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**ROCKETDYNE DIVISION
ENVIRONMENTAL MONITORING
AND
FACILITY EFFLUENT
ANNUAL REPORT
DE SOTO AND
SANTA SUSANA FIELD LABORATORIES SITES
1986**



Rockwell International

Rocketdyne Division
6633 Canoga Avenue
Canoga Park, CA, U.S.A. 91303

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I. INTRODUCTION

Environmental and facility effluent radioactivity monitoring at the Rocketdyne Division of Rockwell International is performed by the Radiation and Nuclear Safety Group of the Health, Safety, and Environment Department. Soil and surface water are routinely sampled to a distance of 10 miles from Division sites. Ground water from site supply water wells and other test wells is periodically sampled to measure radioactivity in these waters. Continuous ambient air sampling and direct radiation monitoring by thermoluminescent dosimetry are performed at several on-site and off-site locations for measuring airborne radioactivity concentrations and site ambient radiation levels. Radioactivity in effluents discharged to the atmosphere from nuclear facilities is continuously sampled and monitored to ensure that amounts released to uncontrolled areas are below appropriate limits and to identify processes that may require additional engineering safeguards to minimize radioactivity in such discharges. In addition, selected nonradioactive chemical constituent concentrations in surface water discharged to uncontrolled areas are determined.

The environmental radioactivity reported herein is attributed to natural sources, to local fallout of radioactive debris from the Chernobyl reactor accident, and to residual fallout of radioactive material from past atmospheric testing of nuclear devices.

Work in nuclear energy research and development in what has become the Rocketdyne Division of Rockwell International Corporation began in 1946. In addition to a broad spectrum of conventional programs in rocket propulsion, utilization of space, and national defense, Rocketdyne is working on the design, development, and testing of components and systems for central station nuclear power plants, on the decladding of irradiated nuclear fuel, and on decontamination and decommissioning of facilities.

The administrative and scientific research facilities associated with the nuclear efforts are located at the De Soto site in Canoga Park, California (Figure 1), approximately 23 miles northwest of downtown Los Angeles. The De Soto site is typical of the San Fernando Valley floor, at an altitude of 875 ft above sea level. Nuclear research programs, licensed by the State of California, are conducted here. These include Building 104 applied nuclear research laboratories and the Gamma Irradiation Facility containing approximately 35 kCi of ^{60}Co and 570 kCi of ^{137}Cs .

The Santa Susana Field Laboratories (SSFL) site (Figure 2) occupies 2,668 acres located in the Simi Hills of Ventura County, approximately 30 miles northwest of downtown Los Angeles. The SSFL site, situated in rugged terrain typical of mountain areas of recent geological age, is underlain by a sandstone bedrock unit called the upper cretaceous Chatsworth formation. The site may be described as an irregular plateau sprinkled with outcroppings above the more level patches and with peripheral eroded ravines. Elevations of the site vary from 1650 to 2250 ft above sea level. The surface mantle consists of unconsolidated gravel, sand, silt, and clay. Both Department of Energy (DOE) and Rockwell International owned facilities, shown in Figure 3, share the Area IV portion of this site. The SSFL site also contains facilities in which nuclear operations licensed by the U.S. Nuclear Regulatory Commission and the State are conducted. The licensed facilities include (1) the Rockwell International Hot Laboratory (RIHL) (Building 020), (2) the Nuclear Materials Development Facility (NMDF) (Building 055), (3) a former neutron radiography facility containing the dismantled L-85 nuclear examination and research reactor (Building 093), (4) several X-ray and radioisotope industrial radiography inspection facilities, and (5) a nuclear instrument calibration laboratory.

The location of these sites in relation to nearby communities is shown in Figure 4. Much of the land surrounding the De Soto site is used for light industry and other commercial uses and for residential apartments and single-family dwellings. Most of the land surrounding the SSFL site is barren, with some minor cattle grazing on the southern portion and some orchard farming at

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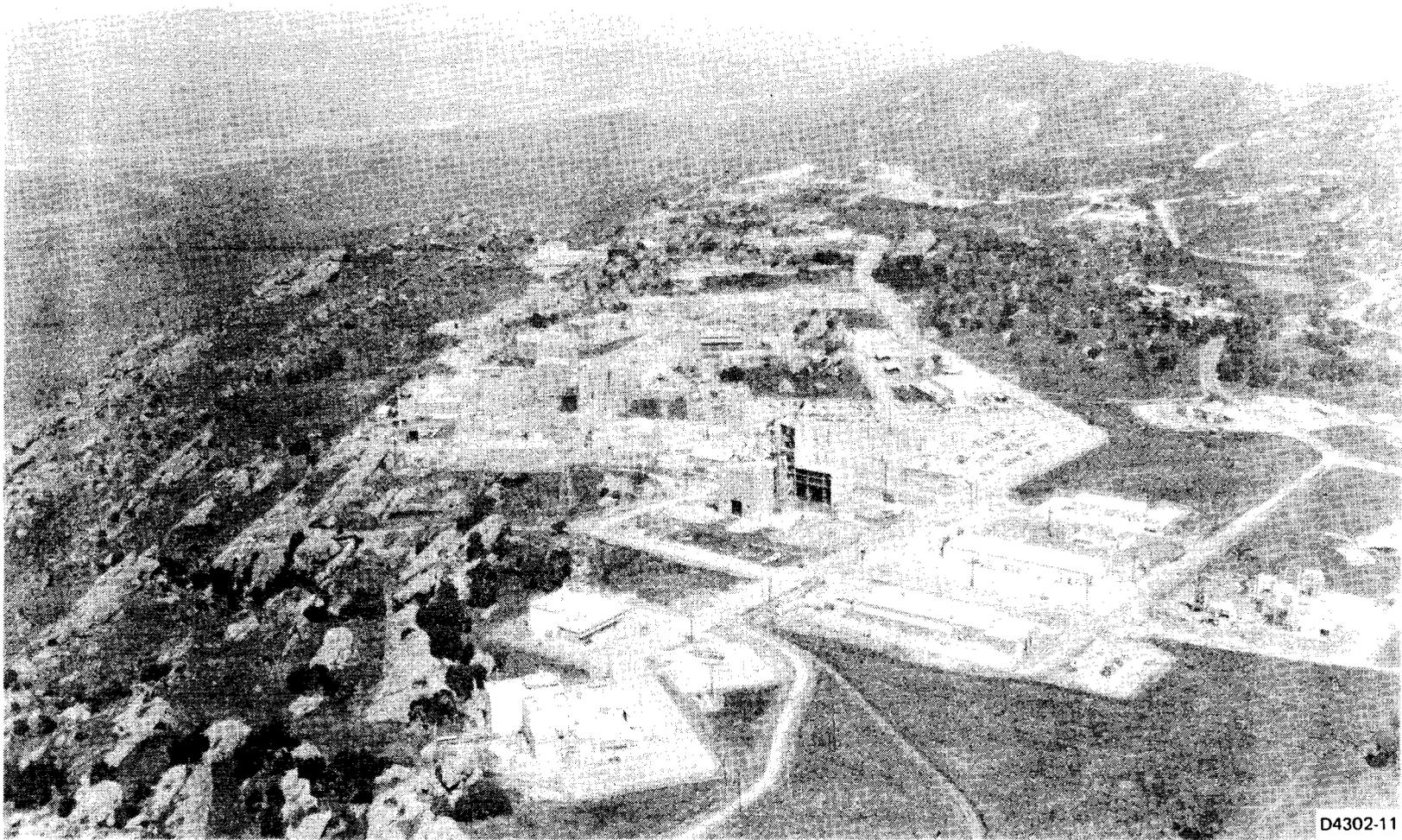
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Figure 1. Rocketdyne Division - De Soto Site

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Figure 2. Rocketdyne Division— Santa Susana Field Laboratories Site

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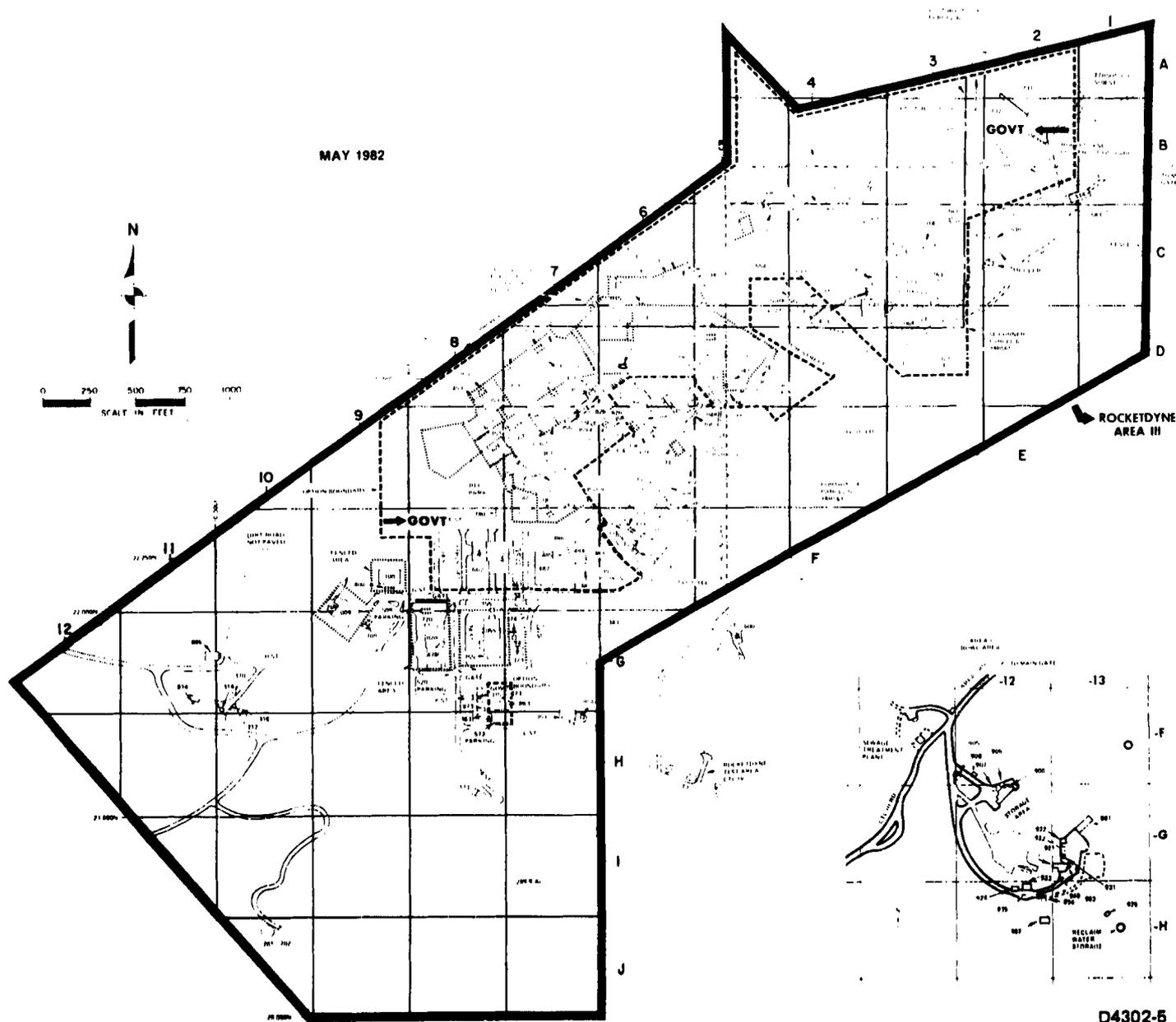
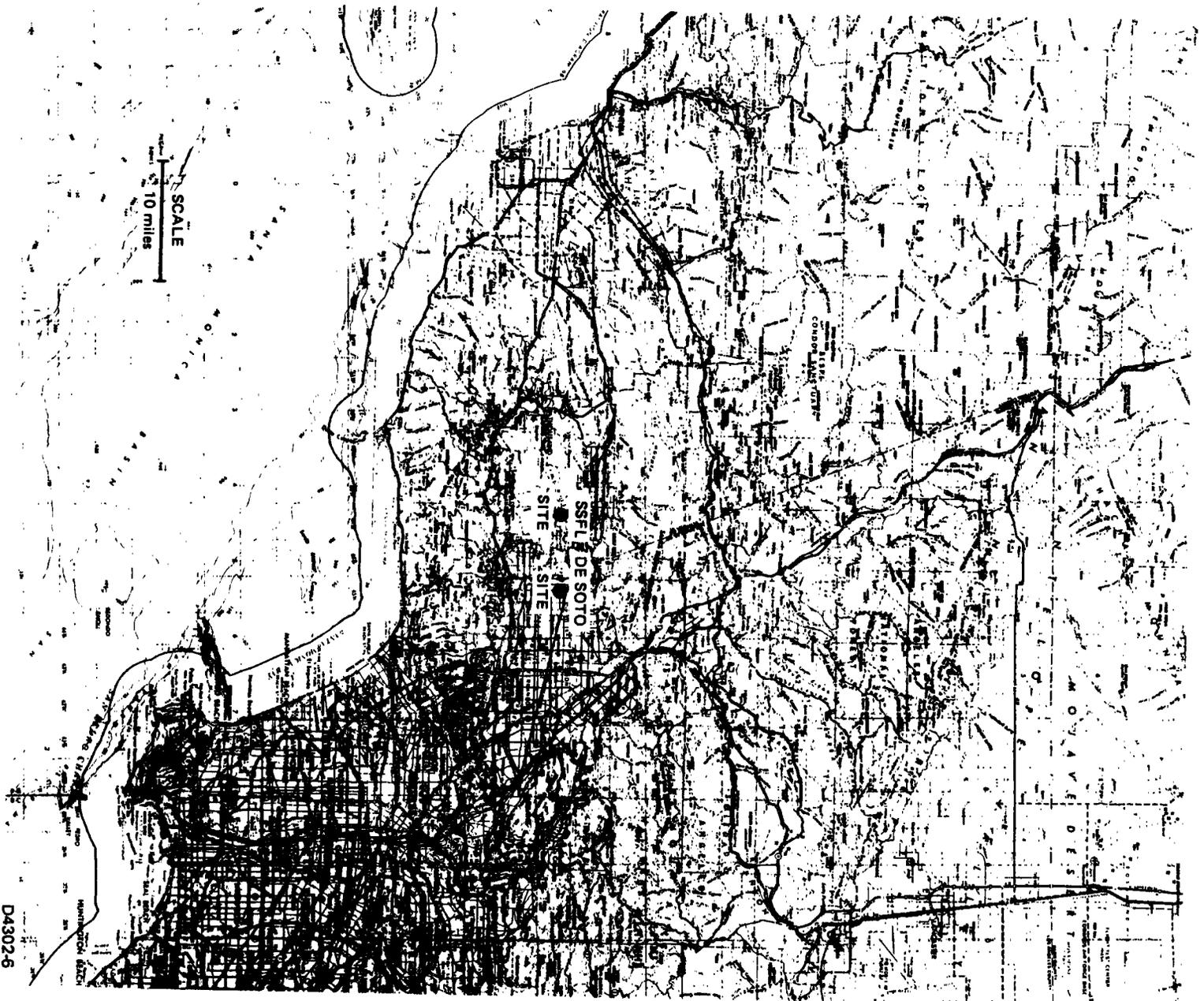


Figure 3. Map of Santa Susana Field Laboratories Site Facilities

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Figure 4. Map of General Los Angeles Area

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the eastern boundary. At greater distances, residences and some light industries become prevalent. Within 30 km of the SSFL site, there is no significant agricultural land use and, except for the Pacific Ocean about 20 km south, there is no significant body of water reserved for recreational use. There are four major reservoirs within 50 km of the site, which provide domestic water to the greater Los Angeles area. The nearest of these is more than 16 km distant.

Included within the SSFL site is an 82-acre government-optioned area where DOE contract activities are conducted, primarily by the nonnuclear Energy Technology Engineering Center (ETEC). The major operational nuclear installation within the DOE-optioned area is the Radioactive Material Disposal Facility (RMDF). This facility is used for storage of irradiated fuel and for packaging radioactive wastes generated as a result of the decommissioning and fuel decladding operations.

Licensed programs conducted during 1986 included (1) the operation of the RIHL for nuclear reactor fuel decladding and reactor system component examination, (2) the final dismantling of the previously defueled L-85 nuclear examination and research reactor, and (3) decommissioning of the Nuclear Materials Development Facility.

The basic policy for the control of radiological and chemical hazards requires that, through engineering controls, adequate containment of such materials be provided and that, through rigid operational controls, facility effluent releases and external radiation levels be reduced to a minimum. The environmental monitoring program provides a measure of the effectiveness of safety procedures and of the engineering safeguards incorporated into facility designs. Specific radionuclides in facility effluent or environmental samples are not routinely identified because of the extremely low radioactivity levels normally detected, but they would be identified by analytical or radiochemistry techniques if significantly increased radioactivity levels were observed. Relatively few different radionuclides are involved in these operations.

Occasional gamma-spectral analyses of bulk samples such as soil, water, and air confirm that the major radionuclides present are normally those of the naturally occurring thorium and uranium decay chains, plus other natural radionuclides such as the primordial ^{40}K , and ^7Be , produced by cosmic ray interactions in the atmosphere. During May, fission product activity from the Chernobyl reactor accident was also detected in ambient air samples.

In addition to environmental monitoring, work area air and atmospheric effluents are continuously monitored or sampled, as appropriate. This provides a direct measure of the effectiveness of engineering controls and allows remedial action to be taken before a significant release of hazardous material can occur.

Environmental sampling stations located within the boundaries of the De Soto and SSFL Area IV sites are referred to as "on-site" stations; those located outside these boundaries, or relatively distant from any nuclear facilities, are referred to as "off-site" stations. The De Soto and SSFL sites are sampled quarterly to determine the concentration of radioactivity in typical surface soil. Soil is also sampled on-site (SSFL) and off-site semi-annually for plutonium analysis. Similar off-site environmental samples, except for plutonium analysis, are also obtained quarterly. Water samples are obtained monthly at the De Soto and SSFL sites from supply water sources, retention ponds, and also from deep and shallow wells on a seasonal frequency. Continuous ambient air sampling provides information concerning long-lived airborne particulate radioactivity. On-site ambient radiation monitoring using thermoluminescent dosimetry (TLD) measures environmental radiation levels at the De Soto and SSFL sites and also at several off-site locations.

Nonradioactive wastes discharged to uncontrolled areas are limited to liquids released to sanitary sewage systems and to surface water drainage systems. No intentional releases of any liquid pollutants are made to uncontrolled areas. Sanitary sewage from all DOE and Rocketdyne facilities at the SSFL site is treated at an on-site sewage plant. The plant outfall drains into retention pond R-2A, located toward the southern boundary of the SSFL

site. The surface water drainage system of SSFL, which is composed of catch ponds and open drainage ditches, also drains to retention pond R-2A. Water from the pond may be reclaimed as industrial process water or released, as necessary, off-site into Bell Creek, a tributary of the Los Angeles River. The pond is sampled monthly for radioactivity and also sampled at discharge for both radioactive and nonradioactive pollutants as required by the discharge permit issued to Rocketdyne Division by the California Regional Water Quality Control Board. In addition, an automatic water sampler takes samples from the discharge stream channel (Bell Creek) whenever water is present.

This report summarizes environmental monitoring results for 1986, which are presented in Section III. The gross alpha and beta radioactivity is reported as results of the monitoring program. Estimates of radionuclide components in effluents provide the basis for dose commitment calculations. The sampling and analytical methods used in the environmental monitoring program for radioactive materials are described in Section IV. A comparison of 1986 radioactivity results with the results from previous years appears in Appendix A, with a summary of the Environmental Monitoring Program Quality Control in Appendix B. Appendix C shows regulatory limits on nonradioactive pollutants in water released from the site. References are listed in Appendix D. The external distribution of this report is shown in Appendix E, and a table of alternative units for radiological data is shown in Appendix F.

II. SUMMARY AND EVALUATION OF ENVIRONMENTAL MONITORING RESULTS

Except as noted below, all radioactivity levels observed in environmental samples for 1986 show close agreement with radioactivity levels measured during recent years and reported in the previous issues of this report. Local environmental radioactivity levels, which result from both natural and manmade radionuclides and have shown the presence of fallout from past atmospheric testing of nuclear devices, have decreased to generally constant levels during the past several years. These levels are now due mainly to the primordial radionuclides.

A large Soviet atomic power reactor, Unit 4, at Chernobyl, which is an extensive complex of several nuclear power reactors located approximately 80 miles northwest of Kiev, USSR, exploded and burned on 26 April 1986. The accident released large quantities of radioactive debris into the atmosphere which subsequently dispersed to northern Europe and later to North America. At the request of the U.S. Department of Energy, Rocketdyne Division began special daily high volume air sampling at the Santa Susana site to identify the arrival of Chernobyl fallout into the Southern California area. Increased levels of airborne radioactivity were detected at SSFL beginning on 9 May 1986, and continued at measurable levels throughout the remainder of May and into early June. The principal radionuclides detected in the air samples were ^{134}Cs , ^{137}Cs , ^{103}Ru , and ^{131}I .

The results of this environmental monitoring indicate that there are no significant sources of unnatural radioactive material in the vicinity of the Rocketdyne sites. Additionally, identical results obtained for on-site and off-site samples further indicate that there is no contribution to general environmental radioactivity attributable to nuclear operations at Rocketdyne. Potentially significant exposure pathways to the general public resulting from Rocketdyne nuclear operations are limited to the atmospheric discharge of radioactive materials for which the only exposure pathways to people result from whole body external exposure and from inhalation exposure to released materials, and to direct radiation exposure of individuals and the general

public beyond the site boundary. No discharge of liquid radioactive wastes is made to the environment. All such materials are processed for disposal at regulated disposal sites.

The maximum individual annual exposures estimated for persons at the site boundary and also at the residence nearest the SSFL site are small when compared with natural radiation and with all applicable guidelines. The estimates of exposure due to inhalation at the boundary and the nearest residence were derived from the AIRDOS-EPA calculated concentrations at those locations and incorporated the dose conversion factors appropriate for radionuclides in process at each nuclear facility. This inhalation exposure estimate is the sum of contributions calculated for the measured releases from each facility. The external radiation exposure estimates at the maximum exposed boundary location and at the nearest residence are based on results for site ambient radiation dosimeters and also for several facility workplace radiation dosimeters. The unattenuated external annual exposure due to operations conducted at the RMDF is estimated to be 450 mrem at the nearest boundary-line location and less than 0.1 mrem for the nearest residence. The boundary-line exposure is conservative in that the rugged terrain at the site boundary nearest the RMDF precludes anything more than the occasional and temporary presence of any person at that location. These values were determined by calculating the unattenuated exposure expected at the boundary and nearest residence on the basis of the highest annual result for area dosimeters in place around the facility. For the nearest residence, radiation attenuation due to air absorption and also to the intervening rock formations will lower direct radiation to practically nonexistent levels with only natural background radiation inherent to the residence location being present. Boundary-line direct radiation exposures for the State of California and U.S. NRC-licensed operations at other Rocketdyne nuclear facilities were very much below 10 mrem for the year. The topography of the SSFL site surrounding the nuclear facilities and out to the site boundary is extremely irregular. Hills and rock outcroppings shield the off-site areas, significantly reducing off-site exposures from on-site sources.

Similarly for the De Soto site, internal dose estimates at the boundary and at the nearest residence are not significantly different from zero. Estimates of the external radiation exposure at the De Soto boundary (less than 0.01 ± 0.01 mrem) and at the nearest residence (less than 0.01 ± 0.01 mrem) are based on the difference between the single highest on-site TLD measurement and the average of off-site measurements. The difference is more likely the result of random variability in the measurements than from actual radiation exposure.

Supply water at the SSFL site is sampled monthly at two locations. This water consists of ground water from deep wells on the site blended with potable water from the Ventura County Water District 17. In addition, shallow ground water is periodically sampled at a standpipe adjacent to the basement level of a deactivated reactor test facility (Building 059). These samples are evaluated to detect any transfer of activation product radioactivity from the underground reactor test vault containment and into the surrounding soil. None has been detected. Therefore, these analyses serve as a measure of radioactivity naturally present in the ground water. Deep well water samples are also evaluated to determine the impact, if any, on the deep ground water system underlying the SSFL due to Rocketdyne Division nuclear operations.

Quality assurance measures incorporated into the environmental monitoring program include participation in DOE-sponsored programs such as the Environmental Dosimeter Intercomparison Program and the DOE Environmental Measurements Laboratory Quality Assessment Program (EML-QAP). Participation in two EML-QAP sample analysis sets (QAP XXIV and XXV), and in the Eighth International Environmental Dosimeter Intercomparison Project, was done in 1986. Analysis of the results indicates that accuracy in measuring radioactivity in the sample media provided for the intercomparison improved; however, additional work is required to develop counting standards that are more representative of the types of samples and analyses addressed in the quality assessment program. In addition to participation in these programs, laboratory analyses

of split and replicate samples are routinely used to evaluate the reproducibility of sample radioactivity measurements of water and soil gross radioactivity. Control charts of counting system radiation response are maintained. These data are periodically evaluated to determine the correlation between sample sets and trends in background.

III. ENVIRONMENTAL MONITORING RESULTS

A. RADIOACTIVE MATERIALS --1986

The average radioactivity concentrations in local soil, surface and ground water, and ambient air for 1986 are presented in Tables 1 through 5. The data shown for gross alpha activity in samples that are generally thick compared to the range of the alpha particles represent a marked change in the manner of calculating and reporting them, compared with earlier reports. This change reflects the gradual redirection of the monitoring program from monitoring to measurement. Previously, alpha count data had been converted to alpha activity concentrations by using an efficiency factor for a thin electroplated source, and the results were monitored for changes from prior values. This resulted in artificially low numerical values for the alpha activity in several sample media. Starting with the 1984 report, the alpha activity concentrations for these media are reported based on an efficiency factor derived from a sample with distributed alpha activity that is thick relative to the alpha particle range. For monitoring purposes, this has no effect. However, the values reported more closely represent the actual alpha activity existing in the environment. In calculating the average concentration values, all values, including negative values, are included. This method of noncensored data averaging, recommended by DOE Order 5484.1, affords a better estimate of the central value and dispersion of the data. All limits of error reported in the tables are for one standard deviation (1 sigma). Usually, these show the dispersion of the measured values about the mean. These two changes in data interpretation result in noticeable differences in the data shown in the historical comparisons. It must be recognized that these differences do not reflect changes in environmental radioactivity but are merely consequences of the evolution of the monitoring program.

The presentation of data in the tables includes the annually averaged data for each sample type and the maximum radioactivity level detected for a single sample from the annual set, which is reported because of its significance in indicating the occurrence of a major episode or an area-wide inci-

dent of radioactive material deposition. Except for soil and air samples, none of the maximum observed values, which (as the tables show) occurred randomly during the year, shows a great increase over the average values beyond inherent variability. Except for May, the ambient air sampling data show no greatly increasing or decreasing trends for most of the year and can be described as generally constant, with some increase in local airborne radioactivity levels occurring during the second and fourth quarters. The intrusion into the local area in May of Chernobyl-related airborne radioactivity was of short duration and did not recur during the remainder of 1986.

To achieve much higher detection sensitivity for plutonium than gross alpha measurements can provide, soil samples are collected and sent to an independent testing laboratory for specific analysis for plutonium. In this analysis, the individual soil samples are leached with acid, and the leachate is treated chemically to separate and concentrate any plutonium present in the sample. In this way, minute quantities of plutonium, such as those distributed globally by testing of nuclear weapons, can be detected and quantitatively measured by alpha spectroscopy. The results are shown in Table 2. Alpha spectroscopy permits identification of $^{239}\text{Pu} + ^{240}\text{Pu}$, predominantly from weapons tests, and ^{238}Pu , partly from the destructive reentry of a Transit satellite over the Indian Ocean in April 1964.

The results of the gross radioactivity measurements in soil (Table 1) show no significant difference between on-site and off-site samples.

For comparison with the plutonium present as a result of fallout from nuclear weapons tests and failure at launch of a radioisotope-powered satellite, published data from soil tests in nearby Burbank, California, in 1970-71 show a plutonium concentration of approximately 0.002 pCi/g for $^{239}\text{Pu} + ^{240}\text{Pu}$ and approximately 0.00006 pCi/g for ^{238}Pu . The data in Table 2 show no significant increases in on-site soil plutonium relative to the Burbank values and no significant variation in soil plutonium concentrations for the 1986 sample sets.

TABLE 1
SOIL RADIOACTIVITY DATA--1986

Area	Activity	Number of Samples	Gross Radioactivity (pCi/g)	
			Annual Average Value and Dispersion	Maximum Observed Value ^a and Month Observed
On-site (quarterly)	Alpha	48	26.7 ± 6.6	40.1 (April)
	Beta	48	26.1 ± 2.2	32.2 (April)
Off-site (quarterly)	Alpha	48	25.1 ± 5.9	39.0 (July)
	Beta	48	24.2 ± 1.3	30.4 (April)
Pond R-2A mud No. 55	Alpha	4	24.9 ± 1.9	26.7 (Apr/Oct)
	Beta	4	24.8 ± 0.5	25.4 (April)
Bell Creek upper stream bed soil No. 62	Alpha	4	15.4 ± 4.4	21.8 (April)
	Beta	4	24.2 ± 1.2	26.0 (April)

^a Maximum value observed for single sample.

TABLE 2
SOIL PLUTONIUM RADIOACTIVITY DATA--1986

Sample Location	25 June 1986 Survey Results		8 December 1986 Survey Results	
	²³⁸ Pu (pCi/g)	²³⁹ Pu + ²⁴⁰ Pu (pCi/g)	²³⁸ Pu (pCi/g)	²³⁹ Pu + ²⁴⁰ Pu (pCi/g)
S-56	0 ± 0.0001	0.0007 ± 0.0004	0 ± 0.0002	0.0002 ± 0.0002
S-57	0.0004 ± 0.0003	0.0005 ± 0.0003	0.0003 ± 0.0002	0.0010 ± 0.0004
S-58	0.0003 ± 0.0003	0.0031 ± 0.0009	0.0003 ± 0.0002	0.0032 ± 0.0006
S-59	0.0002 ± 0.0002	0.0038 ± 0.0009	0.0003 ± 0.0002	0.0020 ± 0.0004
S-60	0.0003 ± 0.0002	0.0028 ± 0.0008	0 ± 0.0003	0.0006 ± 0.0003
S-61 ^a	0 ± 0.0002	0.0005 ± 0.0004	0 ± 0.0002	0.0019 ± 0.0005

^a Off-site location

The detected gross radioactivity in soil is due to some residual Chernobyl related radioactivity, to various naturally occurring radionuclides present in the environment, and to radioactive fallout of dispersed nuclear weapons materials and fission product radioactivity produced by past atmospheric tests of nuclear weapons. No atmospheric nuclear weapons tests were announced during 1986. Naturally occurring radionuclides include ^7Be , ^{40}K , ^{87}Rb , ^{147}Sm , and the uranium and thorium series (including radon and daughters). The radionuclide composition of local area surface soil has been determined to be predominantly ^{40}K , natural thorium, and natural uranium, both in secular equilibrium with daughter nuclides, with less than 1% fission-produced radionuclides, principally ^{137}Cs . Radioactivity in aged fallout consists primarily of the fission produced ^{90}Sr - ^{90}Y , ^{137}Cs , and ^{147}Pm , and also ^{234}U and ^{239}Pu . Gamma spectrometric analysis of composited ambient air samples collected during 1986 detected the cosmogenic radionuclide ^7Be , plus additional natural radionuclides of terrestrial origin, the natural uranium and thorium series, and ^{40}K . Relative amounts of these radionuclides were approximately 65% ^{40}K , 34% ^7Be , and the remainder due to the natural uranium series and natural thorium series. The value for ^7Be is representative for the mixture only at the time of measurement since the physical half-life is extremely short compared with those of the other radionuclides detected. During a 30-day period beginning the second week of May 1986, a significantly increased level of airborne radioactivity from the Chernobyl reactor accident was observed. Gamma-ray spectrometry identified ^{103}Ru , ^{131}I , ^{134}Cs , and ^{137}Cs as the major constituents of this activity. The higher-than-normal levels decreased to pre-accident levels for the remainder of the year.

Supply water is sampled monthly at De Soto and at two widely separated SSFL site locations. The average supply water radioactivity concentration for each site is presented in Table 3. Supply water used at the De Soto site is supplied by the Los Angeles Department of Water and Power. Supply water used at the SSFL site is obtained partly from the Ventura County Water District No. 17, which also supplies nearby communities, and from local well water, and is distributed on the site by the same piping system previously used when the

TABLE 3
SUPPLY WATER RADIOACTIVITY DATA--1986

Area	Activity	Number of Samples	Gross Radioactivity (10^{-9} $\mu\text{Ci/ml}$)	
			Average Value and Dispersion	Maximum Value ^a and Month Observed
De Soto (monthly)	Alpha	12	4.41 ± 2.53	8.70 (January)
	Beta	12	3.75 ± 0.62	4.69 (March)
SSFL (monthly)	Alpha	24	6.55 ± 9.09	45.77 (October)
	Beta	24	3.58 ± 0.95	6.75 (October)

^a Maximum value observed for single sample.

total site water supply was obtained from on-site wells. Two on-site water wells (wells 5 and 13) were operated during 1986 to reduce the consumption of the Ventura County water. The well water proportion in the blend averaged about 65% for the year, for a total well water consumption of about $2.4 \times 10^5 \text{ m}^3$ (6.4×10^7 gal). Pressure for the water system is provided by elevated storage tanks.

A shallow standpipe, connected to a French drain at foundation level, placed during construction of a modification to a now deactivated SNAP reactor test facility, is being used for sampling of ground water adjacent to the underground reactor test vault. Water in the standpipe is periodically sampled for the purpose of detecting any transfer of activation product radioactivity from the containment to the outside environment. Radioactivity in 44 samples taken during 1986 averaged 1.0×10^{-8} $\mu\text{Ci/ml}$ beta with no alpha activity detected. Gamma spectrometric analysis, with a minimum detection limit for ^{60}Co of about 5×10^{-7} $\mu\text{Ci/ml}$, has not identified any specific unnatural radionuclides in the water; thus, the observed activity is attributed to dissolved radioelements of natural origin in the soil bed.

A recent hydrogeologic study at SSFL describes two ground water systems at the site: a shallow, unconfined system in the alluvial surface mantle of the Burro Flats area and along the major drainage channels, and a deeper ground water system in the fractured Chatsworth sandstone. Alluvium along the major surface drainage systems may store and transmit ground water to the underlying Chatsworth formation through fractures. Water levels in the alluvium respond to recharge resulting from surface flows and may vary considerably between wet and dry periods. The alluvium, composed of a heterogeneous mixture of gravel, sand, silt, and clay, has estimated hydraulic conductivities ranging from 0.1 to 1000 gal/day/ft².

The Chatsworth formation is composed of well-consolidated, massively bedded sandstones with interbedded layers of siltstone and claystone. The layer may be as thick as 6,000 ft at the SSFL site. The direction of ground water flow in the formation is probably radially off-site toward the surrounding lowlands and is probably controlled by fracture zones.

The hydrogeologic environment at the SSFL site is a dynamic system. Ground water is recharged at the site, moves through the aquifers, and discharges to the surface or to other aquifers down-gradient of the site. The ground water system is recharged by precipitation and by unlined ponds and drainage channels. Because of the meager rainfall in the area and the relatively large variability in annual precipitation, ground water recharge may vary greatly from year to year. Specific pathways of possible contaminant transport are difficult to predict on the basis of on-site well data. The most likely pathways are along fracture zones that trend off-site.

As discussed earlier, surface waters discharged from SSFL facilities and the sewage plant outfall drain southward into Rocketdyne retention pond R-2A. When full, the pond may be drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Average radioactivity concentrations in Retention Pond R-2A, upper Bell Creek, and test well samples are presented in Table 4.

TABLE 4
 SSFL SITE RETENTION POND, SITE RUNOFF, AND WELL WATER RADIOACTIVITY DATA
 (Sheet 1 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration (x 10 ⁻⁹ μCi/ml)		
			Annual Average Value and Dispersion	Maximum Value ^a and Month Observed	Percent of Samples With Activity <MDL ^b
Pond No. 6 (Monthly)	Alpha	12	2.51 ± 2.88	9.51 (December)	92
	Beta	12	2.92 ± 0.94	4.57 (January)	0
Pond No. 12 (R-2A) (Monthly)	Alpha	12	4.18 ± 2.70	8.7 (December)	92
	Beta	12	3.58 ± 1.14	5.93 (October)	0
Upper Bell Creek No. 17 (Seasonal)	Alpha	6	2.02 ± 2.08	5.90 (March)	100
	Beta	6	2.60 ± 0.52	3.66 (March)	0
Well WS-4A (Seasonal)	Alpha	2	9.94 ± 1.90	11.83 (October)	100
	Beta	2	4.43 ± 0	4.43 (Oct/Dec)	0
Well WS-5 (Seasonal)	Alpha	2	11.34 ± 1.84	13.18 (October)	50
	Beta	2	4.53 ± 0.38	4.91 (December)	0
Well WS-6 (Seasonal)	Alpha	2	12.98 ± 1.66	14.65 (October)	50
	Beta	2	5.80 ± 0.07	5.87 (October)	0
Well WS-7 (Seasonal)	Alpha	2	10.71 ± 4.44	15.15 (December)	50
	Beta	2	5.32 ± 0.01	5.32 (December)	0

TABLE 4
 SSFL SITE RETENTION POND, SITE RUNOFF, AND WELL WATER RADIOACTIVITY DATA
 (Sheet 2 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration (x 10 ⁻⁹ µCi/ml)		
			Annual Average Value and Dispersion	Maximum Value ^a and Month Observed	Percent of Samples With Activity <MDL ^b
Well WS-8 (Seasonal)	Alpha	2	9.40 ± 4.68	14.08 (December)	50
	Beta	2	3.64 ± 0.06	3.70 (December)	0
Well WS-9 (Seasonal)	Alpha	2	22.86 ± 9.32	32.14 (December)	0
	Beta	2	5.86 ± 0.62	6.48 (December)	0
Well WS-9A (Seasonal)	Alpha	2	5.04 ± 0.96	6.00 (October)	100
	Beta	2	3.60 ± 0.24	3.84 (October)	0
Well WS-9B (Seasonal)	Alpha	2	14.64 ± 0.08	14.72 (October)	50
	Beta	2	6.88 ± 0.28	7.16 (October)	0
Well WS-11 (Seasonal)	Alpha	2	13.78 ± 8.16	21.94 (December)	50
	Beta	2	4.84 ± 0.15	4.99 (December)	0
Well WS-12 (Seasonal)	Alpha	2	7.79 ± 0.25	8.04 (December)	100
	Beta	2	4.93 ± 0.07	5.00 (December)	0
Well WS-13 (Seasonal)	Alpha	2	9.72 ± 0	9.72 (December)	100
	Beta	2	4.34 ± 0	4.34 (December)	0

TABLE 4
 SSFL SITE RETENTION POND, SITE RUNOFF, AND WELL WATER RADIOACTIVITY DATA
 (Sheet 3 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration (x 10 ⁻⁹ μCi/ml)		
			Annual Average Value and Dispersion	Maximum Value ^a and Month Observed	Percent of Samples With Activity <MDL ^b
Well WS-14 (Seasonal)	Alpha	2	10.77 ± 2.19	12.96 (December)	50
	Beta	2	4.68 ± 0.23	4.91 (October)	0
Well OS-1 (Seasonal)	Alpha	2	4.05 ± 3.66	6.64 (December)	100
	Beta	2	3.20 ± 0.58	3.78 (December)	0
Well OS-2 (Seasonal)	Alpha	3	5.17 ± 5.38	11.30 (December)	100
	Beta	3	1.75 ± 0.22	1.96 (December)	0
Well OS-3 (Seasonal)	Alpha	3	6.66 ± 2.97	10.79 (December)	66
	Beta	3	3.47 ± 0.25	3.69 (June)	0
Well OS-4 (Seasonal)	Alpha	3	4.16 ± 1.39	6.09 (April)	100
	Beta	3	3.64 ± 0.07	3.72 (December)	0
Well OS-5 (Seasonal)	Alpha	3	6.76 ± 2.72	10.48 (June)	100
	Beta	3	3.69 ± 0.52	4.23 (December)	0
Well OS-8 (Seasonal)	Alpha	3	2.04 ± 3.91	6.05 (December)	100
	Beta	3	2.77 ± 0.46	3.26 (June)	0

TABLE 4

SSFL SITE RETENTION POND, SITE RUNOFF, AND WELL WATER RADIOACTIVITY DATA
(Sheet 4 of 4)

Area	Activity	Number of Samples	Gross Radioactivity Concentration (x 10 ⁻⁹ µCi/ml)		
			Annual Average Value and Dispersion	Maximum Value ^a and Month Observed	Percent of Samples With Activity <MDL ^b
Well OS-10 (Seasonal)	Alpha	3	1.89 ± 0.94	2.80 (December)	100
	Beta	3	0.71 ± 0.46	1.09 (June)	100
Well OS-13 (Seasonal)	Alpha	4	2.06 ± 2.56	4.68 (June)	100
	Beta	4	3.38 ± 0.49	3.77 (June)	0
Well OS-15 (Seasonal)	Alpha	4	19.68 ± 10.31	35.11 (December)	75
	Beta	4	6.54 ± 3.30	12.08 (December)	0
Well OS-16 (Seasonal)	Alpha	4	19.19 ± 5.46	25.98 (December)	25
	Beta	4	5.21 ± 0.67	6.16 (December)	0
Well RS-20 (Seasonal)	Alpha	2	-0.02 ± 0.38	0.36 (September)	100
	Beta	2	1.34 ± 0.44	1.78 (September)	50
Well RS-21 (Seasonal)	Alpha	2	42.54 ± 22.96	65.50 (September)	0
	Beta	2	3.59 ± 1.30	4.89 (September)	0
Well RS-22 (Seasonal)	Alpha	2	2.60 ± 1.94	4.54 (December)	100
	Beta	2	1.46 ± 0.26	1.72 (December)	50

^aMaximum value observed for single sample.

^bMinimum detection level: Approximately 0.4 x 10⁻⁹ µCi/ml alpha; 1.40 x 10⁻⁹ µCi/ml beta for water; approximately 3.1 µCi/g alpha; 0.42 µCi/g for soil.

Comparison of the radioactivity concentrations in water from the ponds with that of the supply water shows no significant differences in either alpha or beta activity. Similarly, comparisons between on-site and off-site soil samples and those of upper Bell Creek stream bed show no significant differences.

The SSFL site surface water and the ambient air radioactivity concentration guide values selected for each site are the most restrictive limits for those radionuclides currently in use at Rocketdyne facilities and should not be taken to indicate the identification of these radionuclides in the samples. Radioactivity concentration guide values are those concentration limits adopted by DOE, Nuclear Regulatory Commission (NRC), and the State of California as maximum permissible concentrations (MPCs) for uncontrolled areas. These values are established in 10 CFR 20, California Administrative Code Title 17, and DOE Order 5480.1A. The MPC values are dependent on the radionuclide and its behavior as a soluble or an insoluble material. For comparison with results of environmental and effluent monitoring, the single lowest MPC value for the various radionuclides present is selected rather than a derived MPC for the mixture. Accordingly, for SSFL site surface water, the guide values of 5×10^{-6} $\mu\text{Ci/ml}$ alpha activity corresponding to ^{239}Pu and 3×10^{-7} $\mu\text{Ci/ml}$ beta activity corresponding to ^{90}Sr are appropriate.

Ambient air sampling for long-lived particulate alpha and beta radioactivity is performed continuously by automatic sequential samplers located at the De Soto and SSFL sites. Air is drawn through glass fiber filters, which are analyzed for retained long-lived radioactivity after a minimum 120-h decay period that eliminates naturally occurring short-lived particulate radioactivity (most radon daughters). The average concentrations of ambient air alpha and beta radioactivity for 1986 are presented for the various sampler locations in Table 5.

TABLE 5
 AMBIENT AIR RADIOACTIVITY DATA--1986

Area (monthly)	Activity	Number of Samples	Gross Radioactivity Concentrations--Femtocuries per m ³ (10 ⁻¹⁵ μCi/ml)			
			Annual Average Value and Dispersion	Maximum Value ^a and Month Observed	Percent of Guide ^b	Percent of Samples With Activity <MDL ^c
De Soto on-site (2 locations)	Alpha Beta	687	2.9 ± 3.4 57.5 ± 103	22.0 (05/15) 1236.4 (05/14)	0.10 0.02	79 34
SSFL on-site (5 locations)	Alpha Beta	1755	2.8 ± 3.3 60.4 ± 93.5	37.0 (05/14) 1578.6 (05/12)	4.7 0.20	90 28
SSFL sewage treatment plant	Alpha Beta	336	3.2 ± 3.7 63.8 ± 89.8	33.3 (05/12) 1233.2 (05/12)	5.3 0.20	86 22
SSFL control center	Alpha Beta	324	2.7 ± 2.9 58.7 ± 89.2	27.1 (05/13) 1153.5 (05/13)	4.5 0.20	91 29
All locations	Alpha Beta	3102	2.8 ± 3.3 60.0 ± 15.2	---	---	---

^aMaximum value observed for single sample.

^bGuide De Soto site: 3 x 10⁻¹² μCi/ml alpha, 3 x 10⁻¹⁰ μCi/ml beta; 10 CFR 20 Appendix B, CAC 17. SSFL site: 6 x 10⁻¹⁴ μCi/ml alpha, 3 x 10⁻¹¹ μCi/ml beta; 10 CFR 20 Appendix B, CAC 17, DOE Order 5480.1A.

^cMDL = 6.4 x 10⁻¹⁵ μCi/ml alpha; 1.3 x 10⁻¹⁴ μCi/ml beta.

The guide value of 6 x 10⁻¹⁴ μCi/ml for SSFL site ambient air alpha activity is due to work with unencapsulated plutonium. The value of 3 x 10⁻¹¹ μCi/ml for beta activity is due to the presence of ⁹⁰Sr in fission products in irradiated nuclear fuel at the SSFL site. The guide value of 3 x 10⁻¹² μCi/ml for De Soto ambient air alpha activity is due to work with unencapsulated depleted uranium. The guide value of 3 x 10⁻¹⁰ μCi/ml is for ⁶⁰Co, for which the ambient air beta activity guide is appropriate, since it is the most restrictive limit for any beta-emitting radionuclide in use at the De Soto site. Guide value percentages are not presented for soil data, since none have been established.

Figure 5 is a graph of the weekly averaged long-lived alpha and beta ambient air radioactivity concentrations for the De Soto and SSFL sites during 1986. The daily data were mathematically smoothed in a moving weekly average of daily data for the year. The average alpha and beta radioactivity concentrations for each month are indicated by horizontal bars. The graph shows an abrupt increase in airborne radioactivity during May which is due to the movement into the Southern California area of radioactive materials released during the Chernobyl reactor accident. By the end of May, activity returned to normal levels and continued to be generally constant during the remainder of 1986. In addition to the Chernobyl-related fallout, the activity detected in ambient air is attributed to naturally occurring radioactive materials and to aged fission products from past atmospheric tests of nuclear devices. In addition to the fission radionuclides attributable to Chernobyl, radionuclides detected in air samples collected during 1986 include ^7Be and ^{40}K plus several naturally occurring radionuclides from the uranium and thorium series. While the data for airborne alpha activity are nearly all below the minimum detection level for a single sample, averaging values from nine daily air samples over seven consecutive days and over calendar months reveal the long-term behavior of this activity. The daily concentrations of the summed beta-emitting fission radionuclides measured by high-purity germanium spectroscopy together with equivalent measurements of the daily gross beta counts for simultaneous low-volume air samples are shown in Figure 6. These data are presented on a time scale of days after the Chernobyl accident which occurred on 26 April 1986. Figure 7 shows the daily concentrations of the beta-emitting fission radionuclides detected by gamma spectroscopy of high-volume air samples taken following public notification of the Chernobyl accident.

Monitoring of ambient radiation is performed with TLDs. Each dosimeter set uses two calcium fluoride ($\text{CaF}_2:\text{Mn}$) low background, bulb-type chip dosimeters. The dosimeter sets are placed at locations on or near the perimeters of the De Soto and SSFL sites. Each dosimeter, sealed in a light-proof energy compensation shield, is installed in a sealed plastic container mounted about 1 m above ground at each location. The dosimeters are exchanged and

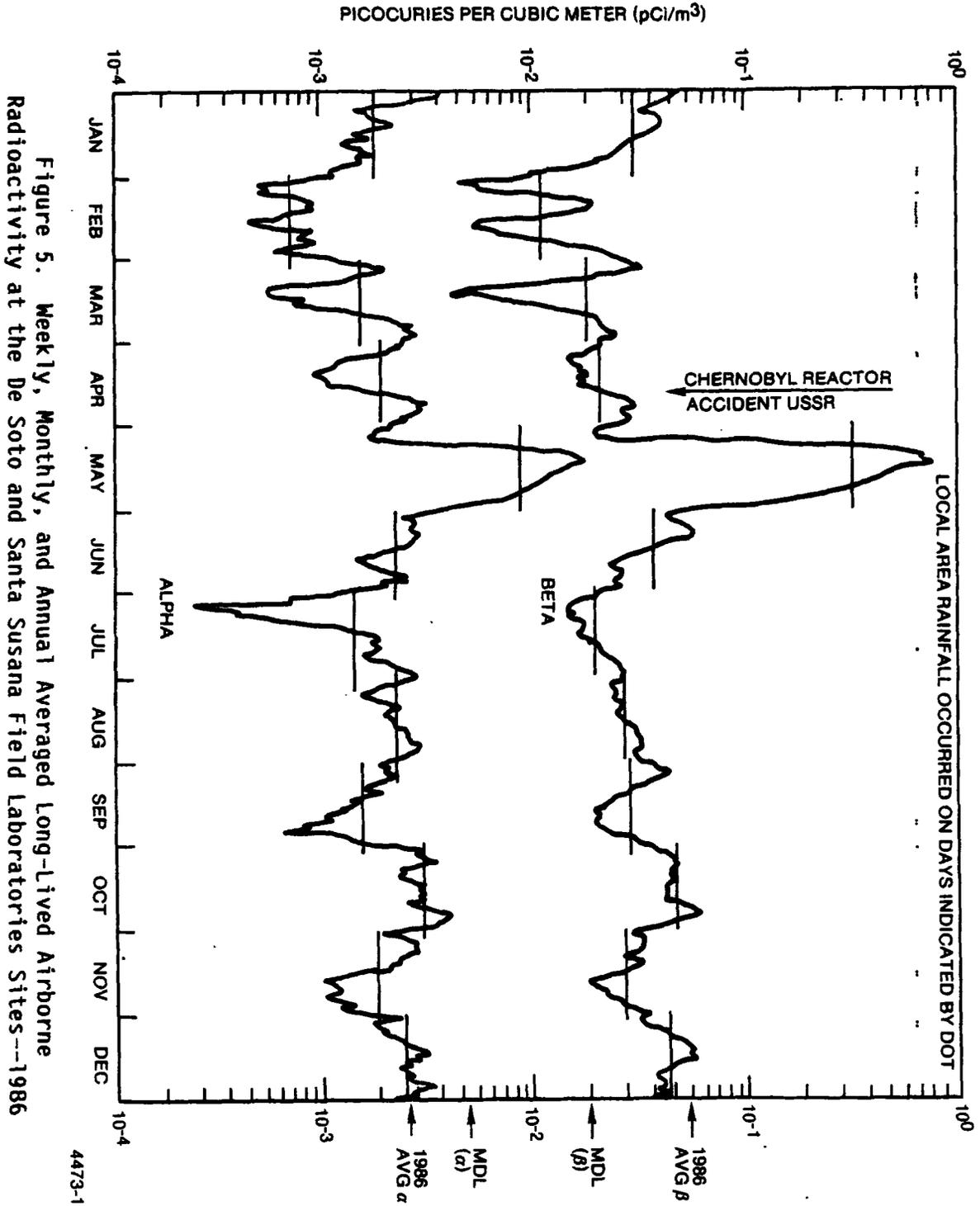


Figure 5. Weekly, Monthly, and Annual Averaged Long-Lived Airborne Radioactivity at the De Soto and Santa Susana Field Laboratories Sites--1986

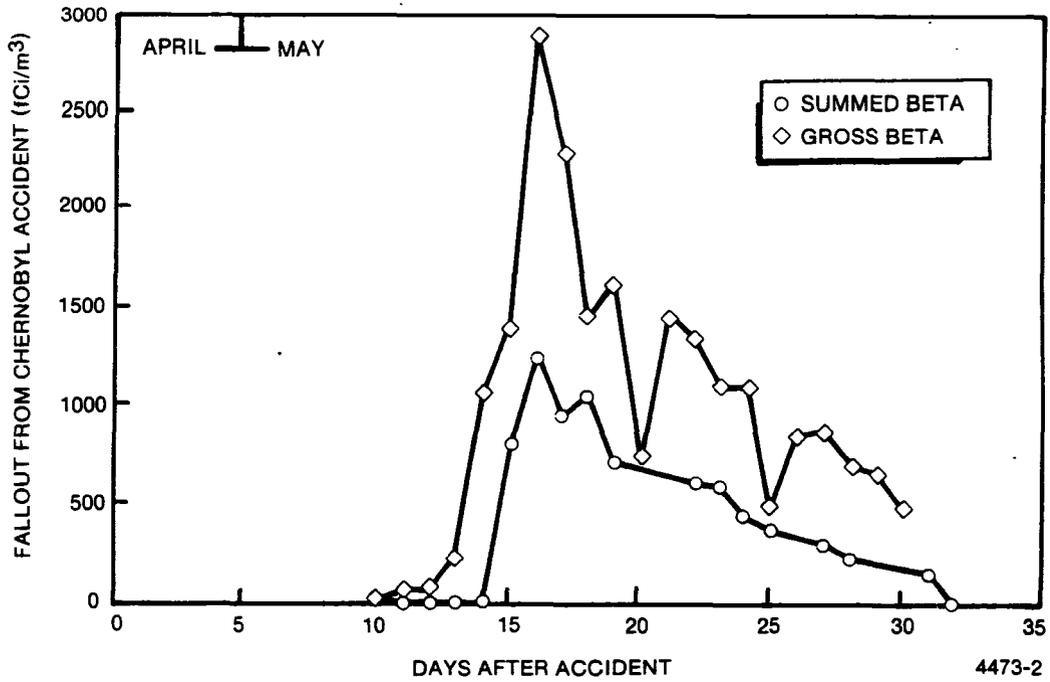


Figure 6. Daily Gamma and Gross Beta Radioactivity Concentrations - April and May 1986

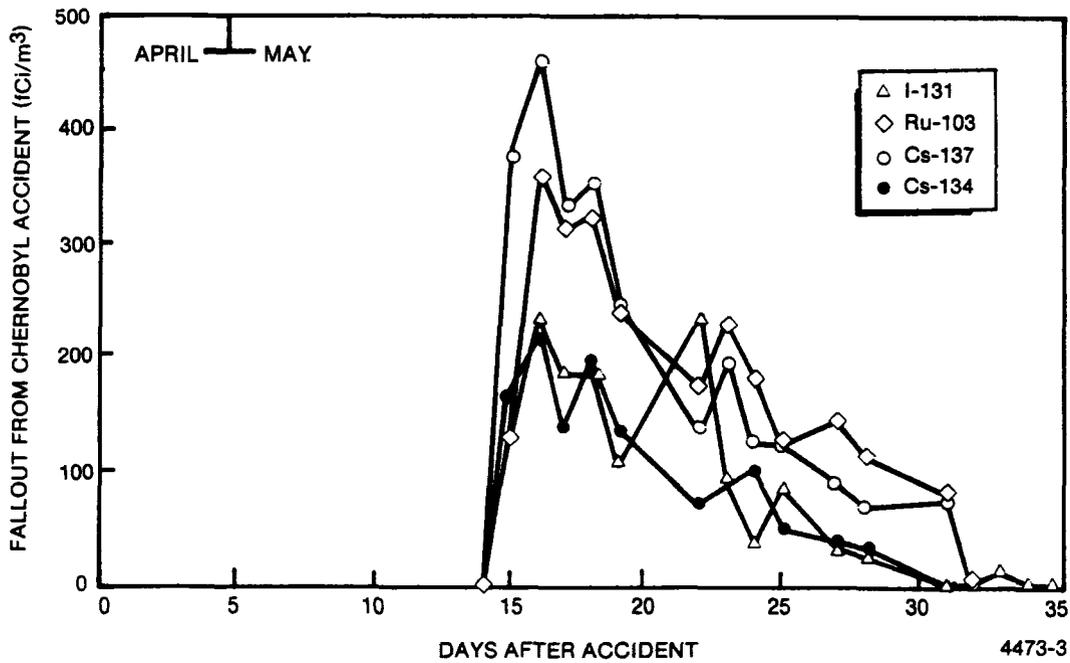


Figure 7. Daily Radionuclide Concentrations - April and May 1986

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evaluated quarterly. During the year, 18 on-site TLD monitoring locations were used. Five additional dosimeter sets, placed at locations up to 10 miles from the sites, are similarly evaluated to determine the local area off-site ambient radiation level, which averaged 12 μ rem/h for 1986. The quarterly and annual radiation exposures and the equivalent absolute and altitude-adjusted annual exposures, and exposure rates determined for each dosimeter location, are presented in Table 6.

Table 6 shows that radiation exposures and equivalent annual exposure rates monitored on-site are nearly identical to levels monitored at the five widely separated off-site locations. These data reflect natural background radiation from cosmic radiation, radionuclides in the soil, radon and thoron in the atmosphere, and local radioactive fallout. Locally, the natural background radiation level as measured by these dosimeters is about 100 mrem/year. The small variability observed in the data is attributed to differences in elevation and geologic conditions at the various dosimeter locations. The altitude range for the dosimeter locations is from about 875 ft ASL (above sea level) at the De Soto site to a maximum of about 1900 ft ASL for one of the SSFL dosimeters. When normalized to a specific altitude by adjusting the measured value by an altitude adjustment factor equal to 15 mrem/1000 ft elevation difference, derived radiation exposures for all locations are essentially identical. The 1986 averaged exposure values adjusted to 1000 ft ASL are 101 ± 7 mrem for the De Soto site, 108 ± 9 mrem for the SSFL site, and 106 ± 10 mrem for the off-site control dosimeters.

During the 4-year period of 1977 through 1980, a steady increase was observed in the TLD readings for all locations. Although the increases were variable from year to year and between locations, averaged over 4 years, the increases were in the range of 14 to 17 mrem/year. Since 1980, there has been a similar decline in TLD readings. The values for 1986 show a slight decrease from the previous year's results when adjusted to a common altitude which continues the currently decreasing trend.

TABLE 6
DE SOTO AND SSFL SITES--AMBIENT RADIATION
DOSIMETRY DATA--1986

TLD Location	Quarterly Exposure (mrem)				Annual Exposure (mrem)	Equivalent Exposure at 1000 ft ASL	
	Q-1	Q-2	Q-3	Q-4		(mrem)	(μ mrem/h)
De Soto DS-1	21	29	28	26	104	106	12
DS-2	19	25	25	b	92	94	11
DS-3	19	28	26	27	100	102	12
DS-4	25	30	29	29	113	115	13
DS-5	20	25	26	b	95	97	11
DS-6	21	27	27	28	103	105	12
DS-7	19	23	24	25	91	93	11
DS-8	18	23	26	26	93	95	11
Mean value	20	26	26	27	99	101	12
SSFL SS-1	22	29	32	24	107	95	11
SS-2	20	31	35	31	117	105	12
SS-3	25	30	34	29	118	106	12
SS-4	24	32	36	33	125	112	13
SS-5	22	29	34	29	114	101	12
SS-6	23	32	36	31	122	111	13
SS-7	22	29	33	33	117	105	12
SS-8	25	33	38	28	124	112	13
SS-9	28	37	46	32	143	131	15
SS-10	23	30	34	25	112	101	12
Mean value	23	31	36	30	120	108	13
Off-site OS-1	23	30	31	32	116	118	14
OS-2	20	25	25	b	93	91	10
OS-3	20	25	25	26	96	98	11
OS-4	21	29	30	b	107	105	12
OS-5	22	30	31	32	115	116	13
Mean value	21	28	28	30	105	106	12

^aMissing dosimeter; annual exposure estimated from data for three quarters.
^bNo data.

Supplementary measurements of ambient radiation levels with high-pressure ion chamber (HPIC) monitors are made at two locations at the SSFL site. The HPIC values for 1986 were equivalent to annual exposures of 106 mrem for the Building 207 monitor and 107 mrem for the Building 363 monitor. These values are in good agreement with results for nearby TLD locations for the year.

For independent monitoring of radiation levels in this area, the Radiologic Health Section of the State of California Department of Health Services provides packages containing lithium fluoride (LiF) chip dosimeters for placement with the packets used for the bulb dosimeters. The State dosimeters are returned to the Radiologic Health Section in Sacramento for evaluation. Data for these TLDs, placed at eight Rocketdyne dosimeter locations, both on-site and off-site, are presented in Table 7 for 1986. Considering the total independence of these measurements and the use of different thermoluminescent materials, the agreement is reasonably good; however, the State results are somewhat lower for each location jointly monitored.

During 1986, Rocketdyne participated in the Eighth International Environmental Dosimeter Intercomparison Project sponsored by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission. This project involves exposure of sets of TLDs to ambient radiation typical of environmental monitoring and also well-controlled exposures to calibrated radioisotope sources. A shipping control set is shielded during most of the project and provides a measure of apparent exposure during shipment. The Rocketdyne measurements of the various exposures are shown in Table 8. The results show very good agreement between the delivered exposures and measured values.

B. NONRADIOACTIVE MATERIALS--1986

Processed wastewater and most of the collected surface runoff discharged from the SSFL site flows to Rocketdyne retention pond R-2A. Water samples from the pond are analyzed for various constituents, as required by the Regional Water Quality Control Board, for each discharge to Bell Canyon. Such

TABLE 7
 DE SOTO AND SSFL SITES--STATE OF CALIFORNIA
 AMBIENT RADIATION DOSIMETRY DATA--1986

TLD Location	Quarterly Exposure (mrem)				Annual Exposure (mrem)	Equivalent Exposure at 1000 ft ASL	
	Q-1	Q-2	Q-3	Q-4		(mrem)	(μ rem/h)
De Soto DS-2	17	15	16	21	69	71	8
DS-6	18	20	19	23	80	82	9
DS-8	17	15	16	21	69	71	8
Mean value	17	17	17	22	73	75	8
SSFL SS-3	20	21	22	a	84 ^b	72	8
SS-6	20	22	a	26	91 ^b	80	9
SS-7	18	17	18	24	77	65	7
Mean value	19	20	19	25	84	72	8
Off-site OS-1	18	16	17	26	77	79	9
OS-5	16	16	17	26	75	76	9
Mean value	17	16	17	26	76	78	9

^aMissing dosimeter; annual exposure estimated from data for the three quarters.
^bAnnualized value.

Note: Results for the first three quarters were determined by dosimeters processed by the California Department of Health Services. Results for the fourth quarter were determined by a vendor laboratory providing TLD services under contract to the State of California.

discharges are normally done only as a result of excessive rainfall runoff during 1986, only six off-site discharges occurred, due to a relatively dry year. The results of the analyses for each discharge during 1986 are presented in Table 9.

TABLE 8
 COMPARISON OF EXPOSURE MEASUREMENTS IN THE
 EIGHTH INTERNATIONAL ENVIRONMENTAL
 DOSIMETER INTERCOMPARISON PROJECT

Type of Exposure	Delivered Exposure (mR)	Measured Exposure (mR)
Field site 1 (Chester, N.J.)	30 ± 2	27 ± 3
Field site 2 (Sandy Hook, N.J.)	10 ± 1	8 ± 2
Laboratory (¹³⁷ Cs)	17 ± 1	15 ± 1
Control	3.1 ± 1.6 ^a	14 ± 2 ^b

^aExposure during intercomparison project duration only

^bExposure during intercomparison plus shipping

TABLE 9

NONRADIOACTIVE CONSTITUENTS IN WASTEWATER DISCHARGED TO UNCONTROLLED AREAS--1986

(Analysis Results for Wastewater Discharged from Pond R-2A to
Bell Creek on Date Indicated--Sample Station W-12)

Constituent	January 30 ^a		February 13 ^a		March 10 ^a		March 17 ^a		April 7 ^a		November 18 ^a	
	Result	Guide (%)	Result	Guide (%)	Result	Guide (%)	Result	Guide (%)	Result	Guide (%)	Result	Guide (%)
Total dissolved solids (mg/L)	188	19.8	175	18.4	204	21.5	157	16.5	269	28.3	240	25.3
Chloride (mg/L)	22	14.7	18	12.0	15	10.0	12	8.0	26	17.3	27	18.0
Sulfate (mg/L)	38	12.7	31	10.3	35	11.7	27	9.0	42	14.0	46	15.3
Suspended solids (mg/L)	57	-	33	-	20	-	30	-	31	-	24	-
Settleable solids (mg/L)	0.1	-	<0.1	-	0.1	-	<0.1	-	<0.1	-	0.1	-
BOD ₅ (mg/L)	3.7	12.3	4	13.3	3	10.0	3	10.0	3	10.0	7	23.3
Oil and grease (mg/L)	<5	<33.3	<5	<33.3	<5	<33.3	<5	<33.3	<5	<33.3	<5	<33.3
Turbidity (TU)	48	-	36	-	25	-	20	-	29	-	38	-
Fluoride (mg/L)	0.1	10.0	<0.1	<10.0	<0.1	<10.0	<0.1	<10.0	0.1	10.0	<0.1	<10.0
Boron (mg/L)	0.1	10.0	0.2	20.0	0.2	20.0	0.2	20.0	0.2	20.0	0.1	10.0
Residual chlorine (mg/L)	<0.04	<40.0	<0.04	<40.0	<0.4	<40.0	<0.4	<40.0	<0.4	<40.0	<0.4	<40.0
Fecal coliform (MPN/100 mL)	<2	<8.7	<2	<8.7	<2	<8.7	<2	<8.7	<2	<8.7	<2	<8.7
Surfactants (MBAS)	0.008	1.6	<0.05	<10.0	<0.05	<10.0	<0.05	<10.0	<0.05	<10.0	0.03	0.06
pH	7.9		8.0		7.5		6.9		7.6		7.7	
Rainfall (cm)	1.4		0.9		1.1		0.9		0.4		0.7	
Estimated rainfall runoff (m ³)	37,760		36,730		158,760		143,640		83,160		117,180	
Release volume (m ³)	18,580		20,697		9,329		17,482		21,720		9,329	

^aRainfall-related discharge.

IV. ENVIRONMENTAL MONITORING PROGRAM

A. DESCRIPTION

A program of soil and vegetation sample collection and analysis for radioactivity was begun in 1952 in the Downey, California area where the nuclear research and development work of the predecessor company to Rocketdyne was initially located. Environmental sampling was subsequently extended to the then proposed Sodium Reactor Experiment (SRE) site in the Simi Hills in May 1954. In addition, sampling was begun in the Burro Flats area, southwest of SRE, where other nuclear installations were planned and are currently in operation. The Downey area survey was terminated when nuclear activities were relocated to Canoga Park in 1955. Sampling of vegetation for radioactivity analysis was terminated and the sampling frequency for soil was reduced to quarterly in 1986. Although the reduction in the number of on-site soil samples taken annually is significant, the number of off-site soil samples taken annually remains the same. Table A-1 shows that the 1986 averaged values for soil activity compares well with values for prior years. The primary purpose of the environmental monitoring program is to adequately survey environmental radioactivity to ensure that Rocketdyne nuclear operations do not contribute significantly to environmental radioactivity. The locations of sampling stations are shown in Figures 8 through 10 and listed in Table 10.

B. SAMPLING AND SAMPLE PREPARATION

1. Soil

Soil is analyzed for radioactivity to monitor for any significant increase in radioactive deposition by fallout from airborne radioactivity. Since soil is naturally radioactive and has been contaminated by atmospheric testing of nuclear weapons, a general background level of radioactivity exists. The data are monitored for increases beyond the natural variability of this background. For most radionuclides, gross alpha and beta radioactivity measurements are adequate for this purpose. Chemically specific analyses are performed for plutonium to provide improved sensitivity.

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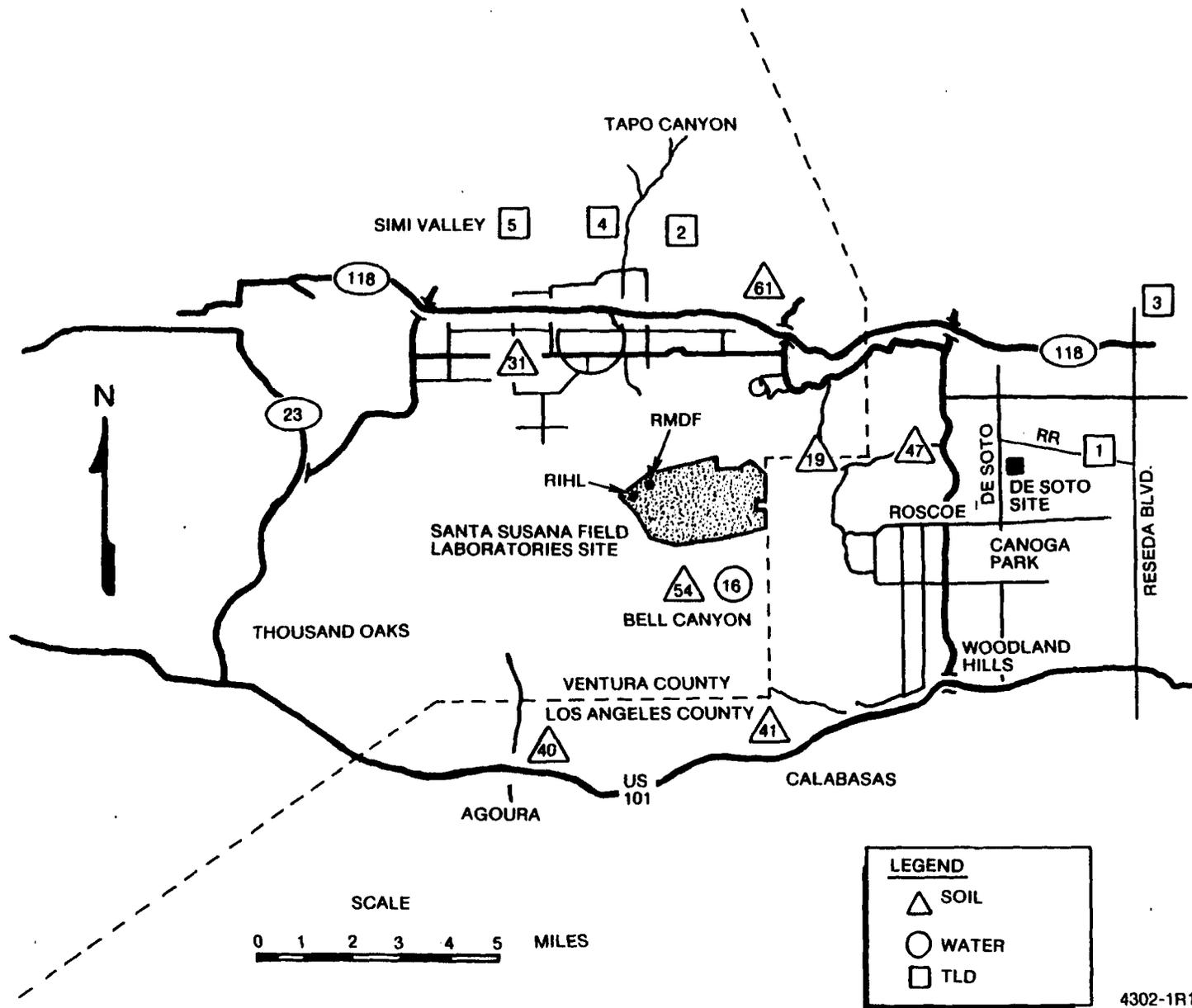


Figure 8. Map of Canoga Park, Simi Valley, Agoura, and Calabasas Sampling Stations

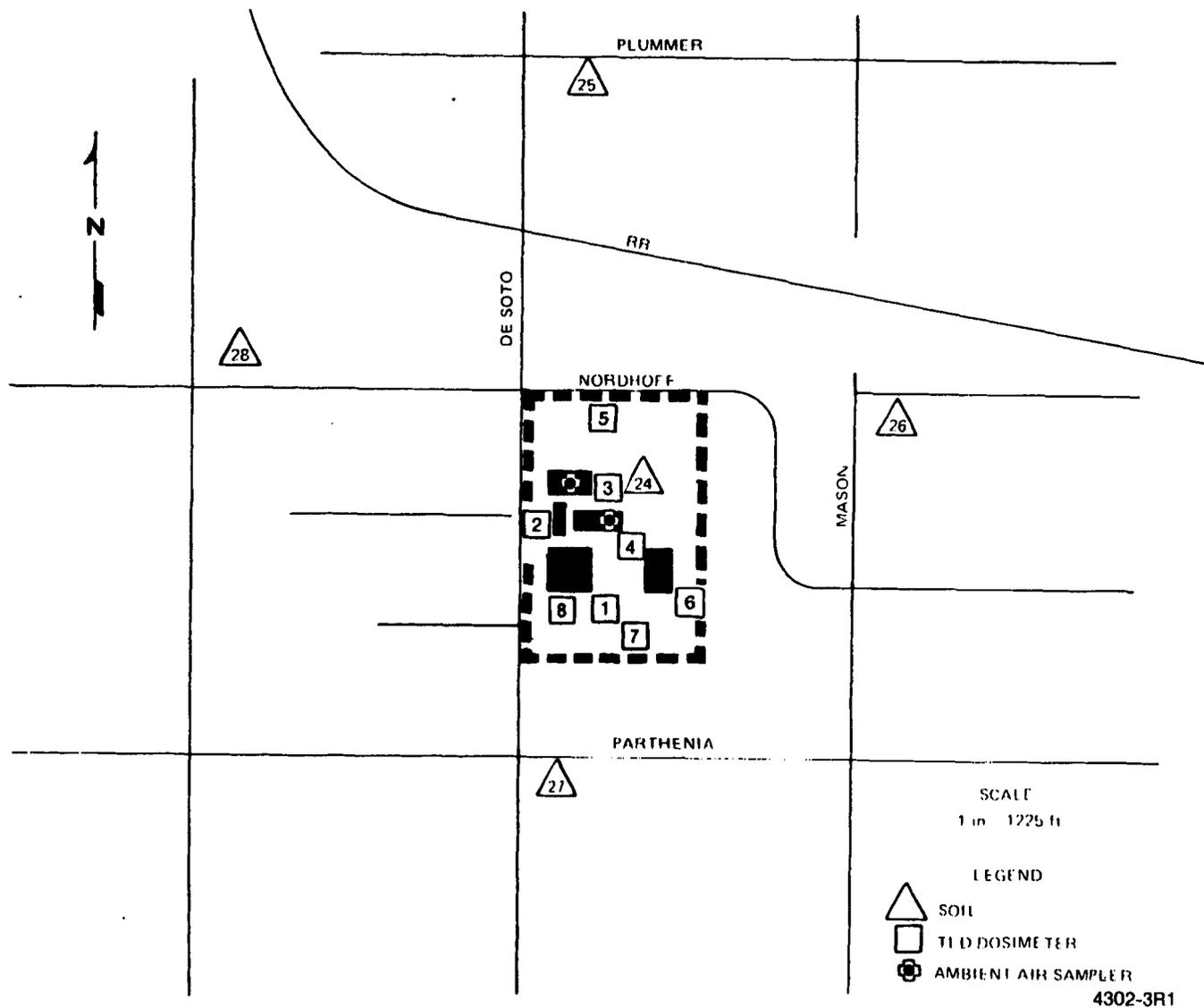
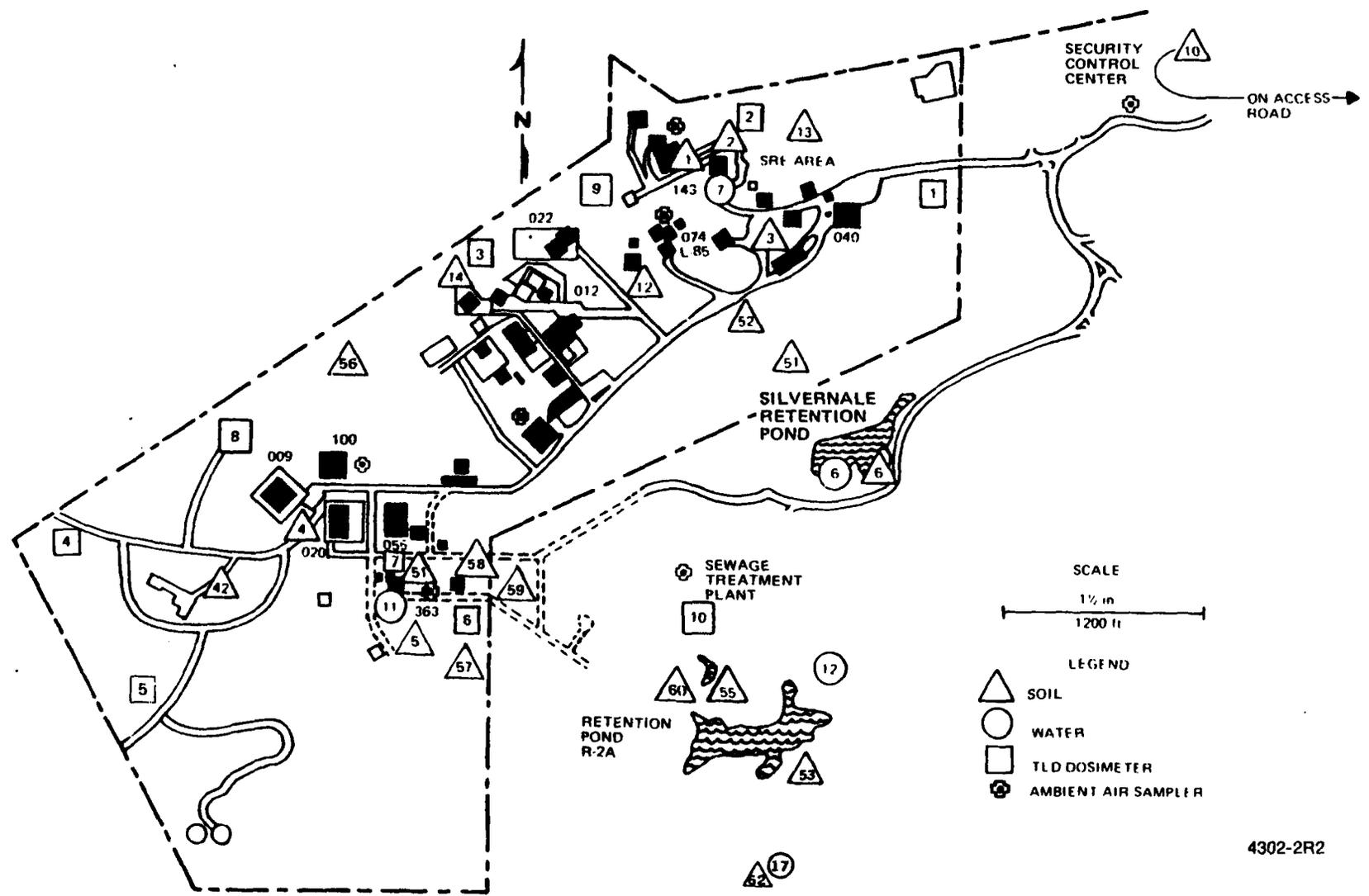


Figure 9. Map of De Soto Site and Vicinity Sampling Stations

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Figure 10. Map of Santa Susana Field Laboratories Site Sampling Stations

TABLE 10
 SAMPLING LOCATION DESCRIPTION
 (Sheet 1 of 5)

Station	Location	Frequency of Sampling ^a
S-1	SSFL Site, Building 143, southeast side	(Q)
S-2	SSFL Site, Building 143, east side	(Q)
S-3	SSFL Site, Building 064, north parking lot area	(Q)
S-4	SSFL Site, Building 020, at west fence	(Q)
S-5	SSFL Site, Building 363, east parking lot area	(Q)
S-6	SSFL Site, Interim Retention Pond, south side	(Q)
S-10	SSFL Site Access Road, at upper mobile home park entrance	(Q)
S-12	SSFL Site, Building 093, at reactor building driveway	(Q)
S-13	SSFL Site, above SRE Retention Pond	(Q)
S-14	SSFL Site, Building 028, upper parking lot area	(Q)
S-19	SSFL Site Entrance, Woolsey Canyon	(Q)
S-24	De Soto Site, Building 104, east side	(Q)
S-25	De Soto Avenue and Plummer Street, southeast corner	(Q)
S-26	Mason Avenue and Nordhoff Street, southeast corner	(Q)
S-27	De Soto Avenue and Parthenia Street, northeast corner	(Q)
S-28	Canoga Avenue and Nordhoff Street, northwest corner	(Q)
S-31	Simi Valley, Alamo Avenue and Sycamore Road, southeast corner	(Q)
S-40	Agoura - Kanan Road and Ventura Freeway at Frontage Road	(Q)
S-41	Calabasas - Parkway Calabasas and Ventura Freeway at Frontage Road	(Q)
S-42	SSFL Site, Building 886, at old sodium disposal facility gate	(Q)
S-47	Chatsworth Reservoir Site North Boundary at north gate	(Q)
S-51	SSFL Site, Building 029, at driveway	(Q)
S-52	SSFL Site, Burro Flats Drainage Control Sump, G Street and 17th Street	(Q)
S-53	SSFL Site, Pond R-2A	(Q)

TABLE 10
 SAMPLING LOCATION DESCRIPTION
 (Sheet 2 of 5)

Station	Location	Frequency of Sampling ^a
S-55	SSFL Site, Pond R-2A (Pond Bottom Mud), north side	(Q)
S-56	SSFL Site, F Street and 24th Street	(S)
S-57	SSFL Site, J Street, south of Building 055 exhaust stack	(S)
S-58	SSFL Site, Building 353, south of road	(S)
S-59	SSFL Site, Test Area CTL 4, entrance, east side	(S)
S-60	SSFL Site, Pond R-2A, northwest side	(S)
S-61	Simi Valley, east end of Alamo Avenue	(S)
S-62	SSFL Site, near south boundary, Bell Creek Weir, Well 9	(Q)
W-6	SSFL Site Interim Retention Pond, south side	(M)
W-7	SSFL Site Domestic Water, Building 003, washroom faucet	(M)
W-11	SSFL Site Domestic Water, Building 363, washroom faucet	(M)
W-12	SSFL Site, Pond R-2A, north side	(M)
W-13	De Soto Site, Building 104, washroom faucet	(M)
W-17	SSFL Site, Pond R-2A, discharge to Bell Creek	(Seasonal)
A-1	De Soto Site, Building 102 roof	(D)
A-2	De Soto Site, Building 104 roof	(D)
A-3	SSFL Site, Building 100, east side	(D)
A-4	SSFL Site, Building 011, west side	(D)
A-5	SSFL Site, Building 600, Sewage Treatment Plant, north side	(D)
A-6	SSFL Site, Building 207, Security Control Center, north side	(D)
A-7	SSFL Site, Building 074, south side	(D)
A-8	SSFL Site, Building 163, Box Shop at east side	(D)
A-9	SSFL Site, Building 363, west side	(D)
A-10	SSFL Site, Building 100, east side - 7-day sampler	(168 h)

TABLE 10
 SAMPLING LOCATION DESCRIPTION
 (Sheet 3 of 5)

Station	Location	Frequency of Sampling ^a
<u>On-Site--De Soto - Ambient Radiation Dosimeter Locations (TLD)</u>		
DS-1	De Soto Site, south of Building 102	(Q)
DS-2	De Soto Site, west boundary inside water supply enclosure (State of California TLD Location Number 2)	(Q)
DS-3	De Soto Site, Guard Post 1, Building 102	(Q)
DS-4	De Soto Site, northeast corner of storage yard fence	(Q)
DS-5	De Soto Site, north boundary at parking lot entry	(Q)
DS-6	De Soto Site, east boundary, southeast corner of fence (State of California TLD Location Number 1)	(Q)
DS-7	De Soto Site, south boundary in parking lot telephone pole stay	(Q)
DS-8	De Soto Site Guard Post 4, southwest corner of Building 101 (State of California TLD Location Number 7)	(Q)
<u>On-Site--SSFL - Ambient Radiation Dosimeter Locations (TLD)</u>		
SS-1	SSFL Site, Building 114 on telephone pole	(Q)
SS-2	SSFL Site, SRE Retention Pond on pump motor control panel	(Q)
SS-3	SSFL Site, Electric Substation 719 on boundary fence (State of California TLD Location Number 3)	(Q)
SS-4	SSFL Site, west boundary on H Street	(Q)
SS-5	SSFL Site, southwest boundary at property line gate	(Q)
SS-6	SSFL Site, Building 854 (State of California TLD Location Number 4)	(Q)
SS-7	SSFL Site, Building 363, north side on HPIC monitor (State of California TLD Location Number 8)	(Q)
SS-8	SSFL Site, Sodium Disposal Facility north boundary	(Q)
SS-9	SSFL Site, Radioactive Materials Disposal Facility, northeast boundary	(Q)
SS-10	SSFL Site, Building 600, Sewage Treatment Plant	(Q)

TABLE 10
 SAMPLING LOCATION DESCRIPTION
 (Sheet 4 of 5)

Station	Location	Frequency of Sampling ^a
<u>Off-Site (TLD)</u>		
OS-1	Off-site, Northridge, approximately Oakdale Avenue and Lassen Street (State of California TLD Location Number 5)	(Q)
OS-2	Off-site, Simi Valley, approximately Tapo Canyon and Walnut Streets	(Q)
OS-3	Off-site, San Fernando Valley, Northridge, approximately Plummer Street and Vanalden Avenue	(Q)
OS-4	Off-site, Simi Valley, approximately Tapo Canyon and Walnut Streets	(Q)
OS-5	Off-site, Simi Valley, approximately east Los Angeles Avenue and Stow Street (State of California TLD Location Number 6)	(Q)
HPI-1	High-Pressure Ion Chambers (HPIC) Ambient Radiation Monitor at Building 207, north side	(C)
HPI-2	High-Pressure Ion Chambers HPIC Ambient Radiation Monitor at Building 363, north side	(C)
^a <u>Code</u> <u>Description</u>		
S	Soil sample station	
W	Water sample station	
A	Air sampler station	
TLD	Thermoluminescent dosimeter	
D	Daily sample	
M	Monthly sample	
Q	Quarterly sample	
S	Semiannual sample	
C	Continuous	

TABLE 10
 SAMPLING LOCATION DESCRIPTION
 (Sheet 5 of 5)

GROUNDWATER SAMPLING STATIONS DEEP AND SHALLOW TEST AND PRODUCTION WELLS (Sampled Quarterly or Seasonally Depending on Groundwater Recharge)	
Well	Description of General Location
WS-4A	On-site: On north boundary
WS-5	On-site: 1500 ft from southeast boundary
WS-6	On-site: 2500 ft from north boundary
WS-7	On-site: 550 ft from north boundary
WS-8	On-site: 300 ft east of Silvernale Reservoir
WS-9	On-site: 1500 ft east of Silvernale Reservoir
WS-9A	On-site: 1000 ft south of Pond R-2A in drainage channel
WS-9B	On-site: 1000 ft from north boundary
WS-11	On-site: 2500 ft from northwest boundary
WS-12	On-site: 800 ft from north boundary
WS-13	On-site: 200 ft from north boundary
WS-14	On-site: On northeast boundary
OS-1	Off-site: 1350 ft from site north boundary
OS-2	Off-site: 1750 ft from site northwest boundary
OS-3	Off-site: 1100 ft from site northwest boundary
OS-4	Off-site: 1100 ft from site northwest boundary
OS-5	Off-site: 1100 ft from site northwest boundary
OS-8	Off-site: 1750 ft from site north boundary (Spring)
OS-10	Off-site: 4250 ft from site north boundary
OS-13	Off-site: 900 ft from site east boundary
OS-15	Off-site: 2900 ft from site northeast boundary
OS-16	Off-site: 800 ft from site northeast boundary
RS-20	On-site: 4400 ft from east boundary
RS-21	On-site: 860 ft from north boundary
RS-22	On-site: 1000 ft from north boundary

WS SSFL on-site water supply well (drilled before 1960)
 OS Off-site water well for ground water monitoring
 RS SSFL on-site shallow zone ground water monitoring well.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the upper 1 cm of undisturbed ground surface for gross radioactivity analysis and to a depth of 5 cm for plutonium analysis. The soil samples are packaged in paper containers and returned to the laboratory for analysis.

Sample preparation of soil for gross radioactivity determination consists of transferring the soils to Pyrex beakers and drying them in a muffle furnace at about 500°C for 8 h. After cooling, the soil is sieved to obtain uniform particle size. Two-gram aliquots of the sieved soil are weighed into copper planchets. The soil is wetted in the planchet with alcohol, evenly distributed to obtain uniform sample thickness, dried, and counted for alpha and beta radiation.

Soil plutonium analysis is performed using a chemically specific method by a certified independent testing laboratory according to the guidelines specified in the U.S. NRC Regulatory Guide 4.5 titled "Measurements of Radionuclides in the Environment--Sampling and Analysis of Plutonium in Soil."

2. Water

Surface and supply water samples are obtained monthly at the De Soto and SSFL sites and from Bell Creek. The water is drawn into 1-liter polyethylene bottles and transferred to the laboratory.

Five-hundred-milliliter volumes of water are evaporated to dryness in crystallizing dishes at about 90°C. The residual salts are redissolved into distilled water, transferred to planchets, dried under heat lamps, and counted for alpha and beta radiation.

3. Ambient Air

Air sampling is performed continuously at the De Soto and SSFL sites with continuous air samplers operating on 24-h sampling cycles. Airborne particulate radioactivity is collected on glass fiber filters, which are automatically changed daily at the end of each sampling period (midnight). The samples are counted for alpha and beta radiation following a minimum 120-h decay period. The volume of a typical daily ambient air sample is about 25 m³.

C. COUNTING AND CALIBRATION

Environmental soil, water, and ambient air samples are counted for alpha and beta radiation with low-background gas flow proportional counting systems. The systems are capable of simultaneously counting both alpha and beta radiation. The sample-detector configuration provides a nearly 2 π geometry. The thin-window detector is continually purged with methane or argon/methane counting gas. A preset time mode of operation is used for all samples. The lower limits of detection shown in Table 11 are those for a single sample determined by using typical values for counting time, system efficiencies for detecting alpha and beta radiation, background count rates (approximately 0.05 cpm alpha and 1.0 cpm beta), and sample size. These limits of detectability, for single samples, are calculated according to U.S. NRC Regulatory Guide 4.16, and assure a 95% probability that the measured activity would be identified as "above background."

Counting system efficiencies are determined routinely with Ra-D+E+F. (with alpha absorber), ³⁶Cl, ²³⁰Th, ²³⁵U, and ²³⁹Pu standard sources and with ⁴⁰K, in the form of standard reagent-grade KCl, which is used to simulate soil, and with soil containing known amounts of highly enriched uranium.

Self-absorption standards for beta counting are made by dividing sieved KCl into samples that increase in mass by 200-mg increments, from 100 to 3000 mg. The samples are placed in planchets of the type used for environmental samples and are counted. The ratio of sample activity to the observed

TABLE 11
LOWER LIMITS OF DETECTION (LLDs)

Sample	Activity	Minimum Detection Level
Soil	Alpha	$(3.1 \pm 1.8) 10^{-6} \mu\text{Ci/g}$
	Beta	$(4.2 \pm 2.0) 10^{-7} \mu\text{Ci/g}$
Water	Alpha	$(3.6 \pm 1.9) 10^{-10} \mu\text{Ci/ml}$
	Beta	$(1.4 \pm 1.2) 10^{-9} \mu\text{Ci/ml}$
Air	Alpha	$(5.6 \pm 2.4) 10^{-15} \mu\text{Ci/ml}$
	Beta	$(2.1 \pm 1.4) 10^{-14} \mu\text{Ci/ml}$

net count rate for each sample is plotted as a function of sample mass and a smooth curve is drawn through these points. The correction factor (ratio) corresponding to the mass of environmental samples is then obtained from the graph. The product of the correction factor and the net sample count rate yields the sample activity (dpm). This method has been proven usable by applying it to various-sized aliquots of uniformly mixed environmental samples and observing that the resultant specific activities fell within the expected statistical counting error, showing the absence of any systematic bias.

Since the observed radioactivity in environmental samples primarily results from natural sources and is at low concentrations, no identification of constituent radionuclides is done for each sample. However, collected samples are composited for gamma spectrometry of accumulated sample materials. The detection of significant levels of radioactivity would lead to an investigation of the radioactive material involved, the sources, and the possible causes.

D. NONRADIOACTIVE MATERIALS

The Rocketdyne Division of Rockwell International Corporation has filed a Report of Waste Discharge with the California Regional Water Quality Control Board and has been granted a National Pollutant Discharge Elimination System permit to discharge wastewater, pursuant to Section 402 of the Federal Water

Pollution Control Act. The permit, NPDES No. CA0001309, which became effective 27 September 1976, was renewed with minor changes effective 17 September 1984. This permit covers discharge of overflow and storm runoff from water reclamation retention ponds into Bell Creek. Discharge generally occurs only during and immediately after periods of heavy rainfall or during extended periods of rocket engine testing that release large amounts of cooling water to the ponds.

Only one of the retention ponds receives influent from the nuclear operating areas of the SSFL site. It is identified as retention pond R-2A, Water Sample Station W-12 in Table 10.

The influent includes sewage treatment plant outfall and surface runoff water. Grab-type water samples taken at the retention pond prior to a discharge are analyzed by a California State certified analytical testing laboratory for nonradioactive chemical constituents and for radioactivity. The specific constituents analyzed for, and their respective limitations in discharged wastewater, are presented in Appendix C. Wastewater originating from facilities located throughout the SSFL site is collected at the retention pond. The point of origin of small amounts of most nonradioactive constituents normally found in wastewater is difficult to determine. In the event of excessive amounts of any of these materials in wastewater, the origin could be determined from the knowledge of facility operations involving their use.

In addition to the wastewater discharge limitations, atmospheric pollutant discharge limitations were imposed by the Ventura County Air Pollution Control District (APCD) Permit 0271 on two natural-gas/oil-fired sodium heaters operated by ETEC. The limitations for 1986 are 0.34 tons/year for reactive organic compounds, 63.89 tons/year for oxides of nitrogen, 1.82 tons/year for particulates, 20.15 tons/year for oxide of sulfur, and 7.23 tons/year for carbon monoxide. Based on fuel consumption records for this facility during 1986, there was essentially no significant discharge to the atmosphere in comparison with the discharge limits. During 1986, the Ventura County APCD permit was renegotiated, resulting in more restrictive pollutant discharge limitations for some pollutants.

V. EFFLUENT MONITORING PROGRAM

Effluents that may contain radioactive material are generated at the Rocketdyne Division facilities as the result of operations performed under contract to DOE, under NRC Special Nuclear Materials License SNM-21, and under the State of California Radioactive Material License 0015-70. The specific facilities are identified as Buildings 020, 021-022, and 055 at the Santa Susana site, SSFL, and Building 104 (previously identified as 004) at the De Soto Facility.

A. TREATMENT AND HANDLING

The only release of radioactivity to uncontrolled areas is by way of discharge to the atmosphere. No contaminated liquids are discharged to unrestricted areas.

The level of radioactivity contained in all atmospheric effluents is reduced to the lowest value by passing the effluents through certified high-efficiency particulate air (HEPA) filters. The effluents are sampled for particulate radioactive materials by means of continuously operating stack exhaust samplers at the point of release. In addition, stack monitors installed at Buildings 020, 021-022, and 055 provide automatic alarm capability in the event of the release of gaseous or particulate activity from Building 020 and particulate activity from Buildings 021-022 and 055. The HEPA filters used for filtering atmospheric effluents are at least 99.97% efficient for particles 0.3 μm in diameter. Particle filtration efficiency increases for particles above and below this size.

The average concentration and total radioactivity in atmospheric effluents to uncontrolled areas are shown in Table 12. The effectiveness of the air cleaning systems is evident from the fact that the atmospheric effluents are less radioactive than is the ambient air. The total shows that no significant quantities of radioactivity were released in 1986.

TABLE 12

ATMOSPHERIC EMISSIONS TO UNCONTROLLED AREAS---1986

	Approximate Emissions Volume (m ³)	Activity Monitored	Approximate Minimum Detection Level (10 ⁻¹⁵ μCi/ml)	Annual Average Concentration (10 ⁻¹⁵ μCi/ml)	Sampling Period Maximum Observed Concentration (10 ⁻¹⁵ μCi/ml)	Total Radio-activity Released (Ci)	Percent of Guide ^a	Percent of Samples with Activity <MDL
104 De Soto	1.7 x 10 ⁸	Alpha	0.38	0.46	0.84	7.6 x 10 ⁻⁸	0.02	30
		Beta	1.40	4.76	25.50	7.8 x 10 ⁻⁷	0.002	15
020 SSFL	5.0 x 10 ⁸	Alpha	0.38	0.26	2.56	1.3 x 10 ⁻⁷	0.43	82
		Beta	1.40	46.09	440.96	2.2 x 10 ⁻⁵	0.15	4
021-022 SSFL	3.3 x 10 ⁸	Alpha	0.38	0.14	0.47	4.6 x 10 ⁻⁸	0.23	92
		Beta	1.40	39.90	279.86	1.3 x 10 ⁻⁵	0.13	0
055 ^d SSFL	1.1 x 10 ⁸	Alpha	0.38	0.36	1.09	4.1 x 10 ⁻⁸	0.60	65
		Beta	1.40	34.93	364.04	4.0 x 10 ⁻⁶	1.2	0
Total	1.1 x 10 ⁹				Total	4.0 x 10 ⁻⁵	---	---
Annual average ambient air radio-activity concentration ^b - 1986		Alpha		2.3	Ambient			
		Beta		73.0	equivalent ^c	8.3 x 10 ⁻⁵	---	---

^aAssuming all radioactivity detected is from Rocketdyne nuclear operations.

Guide: De Soto site: 3 x 10⁻¹² μCi/ml alpha, 3 x 10⁻¹⁰ μCi/ml beta; 10 CFR 20 Appendix B.

SSFL site: 6 x 10⁻¹⁴ μCi/ml alpha, 3 x 10⁻¹¹ μCi/ml beta, 3 x 10⁻¹² μCi/ml beta

(055 only); 10 CFR 20 Appendix B, CAC-17, and DOE Order 5480.1 Chapter XI.

^bAveraged result for 7-day (200 m³) SSFL continuous air sampler.

^cNatural radioactivity contained in equivalent volume of air discharged through exhaust systems after filtration.

^dThis facility was decommissioned during 1986. Exhaust system shut down in July.

Note: All release points are at the stack exit.

B. FACILITY DESCRIPTIONS

1. De Soto Site

a. Building 104--California State Licensed Activities

Operations at Building 104 that may generate radioactive effluents consist of research studies in applied physics and physical chemistry. Only atmospheric effluents are released from the building to uncontrolled areas. Major quantities of radionuclides present in encapsulated form are limited to ^{60}Co and ^{137}Cs . Small amounts of irradiated metallurgical samples and depleted uranium were also used for research purposes but have been removed from the facility.

2. Santa Susana Field Laboratories Site

a. Building 020--NRC and California State Licensed Activities

Operations at Building 020 that may generate radioactive effluents consist of hot cell examination and decladding of irradiated nuclear fuels and examination of reactor components. Only atmospheric effluents are released from the building to uncontrolled areas. The discharge may contain radioactive gases as well as particulate material depending on the operations being performed and the history of the irradiated fuel or other material. No radioactive liquid waste is released from the facility. Radioactive material handled in unencapsulated form in this facility includes the following radionuclides: U, Pu, as constituents in the various fuel materials; and ^{137}Cs , ^{90}Sr , ^{85}Kr , and ^{147}Pm as mixed fission products.

b. Buildings 021 and 022--DOE Contract Activities

Operations at Buildings 021 and 022 that may generate radioactive effluents consist of the processing, packaging, and temporary storage of liquid and dry radioactive waste material for disposal. Only atmospheric effluents are

released from the building to uncontrolled areas. No radioactive liquid waste is released from the facility. Nuclear fuel material handled in encapsulated or unencapsulated form contains uranium and plutonium plus ^{137}Cs , ^{90}Sr , ^{85}Kr , and ^{147}Pm as mixed fission products.

c. Building 055--NRC and California State Licensed Activities

Operations at Building 055 that may generate radioactive effluents consist of decontamination and decommissioning of the facility and equipment pending release for unrestricted use. Only atmospheric effluents were released from the facility to uncontrolled areas through the first half of 1986. The main radioactive exhaust system was eliminated in early July 1986. No radioactive liquid waste is released from the facility.

The various fuel materials that had been used at the facility consisted of depleted and enriched uranium and plutonium. No irradiated fuel materials have been processed at the facility.

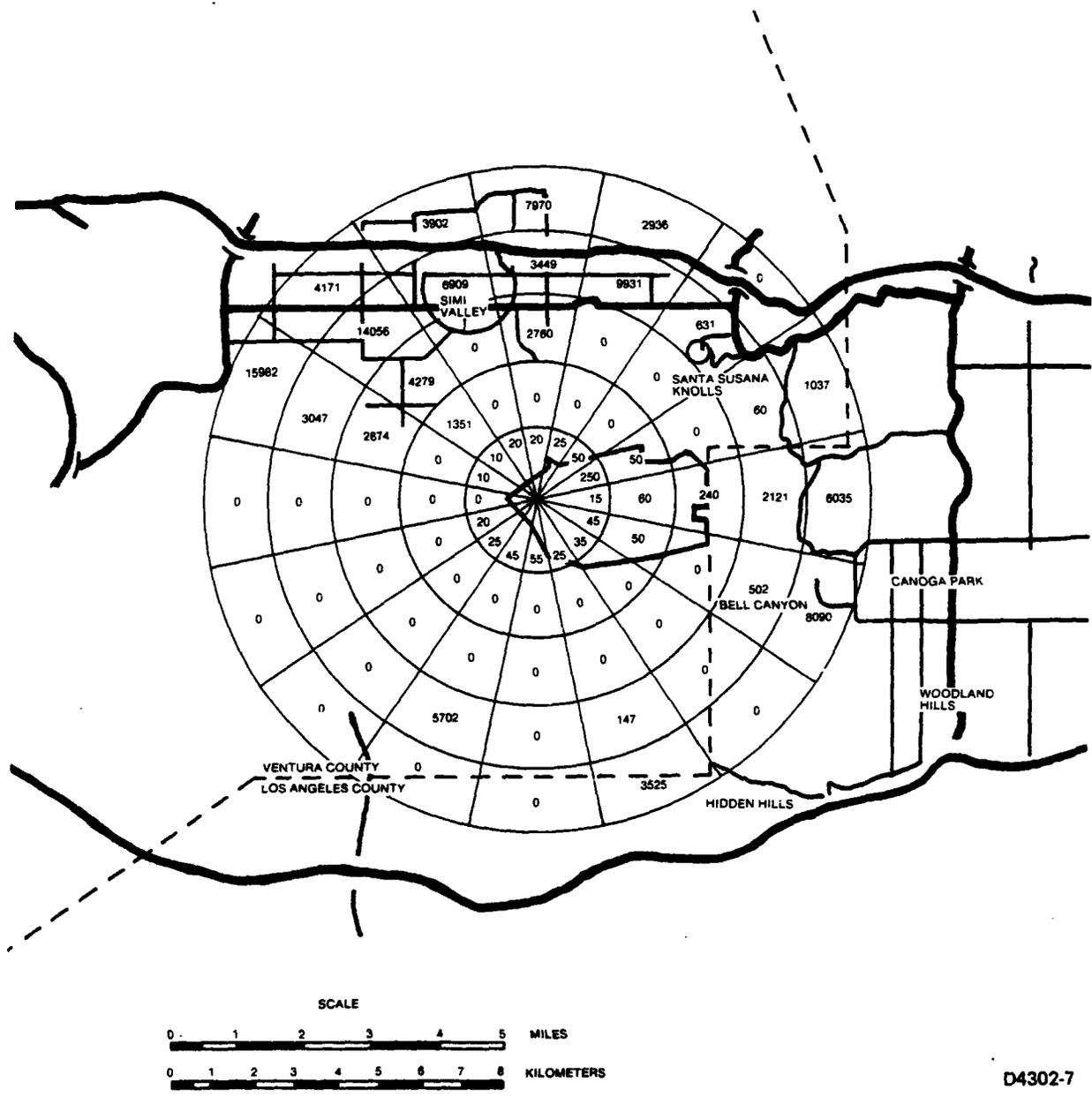
C. ESTIMATION OF GENERAL POPULATION DOSE ATTRIBUTABLE TO ROCKETDYNE OPERATIONS--1986

The Los Angeles basin is a semiarid region whose climate is controlled primarily by the semipermanent Pacific high-pressure cell that extends from Hawaii to the Southern California coast. The seasonal changes in the position of this cell greatly influence the weather conditions in this area. During the summer months, the high-pressure cell is displaced to the north. This results in mostly clear skies with little precipitation. During the winter, the cell moves sufficiently southward to allow some Pacific lows with their associated frontal systems to move into the area. This produces light to moderate precipitation with northerly and northwesterly winds.

The release of airborne material at the De Soto site for summer season weather conditions would generally be under a subsidence inversion into an atmosphere that is typical of slight neutral to lapse conditions. Nocturnal

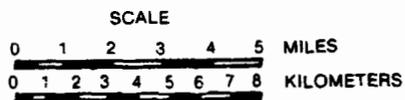
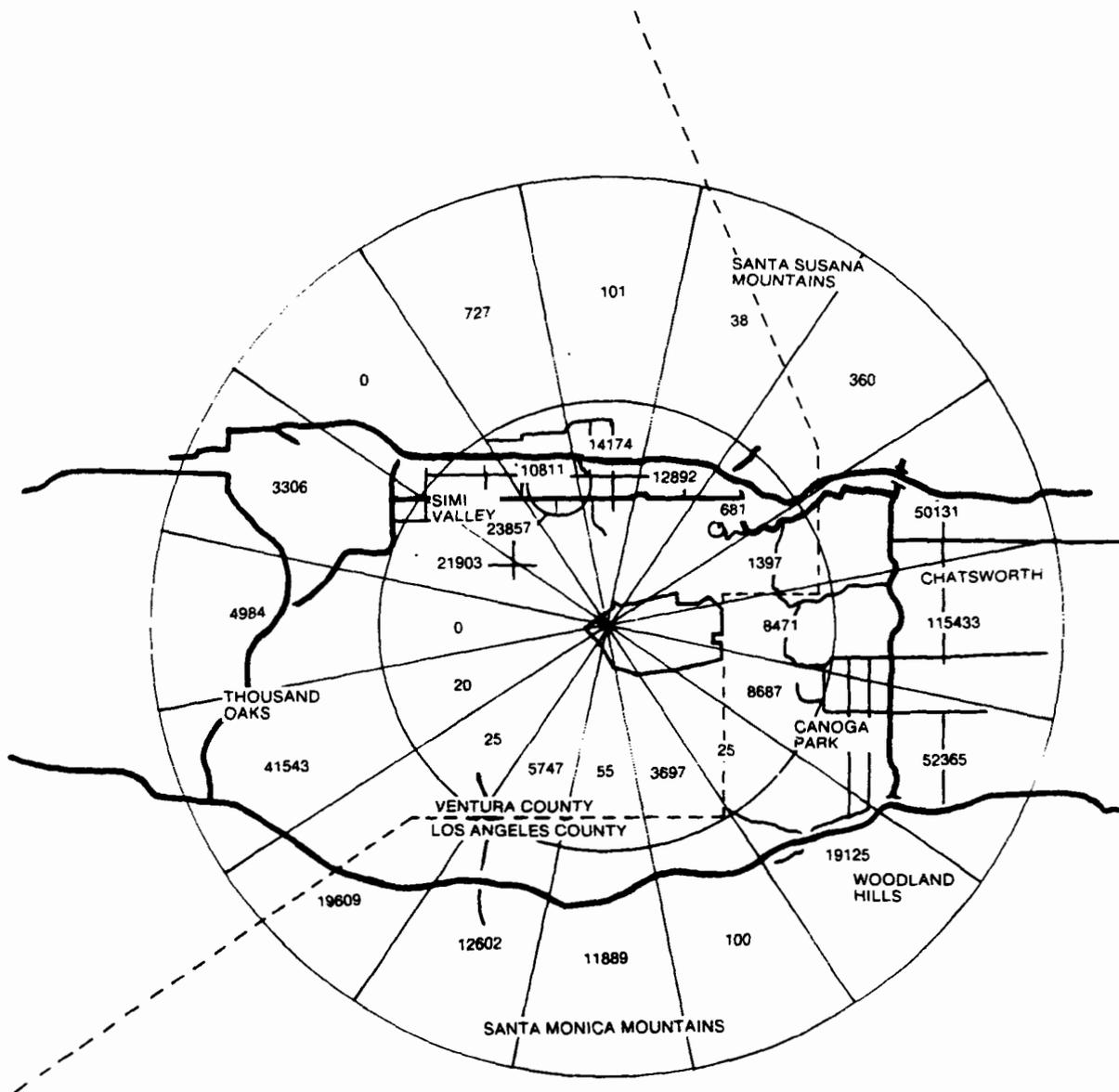
cooling inversions, although present, are relatively shallow in extent. During the summer, a subsidence inversion is present almost every day. The base and top of this inversion usually lie below the elevation of the SSFL site. Thus, any atmospheric release from the SSFL site under this condition would result in Pasquill Type D lofting diffusion conditions above the inversion and considerable atmospheric dispersion, prior to any diffusion through the inversion into the Simi or San Fernando Valleys. In the winter season, the Pacific high-pressure cell shifts to the south and the subsidence inversion is usually absent. The surface airflow is then dominated by frontal activity moving easterly through the area, resulting in high-pressure systems in the Great Basin region. Frontal passages through the area during winter are generally accompanied by rainfall. Diffusion characteristics are highly variable depending on the location of the front. Generally, a light to moderate southwesterly wind precedes these frontal passages, introducing a strong onshore flow of marine air and producing lapse rates that are slightly unstable. Wind speeds increase as the frontal systems approach, enhancing diffusion. The diffusion characteristics of the frontal passage are lapse conditions with light to moderate northerly winds. Locally, average wind speeds for the various stability categories range from 0 to about 4.4 m/s with the greatest frequency occurring for winds from the north to northwest sectors. Local population distribution estimates projected for 1986, based on the 1980 federal census and on direct observation of nearby residences, for areas surrounding the SSFL site and out to 80 km for 16 sectors are shown in Figures 11 through 13.

The downwind concentration of radioactive material emissions to the atmosphere during 1986 from each of the three major Rocketdyne nuclear facilities has been calculated with the AIRDOS-EPA computer code using site-specific input data including local area windspeed, directional frequency, and stability plus facility-specific data such as stack heights and exhaust air velocity.



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Figure 11. Santa Susana Field Laboratories Site-Centered Demography to 8 km Distance



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Figure 12. Santa Susana Field Laboratories Site-Centered Demography to 16 km Distance

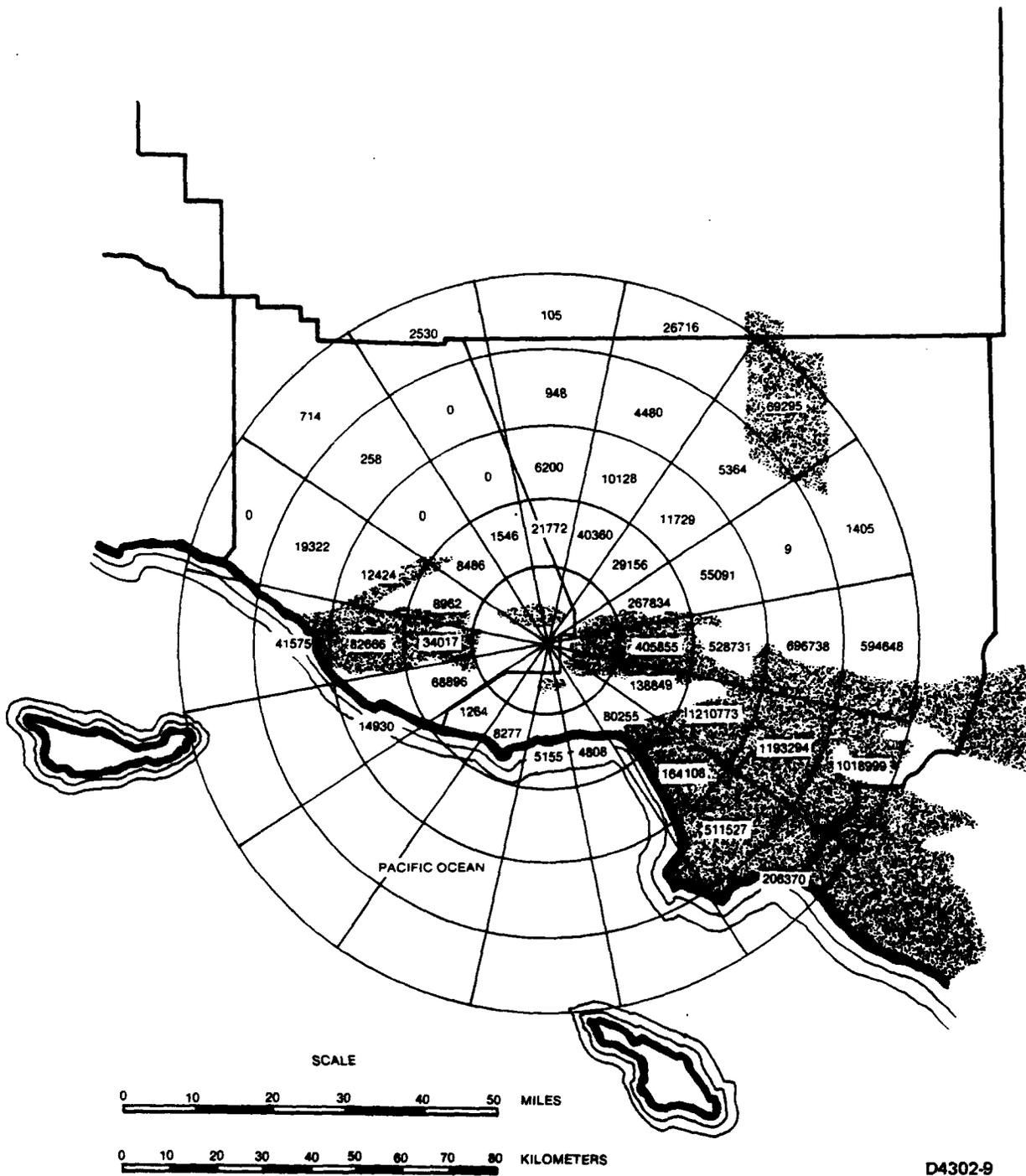


Figure 13. Santa Susana Field Laboratories Site-Centered Demography to 80 km Distance (heavily populated areas are shown by shading)

To determine the maximum possible radioactivity concentrations at the site boundary location nearest to each release point and at the nearest residence, a mean wind speed of 2.2 m/s for each stability class was assumed and used to evaluate the plume centerline (maximum) concentrations toward the sector in which those locations lie. The 80-km concentration was calculated for the greatest wind frequency, which is toward a northerly direction. The concentration estimates are shown in Table 13, and both internal and external radiation dose estimates are shown in Table 14. The internal dose calculations in Table 14 assume a constant unsheltered exposure, adjusted for wind direction frequency, throughout the year and therefore considerably overestimate the actual annual-averaged doses at the nearest boundary and nearest residence. The external dose calculations assume that differences in TLD readings represent true differences in local exposure. These differences are extrapolated to the boundary and nearest residence using an inverse square distance relation from an assumed source of radiation.

TABLE 13
MAXIMUM DOWNWIND PLUME CENTERLINE CONCENTRATIONS OF
ATMOSPHERIC EMISSIONS--1986

Facility	Release Rate (Ci/year)	Distance (m) to		Downwind Concentration (10^{-15} μ Ci/ml) ^a		
		Boundary	Residence	Boundary	Residence	80 km
B/104	7.8×10^{-7}	200 W	315 SW	0.0029	0.0029	0.000022
B/020	2.2×10^{-5}	305 NW	1900 SE	0.023	0.014	0.00052
B/022	1.3×10^{-5}	350 NW	2300 SE	0.0058	0.0049	0.00028
B/055 ^b	0.4×10^{-7}	400 NW	1830 SE	0.00013	0.000040	0.0000010

^aAssume $\bar{u} = 2.2$ m/s average wind speed, wind direction averaged for full year.

^bExhaust permanently shut down in July 1986.

TABLE 14

EXPOSURE TO THE PUBLIC IN THE VICINITY OF ROCKETDYNE FACILITIES--1986 (rem)

Air Pathway Organ	De Soto Building 104		SSFL-T/020 (RIHL)		SSFL-T/021-022 (RMDF)		SSFL-T/055 (NMDF)	
	Boundary	Residence	Boundary	Residence	Boundary	Residence	Boundary	Residence
Gonads	9.1×10^{-11}	9.2×10^{-11}	5.8×10^{-10}	3.6×10^{-10}	2.5×10^{-10}	2.1×10^{-10}	0	0
Breast	5.8×10^{-11}	5.9×10^{-11}	3.1×10^{-10}	1.9×10^{-10}	1.4×10^{-10}	1.1×10^{-10}	0	0
Red bone marrow	4.6×10^{-11}	4.7×10^{-11}	3.3×10^{-8}	2.0×10^{-8}	7.6×10^{-9}	6.4×10^{-9}	3.6×10^{-8}	1.1×10^{-8}
Lungs	3.8×10^{-10}	3.8×10^{-10}	8.1×10^{-8}	5.0×10^{-8}	2.5×10^{-8}	2.1×10^{-8}	1.5×10^{-7}	4.9×10^{-8}
Thyroid	0	0	6.2×10^{-11}	3.8×10^{-11}	1.9×10^{-11}	1.6×10^{-11}	0	0
Bone surfaces	0	0	6.6×10^{-8}	4.1×10^{-8}	1.9×10^{-8}	1.6×10^{-8}	1.1×10^{-7}	3.6×10^{-8}
Liver	4.9×10^{-11}	5.0×10^{-11}	2.7×10^{-8}	1.7×10^{-8}	8.4×10^{-9}	7.1×10^{-9}	5.1×10^{-8}	1.6×10^{-8}
Kidney	0	0	0	0	0	0	0	0
Spleen	0	0	0	0	0	0	0	0
Thymus	0	0	0	0	0	0	0	0
Adrenals	0	0	0	0	0	0	0	0
Pancreas	0	0	0	0	0	0	0	0
Stomach	0	0	0	0	0	0	0	0
Small intestine	0	0	1.4×10^{-10}	8.9×10^{-11}	4.6×10^{-11}	3.9×10^{-11}	0	0
ULI + LLI	4.4×10^{-11}	4.4×10^{-11}	1.4×10^{-10}	8.9×10^{-11}	7.2×10^{-11}	6.1×10^{-11}	0	0
Remainder	4.4×10^{-11}	4.4×10^{-11}	1.5×10^{-10}	9.2×10^{-11}	7.4×10^{-11}	6.2×10^{-11}	0	0
50-yr committed effective whole body dose equivalent	7.1×10^{-10}	7.2×10^{-10}	2.1×10^{-7}	1.3×10^{-7}	6.1×10^{-8}	5.1×10^{-8}	3.5×10^{-7}	1.1×10^{-7}
Other pathways	0	0	0	0	0	0	0	0
External direct whole body - rem	2×10^{-7}	9×10^{-8}	5.8×10^{-6}	2×10^{-10}	0.45	2×10^{-7}	0	0
Total exposure - rem	2×10^{-7}	9×10^{-8}	6×10^{-6}	2×10^{-10}	0.45	2×10^{-7}	4×10^{-7}	1×10^{-7}
SI equivalent-SV	2×10^{-9}	9×10^{-10}	6×10^{-8}	2×10^{-12}	0.0045	2×10^{-9}	4×10^{-9}	1×10^{-9}

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Except for the nearest boundary line exposure for the Radioactive Materials Disposal Facility (RMDF), the estimated off-site doses are extremely low compared to the maximum permissible exposures recommended for the general population in the vicinity of DOE facilities. The effective dose equivalent for any member of the public, for all pathways, shall not exceed 500 mrem/year for occasional exposures, and 100 mrem/year for prolonged periods of exposure. For the air pathway only, the limits are 25 mrem/year for whole body dose, and 75 mrem/year for any organ. The RMDF boundary to the north of the facility, which received an estimated 450 mrem during the year, is an isolated area with no direct access for unobserved members of the general public. No identifiable members of the general public were present at the site boundary during any significant portion of the year. The maximum estimated internal and external exposures to an individual for 1986 at the De Soto and SSFL site boundaries and also at the nearest residence are shown in Table 14. Estimated internal radiation doses due to atmospheric emission of radioactive materials from De Soto and the SSFL nuclear facilities are several orders of magnitude below the radiation standards and are far below doses due to internal exposure to natural radioactivity in air. The committed effective whole body dose equivalent due to inhalation of natural airborne radioactivity is approximately 0.012 rem/year.

The external exposures, above background, are based on the greatest exposure adjusted to a constant altitude (1000 ft MSL) measured by a single dosimeter compared with average adjusted off-site measurements. The mean adjusted value for five off-site dosimeters was 106 mrem with a maximum annually observed value for a single location of 118 mrem. Boundary dose estimates assume 100% occupancy, whereas the actual presence of persons at the boundary is rare or nonexistent. Review of the data indicates that these derived values, except for the RMDF, are not significantly different from zero, as shown by the uncertainties being near the reported value, but result from assumptions in the analysis.

TABLE 15
POPULATION DOSE ESTIMATES FOR ATMOSPHERIC EMISSIONS
FROM SSFL FACILITIES--1986

22.5° Sector	Dose to Receptor Population Segment (person-rem)						
	0-8 km	8-16 km	16-32 km	32-48 km	48-64 km	64-80 km	Total
N	1.7×10^{-4}	4.0×10^{-7}	3.8×10^{-5}	6.6×10^{-6}	7.3×10^{-7}	6.2×10^{-8}	2.2×10^{-4}
NNW	7.5×10^{-5}	1.8×10^{-6}	1.6×10^{-6}	0	0	9.2×10^{-7}	7.9×10^{-5}
NW	2.0×10^{-4}	0	9.8×10^{-6}	0	1.4×10^{-7}	2.9×10^{-7}	2.1×10^{-4}
WNW	2.9×10^{-4}	1.7×10^{-5}	2.2×10^{-5}	1.9×10^{-5}	2.2×10^{-5}	0	3.7×10^{-4}
W	0	1.6×10^{-5}	5.0×10^{-5}	7.8×10^{-5}	2.9×10^{-5}	0	1.7×10^{-4}
WSW	2.7×10^{-7}	6.7×10^{-5}	5.3×10^{-5}	7.4×10^{-6}	1.4×10^{-6}	0	1.3×10^{-4}
SW	2.1×10^{-7}	2.3×10^{-5}	2.2×10^{-7}	0	0	0	2.3×10^{-5}
SSW	2.1×10^{-5}	5.1×10^{-5}	5.3×10^{-6}	0	0	0	7.7×10^{-5}
S	1.3×10^{-6}	3.4×10^{-5}	7.1×10^{-6}	0	0	0	4.2×10^{-5}
SSE	2.7×10^{-5}	3.4×10^{-7}	7.7×10^{-6}	0	0	0	3.5×10^{-5}
SE	6.7×10^{-7}	6.1×10^{-5}	1.2×10^{-4}	1.6×10^{-4}	3.7×10^{-4}	1.2×10^{-4}	8.3×10^{-4}
ESE	4.9×10^{-5}	1.3×10^{-4}	1.6×10^{-4}	9.2×10^{-4}	6.7×10^{-4}	4.5×10^{-4}	2.4×10^{-3}
E	3.4×10^{-5}	1.9×10^{-4}	3.2×10^{-4}	2.7×10^{-4}	2.6×10^{-4}	1.8×10^{-4}	1.3×10^{-3}
ENE	5.7×10^{-6}	5.5×10^{-5}	1.4×10^{-4}	1.8×10^{-5}	2.2×10^{-9}	2.7×10^{-7}	2.2×10^{-4}
NE	3.5×10^{-6}	4.7×10^{-7}	2.1×10^{-5}	5.3×10^{-6}	1.6×10^{-6}	1.8×10^{-5}	5.0×10^{-5}
NNE	8.0×10^{-5}	8.4×10^{-8}	4.1×10^{-5}	6.5×10^{-6}	2.1×10^{-6}	9.7×10^{-6}	1.4×10^{-4}
Total	9.6×10^{-4}	6.5×10^{-4}	1.0×10^{-3}	1.5×10^{-3}	1.4×10^{-3}	7.8×10^{-4}	0.0063

Average individual dose = 7.8×10^{-10} rem for the 80-km radius area total population.

The general population person-rem dose estimates are calculated from the demographic distribution and the sector total inhalation intake (person-pCi/year) generated by AIRDOS-EPA, which uses release rate, wind speed, wind direction and frequency, inversion, lapse, and effective stack height parameters as input data. Population dose estimates centered on the SSFL site are presented in Table 15. Inhalation is the only significant exposure pathway likely to exist. The doses reported for SSFL site emissions are summed for all release points and nuclides.

APPENDIX A

COMPARISON OF ENVIRONMENTAL RADIOACTIVITY DATA FOR 1986 WITH PREVIOUS YEARS

This section compares environmental monitoring results for the calendar year 1986 with previous annual data.

The data presented in Tables A-1 through A-4 summarize past annual average radioactivity concentrations. These data show the effects of both the short-lived and long-lived radioactive fallout from nuclear weapons tests and the Chernobyl accident superimposed on the natural radioactivity inherent in the various sample types.

Over the considerable period of time that the environmental program has been in operation, evolutionary changes have been made in order to provide more effective data. In some cases, this is readily apparent in the data. For example, in Table A-1, a small but abrupt increase in the alpha activity reported for soil occurs in 1971. This increase, which is observed in both the on-site and the off-site samples, resulted from use of an improved counting system with a thinner sample configuration. The thinner sample increases the sensitivity of the detector to alpha-emitting radionuclides in the sample, thus producing a higher measured specific sample activity.

Similarly, prior to 1971, total activity in ambient air was measured, combining both alpha and beta activity. In 1971, measurements were begun that allowed separate identification of these two types of radiation.

In 1984, recalibration of the alpha counting method for thick samples was achieved, resulting in determination of the absolute alpha activity in these samples rather than the relative values previously used for monitoring purposes. Comparison of the values for 1986 as determined by the relative method with those for prior years shows no significant difference.

TABLE A-1
SOIL RADIOACTIVITY DATA--1967 THROUGH 1986

Year	On-site Average (pCi/g)			Off-site Average (pCi/g)		
	Number of Samples	Alpha	Beta	Number of Samples	Alpha	Beta
1986 ^a	48	26.7	26	48	25.1	25
1985 ^a	144	25.2	24	48	26.3	24
1984 ^a	144	25.8	24	48	26.2	23
1983	144	0.61	24	48	0.59	23
1982	144	0.69	25	48	0.68	23
1981	144	0.69	25	48	0.64	23
1980	144	0.60	24	48	0.58	23
1979	144	0.64	25	48	0.50	23
1978	144	0.63	24	48	0.51	24
1977	144	0.56	24	48	0.53	23
1976	144	0.56	25	48	0.56	24
1975	144	0.60	25	48	0.58	24
1974	144	0.60	25	48	0.54	24
1973	144	0.57	25	48	0.51	24
1972	144	0.56	25	48	0.57	24
1971	144	0.55	25	48	0.53	23
1970	144	0.47	27	48	0.48	25
1969	144	0.42	27	48	0.42	25
1968	144	0.47	26	48	0.48	26
1967	144	0.42	28	48	0.39	24

^aThe change in alpha activity after 1983 is the result of an improved calibration method that provides a true measure of alpha activity in thick samples rather than the relative values used previously. This is discussed in detail in Part III, Section A. Values for 1986 using the prior method would be 0.63 for the on-site average and 0.60 for the off-site average.

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TABLE A-2
 SSFL SITE SUPPLY WATER RADIOACTIVITY DATA --
 1967 THROUGH 1986

Year	Number of Samples	Average Alpha (10^{-9} μ Ci/ml)	Average Beta (10^{-9} μ Ci/ml)
1986 ^a	24	6.55	3.6
1985 ^a	24	2.05	2.8
1984 ^a	24	3.53	2.9
1983	24	0.12	3.0
1982	24	0.14	3.0
1981	24	0.24	2.8
1980	24	0.22	2.4
1979	24	0.23	2.8
1978	24	0.26	3.0
1977	24	0.25	2.5
1976	24	0.25	2.0
1975	24	0.24	2.3
1974	24	0.24	2.7
1973	24	0.26	3.4
1972	24	0.22	3.7
1971	24	0.28	4.9
1970	24	0.18	5.3
1969	24	0.11	5.0
1968	24	0.16	5.0
1967	24	0.13	6.1

^aThe change in alpha activity after 1983 is the result of an improved calibration method that provides a true measure of alpha activity in thick samples rather than the relative values used previously. This is discussed in detail in Part III, Section A. The value for 1986 using the prior method would be 0.29.

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TABLE A-3
ROCKETDYNE DIVISION RETENTION POND RADIOACTIVITY
DATA--1967 THROUGH 1986

Year	Interim Retention Pond Water 6			Final Retention Pond R-2A Water 12		
	Number of Samples	Average (10^{-9} μ Ci/ml)		Number of Samples	Average (10^{-9} μ Ci/ml)	
		Alpha	Beta		Alpha	Beta
1986a	12	2.51	2.9	12	4.18	3.6
1985a	12	2.06	3.5	12	3.07	3.5
1984a	12	2.07	4.6	12	0.15	4.2
1983	12	0.12	3.6	12	0.13	4.4
1982	12	0.17	3.9	12	0.11	3.9
1981	12	<0.23	4.3	12	<0.25	5.2
1980	12	<0.22	2.9	12	<0.22	3.9
1979	12	<0.25	3.1	12	<0.23	4.5
1978	12	<0.25	4.3	12	<0.25	4.6
1977	12	<0.24	4.3	12	<0.25	5.2
1976	12	<0.24	4.3	12	<0.28	4.4
1975	12	<0.24	4.2	12	<0.31	4.5
1974	12	<0.22	4.2	12	<0.21	4.5
1973	12	<0.23	4.5	12	<0.37	5.6
1972	12	0.22	5.3	12	0.22	5.5
1971	12	0.18	6.2	12	0.16	6.4
1970	12	0.15	6.9	12	0.12	7.4
1969	12	0.07	5.9	11	0.10	5.7
1968	11	0.23	8.1	12	0.33	7.7
1967	12	0.19	6.6	10	0.17	7.0

^aThe change in alpha activity after 1983 is the result of an improved calibration method that provides a true measure of alpha activity in thick samples rather than the relative values used previously. This is discussed in detail in Part III, Section A. Values for 1986 using the prior method would be as follows:

Interim retention pond: 0.13
Final retention pond: 0.18

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TABLE A-4
 AMBIENT AIR RADIOACTIVITY CONCENTRATION DATA--1967 THROUGH 1986

Year	De Soto Site Average (10 ⁻¹² μCi/ml)			SSFL Site Average (10 ⁻¹² μCi/ml)		
	Number of Samples	Alpha	Beta	Number of Samples	Alpha	Beta
1986	687	0.0029	0.058	2415	0.0028	0.061
1985	544	0.0026	0.044	2450	0.0020	0.040
1984	712	0.0019	0.027	2461	0.0014	0.024
1983	644	0.0024	0.026	2328	0.0010	0.023
1982	727	0.0017	0.026	2347	0.0013	0.022
1981	704	0.0069	0.12	2518	0.0068	0.12
1980	685	0.0065	0.039	2342	0.0064	0.035
1979	697	0.0066	0.021	2519	0.0065	0.020
1978	713	0.0084	0.091	2402	0.0072	0.088
1977	729	0.0066	0.17	2438	0.0066	0.17
1976	719	0.0067	0.096	2520	0.0065	0.11
1975	709	0.0063	0.076	2450	0.0060	0.073
1974	663	0.0056	0.16	2477	0.0057	0.16
1973	715	0.0075	0.041	2311	0.0072	0.038
1972	708	0.0085	0.14	2430	0.0086	0.14
1971 ^a	730	0.0087	0.30	2476	0.0086	0.33
1970	668	-	0.34	2434	-	0.36
1969	687	-	0.27	2364	-	0.26
1968	650	-	0.32	2157	-	0.32
1967	712	-	0.39	2400	-	0.41

^a Ambient air alpha radioactivity values were included in the beta values and not reported separately prior to 1971.

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In late 1985, a new automatic low-background gas flow proportional counting system was placed in operation for the counting of most environmental samples. Following characterization and calibration, the new system was used for all sample types, except soil, that were analyzed during 1986.

The ambient radiation monitoring results show a continuing long-term variation that had been apparant in previous years but is unrelated to operations on-site. Independent measurements and intercomparisons support the values measured by the bulb-type dosimeters. With the exception of apparent changes resulting from improvements in analytical methods and interpretation of the data, the soil, vegetation, water, and air radioactivity results are notably constant over the past 20 years. In particular, environmental radioactivity data for the De Soto site show no reduction in the measured levels below those that had been observed during the fuel fabrication operations that were discontinued in 1982 confirming that those levels represent natural radioactivity.

For all types of samples, the data indicate that there is no concentrated local source of unnatural radioactivity in the environment. Also, the similarity between on-site and off-site results further indicates that Rocketdyne operations contribute essentially nothing to general environmental radioactivity.

APPENDIX B
ENVIRONMENTAL MONITORING PROGRAM QUALITY CONTROL

This appendix describes the quality assurance (QA) elements that are incorporated into the Rocketdyne program to ensure that data produced are as meaningful as possible.

PROCEDURES

Procedures followed include sample selection; sample collection; packaging, shipment and handling of samples for off-site analysis; preparing and analyzing samples; using radioactive reference standards; calibration methods and instrument QA; and evaluating and reporting data.

RECORDS

Records generally cover the following processes: field sample collection and laboratory identification coding; sample preparation method; radioactivity measurements (counting) of samples, instrument backgrounds, and analytical blanks; and data reduction and verification.

Quality control records for laboratory counting systems include the results of measurements of radioactive check sources, calibration sources, backgrounds, and blanks, as well as a complete record of all maintenance and service.

Records relating to overall laboratory performance include the results of analysis of quality control samples such as analytical duplicates, inter-laboratory cross-check samples and other quality control analyses; use of standard (radioactive) reference materials to prepare working standards; and calibration of analytical balances.

The following specific elements of quality control are used for the Rocketdyne program:

- 1) Reagent Quality--Reagent-grade chemicals and certified grade counting gas used.
- 2) Laboratory Ventilation--Room air supply is controlled to minimize temperature variance and dust incursion.
- 3) Laboratory Contamination--Periodic laboratory contamination surveys for fixed and removable surface contamination are performed. Areas are cleaned routinely and decontaminated when necessary.
- 4) Control Charts--Background and reference source control charts for counting equipment are maintained to evaluate stability and response characteristics.
- 5) Laboratory Intercomparisons--Rockwell participates in the DOE-EML-QAP, and in the DOE Environmental Dosimeter Intercomparison Project.
- 6) Duplicate Samples--Duplicate samples are obtained monthly at randomly selected environmental sampling locations. Analytical data are statistically evaluated to determine the correlation coefficients for each media type for the annual sample set.
- 7) Calibration Standards--Counting standard radioactivity values are traceable to the National Bureau of Standards primary standards.

APPENDIX C

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD CRITERIA FOR DISCHARGING
NONRADIOACTIVE CONSTITUENTS FROM ROCKETDYNE DIVISION, SSFL

The discharge of an effluent in excess of the limits given in Table C-1 is prohibited.

TABLE C-1

NPDES NO. CA00-01309, ORDER 84-85, EFFECTIVE 17 SEPTEMBER 1984

Constituent	Discharge Rate (lb/day)*	Concentration Limit (mg/liter)
	30-Day Average	Maximum
Total dissolved solids	1,267,680	950
Chloride	200,160	150
Sulfate	400,320	300
Suspended solids ^a	66,720	-
Settleable solids ^a	-	-
BOD ₅	26,690	30
Oil and grease	13,350	15
Chromium	6.67	-
Fluoride	1,340	1.0
Boron	1,340	1.0
Residual chlorine	-	0.1
Fecal coliform (MPN/100 ml)	-	2.2
Surfactants (as MBAS)	667	0.5
pH		6.0 to 9.0

^aNot applicable to discharges containing rainfall runoff during or immediately after periods of rainfall.

^bWastewater shall be considered adequately disinfected if the median number of coliform organisms does not exceed 23/100 ml.

*Based on a total waste flow of 160×10^6 gal/day.

APPENDIX D
BIBLIOGRAPHY

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2. DOE Order 5480.1A
3. Code of Federal Regulations, Title 10, Part 20 (10 CFR 20)
4. California Radiation Control Regulations, California Administrative Code, Title 17, Public Health
5. California Regional Water Quality Control Board, Los Angeles Region, Order No. 84-85, NPDES No. CA0001309, Effective 17 September 1984
6. R. E. Moore, 1979. AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Doses to Man from Airborne Releases of Radionuclides, ORNL-5532
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11. J. D. Moore, "Radiological Environmental Monitoring Program Quality Assurance," N001DWPO00009, Rocketdyne Division, Rockwell International (25 September 1984)
12. "Investigation of Hydrogeologic Conditions - Santa Susana Field Laboratory, Ventura County, California," Hargis & Associates, Inc., Tucson, Arizona (22 February 1985)

APPENDIX E
EXTERNAL DISTRIBUTION

1. Radiologic Health Branch, Department of Health Services, California
2. Occupational Health and Radiation Management, Los Angeles County Health Department, California
3. Resources Management Agency, County of Ventura, California
4. U.S. Nuclear Regulatory Commission, Region V, Walnut Creek, California
5. U.S. Nuclear Regulatory Commission, Office of Inspection and Enforcement, Washington, D.C.
6. U.S. Department of Energy, Environment, Safety and Quality Assurance Division, San Francisco Operations Office, Oakland, California
7. U.S. Department of Energy, Office of Operational Safety, EP-32, Technical Information Center, Washington, D.C.
8. Rocky Flats Plant, Health, Safety, and Environment, Golden, Colorado

APPENDIX F

ALTERNATIVE UNITS FOR RADIOLOGICAL DATA

	In Non-SI Units	In SI Units	Conversion Factor From Non-SI to SI Units ^a
Activity concentrations (Environmental)			
Airborne particulates and gas	pCi/m ³	Bq/m ³	3.70E - 02
Liquids (water, milk, etc.)	pCi/l	Bq/l	3.70E - 02
Solids (soil, sediment, vegetation, foodstuff, etc.)	pCi/g	Bq/kg	3.70E - 05
Activity concentrations (effluent)			
Gas (air)	(μ Ci/m ³) ^b	Bq/m ³	3.70E + 10
Liquid	(μ Ci/m ³) ^b	Bq/l	3.70E + 07
Exposure rate (environment)	R/h	C/kg h	2.58E - 10
Absorbed dose	mrad	Gy	1.00E - 05
Dose equivalent	mrem	Sv	1.00E - 05
Dose equivalent rate (commitment)	mrem/year	Sv/year	1.00E - 05

^aTo convert non-SI units to SI units, multiply the non-SI units by the conversion factor.

^bAdopted because of established convention and use in maximum permissible concentration (MPC) tabulations.