day	= grams of **vegetables** ingested per day per kg body wt.			
Worst-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)			
10.00	g/kg-day	= grams of **vegetables** ingested per day per kg body wt.			
Exposure Duration					
365	days	= 1 yr exposure duration			
Vegetable Tritium Conversion			**H^3=**	**1.097**	**pCi/mL**
pCi/g of Tritium = pCi/mL tritium X mL/g of water					
water density =	1	g/mL			
Tritium Activity =	**1.097**	**pCi/g**			
Vegetable Uranium Conversion			**U=**	**9.75E-04**	**µg/g**
pCi U isotope/g vegetable = µg total uranium/g vegetable X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
			RMA	**SA**	**CF**
U-238=	3.24E-04	pCi/g	9.93E-01	3.35E+05	1.00E-06
U-235=	1.52E-05	pCi/g	7.20E-03	2.16E+06	1.00E-06
U-234=	3.53E-04	pCi/g	5.80E-05	6.24E+09	1.00E-06
Total U Activity =	**6.92E-04**	**pCi/g**			

TABLE D.3.3–47.—*Ingestion of Metals in Vegetables Grown in Contaminated Soil (No Identified Receptor) (Note: On-Site Los Alamos Canyon Data for Pinto Beans, Sweet Corn, and Zucchini Squash, Frequez et al., 1997, see Table D.3.5–15)*

ANALYTES	WEIGHTED[1] 95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AS	8.70E-02	3.74E-04	8.70E-04	3.0E-04	1.5E+00	1.25E+00	2.90E+00	5.61E-04	1.31E-03
CD	1.07E-01	4.60E-04	1.07E-03	5.0E-04	1.8E-03	9.20E-01	2.14E+00	8.28E-07	1.93E-06
CR	1.14E-01	4.90E-04	1.14E-03	1.0E+00	-	4.90E-04	1.14E-03		
HG	4.60E-02	1.98E-04	4.60E-04	3.0E-04	-	6.59E-01	1.53E+00		
PB	1.21E+01	5.20E-02	1.21E-01	1.4E-03	no data	3.72E+01	8.64E+01		
SB	1.37E-01	5.89E-04	1.37E-03	4.0E-04	-	1.47E+00	3.43E+00		
ZN	3.31E+01	1.42E-01	3.31E-01	3.0E-01		4.74E-01	1.10E+00		

[1] Values represent the 95% UCL of the mean of the individual means of metal concentrations for the three vegetable types, weighted by the appropriate dry weight fractions: Pinto Beans, 0.64; Sweet Corn, 0.26; and Zucchini Squash, 0.049 (Fresquez and Ferenbaugh 1998).

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.

Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Average-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
Worst-Case Ingestion	(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.
Units Conversion	
1.00E-03 mg/µg	= number of milligrams per microgram

TABLE D.3.3–48.—*Ingestion of Regional Vegetables for Comparison to Table D.3.3-48 (Note: Regional Data for Pinto Beans, Sweet Corn, and Zucchini Squash, Fresquez et al. 1997, see Table D.3.5–15)*

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AS	1.00E-01	1.36E-04	3.16E-04	3.0E-04	1.5E+00	4.53E-01	1.05E+00	2.04E-04	4.74E-04
CD	1.20E-01	1.63E-04	3.79E-04	5.0E-04	1.8E-03	3.26E-01	7.58E-01	2.94E-07	6.83E-07
CR	8.00E-02	1.09E-04	2.53E-04	1.0E+00	-	1.09E-04	2.53E-04		
HG	5.00E-02	6.79E-05	1.58E-04	3.0E-04	-	2.26E-01	5.27E-01		
PB	7.60E+00	1.03E-02	2.40E-02	1.4E-03	no data	7.38E+00	1.72E+01		
SB	1.50E-01	2.04E-04	4.74E-04	4.0E-04	-	5.10E-01	1.19E+00		
ZN	5.10E+01	6.93E-02	1.61E-01	3.0E-01		2.31E-01	5.37E-01		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Average-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
4.3 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.	
0.316 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)	
Worst-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
10 g/kg-day	= number of grams of vegetables ingested per day per kg body wt.	
0.316 fraction	= % of grams of vegetables ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)	
Units Conversion		
1.00E-03 mg/µg	= number of milligrams per microgram	

TABLE D.3.3–49.—*Ingestion of Metals in LANL On-Site Fruit (No Identified Receptor)*
(Note: Includes On-Site LANL Data, LANL 1997, see Table D.3.5–11)

ANALYTES	95% UCL (µg/g-dry)	AVERAGE-CASE CHRONIC DAILY INTAKE mg/kg-day	WORST-CASE CHRONIC DAILY INTAKE mg/kg-day	ORAL RfD mg/kg-day	ORAL SLOPE FACTOR per (mg/kg)/day	AVERAGE-CASE HAZARD INDEX	WORST-CASE HAZARD INDEX	AVERAGE-CASE CANCER RISK	WORST-CASE CANCER RISK
AG	1.60E-01	8.16E-05	2.98E-04	5.0E-03	-	1.63E-02	5.95E-02		
AS	4.20E-01	2.14E-04	7.81E-04	3.0E-04	1.5E+00	7.14E-01	2.60E+00	3.21E-04	1.17E-03
BA	3.60E+01	1.84E-02	6.70E-02	7.0E-02	-	2.62E-01	9.57E-01		
BE	6.00E-02	3.06E-05	1.12E-04	5.0E-03	4.3E+00	6.12E-03	2.23E-02	1.32E-04	4.80E-04
CD	1.20E-01	6.12E-05	2.23E-04	5.0E-04	1.8E-03	1.22E-01	4.46E-01	1.10E-07	4.02E-07
CR	4.60E-01	2.35E-04	8.56E-04	1.0E+00	-	2.35E-04	8.56E-04		
HG	1.20E-01	6.12E-05	2.23E-04	3.0E-04	-	2.04E-01	7.44E-01		
NI	4.10E+00	2.09E-03	7.63E-03	2.0E-02	-	1.05E-01	3.81E-01		
PB	3.00E+01	1.53E-02	5.58E-02	1.4E-03	no data	1.09E+01	3.99E+01		
SB	1.50E-01	7.65E-05	2.79E-04	4.0E-04	-	1.91E-01	6.98E-01		
SE	7.80E-01	3.98E-04	1.45E-03	5.0E-03	-	7.96E-02	2.90E-01		
TL	1.50E-01	7.65E-05	2.79E-04	8.0E-05	-	9.56E-01	3.49E+00		

Note: gray shaded cells in Slope Factor column have no known human chemical cancer risk.
Note: gray shaded cells in Carcinogenic Risk columns have no known human chemical cancer risk.

Average-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
3.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.	
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)	
Worst-Case Ingestion		(EPA 1997a, Table 9-3; 9-4)
12.4 g/kg-day	= number of grams of fruit ingested per day per kg body wt.	
0.15 fraction	= % of grams of fruit ingested per day as dry-wt. (Fresquez and Ferenbaugh 1998)	
Units Conversion		
1.00E-03 mg/µg	= number of milligrams per microgram	

TABLE D.3.3–50.—*Ingestion of Pinyon Nuts for a Non-Los Alamos County Resident and a Special Pathway Receptor (Note: Non-Los Alamos County includes Pinyon Nuts from Santa Fe, Nambe, and Abiquiu. Special Pathway includes Pinyon Nuts from LANL TA–15, TA–18, TA–21/53, TA–49, TA–2, and TA–54, 1979, Salazar 1979, see Table D.3.5–16)*

ANALYTE	NON-LOS ALAMOS COUNTY 95% UCL (pCi/g) dry wt.	SPECIAL PATHWAY 95% UCL (pCi/g) dry wt.	DOSE CONVERSION FACTOR (rem/pCi)	NON-LOS ALAMOS COUNTY AVERAGE-CASE DOSE (rem/year)	SPECIAL PATHWAY AVERAGE-CASE DOSE (rem/year)
Beryllium-7	1.40E-01	2.80E-02	1.10E-10	1.39E-09	2.77E-10
Cesium-137	2.00E-02	2.40E-02	5.00E-08	9.00E-08	1.08E-07
Plutonium-238	1.70E-02		3.80E-06	5.81E-06	
Plutonium-239	1.30E-02	2.70E-01	4.30E-06	5.03E-06	1.04E-04
Strontium-90	2.30E-01	9.20E-01	1.30E-07	2.69E-06	1.08E-05
Tritium[1]	5.70E+00	2.80E+01	6.30E-11	5.06E-07	2.49E-06
Uranium	5.68E-02	5.54E-01	2.60E-07	1.33E-06	1.30E-05

[1] Tritium is determined for the percent that is water.
Special pathway tritium is affected by tritium-contaminated soil.

				NON-LOS ALAMOS COUNTY	SPECIAL PATH
Total Dose (rem/yr)				1.55E-05	1.31E-04
Cancer Risk yr-1				7.73E-09	6.54E-08

Non-Los Alamos County Average-Case Consumption (Salazar 1979)

1500	g/yr	= number of grams ingested per year

Special Pathway Average-Case Consumption (Salazar 1979)

1500	g/yr	= number of grams ingested per year

Dry/Wet Weight Fraction (Salazar 1979)

0.06	unitless	= dry/wet weight ratio (mean of 90% to 98% water content)

Tritium Conversion

Non-Los Alamos County H^3=	**5.7**	**pCi/mL**
Special Pathway H^3=	**28**	**pCi/mL**

pCi/g of Tritium = pCi/mL tritium X mL/g of water

water density = 1 g/mL

	Non-Los Alamos County	**Spec. Path.**	
Tritium Activity =	**5.7**	**28**	**pCi/g**

TABLE D.3.3–50.—*Ingestion of Pinyon Nuts for a Non-Los Alamos County Resident and a Special Pathway Receptor (Note: Non-Los Alamos County includes Pinyon Nuts from Santa Fe, Nambe, and Abiquiu. Special Pathway includes Pinyon Nuts from LANL TA–15, TA–18, TA–21/53, TA–49, TA–2, and TA–54, 1979, Salazar 1979, see Table D.3.5–16)*-Continued

Uranium Conversion		**Non-Los Alamos County U=**		**8.00E-02**	**µg/g**
		Special Pathway U=		**7.80E-01**	**µg/g**
pCi U isotope/g = µg total uranium/g X RMA X SA X CF					
RMA = relative mass abundance (g isotope per g total U)					
SA = specific activity (pCi/g)					
CF = conversion factor (1E-06 g/µg)					
	Non-LAC	**Spec. Path.**	**RMA**	**SA**	**CF**
U-238=	2.66E-02	2.59E-01	9.93E-01	3.35E+05	1.00E-06
U-235=	1.24E-03	1.21E-02	7.20E-03	2.16E+06	1.00E-06
U-234=	2.90E-02	2.82E-01	5.80E-05	6.24E+09	1.00E-06
Total U (pCi/g) =	**5.68E-02**	**5.54E-01**			

D.3.4 Comparison of Concentrations of Selected Radionuclides and Metals in Regional and LANL Perimeter/On-Site Samples of Environmental Media

Table D.3.4–1 summarizes an analysis of differences between samples taken on site or at the perimeter of LANL versus those taken in the general region of northern New Mexico. (The network of annual sampling stations for surface water, groundwater, and sediment surveillance includes a set of regional [or background] stations and a group of stations near or within the LANL boundary—these data are addressed in section D.3.5 and are provided in appendix C.) The concentrations of plutonium-239 were found to be elevated from that of the region in the media at the perimeter of LANL. Values for fruits grown on site, honey from on-site TAs, and deer (road kills) on site showed elevated plutonium-239 concentrations. These foodstuffs are not consumed, but were collected to determine concentrations in biological media in known contaminated areas of the LANL reservation.

D.3.4.1 *Arsenic*

For most people, the primary mode of arsenic exposure is from food and water consumption. The average ingestion rate for members of the public is about 25 to 50 micrograms per day in food alone (ATSDR 1989 and EPA 1997b). Typically, exposure from water is less. The estimated maximum exposures (95th percentile) to arsenic from ingestion near LANL are:

- Store-bought vegetables (Table D.3.3–37): approximately 31 micrograms per day
- On-site fruit (not consumed, Table D.3.3–49): approximately 61 micrograms per day
- Fish (special pathways consumption rate, Table D.3.3–43): approximately 68 micrograms per day
- Surface waters (Table D.3.3–8): approximately 0.24 microgram per day
- NPDES discharge (Table D.3.3–12): approximately 0.62 microgram per day
- Groundwater (Los Alamos supply, Table D.3.3–2): approximately 98 micrograms per day
- Groundwater (San Ildefonso supply, Table D.3.3–6): approximately 53 micrograms per day

The primary source of arsenic in food and water sources in the LANL area are naturally occurring in soil and basalt minerals and are almost entirely inorganic in form (LANL 1997) The concentrations of arsenic in groundwater supply wells are not significantly different between Los Alamos and San Ildefonso (appendix C).

The main uses of arsenic in the U.S. are in pesticide formulation. LANL does not utilize arsenic in manufacturing levels in its research and development or processing activities. Arsenic is known to be beneficial or necessary for human metabolism in micro-quantities (ATSDR 1989).

When amounts less than 200 to 250 micrograms per day of arsenic are ingested, the human body can detoxify the inorganic form of arsenic by "methylation" (that is, by the addition of methyl groups to the ionic form). This does provide protection from toxic effects of inorganic arsenic. It does not necessarily protect against carcinogenesis. One hypothesis suggests that the natural methylation are "stolen" from deoxyribonucleic acid (DNA) synthesis making chromosome damage more probable (CLAWS 1997).

The single most characteristic system of ingestion exposure to inorganic arsenic is a pattern of skin abnormalities including the

TABLE D.3.4–1.—*Comparison of Concentrations of Selected Radionuclides and Metals in Regional and Perimeter or On-Site Media*

MEDIUM	NUCLIDE/ METAL	SIGNIFICANT DIFFERENCES IN PROPORTION OF SAMPLES HAVING ABOVE DETECTION CONCENTRATIONS	SIGNIFICANT DIFFERENCES IN CONCENTRATIONS
Surface Water	Cesium-137	NSD	NSD
	Plutonium-239	Perimeter > Regional	Perimeter > Regional
	Strontium-90	Regional > Perimeter	Perimeter > Regional
	Uranium	Regional > Perimeter	Regional > Perimeter
	Arsenic	Regional > Perimeter	Regional > Perimeter
	Beryllium	NSD	NSD
	Lead	Regional > Perimeter	Regional > Perimeter
Sediment	Cesium-137	NSD	NSD
	Plutonium-239	NSD	Perimeter > Regional
	Strontium-90	NSD	NSD
	Uranium	NSD	NSD
	Arsenic	NSD	NSD
	Beryllium	NSD	NSD
	Lead	NSD	NSD
Groundwater	Cesium-137	NSD	San Ildefonso Wells > LA Supply Wells
	Plutonium-239	NSD	NSD
	Strontium-90	NSD	NSD
	Uranium	NSD	NSD
	Arsenic	San Ildefonso Wells > LA Supply Wells	NSD
	Beryllium	San Ildefonso Wells > LA Supply Wells	San Ildefonso Wells > LA Supply Wells
	Lead	NSD	NSD
Soils	Cesium-137	NA	NSD
	Plutonium-239	NA	NSD
	Strontium-90	NA	NSD
	Uranium	NA	NSD
	Arsenic	NA	NSD
	Beryllium	NA	NSD
	Lead	NA	NSD

TABLE D.3.4–1.—*Comparison of Concentrations of Selected Radionuclides and Metals in Regional and Perimeter or On-Site Media*-Continued

MEDIUM	NUCLIDE/ METAL	SIGNIFICANT DIFFERENCES IN PROPORTION OF SAMPLES HAVING ABOVE DETECTION CONCENTRATIONS	SIGNIFICANT DIFFERENCES IN CONCENTRATIONS
Fruit	Cesium-137	NA	NSD
	Plutonium-239	NA	Los Alamos[a] > Neighboring Counties > Store Bought
	Strontium-90	NA	NSD
	Uranium	NA	NSD
Elk	Cesium-137	NA	NSD
	Plutonium-239	NA	insufficient data
	Strontium-90	NA	insufficient data
	Uranium	NA	NSD
Deer	Cesium-137	NA	NSD
	Plutonium-239	NA	Los Alamos[a] > neighboring counties
	Strontium-90	NA	insufficient data
	Uranium	NA	NSD
Honey	Tritium	NA	Los Alamos[a] > neighboring counties
Vegetables	Cesium-137	NA	NSD
	Plutonium-239	NA	NSD
	Strontium-90	NA	NSD
	Uranium	NA	NSD
	Arsenic	NA	NSD
	Beryllium	NA	NSD
	Lead	NA	NSD
Milk	Cesium-137	NA	NSD
	Iodine-131	NA	NSD
	Plutonium-239	no detects	insufficient data
	Strontium-90	no detects	insufficient data
	Tritium	no detects	insufficient data
	Uranium	NA	NSD

Source: Tables D.3.3–1 through D.3.3–49, and D.3.5–1 through D.3.5–9.
NSD = No (statistically) significant difference
NA = Not applicable
[a] These values are for samples collected in known contaminated areas on site. These foodstuffs are not consumed as home produce and are not allowed to be placed into commerce.

appearance of dark and light spots on the skin and small "corns" on the palms, soles, and trunk. While these skin changes are not considered to be a health concern in their own right, some may progress toward skin cancer. In addition, arsenic ingestion has been reported to increase the risk of certain cancers: liver, bladder, kidney, and lung. Organic forms of arsenic such as that found in fish seem to be less toxic than inorganic forms (ATSDR 1989).

EPA has recently held public meetings regarding its activity to develop proposed National Primary Drinking Water Regulations. The current Interim Water Primary Standard for arsenic is 50 micrograms per liter in drinking water and was established in 1976 to protect against skin cancer. This standard was scheduled for finalization with the other phase II compounds in 1991. However, due to new evidence (from Taiwanese epidemiological studies) implicating arsenic in the development of other and more serious internal cancers, the maximum contaminant level (MCL) for arsenic was delayed.

EPA has discussed in public meetings a new MCL between 0.5 and 2 micrograms per liter based on a multistage, linear modeling study of potential human risk. Based on this model, a 1 in 1,000,000 cancer risk level would be 2 parts per billion (2 parts per billion or 2 microgram per liter). The groundwater supplies used in Los Alamos County and San Ildefonso have a 95th percentile UCL of 40 micrograms per liter and 22 micrograms per liter, respectively, based on the 1991 to 1996 LANL Environmental Surveillance Reports. The concentrations are lower than the current MCL for arsenic of 50 micrograms per liter. These concentrations are in and above the ranges EPA is considering in the new MCL for arsenic. While LANL operations do not affect arsenic risk to the public, the range of arsenic concentrations in the region of LANL are in the range that may be potentially be in the range for carcinogenesis at a rate in excess of 1 in 1,000,000.

D.3.4.2 *Beryllium*

Beryllium is a hard grayish metal that, in nature, is usually found in mineral compounds, especially in coal and in volcanic rock and weathered volcanic soils. Some beryllium is soluble but most is insoluble. Most soil beryllium-containing minerals have low solubilities (ATSDR 1993).

Ingestion risks from beryllium are very low, but beryllium is a suspected human carcinogen (EPA 1997b). The oral (ingestion) reference dose (RfD) is limited to soluble beryllium salts and is 5 x 10^{-3} milligrams per kilograms-day. The estimated maximum exposures (95th percentile) from ingestion of total beryllium near LANL range from 10^{-3} to 10^{-5} milligrams per kilograms-day. The concentrations of beryllium in the waters in the LANL area are in the 1 to 10 micrograms per liter range.

The primary risk from beryllium is from inhalation, which can lead to Chronic Beryllium Disease. Beryllium workers at LANL are protected from beryllium in the workplace under the Guidance for Implementation of DOE Order 440.1 section addressing "Chronic Beryllium Disease Prevention Program." The potential consequences of beryllium emissions from HE testing at LANL is discussed in sections 5.2.6.1 and 5.3.6.1.

D.3.4.3 *Lead*

Lead is an element found throughout the Earth's crust. Inorganic lead compounds are much less toxic than organic lead compounds. Exposure is primarily by inhalation and ingestion. Exposure to environmental media containing lead is the primary source of elevated blood levels of lead in children. Lead-containing paint in the home is the principal environmental lead source. At levels less than 20 micrograms per deciliter in the blood of a pregnant woman for even a short term (less than 14 days), low birth rate and learning impairment in the infant may occur. Longer exposures of young children can result in reduced IQ and slowed growth rates. Brain and kidney damage in children can result from blood levels of lead between 70 and 100 micrograms per deciliter.

Concentrations of lead in soil/sediments and water are in the range of 10 to 100 milligrams per kilogram and 1 to 10 micrograms per liter, respectively. In Los Alamos County supply wells, the concentrations of lead are not significantly different from the oral reference dose (1.4 x 10^{-3} milligrams per kilograms-day). Lead in environmental media near LANL is not significantly different from that in the entire region. Concentrations of lead are not expected to be affected by continued LANL operations, even in the Expanded Operations Alternative for HE testing (sections 5.2.6.1 and 5.3.6.1). Although lead is a suspected carcinogen, EPA has not established an oral or inhalation slope factor for risk estimation.

D.3.5 Data Used in the Human Health Analysis

Data used for estimating dose and risk for various pathways and receptors are provided in Tables C–1, C–2, C–4, and C–6 in appendix C as well as the tables included in this section (Tables D.3.5–1 through D.3.5–16). These data were taken from sampling locations that form the network of monitors on and around LANL. These data are routinely reported in the LANL annual environmental surveillance reports (such as LANL 1994).

Not all data sets were collected for the same years. Each data table in this SWEIS specifies the years reported.

Environmental restoration site data are presented in Tables C–8 and C–9 in appendix C. In general, these were not used to estimate risk to MEIs because they are in known contaminated areas that are not subject to public exposure. In cases where use of this data was considered appropriate, the discussion of the methodology and analysis identified the data used.

TABLE D.3.5–1.—*Location of Foodstuffs and Receptors Used for Consequence Analysis (ESH–20 Foodstuffs Database, 1990 to 1994)*

RECEPTOR	MATRIX	LOCATION
Los Alamos Resident	Elk (Bone)	Chama
	Elk (Bone)	Lindreth
	Elk (Bone)	Tres Piedras
	Elk (Muscle)	Chama
	Elk (Muscle)	Lindreth
	Elk (Muscle)	Tres Piedras
	Fruit	Los Alamos
	Fruit	White Rock
	Honey	Los Alamos
	Honey	White Rock
	Milk	Albuquerque
	Vegetable	Los Alamos
	Vegetable	White Rock
Non-Los Alamos Resident	Elk (Bone)	TA–16/S-Site Road
	Elk (Bone)	TA–18/Pajarito Road
	Elk (Bone)	TA–46/Pajarito Road
	Elk (Bone)	TA–49/State Road 4
	Elk (Bone)	TA–49/Water Canyon
	Elk (Bone)	TA–5/Mortandad Canyon
	Elk (Muscle)	TA–16S-Site Road
	Elk (Muscle)	TA–18/Pajarito Road
	Elk (Muscle)	TA–46/Pajarito Road
	Elk (Muscle)	TA–49/State Road 4
	Elk (Muscle)	TA–49/Water Canyon
	Elk (Muscle)	TA–5/Mortandad Canyon
	Fish (Game)	Cochiti
	Fish (Nongame)	Cochiti
	Fruit	San Ildefonso
	Honey	Pojoaque
	Honey	San Ildefonso
	Milk	Nambe
	Vegetable	San Ildefonso

TABLE D.3.5–1.—*Location of Foodstuffs and Receptors Used for Consequence Analysis (ESH–20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	LOCATION
On-Site, No Receptor	Fruit	LANL
	Honey	TA–15
	Honey	TA–16
	Honey	TA–21
	Honey	TA–33
	Honey	TA–35
	Honey	TA–49
	Honey	TA–5
	Honey	TA–53
	Honey	TA–54
	Honey	TA–8
	Honey	TA–9
	Vegetable	LANL
Regional	Fish (Game)	Abiquiu
	Fish (Nongame)	Abiquiu
	Fruit	Cochiti/Peña Blanca/Santo Domingo
	Fruit	Española/Santa Fe/Jemez
	Honey	San Pedro
	Vegetable	Cochiti/Peña Blanca/Santo Domingo
	Vegetable	Española/Santa Fe/Jemez

TABLE D.3.5–2.—*Los Alamos Water Supply Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*

ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Americium-241	pCi/l	29	37	0.002	0.04	0.109	0.093
Cesium-137	pCi/l	28	50	0.08	59.0	431	280.0
Gross Alpha	pCi/l	33	52	0.2	1.3	3	2.7
Gross Beta	pCi/l	52	52	1	3.6	9	7.0
Gross Gamma	pCi/l	32	48	10	140.0	552	410.0
Tritium	nCi/l	30	54	0.003	0.39	1.1	0.84
Plutonium-238	pCi/l	33	60	0.00010	0.01	0.026	0.024
Plutonium-239, Plutonium-240	pCi/l	44	60	0.00010	0.038	0.669	0.24
Strontium-90	pCi/l	10	25	0.2	1.3	4.6	4.5
Uranium	µg/l	34	55	0.15	0.89	2.2	1.8
Silver	µg/l	10	55	2	37.0	58	82.0
Aluminum	µg/l	6	56	30	140.0	280	300.0
Arsenic	µg/l	33	56	2	12.0	48	40.0
Boron	µg/l	37	56	10	44.0	500	200.0
Barium	µg/l	39	45	5	38.0	88	84.0
Beryllium	µg/l	5	56	1	1.4	2	2.5
Cadmium	µg/l	2	56	1.8	3.4	5	7.9
Cobalt	µg/l	2	54	3	67.0	130	250.0
Chromium	µg/l	31	56	2	8.1	30	19.0
Copper	µg/l	27	56	1	12.0	51	33.0
Iron	µg/l	12	56	10	200.0	830	680.0
Mercury	µg/l	6	45	0.1	0.17	0.2	0.27
Manganese	µg/l	11	56	1	8.8	69	49.0
Molybdenum	µg/l	19	56	1	4.7	30	18.0
Nickel	µg/l	3	56	10	16.0	20	27.0

TABLE D.3.5–2.—*Los Alamos Water Supply Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*-Continued

ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Lead	µg/l	17	59	1	15.0	95	64.0
Antimony	µg/l	12	56	0.7	1.5	4	3.4
Selenium	µg/l	4	56	1.7	2.2	2.7	3.0
Tin	µg/l	5	44	10	19.0	34	39.0
Strontium	µg/l	52	56	38	87.0	170	150.0
Thallium	µg/l	4	56	0.3	9.8	19	26.0
Vanadium	µg/l	48	56	7	32.0	260	110.0
Zinc	µg/l	26	56	5	23.0	54	49.0
Calcium	mg/l	56	56	5	15.0	32	28.0
Chlorine	mg/l	52	53	2	3.9	8	7.0
Cyanide	mg/l	1	46	0.01	0.01	0.01	
Carbonate	mg/l	1	56	2	2.0	2	
Fluorine	mg/l	56	56	0.2	0.9	28	8.3
Hardness	mg/l	56	56	5	51.0	119	100.0
Bicarbonate	mg/l	56	56	47	84.0	152	130.0
Potassium	mg/l	48	56	1	2.6	4.4	4.0
Lithium	mg/l	9	9	0.024	0.033	0.043	0.046
Magnesium	mg/l	50	56	0.2	3.4	9.4	8.4
Sodium	mg/l	56	56	10	20.0	45	37.0
Nitrate as Nitrogen	mg/l	58	60	0.1	0.81	9.9	3.5
Phosphate as Phosphorous	mg/l	23	56	0.02	0.15	0.3	0.37
Silica	mg/l	55	56	24	73.0	98	110.0
Sulfate	mg/l	52	53	2	4.2	6.34	6.4
Total Dissolved Solids	mg/l	54	60	90	180.0	320	270.0
Total Suspended Solids	mg/l	4	24	1	1.5	2	2.5

[a] Analytes and number of analyses from Guaje and Pajarito Mesa well fields only. No analyses from the LA well field or the Otowi well field are included here.
[b] pCi/l is picocuries per liter, nCi/l is nanocuries per liter, µg/l is micrograms per liter, and mg/l is milligrams per liter.
[c] Upper confidence limit (UCL) not calculated for number of detected analyses less than two.

TABLE D.3.5–3.—*Well LA–5 Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*

ANALYTE[a]	UNITS[b]	DETECTED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Americium-241	pCi/l	2	0.028	0.03	0.031	0.034
Cesium-137	pCi/l	2	1.7	38.0	74.0	140.0
Gross Alpha	pCi/l	2	0.92	0.96	1.0	1.1
Gross Beta	pCi/l	4	2.0	2.7	4.0	4.7
Gross Gamma	pCi/l	3	50.0	120.0	190.0	270.0
Tritium	nCi/l	2	0.1	0.15	0.2	0.29
Plutonium-238	pCi/l	2	0.0086	0.023	0.038	0.065
Plutonium-239, Plutonium-240	pCi/l	3	0.01	0.022	0.034	0.047
Strontium-90	pCi/l	3	0.1	0.27	0.6	0.84
Uranium	µg/l	3	1.0	1.1	1.2	1.3
Chloroethane	µg/l	1	13.0	13.0	13.0	
Aluminum	µg/l	1	62.0	62.0	62.0	
Arsenic	µg/l	3	2.0	2.7	3.0	3.8
Boron	µg/l	2	8.0	14.0	20.0	31.0
Barium	µg/l	3	58.0	61.0	65.0	68.0
Chromium	µg/l	3	4.8	13.0	26.0	36.0
Iron	µg/l	3	160.0	330.0	630.0	850.0
Mercury	µg/l	1	0.1	0.1	0.1	
Manganese	µg/l	3	8.0	18.0	36.0	49.0
Molybdenum	µg/l	1	1.7	1.7	1.7	
Antimony	µg/l	1	0.3	0.3	0.3	
Selenium	µg/l	1	2.0	2.0	2.0	
Tin	µg/l	1	10.0	10.0	10.0	
Strontium	µg/l	4	160.0	200.0	230.0	260.0
Thallium	µg/l	1	0.04	0.04	0.04	

TABLE D.3.5–3.—*Well LA–5 Detection Statistics Used in Consequence Analysis (Environmental Surveillance Database, 1991 to 1996)*-Continued

ANALYTE[a]	UNITS[b]	DETECTED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Vanadium	µg/l	4	10.0	19.0	31.0	37.0
Zinc	µg/l	4	3.9	380.0	1,300	1,600
Calcium	mg/l	4	18.0	20.0	21.0	23.0
Chlorine	mg/l	4	3.0	3.9	5.5	6.2
Fluorine	mg/l	4	0.5	13.0	49.0	61.0
Hardness	mg/l	4	46.0	52.0	56.0	61.0
Bicarbonate	mg/l	4	68.0	75.0	88.0	93.0
Potassium	mg/l	3	2.0	2.0	2.0	2.0
Magnesium	mg/l	3	0.8	0.84	0.9	0.95
Sodium	mg/l	4	14.0	20.0	34.0	39.0
Nitrate as Nitrogen	mg/l	4	0.2	0.45	0.76	0.92
Phosphate as Phosphorous	mg/l	1	0.1	0.1	0.1	
Silica	mg/l	4	40.0	42.0	43.0	44.0
Sulfate	mg/l	4	4.0	5.6	6.5	7.8
Total Dissolved Solids	mg/l	4	140.0	160.0	180.0	200.0

[a] Analytes and number of detected analyses from LA–5 only.
[b] pCi/l is picocuries per liter, nCi/l is nanocuries per liter, µg/l is micrograms per liter, and mg/l is milligrams per liter.
[c] Upper confidence limit (UCL) not calculated for number of detected analyses less than two.

TABLE D.3.5–4.—*NPDES Analyte Summary Statistics Used in Consequence Analysis (ESH NPDES Data, 1994 to 1996)*

ANALYTE[a]	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL
Aluminum (T)	mg/l	40	117	0.06	0.24	1.2	0.75
Arsenic (T)	mg/l	60	99	0.0016	0.0062	0.072	0.026
Boron (T)	mg/l	118	118	0.01	0.082	2.5	0.54
Cadmium (T)	mg/l	27	117	0.0001	0.0015	0.023	0.01
Chromium (T)	mg/l	79	115	0.004	0.012	0.07	0.038
Cobalt (T)	mg/l	23	118	0.0005	0.0062	0.028	0.017
Copper (T)	mg/l	69	115	0.004	0.044	0.59	0.25
Lead (T)	mg/l	24	117	0.0002	0.0084	0.045	0.032
Mercury (T)	mg/l	6	117	0.0003	0.00063	0.0017	0.0017
Radium-226, Radium-228	pCi/l	117	117	0.02	1.7	18.503	7.3
Selenium (T)	mg/l	18	118	0.001	0.0021	0.0063	0.0046
Tritium	pCi/l	65	118	6	2,900	134143	37,000
Vanadium (T)	mg/l	111	117	0.003	0.018	0.12	0.047
Zinc (T)	mg/l	106	117	0.016	0.082	1.2	0.34

[a] (T) signifies that the total amount of the analyte in the sample was measured (both the dissolved amount and the amount adsorbed to suspended particles).
[b] mg/l is milligrams per liter; pCi/l is picocuries per liter.

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
On-Site (used for both Resident, Recreational User, and Nonresident Recreational User)	Tritium	pCi/ml				0.67		2.3
	Cesium-137	pCi/g				0.45		1.0
	Plutonium-238	pCi/g				0.008		0.02
	Plutonium-239, Plutonium-240	pCi/g				0.077		0.4
	Strontium-90	pCi/g				0.42		0.78
	Uranium	µg/g				3.0		4.8
	Americium-241	pCi/g				0.009		0.019
	Gross Alpha	pCi/g				6.5		14.0
	Gross Beta	pCi/g				6.6		19.0
	Gross Gamma	pCi/g				3.5		4.1
	Silver	µg/g	11			0.9		2.3
	Aluminum	µg/g	10			3.4		4.3
	Arsenic	µg/g	11			2.6		3.7
	Boron	µg/g	10			16.0		24.0
	Barium	µg/g	11			120.0		170.0
	Beryllium	µg/g	11			0.74		1.0
	Cadmium	µg/g	11			0.2		0.27
	Chromium	µg/g	11			8.3		12.0
	Cobalt	µg/g	10			5.2		7.9
	Copper	µg/g	10			6.0		9.7
	Iron	µg/g	10			1.3		1.8
	Mercury	µg/g	11			0.03		0.04
	Manganese	µg/g	10			350.0		610.0
	Molybdenum	µg/g	10			0.66		0.93
	Nickel	µg/g	11			6.3		9.7
	Lead	µg/g	11			17.0		30.0
	Antimony	µg/g	10			0.17		0.45

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
On-Site (used for both Resident, Recreational User, and Nonresident Recreational User) (cont.)	Selenium	µg/g	11			0.31		0.48
	Tin	µg/g	10			8.7		12.0
	Strontium	µg/g	10			27.0		39.0
	Thallium	µg/g	10			0.52		0.93
	Vanadium	µg/g	10			21.0		30.0
	Zinc	µg/g	10			34.0		49.0
Perimeter (used for both Los Alamos County Resident and Non-Los Alamos County Resident)	Tritium	pCi/ml				0.24		0.76
	Cesium-137	pCi/g				0.38		0.98
	Plutonium-238	pCi/g				0.007		0.029
	Plutonium-239, Plutonium-240	pCi/g				0.051		0.21
	Strontium-90	pCi/g				0.34		0.7
	Uranium	µg/g				3.0		4.4
	Americium-241	pCi/g				0.011		0.037
	Gross Alpha	pCi/g				4.6		8.6
	Gross Beta	pCi/g				5.2		8.2
	Gross Gamma	pCi/g				3.7		4.5
	Silver	µg/g	10			0.66		1.4
	Aluminum	µg/g	7			3.3		3.5
	Arsenic	µg/g	10			2.4		3.9
	Boron	µg/g	7			8.0		14.0
	Barium	µg/g	10			96.0		160.0
	Beryllium	µg/g	10			0.66		0.99
	Cadmium	µg/g	10			0.27		0.6
	Chromium	µg/g	10			8.0		13.0
	Cobalt	µg/g	7			4.7		8.2
	Copper	µg/g	7			5.9		9.0
	Iron	µg/g	7			1.2		1.6

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
Perimeter (used for both Los Alamos County Resident and Non-Los Alamos County Resident) (cont.)	Mercury	µg/g	10			0.03		0.05
	Manganese	µg/g	7			380.0		650.0
	Molybdenum	µg/g	7			0.68		0.85
	Nickel	µg/g	10			5.5		8.6
	Lead	µg/g	10			19.0		36.0
	Antimony	µg/g	7			0.14		0.17
	Selenium	µg/g	10			0.34		0.64
	Tin	µg/g	7			7.7		10.0
	Strontium	µg/g	7			23.0		36.0
	Thallium	µg/g	7			0.68		1.7
	Vanadium	µg/g	7			15.0		29.0
	Zinc	µg/g	7			33.0		49.0
Regional	Tritium	pCi/ml				-0.1		0.36
	Cesium-137	pCi/g				0.28		0.54
	Plutonium-238	pCi/g				0.004		0.008
	Plutonium-239, Plutonium-240	pCi/g				0.011		0.019
	Strontium-90	pCi/g				0.3		0.44
	Uranium	µg/g				1.9		2.7
	Americium-241	pCi/g				0.006		0.008
	Gross Alpha	pCi/g				4.8		7.2
	Gross Beta	pCi/g				4.5		5.9
	Gross Gamma	pCi/g				2.8		3.6
	Silver	µg/g	6			1.1		2.1
	Aluminum	µg/g	6			2.9		3.7
	Arsenic	µg/g	6			3.1		6.1
	Boron	µg/g	6			12.0		17.0
	Barium	µg/g	6			130.0		190.0

TABLE D.3.5–5.—*Soil Detection Statistics Used in Consequence Analysis (Environmental Surveillance Soils Data, 1992 to 1996)*-Continued

LOCATION[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
Regional (cont.)	Beryllium	µg/g	6			0.49		0.74
	Cadmium	µg/g	6			0.2		0.2
	Chromium	µg/g	6			10.0		15.0
	Cobalt	µg/g	6			4.8		6.7
	Copper	µg/g	6			7.8		11.0
	Iron	µg/g	6			1.5		2.2
	Mercury	µg/g	6			0.02		0.02
	Manganese	µg/g	6			280.0		420.0
	Molybdenum	µg/g	6			0.63		0.79
	Nickel	µg/g	6			8.0		11.0
	Lead	µg/g	6			11.0		14.0
	Antimony	µg/g	6			0.14		0.2
	Selenium	µg/g	6			0.38		0.62
	Tin	µg/g	6			11.0		16.0
	Strontium	µg/g	6			89.0		260.0
	Thallium	µg/g	6			0.3		0.84
	Vanadium	µg/g	6			26.0		40.0
	Zinc	µg/g	6			34.0		49.0

[a] On-site, perimeter and regional designations in accordance with Environmental Surveillance Program.
[b] pCi/g is picocuries per gram, pCi/ml is picocuries per milliliter, µg/g is micrograms per gram.
[c] Number of detected analyses not available. Values represent the number of means (from Fresquez et al. 1997).
[d] Number of analyses not available.
[e] Minimum and maximum values not available.
[f] Values are means for radiochemical constituents and mean of means for trace metal constituents.

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
Los Alamos County Resident	Elk (Muscle)	Cesium-137	pCi/g dry	5	5	0.0118	0.21	0.504	0.63
	Elk (Muscle)	Uranium	µg/g dry	3	5	0.0005	0.0016	0.0022	0.0035
	Fruit	Cesium-137	pCi/g dry	19	31	0.0076	0.12	0.6427	0.49
	Fruit	Tritium	nCi/l	27	31	0.2	2.1	16	9.1
	Fruit	Plutonium-238	pCi/g dry	15	31	0.000056	0.00032	0.001231	0.00097
	Fruit	Plutonium-239	pCi/g dry	22	31	0.00003	0.0013	0.020374	0.0099
	Fruit	Strontium-90	pCi/g dry	25	25	0.0069	0.042	0.1647	0.12
	Fruit	Uranium	µg/g dry	30	30	0.0006	0.012	0.08278	0.045
	Honey	Tritium	nCi/l	4	4	0.2	10.0	37.3	46.0
	Milk	Cesium-137	pCi/l	1	1	2.41	2.4	2.41	
	Milk	Iodine-131	pCi/l	1	1	10	10.0	10	
	Milk	Uranium	µg/l	1	1	0.1	0.1	0.1	
	Vegetable	Cesium-137	pCi/g dry	27	45	0.0031	0.13	0.7328	0.44
	Vegetable	Tritium	nCi/l	41	45	0.1	0.52	1.3	1.1
	Vegetable	Plutonium-238	pCi/g dry	29	45	0.000015	0.00021	0.00098	0.00065
	Vegetable	Plutonium-239	pCi/g dry	33	45	0.000023	0.00083	0.0196	0.0076
	Vegetable	Strontium-90	pCi/g dry	36	36	0.0053	0.064	0.855	0.34
	Vegetable	Uranium	µg/g dry	43	45	0.00026	0.0042	0.02085	0.011
Non-Los Alamos County Resident	Elk (Muscle)	Cesium-137	pCi/g dry	6	8	0.0113	0.12	0.2504	0.3
	Elk (Muscle)	Tritium	nCi/l	3	3	0.1	1.8	4.7	6.9
	Elk (Muscle)	Plutonium-238	pCi/g dry	1	8	0.00002	0.00002	0.00002	
	Elk (Muscle)	Plutonium-239	pCi/g dry	4	8	0.00002	0.000086	0.000252	0.00031
	Elk (Muscle)	Strontium-90	pCi/g dry	3	8	0.0042	0.0072	0.0126	0.017
	Elk (Muscle)	Uranium	µg/g dry	4	7	0.0001	0.0028	0.0086	0.011
	Fish (Game)	Cesium-137	pCi/g dry	4	5	0.006	0.093	0.203	0.28
	Fish (Game)	Plutonium-238	pCi/g dry	5	5	0.00003	0.000049	0.00008	0.000088
	Fish (Game)	Plutonium-239	pCi/g dry	4	5	0.00004	0.000062	0.00009	0.00011
	Fish (Game)	Strontium-90	pCi/g dry	5	5	0.041	0.072	0.092	0.11

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
Non-Los Alamos County Resident (cont.)	Fish (Game)	Uranium	µg/g dry	5	5	0.0048	0.0054	0.00664	0.0069
	Fish (Nongame)	Cesium-137	pCi/g dry	5	5	0.001	0.059	0.178	0.22
	Fish (Nongame)	Plutonium-238	pCi/g dry	4	5	0.00003	0.000047	0.000076	0.000087
	Fish (Nongame)	Plutonium-239	pCi/g dry	3	5	0.00002	0.000044	0.00006	0.000087
	Fish (Nongame)	Strontium-90	pCi/g dry	5	5	0.015	0.026	0.049	0.057
	Fish (Nongame)	Uranium	µg/g dry	5	5	0.0059	0.011	0.02042	0.022
	Fruit	Cesium-137	pCi/g dry	8	12	0.007	0.058	0.1588	0.18
	Fruit	Tritium	nCi/l	5	11	0.1	0.28	0.7	0.76
	Fruit	Plutonium-238	pCi/g dry	6	11	0.000058	0.000098	0.000205	0.00021
	Fruit	Plutonium-239	pCi/g dry	8	12	0.000019	0.00034	0.002132	0.0018
	Fruit	Strontium-90	pCi/g dry	9	11	0.0026	0.023	0.0896	0.084
	Fruit	Uranium	µg/g dry	12	12	0.0007	0.003	0.00788	0.0078
	Honey	Tritium	nCi/l	6	9	0.1	0.38	0.7	0.79
	Milk	Cesium-137	pCi/l	1	1	3.1	3.1	3.1	
	Milk	Tritium	nCi/l	1	1	0.1	0.1	0.1	
	Milk	Iodine-131	pCi/l	1	1	4.7	4.7	4.7	
	Milk	Plutonium-238	pCi/l	1	1	0.003	0.003	0.003	
	Milk	Uranium	µg/l	1	1	0.24	0.24	0.24	
	Vegetable	Cesium-137	pCi/g dry	11	13	0.0119	0.46	2.484	2.0
	Vegetable	Tritium	nCi/l	9	13	0.1	0.53	1	1.1
	Vegetable	Plutonium-238	pCi/g dry	6	13	0.000025	0.001	0.0024	0.0028
	Vegetable	Plutonium-239	pCi/g dry	10	13	0.000036	0.00025	0.000959	0.00079
	Vegetable	Strontium-90	pCi/g dry	11	11	0.0252	0.12	0.2898	0.28
	Vegetable	Uranium	µg/g dry	13	13	0.00066	0.046	0.27489	0.2
On-Site, No Receptor	Fruit	Cesium-137	pCi/g dry	11	27	0.0004	0.061	0.2427	0.21
	Fruit	Tritium	nCi/l	25	27	0.1	2.2	8.9	7.0
	Fruit	Plutonium-238	pCi/g dry	14	26	0.000025	0.00017	0.000778	0.00055
	Fruit	Plutonium-239	pCi/g dry	17	27	0.00005	0.00018	0.000488	0.00043
	Fruit	Strontium-90	pCi/g dry	20	21	0.005	0.044	0.1344	0.12

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
On-Site, No Receptor (cont.)	Fruit	Uranium	µg/g dry	27	27	0.00027	0.011	0.0394	0.034
	Honey	Tritium	nCi/l	49	54	0.1	62.0	1300	460.0
	Vegetable	Cesium-137	pCi/g dry	4	10	0.0014	0.0042	0.0092	0.011
	Vegetable	Tritium	nCi/l	10	10	0.1	0.78	2.7	2.6
	Vegetable	Plutonium-238	pCi/g dry	5	10	0.000047	0.00023	0.000363	0.00055
	Vegetable	Plutonium-239	pCi/g dry	8	10	0.000044	0.00029	0.000678	0.00079
	Vegetable	Strontium-90	pCi/g dry	9	10	0.0154	0.038	0.059	0.065
	Vegetable	Uranium	µg/g dry	10	10	0.00132	0.0036	0.00655	0.0074
Regional	Fish (Game)	Cesium-137	pCi/g dry	5	5	0.001	0.046	0.108	0.15
	Fish (Game)	Plutonium-238	pCi/g dry	3	5	0.00002	0.000032	0.000045	0.000057
	Fish (Game)	Plutonium-239	pCi/g dry	4	5	0.00003	0.000068	0.00014	0.00017
	Fish (Game)	Strontium-90	pCi/g dry	5	5	0.01	0.043	0.116	0.13
	Fish (Game)	Uranium	µg/g dry	5	5	0.00091	0.0021	0.0033	0.0043
	Fish (Nongame)	Cesium-137	pCi/g dry	5	5	0.008	0.11	0.268	0.31
	Fish (Nongame)	Plutonium-238	pCi/g dry	5	5	0.00001	0.000041	0.000076	0.00009
	Fish (Nongame)	Plutonium-239	pCi/g dry	4	5	0.000029	0.000067	0.00018	0.00022
	Fish (Nongame)	Strontium-90	pCi/g dry	5	5	0.026	0.038	0.047	0.056
	Fish (Nongame)	Uranium	µg/g dry	5	5	0.0043	0.0057	0.00748	0.0082
	Fruit	Cesium-137	pCi/g dry	22	45	0.0005	0.075	0.374	0.27
	Fruit	Tritium	nCi/l	27	44	0.1	0.41	1	0.93
	Fruit	Plutonium-238	pCi/g dry	21	45	0.000023	0.00016	0.0005	0.00041
	Fruit	Plutonium-239	pCi/g dry	32	45	0.000023	0.00017	0.00117	0.00065
	Fruit	Strontium-90	pCi/g dry	32	34	0.0019	0.026	0.0798	0.073
	Fruit	Uranium	µg/g dry	45	45	0.00052	0.011	0.08295	0.041
	Honey	Tritium	nCi/l	2	5	0.2	0.25	0.3	0.39
	Vegetable	Cesium-137	pCi/g dry	44	59	0.0004	0.12	0.4133	0.35
	Vegetable	Tritium	nCi/l	44	58	0.1	0.35	0.9	0.79
	Vegetable	Plutonium-238	pCi/g dry	21	58	0.00001	0.00016	0.000492	0.00042
	Vegetable	Plutonium-239	pCi/g dry	32	59	0.00001	0.00025	0.002394	0.0012

TABLE D.3.5–6.—*Foodstuffs Used in Consequence Analysis Sorted by Receptor (ESH-20 Foodstuffs Database, 1990 to 1994)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[b]
Regional (cont.)	Vegetable	Strontium-90	pCi/g dry	43	45	0.003	0.038	0.1592	0.11
	Vegetable	Uranium	µg/g dry	58	59	0.0003	0.0089	0.03991	0.027

[a] pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight, nCi/l is nanocuries per liter, and µg/l is micrograms per liter.
[b] Upper confidence limit (UCL) not calculated for number of detected analyses less than two.

TABLE D.3.5–7.—*Free-Range Steer Muscle Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data for 1996)*

LOCATION	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Perimeter	Tritium	nCi/l				-0.4		0.2
San Ildefonso (used for Non-Los Alamos County Resident)	Strontium-90	pCi/g dry				0.011		0.026
	Plutonium-238	pCi/g dry				0.0		0.00003
	Plutonium-239	pCi/g dry				0.000074		0.00015
	Cesium-137	pCi/g dry				0.014		0.021
	Americium-241	pCi/g dry				0.000037		0.000067
	Uranium	µg/g dry				0.0015		0.0018

[a] nCi/l is nanocuries per liter, pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–8.—*Deer Muscle Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data for 1996)*

LOCATION	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
On-Site (Non-Los Alamos County Resident)	Tritium	nCi/l				0.36		0.99
	Strontium-90	pCi/g dry				-0.0023		0.023
	Plutonium-238	pCi/g dry				0.000012		0.00005
	Plutonium-239	pCi/g dry				0.000016		0.000056
	Cesium-137	pCi/g dry				0.11		0.5
	Americium-241	pCi/g dry				0.000023		0.000079
	Uranium	µg/g dry				0.7		0.7
Regional (Los Alamos County Resident)	Tritium	nCi/l				0.15		0.86
	Strontium-90	pCi/g dry				0.01		0.038
	Plutonium-238	pCi/g dry				-0.000025		0.000046
	Plutonium-239	pCi/g dry				0.00005		0.00019
	Cesium-137	pCi/g dry				0.018		0.027
	Americium-241	pCi/g dry				0.0		0.0
	Uranium	µg/g dry				0.00075		0.0015

[a] nCi/l is nanocuries per liter, pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–9.—*Analysis of Fish Used in Consequence Analysis (ESH–20 Foodstuffs Database, 1990 to 1994)*

ANALYTE	UNITS[a]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL
Cesium-137	pCi/g dry	19	20	0.001	0.075	0.268	.024
Plutonium-238	pCi/g dry	17	20	0.00001	0.000043	0.00008	0.000082
Plutonium-239	pCi/g dry	15	20	0.00002	0.000061	0.00018	0.00015
Strontium-90	pCi/g dry	20	20	0.01	0.045	0.116	0.1
Uranium	µg/g dry	20	20	0.00091	0.0061	0.02042	0.015

[a] pCi/g dry is picocuries per gram dry weight, and µg/g dry is micrograms per gram dry weight.

TABLE D.3.5–10.—*Bottom-Feeding Fish Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*

RECEPTOR[a]	ANALYTE	UNITS[b]	DETECTED[c]	ANALYZED[d]	MINIMUM[e]	MEAN[f]	MAXIMUM	95% UCL
Non-Los Alamos County Resident	Silver	µg/g wet				0.13		0.13
	Arsenic	µg/g wet				0.25		0.25
	Barium	µg/g wet				0.063		0.063
	Beryllium	µg/g wet				0.053		0.053
	Cadmium	µg/g wet				0.11		0.11
	Chromium	µg/g wet				0.63		0.63
	Copper	µg/g wet				0.82		0.82
	Mercury	µg/g wet				0.34		0.34
	Nickel	µg/g wet				1.1		1.1
	Lead	µg/g wet				1.3		1.3
	Antimony	µg/g wet				1.3		1.3
	Selenium	µg/g wet				0.28		0.28
	Thallium	µg/g wet				1.3		1.3
	Zinc	µg/g wet				5.8		9.1

[a] Data from Abiquiu, Heron, and El Vado.
[b] µg/g wet is micrograms per gram wet.
[c] Number of detected analyses not available.
[d] Number of analyses not available.
[e] Minimum and maximum values not available.
[f] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–11.—*Produce Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Los Alamos County Resident	Fruit	Silver	µg/g dry		2	0.27	0.43	0.58	0.86
		Arsenic	µg/g dry		2	0.1	0.1	0.1	0.1
		Barium	µg/g dry		2	1.91	2.1	2.27	2.6
		Beryllium	µg/g dry		2	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		2	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		2	0.5	1.0	1.51	2.4
		Mercury	µg/g dry		2	0.05	0.05	0.05	0.05
		Nickel	µg/g dry		2	2.76	3.9	5.09	7.2
		Lead	µg/g dry		2	2.8	3.1	3.3	3.8
		Antimony	µg/g dry		2	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		2	0.1	0.1	0.1	0.1
		Thallium	µg/g dry		2	0.15	0.15	0.15	0.15
	Vegetable	Silver	µg/g dry		12	0.27	0.32	0.56	0.54
		Arsenic	µg/g dry		12	0.1	0.1	0.1	0.1
		Barium	µg/g dry		12	0.26	10.0	27.7	25.0
		Beryllium	µg/g dry		12	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		12	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		12	0.13	0.7	3.09	2.5
		Mercury	µg/g dry		12	0.05	0.05	0.05	0.05
		Nickel	µg/g dry		12	1.36	5.6	17	17.0
		Lead	µg/g dry		12	0.6	8.7	48	39.0
		Antimony	µg/g dry		12	0.15	0.19	0.4	0.39
		Selenium	µg/g dry		12	0.1	0.22	0.4	0.44
		Thallium	µg/g dry		12	0.15	0.15	0.15	0.15

TABLE D.3.5–11.—*Produce Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Non-Los Alamos County Resident	Vegetable	Silver	µg/g dry		5	0.16	0.16	0.16	0.16
		Arsenic	µg/g dry		5	0.15	0.2	0.4	0.42
		Barium	µg/g dry		5	0.82	13.0	29.9	36.0
		Beryllium	µg/g dry		5	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		5	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		5	0.08	0.17	0.4	0.46
		Mercury	µg/g dry		5	0.05	0.06	0.1	0.1
		Nickel	µg/g dry		5	0.36	1.2	3.6	4.1
		Lead	µg/g dry		5	1	6.8	27.1	30.0
		Antimony	µg/g dry		5	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		5	0.1	0.34	0.7	0.78
		Thallium	µg/g dry		5	0.15	0.15	0.15	0.15
On-Site, No Receptor	Fruit	Silver	µg/g dry		6	0.16	0.16	0.16	0.16
		Arsenic	µg/g dry		6	0.1	0.17	0.5	0.49
		Barium	µg/g dry		6	2.49	6.7	16.7	17.0
		Beryllium	µg/g dry		6	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		6	0.12	0.12	0.12	0.12
		Chromium	µg/g dry		6	0.08	0.1	0.22	0.22
		Mercury	µg/g dry		6	0.05	0.067	0.1	0.12
		Nickel	µg/g dry		6	0.36	0.86	1.43	1.7
		Lead	µg/g dry		6	2.9	7.0	12.6	15.0
		Antimony	µg/g dry		6	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		6	0.1	0.15	0.3	0.32
		Thallium	µg/g dry		6	0.15	0.15	0.15	0.15

TABLE D.3.5–11.—*Produce Chemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*-Continued

RECEPTOR	MATRIX	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Regional	Vegetable	Silver	µg/g dry		13	0.16	0.24	0.58	0.47
		Arsenic	µg/g dry		13	0.1	0.18	1.1	0.73
		Barium	µg/g dry		13	0.35	6.0	18.4	17.0
		Beryllium	µg/g dry		13	0.06	0.06	0.06	0.06
		Cadmium	µg/g dry		13	0.12	0.14	0.32	0.25
		Chromium	µg/g dry		13	0.13	1.0	4.35	4.0
		Mercury	µg/g dry		13	0.05	0.054	0.1	0.082
		Nickel	µg/g dry		13	0.36	6.5	28.6	25.0
		Lead	µg/g dry		13	1.1	8.4	26.4	28.0
		Antimony	µg/g dry		13	0.15	0.15	0.15	0.15
		Selenium	µg/g dry		13	0.1	0.22	0.4	0.44
		Thallium	µg/g dry		13	0.15	0.15	0.15	0.15

[a] µg/g dry is micrograms per gram dry weight.
[b] Number of detected analyses not available. The dataset included substituted values in place of nondetects, and then all analyses were used in calculating the summary statistics.
[c] Data are 1996 surveillance data.

TABLE D.3.5–12.—*Bottom-Feeding Fish Regional Statistic Reference Levels Used in Consequence Analysis (ESH-20 Data, 1996)*

RECEPTOR	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN	MAXIMUM	95% UCL[e]
Special Pathway	Silver	µg/g wet						1.2
	Arsenic	µg/g wet						0.4
	Barium	µg/g wet						1.2
	Beryllium	µg/g wet						1.3
	Cadmium	µg/g wet						0.3
	Chromium	µg/g wet						1.5
	Copper	µg/g wet						1.4
	Mercury	µg/g wet						0.4
	Nickel	µg/g wet						1.5
	Lead	µg/g wet						4.0
	Antimony	µg/g wet						2.1
	Selenium	µg/g wet						0.4
	Thallium	µg/g wet						2.1
	Zinc	µg/g wet						6.6

[a] µg/g wet is micrograms per gram wet.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum, maximum, and mean values not available.
[e] Upper confidence limit, given as the regional statistical reference level, was obtained from 1996 surveillance data. The calculations includes negative and zero values.

TABLE D.3.5–13.—*Elk Tissue Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data for 1991 to 1993)*

LOCATION	TISSUE	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
On-Site (No Receptor)	Heart	Cesium-137	pCi/g dry				0.041		0.12
		Plutonium-238	pCi/g dry				0.00005		0.00017
		Plutonium-239	pCi/g dry				0.000023		0.000065
		Strontium-90	pCi/g dry				0.002		0.009
		Uranium	µg/g dry				0.0007		0.0041
	Liver	Cesium-137	pCi/g dry				0.17		0.49
		Plutonium-238	pCi/g dry				0.000013		0.000059
		Plutonium-239	pCi/g dry				0.000033		0.000095
		Strontium-90	pCi/g dry				0.004		0.012
		Uranium	µg/g dry				0.0046		0.017
Regional (Special Pathways)	Heart	Cesium-137	pCi/g dry				0.058		0.068
		Plutonium-238	pCi/g dry				0.0		0.0
		Plutonium-239	pCi/g dry				0.00015		0.00066
		Strontium-90	pCi/g dry				0.0023		0.0065
		Uranium	µg/g dry				0.011		0.049
	Liver	Cesium-137	pCi/g dry				0.22		0.6
		Plutonium-238	pCi/g dry				0.000017		0.000075
		Plutonium-239	pCi/g dry				0.000033		0.000095
		Strontium-90	pCi/g dry				0.003		0.0082
		Uranium	µg/g dry				0.0052		0.023

[a] pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from Frequez et al. 1994. The calculation of mean values may include negative and zero values in their calculation.

TABLE D.3.5–14.—*Navajo Tea (Cota) Radiochemical Summary Statistics Used in Consequence Analysis (ESH-20 Data, 1996)*

LOCATION	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
Perimeter San Ildefonso (Special Pathway)	Tritium	nCi/l				-0.11		0.16
	Strontium-90	pCi/l				0.4		1.2
	Plutonium-238	pCi/l				0.018		0.028
	Plutonium-239	pCi/l				0.011		0.022
	Cesium-137	pCi/l				18.0		53.0
	Americium-241	pCi/l				0.015		0.073
	Uranium	µg/l				0.75		0.91

[a] nCi/l is nanocuries per liter, pCi/l is picocuries per liter, µg/l is micrograms per liter.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from 1996 surveillance data. The calculation of mean values includes negative and zero values.

TABLE D.3.5–15.—*Edible Portions of Beans, Corn, and Squash Used in Consequence Analysis (ESH-20 Data, 1996)*

LOCATION	FOODSTUFF	ANALYTE	UNITS[a]	DETECTED[b]	ANALYZED[c]	MINIMUM[d]	MEAN[e]	MAXIMUM	95% UCL
On-Site (Special Pathway)	Vegetables	Tritium	nCi/l				0.9		1.3
		Cesium-137	pCi/g dry				3.0		5.5
		Strontium-90	pCi/g dry				11.0		14.0
		Plutonium-238	pCi/g dry				0.000056		0.00022
		Plutonium-239	pCi/g dry				0.00032		0.0006
		Americium-241	pCi/g dry				0.00077		0.0013
		Uranium	µg/g dry				0.002		0.0044
		Arsenic	µg/g dry				0.14		0.34
		Cadmium	µg/g dry				0.15		0.22
		Chromium	µg/g dry				0.16		0.5
		Mercury	µg/g dry				0.05		0.05
		Lead	µg/g dry				7.5		9.4
		Antimony	µg/g dry				0.15		0.15
		Zinc	µg/g dry				47.0		71.0
Regional	Vegetables	Tritium	nCi/l				0.03		0.66
		Cesium-137	pCi/g dry				0.021		0.069
		Strontium-90	pCi/g dry				0.038		0.06
		Plutonium-238	pCi/g dry				0.000019		0.000097
		Plutonium-239	pCi/g dry				0.000054		0.00013
		Americium-241	pCi/g dry				0.00013		0.00025
		Uranium	µg/g dry				0.0034		0.0042
		Arsenic	µg/g dry				0.1		0.1
		Cadmium	µg/g dry				0.12		0.12
		Chromium	µg/g dry				0.08		0.08
		Mercury	µg/g dry				0.05		0.05
		Lead	µg/g dry				4.6		7.6
		Antimony	µg/g dry				0.15		0.15
		Zinc	µg/g dry				31.0		51.0

TABLE D.3.5–15.—*Edible Portions of Beans, Corn, and Squash Used in Consequence Analysis (ESH-20 Data, 1996)*-Continued

[a] nCi/l is nanocuries per liter, pCi/g dry is picocuries per gram dry weight, µg/g is micrograms per gram dry weight.
[b] Number of detected analyses not available.
[c] Number of analyses not available.
[d] Minimum and maximum values not available.
[e] Means and standard deviation values (not given here) are from Frequez et al. 1997. The calculation of mean values includes negative and zero values.

TABLE D.3.5–16.—*Analysis of Pinyon Nuts Used in Consequence Analysis (Salazar 1979)*

RECEPTOR[a]	ANALYTE	UNITS[b]	DETECTED	ANALYZED	MINIMUM	MEAN	MAXIMUM	95% UCL[c]
Special Pathways	Beryllium-7	pCi/g dry	6	6	0.005	0.013	0.024	0.028
	Cesium-137	pCi/g dry	6	6	0.003	0.0092	0.019	0.024
	Tritium	nCi/l	5	5	5.6	13.0	24.2	28.0
	Plutonium-239	pCi/g dry	4	6	0.007	0.068	0.22	0.27
	Strontium-90	pCi/g dry	6	6	0.01	0.33	0.84	0.92
	Uranium	µg/g dry	6	6	0.05	0.21	0.79	0.78
Non-Los Alamos County Resident	Beryllium-7	pCi/g dry	NA	NA	NA	0.023	NA	0.14
	Cesium 137	pCi/g dry	NA	NA	NA	0.004	NA	0.02
	Tritium	nCi/l	NA	NA	NA	4.9	NA	5.7
	Plutonium-238	pCi/g dry	NA	NA	NA	0.007	NA	0.017
	Plutonium-239	pCi/g dry	NA	NA	NA	0.003	NA	0.013
	Strontium-90	pCi/g dry	NA	NA	NA	0.17	NA	0.23
	Uranium	µg/g dry	NA	NA	NA	0.08	NA	0.08

[a] Special pathway receptor data is from on-site locations (TA–15, TA–18, TA–21/53, TA–49, TA–52, and TA–54). Non-Los Alamos County Resident data is from regional locations (Nambe, Santa Fe, and Abiquiu).
[b] pCi/g dry is picocuries per gram dry weight, nCi/l is nanocuries per liter, and µg/g dry is micrograms per gram dry weight.
[c] Upper Confidence Limits (UCL) calculated as the mean plus two standard deviations.
NA = Not available

REFERENCES

ACGIH 1997 — "Beryllium and Compounds," 1997 Supplement, Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th Edition. American Conference of Governmental Industrial Hygienists. Cincinnati, Ohio. 1997.

Athas 1996 — *Investigation of Excess Thyroid Cancer Incidence in Los Alamos*. W. F. Athas. New Mexico Department of Health. April 1996.

Athas and Key 1993 — *Cancer Incidence in Los Alamos County, 1970-1990*, Final Report—*Los Alamos Cancer Rate Study: Phase I*. W. F. Athas and C. R. Key. New Mexico Department of Health. Santa Fe, New Mexico. March 1993.

ATSDR 1989 — *Arsenic*. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registering. Available on-line at: http://www.enznetinc.net/users/ themissinglink/Arsenic.htm.

ATSDR 1993 — *Toxic Substances: Beryllium.* U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registering. Available on-line at: http://www. enznetinc.net/users/themissinglink/ beryllium.htm.

BEIR V 1990 — *Health Effects of Exposures to Low Levels of Ionizing Radiation.* National Research Council, Committee on the Biological Effects of Ionizing Radiation. National Academy Press. Washington, D.C. 1990.

Bork 1987 — *Natural Resources Defense Council vs. U.S. Environmental Protection Agency*. Opinion, Bork, Circuit Judge. 263 U.S. Appeals, D.C. 166. Decided July 28, 1987.

Calder 1984 — *Size, Function, and Life History*. William Calder. Harvard College. Boston Massachusetts. 1984.

Cember 1996 — *Introduction to Health Physics*, 3d ed. Herman Cember. McGraw-Hill. New York, New York. 1996.

CLAWS 1997 — *Arsenic*. City of Los Angeles Water Services. Available on-line at: http://www.dwp.ci.la.ca.us/ water/quality/wq-arsnc.htm.

DOC 1990 — *1990 Census of Population: Social and Economic Characteristics, New Mexico*. U.S. Department of Commerce, Bureau of the Census. Washington, D.C. 1990.

EPA 1989 — *Exposure Factors Handbook*. U.S. Environmental Protection Agency. Washington, D.C. 1989.

EPA 1990 — *Protection of Environment*. 40 CFR 300.430. U.S. Environmental Protection Agency. July 1, 1990.

EPA 1992 — *User's Guide for CAP–88 PC.* U.S. Environmental Protection Agency, Air and Radiation Office. 402-B-92-001. Washington, D.C. 1992.

EPA 1997a — *Exposure Factors Handbook*. U.S. Environmental Protection Agency. Washington, D.C. 1997.

EPA 1997b — *Integrated Risk Information System (IRIS) Data Base.* U.S. Environmental Protection Agency, Office of Research and Development. Washington, D.C. 1997.

ESR Data — See individual entries for LANL Environmental Surveillance Reports: LANL 1992 (1990 ESR), LANL 1993 (1991 ESR), LANL 1994 (1992 ESR), LANL 1995 (1993 ESR), LANL 1996a (1994 ESR), LANL 1996b (1995 ESR), LANL 1997 (1996 ESR).

Foodstuffs Database — Data on Food Consumption, obtained from LANL ESH-20 database.

Fresquez et al. 1994 — *Radionuclide Concentrations in Elk that Winter on Los Alamos National Laboratory Lands.* P. R. Fresquez, D. R. Armstrong, and J. G. Salazar. Los Alamos National Laboratory. LA-12795-MS. Los Alamos, New Mexico. 1995.

Fresquez et al. 1996 — *Radionuclides and Radioactivity in Soils Within and Around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparisons.* P. R. Fresquez, M. A. Mullen, J. K. Ferenbaugh, and R. A. Perona. Los Alamos National Laboratory. LA-13149-MS. Los Alamos, New Mexico. April 1996.

Fresquez et al. 1997 — *Radionuclide Concentrations in Pinto Beans, Sweet Corn, and Zucchini Squash Grown in Los Alamos Canyon at Los Alamos National Laboratory.* P. R. Fresquez, D. R. Armstrong, M. A. Mullen, and L. Narranjo, Jr. Los Alamos National Laboratory. LA-13304-MS. Los Alamos, New Mexico.

Fresquez and Ferenbaugh 1998 — *Moisture Conversion Ratios for the Foodstuffs and Biota Environmental Surveillance Programs at Los Alamos National Laboratory*. P. R. Fresquez and J. K. Ferenbaugh. Los Alamos National Laboratory. LA-UR-98-1054. Los Alamos, New Mexico. March 1998.

ICRP 1991 — "1990 Recommendations of the International Commission on Radiological Protection." Publication 60, Volume 21, No. 1-3. *Annals of the ICRP*. Pergamon Press. New York, New York. 1991.

LANL 1992 — *Environmental Surveillance at Los Alamos During 1990*. Los Alamos National Laboratory. LA-12271-M8. UC-1990. Los Alamos, New Mexico. March 1992.

LANL 1993 — *Environmental Surveillance at Los Alamos During 1991.* Los Alamos National Laboratory. LA-12572-ENV, UC-902. Los Alamos, New Mexico. August 1993.

LANL 1994 — *Environmental Surveillance at Los Alamos During 1992.* Los Alamos National Laboratory. LA-12764-MS, UC-902. Los Alamos, New Mexico. July 1994.

LANL 1995 — *Environmental Surveillance at Los Alamos During 1993.* Los Alamos National Laboratory. LA-12973-ENV, UC-902. Los Alamos, New Mexico. October 1995.

LANL 1996a — *Environmental Surveillance at Los Alamos during 1994.* Los Alamos National Laboratory, Environmental Assessments and Resource Evaluations Group. LA-13047-ENV. Los Alamos, New Mexico. July 1996.

LANL 1996b — *Environmental Surveillance at Los Alamos During 1995.* Los Alamos National Laboratory. LA-13210-ENV, UC-902. Los Alamos, New Mexico. October 1996.

LANL 1997 — *Environmental Surveillance and Compliance at Los Alamos During 1996.* Los Alamos National Laboratory. LA-13343-ENV. Los Alamos, New Mexico.

Miller et al. 1996 — *Racial/Ethic Patterns of Cancer in the United States 1988–1992.* B. A. Miller, L. N. Kolonel, L. Bernstein, J. L. Young, Jr., G. M. Swanson, D. West, C. R. Key, J. M. Liff, C. S. Glover, G. A. Alexander, et al. (eds). National Cancer Institute. NIH Pub. No. 96-4104. Bethesda, Maryland. 1996.

NBS 1952 — *Radiological Monitoring Methods and Instruments.* National Bureau of Standards Handbook #51. April 1952.

NCRP 1981 — *Radiofrequency Electromagnetic Fields–Properties, Quantities and Units, Biophysical Interaction, and Measurements.* National Council on Radiation Protection. NCRP Report No. 67. Bethesda, Maryland. 1981.

NCRP 1986 — *Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields.* National Council on Radiation Protection and Measurements. NCRP Report No. 86. Bethesda, Maryland. 1986.

NCRP 1987 — *Exposure of the Population in the United States and Canada from Natural Background Radiation*. Recommendations of the National Council on Radiation Protection and Measurements. NCRP Report No. 94. Bethesda, Maryland. December 1987.

NCRP 1989 — *Comparative Carcinogenicity of Ionizing Radiation and Chemicals*. National Council on Radiation Protection and Measurements. NCRP Report No. 96. March 1, 1989.

NCRP 1993 — *A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields.* National Council on Radiation Protection. NCRP Report No. 119. Bethesda, Maryland. December 31, 1993.

NPDES Data — Data on Water Quality, obtained from the LANL Water Quality and Hydrology Group (ESH-18) NPDES Chemical Database. Only 1994–1996 data available currently.

OSHA 1997 — "Quantitative Risk Assessment." Occupational Safety and Health Administration. *Federal Register*, Vol. 62, No. 7, pp. 1516–1563. January 10, 1997.

Ries et al. 1996 — *SEER Cancer Statistics Review*, 1973-1993, tables and graphs. L. A. G. Ries, C. L. Kosary, B. F. Hankey, A. Harras, B. A. Miller, and B. K. Edwards (eds.). National Institute of Health/National Cancer Institute. Bethesda, Maryland. 1996.

Robinson and Thomas 1991 — *Time Spent in Activities, Locations and Microenvironments: A California-National Comparison Project Report.* J. P. Robinson and J. Thomas. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory. Las Vegas, Nevada. 1991.

Salazar 1979 — *Radionuclide Content of Pinyon Nuts in the Vicinity of the Los Alamos Scientific Laboratory.* J. G. Salazar. Los Alamos Scientific Laboratory. LA-UR-79-238. Los Alamos, New Mexico. 1979.