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RCRA Facility Investigation for the Townsite of Los Alamos, New Mexico.

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ABSTRACT

During World War II, Los Alamos, New Mexico was established as an ideal location for the secrecy and safety needed for the research and development required to design a nuclear fission bomb. Experiments carried out in the 1940s generated both radioactive and hazardous waste constituents on what is presently part of the Los Alamos townsite. Under the RCRA permit issued to Los Alamos National Laboratory in 1990, the Laboratory is scheduled for investigation of its solid waste management units (SWMUs). The existing information on levels of radioactivity on the townsite is principally data from soil samples taken during the last site decontamination in 1976; little information on the presence of hazardous constituents exists today. This paper addresses pathway analysis and a preliminary risk assessment for current residents of the Los Alamos townsite. The estimated dose levels, in mrem per year, show that the previously decontaminated SWMU areas on the Los Alamos Townsite will not contribute a radiation dose of any concern to the current residents.

INTRODUCTION

During the initial stage of U.S. involvement in World War II, Los Alamos, New Mexico was identified as the prime location for the operation of a top-secret project to develop an atomic bomb. In 1943, work on the project was initiated and the Los Alamos National Laboratory's (the Laboratory) first technical area, known as The Technical Area (TA-1) was established on an isolated, remote site deep within the sparsely populated state of New Mexico.

With the exception of high explosives research and development, the majority of the theoretical and technical work accomplished at the Laboratory from 1943-1954 was conducted at TA-1. The Laboratory's initial bench-scale physical and chemical experiments involving plutonium, uranium and other radionuclides were almost exclusively conducted at TA-1. During the early years of the Laboratory, purification and processing operations for ^{235}U and ^{239}Pu also were performed at TA-1. These activities generated considerable radioactive and hazardous waste products. In addition, machining and fabrication operations, as well as general non-radioactive chemistry and physics laboratory work, produced hazardous waste constituents.

From 1954 to 1965, TA-1 operations steadily decreased as the operations gradually were relocated to newly constructed technical areas. By 1965, all but one of the original Laboratory technical structures erected at TA-1 had been dismantled and removed. The Los Alamos Community Building occupies the only remaining, unchanged structure from the former TA-1 Laboratory. Decommissioned TA-1 property was transferred to Los Alamos County and to private ownership for residential, commercial, and recreational development.

Since the last decommissioning and decontamination activities ended in 1976, construction activity in the former TA-1 area of the Los Alamos community has not ceased. Residential buildings have been built at the western portion of the parcel, while commercial and municipal buildings have been established along both sides of the town's main east-west thoroughfare, Trinity Drive. All residential buildings are multiple-unit dwellings consisting of privately-owned condominiums or rented townhouses. Much landscaping has been completed around the residential units. In general, commercial properties have more paving (for parking) and less landscaping than residential buildings.

In November 1989, the New Mexico Environmental Improvement Division issued a Resource Conservation and Recovery Act permit to the DOE and

University of California for operating the Laboratory. Additionally, on March 8, 1990, the EPA issued a Hazardous and Solid Waste Amendments (HSWA) Module, effective on May 23, 1990, to the RCRA operating permit. The HSWA Module mandates procedural requirements for assessing and remediating sites that meet the definition of solid waste management units (SWMUs). The Module stipulates that corrective actions investigations be taken for any potential releases at any SWMU at the Laboratory "regardless of the time at which the waste was placed in such unit." The EPA further identified and prioritized all SWMUs for which the Laboratory must take action to verify and determine the nature and extent of releases of hazardous constituents or waste. SWMUs located within TA-1 were identified by their proximity to former Laboratory buildings in which the storage or handling of radioactive or hazardous materials was suspected to have occurred, or by their proximity to former septic tanks, drain lines, or liquid waste lines that may have carried radioactive and chemical waste to outfalls located at the rim of Los Alamos Canyon. Thus, SWMUs are associated with former TA-1 structures and have no bearing to structures currently occupying the TA-1 area where they are located (Figure 1). During the decommissioning and decontamination activities of the mid-1970s, many of the areas where TA-1 SWMUs are located were sampled for radionuclide presence in soils. Although the sampled areas were deemed clean at the time, no surveys or analyses were done to determine whether hazardous chemical constituents may have been present in the remaining soils.

ENVIRONMENTAL SETTING

The TA-1 area is located at an elevation of approximately 7,000 ft. on the western portion of New Mexico's Pajarito Plateau, at a point roughly one third of the distance between the rising of the Jemez Mountains to the west and the White Rock Canyon of the Rio Grande to the east. TA-1 is underlaid by approximately 800 ft. of volcanic ash bedrock formation, the Bandelier Tuff. The regional aquifer lies at a depth of approximately 1,250 ft. below the top of the mesas on which the Laboratory is built.

TA-1 currently straddles the Laboratory's boundary. The mesa top portion of TA-1 lies outside the Laboratory's boundary while the canyon walls portion (down to the bottom of Los Alamos Canyon) is within the Laboratory's boundary. A portion of the present Los Alamos townsite's eastern sector currently encompasses the approximately 50 acre area formerly occupied by TA-1.

Los Alamos County has a semiarid, temperate mountain climate. Strong winds occur predominantly in the spring. The prevalent wind direction, especially for strong winds, is south-southwest. Los Alamos precipitation is typical for a semiarid climate. It receives a normal annual precipitation, including rainfall and water-equivalent snowfall, of 18 inches. As is characteristic for semiarid climatic regions, actual precipitation from year to year varies considerably. Annual precipitation extremes range from 6.8 to 30.3 in. over a 69-year period (1). Brief, intense thunderstorms during July and August account for forty percent of the area's annual precipitation. These summer storm events are associated with significant run-off of surface water. Incidences of brief, intense precipitation events ensure that surface erosion and transport via surface water run-off are primary mechanisms for transport of soil contaminants at TA-1.

Soils in the vicinity of TA-1 are loamy, mixed, figid Lithic Ustorthent (Pogna series) (2). In general, the Pogna series consists of shallow well-drained soils that formed in material weathered from tuff on gently to strongly sloping mesa tops. The available water capacity of this moderately rapid permeable soil is low, and the effective rooting depth is relatively shallow at 7.9-19.7 inches. Runoff is medium, and there is a moderate water erosion. The slopes between the mesa tops and canyon bottoms primarily consist of steep rock outcrop intermixed with shallow patches of soils.

Los Alamos Canyon, located directly south of the TA-1 area, has ephemeral stream flow for a majority of the year, dependent upon annual precipitation and releases from the upstream Los Alamos Reservoir. Run-off and infiltration are the significant aspects of surface water hydrology at TA-1. Via run-off, TA-1 contaminants might move into surface waters, become concentrated in drainages, and deposit downstream. It is expected that, during the 26 years since the last technical building was demolished at TA-1, significant removal of contaminants from TA-1 by surface water run-off has occurred. TA-1 contaminants might be transported into subsurface soils and the vadose zone and alluvial aquifers at the bottom of Los Alamos Canyon via the mechanism of surface water infiltration.

During summer thunderstorms and spring snowmelt, run-off flows into an ephemeral stream below TA-1 in Los Alamos Canyon. Summer storm run-off achieves maximum discharge in less than 2 hours but generally lasts less than 24 hours (3). This high discharge rate can transport large masses of suspended and bed sediments for considerable distances possibly including the entire stream length.

Laboratory studies indicate infiltration of water into the tuff bedrock is not a significant mechanism for the movement of contaminants on the mesa tops occupied by Laboratory facilities (4). These studies have shown that even the prolonged presence of a water source on the mesa top (which is not the case at TA-1) produces only a limited transfer of moisture to or through the tuff. Strong evaporative potential associated with the semi-arid climate paired with transpiration in vegetated areas leads to rapid removal of water from soils and upper tuff.

The Laboratory's environmental surveillance program includes several hundred stations monitoring various media (5). Regional stations located within 50 miles of the Laboratory determine conditions beyond the range of potential influence from Laboratory operations. Perimeter stations located closer to Laboratory boundaries are used to confirm that any releases beyond the Laboratory boundary remain minimal. On-site stations monitor the effect of releases close to the source.

ENVIRONMENTAL TRANSPORT MECHANISMS AND RECEPTOR PATHWAYS

When assessing potential environmental pathways, it is important to note that TA-1 SWMUs are located either totally on the mesa top, the canyon wall, or partially on both. The two physical settings greatly differ in their geological characteristics and land-use scenarios. For risk assessment analyses and sampling strategy plans, the mesa top and canyon wall classifications lead to two distinct conceptual models. When defining the types of release mechanisms from primary sources of contaminants, SWMUs fall into four release and transport categories:

- **Surface contamination areas on mesa tops** include SWMUs comprised of contaminated surface soils resulting from contaminated building structures, solid waste leaching, and inadvertent surface liquid waste leaks or spills of limited volume. Surface soils may be contaminated from past operations, including spills, overflows, stack emissions, windblown dust releases and similar processes.

- **Subsurface liquid releases on mesa tops** include SWMUs having areas contaminated by past releases from leaks of buried septic tanks and waste lines. These areas are diffusely located, relatively shallow in depth, and unlikely to have high concentrations of contaminants.

- **Solid waste disposal on canyon walls** include SWMUs predominantly comprised of exposed rubble and soils that were bulldozed or dumped over the canyon wall during demolition of TA-1 buildings.

- **Liquid releases on canyon walls** occurred directly over the edge of Los Alamos Canyon during the years of TA-1's active operation. Liquid releases include wastes from laundry facilities, sanitary sewer lines, cooling tower drains and storm drains. Soils and tuff outcrops at the site of the outfalls and along the canyon wall may be contaminated.

Potential human exposure to residual contaminants may result from six release and transport mechanisms that are relevant for TA-1:

- atmospheric dispersion,
- surface water run-off,
- infiltration and migration in the vadose zone,
- erosion,
- external exposure to radiation, and
- direct contact.

Because the regional aquifer and the surface of the mesa on which TA-1 lies are separated by approximately 1,250 ft. of Bandelier Tuff and underlying sediments, it has been concluded that no pathway exists for the migration of contaminants to ground water. Therefore, ground water is not considered a viable pathway for dissemination of contaminants at TA-1.

Atmospheric Dispersion Pathway. Contamination of surface soils at TA-1 has occurred through either intentional or inadvertent release of solid or liquid wastes onto mesa top or hillside soils. Surface soils constitute a major source of contaminants that may now be suspended and redeposited through airborne dispersion. For the mesa tops, however, most soil contamination events occurred almost 40 years ago. As a result of subsequent decontamination and decommissioning activities in the 1960s and 1970s, these contaminated soils may now be under several feet of clean fill.

Release mechanisms from sediments would include anthropogenic activities, such as construction or gardening. Canyon wall contamination is also the result of past exposures, but chemical releases from mesa top activities onto the hillside areas would have been deposited onto soils that have been undisturbed by human activities. Demolition debris, possibly containing contaminants, was dumped over the edge of the mesa rim, or was bulldozed over the rim during decommissioning of the former TA-1 buildings. Therefore, radionuclides and chemical constituents could have directly contaminated bedrock, soils on small hillside bench areas, or could be present as exposed rubble. The atmospheric dispersion pathway for contaminant release on canyon walls is resuspension of exposed soils and rubble surface dusts.

Surface Water Run-off Pathway. Surface water run-off events generate water flow at the foot of the TA-1 hillside along portions of Los Alamos Canyon. Although summer run-off events may be particularly heavy, surface water from upper Los Alamos Canyon reaches the Rio Grande less frequently than once per year (3). Snowmelt causing spring run-off can last long enough to saturate the canyon bottom and support flow along the entire length of the canyon. Thus, spring run-off may contribute an important pathway for off-site transport of potential TA-1 contaminants.

Sediment transport by surface water run-off is dependent upon soil properties and water velocity. Transported soils include those suspended in water as well as heavier particles moved by the force of the water along the bed of the drainage. The quantity of contaminants transported is dependent on physical and chemical properties of both soil and contaminant. Contaminants that may have been originally released onto the mesa top and hillside soils may chemically bind to and be transported with soil particles. The silt-clay fraction of soil often enhances contaminant retention because of the mineralogy and the higher specific surface area of the small clay particles. Once detached from the soil, silt-clay sediments are readily transported in suspension; thus surface water run-off is an efficient contaminant transport mode. Movement with sediment is the primary mode of surface water transport in the semiarid ecosystem of Los Alamos for insoluble contaminants such as uranium and plutonium (6,7,8).

Infiltration and Vadose Zone Migration Pathway. Liquid-phase migration of either precipitation or liquid wastes releases in the vadose zone is highly unlikely in Bandelier Tuff. Thus, while some migration into the tuff may have occurred 30 years ago when liquid wastes were originally released, such migration would stop soon thereafter because of the lack of significant recharge and great thickness of the vadose zone (4).

Erosion Pathway. On the Pajarito Plateau, long-term exposure of subsurface contaminated soils or buried wastes is dependent on two major mechanisms: 1) loss of surface soil cover via wind and water erosion and; 2) mass-wasting of canyon walls. These mechanisms might expose contaminated surface soils, or wastes from the canyon side, that could then be dispersed into the environment by atmospheric dispersion or surface water runoff. Mass-wasting, or cliff retreat, of canyon walls is a very long-term process. Several 600- to 800-year-old prehistoric Indian cave dwellings continue to exist in the mesa walls of the Pajarito Plateau indicating the tremendous time scale for this event.

External Exposure and Direct Contact. Although not strictly release or transport pathways, external exposure to radiation and direct contact are included as potential exposure pathways to human receptors. Exposure to potential contamination may be dependent on external penetrating radiation from exposed contaminated surfaces, absorption through inhalation or ingestion, or dermal absorption of hazardous chemical constituents or tritium from potentially contaminated surface soils, tuff, or rubble.

Due to the long interim period since tritium and volatile hazardous constituents have been released, their continued presence on the surface is highly unlikely. However, heavy metals, radionuclides, or persistent chemicals may exist on surface soils, tuffs, or exposed rubble. Over time, erosion may expose current subsurface soils and tuff to the surface via either mechanism mentioned above.

Local Populations. Most TA-1 area residents, comprised generally of elderly or young families with small children, have access to open grass areas in the form of yards or common recreational areas. The population group in the TA-1 mesa top area that is most likely to be exposed is a family who may garden on their land. Current residential and commercial land use is expected to continue and presents the most important land use scenario of concern for possible human exposure to radioactive and toxic materials potentially present in existing TA-1 mesa top SWMUs.

Future land use must also be considered. A scenario of increased construction and habitation of residences, perhaps having larger yard and garden areas, may be possible. It is highly improbable that residents will ever raise their own livestock. Another population of concern for exposure at the site is construction site workers. Such workers would be in the TA-1 area for eight hours a day, for several months at a time, and may be exposed dermally to soils that are at present both surface and subsurface and to dust raised during construction activities.

The canyon wall portion of TA-1 is owned by DOE and is fenced at the mesa rim to deter access. However, access to the canyon walls is not prevented from below and the area is used by an occasional hiker through the canyon. If the canyon wall should ever be released to the townsite, recreational users would be expected to increase. More importantly, children from mesa top residences would have free access to the canyon wall area and frequent playing among the boulders and soils would be expected.

EXPOSURE SCENARIOS

In estimating human health risk from the TA-1 area SWMUs, a conceptual site model has been developed. The conceptual model identifies the scenario for estimating exposure to an individual maximally exposed at the site. The conceptual model for contaminant release and transport and potential routes of exposure is presented in Figure 2. Pathway descriptions include primary release mechanisms, environmental transport processes, and resulting contaminated media for each pathway for both the mesa top and canyon wall areas of TA-1.

The resident who gardens and produces fruits and vegetables for some portion of his or her diet is expected to receive the highest predicted lifetime dose from any contaminants present on the mesa top. The resident who gardens is a highly probable scenario for the TA-1 area because much of TA-1 is currently occupied by privately-owned townhouses or condominiums and, although land available for gardening is quite small at present, it is conceivable that in the future some of the mesa top might be used for larger family units. An exposure unit of 5,000 sq. ft. has been chosen to define the area that a family-garden scenario would use (9).

Contaminant exposure pathways to the resident who gardens are 1) inhalation of contaminated dust; 2) ingestion of fruits or vegetables grown in contaminated soils; 3) direct dermal contact with contaminated soils and debris; 4) external exposure to radiation; and 5) ingestion of contaminated soil by a child, or accidental ingestion by an adult. Nonviable pathways include routine ingestion of drinking water drawn from on-site sources, ingestion of either meat or milk from livestock raised on-site, and ingestion of aquatic foods raised in an on-site pond.

The canyon wall is inaccessible for human habitation and is likely to be used for recreational activities in the future, if not presently. The maximally exposed individual for the TA-1 canyon wall has been identified as the child who plays on the hillside. This scenario can be termed a "recreational" scenario, with emphasis on a child. An exposure unit of 1 acre is a likely area in which a child might roam. An important factor in calculating risk via a recreational scenario will be the relatively small amount of on-site time spent at the activity. Pathways for exposure include 1) direct dermal contact with contaminated soils and debris; 2) inhalation of re-entrained dusts; 3) external exposure to radiation; and 4) ingestion of contaminated soils. Exposure through consumption of vegetables, meat, milk, or drinking water are nonviable pathways in the recreational scenario. For TA-1, many of the site-specific parameters needed to calculate exposure on the canyon walls are unknown at this time. Therefore, the risk assessment for the recreational scenario on the canyon walls of TA-1 will not be developed further until proposed sampling results are determined.

PRELIMINARY RADIOLOGICAL RISK ASSESSMENT FOR TA-1

Because our first priority is to determine risk for current residents of the Los Alamos Townsite area, and because baseline risk analysis will use soil sampling data from the 1974-1976 site decontamination and decommissioning, preliminary risk assessment procedures will focus on the mesa top exposure scenario. Further, the risk calculated will be risk due only to residual radioactivity. Risk due to hazardous chemical constituents that may be present in TA-1 SWMUs will be calculated after results from soil samples indicate the presence of chemicals of concern.

The Department of Energy (DOE Order 5400.5) has approved the use of a standardized computer code, developed by Argonne National Laboratory (10), to calculate dose, as Committed Effective Dose Equivalents (CEDE), to a maximally exposed population group. The code, Residual Radioactive Materials (RESRAD), applies site-specific parameters for each effective pathway in a chosen exposure scenario. For TA-1, the choice of the family-garden scenario leads to activation or deactivation of pathways discussed above. The RESRAD code requires input of parameters, some site-specific, to assess relative importance of exposure pathways for the family-garden scenario. Many parameters--inhalation, dietary and nondietary pathways, and soil ingestion parameters--are DOE recommended default values based on the recommendations of the International Commission on Radiological Protection (11). TA-1 site-specific climatic values, such as precipitation, irrigation, runoff coefficient, wind speed, and erosion rate are used.

Hydrologic parameters for TA-1's three geologic strata--the contaminated, saturated, and unsaturated zones--are also site specific. The ground water pathway is not a viable route of exposure for TA-1. Climatic and hydrologic parameters peripherally affect other pathways, such as uptake of radioactive contaminants by root systems.

Once site-specific parameters are entered in the RESRAD code, the program computes a dose (CEDE) in mrem/yr from a known concentration of a singl radioisotope, or a combination of radionuclides. Radionuclide concentrations can be entered as soil concentration (in pCi/gr.), concentration in water (in pCi/l), or both. For TA-1, single radionuclide concentrations are estimated from soil sampling data collected in 1976. In computing the total dose (CEDE) to a maximally exposed individual, RESRAD considers the radionuclide decay products' contribution.

The 1974-1976 decontamination and decommissioning activities at TA-1 mainly focused on removal of radionuclide contamination. Most SWMUs have data for gross alpha and beta levels, however, quantitative isotopic concentrations are restricted to select sites. Based on historic documentation of TA-1 waste practices, research activities, and operational procedures, each of the SWMU aggregates can be associated with a discrete radioactive contaminant and the gross alpha concentrations can be assumed to have resulted from that radionuclide.

In the 1974-1976 radiological survey and cleanup, contaminated areas were excavated until radiation levels in remaining soils or sediments measured as low as practicably achievable (generally, less than 20 pCi/gr. gross alpha or beta above background). After the 1976 TA-1 cleanup, a PHOSWICH surface survey indicated 17 areas needing further cleanup. The remainder of the site's surface was considered safe when a PHOSWICH surface survey found no radioactive contamination. The 1977 sampling data collected by Ahlquist and colleagues (12) can be associated with SWMU aggregates for the purpose of calculating radiological risk. Gross alpha values used here are those from samples collected after the 1976 cleanup effort. Table 1 presents the mean gross alpha (in pCi/gr.) for the 1976 data and describes sample locations corresponding to both the former TA-1 buildings and current SWMU aggregates. The table also includes information on the number of soil samples having detectable levels of alpha radiation (above the 20 pCi/gr. detection limit). In order to compute mean gross alpha levels for each area, data points below the limit of detection were ascribed a value of 10 pCi/gr., or one half the detection limit.

In an attempt to determine any effect the shape and size of an exposure unit might have on contaminant concentration within a sampling set, different exposure units were characterized statistically. Sampling data means for exposure units shaped as squares, rectangles, wedges, and circles of 5,000 and 3,000 sq. ft. were compared and their distributions plotted. For the 5,000 sq. ft. exposure unit, circularly-shaped areas generally had the smallest mean and variance of the mean and were normally distributed. Exposure units of 5,000 sq. ft. will be used to calculate dose (CEDE) on the mesa top and 5,000 sq. ft. circles have been used to calculate means. As an example, Table 1 shows the mean gross alpha value calculated for each sampling data set, grouped by SWMU aggregate. In the case of the central area of the D building in the D Building aggregate, many soil samples were taken over an area larger than 5,000 sq. ft. We have reported the overall mean of the area, 23.7 pCi/gr., and the range of 29 randomly-determined 5,000 sq. ft. circular areas. The low value of the range, 11.9 pCi/gr., indicates a random circle that encompassed only 4 of 54 data points above the detection limit; the high value of the range, 28.4 pCi/gr., had 26 of 57 soil samples above 20 pCi/gr. gross alpha.

The RESRAD code has been used to calculate total dose (CEDE, in mrem/yr) for each set of TA-1 sampling means and the results are presented in Table 1. For each SWMU area, the gross alpha data are entirely applied as ^{239}Pu or as ^{235}U (both alpha emitters), depending upon the principal radioisotope contaminant expected for the SWMU aggregate. An assumption has been made that the 1976 sampling data is representative of residual radioactivity on the ground surface today. This assumption is extremely conservative because clean fill was brought in and the ground which was sampled then may be currently buried under 0.2-2 m of soil. Therefore, dose values to a maximally exposed individual would be considerably lower under present day conditions. The protection offered by dirt cover of various depths is presented in Figure 3. A hypothetical dose of 38 mrem/yr with no cover drops one and one half orders of magnitude with 0.2 m of cover and approaches zero with 1 m of cover material.

The projected dose (CEDE) values for the mesa top SWMU areas range between 7.5 to 30.3 mrem/yr. These doses result from sampling data means that ranged from 10.8 to 28.7 pCi/gr. gross alpha levels. The International Commission on Radiological Protection has set a basic limit for the annual radiation dose to a member of the general public above background as 100 mrem/yr (13). Based on this annual limit, guidelines for residual concentrations of radionuclides in soils can be calculated using site-specific parameters with the RESRAD computer code. Site-specific guidelines for the TA-1 mesa top would be 89.7 pCi/gr. for ^{239}Pu and 144.4 pCi/gr. for ^{235}U. These target concentrations correspond to a carcinogenic risk of 3.4×10^{-5} for ^{239}Pu and a risk of 1.2×10^{-4} for ^{235}U, based on EPA slope factors (14, 15). The results of our preliminary dose calculations suggest that the previously decontaminated SWMU areas on the TA-1 mesa top will not contribute a radiation dose of any concern to the current residents.

Several of our assumptions using the RESRAD code have led to conservative estimates of the dose. Those assumptions include 1) the soil samples taken in 1976 represent the levels present in the soils today; 2) the gross alpha counts are on the surface; 3) all gross alpha counts have been assigned to the most probable, and worse case, radionuclide at each site; and 4) mesa top residents would be exposed through all pathways chosen, including a large amount of their diet taken from foodstuffs grown on-site. Based on the available information, our calculations indicate the Los Alamos residents living in the TA-1 area are assured of adequate protection from residual radiation in the soils.

The total dose values (CEDE) per exposure unit generated above by the RESRAD code each have an associated level of risk to the maximally exposed population. A one in one million risk, or 1×10^{-6}, represents the chance that within a population exposed to residual radioactivity in the soil via the pathways attributed to the associated exposure scenario, one individual in one million might contract cancer. The carcinogenic risk associated with the mrem/yr dose calculated for ^{239}Pu or ^{235}U will be determined using EPA slope factors for ^{239}Pu and ^{235}U (15).

As mentioned above, risk analysis results presented here are based on soil sampling data collected in the mid-1970s. At that time, although much soil was removed from the TA-1 area (more than 19,000 cubic yards), radionuclides were the only contaminants for which soil samples were analyzed. In order to ensure that the preliminary risk assessment results presented represent true health risks to current residents of the TA-1 area, verification sampling will be conducted. Some sampling will be of a confirmatory nature, that is, radionuclide analyses in the areas for which soil sampling data indicate highest residual radioactivity. In addition, many samples will be analyzed for hazardous chemical constituents, heavy metals and semi-volatile organics (in a simple random manner) to certify to the extent possible that the TA-1 area poses no unacceptable health risk to current, and future, inhabitants.

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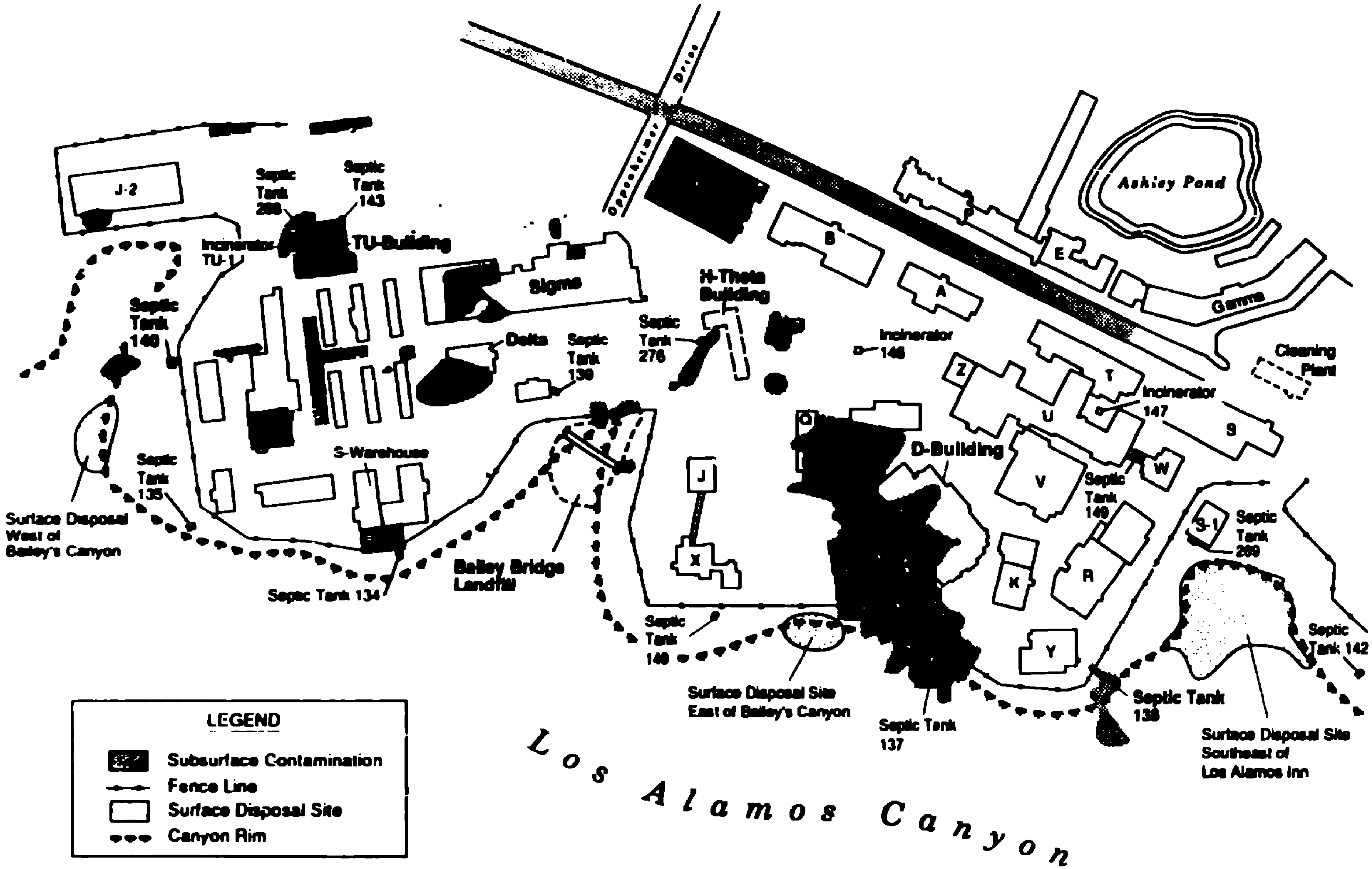

Figure 1. Former buildings and current SWMU's at TA-1.

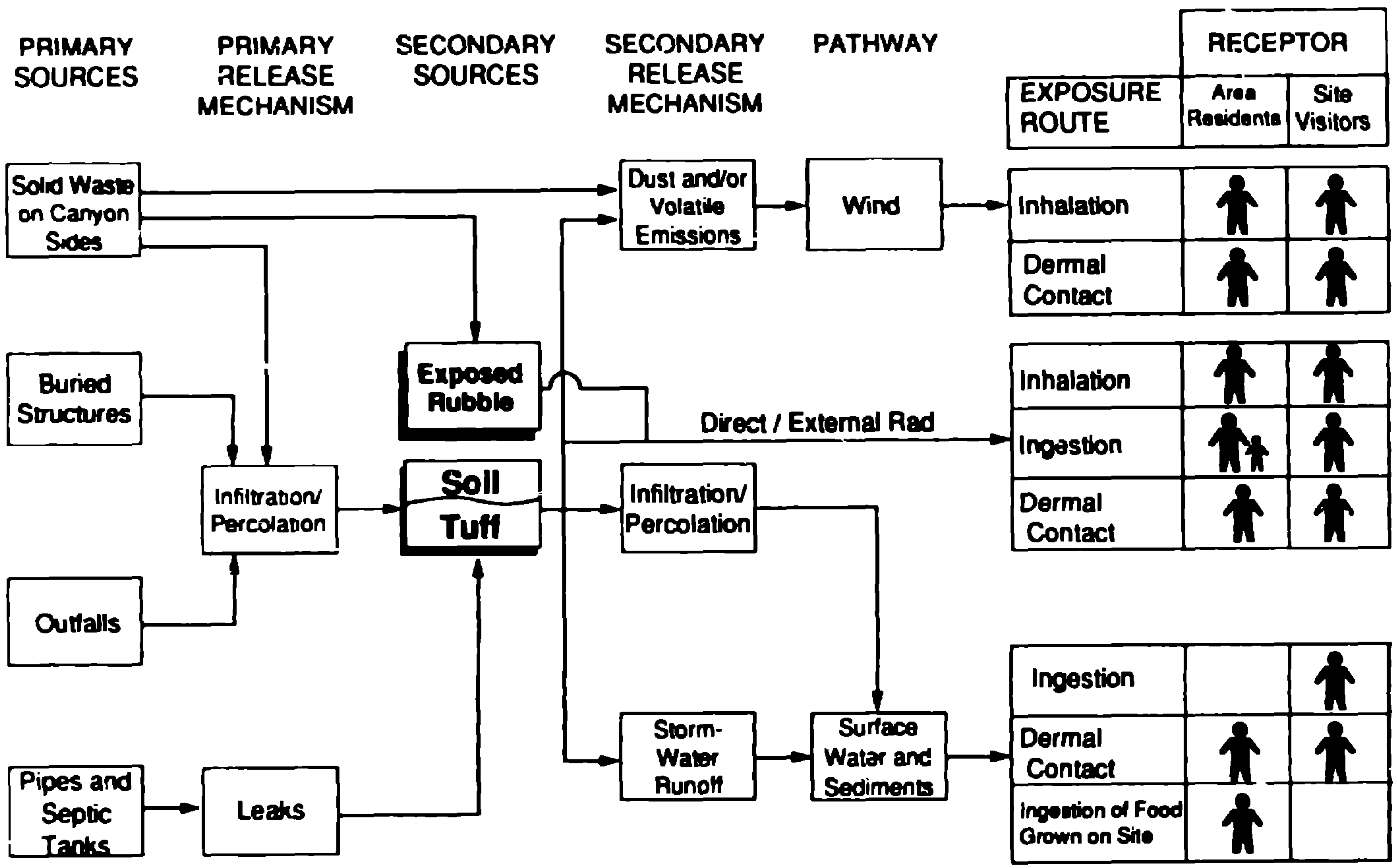

Figure 2. Conceptual Site Model for Mesa Top and Canyon Walls of TA-1.

Table 1. TA-1 sampling points and dose estimates using RESRAD parameters for gardening scenario on TA-1 mesa top.

SWMU Description	Number of Sampling Points	Number of samples >20 pCi/g	Mean GROSS ALPHA (pCi/g)	TOTAL DOSE† (mrem/yr)
D Building Aggregate				
NW of D Building, surface	21	4	15.9	17.7 ^{239}Pu
NW of D Building, 1m	21	7	19.1	21.3
S of D Building	160	50	27.2	30.3
Central D Building	421	125	23.7	26.5
range			11.9 to 28.4	
Bailey Bridge Aggregate				
H-Theta Trench	53	12	21.7	15.0 ^{235}U
H-Theta Building Area	59	7	23.5	16.3
S Warehouse	11	3	20.9	14.5
Sigma Building Vicinity				
Sigma Building	35	2	11.4	7.9 ^{235}U
Delta Building	7	3	28.7	19.9
TU Area	27	1	11.1	7.7
Septic Tank 140				
Warehouse Area	59	2	10.8	7.5 ^{235}U
J-2 Building Area	22	2	12.6	8.7

†Dose is calculated by the RESRAD computer code and assumes that, for each sampling location, gross alpha levels are due to either ^{239}Pu or ^{235}U.

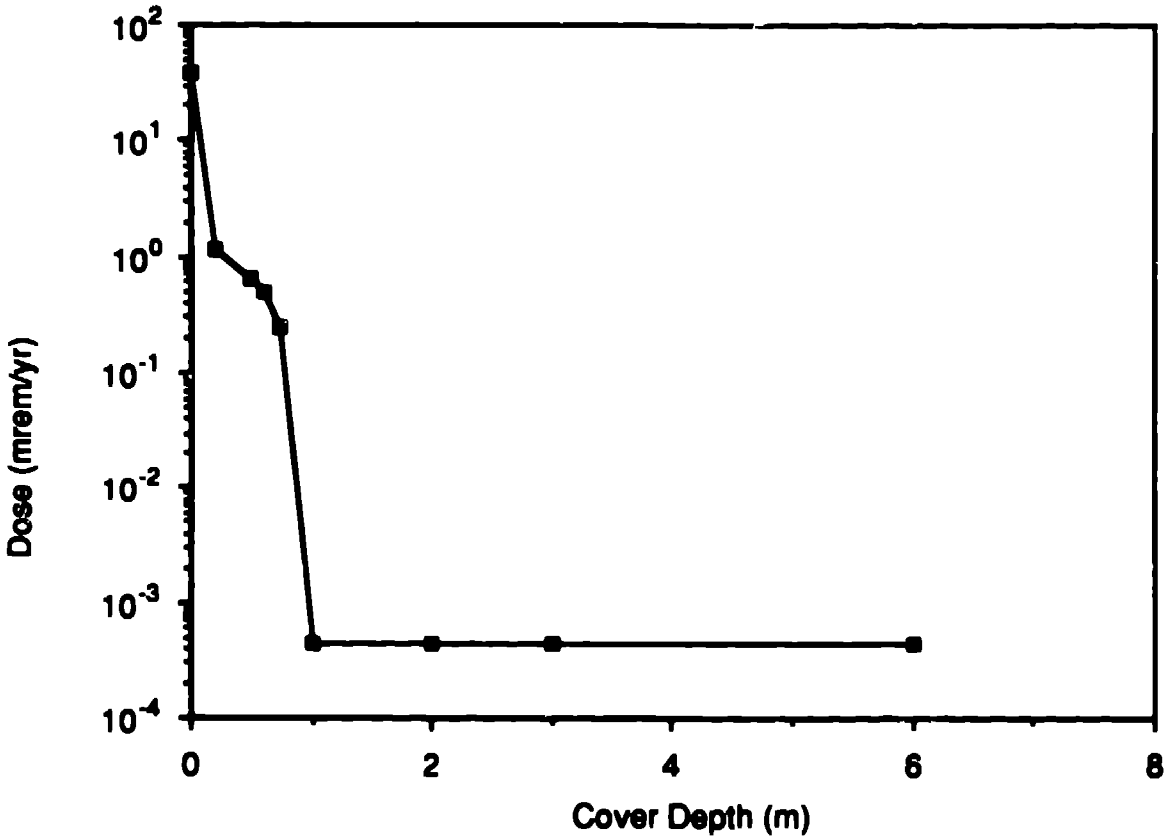

Figure 3. Log of dose versus cover depth for a dose of 38 mrem/yr with no cover.