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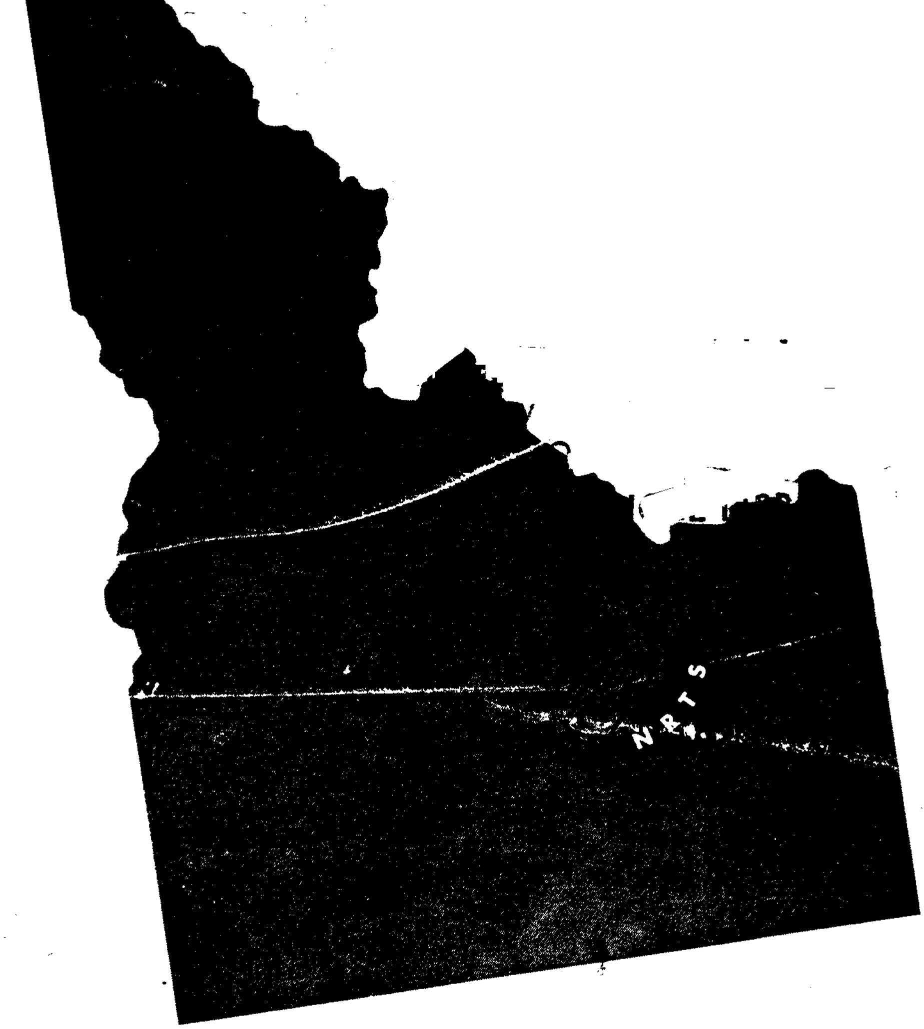
IDO REPORT
ON THE
NUCLEAR INCIDENT AT THE SL-1 REACTOR

JANUARY 3, 1961

AT THE

NATIONAL REACTOR TESTING STATION



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IDO Report
on the
NUCLEAR INCIDENT AT THE SL-1 REACTOR
on
January 3, 1961
at the
National Reactor Testing Station

Prepared
by
The SL-1 Report Task Force
U. S. Atomic Energy Commission
Idaho Operations Office
Idaho Falls, Idaho

ACKNOWLEDGEMENT

The SL-1 Report Task Force wishes to acknowledge the contributions made by members of the Idaho Operations Office Staff and military personnel attached to the Idaho Nuclear Power Field Office of the United States Army Engineers Reactor Group whose diligent efforts made this report possible.

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FOREWORD

On Tuesday, January 3, 1961, at 9:01 p.m. a nuclear incident occurred at the Stationary Low Power Reactor No. 1, known as the SL-1, located at the National Reactor Testing Station (NRTS), Idaho. This nuclear incident resulted in three fatalities and extensive damage to the reactor core. Only slight physical damage was incurred to the reactor building, and no significant amount of contamination was released into the surrounding environs.

This IDO SL-1 Report is intended to summarize those activities which took place following the incident and does not attempt to determine the cause of the incident, which is the subject of a separate report by the AEC Board of Investigation. To make the report as complete as possible with respect to the operational aspects following the SL-1 Incident, certain limited areas covered in the AEC Board of Investigation Report appear in this report.

Since the reader may be unfamiliar with the SL-1 Facility, a brief description of the SL-1 Reactor and the operating training program which was utilized prior to the incident has been included in the initial portion of the report. This introductory section is followed by a brief resume' of events which took place after the incident, while the remainder of the report supplies detailed information on various aspects of the post-incident developments.

What began as a routine fire-alarm situation eventually involved all of the Divisions at the Idaho Operations Office, AEC, a number of federal agencies, many AEC on- and off-site contractors, and other outside groups.

SECTION 1

THE SL-1 REACTOR, PRE- AND POST-INCIDENT

I. BASIC DESIGN DATA

The SL-1 Reactor, Stationary Low Power Reactor #1, was designed by Argonne National Laboratory as the prototype for a power plant to provide power and heat for a remote radar installation and its support facilities. Originally designated as the Argonne Low Power Reactor (ALPR), the SL-1 was a direct cycle, boiling water moderated and cooled, natural circulation reactor. The architect engineer was Pioneer Service and Engineering Company, and the operating contractor since February 5, 1959, has been Combustion Engineering, Incorporated.

Some of the advantages of an SL-1 type reactor are: (1) its components can be transported in cargo aircraft, (2) it will operate continuously for a period of three years on one fuel loading, (3) it is constructed above ground to allow for remote arctic construction requirements, and (4) it does not require a large amount of water.

Other details of design are discussed briefly in the following sections and have been tabulated in Table 1.1.

Site. The SL-1 is located at the National Reactor Testing Station, Idaho. The location of the reactor on the NRTS Site is shown in Figure 1.1. The reactor building and associated buildings within the SL-1 Area are shown in Figure 1.2 and Figure 1.3.

Core Structure. With the exception of minor fittings of stainless steel, the entire SL-1 core was fabricated of an aluminum-nickel alloy (x-8001) (see Figure 1.4).

The core was divided into sixteen boxes, twelve of which could accommodate four fuel elements each and four of which (the corner boxes) could accommodate three elements each (see Figure 1.5). The maximum capacity of the core was 59 fuel assemblies and one neutron source assembly.

The sides of the boxes were defined by the four tee and five cruciform control-rod channels. Five control rods were used for a 40 fuel-element loading and four (4) tee channels were provided for additional control rods with a 59 fuel-element loading (see Figure 1.6).

Fuel Elements. The loading of the SL-1 Reactor consisted of 40 fuel elements (see Figure 1.7). These elements were plate type with nine plates per element and were 34 1/2 inches long by 3 7/8 inches square. Each fresh fuel element contained approximately 350 gm of U^{235}, with a total of 14 kg of U^{235} per 40 fuel-element core.

Burnable poison was provided by aluminum-nickel strips which contained known amounts of B^{10}. The strips were spot welded to the side plates of the fuel elements.

By some undetermined mechanism, there was a loss of boron from the core. Although an evaluation is planned to determine the mechanism of this loss, the tentative conclusion is that the loss was radiation sensitive. The differences between the measured control rod bank positions and those predicted by the "window shade" technique were used to infer that the approximate increase in reactivity of $\sim 2\% \Delta K/K$ could be attributed to the loss of boron in the core; however, calculations and inspection of core conditions are not adequate at this time to determine the % of boron lost from the core. In view of the uncertainties attached to the boron self-shielding and the "window shade" calculations, estimates of the loss by use of rod bank positions, predicted and observed, are not reliable.

Although the shutdown margin of the core reached a minimum of 2.1% $\Delta K/K$ at 710 MWD, remedial action was taken by the addition of six cadmium strips (4 13/16" x 29" x 60 mils clad with 20 to 40 mils of 2S Al) placed in T-rod slots. Three cadmium strips each were placed in the slots for rod #2 and rod #6. The total worth of the six cadmium strips was determined empirically to be $\sim 1\% \Delta K/K$, giving a total shutdown capability of $\sim 3\% \Delta K/K$. There was no feeling that the loss of boron precluded operation of the reactor at power levels up to 4.7 MW. (see CEND-1005, "Evaluation of the Loss of Boron in the SL-1 Core", and explanatory notes by Army Reactors, AEC Contract AT(10-1)-967, for full details)

Control Rods and Drive Mechanisms. The five control rods were constructed of cadmium cruciforms clad with an aluminum-nickel alloy. The cadmium was not bonded to the cladding.

The control rods were positioned vertically by a rack-and-pinion mechanism mounted external to the reactor vessel (see Figure 1.8).

The external drive motor was engaged with the pinion shaft by means of an electromagnetic clutch. Scram action by gravity was initiated by interrupting the current to the electromagnetic clutch. The scram was accomplished within 2 seconds for full rod travel of 30 inches. Scram action by gravity was backed up by a unidirectional cam clutch driving the rod down in the event of sticking or hanging up of the rod.

Pressure Vessel. The pressure vessel, fabricated of Type SA-212 Grade B Firebox steel, 3/4 inches thick, and clad with 3/16 inches of Type 304 stainless steel, was designed for 400 psig at a water and steam temperature of 450°F and a pressure vessel metal temperature of 500°F (see Figure 1.4).

The pressure vessel, 14 1/2 feet high and 4 1/2 feet O.D., was equipped with an ellipsoidal dished head at its lower end, while the upper end of the pressure vessel had a flange and was closed with a flat coverplate.

The 8-inch thick coverplate had nine 6-inch diameter flanged-nozzle openings for the control-rod drive mechanisms and two smaller openings for liquid-level sensing devices; one of the openings could be used for source handling.

Internal base pads at the lower end of the pressure vessel wall supported the inner thermal shield and core structure.

Shielding. The main bulk of the shielding was gravel. The gravel for the biological shield had a density of approximately 105 pounds/cubic foot. Although 12 feet of shielding had been estimated as sufficient to attenuate the radiation to AEC tolerance levels, 16 feet had been provided (see Figure 1.4).

Additional shielding was installed during the initial construction of the pressure vessel and the support cylinder and is described in detail in ANL-5744 (Hazard Summary Report on the Argonne Low Power Reactor /ALPR/).

The top biological shielding consisted of removable steel and masonite plates and concrete shield blocks. The blocks were shaped with offsets to minimize radiation streaming through the joints. The shield blocks covered an area which had a 6-foot radius from the reactor centerline. These shield blocks had to be removed from the reactor vessel head in order to allow personnel to work on the control rod mechanisms.

The pressure vessel coverplate was covered with a 3-inch layer of magnesia for thermal insulation. Above this layer and around the control rod nozzles was a mixture of shielding material, 13 inches thick, each cubic foot of which contained 100 pounds of steel punchings, 30 pounds of boric oxide, with the balance composed of local gravel. The dry mix was a satisfactory material for attenuating gamma rays.

Additional shielding directly above the control rod drives was provided by a stack of steel and masonite plates. This reduced the neutron and gamma doses to less than 100 MR/hr directly above the reactor when operated at full power.

II. OPERATING HISTORY

The SL-1 Reactor went critical on August 11, 1958. Full power operation was achieved in October 1958. Start-up and testing operations to include a 500 hour test, continued until February 5, 1959, under the direction of the Argonne National Laboratory.

On February 5, 1959, the reactor was turned over to Combustion Engineering, Incorporated, for operation as a test, demonstration, and training facility.

Until the time of shutdown prior to the incident, the SL-1 Reactor had been operated for a total of 931.5 MWD; approximately 40.5 per cent of the core life had been expended.

Immediately prior to reactor shutdown on December 23, 1960, the reactor was operated for core burn-up and for testing and final check-out of a Portable Low (PL) Power Reactor Loop condenser (a loop for testing components of the PL type reactor). The reactor was then shut-down and secured on December 23, 1960, for the Christmas period.

During the period of December 27 to 30, 1960, routine maintenance, instrumentation calibration, modification of the condensate pump with accompanying valving, piping, and controls, addition of a new type of valve to the auxiliary steam system, and minor modifications to the plant load condenser system were accomplished.

An operating crew of four opened the SL-1 buildings on the midnight-to-eight shift of January 3, 1961, and, under written instructions from the Plant Superintendent, proceeded to remove the shield blocks from around the reactor head. Next, the reactor pressure vessel was filled with water to within one foot of the top prior to removing the control rod drive assemblies and shield plugs. The reactor pressure vessel was then filled with water to within six inches of the bottom of the head in preparation for insertion of flux rods.

During the day of January 3, routine maintenance was performed and a total of 44 flux rods was inserted into the reactor between fuel plates inside of the fuel assemblies. Locations were chosen to obtain maximum information about flux conditions within the core. These flux rods were of tubular aluminum construction with short lengths of 0.5 per cent cobalt-aluminum alloy wire, 3/32 inches long by approximately 20 mils in diameter, placed inside. These segments were spaced within the rods with aluminum spacers. The purpose of these flux rods was to determine the neutron flux distribution of the reactor core, and the flux rods were of a type used in previous flux mapping experiments.

At 4:00 p.m., January 3, a three-man crew relieved the day-shift operating crew. Instructions for the night of January 3, issued by the Plant Superintendent in the night order book were as follows:

1. Perform a reactor water pump-down - Procedure No. 54.

2. Reassemble control rods, install plugs, place shield blocks in place, leave top shield off.

3. Connect rod drive motors.

4. Electrically and mechanically zero control rods.

5. Accomplish control room and plant startup check lists.

6. Perform cold rod drops.

7. At 300 psi pressure check for leaks, replace top shield plug.

8. Perform hot rod drop tests.

9. Accomplish a normal startup to 3 MW operation.

At the time of the incident the operating crew was performing step number 2 described above.

III. OPERATOR TRAINING PROGRAM

By the spring of 1958, military training personnel arrived at the NRTS to assist in the final assembly, core loading, and criticality and power tests of the SL-1 Reactor. Five military men had been assigned to NRTS since August 1956 and had been training at other reactor facilities. In addition to reactor operator duties, these personnel assisted in the preparation of standard operating procedures for the plant and helped formulate a program for the training of additional military personnel assigned to the SL-1 as Cadre.

The training program for military nuclear power plant operators began with an eight-month course of instruction at Fort Belvoir, Virginia. This program included four months of intensive academic study in the fields of mechanical engineering, electrical engineering, nuclear engineering, health physics, and various other subjects applicable to the nuclear power plant industry. The remaining four months were spent in maintenance specialty instruction in mechanical, electrical, electronics, or health physics fields. Not only is the individual required to be able to perform various types of routine maintenance in his specialty field, but he must be familiar with many types of pumps, motors, instruments, and other pieces of equipment that may be found in an allied U. S. military reactor system.

At the completion of the initial training program at Fort Belvoir, the trainees were assigned to either the SM-1 (Stationary Medium Power) Plant at Fort Belvoir or the SL-1 (Stationary Low Power) Plant at NRTS for training with an actual operating plant.

Using the SL-1 as an example, a typical operator training program would be outlined as follows:

> The initial three weeks were spent in detailed study of the SL-1 Plant and equipment. After the three weeks academic study was completed and the trainee had demonstrated a thorough knowledge of the plant, he was assigned to an operating crew. The supervisor of the crew was responsible for the practical instruction of the trainees in the operation and maintenance of the plant and its equipment as outlined by established operator training guides.

After approximately three months of working with the operating crew, the trainee was required to take a comprehensive written examination that dealt with every aspect of the SL-1 Plant. After demonstrating a satisfactory knowledge of the plant on the written examination, the trainee was required to take oral examinations conducted by two separate boards. The first board was composed of at least three members of the SL-1 Cadre. The second board was composed of personnel from Combustion Engineering, Inc., the operating contractor. This board conducted an operational type of examination. If the trainee passed all of these examinations, the individual was certified by Combustion Engineering, Inc., as a reactor operator and was assigned to a regular shift crew.

Training for shift supervisor consisted of a minimum of six months on-the-job training as a qualified operator on a regular crew. During this period the operator must have demonstrated his leadership ability and his knowledge of the various plant systems and their operating limits. After this minimum period, and upon recommendation by his shift supervisors and the Plant Superintendent, the operator was given a comprehensive written examination covering plant operations from a supervisory aspect. Successful completion of this written examination was followed by oral examinations given by the SL-1 Cadre and Combustion Engineering, Inc., Boards. These examinations were similar to, but more detailed and broader in scope, than the examinations given trainees. A thorough knowledge of all operating, health physics, and emergency procedures as well as leadership ability and mature judgment had to be demonstrated to both the Boards. Upon the successful completion of these examinations, the operator was certified by Combustion Engineering, Inc., as a shift supervisor and could then be placed in charge of a shift. Prior to Combustion Engineering ,Inc. assuming the duties of operating contractor, the Argonne National Laboratory qualified four (4) military personnel as Chief Operators (Shift Supervisor) and eight (8) additional military personnel as operators. These individuals were later re-examined by Combustion Engineering, Inc., and certified for the duties as previously stated.

IV. POST INCIDENT PHOTO ANALYSIS OF THE SL-1 REACTOR CORE

In order to determine, as accurately as possible, the safety aspect as related to the reactor core and the extent of damage that had taken place within the SL-1 reactor pressure vessel and, specifically, to the reactor core, several entries were made into the SL-1 Area to obtain photographs and motion pictures of the interior of the reactor pressure vessel.

As soon as the photographic evidence became available, photo interpretation studies were undertaken by the U. S. Naval Photographic Interpretation Center, Washington, D. C., and by personnel from and associated with Combustion Engineering, Inc.

From the motion pictures taken on February 22, and the photographs and films obtained from the television entries made on March 16 and 17 (see Appendix C), the U. S. Naval Photographic Interpretation Center reported the following preliminary damage evaluation to the SL-1 reactor core and pressure vessel:

Position No. 1 (Figure 1.5)	The shrouds have been folded flat and crushed against the thermal shield. The control rod appears to be in a completely down position (see Figure 1.6). The upper spray ring obscures a portion of the No. 1 area.
Position No. 2	The area is partially obscured by Control Rod #9. Several fuel elements are identifiable.
Position No. 3	The shrouds have been bent, twisted, and moved toward the thermal shield. The control rod is in a down position and has moved about eight inches toward the downcomer. A gaping hole remains at the former position of the control rod and the shroud. A probable cross-stanchion lies across the No. 3 area tilted at 45° angle from the vessel wall, downward toward the No. 9 position.
Position No. 4	The shroud, part of which is visible, has been smashed against the pipes at the vessel wall. The upper end of the $1\frac{1}{4}$ inch filler pipe to the lower spray ring has been ripped loose and twisted toward No. 3. Most of the area lies in the shadow of Control Rod No. 9.
Position No. 5	The rod extension appears to be in a full down position. Part of Control Rod No. 9 is crushed against it and obscures the shroud. It has been moved toward the downcomer, but how much is not determinable.
Position No. 6	Part of the shroud is visible. Most of the area is hidden by Control Rod No. 9, No. 7 rod extension, and the upper and lower spray rings.
Position No. 7	The control rod is in the down position. The rod and shroud have been twisted and displaced toward the vessel wall about six to eight inches. The rod extension and the rack have bent or broken at the union joint. A probable fuel box top lies between the shroud and the vessel wall (see Figure 1.7).

Position No. 8

The shroud has been twisted and warped at the level of the fuel elements and has been pushed against the thermal shield. Debris is wedged between the shroud and the pressure vessel wall, including a fuel box top. The hold-downs at No. 8 have been badly twisted. Six of the eight fuel boxes and spares have been identified. An unidentified item between Nos. 1 and 8 may be a spare box.

Position No. 9

The area No. 9 has been blocked from view by the No. 9 control rod blades, which appear to be lying almost horizontally from shrouds 1 and 2 to 6 and 7. The outer covering of the control rod blades have been torn, twisted, and peeled from the center plate in sections of the rod. A section of shroud, possibly from No. 9, lies near No. 3, and another possible section of shroud lies in the No. 1 area.

Other Comments:

Little or no downcomer regions remain according to the photographs obtained. A badly twisted possible cross stanchion appears to be lying across fuel element boxes between the No. 8 and 9 positions.

The lower spray ring has been ripped from the vessel wall and from No. 6 toward Nos. 7 and 8. The spray ring has been twisted upward around the vessel wall. At a point above No. 8, it is approximately six feet above the core surface and there are two fuel box top sections resting on it.

The upper spray ring has been torn loose at several points and has pulled away from the wall between No. 1 and No. 7, such that it passes above the core between No. 8 and No. 9.

A total of nineteen fuel element boxes in the core have been identified. Two others are possible.

These are in addition to the four top sections already identified.

As a result of the television entries which were made on March 16 and 17, Combustion Engineering, Inc., reported the following photo interpretation results:

Core Condition

Control rods No. 1, 3, 5, and 7, appear to be fully or partially inserted in the core region. Control rod No. 9 is fully out of the core region and is resting on top of the core structure.

Approximately one-half of the fuel elements can be identified and these elements appear to be severely twisted, collapsed, and have moved from their original positions toward the vessel walls.

The core has been expanded such that the nine inch wide downcomer region is essentially filled. No major holes can be observed in the core regions. However, No. 9 rod and shroud obscure the center of the core from view.

All control rod shrouds appear to be partly collapsed, twisted away from the center of the core, and are dislocated toward the vessel walls. Rod No. 9 shroud has been partially blown out of the core and is engaged with the lower part of rod blade No. 9.

The lower spray ring has been blown to a position several feet above the core structure. The ring is bent out of round, twisted, and partially collapsed. The upper spray ring has been bent out of round and has dropped below its original elevation in the pressure vessel.

No damage to either the pressure vessel wall or the thermal shield is apparent.

No water level reflections or other evidence of water were observed during the entries.

In conclusion, it would appear that a general disarrangement of the reactor core had taken place and that a detailed analysis of the present core structure would have to be performed before information as to the amount of displacement and condition of the lower portion of the core could be obtained.

TABLE 1.1

CHARACTERISTICS OF SL-1

Location:	National Reactor Testing Station, Idaho
Designer:	Argonne National Laboratory
Owner:	U. S. Atomic Energy Commission
Start of Operations:	October 24, 1958
Output--thermal:	3,000 kw
--electrical:	300 kw
--heat:	400 kw

Component Design Data

(Pressure vessel)

Inside height:	14½ ft
Inside diameter:	4.34 ft
Wall thickness:	0.75 in.
Composition:	carbon steel (SA-212)
Cladding	
--material:	stainless steel (304)
--thickness:	0.188 in.
Design pressure:	400 psig
Test pressure:	600 psig

(Core)

Configuration:	right cylinder
Size:	31.5 in. dia x 25.8 in.
Fuel load:	14.0 kg U^{235}
Burnable poison:	23 gm B^{10}
Composition	
--H_2O:	33 vol%
--Al-Ni-U:	8 vol%
--Al-Ni:	59 vol%

(Control rods)

Configuration:	cruciform
Number	
--shim:	4
--regulating:	1

TABLE 1.1

(Control rods--Continued)

Composition	
--poison:	Cd
--cladding:	Al-Ni
Total rod worth:	17% $\Delta k/k$
Weight:	49 lb
Withdrawal rate	
--shim:	2.85 in./min
--regulating:	1.85 in./min
Scram time:	$<$2 sec

(Control-rod drives)

Type:	rack and pinion
Number:	5
Power requirement:	220v, 3 Ø
Motor rating:	0.48 rpm, 1/8 hp
Position-indicator accuracy:	$\pm$ 0.05 in.

(Fuel elements)

Type:	plate
Number:	40
Enrichment:	91%
Plates per element:	9
Meat dimensions:	0.05 x 3.5 x 25.8 in.
Meat composition	
--Al:	80.5 wt%
--Ni:	2 wt%
--U:	17.5 wt%
Cladding:	Al-Ni
Plate temp.--avg:	440° F
--max:	450° F

Nuclear Design Data

(Moderator)

Type:	light water
Average neutron energy:	~0.053 ev
Thermal-neutron flux-avg:	7.5 x 10^{12}n/cm^2/sec
--max:	~2 x 10^{13}n/cm^2/sec

TABLE 1.1

(Moderator--Continued)	
Prompt-neutron lifetime:	4-8 x 10^{-5} sec
Eff. delayed-neutron fraction:	0.0065
Over-all temp. coefficient:	~1.5%/°F
(Control requirement)	
Burnup:	~3% Δ k/k
Peak xenon:	0.6% Δ k/k
Equilibrium xenon and samarium:	2.6% Δ k/k
Temp. coefficient:	1.5-2% Δ k/k
Voids:	1.3-2% Δ k/k
Total:	9-10% Δk/k

Heat Transfer Data

(Coolant)	
Type:	light water
Volume--total:	3,800 liters
--in core:	215 liters
Inlet flow:	18 gpm
Inlet temperature:	175° F
Operating pressure:	300 psig
Outlet steam temp:	420° F
Outlet steam flow:	9,020 lb/hr
Recirculation rate:	130 lb/lb of steam
(Heat flux)	
Max/avg ratio	
--axial:	1.3
--radial:	1.6
Core--average:	~22,500 Btu/hr/ft^2
--maximum:	~65,000 Btu/hr/ft^2

NATIONAL REACTOR TESTING STATION

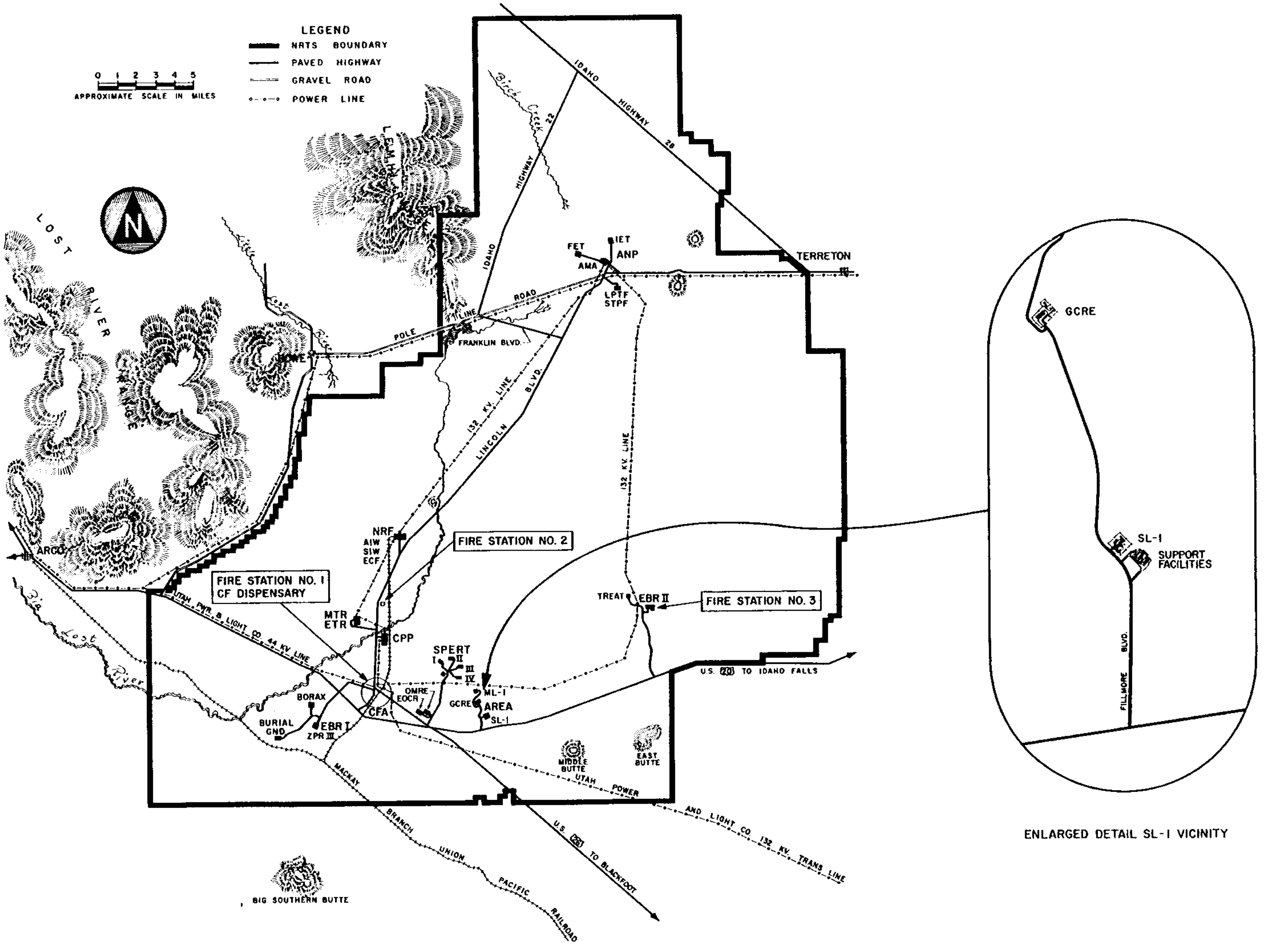


FIGURE 1.1

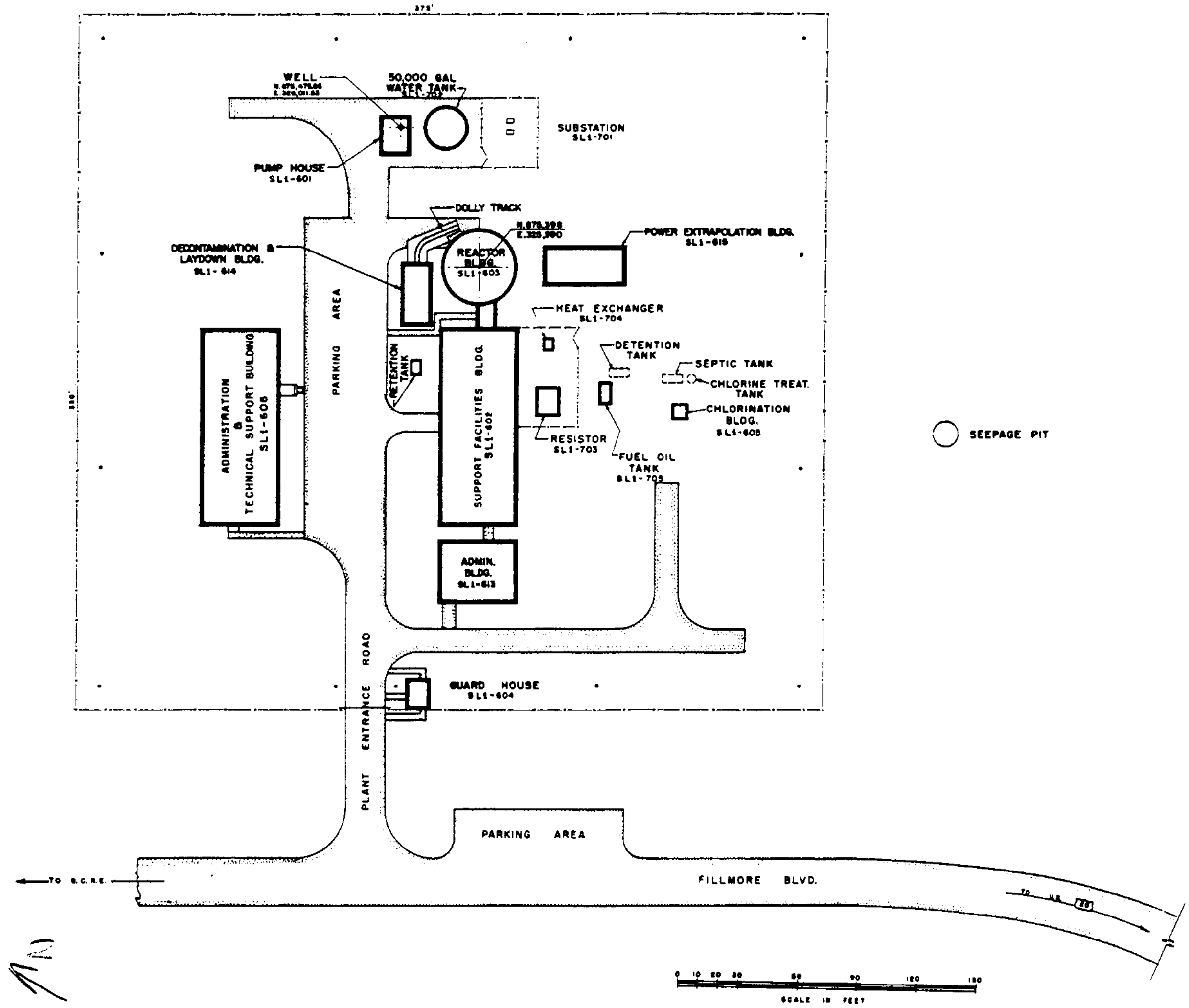


FIGURE 1.2
PLOT PLAN
OF
SL-1 AREA
NATIONAL REACTOR TESTING STATION

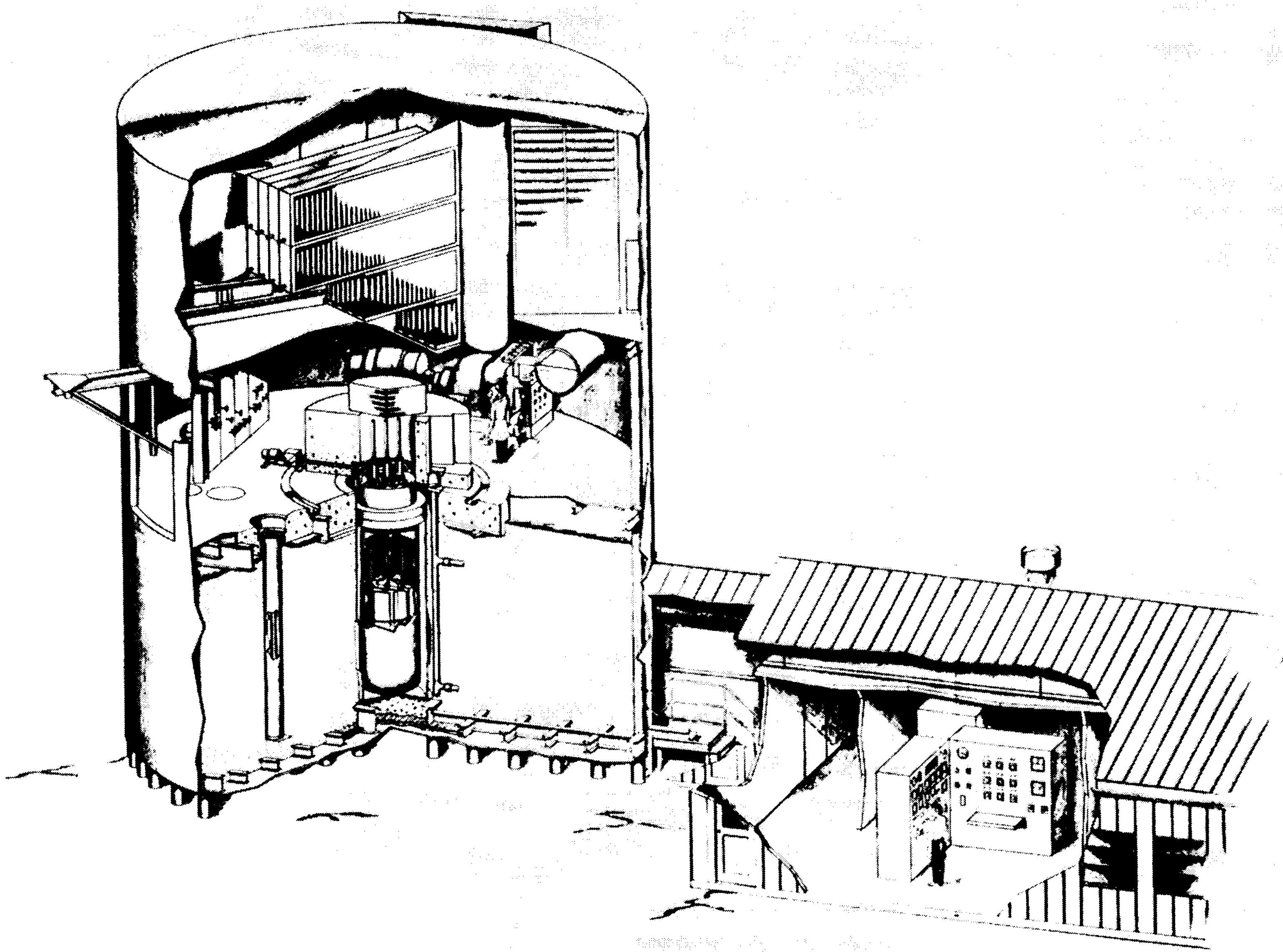


FIGURE 1.3
REACTOR BUILDING

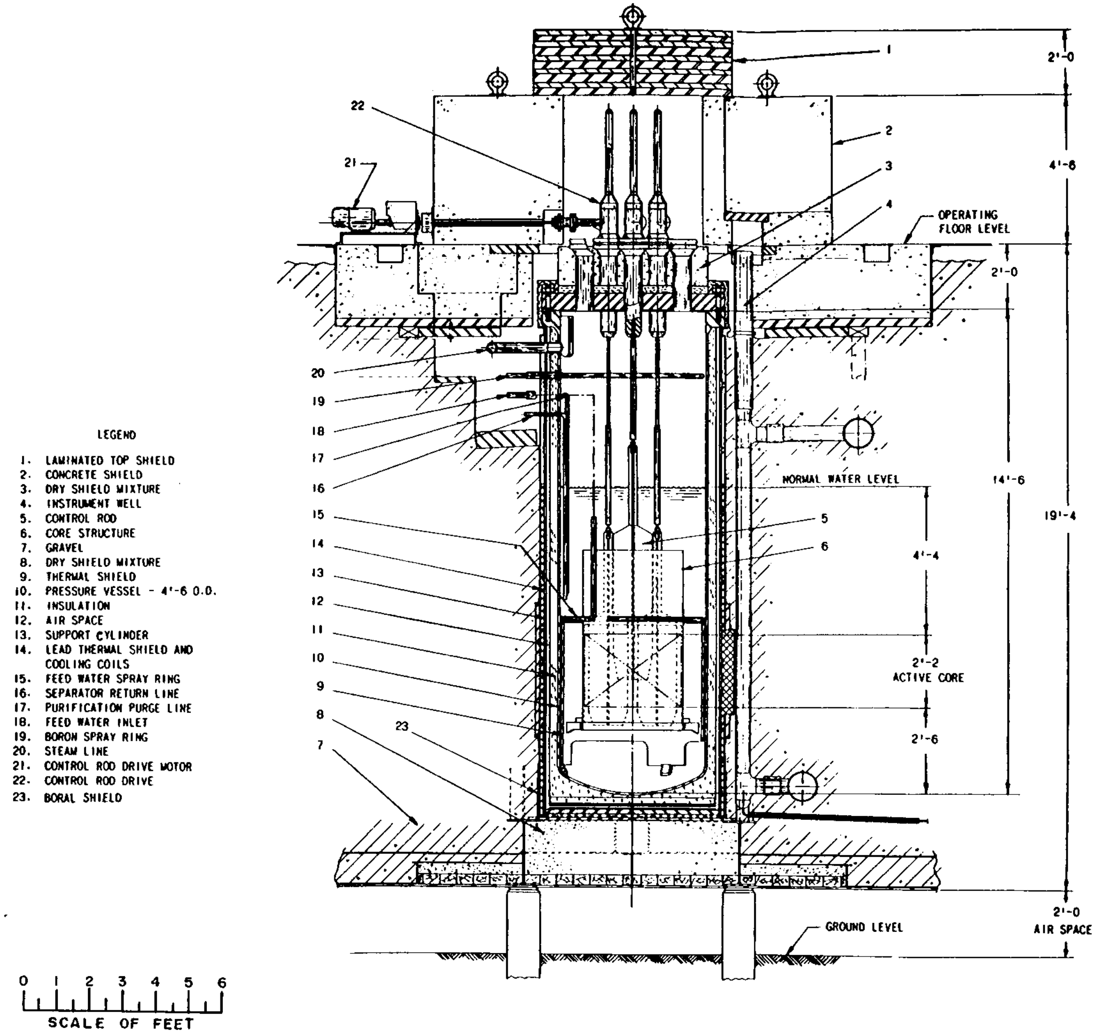


FIGURE 1.4

REACTOR INSTALLATION VERTICAL SECTION

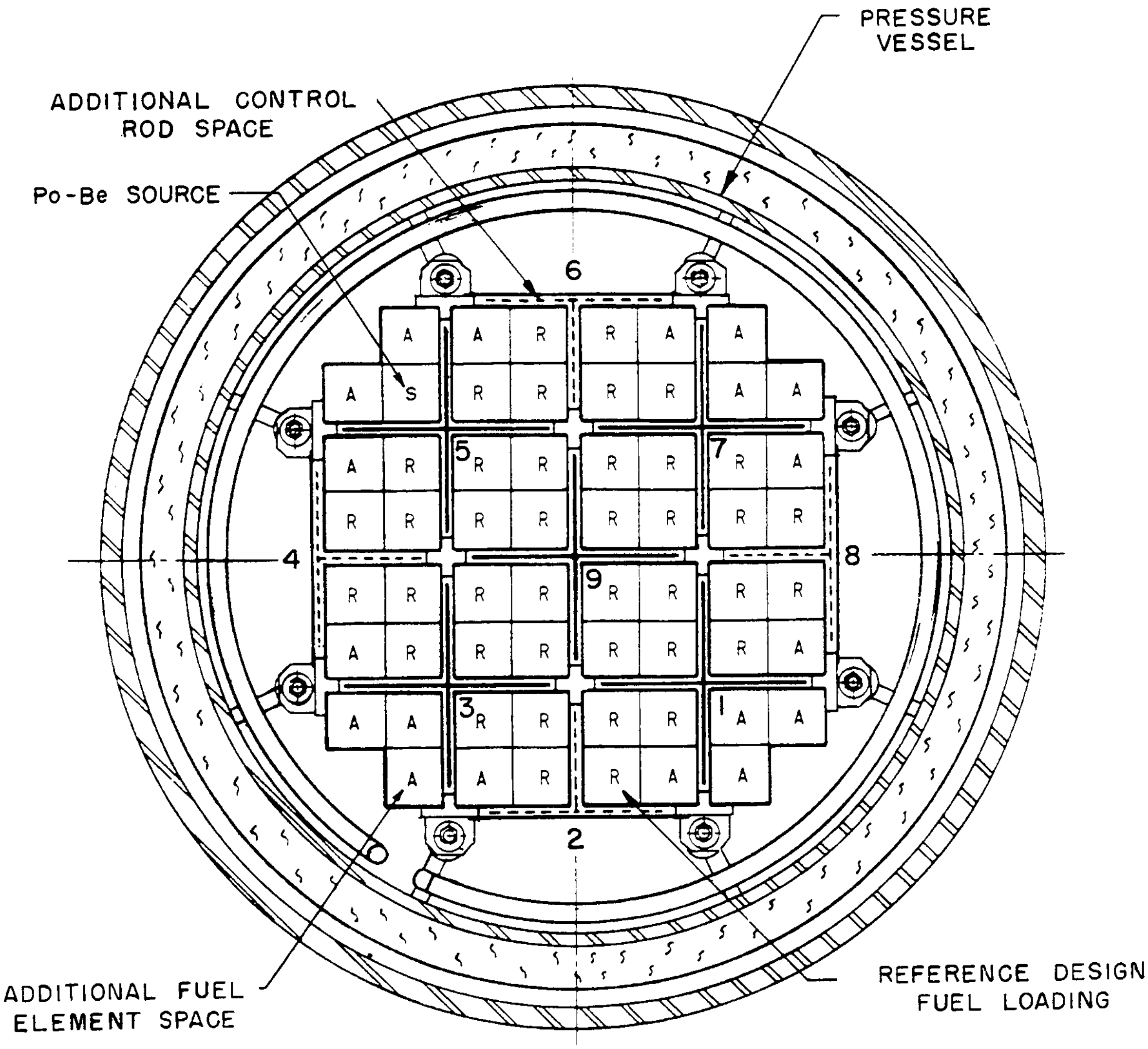


FIGURE 1.5
LOCATION OF POSITIONS
AND
CORE LOADING PATTERN

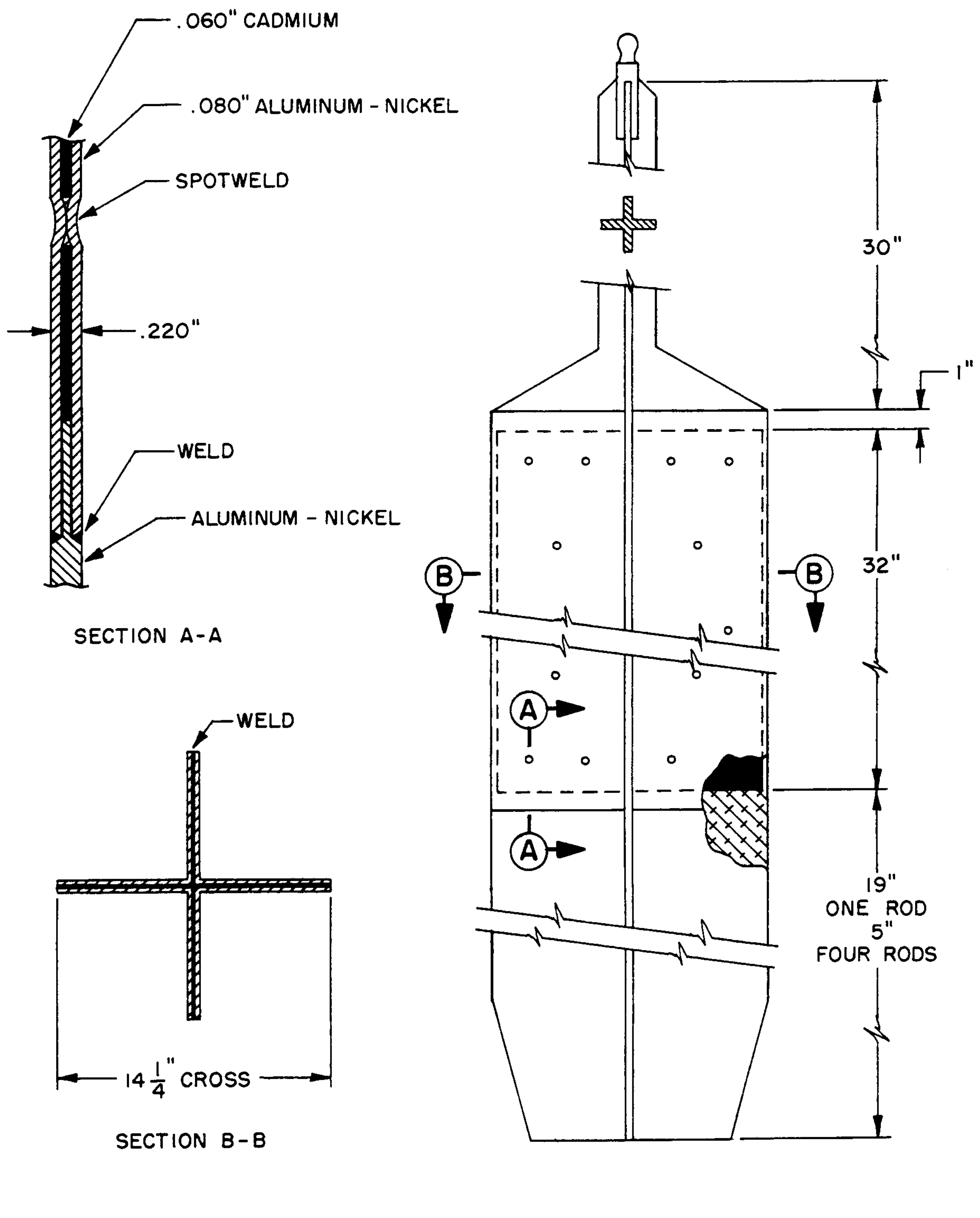


FIGURE 1.6

CROSS TYPE CONTROL ROD

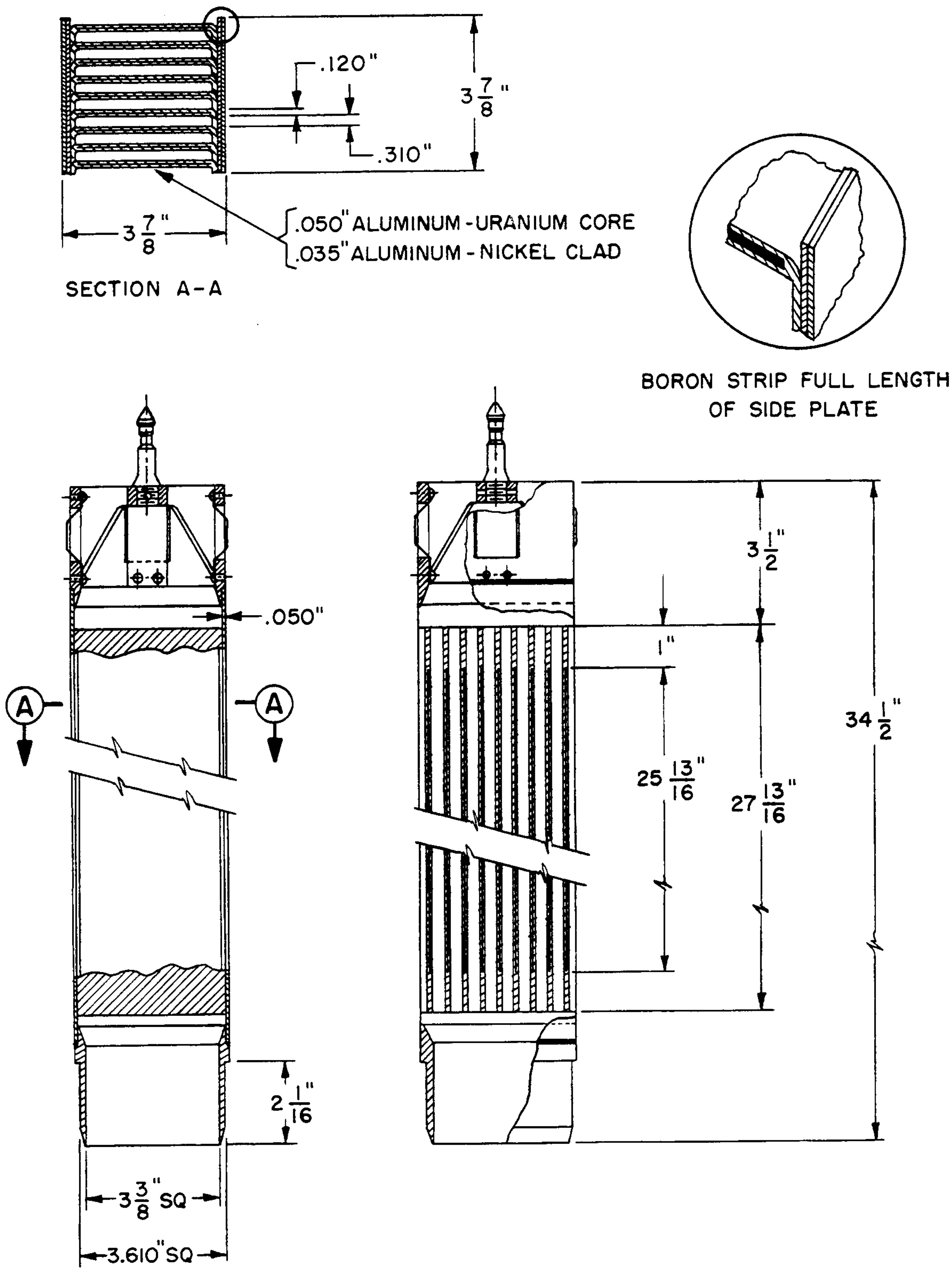


FIGURE 1.7

FUEL ELEMENT

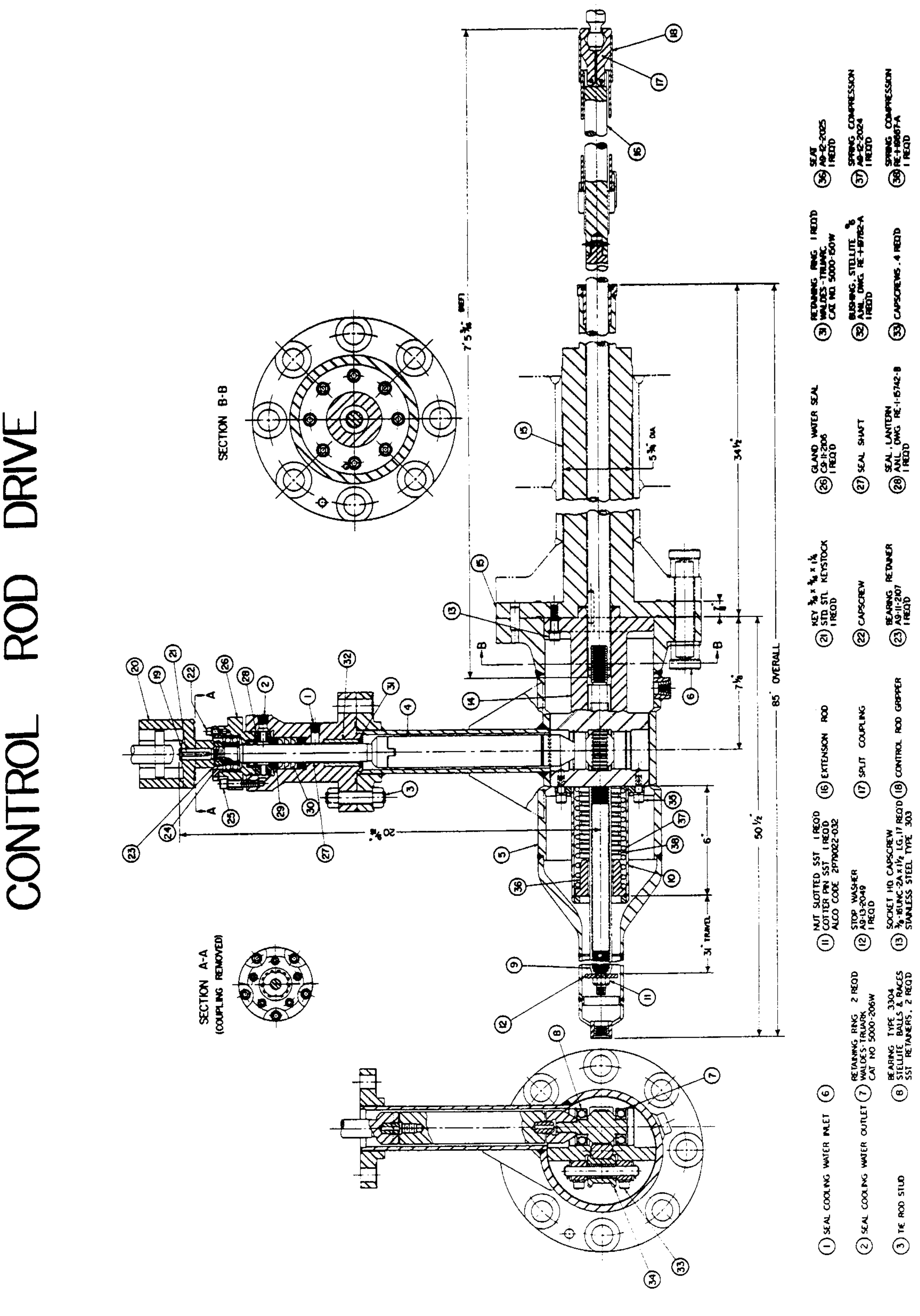

CONTROL ROD DRIVE
SECTION A-A
(COUPLING REMOVED)
SECTION B-B
31" TRAVEL
6"
50 1/2"
85" OVERALL
7 1/8"
34 1/2"
5 3/4" DIA
7'5 3/16" (REF)
1 SEAL COOLING WATER INLET
2 SEAL COOLING WATER OUTLET
3 TIE ROD STUD
4 PINION SHAFT EXTENSION
5 THIMBLE
6
7 RETAINING RING 2 REQ'D WALDES-TRUARK CAT NO 5000-206W
8 BEARING TYPE 3304 STELLITE BALLS & RACES SST RETAINERS, 2 REQ'D
9 RACK ANL DRG RE-1-19533-C 1 REQ'D
10 SPRING HOUSING B9-12-2029 1 REQ'D
11 NUT SLOTTED SST 1 REQ'D COTTER PIN SST 1 REQ'D ALCO CODE 2P79022-032
12 STOP WASHER A9-13-2049 1 REQ'D
13 SOCKET HD. CAPSCREW 3/8-16UNC-2A x 1 1/2 LG, 17 REQ'D STAINLESS STEEL TYPE 303
14 SUPPORT D9-12-2023 1 REQ'D
15 HOUSING
16 EXTENSION ROD
17 SPLIT COUPLING
18 CONTROL ROD GRIPPER
19 SNAP RING, WALDES TRUARC 5100-62-5 1 REQ'D
20 COUPLING, DRIVEN ANL DWG RE-1-21092-B 1 REQ'D
21 KEY 3/16 x 3/16 x 1 1/4 STD. STL KEYSTOCK 1 REQ'D
22 CAPSCREW
23 BEARING RETAINER A9-11-2107 1 REQ'D
24 LOCKNUT BEARING A9-11-2108 LOCKWASHER A9-11-2027 1 (EACH) REQ'D
25 SOCKET HEAD CAPSCREW
26 GLAND WATER SEAL C9-11-2106 1 REQ'D
27 SEAL SHAFT
28 SEAL, LANTERN ANL DWG RE-1-15742-B 1 REQ'D
29 SEAL DIAPHRAGM ANL DWG RE-1-15743-C 4 REQ'D
30 SEAL, FLOATING RING ANL DWG RE-1-15744-C 5 REQ'D
31 RETAINING RING 1 REQ'D WALDES-TRUARC CAT NO 5000-150W
32 BUSHING, STELLITE ANL DWG RE-1-19782-A 1 REQ'D
33 CAPSCREWS, 4 REQ'D
34 ROLLER A9-12-2040 1 REQ'D
35 SOCKET HD CAP SCR 3/8-16 UNC-2A x 1 LG SST 303-6 REQ'D
36 SEAT A9-12-2025 1 REQ'D
37 SPRING COMPRESSION A9-12-2024 1 REQ'D
38 SPRING COMPRESSION RE-1-19867-A 1 REQ'D

FIGURE 1.8

SECTION 2

SEQUENCE OF EVENTS RELATED TO THE SL-1 INCIDENT AT THE NRTS JANUARY 3 THROUGH 15, 1961

Log Status

On January 3, 1961, between 5:30 and 9:00 p.m. the following final entry was written into the Operations Log Book at the SL-1 facility: "Pumped reactor water tank until reactor water level recorder came on scale. Indicates + 5 ft. Replacing plugs, thimbles, etc., to all rods."

Weather Conditions

The estimated weather conditions at the SL-1 Area at 9:00 p.m. were: temperature at 5 ft., + 1.4 $\pm$ 2^{o}F.; at 250 ft., + 13.8 $\pm$ 2^{o}F. Winds at the surface, 2 miles per hour from 000^{o}; above 100 ft., 6 miles per hour from 045^{o}; inversion conditions extended to 3500 ft.

Chronology of Events

At 9:01 p.m. an automatic heat detection alarm located in the SL-1 Reactor Building started transmitting a continuous signal to: (1) Fire Station No. 1 located in the Central Facilities Area (CFA), (2) Fire Station No. 2 located on Lincoln Blvd. between the Materials Testing Reactor (MTR) and the Naval Reactor Facility (NRF), and (3) the Communications Building located at CFA (see Figure 1.1).

At approximately 9:01 p.m. the Idaho Operations Office Patrolman on duty at the Gas-Cooled Reactor Experiment (GCRE) Gate House, situated about 0.9 miles northwest of the SL-1, notified an Aerojet-General Nucleonics official stationed in the GCRE control room that, (1) the personnel monitor at the gate house had alarmed with all meter needles on full scale, and (2) the instrument could not be reset. A check of radiation monitors in the control room of the GCRE indicated no release of radiation, and a radiation survey made of the GCRE Gate House showed only background radiation levels.

As a result of the fire alarm from the SL-1, a six-man crew boarded Fire Engine No. 3 stationed at Fire Station No. 1 and departed for the SL-1 Area. In addition, the Assistant Fire Chief departed by automobile for the SL-1 Area. In accordance with standard operating procedures, the Fire Department Alarm Operator on duty notified the IDO Chief, Hazards Control Branch, and the IDO Chief, Fire Department, of the alarm.

At 9:02 p.m. the Alarm Operator informed the IDO Dispatcher by intercom that a fire engine had been dispatched to the SL-1 Area. The Dispatcher subsequently broadcasted the alarm over the National Reactor Testing Station (NRTS) radio network. He then informed an official of the IDO-Security Division of the alarm and, next, requested the Phillips Petroleum Company (Phillips) Security Duty Officer located at the MTR to bring a Health Physicist (H.P.) to the SL-1 Area.

Immediately upon notification of the alarm, an IDO Security Captain, Lieutenant, and Patrolman departed for the SL-1 from CFA. In response to the request for an H.P., the Phillips' Duty Officer located an MTR H.P. and departed with him for the SL-1 at 9:04 p.m. Enroute to the SL-1 Area, the Duty Officer and MTR H.P. received Scott Air-Paks from a Phillips' Security Guard who had been dispatched at the request of the MTR H.P. Office.

At approximately 9:10 p.m. the Assistant Fire Chief followed by Fire Engine No. 3 arrived at the SL-1 Area, approximately eight miles from CFA. All of the Firemen wore regular fire protection clothing. Upon arrival at the SL-1 Area, the Assistant Fire Chief noted that the steam he observed above the reactor building appeared normal. The Fire Captain of Engine No. 3 entered the SL-1 guard house and telephoned the SL-1 control room, but received no answer. During this time, the Fire Captain heard an alarm buzzing; whether this was a radiation or fire alarm could not be determined by the sound. Also, at about 9:10 p.m. the IDO Security Lieutenant and Patrolman arrived at the SL-1 Area and parked their vehicle about fifteen feet from the vehicle gate. The Patrolman then unlocked and opened the vehicle gate.

At 9:12 p.m. Fire Engine No. 3 entered the SL-1 Area and parked at the southeast side of Building 613 (see Figure 1.2). The Assistant Fire Chief, wearing a fifteen minute Scott Air-Pak, made his way to the southeast door of the corridor which connects Building 613 with Building 602. Upon finding the door locked, he kicked and pounded upon it but got no response. Next, the Assistant Fire Chief went to the southwest entrance to Building 613 where he was joined by the Captain of Fire Engine No. 3 and the Security Force Captain and Lieutenant, who unlocked the electrical control door to Building 613. In the meantime, a Fire Inspector went to the northeast side of Building 613 where he entered and checked the boiler room.

The four people already at the southwest entrance were soon joined by a Fire Inspector and Fireman. This group then entered Building 613. The Fire Inspector went through Building 613, blocked open the corridor door and returned to the southwest entrance. A check of two Jordan Radiation Detectors made at the southwest entrance indicated a 1.5 R/hr radiation level.

Because of this high radiation level, the Assistant Fire Chief ordered the fire crew to take Fire Engine No. 3 out of the SL-1 Area to Fillmore Blvd. and to await the arrival of health physics assistance. In addition, the security men returned to the guard house area. The Assistant Fire Chief saw no personnel, smoke, nor fire from his position at the main entrance. No Fire Department personnel had gone beyond Building 613, and it was estimated that about two to two and one-half minutes had elapsed from the initial entry.

At 9:15 p.m. the Assistant Fire Chief obtained a Jordan Radiation Detector and proceeded through Buildings 613 and 602 as far as the doorway to the covered stairway which leads up to the reactor operating room. He quickly made his way back through Buildings 602 and 613 to Fillmore Blvd. The Assistant Fire Chief observed during this entry that, (1) no personnel, fire or smoke could be seen on the main floor, (2) the control room contained jackets and outer coats for three men, as well as lunch pails and coffee cups, (3) the lights on the control panel were out, (4) it appeared dark beyond the control room, (5) fogging of the face mask made it extremely difficult to see, and (6) radiation levels from 200-250 MR/hr were encountered at the entrance to the stairway.

About the time the Assistant Fire Chief started the penetration, the Security Lieutenant observed a reading of 100 MR/hr near an automobile located by the guard house; therefore, all personnel in the SL-1 Area donned Scott Air-Paks.

All of the above personnel were outside the SL-1 Area and on Fillmore Blvd. by or before 9:17 p.m.

First Entry to SL-1 Area with Health Physicist

The Phillips MTR H.P. arrived at the SL-1 Area at 9:17 p.m. He immediately surveyed the area in front of the SL-1 guard house and observed radiation rates from 125 to 150 MR/hr. Since the wind was coming out of the north-northeast at about six miles per hour, the H.P. instructed the firemen to position themselves and their equipment upwind.

Then the MTR H.P. and the Fire Captain, wearing Scott Air-Paks, made their way from the vehicle gate to the main door on the southwest side of Building 613. Because this door was found locked, they proceeded to the door on the southeast side of the corridor between Buildings 613 and 602 in order to gain entrance. During this penetration, the MTR H.P. measured a radiation level of 700 MR/hr near the southwest corner of Building 613, 250 MR/hr at the southwest entrance, and 500 MR/hr near the corridor door.

As these two people made their way through Building 602 towards the reactor building, they took a quick look into almost every room trying to locate the three military personnel believed to be in the area, but found no one. When the two men came to the covered stairway leading to the reactor operating room, the Fire Captain remained at the base of the stairway as the MTR H.P. proceeded up the stairs. At about the third or fourth step the Juno Radiation Detector which the MTR H.P. was carrying pegged at 25 R/hr. The Fire Captain and the MTR H.P., therefore, evacuated from the area stopping at the guard house. The total estimated time for this entry was one and one-half to two minutes. Again, as during the previous entry, no personnel, fire or smoke were seen. Outside the buildings, the MTR H.P. noted steam coming from the top of the reactor building. It should be noted that the fogging and the frosting of the masks' eyepieces partially impeded viewing during the operation.

At 9:22 p.m. the IDO Dispatcher reported that the IDO Chief, Site Survey Branch, had been notified of the emergency situation. The IDO

Dispatcher also had attempted to contact the IDO Director, Health and Safety Division, but he had been unsuccessful. At about 9:25 p.m. the IDO Dispatcher had contacted the H.P. from Combustion Engineering, Inc. (CEI).

By this time, IDO Security had radiochecked other NRTS installations and confirmed that the three SL-1 people who were supposed to be on duty in the area had not gone to any other site. It was then presumed that these men must be in the reactor building.

At 9:25 p.m. a fire crew drove Fire Truck No. 1 from Fire Station No. 1, CFA, to the junction of Fillmore Blvd. and Highway 20 to stand-by with Scott Air-Paks. In addition, a Security Patrolman had been dispatched to the junction to set up a roadblock. Between 9:25 and 9:30 p.m. the MTR H.P. at the SL-1 requested IDO Security to radio NRTS facilities for additional health physics support, radiation detectors and more protective equipment. In response to this request, available H.P.s from several sites departed, as soon as possible, for the SL-1 with anti-c-clothing, shoe covers, Scott Air-Paks, reserve air bottles, Comfo-respirators and various types of radiation detectors.

Second Entry With Health Physicist

After the request for assistance had been conveyed, the MTR H.P. and a Fireman entered Buildings 613 and 602 searching every room for the three persons believed to be on the night shift. Again, they found no one in either of the buildings. In the reactor control room, the MTR H.P. observed (1) a radiation level of 10 R/hr, and (2) that a majority of the control panel switches were in the off position with the dials reading zero or approximately zero. The Fireman noted that the atmosphere in the buildings appeared steamy, but this appearance may have been caused by the fogging of the Scott Air-Pak's eyepieces. Before leaving the area, the two men blocked open the door on the northwest side of Building 602 and, also, the doors to the boiler and diesel rooms. Approximately five minutes were consumed in the second entry with an H.P.

At about 9:30 p.m. a Phillips H.P. located at the Chemical Processing Plant (CPP) was notified of the emergency conditions existing at the SL-1 Area. The H.P. immediately checked the Constant Air Monitors in the CPP and found no evidence of air contamination.

At this same time, Fire Engine No. 2 stationed at Fire Station No. 3, located near the Experimental Breeder Reactor-II (EBR-II) facility, departed for the junction at Fillmore Blvd. and Highway 20 for stand-by duty with Scott Air-Paks.

By about 9:36 p.m. the IDO Dispatcher had been able to relay the information to key AEC-IDO personnel that an accident had taken place at the SL-1. Shortly thereafter, officials of Phillips Petroleum Company and Combustion Engineering, Inc., had been contacted about the incident.

At 9:48 p.m. the SL-1 Plant Superintendent called and informed the IDO Dispatcher of the names of the three military men who were scheduled to be on night duty at the SL-1 facility.

Third Entry with Health Physicist

At approximately 9:50 p.m. a third entry was made by another Phillips H.P. accompanied by the Assistant Fire Chief and Fire Captain. These men went through Buildings 613 and 602 and up the steps to the first landing of the covered stairway leading to the operating room of the reactor building. At this location the H.P. observed a reading of 200 R/hr and immediately had the group evacuate the area. The estimated time spent on the entry was two to three minutes.

While this third entry was in process, the IDO Chief, Site Survey Branch, who was enroute to the SL-1 Area from Idaho Falls, established radio contact with IDO Security located at the scene of the incident and requested a roadblock be set up at the junction of Fillmore Blvd. and Highway 20.

At about 10:00 p.m. the MTR H.P. at the SL-1 was authorized to allow personnel to enter radiation fields greater than 200 R/hr by the enroute IDO Chief, Site Survey Branch; it was stipulated that Scott Air-Paks should be worn by all people involved in penetration operations.

In view of this authorization, plans were made for another entry into the SL-1 Area. It was decided by the health physics staff at the scene that the planned entry should be halted when a radiation rate of 500 R/hr was observed, because this was the maximum dose rate which could be read on the high range Jordan Radiation Detector.

Therefore, at 10:10 p.m. a Phillips H.P. accompanied by the Assistant Fire Chief and a Fire Inspector entered Building 613 by the southwest entrance. They proceeded through Building 613 and 602 and then climbed the covered stairway leading to the reactor operating room. At the top of the stairway, the door to the reactor operating room was found open. The Phillips H.P. held a high range Jordan Detector in the doorway and observed that the radiation detector pegged on the 500 R/hr scale. Next, with the Assistant Fire Chief holding a light in the doorway, in order to better illuminate the reactor room, the Phillips H.P. took a brief look into the room. Because either the light was dim or the mask's eyepieces were fogged, the Phillips H.P. did not see very much of the reactor room and none of the ceiling. He was able to observe some wreckage in the reactor room, but saw no personnel. They then hastened down the stairs and out the building via a door on the southeast side of the corridor leading from Building 602 to the reactor building. Before returning to the guard house area, the three men went to Building 615, which is located just a few yards from the reactor building. They checked there for the three personnel believed to be in the SL-1 Area and, finding no one, proceeded north around the reactor building, returning to Fillmore Blvd. Approximately one minute was spent in Building 602, twenty seconds in the reactor room, ten seconds in Building 615, 30 seconds circling the reactor building, and a total time of about three minutes in the SL-1 Area.

At 10:13 p.m. the MTR H.P. radioed information as to the latest entry to the IDO Chief, Site Survey Branch, who was estimated to be less than fifteen minutes away. The H.P. was informed not to make any additional entries until further notice.

At approximately 10:25 p.m. four CEI supervisory personnel arrived at the Control Point and received permission from the MTR H.P. to proceed north of the SL-1 gate to where the fire trucks were positioned. (Permission to proceed to the SL-1 gate was interrupted by the Class I Disaster broadcast.)

The AEC-IDO Director, Health and Safety Division, after he had been informed of the latest events at the SL-1 Area, declared that a Class I Disaster existed at the SL-1 facility. This announcement was broadcast over the NRTS radio network to all stations at 10:25 p.m.

Upon the arrival at the SL-1 Area of the IDO Chief, Site Survey Branch, at approximately 10:35 p.m., the direction of operational activities transferred from the first Phillips MTR H.P. on the scene to AEC-IDO. In a matter of minutes the following activities were initiated: (1) the Control Point was established as the center of operations, (2) people who had been in the SL-1 Area were checked for contamination at the Control Point by an IDO H.P., (3) radiation surveys were made in the vicinity of the SL-1 vehicle gate and guard house, (4) an air sampler was installed in the south window of the SL-1 guard house, and (5) the fire engine was ordered moved to a point 200 feet west of the SL-1 on Fillmore Blvd.

At 10:45 p.m. two CEI personnel (Operations Supervisor and Health Physicist) wearing Scott Air-Paks proceeded to the reactor building. At about the first landing on the covered stairway leading up to the reactor operating room, the CEI H.P. heard some sounds. At the top of the stairs a dose rate of 500 R/hr was observed, and it was estimated that a radiation field of 500-700 R/hr existed about two feet inside the operating room. A quick observation made of the reactor room indicated one person positioned on the floor near the Motor Control Center (MCC) and moving, and another person positioned between a shield block and the reactor head. Radiation fields of 500 to 600 R/hr were estimated to be near the MCC and greater than 1000 R/hr directly over the core. The two CEI personnel then departed from the reactor room to obtain assistance and equipment for a rescue. The entire entry and return operation took approximately three minutes.

As a result of the information obtained from this penetration, an ambulance was dispatched to the SL-1 Area. In addition, a nurse from the CFA Dispensary departed for the SL-1 Area in another vehicle.

Recovery of the First Casualty

At 10:50 p.m. the IDO SL-1 Site Coordinator along with four CEI personnel returned to the reactor building to execute a rescue operation. During the removal of the first casualty from the reactor room, it was determined that the second casualty was dead and, although the third person was supposedly in the reactor building, he was not located. Approximately eight minutes after the start of the rescue operation, the stretcher containing the first casualty was placed on the ground near the SL-1 vehicle gate.

At 11:00 p.m. the first casualty was placed into a courier vehicle which was then dispatched to meet the ambulance. Also, about this same time, a four-man team composed of IDO, Military, and Phillips personnel donned Scott Air-Paks and made their way to the reactor operating room. The third person was located by the team and determined beyond any reasonable doubt to be dead. Total entry time took about two minutes.

A contamination check was made of all personnel involved in the rescue operation and it revealed that many persons were contaminated in excess of 5 R/hr on their extremities. The IDO SL-1 Site Coordinator directed that these contaminated people be taken to the GCRE for initial decontamination.

After the first casualty had been transferred from the courier vehicle and placed into an ambulance, the ambulance proceeded to the Control Point where an IDO Physician examined the body and pronounced the victim dead at 11:14 p.m. Later, the ambulance was moved to a stand-by position near the SL-1 gate.

In order to assist in the decontamination of personnel, a decontamination trailer was transported from CFA and installed at the Control Point. By 11:48 p.m. the Control Point at the junction of Fillmore Blvd. and Highway 20 and the access points to the SL-1 were being operated by IDO personnel.

On January 4, at 12:03 a.m. the IDO Manager notified the Director, Division of Reactor Development, AEC Headquarters, Washington, D. C., that an incident had taken place at the SL-1 facility.

To determine whether there had been any spread of contamination, two IDO Security Patrolmen were dispatched at approximately 12:10 a.m. to conduct a radiological survey of Highways 20 and 26 plus Atomic City.

Because the open doors and windows in Building 602 might have allowed the building furnace to overheat and cause a fire, two IDO personnel entered the SL-1 Area at 1:00 a.m. and proceeded to Building 602 to secure the doors and windows. The entry lasted less than one minute, and the two men did not penetrate past the door to the reactor building. A radiation level of 3.5 R/hr was measured five feet from the door to the reactor building.

Between 1:00 and 4:30 a.m. a greater portion of the activities at the scene of the disaster centered about the decontamination of personnel. The Central Facilities Dispensary received the greatest number of people and all decontamination locations were very successful in the decontamination efforts by utilizing standard operating procedures. Other events during the stated times included: (1) discontinuance of the radiological survey of Atomic City (continued survey of Highway 20 until 8:00 a.m., but no readings above background were observed), (2) notifying the IDO Agronomist of the incident, and (3) supplying gas to vehicles located in the SL-1 control area.

At 4:30 a.m. arrangements were made by the IDO Chief, Medical Branch, with the IDO Director, Division of Health and Safety, and Phillips Chief, Health and Safety, to transport the first casualty to the CPP Decontamination Room. Preparations for traffic to be given priority to the CPP and adequate receiving measures were made by 6:27 a.m., at which time the ambulance departed the SL-1 Area. About 6:43 a.m., the ambulance was parked in the CPP Decontamination Room.

To determine whether air contamination or the spread of activity was a problem, an aerial survey of the NRTS and vicinity was started at 6:35 a.m. and was completed about 1:30 p.m. No detectable contamination was found downwind and no damage to the roof of the reactor building was observed.

At 7:00 a.m. an IDO H.P. accompanied a CEI employee into the SL-1 control room to retrieve recorder charts and turn off all instrumentation switches. The entry lasted approximately five minutes and radiation fields of 1.5 to 3.0 R/hr were encountered.

The next major action that took place was at 9:00 a.m. when IDO and CEI personnel held discussions concerning materials and assistance in adding boron to the SL-1 Reactor. After a boric acid solution had been prepared, it was decided, however, not to add the poison to the SL-1 Reactor due to the uncertainties that prevailed at that time concerning the possibilities of further reactions.

At the CPP Decontamination Room at 9:30 a.m., five IDO personnel began decontamination efforts on the first casualty. Because no appreciable results were noted by 11:30 a.m., the decontamination efforts were suspended.

In an effort to determine the extent, if any, of external damage to the SL-1 Reactor Building, the IDO SL-1 Site Coordinator at 9:45 a.m. traveled around the reactor building and inspected it with field glasses. No visible damage to the cylinder or to the pilings underneath was observed and radiation readings of 2.5 R/hr were obtained about 25 feet from the base of the reactor building.

At 9:45 a.m. two IDO personnel entered the SL-1 Reactor Building and recovered the Nuclear Accident Dosimeter (NAD) which was located on the wall outside of the door opening onto the reactor operating room. The time spent on the covered stairway was less than forty-five seconds. Shortly after the recovery of the NAD, it was sent to the IDO Analysis Branch.

Between 11:00 and 12:00 a.m. two entries were made into the SL-1 Area, one to retrieve personnel records from Building 606, and another to recover the Log Books from the SL-1 control room. The former entry team, composed of an IDO H.P. and a military person, accomplished this task in one and one-half minutes. The latter entry team, composed of an IDO H.P. and a Westinghouse employee, completed the job in two minutes.

Recovery of the Second Casualty

At 12:00 noon the IDO Manager approved the recovery of the second casualty from the SL-1 Reactor Building. Between the hours of 12:00 noon and 3:30 p.m. officials of IDO, the Military and CEI planned the procedures to be followed in the recovery operations.

An entry was made in Building 606 at 2:10 p.m. by a two-man team, from IDO and the Military Cadre, to obtain the blueprints and the assembly and disassembly procedures for the control rod drive mechanism. Radiation levels of 750 MR/hr on the outside and 200 MR/hr on the inside of Building 606 were observed during the entry.

At 3:30 p.m. the IDO Military Reactors Division was requested to dispatch a six-man military recovery team to the Control Point. Meanwhile, two men from IDO and the Military Cadre entered Building 602 to close auxiliary station breakers, thereby turning on heaters and lights in the reactor building. In preparation for the recovery operation, two IDO personnel were dispatched to the CPP site in order to return the contaminated ambulance to the SL-1 Area. A radiation survey taken of the ambulance showed: (1) 20 R/hr on the rear bumper, (2) 10 R/hr on the floor boards in the rear compartment, (3) .002 R/hr on the tires, and (4) .150 R/hr in the driver's position. The ambulance was returned to the Control Point and parked near the SL-1 vehicle gate.

The six-man military recovery team arrived at the Control Point at 5:45 p.m. and was later briefed by IDO and CEI personnel on the recovery operation.

At 7:20 p.m. the first two-man team accompanied by two IDO personnel entered Building 602. The first team carried the victim from the reactor operating room to the control room and placed the victim on a blanket. Next, the second two-man team carried the victim from the control room to a location about eight feet outside the SL-1 vehicle gate. The third two-man team was, therefore, not utilized in the recovery operation but was sent onto the reactor operating floor to: (1) determine whether there was any water in the reactor vessel and (2) retrieve a metal object for activation analyses. Although the attempt to determine whether there was water in the reactor vessel proved unsuccessful, the team was able to recover a metal punching for analyses. In summary, the first team was in the reactor operating room about fifty seconds, the second team spent about one minute with the victim, and the third team was approximately one minute in the reactor operating room.

By 8:15 p.m. the victim was placed into the ambulance, and at 9:11 p.m. the ambulance departed from the SL-1 Area for the CPP Decontamination Room. Upon arrival of the ambulance at the decontamination room, the second casualty was removed from the ambulance and placed with the first casualty.

On January 5, during the hours from 1:00 to 10:00 a.m., radiation check points were established throughout the SL-1 Area and radiation surveys at these check points were taken at two-hour intervals.

At 10:40 a.m. IDO personnel at the Control Point were informed that a radiation exposure limit of 3R per person had been established by the IDO Director, Division of Health and Safety. This limiting value was not to be exceeded without the IDO Health and Safety Director's approval.

Further entries were made into the SL-1 Area at 11:00 a.m. by an IDO H.P. and CEI employee in order to: (1) monitor the areas north of the reactor building, (2) obtain SL-1 Plant "as built" drawings from Building 613, and (3) place Hi-Vol air samplers in the reactor control room and in the reactor operating room.

At 1:15 p.m. two Argonne National Laboratory (ANL) photographers arrived at the Control Point to attempt to obtain photographs of the interior of the reactor operating room. It was hoped that such photographs would indicate the position of the third victim and the condition of the reactor room.

Prior to the photographic entry, an IDO H.P. had been instructed at 1:30 p.m. to conduct a radiological survey outside the SL-1 Area fence. The survey grid was started at the southeast side and proceeded clockwise, extending out from the fence approximately 1200 feet. A maximum radiation reading of 700 MR/hr was observed at the fence on the northeast side, and a radiation level of about 250 MR/hr was observed at the remaining three sides. The survey was completed in about two and one-half hours with thirty to forty minutes per side.

At approximately 4:00 p.m. an IDO employee accompanied an ANL photographer from the Control Point to the SL-1 Reactor Building. In order to keep the radiation exposure dose of the photographer to as low a value as possible, the photographer stepped into the open doorway of the reactor operating room, took a picture, and then retreated down the stairs to change the film. This procedure was repeated several times. Before returning to the Control Point, the IDO employee surveyed around the outside of the reactor building at ground level. Most of the readings observed were less than 1 R/hr, although a maximum of 5 R/hr was obtained about twenty feet from the north side of the reactor building.

The ANL photographer departed the decontamination trailer at 5:45 p.m. to go to the EBR-II for film processing. By 10:40 p.m. copies of the photographs had been delivered to IDO and CEI officials. (see Figures 2.1 and 2.2)

During the hours from midnight to 8:00 a.m. on January 6, the mobile crane which was to be utilized in the recovery of the third victim underwent modifications at the Control Point. A stretcher type apparatus was fastened to the end of the crane's jib. The stretcher was designed to act as a net to catch the victim.

From 8:00 a.m. to 12:52 p.m. constant radiological monitoring of the SL-1 Area continued, equipment was decontaminated, and additional air samples were obtained for analyses.

Between 12:52 and 1:40 p.m. a Lorain 25-ton mobile crane was positioned just north of the reactor building to attempt to open the freight doors, thereby allowing an opening into the reactor operating room. The crane was equipped with a seventy foot boom and a "manipulating wedge", which was specially designed and fabricated to fit into the grooves of the corrugated freight doors. After ensuring that the wedge would open and close the freight doors, the four personnel involved in the operation departed for the Control Point. Photographs of this operation were taken.

At 2:45 p.m. the crane with the manipulating wedge was brought out of the SL-1 Area to remove the top twenty foot section of the boom. The operation took approximately seventy minutes and involved two H. K. Ferguson and one General Electric (GE) personnel.

Because it appeared that the top of the reactor building had been punctured by some objects, two ANL photographers were requested at 4:15 p.m. to obtain aerial photographs of the reactor building before dark. About 10:00 p.m. the photographs were delivered to IDO officials. What had appeared to be a puncture of the reactor building was discovered to be wrappings around an air ejector vent located on the roof.

At 9:30 p.m. an IDO H.P. accompanied three military personnel to the reactor operating room to position a television camera. Subsequently, an IDO H.P. with five men laid cables and made the ground-floor connections in Buildings 613 and 602 for the television system.

On January 7, between midnight and 6:30 a.m., three unsuccessful attempts were made to correct the malfunctioning television system. (Reference

Appendix C). The first entry was into Building 602 by an IDO H.P. and a CEI engineer and took approximately one minute. The second entry by an IDO H.P., CEI and Phillips' employee was into Building 602 and 613 and lasted fifty minutes. The third entry by an IDO H.P. and three military personnel was into Building 602; two military persons spent thirty seconds in the reactor operating room removing the television camera.

Recovery of the Third Casualty

Meanwhile, it had been determined that the monorail "I" beam which protruded out of the reactor building through the freight doorway would impede recovery operations for the third victim. As a result, it was decided to remove a portion of the "I" beam. To accomplish this task, a welder was housed in a lead shield box (see Figure 2.3). Then, the shield box was attached to the boom of a crane and raised to a position near the protruding "I" beam. From this location, the welder would attempt to cut away a portion of the "I" beam. Dosimetry studies were made on the shield box by attaching film badges to the inner and outer surfaces of the box, and then raising the shield box, without the welder inside, to the position where the welder would be working to cut the "I" beam. Later, the film badges were removed and processed. A fifteen minute exposure to the film badges revealed a radiation dose of 75 to 90 MR on the inside of the box and about 8R on the outer surface.

At 10:30 a.m. a GE H.P. and three H. K. Ferguson employees proceeded to the north side of the reactor building to attempt to cut the "I" beam. At this same time, three Phillips' employees positioned themselves outside the SL-1 fence to obtain photographs of the general area and the "I" beam cutting operations. These people returned to the Control Point at 11:30 a.m. The "I" beam had been nearly cut through, but it had not fallen because of a re-fusing of the melted metal.

In order to complete the removal of the "I" beam, an IDO H.P. with four H. K. Ferguson employees entered the SL-1 Area at 12:30 noon and with the use of the crane's boom knocked the partially cut beam to the ground. The remainder of the day was spent repairing the crane's cables and preparing for the recovery of the third casualty. Also, during part of the day, radiation monitoring and equipment decontamination efforts continued.

On January 8, one military person along with two GE personnel entered the SL-1 reactor operating room to: (1) move a welding cart out of the cargo doorway (2) retrieve an indium foil which had been placed there during an earlier entry, and (3) to take photographs of the reactor operating room. These men returned to the Control Point at 1:54 a.m. after successfully taking photographs and moving the welding cart. The indium foil could not be recovered because the line to which it was tied was broken during the removal operation.

At 3:07 p.m. three Phillips and two H. K. Ferguson employees entered the SL-1 Area and positioned the lead cask in which the third casualty was to be placed. Next, an eleven-man crew, composed of seven H. K. Ferguson, two Westinghouse and two Phillips' employees entered the SL-1 Area to position the stretcher, which had been attached to the end of a crane's jib, under the third victim.

At 7:01 p.m. a two-man team composed of military personnel entered the reactor operating room to determine whether the stretcher was properly positioned; they accomplished this task staying less than one minute in the operating room. The services of three additional two-man teams were utilized in order to recover the victim. A fifth crew removed the stretcher via the crane from the reactor building and lowered it to within three feet of the ground.

On January 9, at 3:35 a.m. an IDO H.P. accompanied one IDO and two GE employees into the SL-1 Area in order to obtain contaminated clothing and metal samples from the victim. The group returned to the Control Point at 4:40 a.m. and reported that they had been successful in their mission. At 4:42 a.m., the recovery of the third casualty was declared complete.

Due to the level of radiation being emitted from the victim, it was not until 2:27 p.m. on January 10, that the victim was transferred from the stretcher and placed into the lead cask. By 3:10 p.m., the cask had been transferred to the CPP Decontamination Room.

At 5:25 p.m. an IDO H.P. accompanied five CEI and three military persons into the SL-1 Area to retrieve records and determine radiation levels. The group returned to the Control Point at 6:00 p.m. No further entries were made on January 10.

On January 11, smears were taken of the ambulance used to transport the victims as a check on alpha contamination. Results of 465 MR/hr beta-gamma, no alpha, were obtained. During the day, some operating logs and administrative files were recovered from Building 613, and sagebrush samples were collected outside the SL-1 fence. At 2:10 p.m. the IDO Site Survey Branch reported that some radioactive particles were found east of Fillmore Blvd. along Highway 20 (one particle measured 25 R/hr). As a result, monitoring and clean-up (by a portable vacuum cleaner) were begun. At 5:15 p.m. all operations at the SL-1 Area, except guard duties, were terminated for the day.

During January 12, no major activities were undertaken at the SL-1 facility. At the CPP Decontamination Room, however, a team of physicians and health physicists were engaged in decontamination and autopsy duties on the three recovered victims.

On January 13, the IDO Manager reiterated a directive that all entries, exclusive of routine entries (e.g., checking boilers at the Area Hot

Cell), must have prior approval from AEC Headquarters in Idaho Falls. This was to ensure that supervisory personnel would be aware of all persons entering the radiation zone. The IDO Health and Safety Coordinator could approve routine entries.

Between 2:40 and 3:10 p.m., a site was selected by U. S. Weather Bureau personnel for a weather station to be located within the controlled area outside the SL-1 fence and, in addition, two air samples were collected by these personnel utilizing hi-volume air samplers equipped with carbon cartridges.

At the CPP Decontamination Room, the three victims were prepared for burial and shipment. Operations at the SL-1, on January 13, were terminated at 5:40 p.m.

On January 14, the IDO Manager assigned responsibility for the control area to Combustion Engineering, Inc. IDO would, however, maintain a coordinator at the control area who would have complete access to all information in the CEI log books kept at the Control Point and the decontamination trailer. Routine radiological monitoring and sampling continued throughout the day and the SL-1 Area boilers were routinely checked. At 5:40 p.m. operations at the SL-1 Area were secured.

On Sunday, January 15, there were no activities at the SL-1 Area, and the Control Point was secured for this period.

FIGURE 2.1

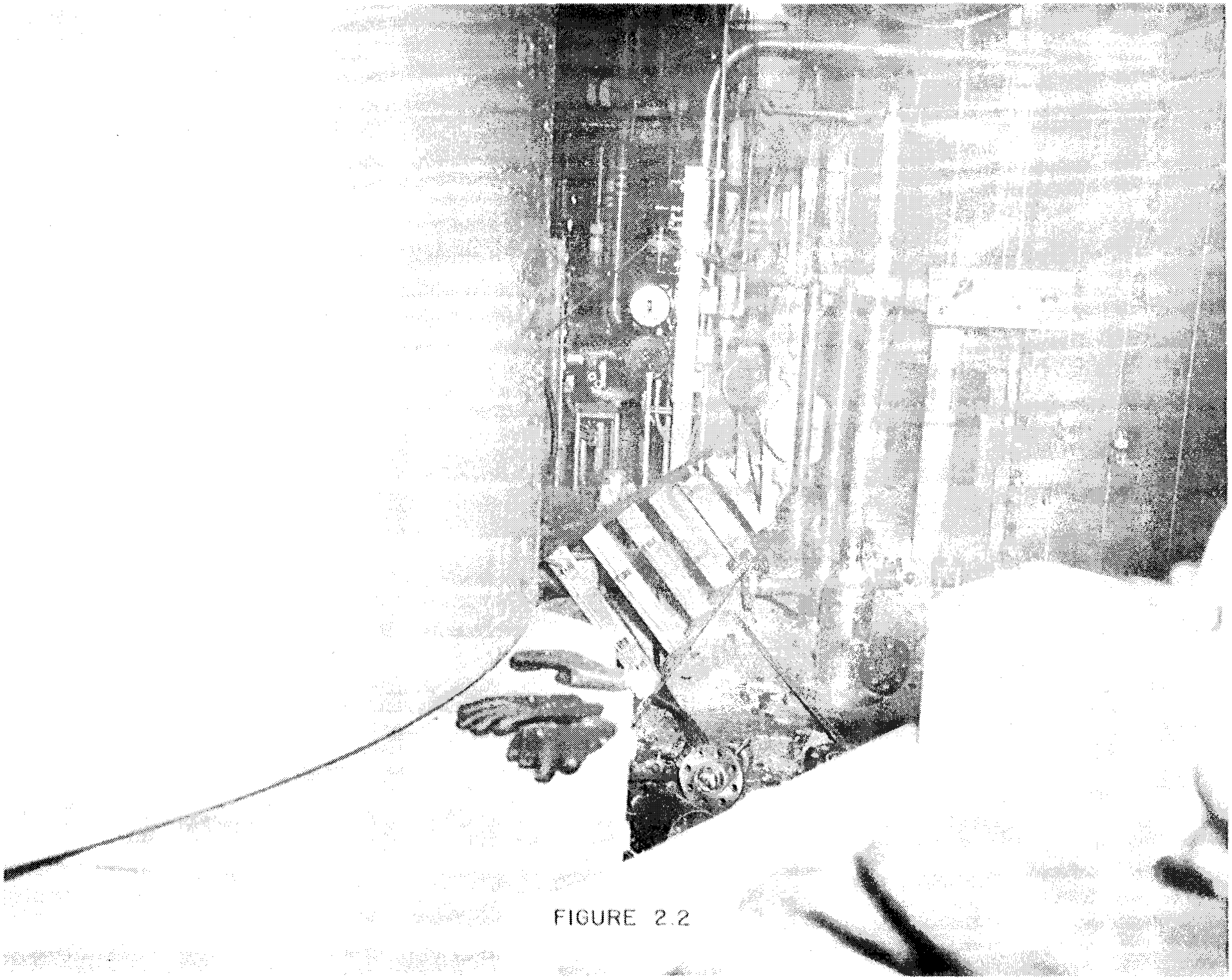


FIGURE 2.2

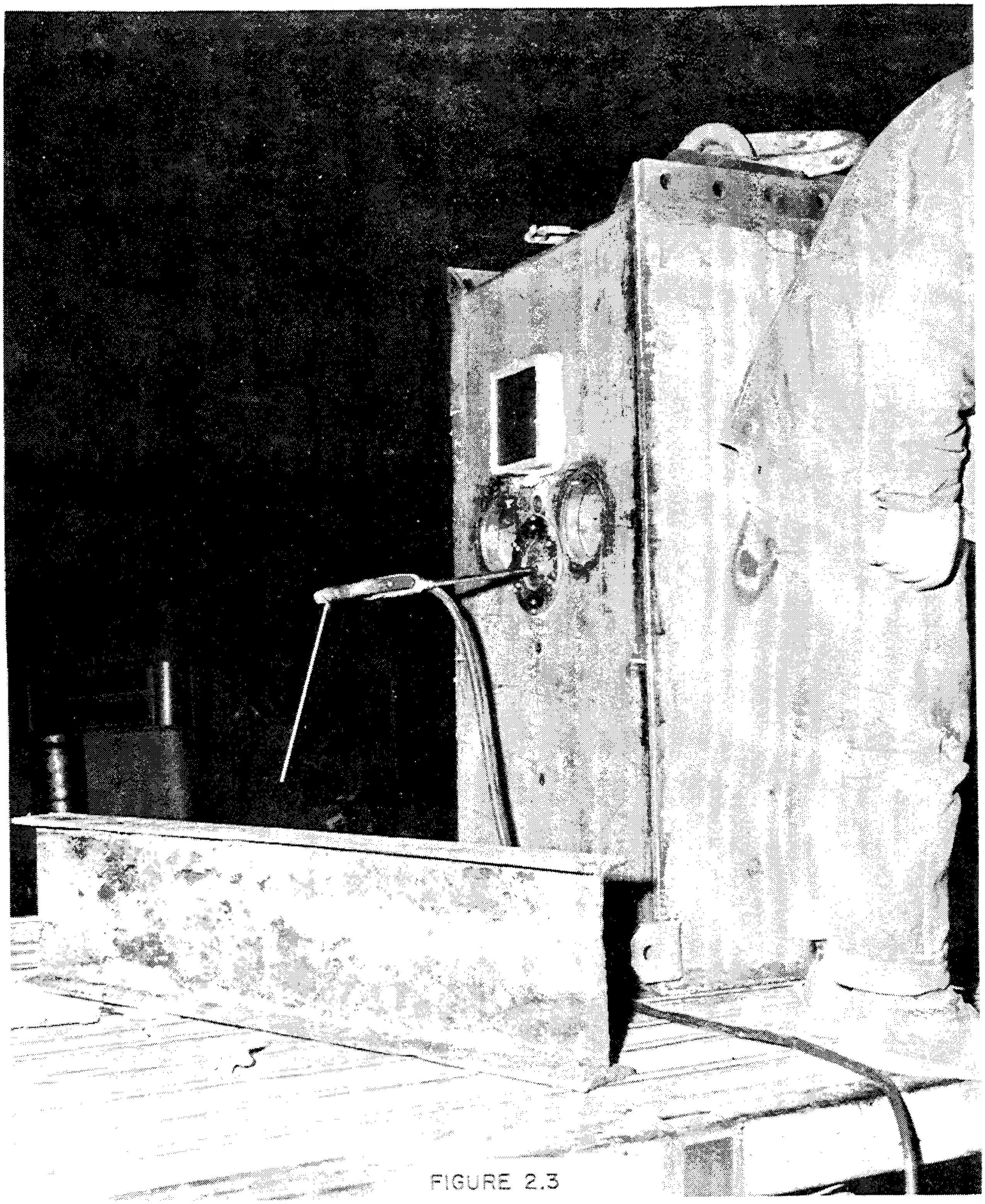


FIGURE 2.3

SECTION 3

PERSONNEL MONITORING AND DECONTAMINATION

The purpose of this section is to describe the general personnel monitoring for radiation exposure from external and internal sources, the personnel decontamination operations which were performed for the SL-1 Facility prior to the incident, and those personnel monitoring and decontamination operations which became necessary following the incident.

Personnel Metering -- During the normal operation of the SL-1 Plant, the SL-1 Health Physicist was responsible for assigning film badges and dosimeters to all personnel in the SL-1 Area. Approximately eighty people were supplied with these radiation detection devices, which were serviced regularly by the Personnel Metering Branch, Division of Health and Safety, IDO. In addition to these pieces of equipment, finger rings and wrist badges were issued upon request from the SL-1 Health Physicist. The film badges were regularly serviced at the SL-1 Area every four weeks with fresh film being placed in the badges. A copy of the recorded readings obtained from the processed film was forwarded to the SL-1 Health Physicist who, in turn, kept the data available for his own health physics needs. It should be noted that a complete and permanent record is maintained by IDO on all persons utilizing the personnel metering service.

In addition to the routine badge processing procedure, should the SL-1 Health Physicist have suspected that a person received a significant radiation dose, the exposed film would be sent to IDO's Personnel Metering Branch for immediate processing. The results from the processed film would be available to the Health Physicist in two hours or less.

In the event that an SL-1 employee's exposure reached a total of 1000 mr or more during the month, a Personnel Exposure Questionnaire, ID-102, would be forwarded to the SL-1 Health Physicist. The employee's supervisor would be requested to complete the questionnaire, which consists of an explanation of how the radiation dose was received and the Health Physicist's recommendations.

The employee's exposure record was cataloged by his health badge number. Every four weeks the individual's exposure record cards would be pulled from the files and processed with the area master cards, which include detailed information on the employee. From this data processing, a report would be prepared indicating the individual's exposure in a specified area for the four-week period. In addition to the report, a card would be punched recording the employee's total exposure for that period of time. Quarterly all of the employee's monthly cards would be summarized statistically and significant information would be cataloged.

In addition to processing film badges, maintaining exposure records, and supplying exposure information on persons located at the SL-1 Plant, it was the function of IDO's Personnel Metering Branch to perform this same type of service for all contractor personnel located on the National Reactor Testing Station (NRTS). Because a vast amount of data, therefore, had to be processed on a regular basis, an automatic data processing system was installed.

Following the incident, the routine service, of course, terminated; and it soon became apparent from the increased numbers of persons that were becoming involved with SL-1 rescue operations, etc., that a unique type of data processing system had to be instituted. The system would have to (1) maintain a radiation dosage record of those personnel brought in from other sites, (2) supply compiled information for appropriate officials and the person's permanent work location indicating the radiation dose received while in the SL-1 Area, and (3) provide a total radiation dose tabulation for all officials concerned in order to prevent an exposure in excess of guide values. As a result, summary cards were prepared at the same time a newly accumulated exposure list was being prepared. The summary cards were then used to prepare reports which provided management with current information concerning the number and levels of radiation exposures received by the personnel participating in activities at the SL-1 Site. This information was utilized in scheduling work assignments and planning operations.

In order to prevent persons who were involved not only in daily duties at the SL-1 Area but also in daily duties at other NRTS Site Facilities from receiving excessive exposure, each individual's daily film badges, perhaps two or more, had to be processed and recorded. Next a report listing the individual's name, date and location of exposure, and amounts of beta and gamma radiation received had to be tabulated. This created a record retrieval problem which would have proven extremely difficult, if not impossible, without the central data processing system which maintains <u>all</u> radiation exposure records at the NRTS.

Figures 3.1, 3.2, 3.3, and 3.4 describe the general system which was placed into operation to generate the special reports required following the SL-1 Incident.

On January 5, 1961, the IDO Personnel Metering Branch began issuing daily a report which listed the person's name and date and amount of radiation exposure chargeable to the SL-1 Incident. On January 10, a summary report which tabulated the individual's accumulated dose that was received from performing duties in the SL-1 Area was regularly distributed.

Table 3.1 is a breakdown of the number of people involved in the SL-1 Incident, from a radiation standpoint, arranged according to selected radiation dose increments. This type of data presentation was first made available on January 7, and proved to be very useful throughout the days following the incident, since it provided a means to view the composite picture from which the determination could be made as to whether more stringent health physics controls in the SL-1 Area were necessary.

Chemical and Radiochemical Analyses -- Another phase of the personnel monitoring program that IDO provided the SL-1 was that of chemical and radiochemical analysis (see Appendix B - Analytical Report). The service ranged from the analyses of reactor liquid waste to that of urine. The Health Physicist at the SL-1 was responsible for establishing the plant's urinalysis program. All samples submitted to IDO's Analysis Branch were analyzed for gross activity. If activity was detected, a follow-up sample would be obtained and analyses for specific isotopes would be made.

Following the incident, because personnel involved in the rescue operations were exposed to airborne radioactive materials, spot urine samples were collected from these people as soon as was possible. It was determined by gamma spectra analyses that the major portion of the radioactive material contained in the urine samples was iodine 131. Table 3.2 lists the sixteen persons who showed the highest urinary excretion of iodine 131 and the estimated thyroid dose that was calculated for each person. Also, Figure 3.5 illustrates a typical plot made of the activity in d/m/75 ml of urine as a function of time following the incident.

In conjunction with the iodine-131 analysis, strontium 90 and cesium-137 analyses were performed. In all cases of the cesium-137 analyses, no activity greater than 15 milli-rem per year, infinity dose, was ascertained. Spot urine samples were collected from about 110 individuals at intervals during the first few days after the incident and were analyzed for strontium 90. Eight individuals whose urinary excretion of strontium 90 continued beyond the 10th day then submitted 24-hour urine samples for strontium 90 analyses. Table 3.3 lists the three persons who showed the highest strontium 90 dose and the estimated strontium 90 dose to the bone critical organ. Also, Figure 3.6 illustrates a typical plot made of the activity in micro-curies per milliliter of urine as a function of time following the incident.

Again, the data processing system was called upon to provide a report listing the individual's daily urinalysis results. Figure 3.7 is a flow diagram of the general urinalysis reporting system in operation. The central data processing system accounted for the maximum utilization of NRTS personnel in the SL-1 Area by providing those people in charge of the operations with a rapid accountability of the individual's internal exposure experience.

Whole Body Counting -- Six persons involved with the SL-1 Incident reported for whole body counting during the first week following the incident. Identification of iodine-131, barium-lanthanum-140, and cesium-137 was made by gamma spectra of all six of these persons. However, the amount of iodine-131 made it impractical to do much further total body counting until most of the iodine-131 had left the body. Since that time a preliminary calibration of the whole body counter has been made for iodine-131 using the Remcal (phantom). A total body spectrum of one person obtained on January 20, 1961, indicated a maximum body burden of 0.2 microcurie of iodine-131 on that date. This value is subject to correction when further calibration work is completed.

Now that most of the iodine-131 has left the bodies of these individuals, the total body counter is being used to follow the other isotopes still present. Six individuals are receiving a weekly total body count and are furnishing a weekly 24-hour urine specimen to permit a correlation between the body burden of cesium-137 and the urinary excretion of cesium-137. Similar plans have been formulated for other persons where the need is indicated.

Personnel Monitoring -- In addition to the previously described support operations that were performed for SL-1 personnel, IDO was prepared to make available, in case of a spill or incident, personnel and equipment for emergency radiation monitoring functions. As a result, during the first hour following the incident, IDO had Phillips Petroleum Company Health Physics personnel accompany any individual or team involved in a penetration operation. The Health Physicist was responsible for the radiation safety of the persons in the immediate radiation zone and nearby area. Later, when a penetration was made to locate the victims presumed to be in the reactor operating room, a Combustion Engineering and an AEC Health Physicist participated as members of the rescue team and monitored the radiation fields existing in the reactor room.

Following the rescue operation for the first victim, it was decided that health physics people need not be utilized for the purpose of directly monitoring teams that were to go onto the reactor operating floor. This policy was set forth in order to prevent health physics personnel from needlessly consuming their permissible dose at too rapid a pace, thereby limiting their future radiation working capabilities. In view of this operating procedure, some health physics personnel saw to it that all persons who were scheduled to penetrate onto the reactor floor (1) were dressed in proper anti-c-clothing, (2) possessed film badges and, if necessary, radiation instruments, and (3) were briefed as thoroughly as possible and then required to describe the task they were about to perform to ensure a minimum of time being spent in the high radiation zone. A Health Physicist would accompany to the base of the covered stairway leading to the reactor operating room all teams making their way into the reactor operating room. At the stairway location, the Health Physicist would act as a timer for the operation (a one-minute period was established as the maximum time the team would be permitted to remain in the reactor room), and also as a safety man in case an unfortunante event would befall any member of the team.

In order to prevent highly radioactive particles from remaining upon rescue team members for any period of time and to keep these particles from being carried to the Control Point from the SL-1, team members were outfitted with two pair of anti-c-coveralls and shoe covers. After the team would complete their work within the Reactor Building, the men would deposit their outer garment outside the Support Facilities Building, and then the men would be transported to the decontamination trailer where they would shed their final garment and be surveyed. The film badges worn by the team were collected, at this time, and later taken to the Personnel Metering Branch for processing.

Personal Decontamination -- Under the SL-1 Health Physics Manual (CEND-1001) each individual at the SL-1 Facility was responsible for personal decontamination. Should the contamination persist following repeated decontamination efforts, however, the SL-1 Health Physicist who was responsible for recommending alternate methods of decontamination was to be notified. If activity levels greater than 5 MR/hr were observed following the use of alternate decontamination procedures, the person would be required to report to the IDO Medical Services Branch at the Central Facilities Area. This was the personal decontamination procedure followed at the SL-1 Site prior to the incident.

After the recovery of the first victim from the reactor operating room of the SL-1, a radiation survey was made of all personnel participating in the rescue operation. Eleven of the persons surveyed were found to be highly contaminated, many exceeding a radiation level of 10 R/hr on their extremities; and, as a result, they were directed by an IDO Health Physicist to be taken to the Gas Cooled Reactor Experiment (GCRE) Plant for decontamination. Upon arrival at the GCRE facility, the men disrobed outside the decontamination area, then entered the decontamination room and showered. After repeated washings, these people were surveyed, issued coveralls and shoe covers, and dispatched to the decontamination trailer which had been set-up at the Control Point. Upon arrival at the decontamination trailer, the eleven persons were radiation surveyed, issued clean coveralls and shoe covers, and then sent to either the CPP or the Central Facilities Dispensary for additional decontamination.

At the dispensary it was discovered that, in a majority of the cases, most radiation levels observed above 2 MR/hr were localized in an area between the wrist and the fingertips. It was found that, in most instances, the use of potassium permanganate or Turco Decontamination Hand Soap on these areas would reduce the radiation levels to below 2 MR/hr.

During the early hours following the incident, in order to prevent a single decontamination facility from becoming over-burdened, personnel processing through the decontamination trailer who were found to be contaminated were disrobed, supplied with clean clothing, and transported to a decontamination facility of either the GCRE, CPP or the Central Facilities Dispensary.

It is believed that the transporting of some thirty contaminated personnel to a number of decontamination facilities, and the utilization of standard practiced decontamination procedures, resulted in the most efficient means of performing the decontamination of a number of persons in as short a time as was possible.

Approximately twelve hours after the incident and thereafter, the few persons that were discovered to be contaminated on their way through the decontamination trailer were sent directly to the Central Facilities Dispensary from the Control Point for further decontamination.

TABLE 3.1

DISTRIBUTION OF THE SL-1 INCIDENT GAMMA RADIATION EXPOSURES BY THE LEVELS OF EXPOSURES

DATE	TOTAL	0 MR to 300 MR	300 MR to 900 MR	900 MR to 3000 MR	3000 MR to 12000 MR	12000 MR to 25000 MR	OVER 25000 MR	HIGHEST
January 5, 1961	104	61	14	13	7	6	3	27000
January 7, 1961	123	74	15	16	9	6	3	27000
January 8, 1961	168	96	26	27	10	6	3	27000
January 9, 1961	231	136	31	41	14	6	3	27000
January 10, 1961	262	165	33	41	14	6	3	27000
January 11, 1961	288	172	42	51	14	6	3	27000
January 12, 1961	304	186	39	55	15	6	3	27000
January 13, 1961	310	191	39	56	15	6	3	27000
January 16, 1961	335	208	47	55	16	6	3	27000
January 17, 1961	389	264	46	53	17	6	3	27000
January 18, 1961	393	268	46	53	17	6	3	27000
January 19, 1961	429	303	47	53	17	6	3	27000
January 20, 1961	457	327	51	53	17	6	3	27000
January 23, 1961	497	358	60	52	18	6	3	27000
January 24, 1961	500	359	59	55	18	6	3	27000
January 25, 1961	503	360	61	55	18	6	3	27000
January 26, 1961	521	376	61	57	18	6	3	27000
January 27, 1961	556	406	64	59	18	6	3	27000
January 30, 1961	569	405	71	66	18	6	3	27000
January 31, 1961	577	413	71	66	18	6	3	27000

TABLE 3.2

ESTIMATED THYROID DOSE

Individual	I-131 excreted via urine on 11th day uc x 10^3	Body burden of "fixed" I-131 uc	Dose assuming 100% of I-131 in thyroid Rads
ID 15	0.68	0.06	0.3
MC 10	5.4	0.43	1.8
PI 8	1.7	0.14	0.6
PI 5	1.0	0.08	0.4
CE 4	1.9	0.15	0.6
CE 2	3.6	0.28	1.2
ID 18	13.0	1.0	4.2
MC 7	2.0	0.16	0.7
ID 27	1.6	0.13	0.6
MC 2	5.9	0.47	2.0
PI 10	1.4	0.11	0.5
CE 3	3.5	0.28	1.2
PI 4	1.1	0.09	0.4
PI 2	0.68	0.06	0.3
ID 31	1.4	0.11	0.5
CE 1	16.0	1.3	5.5

TABLE 3.3

ESTIMATED STRONTIUM 90 DOSE - BONE CRITICAL ORGAN

	Dose/365 days	
Individual	mrads	mrem*
ID-18	10	50
MC-10	1	5
MC-7	2	8

*Damage factor of 5 used in converting mrads to mrem.

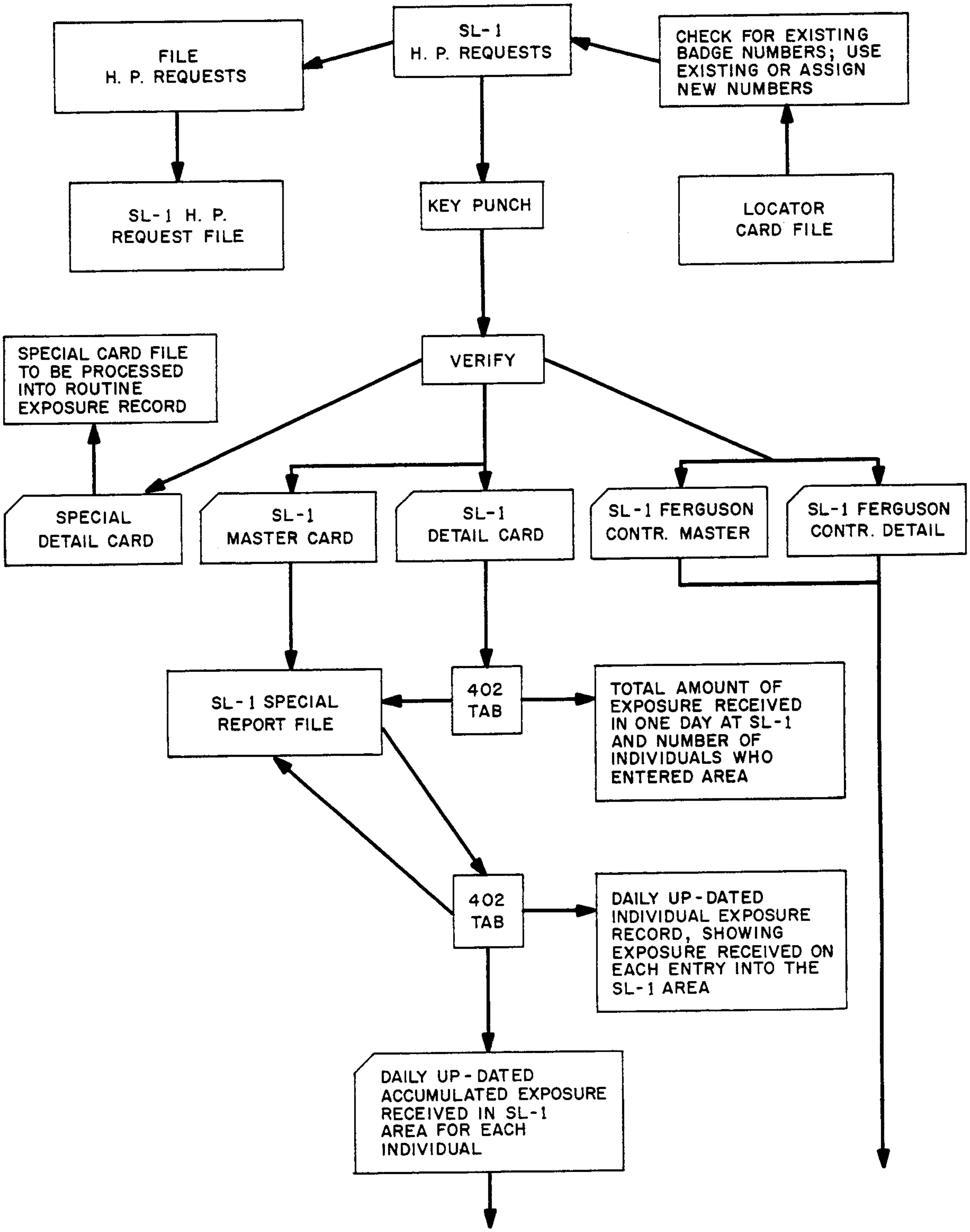
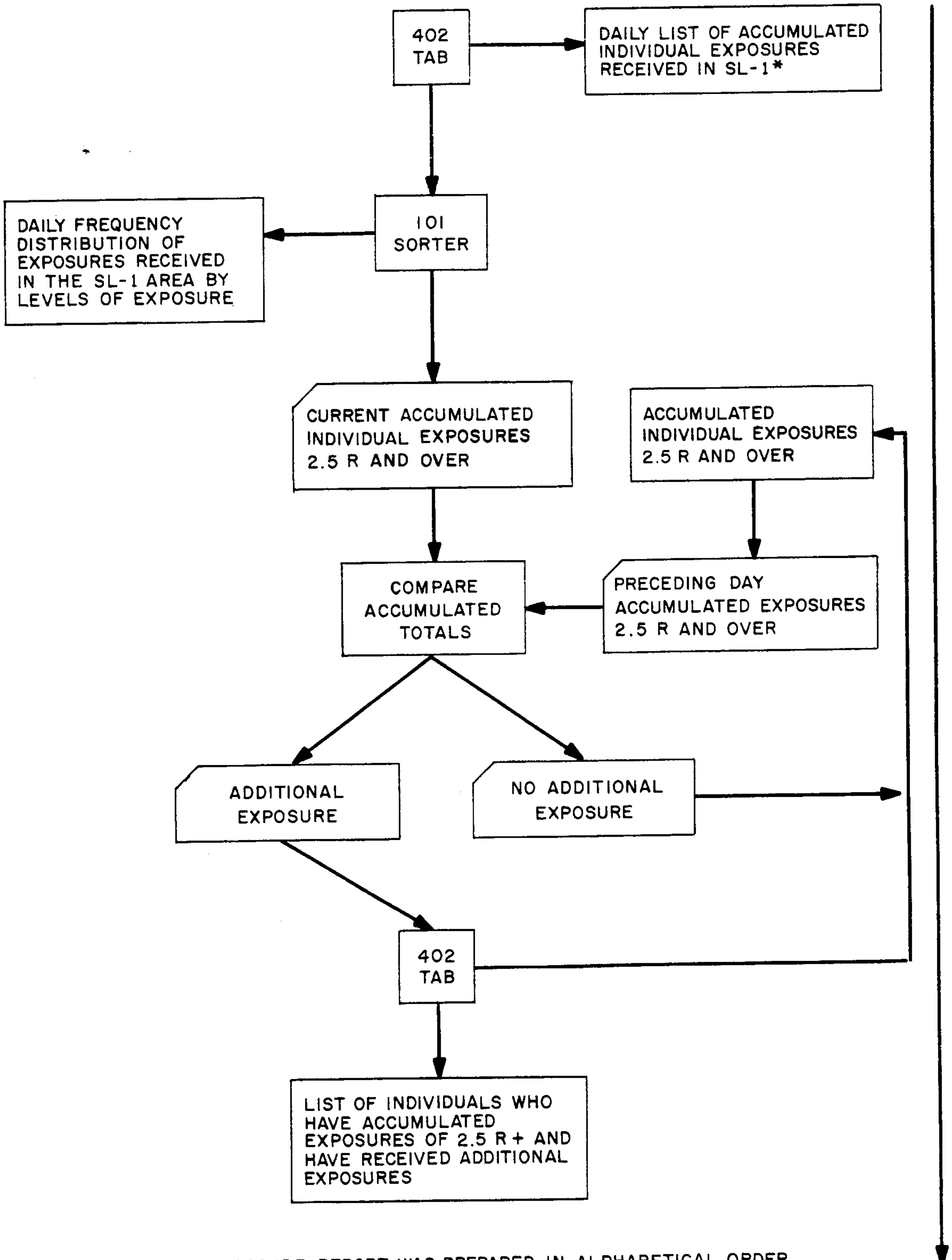


FIGURE 3.1

SL-1 SPECIAL REPORTS OF FILM BADGE RESULTS



* THE ACCUMULATED EXPOSURE REPORT WAS PREPARED IN ALPHABETICAL ORDER FOR ALL ENTRIES INTO SL-1 AND ALSO DIVIDED INTO SEPARATE REPORTS FOR EACH CONTRACTOR HAVING PERSONNEL ENTERING THE AREA.

FIGURE 3.2

SL-1 SPECIAL REPORTS OF FILM BADGE RESULTS

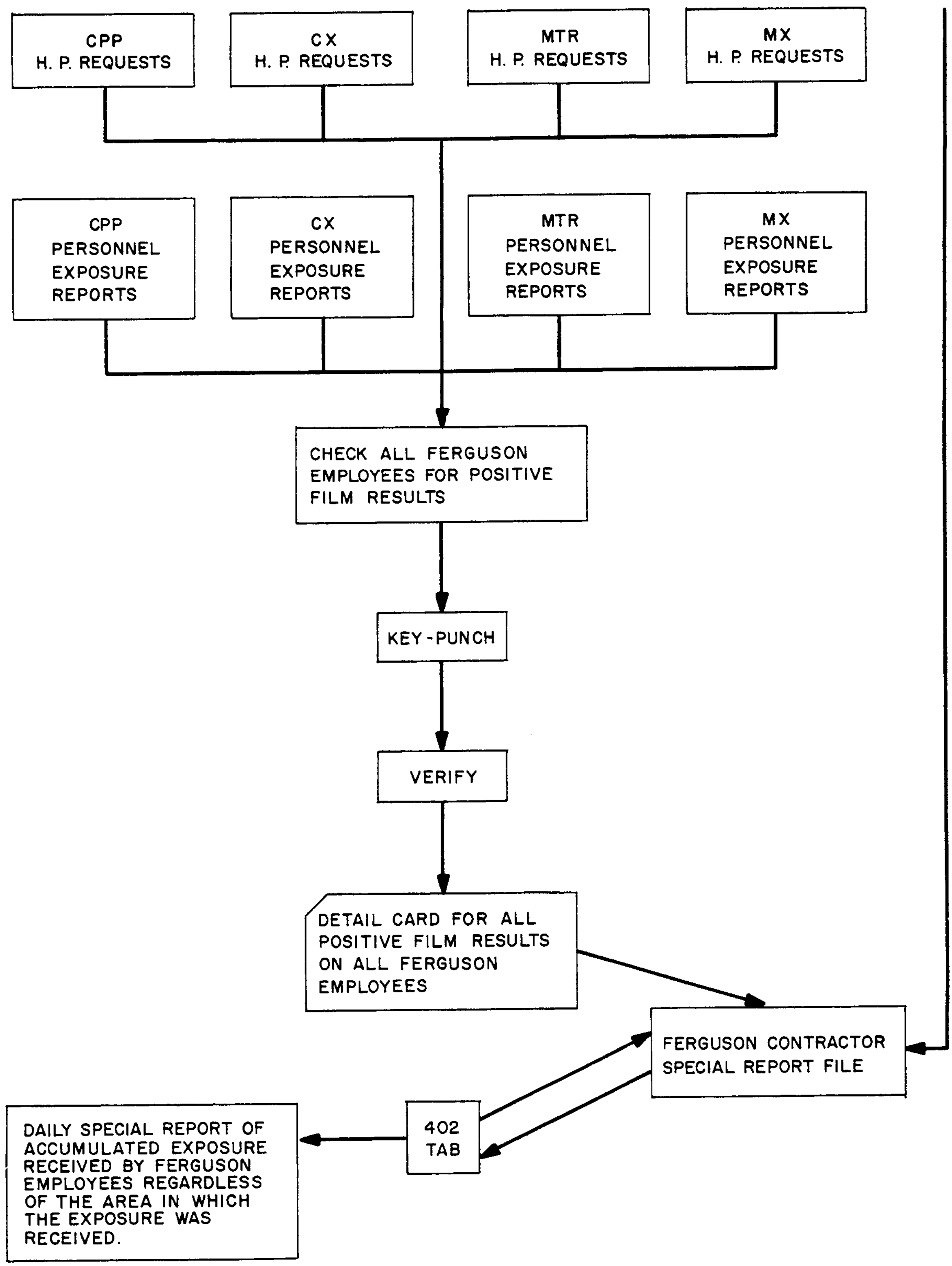


FIGURE 3.3

SL-1 SPECIAL REPORTS OF FILM BADGE RESULTS

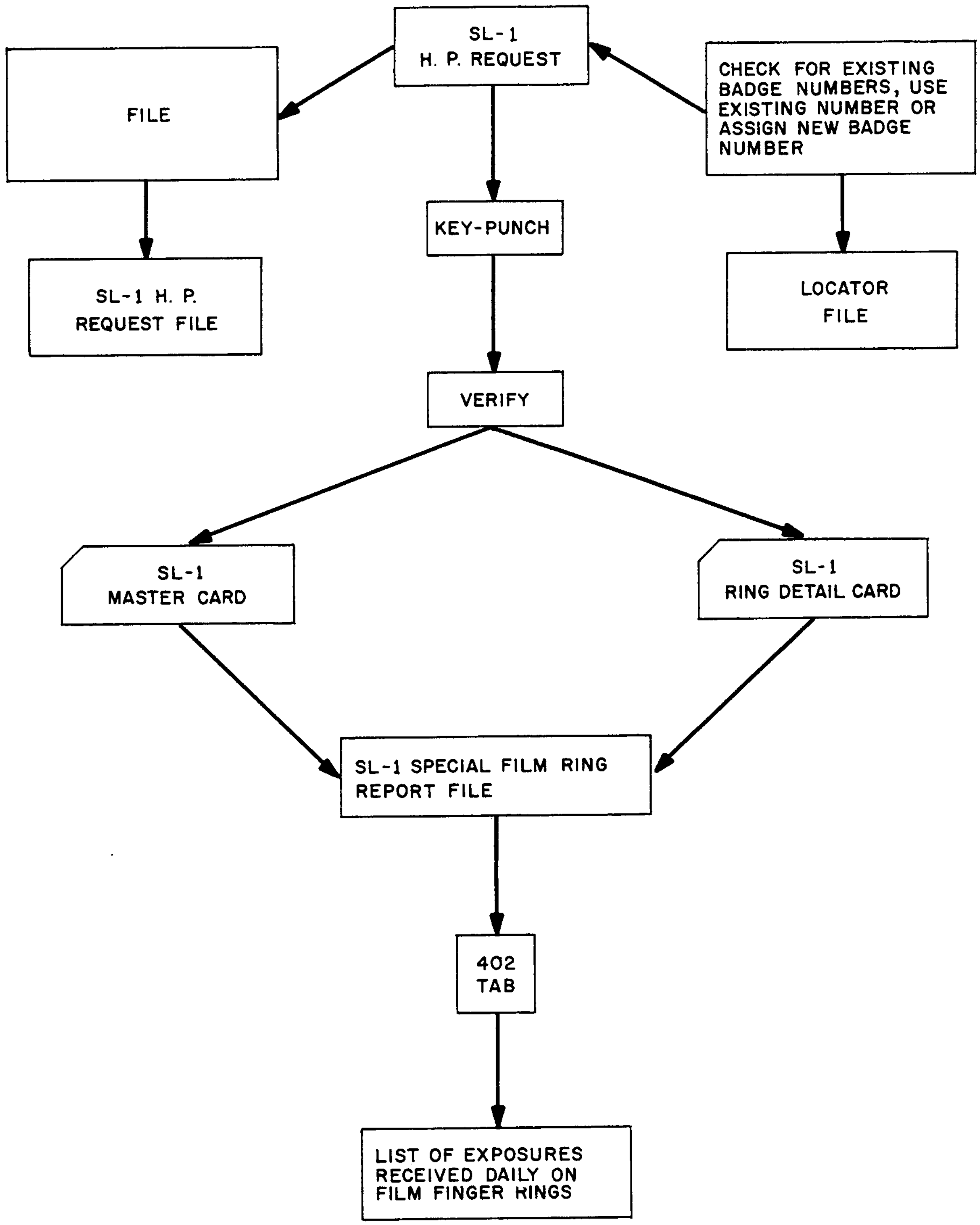


FIGURE 3.4

SL-1 SPECIAL REPORT
OF FILM FINGER RING RESULTS

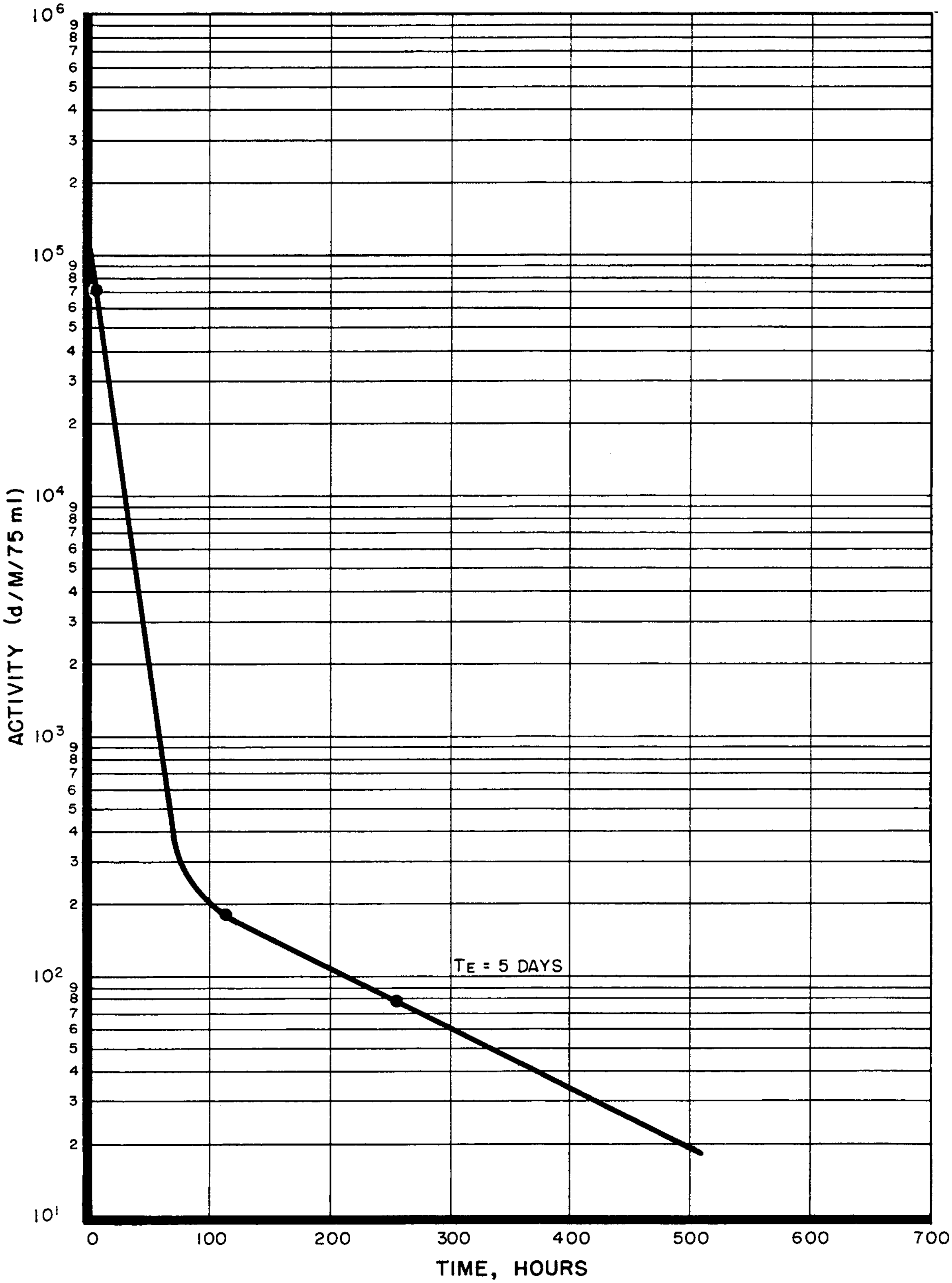


FIGURE 3.5

I^{131} ACTIVITY vs. TIME

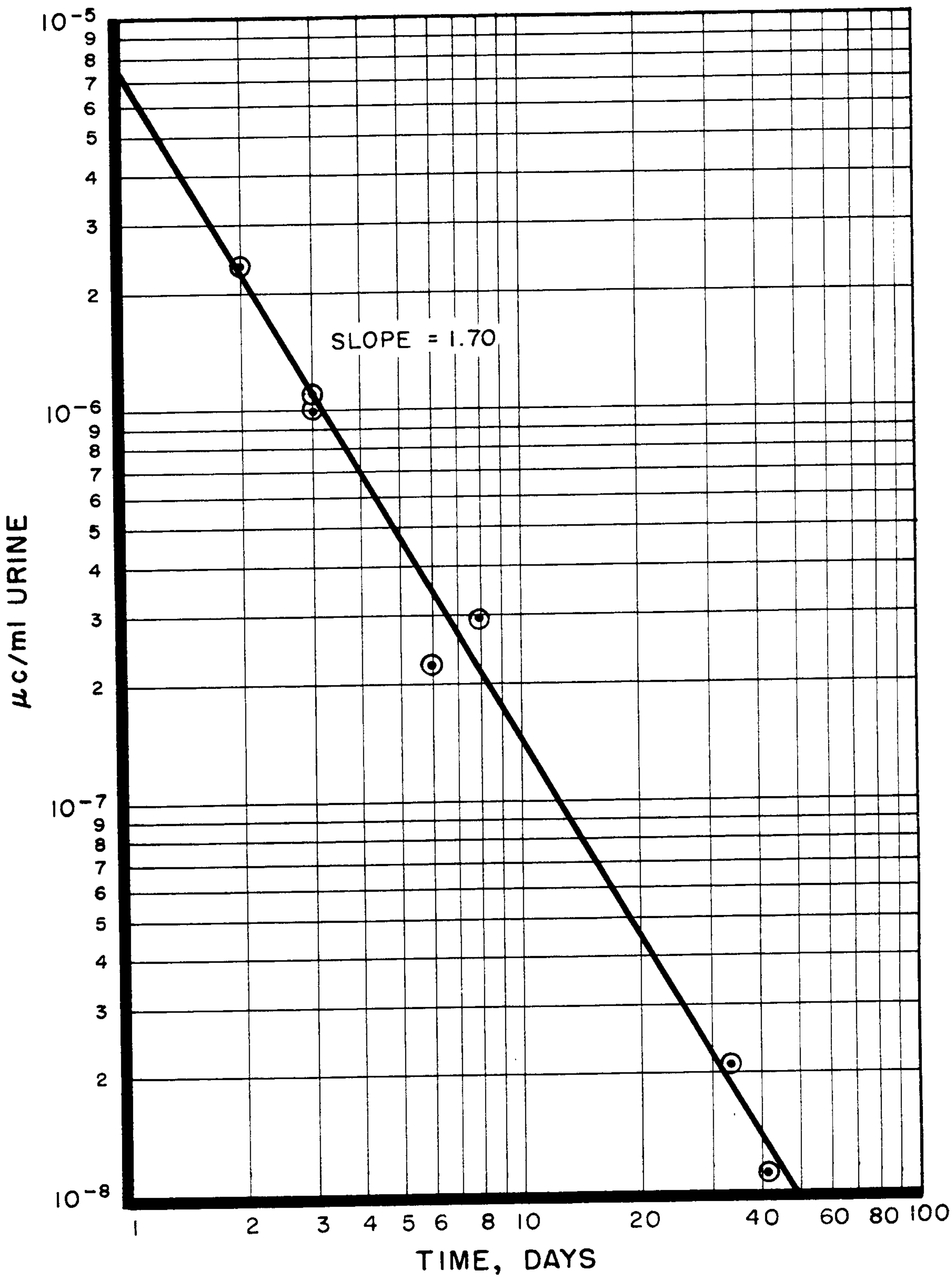


FIGURE 3.6

Sr^{90} ACTIVITY vs. TIME

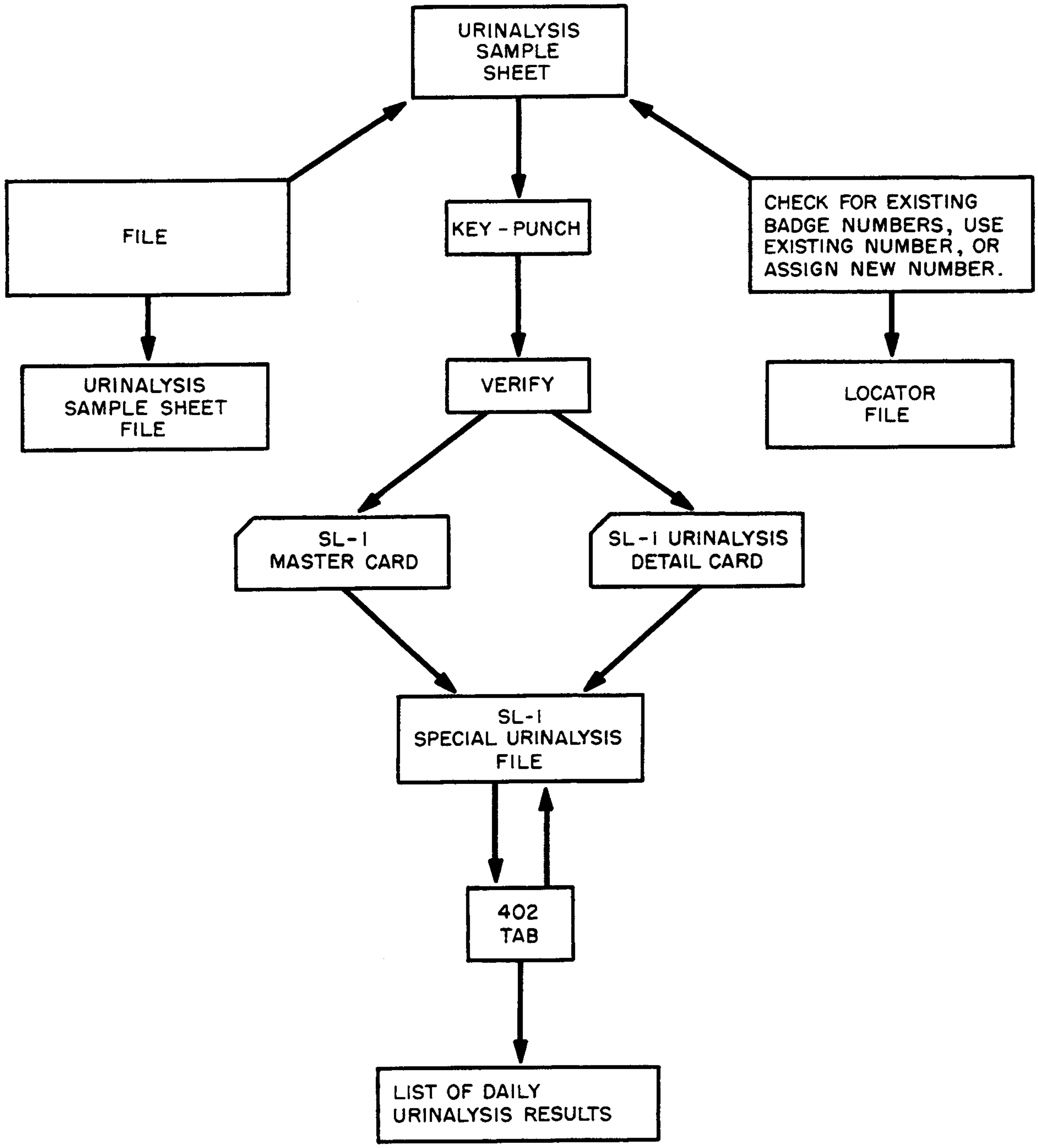


FIGURE 3.7

SL-1 SPECIAL REPORTS OF URINALYSIS RESULTS

SECTION 4

ENVIRONMENTAL MONITORING

This section is a resume of IDO health and safety capabilities in the areas of aerial monitoring, ecology, and site survey, and outlines the activities in these areas which took place following the SL-1 Incident. The main objectives of the programs were to monitor the radioactivity released to the environs, both on and off-site, and to determine the concentration and distribution of radioactive contaminants through the physical and biological sampling of the environment.

It should be noted that much of the environmental monitoring program has been carried on routinely for background data and/or in conjunction with scheduled and non-scheduled releases from reactors, processing plants, and field tests. The direction of each phase of environmental data collection, therefore, was predetermined from past training and field experience with special direction from the Health and Safety Director's office as necessary to cover unusual or possibly related environmental aspects.

I. AERIAL MONITORING

Capability. An aerial-monitoring capability was added to IDO in 1959 to supplement ground monitoring in tracking the path and level of radioactive effluent that might be released in a site emergency and to afford the prompt action necessary for the protection of the public and other interests of the AEC. The aerial-monitoring team formed was composed of IDO Health and Safety personnel and of attached U. S. Public Health Service personnel.

Arrangements were made to have a local (Idaho Falls) airplane available on call. Aerial-monitoring instruments (three scintillators) are stored in the AEC-IDO Headquarters Building where they are available at all times. Under emergency conditions, with the present system, team members will respond on call, pick up their equipment, and be airborne in less than one hour.

The efficiency of this team has been developed through cloud-tracking training flights on known controlled releases from the NRTS. Aerial-monitoring flights over the NRTS are under the additional guidance of IDO Manual Chapter 2400-3. (see Appendix G)

Instrumentation. The detector used by IDO aerial-monitoring team is the Aerial Survey Analyzer (ASA). This instrument is a battery-powered single-crystal analyzer. The probe may be either a one or three inch thallium-activated NaI scintillation crystal with appropriate photomultiplier. The analyzer output is fed into a log rate meter, which translates the impulses received into a d-c current which is proportional to the logarithm of the number of pulses received. The output of the ratio meter drives the recording pen of a spring-driven Esterline-Angus recorder. The readings given are comparative with a set point established before actual operation and show only an increase or decrease in pulses received.

Activities following the Incident. At approximately 10:20 p.m. on January 3, the aerial-monitoring team was alerted, and the aircraft was placed on stand-by. The team reported to AEC-IDO Headquarters, picked up their equipment, and remained on stand-by until approximately 12:00 p.m. At this time, the team was advised by the Director, Health and Safety Division, that no flight would be made until daylight because of safety considerations. The team had never performed low level monitoring under night time conditions.

At 6:35 a.m., January 4, the first survey team departed from Idaho Falls, in a Cessna 172 aircraft equipped with the Aerial Survey Analyzer. The team searched for evidence of airborne or deposited activity in the more populated areas along the Snake River downwind of the SL-1 Area. The areas surveyed were determined by the best available meteorological information (see Appendix A - Meteorological Evaluation) regarding the trajectory of the cloud. The flight pattern was set up to intercept the predicted cloud trajectory.

No activity above background was detected on this flight except in the immediate vicinity of the SL-1 Area. The flight track is shown in Figure 4.1 (mean altitude of NRTS is 5,000 feet). Figure 4.2 indicates the preliminary trajectory of the cloud as influenced by the winds at 250 feet.

At 2:44 p.m., January 7, a second flight was initiated to recheck certain areas in which sagebrush samples gathered by the ecology team had indicated the presence of minor deposits of activity. The area of peak values reported for the sagebrush samples was not detected; however, a series of activity peaks extending to a point approximately three miles southwest of the SL-1 Area was detected. The maximum activity recorded was 125 c/s above a background of 200 c/s. As a result of a northeast wind that prevailed throughout the flight, these peaks were aligned downwind of the SL-1 Area. The flight track is shown in Figure 4.3.

At 3:05 p.m., January 8, a third flight departed from Idaho Falls in an effort to confirm the peaks detected on the January 7, flight. This flight could confirm only the peaks directly over the junction of Highway 20 and Fillmore Boulevard. Minor activity (120 c/s above 220 c/s background) was detected up to a distance of four miles north-northeast of the SL-1 Area. This pattern was downwind of the SL-1; winds reported for the flight were south-southwest. The flight track is shown in Figure 4.4.

At 7:55 a.m., January 12, a fourth flight was initiated. This flight recorded the presence of minor activity at the junction of Fillmore Boulevard and Highway 20, at the SL-1 Area. The flight track is shown in Figure 4.5.

II. ECOLOGICAL SURVEYS

Capability. The reactors and processing plants of the NRTS release under controlled conditions or by accident radioactive gases, liquids, and particulate matter to the air, soil, and water of the NRTS and its environs. These releases result in low-level radioactive contamination of the biota.

The Ecology Branch, Health and Safety Division, IDO, performs a quarterly biological monitoring survey of the soil, vegetation, and animals of the NRTS and environs (see Figure 4.6) to assess the levels of radioactive contamination. In the event of accidental releases of radioactive material, the Ecology Branch, IDO, follows a pretested plan used for controlled releases from operational plants. The plan is outlined below:

1. Wind direction and velocity during the release are obtained from the U. S. Weather Bureau, NRTS.

2. Crosswind sampling arcs are then established at geometric distances downwind from the release point. The distance between sampling stations on an arc is approximately one-tenth of the downwind distance.

3. Samples are collected along these arcs in the order of their distance from the release point.

4. Sagebrush samples from the first downwind sampling arc are collected and analyzed, as rapidly as possible, for gross gamma activity to determine whether the deposition pattern agrees with meteorological predictions and whether changes in sampling techniques at further downwind distances are necessary.

5. Milk samples: Collection and analysis of milk samples in the off-site deposition area is usually started 24 to 36 hours following a release.

6. Jack rabbit thyroids for Iodine-131: the Iodine-131 in the jack rabbit thyroid after a single release reaches a maximum five to ten days after the initial deposition. Jack rabbit thyroids are usually collected and counted ten days after a release.

Sampling and Counting Methods. Single samples of flower stock and leaves are taken near the top of 10 to 15 plants in a 100 foot square area. The total sample from the area (100 to 200 grams) is placed in a polyethylene bag and the bag placed in a one quart ice cream container. The container and contents are gamma counted in a thallium-activated sodium iodide well counter.

Sagebrush Sampling. The U. S. Weather Bureau, NRTS, reported winds from the northeast at approximately six (6) miles per hour during the evening of January 3, and the morning of January 4. Sagebrush sampling started at 6:55 a.m. on January 4, one mile south of the SL-1 on Highway 20, and samples were collected from downwind arcs approximately 1 mile and 4 miles south of the SL-1 Area on this date. All samples were gamma counted in a thallium-activated sodium iodide well counter and the results are shown in Figure 4.7 in counts per minute per gram of sample at each location. Gamma spectra of representative samples indicated that the activity was due to Iodine-131. The plotted activity (Figure 4.7) confirms that the released material was distributed in a southerly direction with the highest activity south and southeast of the SL-1 Area. Results of resampling along the 1 mile arc on January 9, (Figure 4.7) show increased activity over that obtained on January 4, and indicates a continuing or subsequent release of activity from the SL-1 Area following the initial deposition. Results from vegetation samples taken on January 6, north and northeast of the SL-1 Area (Figure 4.7) verify that the general deposition pattern was south and southeast of the SL-1 Area.

Additional samples were collected and counted on January 5 and 6, from arcs approximately 8 and 18 miles south of the SL-1 Area. Results in counts per minute per gram of sample shown in Figure 4.8 indicate the maximum activity on these arcs was found south-southeast of the SL-1 Area.

From the results of sagebrush sampling through January 7, the area of effluent deposition can be approximated as follows:

Distance from SL-1 Area (miles)	Deposition Width (miles)
1	3
4	9
5 (NRTS boundary)	11
10	15
20	20

The over-all cloud trajectory is described in greater detail in Appendix A - Meteorological Evaluation.

Since the results of all samples collected indicated that the effluent had been carried in a southerly direction on the night of

January 3, and during the five day period immediately following, samples were collected along the highways south of the NRTS from Moreland to Shoshone on January 9. The results of this sampling program are shown in Figure 4.8 with the maximum activity 7.5 miles northeast of Aberdeen. Vegetation samples were also collected on this date from dairy farms in the Taber area and the results are shown in Figure 4.8.

The results of resampling of the 8-mile arc on January 11, indicated that the activity level had increased approximately 50% over that determined on January 5. Results of resampling of the off-site area north of Aberdeen and west of Springfield verified the activity levels found on January 9. Also on January 11, the eastern and southern boundaries of the deposition pattern were generally established by sampling along the highway from Blackfoot to Pocatello to American Falls, and to Rockland. The results of the January 11 survey are shown in Figure 4.8. On January 11, duplicate samples were taken in the immediate vicinity of the SL-1 Area and one set of samples was given to an observer from the U. S. Air Force, Tactical Air Command, Nuclear Chemistry and Ecology. The samples retained by the Ecology Branch, IDO, were too high a level of radioactivity to be counted in a well counter. The Iodine-131 content of two of these samples and of representative samples from other locations were obtained from gamma spectra and are given in Table 4.1.

Samples collected east of the SL-1 Area along Highway 26 on January 16, indicated additional radioactive material had been deposited east of the area following the January 9 survey. Results are shown in Figure 4.7.

For comparison with sagebrush survey results following the SL-1 Incident, Table 4.2 presents gross gamma activities in counts per minute per gram of sample obtained at various locations in December 1960. A summary of the sagebrush sampling program through January 16, following the SL-1 Incident is given in Table 4.3.

Jack Rabbit Thyroid Iodine-131. Since the Iodine-131 in the jack rabbit thyroid following a single release does not reach a maximum until five to ten days after the initial release, jack rabbit sampling was not started until January 8. Between January 8 and January 14, thirteen samples were collected south of the NRTS boundary. A summary of pre-incident and post-incident Iodine-131 levels in jack rabbit thyroids is given in Table 4.4.

Milk Sampling. Milk sampling was initiated on January 4. Between January 4 and 19, twenty-eight milk samples were collected from five farms. One farm was located at Taber and the remaining four farms were eight or more miles south of Taber. These farms with dairy cows were located nearest to the southern boundary of the

NRTS. Six of the twenty-eight samples showed gross gamma activity slightly greater than three standard deviations of the net count. The remainder of the samples showed no detectable activity under the conditions used for counting, which are capable of detecting 2×10^{-7} microcuries of Iodine-131 per ml.

Two 50-lb. powdered milk samples were obtained from a local dairy firm in Idaho Falls. One sample was of milk collected on January 4, 5, and 6, and the other sample was of milk collected on January 7, 8, and 9. No Iodine-131 was found in either sample at the detection limit of 2×10^{-7} microcuries per gram.

The results of the milk sampling program confirmed that any Iodine-131 present in milk as a result of the SL-1 Incident was well below the Radiation Concentration Guide value of 2×10^{-6} microcuries per ml for non-occupational exposure. A summary of results of the milk-sampling program through January 19, is given in Table 4.5.

III. SITE SURVEY

Capability. The Health and Safety Division, IDO, maintains a continuous radiological monitoring program to determine the concentrations of radioactive materials on and surrounding the NRTS. This monitoring program is divided into two sections: (1) on-site, which includes 894 square miles, and (2) off-site, which covers approximately 7000 square miles outside the NRTS. As a further sub-division, the program can be classified as routine and/or special monitoring. The air and water sampling portions of the program are carried out by the Health Physics Section of the Site Survey Branch, IDO. The purposes of the program are to measure the natural radioactivity content of the NRTS and its environment, to determine the magnitude and origin of any radioactivity above the natural levels and, of primary interest, to ensure that any radioactive materials released to the environment by operations at the NRTS are below the Radioactivity Concentration Guides (RCG) as specified by the Federal Radiation Council. The RCG is utilized as a benchmark against which the environmental contamination levels can be evaluated. The survey data presented in this report provided information which was used to determine the amount of radioactivity released to the environs as a result of the SL-1 Incident.

In order to ascertain the amount of radiation in the air two different sampling systems are employed at the NRTS. The first system, which may be of special interest to monitoring personnel, uses a radio-telemetering network to report the results. The NRTS telemetering system consists of 11 monitoring stations, 19 radio-controlled stations and a control center located in the Central Facilities Area. The control center automatically receives sampling reports at predetermined intervals from the 11 monitoring stations. The 19 radio-controlled stations, which utilize high volume sampling equipment, can be activated from the control center or any other location by telephone when additional radiation monitoring is needed.

Each of the 11 radiation monitoring stations constantly samples the atmosphere by forcing air through a combination filter and carbon cartridge at the rate of one cubic foot per minute. These stations determine whether the radiation level is above or below a predetermined background level. Each station is capable of transmitting this information when periodically requested by the control center--if necessary, as often as every fifteen minutes. The information is telemetered to a teleprinter located at the control center. Figure 4.9 shows the location of the stations.

The second system, which provides quantitative air concentration data, consists of 23 low-volume air samplers operated on a continuous basis. Fourteen of these samplers are located beyond the NRTS boundary and the remainder are strategically located on the NRTS. These samplers like those discussed previously, also utilize a carbon cartridge with a pre-filter to remove any radioactive particulates.

Samples are changed weekly and results are recorded by automatic data processing equipment. Figure 4.10 shows the location of the off-site samplers and Figure 4.11 indicates where the on-site samplers are located.

Underground water samples are taken every two months from 31 locations beyond the NRTS Area. In addition, 22 wells which produce water for human consumption on the NRTS are sampled weekly. Figures 4.10 and 4.12 show the location of the off-site and on-site water sampling stations respectively. All water samples are analyzed for alpha and beta activities and the analytical results are placed on IBM cards.

A network of 313 film dosimetry stations is maintained to detect and define radiation levels which might result from unscheduled releases of radioactive contaminants to the atmosphere. Table 4.6 indicates the location of these monitoring areas along with the number of stations at each location. Figure 4.13 shows the film stations that are located around the SL-1 Area.

A majority of the analyses methods presently in effect at IDO can detect traces of radioactive materials several orders of magnitude below that of hazardous significance. Frequently, minute quantities of radioactivity cannot be detected in environmental samples; in such instances, the minimum detection limit of analysis is used in determining the average concentrations. In general, the radioactivity contributed by operations at the NRTS is either so small that it is indistinguishable from that which exists naturally or is obscured by the worldwide fallout of radioactivity. Similarly, it is difficult at times to differentiate the various sources of radioactivity within the NRTS. As an example, the periodic dissolution of short-cooled MTR elements releases Iodine-131 to the atmosphere. Therefore, the concentrations of radio-iodine reported cannot be attributed solely to the SL-1 Incident.

Air Sampling. The 19 radio-controlled air sampling stations were started about 10:00 p.m. on January 3. The filters from one of these stations - Atomic City - were removed at 3:20 p.m. on January 4, and analyzed for gross gamma activity and radioactive iodine. A gamma spectrum indicated that the activity (3.6×10^{-11} uc/cc) was essentially Iodine-131. On-site sampler filters were not collected immediately because of urgent personnel support activities at the SL-1 Area, and because the wind was from the northerly quadrant at the time of the incident and for the following five days.

The air concentration of Iodine-131 at Atomic City is shown in Figure 4.14. The RCG value for Iodine-131 for continuous exposure to the adjacent off-site populace is also shown to illustrate that this value was not exceeded by the off-site population nearest the SL-1 Area. It should not be concluded that the values given are the maximum concentration at the NRTS boundary. The initial cloud is estimated to have passed over the NRTS boundary about 3 miles east of Atomic City. Comparison of vegetation samples analyzed from this point and from Atomic City indicates that the maximum concentration at the NRTS boundary may be approximately three times that measured at Atomic City.

Air concentrations of Iodine-131 at other low volume air sampling stations located on-site and off-site are tabulated in Tables 4.7 and 4.8.

Following the incident, a special air sampling network was established. Table 4.9 shows the starting dates for each station.

Sampling stations utilized a Staplex high volume air sampler with a carbon cartridge filter and a 7" x 9" MSA-2133 paper as a pre-filter for the carbon. Generally, samples were changed daily at all stations and later analyzed for Iodine-131, the predominant isotope. From these results, daily maps showing iso-concentration lines for Iodine-131 around the SL-1 Area were drawn. Figure 4.15 shows the map for a typical day with a NE prevailing wind as well as the location of each sampling station.

Calculations of the infinity dose to the thyroid resulting from Iodine-131 by inhalation were made from air sampling data obtained from Atomic City. The cumulative infinity dose to the thyroid was less than 35 millirads, or approximately 1/100 of the RCG value. Figure 4.16 presents the cumulative dose for the exposure period January 3 through February 20.

Radiation Surveys. Radiation surveys were started outside the SL-1 Area on January 5. A total of twenty-eight stations were established, and markers were placed at each location so that later readings could be taken at these same locations (see Figure 4.17). Data taken from the seven positions on the NE side of the SL-1 Area for the period January 5 through March 8, are shown in Figure 4.18.

Data from these radiation surveys permitted the decay rate of the gamma radiation to be determined empirically. Using the data between January 5 and February 8, it was determined that the half-life was 31 $\pm$ 7 days. Empirically it was found that the equation expressing the decrease in dose rate with time was:

$$A_t = A_o \exp -\left(\frac{.693\ t}{T}\right)$$

where A_t = dose rate at any time t
A_o = dose rate on January 5
T = half life (31 days)
t = time after January 5, in days

As late as April 8, 1961, this equation could be used to predict the dose rate to within 10% of the actual values at locations close to the SL-1 fence.

Water Sampling. Routine weekly sampling of 15 on-site production wells and special daily sampling of wells at Atomic City, OMRE, GCRE, and SPERT following the SL-1 Incident indicated no significant rise in activity.

External Radiation Dose. Film badges from stations along Highway 20 south-southwest of the SL-1 Area (SL-1 stations #2 through 9) were collected at approximately 3:00 a.m. on January 4, for analyses. These film badges had been changed previously on December 1, 1960. Results indicated a radiation dose from 40 to 55 mr gamma for this period as compared to an average of from 15 to 30 mr gamma in the two months previous. However, film badges which were placed at one mile intervals on the south side of Highway 20 approximately five hours prior to the SL-1 Incident indicated a direct radiation exposure of less than 10 mr. Results from these SL-1 film badge stations are given in Figure 4.13.

TABLE 4.1

I^{131} ACTIVITY ON SAGEBRUSH

Date	Sample No.	Location	I^{131} in $\mu c/g$
1-4-61	2847	.5 mi S of Jct SL-1 Rd & Hwy 20	0.2×10^{-4}
1-4-61	2869	Butte Rd., 1 mi North	0.9×10^{-4}
1-5-61	2876	1 mi E & 7 mi South of Taber	0.7×10^{-4}
1-5-61	2876	3 mi West of Taber	1.5×10^{-4}
1-5-61	2880	9 mi West of Taber	0.8×10^{-4}
1-5-61	2894	Hiway 26, MP 294	1.6×10^{-4}
1-5-61	2898	Hiway 26, MP 298	1.5×10^{-4}
1-6-61	2936	Cox Well Road	0.5×10^{-4}
1-9-61	2941	Taber, 10 mi S & 3 mi W	1.9×10^{-4}
1-9-61	2959	Aberdeen	0.7×10^{-4}
1-11-61	2992	SL-1, 100 yds south fence	$1000. \times 10^{-4}$
1-11-61	2995	SL-1, 100 yds west fence	42.0×10^{-4}
1-11-61	3029	Springfield, 4.5 mi west	0.9×10^{-4}

TABLE 4.2

BACKGROUND SAGEBRUSH READINGS

Location	Date	Counts/min/g
GCRE, SW	12-15-60	1 ± 0.3
GCRE, NE	12-15-60	2 ± 0.3
Jct. Hys. 26 and 20	12-15-60	1 ± 0.2
Taber	12-15-60	2 ± 0.2
Moreland	12-15-60	1 ± 0.3
Aberdeen	12-14-60	0.3 ± 0.2
Shoshone	12-12-60	2.0 ± 0.2
American Falls	12-12-60	0.2 ± 0.2
Idaho Falls, 10 miles W	12-12-60	3.0 ± 0.4
Highway 20, east Site B	12-19-60	2.0 ± 0.3

TABLE 4.3

VEGETATION (SAGEBRUSH) SAMPLING FOR GROSS GAMMA ACTIVITY

Location	Sampling Line		No. Samples	Collection			Completed Analysis	
	Beginning	End		Date	Time Start	Time Finish	Date	Time
Highway 20	Jct. Hy. 26	1/4 mi. E. of SL-1 Jct.	11	1-4	0655	0730	1-4	1000
Highway 26	Jct. Hy. 20	Site Boundary	20	1-4	0735	1055	1-4	1330
Site Boundary	2 mi. W of Atomic City	East Twin Butte	15	1-4	1050	1435	1-4	1630
Old Blackfoot Hy.	Atomic City	8 mi. S. of Taber	5	1-5	0730	0930	1-5	1400
Along UPRR	Scoville Jct.	Taber Hy.	12	1-5	1100	1300	1-6	1930
Highway 26	Atomic City	Moreland	14	1-5	1600	1800	1-6	1600
Old Blackfoot Hy.	Moreland	Taber	7	1-6	0720	0820	1-6	1600
Burn Rd. & Pole Line Rd.	1 mi. E. of SL-1	2 mi. N. of SL-1	14	1-6	1240	1400	1-6	1630
#2 Well Road	5 mi. S. of Taber	Big Southern Butte	12	1-6	1100	1400	1-6	1630
Highway 20	SL-1 Jct.	2 mi. E. SL-1 Jct.	10	1-9	1345	1415	1-9	1430

TABLE 4.3 (CONTINUED)

	Sampling Line			Collection			Completed Analysis	
Location	Beginning	End	No. Samples	Date	Time Start	Time Finish	Date	Time
Highway 39	Moreland	Springfield						
Highway 39	Springfield	Aberdeen						
Highway 30N	Aberdeen	American Falls	33	1-9	1100	1645	1-10	1100
Highway 30N	American Falls	Rupert						
Highway 24	Rupert	Minidoka						
Highway 24	Minidoka	Shoshone						
Taber Area	Dairy Farms		2	1-9	0730	0800	1-9	1100
3.5 mi. S. of Atomic City			7	1-11	1000	1200	1-12	0930
SL-1	100 yds. N, E, S, W.		4	1-11	1300	1500	1-12	1000
SE of SL-1	1/5, 3.5, & 5.0 miles		3	1-11	1300	1500	1-12	1000
Highway 91-191	Blackfoot	Pocatello						
Highway 30N	Pocatello	American Falls	34	1-11	0725	1600	1-12	1300
Highway 37	American Falls	Rockland						
Highway 39	Springfield	9 mi. W. of Springfield	9	1-11	1300	1400	1-12	1000
Highway 20	MP* 290 (SL-1)	MP 298 (EBR-II)	6	1-16	1330	1430	1-17	1000

* MP=Nite Post

TABLE 4.4

JACK RABBIT THYROID I^{131} LEVELS, BEFORE AND AFTER SL-I INCIDENT

Date	Location	I^{131} $\mu c/g$ of thyroid
December 1960	GCRE	$<0.8 \times 10^{-4}$
December 1960	Taber	$1.0 \times 10^{-4} + 3.0 \times 10^{-5}$
December 1960	Moreland	$<0.8 \times 10^{-4}$
December 1960	Aberdeen	$<0.8 \times 10^{-4}$
December 1960	Shoshone	$<0.8 \times 10^{-4}$
December 1960	American Falls	$1.0 \times 10^{-4} + 2.0 \times 10^{-5}$
December 1960	Idaho Falls	$<0.8 \times 10^{-4}$
January 8, 1961	Aberdeen	1.0×10^{-2}
January 8, 1961	Aberdeen	0.7×10^{-2}
January 12, 1961	Atomic City	14.0×10^{-2}
January 12, 1961	Atomic City	11.0×10^{-2}
January 13, 1961	Taber	14.0×10^{-2}
January 13, 1961	Taber	3.0×10^{-2}
January 13, 1961	Taber	0.9×10^{-2}
January 14, 1961	Springfield	0.6×10^{-2}
January 14, 1961	Springfield	2.0×10^{-2}
January 14, 1961	Springfield	0.8×10^{-2}
January 14, 1961	Aberdeen	0.9×10^{-2}
January 14, 1961	Aberdeen	0.6×10^{-2}
January 14, 1961	Blackfoot	0.2×10^{-2}

TABLE 4.5

MILK SAMPLING FOLLOWING SL-I INCIDENT*

		FARM LOCATION			
Date	Taber	7.7 mi. S, 1.5 mi. E of Taber	10 mi. S, 1 mi. E of Taber	10 mi. S. of Taber	10 mi. S, 3 mi. W. of Taber
1-4	0	0,0			
1-5	0	0			
1-8	348±108	357±108	0	0,0	0,0
1-9	0	0	0	0	0
1-10	537±108	0	0	366±108	0
1-11	561±111	-	330±108	0	0
1-19	0	0	-	0	0
No. Samples	7	6	4	6	5

* I^{131} activity is expressed in disintegrations per minute per 900 ml of sample

TABLE 4.6

FILM BADGE LOCATIONS

Location	Number	Location	Number
Idaho Falls	1	SPERT	15
Aberdeen	1	OMRE	4
Telemetering	19	SL-1	14
EBR-1	5	GCRE	4
Burial Ground	35	TREAT	15
CFA	4	EBR-II	1
MTR-ETR	12	Lincoln Blvd.	21
CPP	25	Highway 88	19
NRF	8	Highway 22	27
IET	17	Highway 28	24
LPTF	8	Highway 20	30
FET	4		

TABLE 4.7

OFF-SITE IODINE-131 AIR CONCENTRATION DATA (1 x 10^{-12} uc/cc)

	12/12-12/19	12/19-12/27	12/27-1/3	1/3-1/9	1/9-1/16	1/16-1/23	1/23-1/30
Idaho Falls	0.23 ± .07	*	*	*	1.6 ± 0.4	0.8 ± 0.2	*
Mud Lake	0.63 ± .11	0.4 ± .07	0.3 ± 0.1	0.9 ± 0.1	2.6 ± 0.2	0.9 ± 0.2	0.8 ± 0.1
Monteview	0.4 ± .08	0.5 ± .08	0.2 ± 0.1	1.0 ± 0.2	1.3 ± 0.2	0.4 ± 0.2	0.6 ± 0.1
Reno Ranch	#	#	*	0.8 ± 0.1	1.4 ± 0.2	*	0.4 ± 0.1
Howe	1.0 ± .12	0.4 ± .09	0.4 ± 0.1	0.4 ± 0.1	2.4 ± 0.2	0.8 ± 0.2	2.0 ± 0.1
Idaho Falls (11 miles west)	0.4 ± .10	*	0.2 ± 0.1	0.2 ± 0.1	1.4 ± 0.2	0.6 ± 0.2	0.4 ± 0.2
Atomic City	0.8 ± .12	0.3 ± .07	0	37 ± 0.6	30 ± 0.6	2.4 ± 0.6	5.5 ± 0.2
Butte City	0.8 ± .12	0.4 ± .07	0.2 ± 0.1	0.2 ± 0.1	1.2 ± 0.2	1.0 ± 0.2	1.5 ± 0.1
Roberts	0.3 ± .08	0.2 ± .07	0.2 ± 0.1	0.4 ± 0.1	3.5 ± 0.2	0.6 ± 0.2	0.9 ± 0.1
Aberdeen	0.4 ± .10	*	0.2 ± 0.1	13 ± 0.4	4.8 ± 0.2	1.7 ± 0.2	0.5 ± 0.1
Carey	#	#	#	*	0.5 ± 0.1	1.0 ± 0.2	0.2 ± 0.1
Minidoka	#	#	#	1.6 ± 0.2	1.1 ± 0.1	1.3 ± 0.2	0.8 ± 0.1
Dietrich	#	#	#	0.6 ± 0.1	0.3 ± 0.1	0.6 ± 0.2	0.5 ± 0.1

\# Station not in operation for this period

0 Data missing for this period

* Insignificant

TABLE 4.8

ON-SITE IODINE-131 AIR CONCENTRATION DATA (1×10^{-12} uc/cc)

	12/15 - 12/22	12/22 - 12/29	12/29 - 1/11	1/11 - 1/19	1/19 - 1/26
OMRE	6.0 ± 0.3	1.2 ± .12	*	24 ± 0.8#	5 ± 0.3
EBR-I	3.9 ± 0.2	0.6 ± 0.9	0.6 ± .10	9.2 ± 0.3	11 ± 0.3
SPERT	7.6 ± 0.3	0.8 ± .11	14 ± .30	66	19 ± 0.3
CFA	3.5 ± 0.2	0.7 ± .09	1.6 ± .10	6.9 ± 0.3	4.9 ± 0.3
CPP	5.3 ± 0.2	1.9 ± .16	1.3 ± .10	13 ± 0.4	4.2 ± 0.3
NRF	8.9 ± 0.3	1.1 ± .13	*	6.4 ± 0.3	0.3 ± 0.1
Fire Station #2	7.7 ± 0.3	1.0 ± .12	1.4 ± .10	11 ± 0.5	2.9 ± 0.3
MTR	7.9 ± 0.3	1.2 ± .12	2.4 ± .10	6.8 ± 0.3	1.7 ± 0.2

Sampler inoperative until 1/16/61

* Data missing for this period

TABLE 4.9

SL-1 NONROUTINE HI-VOL AIR-SAMPLING STATIONS

Station No.	Date Started	Date Stopped
1	January 21	March 6
2	January 14	March 6
3	January 3	March 6
4	January 14	March 6
5	January 14	March 6
6	January 14	March 6
7	January 14	March 6
8	January 21	March 6
9	January 21	March 6
10	January 21	March 6
GCRE	January 27	March 6

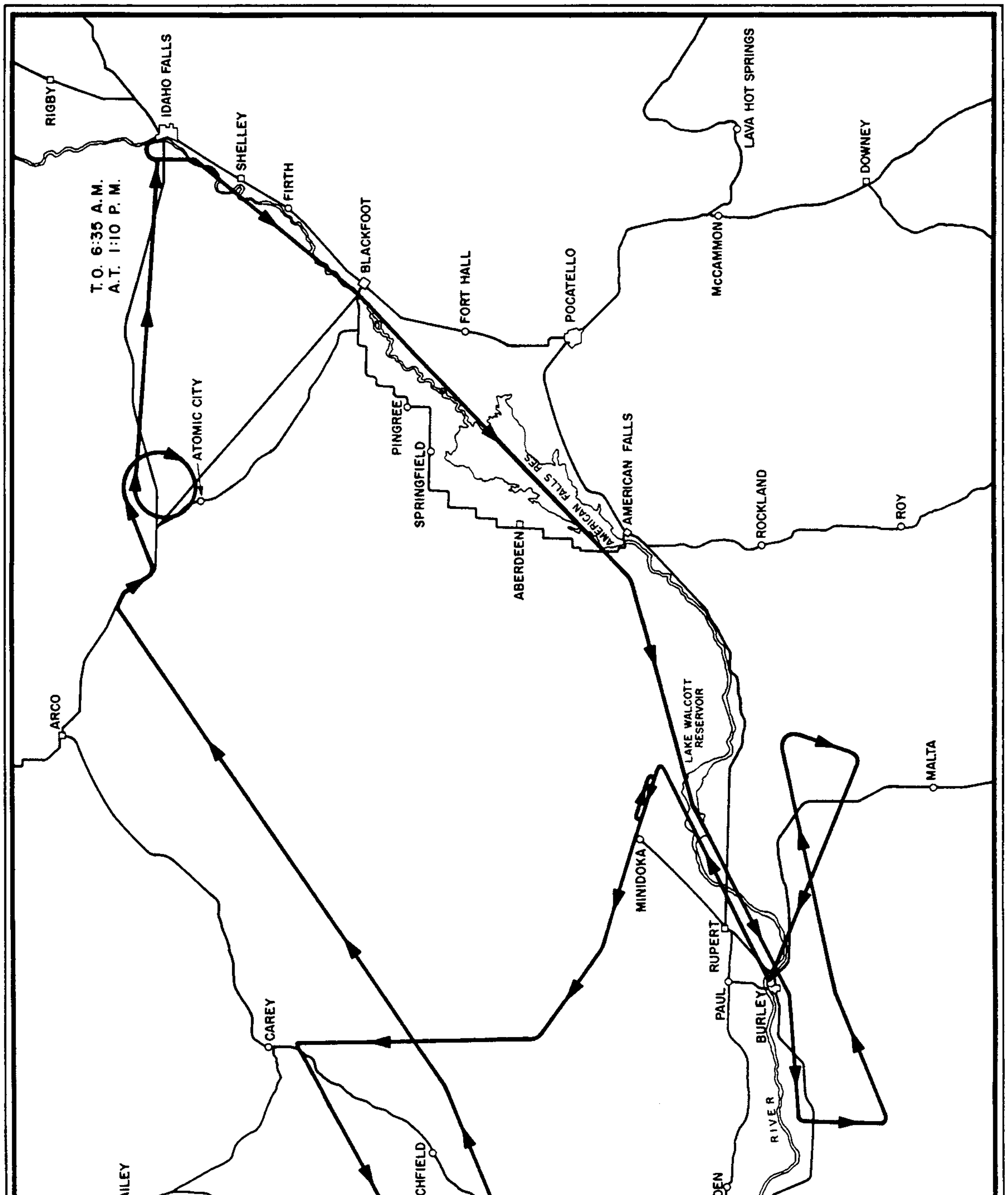


FIGURE 4.1
FLIGHT PATH
JAN. 4, 1961

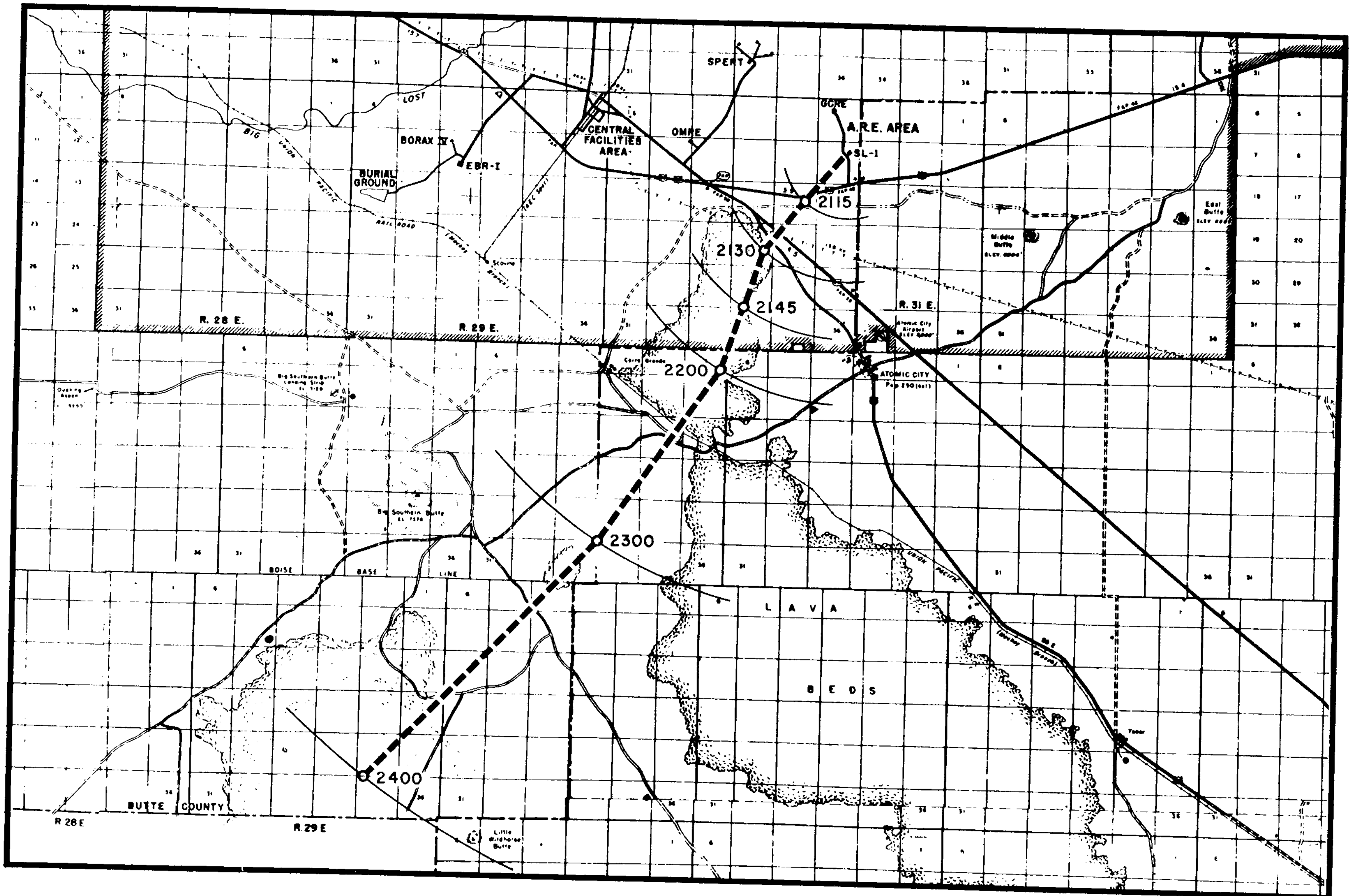


FIGURE 4.2
PRELIMINARY TRAJECTORY FROM 250 FT. WINDS AT CFA - JAN. 4, 1961

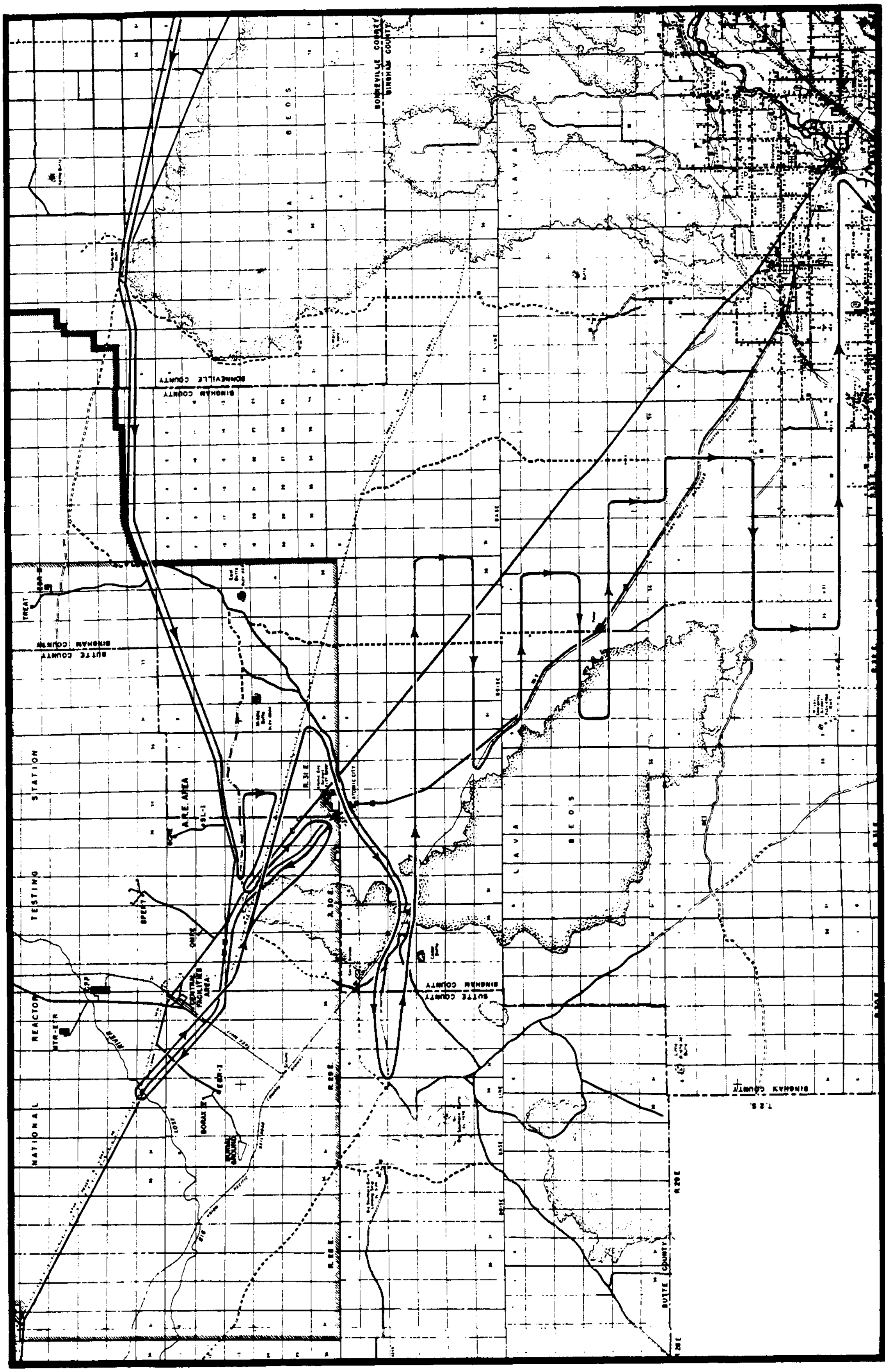


FIGURE 4.3
FLIGHT PATH
JAN. 7, 1961

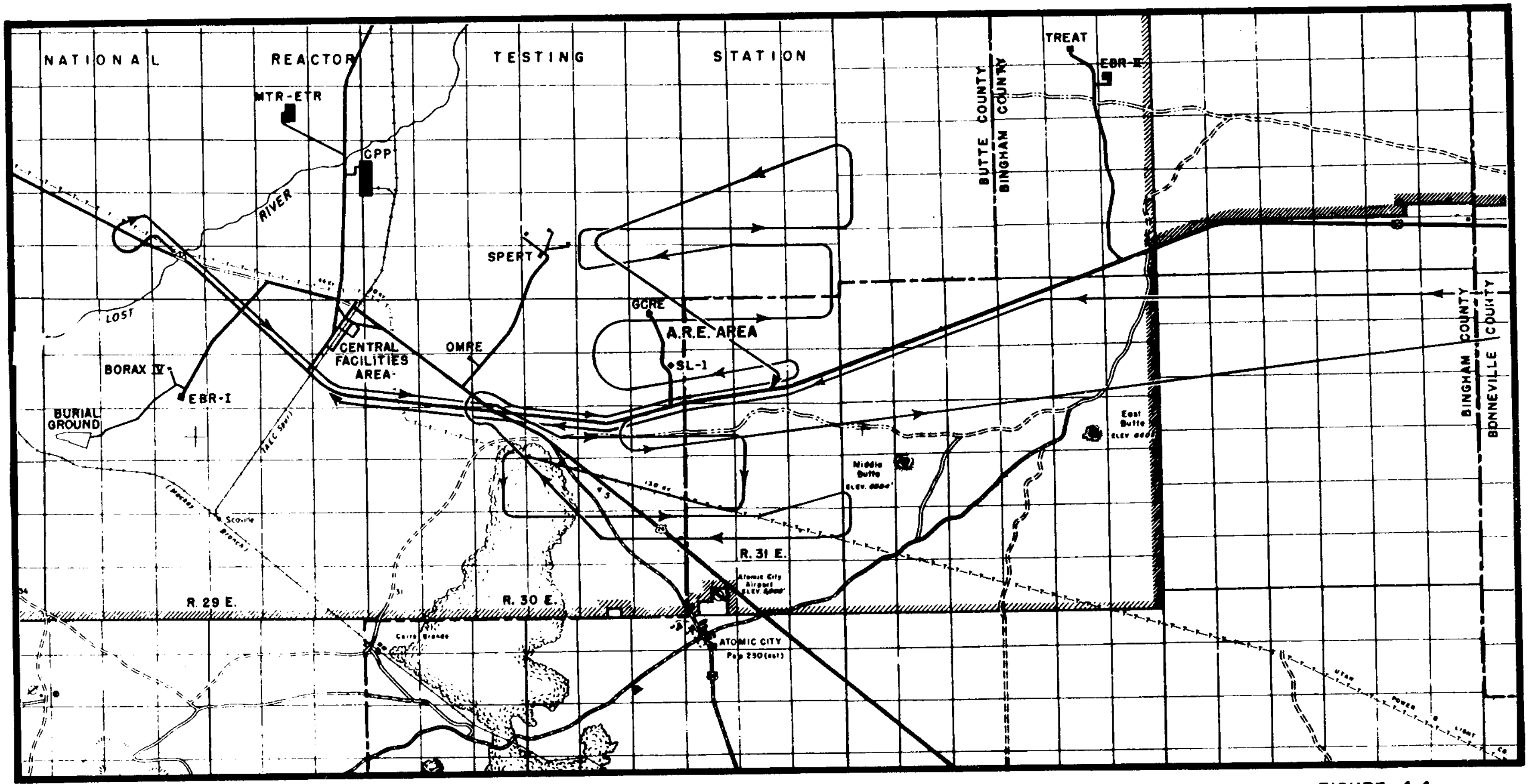


FIGURE 4.4

FLIGHT PATH

JAN. 8, 1961

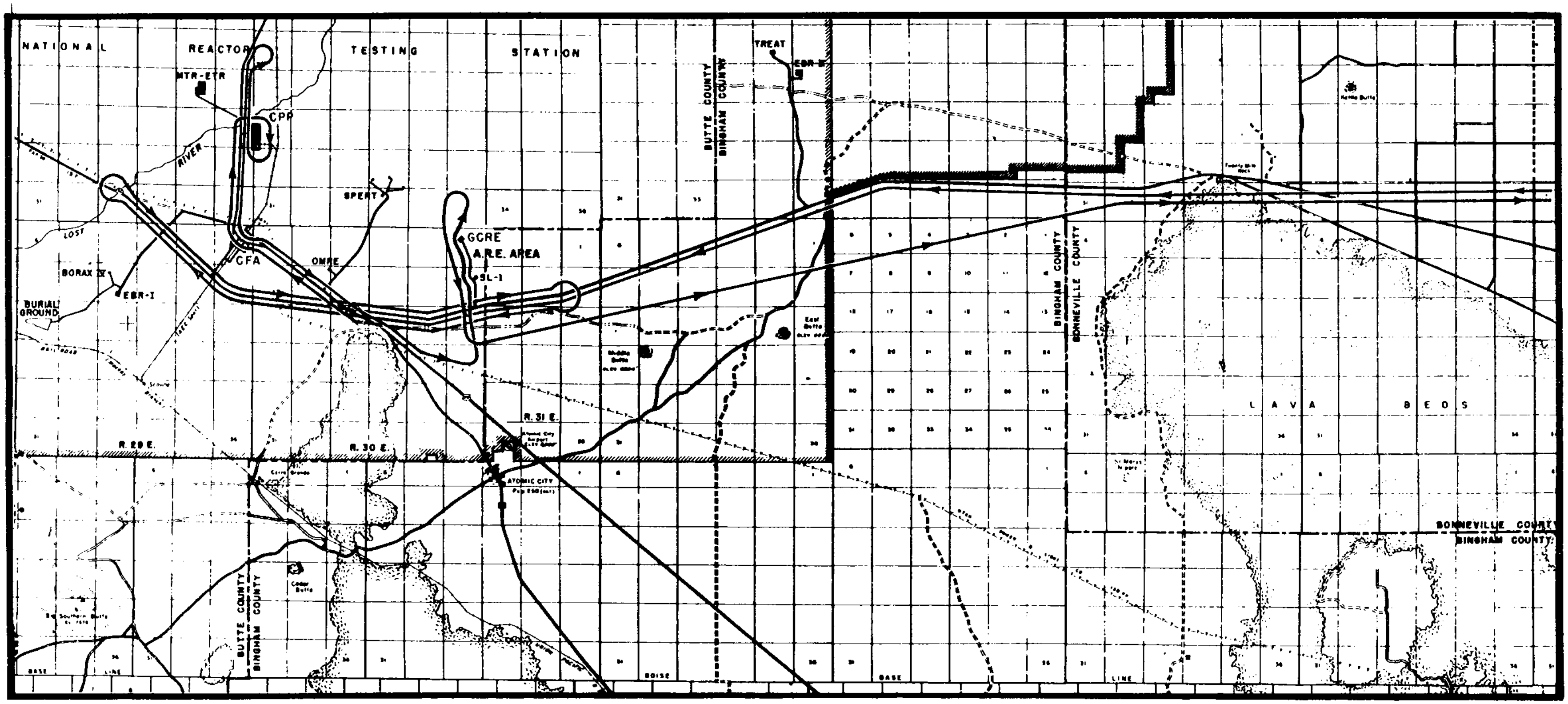


FIGURE 4.5

FLIGHT PATH

JAN. 12, 1961

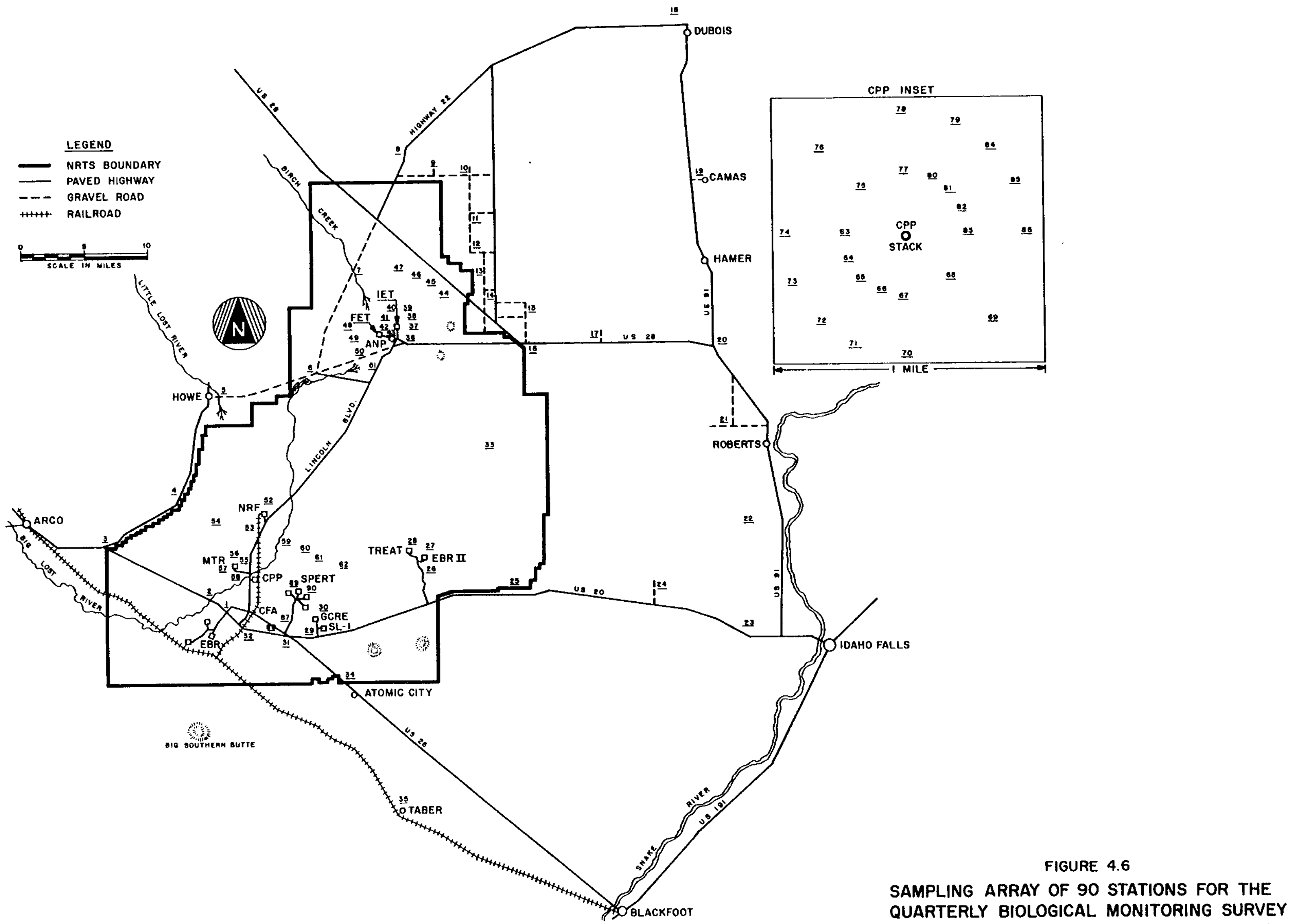


FIGURE 4.6

SAMPLING ARRAY OF 90 STATIONS FOR THE QUARTERLY BIOLOGICAL MONITORING SURVEY OF THE SOILS, VEGETATION, AND ANIMALS OF THE N.R.T.S. AND ENVIRONS.

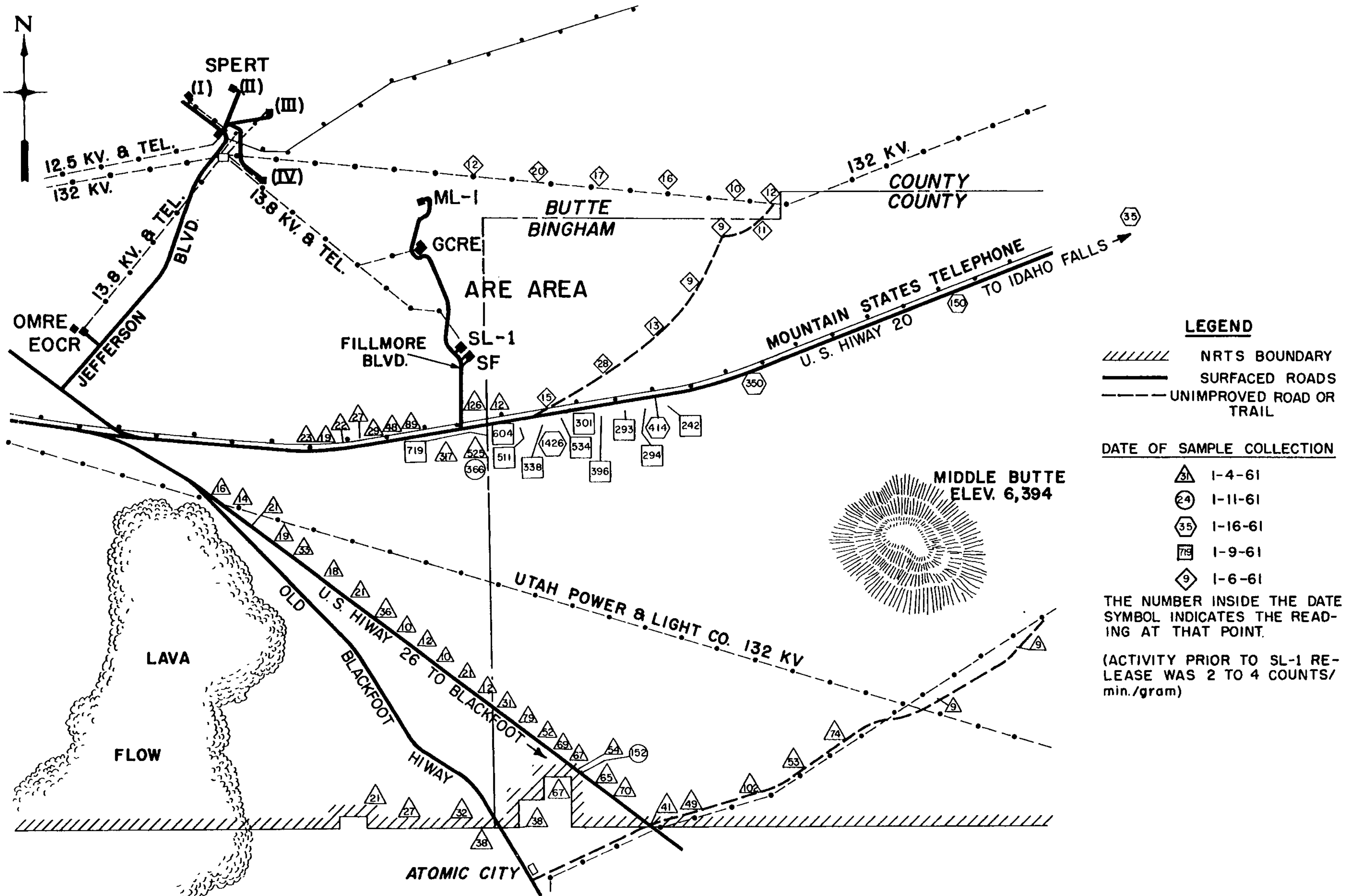


FIGURE 4.7

GAMMA ACTIVITY IN COUNTS/min./gram SAGEBRUSH AS FUNCTION OF LOCATION

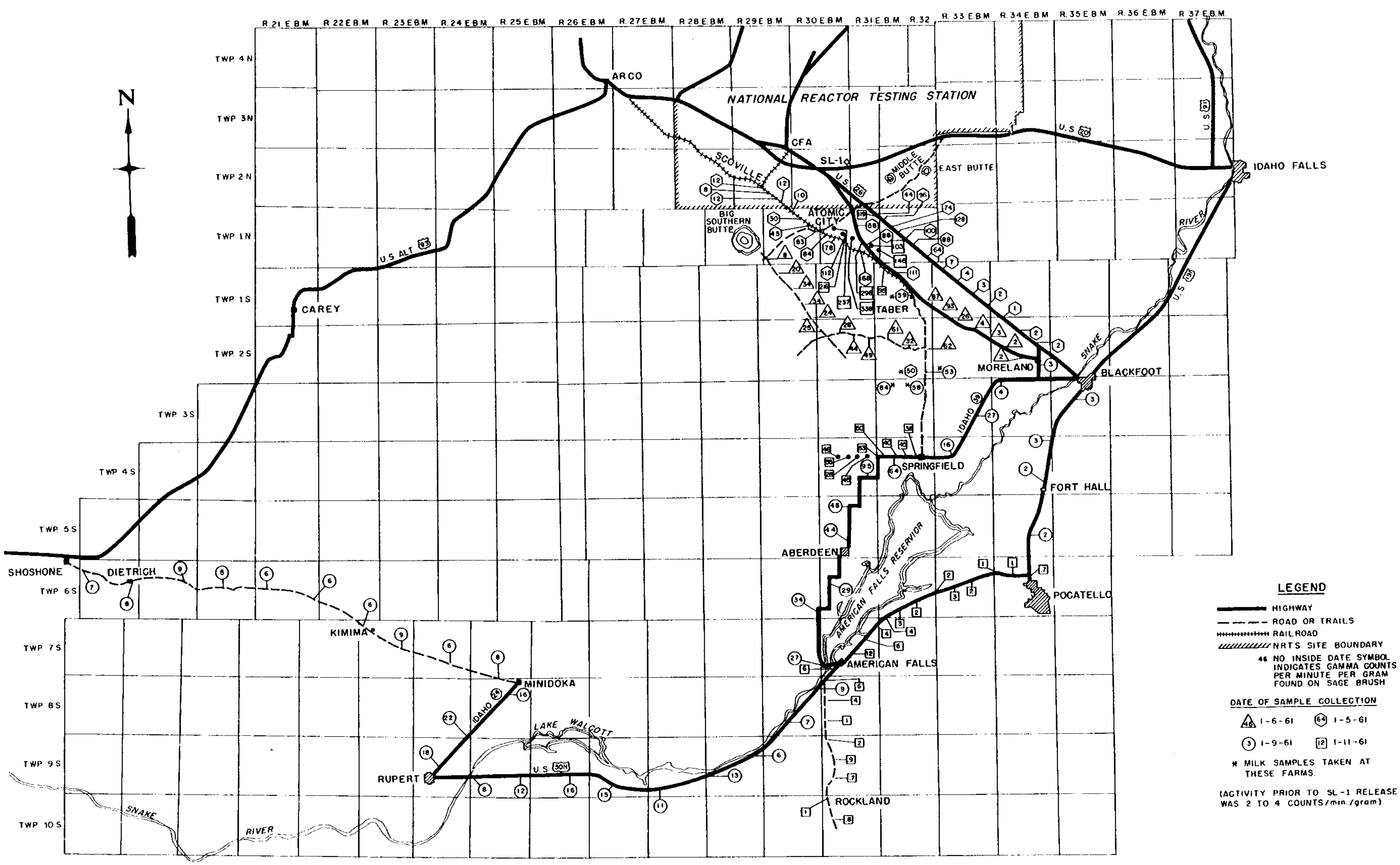


FIGURE 4.8
GAMMA ACTIVITY IN COUNTS/min./gram SAGEBRUSH AS FUNCTION OF LOCATION

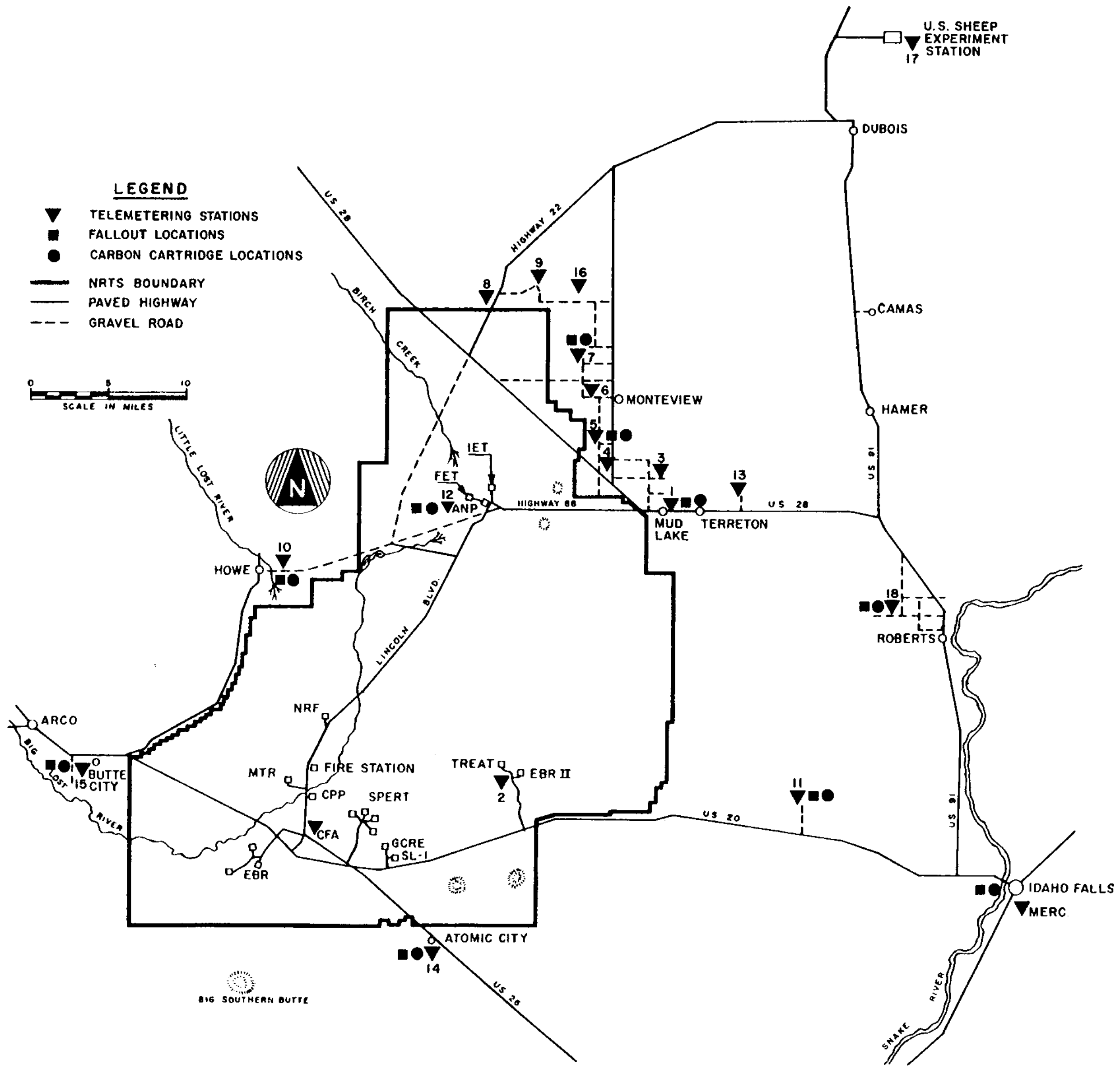


FIGURE 4.9
LOCATION OF RADIATION
MONITORING STATIONS

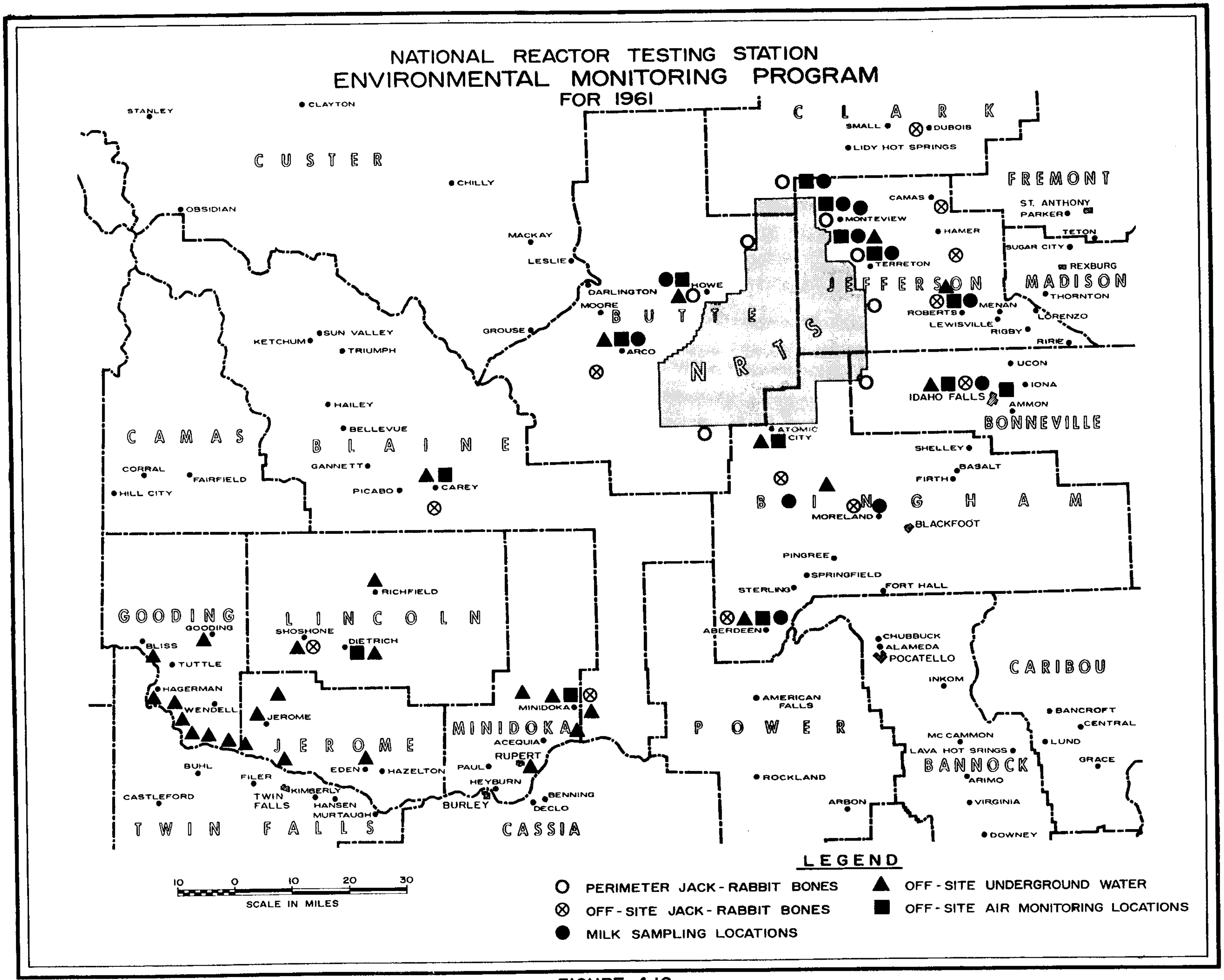

NATIONAL REACTOR TESTING STATION
ENVIRONMENTAL MONITORING PROGRAM
FOR 1961
CUSTER
CLARK
FREMONT
MADISON
JEFFERSON
BUTTE
NRTS
BONNEVILLE
BINGHAM
CAMAS
BLAINE
GOODING
LINCOLN
JEROME
MINIDOKA
TWIN FALLS
CASSIA
POWER
BANNOCK
CARIBOU
STANLEY
CLAYTON
CHILLY
OBSIDIAN
MACKAY
LESLIE
DARLINGTON
MOORE
HOWE
ARCO
GROUSE
KETCHUM
SUN VALLEY
TRIUMPH
HAILEY
BELLEVUE
GANNETT
PICABO
CAREY
CORRAL
FAIRFIELD
HILL CITY
SMALL
DUBOIS
LIDY HOT SPRINGS
CAMAS
MONTEVIEW
HAMER
TERRETON
ROBERTS
MENAN
LEWISVILLE
RIGBY
RIRIE
ST. ANTHONY
PARKER
TETON
SUGAR CITY
REXBURG
THORNTON
LORENZO
UCON
IONA
IDAHO FALLS
AMMON
ATOMIC CITY
SHELLEY
BASALT
FIRTH
MORELAND
BLACKFOOT
PINGREE
SPRINGFIELD
STERLING
FORT HALL
ABERDEEN
CHUBBUCK
ALAMEDA
POCATELLO
INKOM
AMERICAN FALLS
ROCKLAND
ARBON
MC CAMMON
LAVA HOT SPRINGS
ARIMO
VIRGINIA
DOWNEY
BANCROFT
CENTRAL
LUND
GRACE
RICHFIELD
SHOSHONE
DIETRICH
GOODING
BLISS
TUTTLE
HAGERMAN
WENDELL
JEROME
BUHL
FILER
TWIN FALLS
KIMBERLY
HANSEN
MURTAUGH
EDEN
HAZELTON
MINIDOKA
ACEQUIA
RUPERT
PAUL
HEYBURN
BURLEY
BENNING
DECLO
CASTLEFORD
10 0 10 20 30
SCALE IN MILES
LEGEND
PERIMETER JACK-RABBIT BONES
OFF-SITE JACK-RABBIT BONES
MILK SAMPLING LOCATIONS
OFF-SITE UNDERGROUND WATER
OFF-SITE AIR MONITORING LOCATIONS

FIGURE 4.10

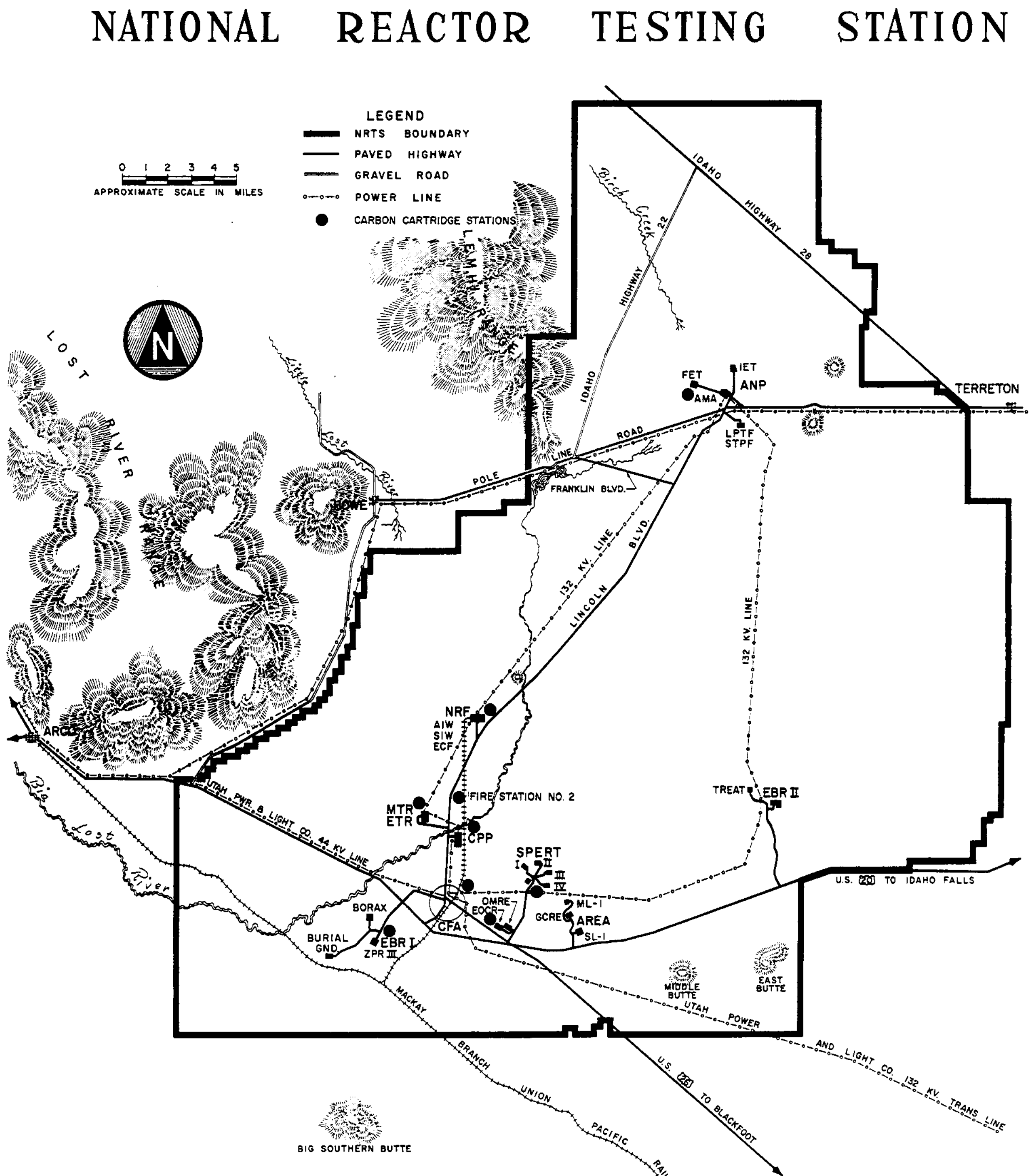


FIGURE 4.11

LOW VOLUME AIR SAMPLING STATIONS ON N.R.T.S.

NATIONAL REACTOR TESTING STATION

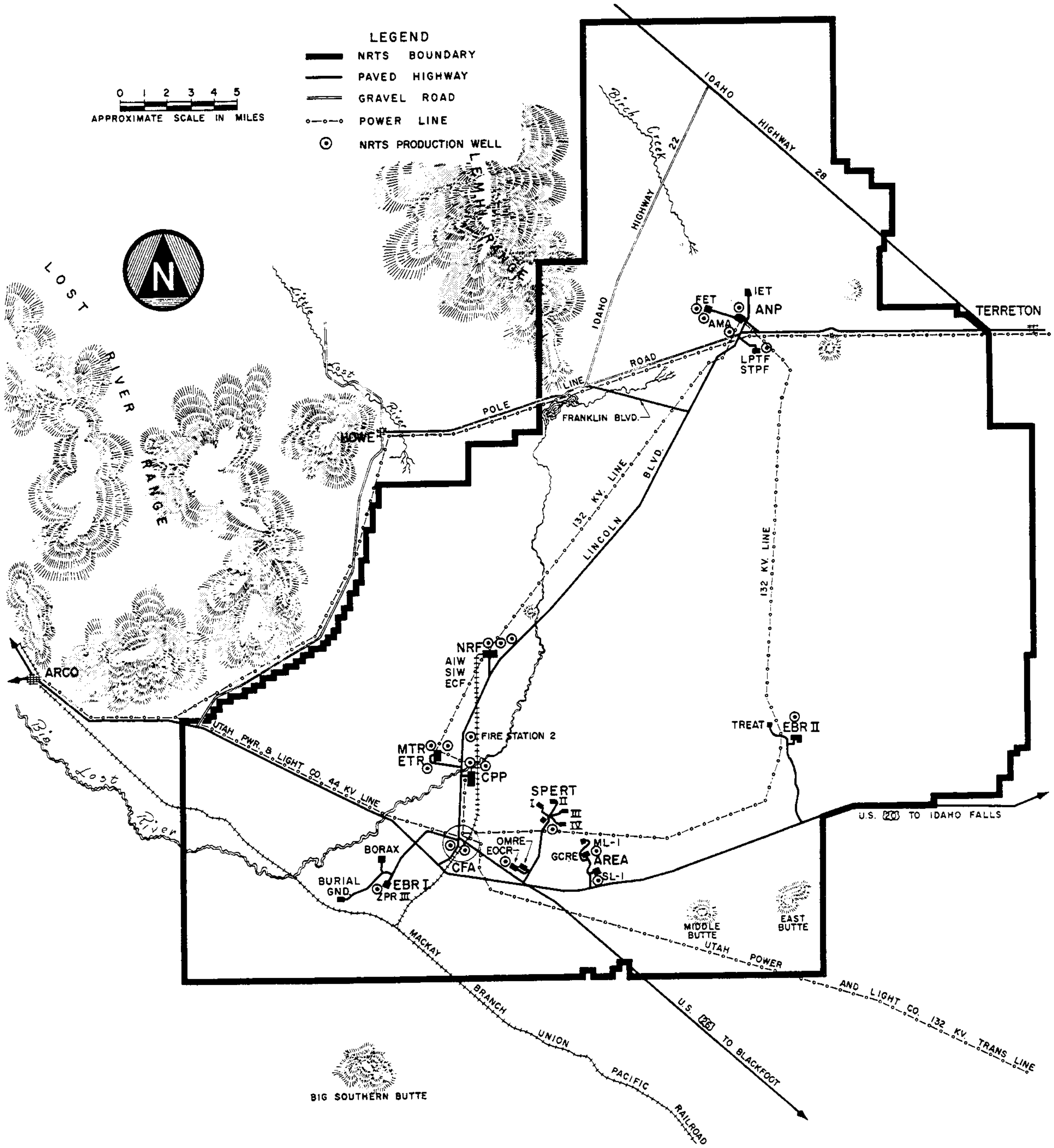
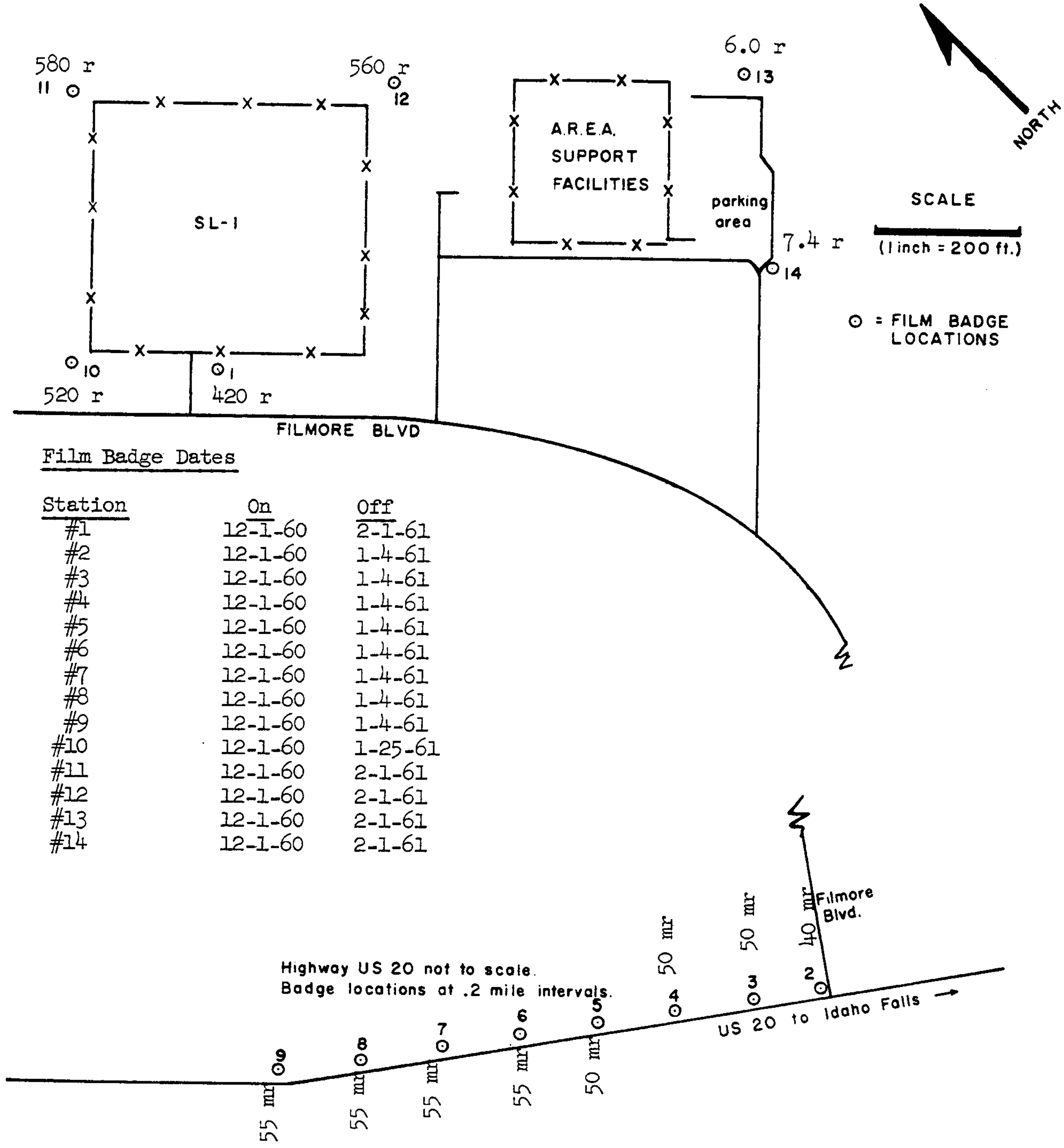


FIGURE 4.12

ON-SITE PRODUCTION WELL LOCATIONS

SL-1 AREA
FILM BADGE LOCATIONS AND RESULTS



Film Badge Dates

Station	On	Off
#1	12-1-60	2-1-61
#2	12-1-60	1-4-61
#3	12-1-60	1-4-61
#4	12-1-60	1-4-61
#5	12-1-60	1-4-61
#6	12-1-60	1-4-61
#7	12-1-60	1-4-61
#8	12-1-60	1-4-61
#9	12-1-60	1-4-61
#10	12-1-60	1-25-61
#11	12-1-60	2-1-61
#12	12-1-60	2-1-61
#13	12-1-60	2-1-61
#14	12-1-60	2-1-61

FIGURE 4.13

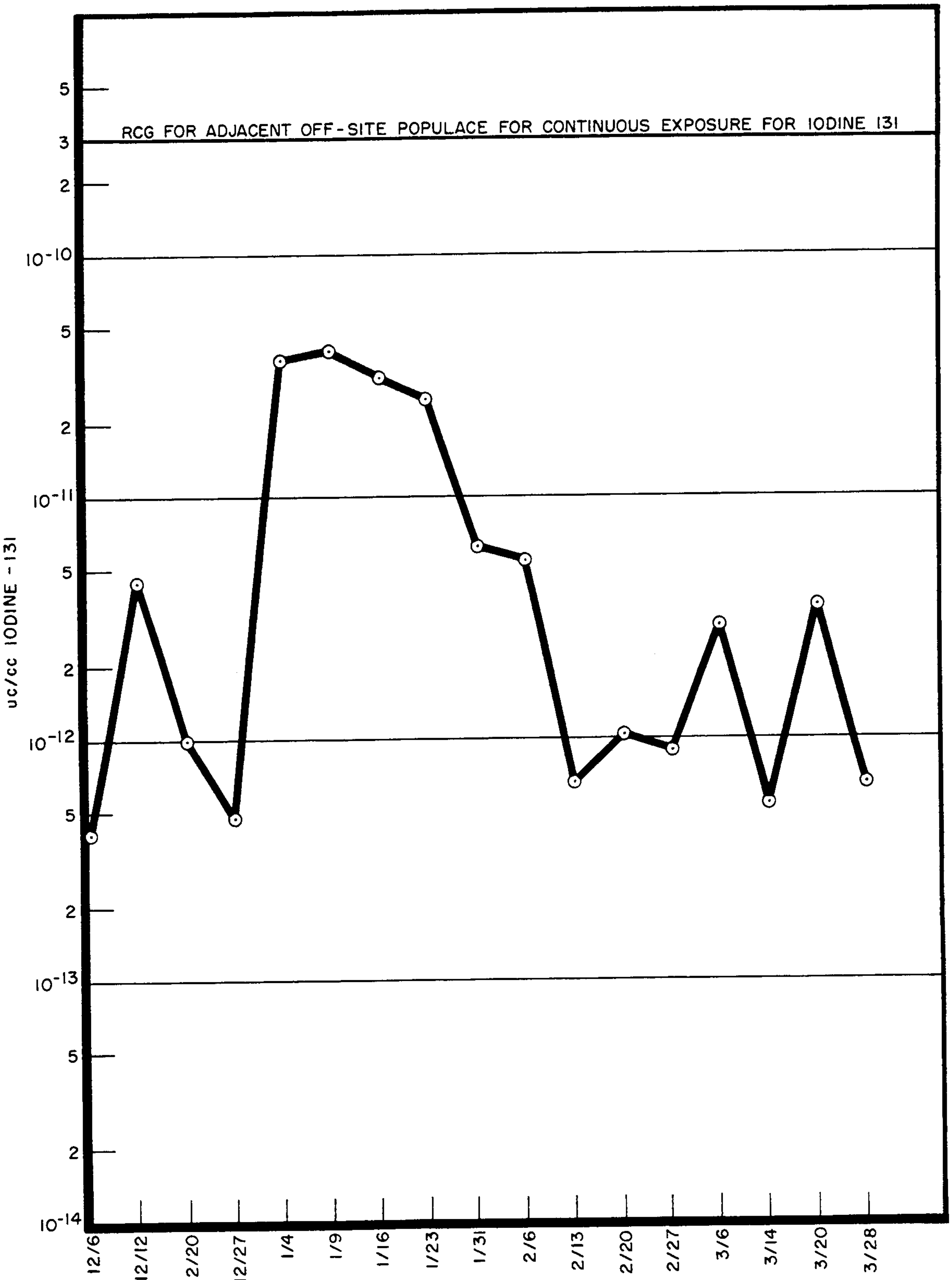
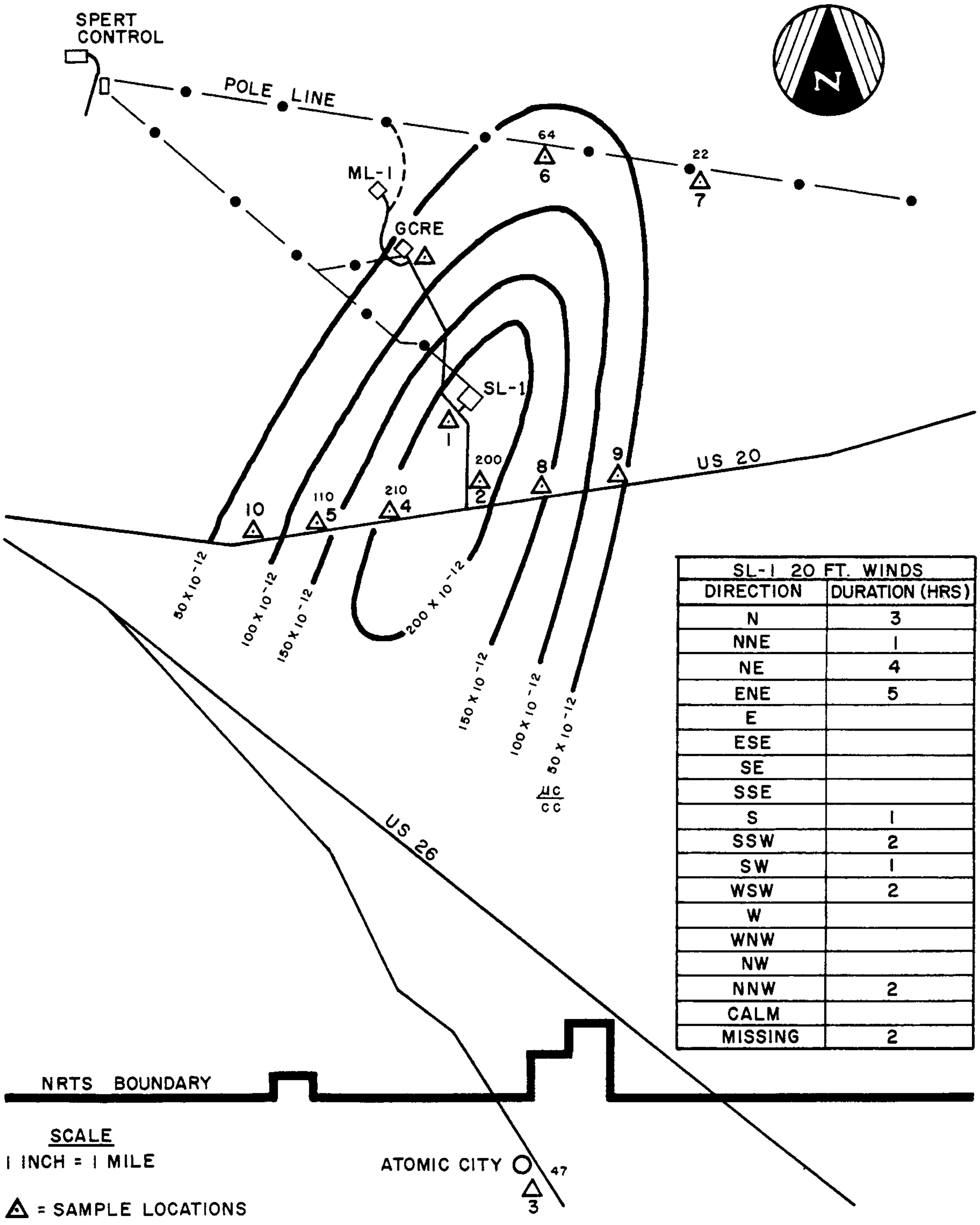


FIGURE 4.14

IODINE 131 CONCENTRATIONS - ATOMIC CITY

DATE ON 1/17/61 TIME 1300

DATE OFF 1/18/61 TIME 1200



SL-1 20 FT. WINDS	
DIRECTION	DURATION (HRS)
N	3
NNE	1
NE	4
ENE	5
E	
ESE	
SE	
SSE	
S	1
SSW	2
SW	1
WSW	2
W	
WNW	
NW	
NNW	2
CALM	
MISSING	2

FIGURE 4.15

SL-1 SAMPLING STATION LOCATIONS & IODINE 131 ISO-CONCENTRATION MAP

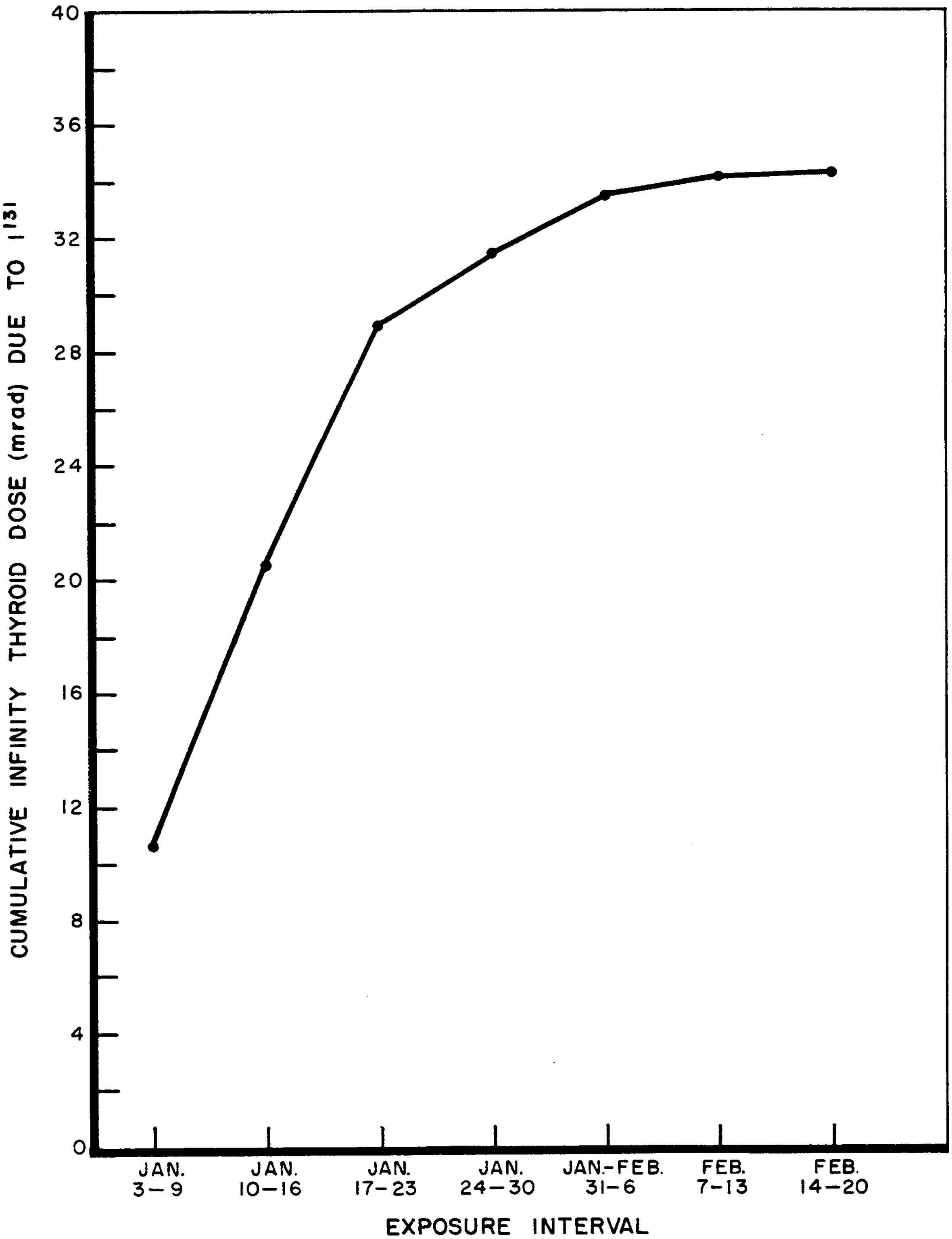


FIGURE 4.16

INFINITY IODINE-131 THYROID DOSE CALCULATED FROM AIR CONCENTRATIONS AT ATOMIC CITY DURING PERIOD JAN. 3, TO FEB. 20, 1961.

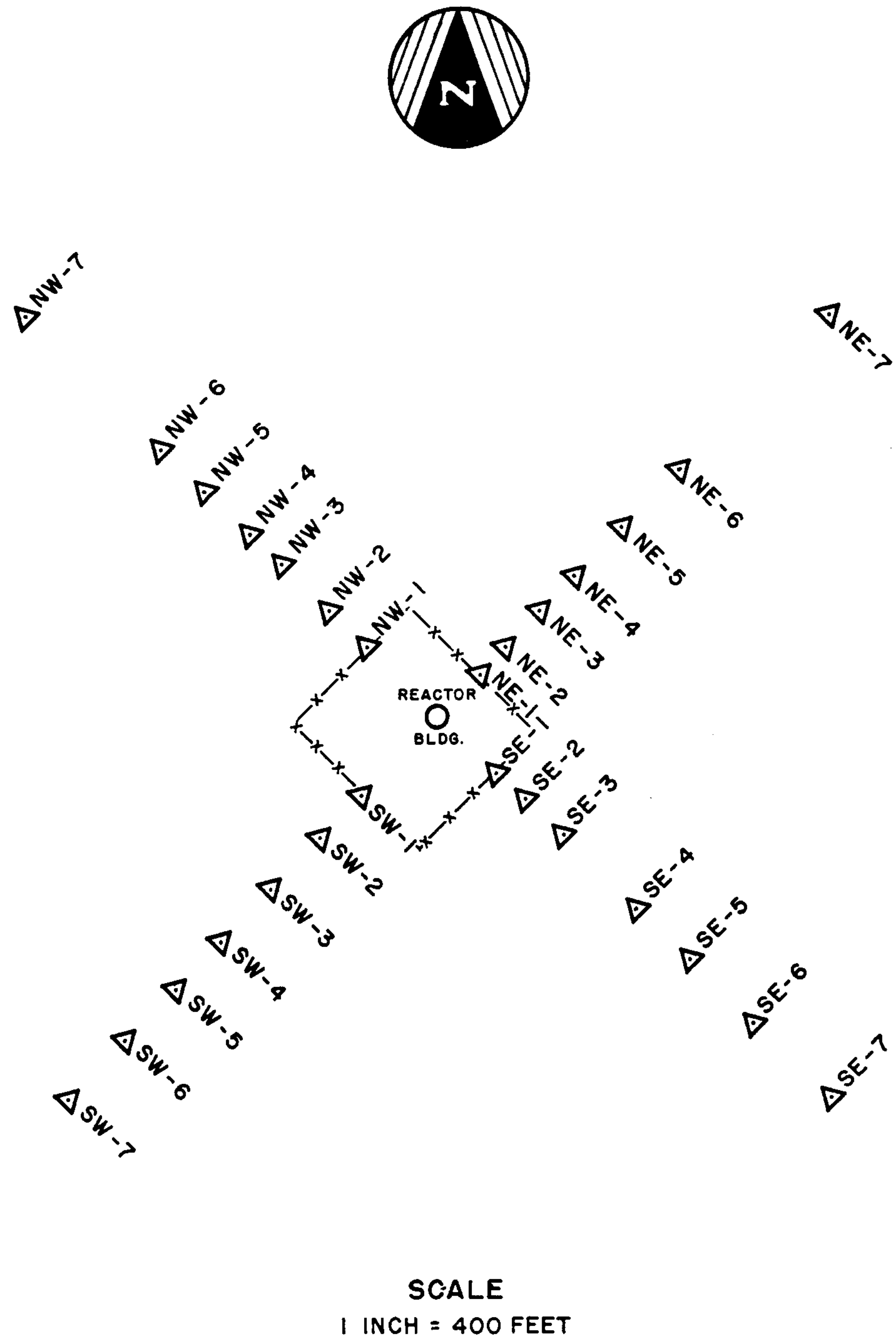


FIGURE 4.17

RADIATION SURVEY & FILM BADGE LOCATIONS SURROUNDING SL-1

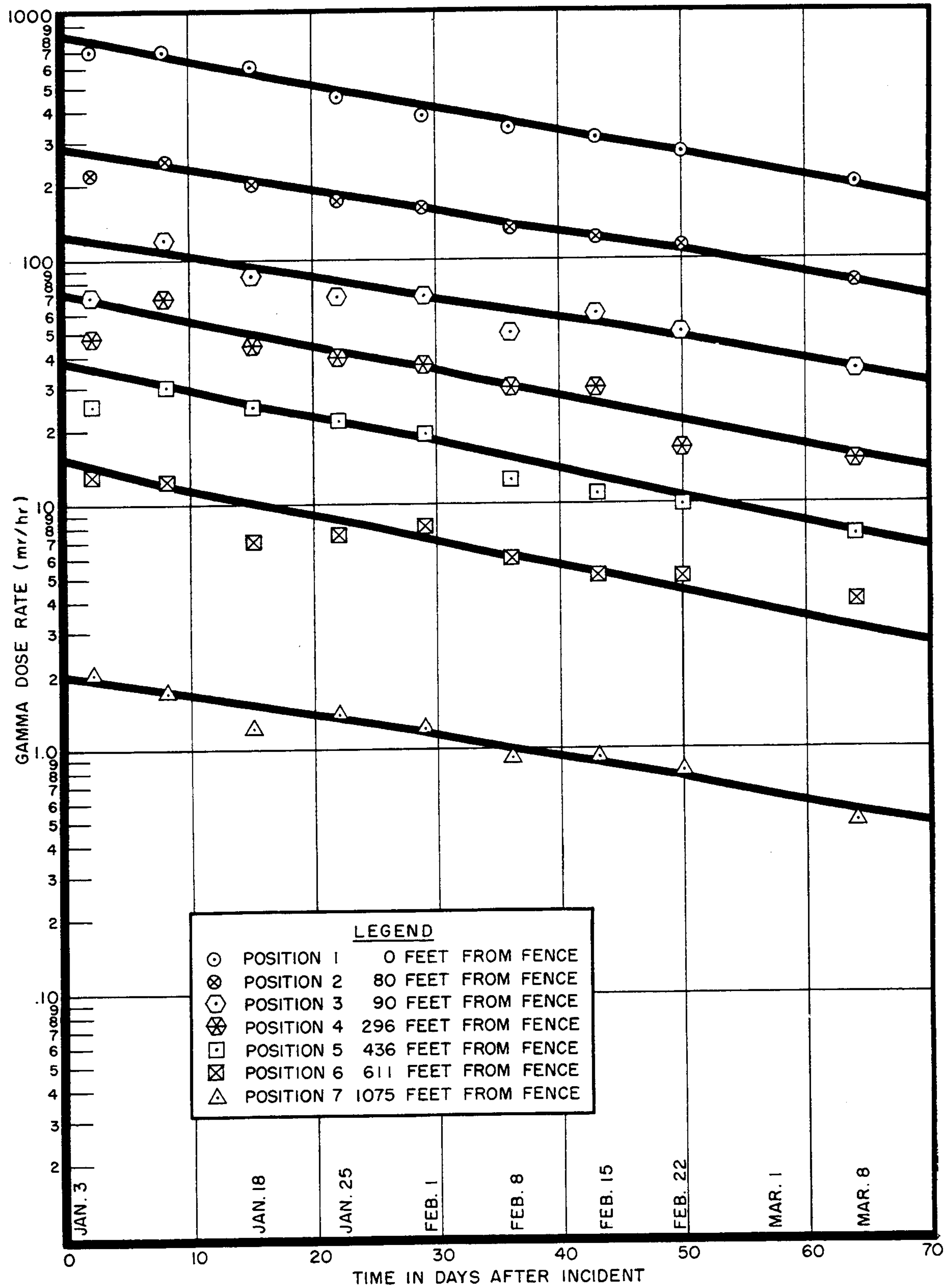


FIGURE 4.18

GAMMA DOSE RATE DATA - NE OF SL-1

SECTION 5

CASUALTY REPORT

The purpose of this section is to reconstruct, as accurately as possible, the events which took place in connection with the recovery of each casualty from the SL-1 Reactor Building, the transfer of each casualty from the SL-1 Area to the Chemical Processing Plant (CPP), the activities after the receipt of each casualty at the CPP, and the circumstances surrounding the burial of each casualty.

Location of Personnel

At approximately 10:45 p.m. on January 3, 1961, two men equipped with Scott Air-Paks made their way through the Support Facilities Building (#602) (see Figure 1.2) and up the covered stairway to the reactor operating room in search of three persons believed to be in the area. Prior attempts to locate these three people in nearby facilities and adjacent sites had proven unsuccessful.

Penetration of two to three feet onto the reactor floor revealed one person positioned near the Motor Control Board (MCB), and another person positioned between the shield block and the reactor head (see Figure 5.1). Radiation readings of 500 R/hr were noted at the top of the landing to the operating floor, and a radiation level of 500 - 700 R/hr was estimated to exist about two feet inside the room. Because movement of the first victim had been observed during the search, the two investigators hurriedly departed to obtain assistance for a rescue operation. The entire operation to locate the first and second victims was accomplished in approximately three minutes. As a result of these observations, an ambulance and a dispensary vehicle were dispatched to the SL-1 Area.

Following the recovery of the first casualty, a two-man team entered the reactor operating room and located the third deceased victim impaled to the ceiling of the reactor operating room.

Rescue Operation for the First Casualty

At 10:50 p.m. five men, including the two who made the initial entry, entered the reactor operating room with two stretchers to rescue the first casualty and, if necessary, the second casualty.

Arriving on the operating floor, the men positioned one stretcher near the entrance. Next, two men carried the casualty to where this stretcher was located and placed him upon it. During this operation, it was determined that the second casualty was dead.

Because one member of the rescue party developed a clogged Scott Air-Pak, it was decided to attempt to depart the reactor room with the stretcher via the emergency exit. This plan proved to be unsuccessful because the stretcher could not be maneuvered past the electrical generator; and, as a result, the two men had to depart with the stretcher the way they entered. The entire rescue operation was accomplished in about eight minutes; about three minutes were spent in the operating room and about five minutes within the SL-1 fence area.

Transfer of the First Casualty from SL-1 to CPP Area

At 11:00 p.m. the stretcher was placed into a courier vehicle which was then driven from the SL-1 gate to meet the ambulance. In the meantime, the ambulance had departed from the Control Point for the SL-1 gate. The vehicle and ambulance met about one-quarter of a mile from the SL-1 gate on Fillmore Boulevard where the stretcher was transferred into the ambulance. The ambulance then returned to the Control Point. At 11:05 p.m. the first victim was examined by a nurse at the Control Point and, even though he appeared to expire in the nurse's presence, a resuscitator was applied. At 11:14 p.m. the first victim was pronounced dead.

In an attempt to reduce the high radiation levels from the first victim, it was decided to remove the contaminated clothing. On January 4, at 5:30 a.m. a five-man team performed the disrobing operation. One member acted as timer, one as health physicist, another as recorder, and two persons did the actual disrobing. A one minute working interval was established for this task. During the operation readings of 100 - 200 R/hr were observed over the body and 300 R/hr at the upper extremity; however, the operation failed to decrease the radiation level by any noticeable amount. Subsequently, the first victim was wrapped in a blanket and placed into the ambulance against lead aprons situated behind the driver's seat. A radiation level of 800 MR/hr was observed in the driver's seat.

Prior arrangements had been made both for priority to be given the traffic transferring the first victim and for CPP Health Physics assistance. At 6:27 a.m. the ambulance departed from the SL-1 Area for the CPP

Decontamination Room. The ambulance was backed into the decontamination room where it was left (the body remaining inside the vehicle).

Decontamination of the First Casualty

On January 4, at 4:00 a.m. the CPP Decontamination Room was prepared to receive the first casualty. At 7:00 a.m. a three-man team prepared to attempt decontamination of the body. These personnel waited for film badge results of previous exposures, and at 9:30 a.m. they were permitted to proceed into the decontamination room accompanied by a Phillips Health Physicist who monitored the operation. Two men removed the body from the ambulance and placed the victim in the decontamination sink which had been prepared by CPP Personnel. The time involved in the transfer was approximately one minute. A quick attempt to reduce surface contamination by washing proved unsuccessful; as a result, extensive decontamination efforts were initiated which included detergents, etc. but still failed to accomplish a gross decontamination.

Rescue Operation for the Second Casualty

On January 4, at 7:00 p.m. a team was assembled and briefed on the procedures to be followed in the recovery operation for the second casualty. In order to keep the radiation dosages that would be received by the participating persons to a minimum, two two-man recovery teams were utilized.

At 7:20 p.m. the first two-man team, accompanied by two additional personnel, entered through the side entrance into the maintenance area of the support facilities building. A blanket was removed from the emergency equipment storage box located in the maintenance area and taken to the control room where it was spread on the floor. One member remained in the maintenance area while the other proceeded to the base of the covered stairway to act as timer for the first team. A limit of one minute in the reactor operating room was established, and the man positioned near the bottom of the stairway was to signal the first team the end of the minute.

The two men entered the reactor operating room and proceeded directly to the second casualty. The body was carried from the reactor operating room, down the covered stairway, and placed on the blanket in the control room. The time spent in the operating room was approximately fifty seconds.

The second two-man team, which had been waiting in the guard house, departed for the support facilities building at 7:30 p.m. The team made their way into the maintenance area through the side door, entered the control room, picked up the blanket containing the body, and departed. The second casualty was carried to a location approximately eight feet outside the SL-1 gate.

At 7:45 p.m. a clothing removal team composed of four people departed from the Control Point and completed this assignment by 8:15 p.m.

Again the clothing removal effort to reduce the radiation level proved relatively unsuccessful, since radiation readings of approximately 100 R/hr were observed at the upper extremities, while a radiation level of 500 R/hr was recorded near the center of the body.

Transfer of the Second Casualty from SL-1 to CPP Area

Another two-man team departed at 8:45 p.m. from the Control Point for the SL-1 Area in order to place the body into the rear of the ambulance which had been previously returned to the SL-1 Area. After this transfer operation was completed, a lead apron was placed over the body for shielding purposes.

At 9:11 p.m. the ambulance departed the SL-1 Area for the CPP Decontamination Room where the first casualty was located. After the ambulance was positioned in the CPP Decontamination Room, four men removed the lead apron from the body and placed the body in the decontamination sink where the first casualty was located.

Rescue Operation for the Third Casualty

Because the third casualty was believed impaled to the ceiling of the reactor operating room, it was decided to: (1) attach a stretcher to the end of a jib which was connected to the boom of a crane, (2) position the crane near the reactor building so that the stretcher would be beneath the body, and (3) dislodge the body in such a way that it would fall into the stretcher. On January 8, ten men entered the SL-1 Area at 5:04 p.m. to position the stretcher. These personnel returned to the Control Point at 6:00 p.m. To ensure that the stretcher was properly positioned, a two-man recovery team proceeded to the SL-1 Reactor Building at 7:01 p.m. Upon their return to the Control Point, they confirmed that the stretcher was in position. The second team proceeded at 8:06 p.m. to the reactor building to attempt to position the body in the stretcher. Subsequently, the second team returned to the Control Point and informed officials they were unsuccessful in this operation.

On January 9, at 12:30 a.m. four men entered the SL-1 Area near the reactor building, and by 12:45 a.m. successfully dropped the body into the stretcher. To verify that the body had fallen into the stretcher, two men entered the reactor room at 1:00 a.m. Again, as during all previous entries into the reactor room, an H.P. accompanied these two personnel to the foot of the stairway to act as a timer for the entry. They returned to the Control Point and reported the body was in the stretcher. Work was then suspended for the night.

Transfer of the Third Casualty from SL-1 to CPP Area

At 2:27 p.m. on January 10, the third casualty was lowered into a cask which had 4 inches of lead-lining and which had been positioned on a hot-waste, low-boy trailer. The truck-tractor attached to the trailer was driven to the Control Point where it was surveyed for radiation level. At 2:54 p.m. the unit departed from the Control Point escorted by four AEC Security vehicles; a roadblock was established for the entire course traveled. The following radiation levels were recorded in the control log:

50 MR/hr on the left side of the cask surface
500 MR/hr on the right side of the cask surface
5 R/hr at the right front corner of the cask

At 3:10 p.m. the transfer to CPP was complete.

During the next two days, efforts were made to decontaminate the three victims. Later, autopsies were performed.

PREPARATION OF CASUALTIES FOR BURIAL

On the morning of January 13, 1961, at the CPP Decontamination Room a team composed of eight men prepared the three bodies recovered from the SL-1 Reactor Building for burial.

First Casualty

Prior to preparing the first casualty for placement in the casket, a survey was performed and the following radiation readings were observed at contact:

Head --2.0 R/hr (Front)
--6.5 R/hr (Back)

Chest	--1.5 R/hr
Buttocks	--5.0 R/hr
Feet	--0.6 R/hr

The body was wrapped in 1/8 inch lead sheeting with extra pieces added about the head. A maximum reading of 2.1 R/hr was observed on contact in the head region; and at a distance of one foot above the "hot" spot, a reading of 500 MR/hr was obtained. Next, the leaded package was banded with metal straps and placed in a casket. After extra lead strips were positioned in the casket to further reduce the radiation levels, the lid was closed. Before locking the casket a cardboard "Caution - High Radiation Area" and a plastic "Caution - Radioactive Materials" sign were placed into the casket. Subsequently, the casket was locked, the vault cover positioned, and the surface surveyed at contact. The maximum radiation readings observed were 375 MR/hr on the vault cover and 1.3 R/hr on the vault base. Radiation readings taken at a distance of one foot from the vault cover yielded a maximum of 130 MR/hr. All points normally accessible were below 1.0 R/hr at contact.

Second Casualty

Prior to preparing the second casualty for placement in the casket, a survey was performed and the following radiation readings were observed at contact:

Head	--12.0 to 15.0 R/hr
Body	-- 2.5 R/hr
Knee	-- 2.5 R/hr

After wrapping the body in 1/8 inch thick lead sheeting, extra strips were placed about the head to reduce the radiation levels in that region to 2.1 R/hr maximum on contact. Next, the leaded package was placed into a casket. Because of the high radiation levels noted from the package, the casket had been provided with extra lead sheeting on the bottom, sides, and end where the head was located. After placing the lead encased body into the casket, the entire package was completely covered with a lead sheet 1/8 inch thick and banded with steel straps. Additional lead strips were strategically placed on the inside of the casket to further reduce the radiation level. A "Caution - Radioactive Materials" and a "Caution - High Radiation Area" sign were placed into the casket prior to closing the cover. The entire surface of the casket was surveyed and a 750 MR/hr maximum on the upper surface of the casket and a 1.8 R/hr maximum at one point underneath the vault was observed. All points normally accessible were below 1.0 R/hr. Upon completion of this preparation operation, the casket lid was locked, the vault cover positioned, and the surface surveyed at contact. A maximum reading of 450 MR/hr was observed.

Third Casualty

The following radiation readings were observed at contact:

Head	--30 R/hr
Chest	--50 R/hr

The third casualty previously covered with 3/4 inch lead sheets, was placed into a casket and the casket lid closed. Except for the bottom surface of the casket, a radiation survey revealed a maximum reading of 500 MR/hr on contact. After a cardboard "Caution - High Radiation Area" and a plastic "Caution - Radioactive Materials" sign were placed into the casket, the casket was locked, and the metal vault cover was positioned. The entire surface of the vault was surveyed, and a maximum reading of 600 MR/hr was observed at one point on the bottom and a reading of 350 MR/hr at contact on the cover. A maximum reading of 200 MR/hr was obtained from a survey meter held at a distance of one foot from the vault cover.

BURIALS OF CASUALTIES INVOLVED IN THE SL-1 INCIDENT

From January 13-22, arrangements were made for the final interment of the three victims, and on January 22, a U. S. Air Force C-54 aircraft containing the caskets of two of the casualties departed Idaho Falls, Idaho, accompanied by two U. S. Army Representatives and an AEC Official. The plane arrived late that same evening at Griffis Air Force Base, Rome, New York, where one casket was removed; one military escort and the AEC official accompanied this casket. Later, the aircraft continued on to Washington, D. C. where the remaining casket was delivered for burial in Arlington, Virginia.

At Griffis Air Base, the casket was removed from the plane by means of a fork lift, transferred to an Air Force truck and transported to the garage of an armory located in Utica, New York.

On the morning of January 23, radiation measurements were taken at the surface of the vault with a Jordan detector instrument, and are listed below. Contamination surveys were made by means of smears which were read on a Geiger Mueller (GM) instrument.

Radiation Measurements (MR/hr)

	Head	Middle	Foot
Top of Vault:	100 - 200	200	75 - 200
Left Side of Vault:	500	400	300
Right Side of Vault:	400	300	250
Bottom of Vault:	Maximum at head	1 R/hr at horizontal plane of base 2 R/hr at surface with arch	

Contamination Checks

Nine soft paper smears were taken covering all outer surfaces (except the bottom). These were counted with a G. M. instrument and were all determined to be at normal background level (approximately .03 MR/hr). No radiation readings were taken other than those listed above.

On January 24, the grave was opened and a cement base of fourteen inches was poured. On the morning of January 25, the truck containing the vault and a mobile crane arrived at the cemetery. The mobile crane lifted the vault from the truck, placed it on a vault hoist, and then the truck and crane departed. The depth of the grave to the top of the concrete base is approximately six and one-half feet. All sides and the top of the vault are contained in approximately twelve inches of concrete.

Film badges and dosimeters were not worn by personnel after the arrival of the body in Utica. It is believed that the health physics procedures which were followed are substantiated by the low radiation doses estimated to have been received by the populace.

1. The maximum reading at the surface of the vault (excluding the bottom) was 500 MR/hr.

2. The maximum reading at one meter from the vault was 90 MR/hr, with an average of 80 MR/hr.

3. Persons working in close proximity to the vault would be exposed to less than 80 MR/hr (considering whole body).

4. Shoring of the vault was accomplished in approximately two hours and intimate exposure was at a minimum during this period.

It was estimated that no person received in excess of 100 MR (vault shoring) and that the majority of those persons who had anything to do with the burial received appreciably less than 25 MR.

The Air Force C-54 aircraft with the remaining casket aboard arrived at Bolling Air Force Base, Washington D. C., at approximately 3:30 a.m. on January 23, 1961. The aircraft was parked in a remote section of the Base and placed under guard.

At 10:45 a.m. a team composed of military personnel and an AEC Representative arrived at the aircraft to remove the vault. After entering the aircraft the vault was surveyed with a Juno radiation detector and the maximum results are listed below. Contamination surveys were made by means of smears which were read on a Geiger Mueller (GM) instrument.

Radiation Measurements (MR/hr)

	Head	Foot
Top of Vault:	100	20
Base of Vault:	200	50
Sides of Vault:	150	50
Bottom of Vault:	500	--

Contamination Checks

Individual smears were taken at the base near the head and the foot of the vault, and the top of the vault. These smears were checked with a GM instrument (beta shield open) and no reading above background was observed.

The vault was then removed from the aircraft by a fork-lift and placed on a flatbed truck in approximately fifteen minutes. Pocket dosimeters worn by two of the personnel involved in the transfer recorded a radiation dose of 5 MR.

In the cab of the truck a dose rate of 7 MR/hr was measured, and the trip from Bolling Air Force Base to the cemetery took about one-half hour. At the cemetery the vault was removed from the truck by a fork-lift, placed on a dolly and taken into an unused chapel. The transfer operation required approximately five minutes.

The chapel was divided into two sections by a large sliding door. Radiation surveys taken outside of the chapel indicated no levels above background. A radiation rate of 5 MR/hr was observed at the sliding door which separated the vault storage area from the chapel. No person was allowed to enter the vault storage area and only one person was allowed to enter the chapel area while the vault was being stored. During the nights of January 23 and 24, the chapel was periodically checked to assure that it was locked. On the morning of January 24, a second radiation survey was made outside the chapel, and again only background radiation levels were observed.

On January 25, the vault was surveyed prior to its transfer from the chapel to the grave site. The results obtained from this survey essentially corresponded to those previously noted at the aircraft. After the survey, the vault was removed from the chapel and placed on a flatbed truck by a fork-lift. The vault was then transported to the grave site where it was removed by a mobile crane and placed over the grave on a vault hoist. Then the truck and mobile crane departed.

The interment service took approximately eight minutes, during which time six men were positioned about one foot from the vault, their estimated dose not exceeding 10 MR. Other personnel were located at approximate distances greater than four feet from the vault, and the majority of attendees were at least twenty feet from the vault.

After the interment service had been completed and the public had departed, the vault was lowered ten feet below the surface of the ground and placed onto a concrete base. Next, several yards of concrete were poured into the grave. It is estimated that at least twelve inches of concrete surround the vault. A radiation survey was then made using a Juno and G.M. survey meter and indicated no radiation levels above background.

The remaining casket was shipped by a Navy R 5 D aircraft from Pocatello, Idaho, on January 22, 1961, and arrived at the Tri-City Airport, Saginaw, Michigan, that same evening. Arrangements had been made with the Chicago Operations Office for the Director, Health and Safety Division, to monitor the burial operation.

Upon arrival of the Navy plane, the shipping container was removed by a fork-lift and loaded on a truck, which then transported the container to a local vault corporation where it was stored under lock overnight. On January 23, the container was transported to Kingston, Michigan, which is approximately sixty miles west of Saginaw.

Radiation readings taken with a Juno detector instrument held about three inches from the surface of the container were: 180 MR/hr at the foot to a maximum of 300 MR/hr at the bottom left hand corner of the casket head.

At the Kingston Cemetery, a request was made that the casket be removed from its shipping container and displayed. As a result, the casket was displayed in military style. Radiation readings taken three inches from the surface ranged from 240 MR/hr to 500 MR/hr, the lowest reading being at the foot and the highest at the head. The graveside interment service took about five minutes. It should be noted that most of the persons attending the service were located at an approximated distance of more than five feet from the casket.

Approximately ten minutes were spent placing the casket into the grave. Two yards of concrete had been previously poured to form the base of the grave, and another six or seven yards of concrete were added over the casket. It is estimated that the casket is encased in a crypt of concrete measuring approximately eighteen inches on the bottom, two feet on all sides and approximately twenty inches to two feet on top.

Time was allowed for the newly poured concrete to harden after which a set of radiation measurements were taken. The measurement did not indicate any activity above background. The grave was then covered with earth and the readings repeated with the same results.

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has been deleted from this report -

TABLE 5.1

SUMMARY OF SURVEYS ON CASKETS AND VAULTS*

All Readings (mr/hr) Below are Maximum and at Contact.

	Top	Front	Back	Head	Foot	Bottom	Est. Weight Lead Used
Third Casualty - Casket	440	500	450	165	20	---	750 Lbs
Vault	350	320	320	100	10	600	
Vault (at one foot)	200	200	200	80	12		
First Casualty - Casket	310	450	850	380	85	---	450 Lbs
Vault	220	320	375	325	50	1300	
Vault (at one foot)	100	120	130	110	40	---	
Second Casualty - Casket	310	350	750	115	120	---	650 Lbs
Vault	230	310	450	110	80	1800	

It should be noted that all areas normally accessible to persons viewing a casket during the funeral ceremony are below the 20 mr/hr radiation level at a distance of six feet.

*Metal vaults were used.

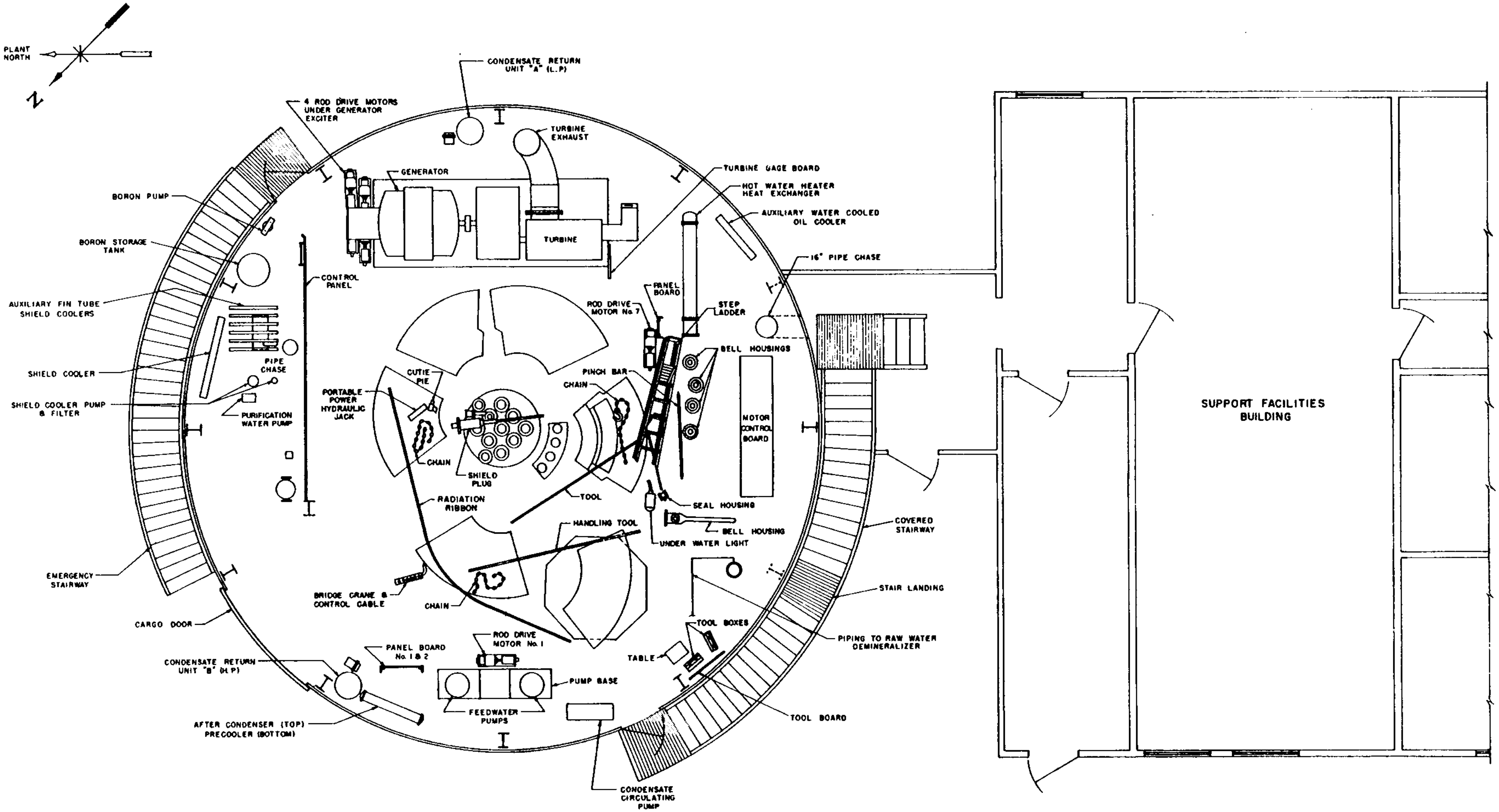

FIGURE 5.1
DIAGRAM OF
SL-1 OPERATING FLOOR AFTER INCIDENT

SECTION 6

ADMINISTRATION

I. MOBILIZATION

On January 3, 1961, at 9:01 p.m. personnel from the AEC-IDO Fire Department and Security Division responded to a fire alarm received from the SL-1 Reactor Building. Approximately nine minutes later, at 9:10 p.m., those personnel arrived at the SL-1 Area, which is located about eight miles from their station. In order to provide health physics coverage at the SL-1 facility in the event radiation was involved, the IDO Dispatcher requested that a Phillips Petroleum Company (PPCo) Health Physicist located at the nearby Materials Testing Reactor (MTR) be dispatched to the SL-1 Area. The PPCo Health Physicist arrived on the scene at 9:17 p.m., whereupon he assumed charge of the operational activities from the IDO Fire Department.

Between 9:25 p.m. and 9:30 p.m. the request for additional health physics support, i.e., personnel and equipment, was broadcast via the National Reactor Testing Station (NRTS) radio network.

By 9:36 p.m., AEC-IDO Management and Combustion Engineering, Inc., Officials were informed that an accident had taken place at the SL-1 Facility.

At 9:50 p.m. radio contact was established between the IDO Health and Safety Division personnel enroute to the SL-1 and the PPCo-MTR Health Physicist at the SL-1. IDO assumed control responsibilities at this time.

By 10:25 p.m. a Control Unit was established at the Idaho Operations Office and declared the SL-1 Incident to be a Class I Disaster. The declaration was broadcast via the NRTS radio network.

At approximately 10:35 p.m. personnel from the IDO Health and Safety Division arrived at the SL-1 Area and assumed direction of the operational activities. The control and operational direction of the SL-1 Disaster Operation was, therefore, under IDO direction at this time.

In the days that followed, personnel from NRTS on-site contractors, AEC off-site contractors, and military groups were mobilized to assist in all phases of the SL-1 Disaster Program.

II. ORGANIZATION

A. Disaster Operations

Prior to the arrival of IDO Health Physics personnel at the SL-1 Area, the responsibility for directing operational activities was assumed by the first PPCo. MTR Health Physicist on the scene. After the SL-1 Incident had been declared a Class I Disaster and upon the arrival of IDO Health Physics personnel at the SL-1 Area, IDO assumed control of the SL-1 Area.

The IDO Manager assumed responsibility for the approval of the over-all emergency plans and procedures which were to be implemented in the SL-1 Area. In order to assist the IDO Manager in the evaluation of the proposed plans submitted to IDO, a Technical Advisory Committee was appointed on January 4 (see Figure 6.3). The IDO SL-1 Site Coordinator was responsible for the execution of those plans approved by authorized IDO officials.

The organizational structure utilized throughout the SL-1 Incident was composed of (see Figure 6.1):

1. The Control Unit which consisted of the IDO officials who reviewed and approved program plans and procedures for SL-1 activities.

2. The Directional Unit which consisted of the SL-1 Site Coordinator and his staff who supervised the execution of the SL-1 activities.

3. The Operational Unit which consisted of the personnel who performed the SL-1 activities.

AEC-IDO maintained the authority to review and approve all plans and procedures that related to the SL-1 throughout the incident. The Operational Unit in all cases submitted a proposed plan which described a specific task to be performed within the SL-1 controlled area. The proposal was then reviewed by the Control Unit and, if deemed necessary, by the Technical Advisory Committee (TAC) to the Control Unit. If the proposal was approved, the Directional Unit would be informed of the approved mission and would be requested to supervise the operation.

On January 4, at 9:00 p.m. the responsibility of the Operational Unit (with the exception of Health Physics) was transferred from IDO to Combustion Engineering, Inc. The direction of health physics functions was not transferred at this time because of the lack of numbers of trained contractor health physicists.

On January 5, the IDO Manager approved IDO Manual Appendix 0502, quoted below, which assigned the chain of command responsibilities:

"Chain of Command for the SL-1 Recovery Operation"

"To reiterate the responsibilities for the SL-1 Incident Recovery Operation and in order that there shall be no misunderstanding, the following is the chain of command:

I. IDO has responsibility for:

(a) Administration of the Combustion Engineering contract, including approval of the Contractor's recovery operations.

(b) Over-all coordination of recovery operations during the present SL-1 emergency.

(c) Handling all public relations aspects of the operations.

More specific responsibilities under (b) are:

(1) IDO Security Division controls access to NRTS and particularly to the SL-1 Area.

(2) IDO Health and Safety Division controls access to hazardous areas, including the setting of radiation exposure limits.

II. Combustion Engineering as SL-1 operating contractor has the responsibility, with IDO concurrence, for:

(a) Administrative control of Health and Safety and Security within the SL-1 perimeter in accordance with (1) and (2) above.

(b) Operational activities, including the integrated use of military personnel, for:

(1) Over-all SL-1 operations, including the present recovery operations.

(2) Providing supervisory personnel.

(3) Arranging for consulting services.

(4) Evaluation of operational and research data and the submission of required reports."

IDO maintained complete health physics control until January 15, whereupon Combustion Engineering, Inc., was delegated this function. Thereafter, IDO continued to provide health physicists at the SL-1 Control Point in order to observe operations and to ensure adequate protection of personnel and criteria for exposure limits.

During the early days of the incident, the IDO SL-1 Site Coordinator was authorized to approve personnel access into the SL-1 Area. The IDO Security Division, which was responsible for guarding the area throughout the incident, was notified by the IDO SL-1 Site Coordinator of those persons obtaining access.

Later, on January 7, the IDO Manager directed that all entries into the SL-1 Reactor Building must have the prior approval from the IDO Control Unit. This would ensure that directing personnel would be cognizant of all persons entering the radiation zone.

On January 15, at 8:00 a.m. the responsibility for the Directional Unit was transferred from IDO to Combustion Engineering, Inc.

After Combustion Engineering, Inc. (CEI), assumed responsibility for the Directional and Operational Units, missions were planned and executed as follows:

1. CEI, IDO, or TAC conceived the idea for a specific mission to be performed. CEI reviewed the idea and would prepare a proposal.

2. The proposal was submitted to the Control Unit and TAC for its review. TAC would submit its recommendations to the IDO Manager.

3. The IDO Manager, as head of the Control Unit, approved, with or without revision, or disapproved the proposal. If approved, the proposal was assigned to CEI for implementation.

4. CEI briefed the personnel involved in the operation and informed IDO Health Physics members.

5. When appropriate, practice runs were performed. Just prior to executing the mission, participants attended a health physics briefing.

6. Upon satisfactory completion of these initial procedures, the operation was executed.

7. After the mission, the people who performed the task were debriefed by CEI personnel, who, in turn informed IDO Officials. CEI maintained close liaison with the

Director, Health and Safety Division, throughout the planning and operational phases of the mission.

B. AEC Committees

1. AEC Board of Investigation

On January 4, the AEC General Manager established an AEC Board of Investigation to investigate and report to him on the incident (see Fig. 6.4). The General Manager requested the Board to provide in its report information as to (1) nature and extent (including costs of the Incident), (2) cause of and responsibility for the incident, (3) corrective action appropriate to minimize or preclude similar incidents, (4) probability and validity of claims against the Government, and (5) improvement of AEC policies, standards and regulations and operations thereunder. The General Manager instructed the IDO Manager to make the IDO Chief Counsel and other personnel of IDO available as required. It should be noted that the AEC Board of Investigation had no line of authority for the administration of any disaster operations but reported solely to the General Manager.

The Board received technical advice and assistance from several observers who attended some of the sessions during which the witnesses were interviewed. These observers included members of the following organizations: Idaho Operations Office, AEC; Division of Reactor Development, AEC; Joint Committee on Atomic Energy; Argonne National Laboratory; Combustion Engineering, Inc.; Phillips Petroleum Company; Air Force Inspector General Staff, Division of Nuclear Safety and Research, Kirtland Air Force Base; Special Weapons Center, Kirtland Air Force Base; and the National Aeronautical and Space Administration, Kirtland Air Force Base.

2. Technical Advisory Committee

The Technical Advisory Committee was appointed on January 4, by the Manager, IDO, and was established in order to assist the IDO Manager, to: (1) achieve a maximum understanding of the incident, (2) obtain information useful to the reactor program and the safety of all operations pertaining to the incident and (3) evaluate proposed plans of action (see Fig. 6.3). The Committee reviewed the proposed missions into the SL-1 Reactor Operating Room and made recommendations for such items as sample acquisition, core-status investigations, and body-recovery methods. The Committee reported directly to the Manager, IDO, and had no formal relationship with any other AEC Committee established for the SL-1 Incident.

On February 7, the Manager, IDO, disbanded the TAC organization and appointed a Resident Technical Advisory Committee (RTAC), (see Fig. 6.5). The RTAC Group performed the same functions as TAC and was formed because of the long range aspects of the SL-1 Disaster Program. Many members of and consultants to RTAC were personnel who had previously comprised the TAC Group. Therefore, continuity of the technical review and advisory program was maintained.

3. Report Task Force for the SL-1 Incident

The Manager, IDO, appointed a Report Task Force for the SL-1 incident on January 5, to: (1) compile a complete and comprehensive sequence of events pertaining to the SL-1 Incident, (2) prepare answers to inquiries by investigating or consulting with operational personnel, (3) compile and maintain the official library of all available documents pertaining to pre- and post-incident analysis. The Report Task Force was also requested to develop a series of recommendations which might assist in increasing the capabilities of IDO and all NRTS Contractors to effectively cope with the problems resulting from disaster, incidents, or serious operational problems (see Fig. 6.6).

4. SL-1 Ad Hoc Committee

On January 11, the AEC General Manager appointed an SL-1 Ad Hoc Committee to: (1) advise the Commission with respect to the particular measures on the future use or disposition of the SL-1 Facility, together with the advantages and disadvantages of such measures, and (2) recommend to the Commission a use or disposition of the facility and the general procedure to be followed in such use or disposition (see Fig. 6.7). The Ad Hoc Committee had no disaster-operation line of authority but reported directly to the General Manager.

C. Contractor Committee

On January 6, Combustion Engineering, Inc., appointed a CEI Investigation Group to investigate the incident and to provide assistance and liaison with CEI Management Officials located in Windsor, Connecticut (see Fig. 6.8). In addition to these tasks, members of the Investigation Group have worked on recovery operations, have assisted in the planning stage for penetration missions into the reactor operating room, and have been associated with many of the undertakings of the Directional and Operational Units.

D. Support Organizations

The organizations listed below assisted IDO in varying capacities with SL-1 disaster operations. Detailed reports concerning the activities of some of the groups that were extensively involved in the disaster program are on file in the SL-1 Report Task Force Library.

On-Site Organizations	Duties Performed
1. SL-1 Cadre (Military)	Assisted in recovery operations under supervision of C.E.I. Provided staff assistance to the Control Unit, RTAC, Health and Safety Division, and the SL-1 Reports Task Force, IDO.
2. Phillips Petroleum Company	Health Physics Staff assistance. Emergency supplies and equipment. Photographic assistance. Transportation and road construction. Decontamination of personnel and equipment. Performed analyses operations. Consultants.
3. H. K. Ferguson Company	Extensive support of final recovery operation and television camera installation. Heavy equipment operations.
4. Argonne National Laboratory	Health physics staff assistance. Photographic assistance. Consultants.
5. General Electric Company	Health physics staff assistance. Television camera aid. Photographic assistance.
6. Westinghouse Electric Corporation	Health physics staff assistance; emergency supplies and equipment.
7. U. S. Public Health Service	Aerial monitoring team. Health physics staff assistance.
8. U. S. Geological Survey	Water samples both on and off the NRTS.
9. U. S. Weather Bureau	Weather reporting and forecasting. Aerial monitoring team.

10. Aerojet-General Corporation	Decontamination of personnel.

Off-Site Organizations	Duties Performed
1. AEC - Grand Junction Operations Office	Health Physics staff assistance.
2. AEC - Division of Reactor Development (Army Reactor Branch)	Staff assistance.
3. AEC - Information Offices, Washington, San Francisco and Oak Ridge	Assisted IDO Information Officer. Provided information personnel.
4. AEC - Chicago Operations Office	Liaison with family and funeral director on casualty burial.
5. General Electric Company, Hanford, Washington	Analyzed special film badges from the SL-1.
6. Dugway Proving Ground Radiological team, Chemical Corps, U. S. Army	Provided personnel for recovery operations. Supplied gas masks. Assisted in television installation. Furnished emergency air transportation.
7. Los Alamos Scientific Laboratory Pathology and Decontamination Team	Decontamination and autopsy of casualties. Provided emergency equipment.
8. Quartermaster General, U. S. Army, and Fort Douglas, Utah	Staff assistance on decontamination and autopsy of victims. Assisted in transportation of victims.
9. Edgerton, Germeshausen and Grier	Expedited delivery of NAD-1 dosimeters and referee analyses of chemical dosimeters. Advised on radiation resistant film.
10. Sandia Corporation	Assisted in and provided technicians for television operation.
11. Oak Ridge National Laboratory	Provided consultants. Furnished emergency equipment. Provided television units and technicians.

Off-Site Organizations	Duties Performed
12. Reynolds Electrical Engineering Company Nevada Test Site	Health physics staff assistance.
13. Naval Radiological Defense Laboratory, San Francisco	Provided pin-hole camera and staff assistance.
14. Atomic Energy of Canada, Limited	Consultant services. Emergency equipment (pin-hole camera).
15. Chemical Corps, U. S. Army	Staff assistance for Dugway teams.
16. Hill Air Force Base, U. S. Air Force	Air transportation for Dugway team.
17. Signal Corps, U. S. Army	Communication equipment. Photographic team.
18. Surgeon General, U. S. Army	Medical evaluation assistance.
19. National Guard, U. S. Army	Equipment; emergency facilities (SL-1 Cadre).
20. U. S. Army Reserve Unit Idaho Falls, Idaho	Survivor assistance for Army personnel.
21. Advisory Group, NNPTU, NRF, U. S. Navy and 13th Naval District	Survivor assistance for Naval personnel.
22. CO, Fort Carson, Colorado	Army aviation for the supply of equipment.
23. Navy photographic Interpretation Center Washington, D. C.	Photograph evaluation.

E. AEC-CEI Contractual Relationship

Contract No. AT(10-1)-967 between the Atomic Energy Commission and Combustion Engineering, Inc., began on December 14, 1958. The cost-plus-a-fixed-fee contract was for the operation of the SL-1 Reactor at NRTS and included the performance of research and development work to be accomplished at Combustion Engineering's plant in Windsor, Connecticut.

The objectives of the contract were:

1. To gain, through SL-1 Plant operation:

    a. Data and experience at design and off-design conditions in support of the Army Boiling Water Reactor Program,

    b. Knowledge of the costs of operating the SL-1 on both a commercial and a Government-accounting basis,

    c. Familiarity with the problem areas encountered through sustained operation.

2. To carry on the Army Boiling Water Reactor Program of research and development toward meeting the over-all Commission objective of obtaining simple, economical, and easily erected boiling-water nuclear power plants of various power capacities.

3. To train, and assist others in training, crews to operate the SL-1 and other reactor installations.

4. To carry out other research and development work on military reactors.

The contract was administered by the Idaho Operations Office, AEC, with the day-to-day administration activities carried on by the Military Reactors Division, IDO. The Idaho Operations Office reported to the Division of Reactor Development, AEC, Washington. Within the Division of Reactor Development, the Army Reactor Branch had staff responsibility for the reactor program performed by Combustion Engineering, Inc., under Contract No. AT(10-1)-967. Informal contacts existed between the Idaho Operations Office and the Army reactors Branch in the connection with technical, programmatic, and budgetary matters.

Military personnel from the services (Army, Navy and Air Force) were assigned to the SL-1 Cadre, Idaho Nuclear Power Field Office. After completion of the initial training program, these military personnel performed operational and maintenance functions under the over-all management and technical direction of Combustion Engineering, Inc. An organizational chart of Combustion Engineering, Inc., operations at the SL-1 Facility prior to the incident can be found in Figure 6.2.

F. AEC and SL-1 Cadre Relationship

1. SL-1 Operations Organization

All SL-1 Plant operations were conducted under the direction of the Plant Superintendent (military) who received his instructions, verbally and/or in writing, from the Operations or Assistant Operations Supervisor (CEI). The Operations and Assistant Operations Supervisor performed the scheduling of reactor operations, including start-ups and shut-downs. These schedules were then forwarded to the Plant Superintendent who, in turn, gave direction to the shift supervisors in order to carry out instructions received. These orders included tasks to be conducted, as well as start-up and shut-down operation, and general work to be performed by the shift members. During shutdown, each section received work orders which described the work that was to be accomplished during that period.

2. Functions of CEI Personnel

The CEI Operations Staff was normally present throughout the day shift, excluding the weekends. During most test operations, a CEI Staff member was on duty during each shift. CEI personnel were always present during any non-routine tests, for example, CEI personnel were present in the reactor control room when (1) the SL-1 Reactor was placed in operation over 3-MW (t), (2) scram points were changed or by-passed, (3) tests involved altering the reactor-water level or pressure, and (4) control-rod worth tests were performed.

When tests of these general types were undertaken, the shift supervisor performed the operation tasks at the direction of the CEI representative present. The test data was obtained by CEI personnel and the operating crew.

The CEI Health Physics and Safety Supervisor was responsible in all matters pertaining to the health and safety of all personnel within the SL-1 Area.

3. Normal Operating Crew

A normal operating crew consisted of one shift supervisor and at least one qualified operator. These personnel came from any specialty group but preferably not from the same specialty. Although a health physicist was not present with each shift, generally each operator was trained in radiation-survey techniques. This training included area monitoring, taking smears, air and water samples, and counting techniques. When applicable, trainees were assigned to each shift and worked under the direct supervision of the shift supervisor. At no time were the trainees allowed to operate the reactor without close supervision. This type of supervision was maintained until the trainee had completed the prescribed training course and had been examined and certified as a reactor operator by CEI.

4. Tests and Test Procedures

Routine test requests were submitted to the Operations Supervisor by the Test Branch of CEI on-site personnel. Routine tests were administered on standard procedures utilized at the SL-1 Plant and included such items as Xenon equilibrium, steam quality runs, etc.

Non-routine tests were administered in a similar manner. The test request originated at CEI in Windsor or from within the Test Branch. The special test procedure was written by the Test Branch and submitted to the Operations Supervisor. Next, the procedure was reviewed by a five-member Safety Committee of CEI on-site personnel to determine what, if any, hazards were involved and what special action was needed to ensure safe operation during the test. Upon completion of the review, the completed test procedure was forwarded to the Plant Superintendent, who gave a copy of the procedure to the shift supervisor. The shift supervisor was then briefed on the objectives of the test. On all non-routine tests, CEI had a supervisor present. Non-routine tests included operations that would change the normal operating conditions of the plant, i.e., power extrapolation, induced transients, scram by-passes, etc.

III. PREPLANNING

Emergency and disaster planning for the Idaho Operations Office (IDO) and the National Reactor Testing Station (NRTS) originated in 1951-1952. Since that time the procedures developed have been continuously revised to keep pace with the expansion and complexity of NRTS activities.

The IDO Disaster and Emergency Plan Manual is based on the Idaho Operations Office Manual IDO-0615, "Assumptions and Standards for NRTS Emergency and Disaster Plans", which establishes responsibilities and procedures to be followed by NRTS participants in preparing plans to cope with an enemy attack, natural disaster, plant incident, security alert, or any other emergency situation.

Some excerpts of the IDO Disaster Plan are listed below. SL-1 operations were conducted in accordance with said plan whenever appropriate.

3.10 The Manager, AEC-IDO, with assistance from the Control Unit, is responsible for the executive direction of all activities during periods of emergency at the NRTS.

4.21.b The Health Physicist notified and on the scene will assume complete IDO Health Physics control until relieved of this responsibility by the Control Unit. His actions will be governed by the magnitude of the disaster and specific orders of the Control Unit.

4.33 Architect, engineer or construction contractors will be called in for assistance when so needed. A directory of contractors and their key personnel is maintained by the Engineering and Construction Division.

4.34 All emergency procurement will be handled by Phillips Petroleum Company through the AEC Chief, Supply Management Branch.

4.43 The Chief, Contract Administration Branch (or alternate) (Operations Division) shall maintain continuing contact with the responsible supervisor of Phillips' operating and maintenance forces to assure that the needs, as determined by technical specialists, for workers and/or equipment at the scene of the disaster are properly handled...

4.10 The Security Division Radio Communications Control Center Operator will:

a. Broadcast the type of occurrence, extent of damage, location and name of contact at the disaster scene on all radio nets.

b. Notify the Senior Patrol and Enforcement Branch Officer on duty.

c. Notify the NRTS Telephone Operator.

4.12 Pending specific instructions from the Manager, AEC-IDO, or the Control Unit, the Senior Patrol Enforcement Branch Supervisor on duty will:

a. Establish his control point in the Communications Control Center.

b. Establish roadblocks, barricades and personnel admittance controls to the general disaster area. Access to the general disaster area will be as approved by the Emergency Radiation Group.

c. Request the services of contractor guard force personnel in establishing controls or for other services as required.

d. Initiate an "All-net" tie-in for effecting the announcement of an alert situation.

e. Assign an additional operator to the Radio Communications Control Center.

f. Initiate traffic controls as required throughout the NRTS.

g. Initiate appropriate action to preserve evidence of cause of disaster and protect materials, records, etc.

The Disaster and Emergency Plan Manual is composed of several major sections that cover all facets of planning, and Health and Safety Division participation is interwoven throughout. The emergency capabilities of the Health and Safety Division have been developed to encompass those responsibilities listed in IDO Manual Chapter 0615, Appendix 052-G, dated April 29, 1960.

With the establishment of the AEC - Department of Defense Radiological Assistance Plan in 1959, Idaho Operations Office was requested to provide assistance capability following a radiological incident that might occur in Region 6 (five-state area including Idaho, Montana, Wyoming, Utah, and Colorado). The IDO Radiological Assistance Plan (IDO-12013) was formulated and was issued in 1959. This plan, as developed, has an integral relationship with the Health and Safety functions of the IDO Emergency and Disaster Plan and has improved the capability of coordinated health and safety action in any emergency at the NRTS as well as in Region 6.

In June 1960 the Director, Health and Safety Division, IDO, assigned a special assistant the responsibility for maximum credible accident studies, revisions of Health and Safety functions (as necessary, to the Disaster and Emergency Plan Manual), and development of Radiological Assistance Plan use capability. The response capability to the Radiological Assistance Plan has been developed through monthly meetings of members of the Radiological Assistance Team for the purpose of the discussions or lectures on plan activation, incident reviews, field response to simulated incidents, and other development and training activities.

The Annual Report of the Health and Safety Division, IDO-12014, presents considerable detail on the accomplishments and planning of the various branches of the Health and Safety Division and on cooperative programs with other government agencies. The interested reader is referred to this report for an over-all picture of the capacity and development of the Health and Safety Division.

The following is a general outline of Health and Safety responsibilities under emergency or disaster plans.

Director, Health and Safety Division, will be responsible for:

1. Mobilization of Health and Safety Division personnel during an emergency.

2. Coordinating and deploying emergency monitoring teams and other Health and Safety Division personnel to realize the optimum assistance to affected areas.

3. Directing the activities of the NRTS emergency monitoring team.

4. Providing field medical services and facilities, including the mobilization and specific assignment of local emergency medical-assistance groups.

5. Providing firefighting equipment and personnel, including mobilization of firefighting personnel from neighboring communities.

6. Providing ambulance drivers trained in first aid.

7. Providing information, guidance, and assistance to other members of the Control Unit in all matters relating to radiological hazards, safety, and medical emergency measures.

8. Providing assistance, guidance, and material aid to surrounding communities in the event of a plant incident at the NRTS or an enemy attack that results in radioactive contamination.

9. Maintaining, training, and coordinating the IDO Emergency Monitoring Team composed of NRTS personnel for on-site and off-site emergencies.

10. Establishing a program that includes the location and identification of AEC-controlled emergency equipment and emergency personnel that may be called on to provide assistance in the survival efforts of local, state, and federal governments and local populations.

11. Assisting in the preparation of emergency-procedure test plans and in monitoring test procedures when these services are requested by the responsible administering officials.

12. Maintaining a supply of emergency equipment and supplies needed by the emergency radiation-detection groups.

13. Preparing a plan of action (including succession of command) for his area of command.

A copy of the IDO Disaster Plan is on file in the SL-1 Reports Task Force Library.

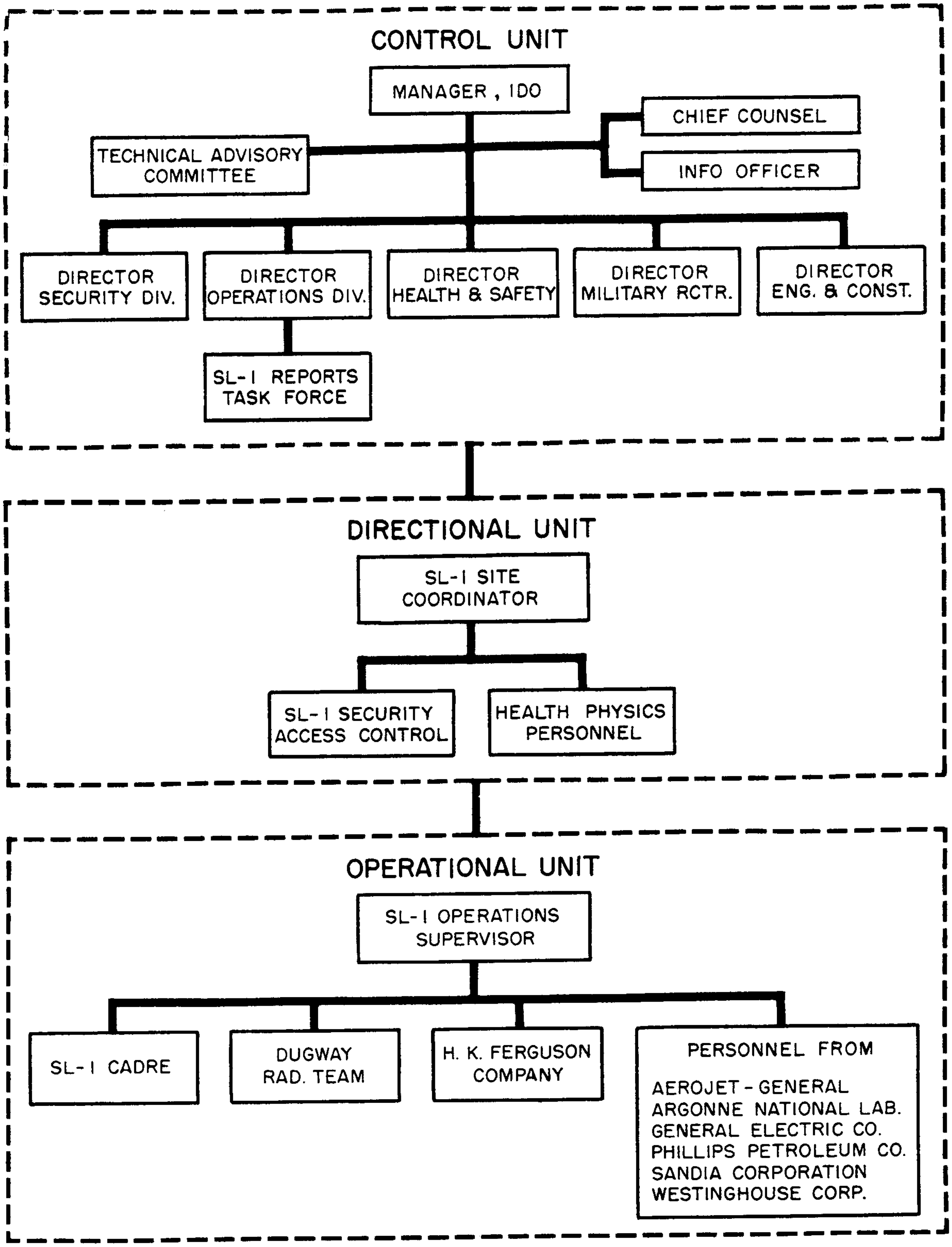

FIGURE 6.1

SL-1 DIASTER ORGANIZATION

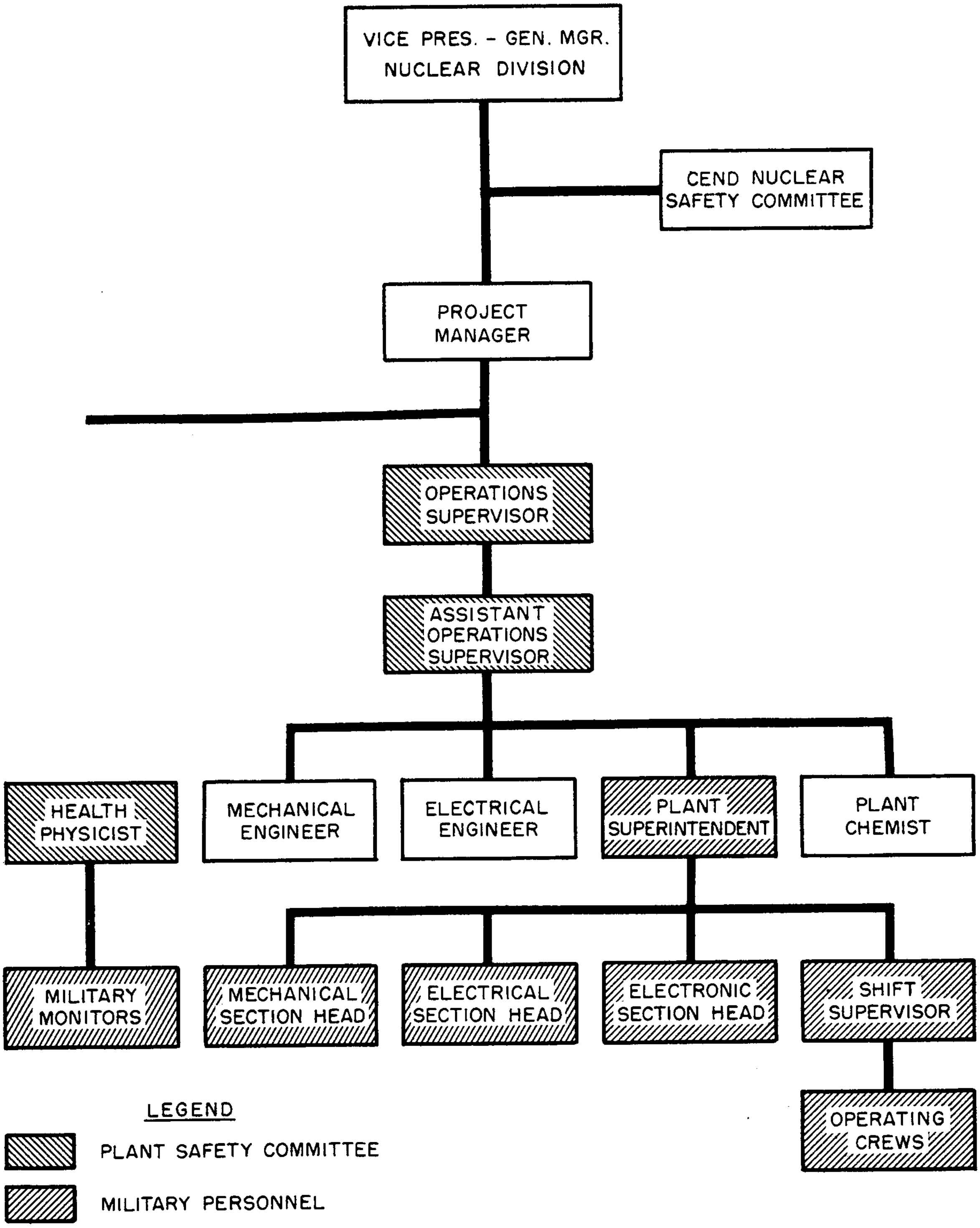

FIGURE 6.2

SL-1 OPERATIONS ORGANIZATION

FIGURE 6.3

Title:	Technical Advisory Committee
Appointed by:	Allan C. Johnson, Manager, Idaho Operations Office
Date Convened:	January 4, 1961
Chairman:	Dr. C. Wayne Bills, Idaho Operations Office
Members:	F. W. Thalgott, Argonne National Laboratory, Lemont, Illinois Milton Levenson, Argonne National Laboratory, Lemont, Illinois D. H. Shaftman, Argonne National Laboratory, Lemont, Illinois W. C. Lipinski, Argonne National Laboratory, Lemont, Illinois R. O. Brittan, Argonne National Laboratory, Lemont, Illinois D. R. deBoisblanc, Phillips Petroleum Company, Idaho Falls, Idaho Warren Burgus, Phillips Petroleum Company, Idaho Falls, Idaho K. Z. Morgan, Union Carbide Nuclear, Oak Ridge, Tennessee
Consultants:	J. H. Kittel, Argonne National Laboratory, Lemont, Illinois R. T. Vogel, Argonne National Laboratory, Lemont, Illinois

<u>FIGURE 6.4</u>

Title:	AEC Board of Investigation
Appointed by:	General A. R. Luedecke, General Manager, AEC
Date Convened:	January 4, 1961
Chairman:	C. A. Nelson, Director, Division of Inspection, AEC Headquarters, Washington
Members:	Dr. P. A. Morris, Assistant Director for Reactors, Division of Compliance, AEC Headquarters Dr. C. K. Beck, Assistant Director for Nuclear Facility Safety, Division of Licensing and Regulation, AEC Headquarters Dr. F. Western, Deputy Director, Office of Health and Safety, AEC Headquarters Dr. D. I. Walker, Director, Licensee Compliance Division, Idaho Operations Office
Consultants:	Dr. B. Lustman, Westinghouse Bettis Laboratory, Pittsburgh, Pennsylvania Dr. W. E. Nyer, Phillips Petroleum Company, Idaho Falls, Idaho Dr. J. H. Stener, Eastman Kodak Company, Rochester, New York Dr. W. K. Ergen, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Member Advisory Committee on Reactor Safeguards.
Advisors:	H. K. Shapar, Chief Counsel, Idaho Operations Office, Idaho Falls, Idaho E. B. Johnson, Assistant Director for Investigation, Division of Inspection, AEC Headquarters

FIGURE 6.5

Title:	Resident Technical Advisory Committee
Appointed by:	Allan C. Johnson, Manager, Idaho Operations Office
Date Convened:	February 7, 1961
Chairman:	Dr. C. Wayne Bills, Idaho Operations Office
Members:	E. F. Thurston, General Electric, Idaho Falls, Idaho Warren H. Burgus, Phillips Petroleum Company, Idaho Falls, Idaho Kenneth A. McCollom, Phillips Petroleum Company, Idaho Falls, Idaho Fred W. Thalgott, Argonne National Laboratory, Idaho Falls, Idaho
Consultants:	R. O. Brittan, Argonne National Laboratory, Lemont, Illinois Milton Levenson, Argonne National Laboratory, Lemont, Illinois D. L. deBoisblanc, Phillips Petroleum Company, Idaho Falls, Idaho Karl Z. Morgan, Union Carbide Nuclear, Oak Ridge, Tennessee Walter C. Lipinski, Argonne National Laboratory, Lemont, Illinois David H. Shaftman, Argonne National Laboratory, Lemont, Illinois Edward S. Brown, Phillips Petroleum Company, Idaho Falls, Idaho Robert L. Drexler, General Electric, Idaho Falls, Idaho J. Howard Kittel, Argonne National Laboratory, Lemont, Illinois Richard C. Vogel, Argonne National Laboratory, Lemont, Illinois

FIGURE 6.6

Title:	Report Task Force for SL-1 Incident
Appointed by:	Allan C. Johnson, Manager, Idaho Operations Office
Date Convened:	January 5, 1961
Chairman:	William L. Ginkel, Director, Operations Division, Idaho Operations Office
Members:	Brewer Boardman, Director of Technical Information, Atomic Energy Division, Phillips Petroleum Company John C. McKinley, Reactor Engineer, Reactor Division, Idaho Operations Office Robert C. Paulus, Inspector, Licensee Compliance Division, Idaho Operations Office Bernard J. Rock, Reactor Engineer, Reactor Division, Idaho Operations Office.

Note: Personnel from IDO and SL-1 Military Cadre assisted the Report Task Force in compiling pertinent information on the SL-1 Incident.

FIGURE 6.7

Title:	SL-1 Ad Hoc Committee
Appointed by:	General A. R. Luedecke, General Manager, AEC
Date Convened:	January 11, 1961, at Idaho Operations Office
Chairman:	Dr. F. K. Pittman, Director, Division of Reactor Development, AEC Headquarters
Members:	Dr. Eugene P. Wigner, Palmer Physical Laboratory, Princeton University, Princeton, New Jersey Dr. Theos J. Thompson, Director, Massachusetts Institute of Technology Nuclear Reactor, Cambrdige, Massachusetts Lombard Squires, Manager, Atomic Energy Division, Explosives Department, E. I. du Pont de Nemours, Wilmington, Delaware H. M. Parker, Manager, Hanford Laboratory, Hanford Atomic Products Operations, General Electric Company, Richland, Washington Dr. John A. Swartout, Deputy Director, Oak Ridge National Laboratory, Oak Ridge, Tennessee Dr. R. L. Doan, Manager, Atomic Energy Division, Phillips Petroleum Company, Idaho Falls, Idaho Dr. Stephen Lawroski, Director, Chemical Engineering Division, Argonne National Laboratory, Lemont, Illinois

FIGURE 6.8

Title:	Combustion Engineering, Inc., SL-1 Investigation Group
Appointed by:	Combustion Engineering Management, Windsor, Connecticut
Date Convened:	January 6, 1961
Chairman:	John B. Anderson, Assistant Director, Nuclear Division, Combustion Engineering, Inc., Windsor, Connecticut
Members:	Dr. R. L. Hellens, Physicist Mr. H. Cahn, Physicist Mr. C. Brown, Radiological Chemist Dr. J. R. Dietrich, Physicist (GNEC)

APPENDIX A

METEOROLOGICAL EVALUATION

The U. S. Weather Bureau, under the auspices of the AEC, maintains an operational and research type weather station at the National Reactor Testing Station (NRTS). Weather forecasts of certain meteorological conditions, such as wind speed and direction, temperature, and precipitation, are routine. Other capabilities at the weather station include diffusion forecasts and climatological statistics. The Weather Bureau maintains on the NRTS a number of meteorological towers which measure wind and temperature at several heights and telemeter this data to the Central Facilities Area Weather Station. Wind and temperature from the Central Facilities Tower is also transmitted directly to the Security Communications Center, where Security Division personnel have been trained to read these instruments. Information from the Central Facilities Tower is considered representative for the southeastern portion of the NRTS; however, during the winter spatial variations of winds have been experienced between the Central Facilities and the Transient Reactor Test Facility (TREAT) locations.

The Weather Bureau has specialized equipment, not common to most weather stations, which include a radio device which will measure and transmit air temperature from a balloon located at a height of 5,000 foot above the ground. In addition, the weather station has wind and diffusion measuring equipment to determine fluctuations of wind direction, both horizontal and vertical.

For further details on the Weather Bureau see IDO-12014, 1959, Annual Report of Health and Safety Division, Chapter 10.

Meteorological Conditions Following the Incident

A general anticyclonic weather regime, with its customary clear skies, light winds, and strong nocturnal cooling permitting strong deep inversions, was in existence from January 3 to January 8. During this period the winds over the Upper Snake River Plain were blowing predominately from the north to northeast direction. The wind direction at the 250 foot level of the weather tower at Central Facilities for the 104 hour period following the incident (to 0500 MST, January 8) showed 6 hours of north, 62 hours of north-northeast, 31 hours of northeast, 3 hours of calm, and 2 hours of other directions with a mean speed for the 104 hour period of 7.5 mph. Strong deep nocturnal inversion conditions existed during this period, with the top of the inversion near 3,000 foot above ground. The inversion broke each day about 1000 MST to the 250 foot level, with a consequent period of temperature lapse conditions in the lower layers of the air to near 1700 MST, at which time the nocturnal temperature inversion would be reformed at the surface. A strong capping inversion above 1000 to 1500 feet persisted for the entire day preventing strong surface winds.

During such conditions of strong temperature inversion at the surface, surface winds are very light and are strongly affected by local topographic features. Great variations of direction in short distances are experienced, making it difficult to use surface winds for computing trajectories, and even more precarious for the extrapolation of winds measured at one point to any great distance. This was a problem for the SL-1 Incident since the next wind stations to the south of Central Facilities are the Weather Bureau Airport Stations at Burley and Pocatello, more than 50 miles away. To illustrate the extreme variability of nocturnal surface drainage winds, at the time of the SL-1 Incident the surface winds at Central Facilities were 270°/02 mph, whereas at TREAT they were 90°/04 mph. These two stations, the closest to SL-1, are 6 miles west and 10 miles northeast of SL-1, respectively. In general, surface drainage winds will blow down the height contours of the terrain. Winds somewhat above the surface, where terrain effects are greatly reduced, are more representative and more readily used for trajectory computations. Figures A.1 and A.2 indicate the local climatological data for the month of January, 1961.

Trajectories and Areas of Contamination

For the reasons discussed above, initial trajectory information for the ecology and aerial monitoring crews was constructed from information obtained from the 250 foot weather tower located at the Central Facilities Area. These winds were predominantly NNE to NE resulting in an anticipated trajectory to the southwest passing some 10 to 15 miles east of Burley. Winds at Burley were also from the northeast and were used when the anticipated trajectory approached that region. The upper-tower-level winds would be especially appropriate for any material that rose to some distance above the ground after release.

The measured surface pattern of vegetation deposition is shown in Figures A.3 and A.4. The deposition in the first 12 miles was measured within 48 hours after the incident, and the farthest surveys shown in Figure A.4 were made on January 9. Because of the consistent winds for four days after the incident, the trajectory should have remained fairly constant for material released during that time.

The wide deposition pattern shown in Figures A.3 and A.4 is typical of a release that continued for long periods of time and is spread by both spatial and time variable winds. The area of deposition agrees well with the wind directions observed during this period. The apparent center of the ground-level plume (the highest readings) went somewhat to the east of the forecast trajectory. This is not surprising from considerations mentioned in the meteorological conditions following the incident. In general, there appeared to be a drainage type movement of material toward the Snake River and then a curvature along the lower elevations of the Snake River region towards the west. The eastern edge of the deposition pattern was sharply defined, as shown in Figures A.5 and A.6. These plots of deposition surveys across the prevailing direction of motion, taken along Highway 26 and the railroad tracks to the southeast of the Scoville Junction, also show the appearance of a double-peaked plume. An idea of the decrease of activity with downwind distance can be obtained from Figure A.7. This is an estimate of the downwind decrease of deposition in the plume center made by taking the highest readings in the approximately crosswind surveys as the plume center.

Release Calculations

Estimates of the release of iodine-131 from the SL-1 Incident, made from approximate cross-plume ecological vegetation surveys, should be considered as probable upper limits. The release estimates are based on a 0.2 cm/sec deposition velocity which was determined empirically following the incident. One survey along Highway 26 was made on January 4, and another was made along the railroad tracks southeast of the Scoville Junction on January 5. These surveys are shown in Figures A.5 and A.6. The crosswind integrated deposition along the first survey (average downwind distance = 6 miles) would give the release up to midmorning of January 4. The next survey (about 12 miles downwind on the average) would give the release for the period up to midmorning of January 5. With the assumptions shown in Table A.1, it is estimated that 10 curies of iodine-131 had become airborne on the first day after the incident by midmorning, and 20 curies had become airborne 24 hours later. In addition, it is estimated that another 50 curies of iodine-131, at least, were released between January 6 and 30, 1961.

TABLE A.1

ASSUMPTIONS FOR COMPUTING RELEASE FROM SL-1

Cross-wind-integrated air concentration *(CIC) times Deposition velocity (Vg) equals Cross-wind-integrated deposition (Dep):

CIC x Vg = Dep   where Vg = 0.002 meters/sec

$$CIC = \frac{2Q}{\sqrt{\pi}\ UC_z\ X^{\frac{2-N}{2}}}$$

where the parameters have the usual definition in Sutton's Diffusion Theory.

Assign:

U (wind speed) = 2 meters/sec

C_z = 0.06 for strong inversion

N = 0.5

The following conversion factors are used:

1.4×10^{-6} uc I^{131} per count/minute

50 gm/meter squared = sagebrush density

X (downwind distance) = 6 miles (9.65×10^3 meters)

for first and second surveys = 12 miles (1.93×10^4 meters)

*Actually the total integrated dose

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

LOCAL CLIMATOLOGICAL DATA

IDAHO FALLS 46 W, IDAHO
C/O USAEC, BOX 2108
JANUARY 1961

Latitude 43 ° 32 ′ N. Longitude 112 ° 57 ′ W. Elevation (ground) 4933 ft. Mountain Standard time used

Date	Temperature (°F) Maximum	Minimum	Average	Departure from normal	Degree days (base 65°)	Precipitation Total (Water equivalent) (In.)	Snow, Sleet (In.)	Snow, Sleet, or Ice on ground at 8:00AM (In.)	Wind Prevailing direction	Average speed (m. p. h.)	Maximum Hourly Average Speed (m. p. h.)	Direction	Sunshine Total (hours and minutes)	Percent of possible	Sky cover Sunrise to sunset (tenths)	Midnight to midnight (tenths)	ø Thunderstorm or distant lightning	ø Weather restricting visibility to ¼ mile or less	State of Ground ‡ 8 AM 2 PM	Hourly Wet - Bulb Temperature (F°) Max.	Min.	Avg.	Date
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	24	- 1	12	- 5	53	0	0	T	SW	4.8	15	SW							Sl Sl	19.8	0.2	10.0	1
2	25	- 5	10	- 6	55	0	0	T	N	2.2	8	N							Sl Sl	20.1	-4.0	8.1	2
3	25	- 9	8	- 8	57	0	0	T	NE	2.3	8	NE							Sl Sl	20.5	-7.9	6.3	3
4	28	- 6	10	- 6	55	0	0	T	WNW	2.2	8	NE							Sl Sl	21.0	-6.2	7.4	4
5	28	- 8	10	- 6	55	0	0	T	NNE	2.5	7	NE							Sl Sl	21.2	-6.6	7.3	5
6	36	0	18	+ 2	47	0	0	T	NNW	2.2	8	NNW							Sl Sl	24.5	0.5	12.5	6
7	39	3	21	+ 5	44	0	0	T	NNE	2.6	9	NNE							Sl Sl	28.5	4.5	16.5	7
8	46	6	26	+ 10	39	0	0	T	SW	3.7	15	SW							Sl F	33.3	6.9	20.1	8
9	44	5	25	+ 10	40	0	0	0	WSW	3.2	18	SW							F F	31.3	6.9	19.1	9
10	32	4	18	+ 3	47	0	0	0	NNE	1.8	8	N						F	F F	27.0	6.1	16.6	10
11	38	7	23	+ 8	42	0	0	0	NNE	1.8	8	NNE							F F	30.0	8.8	19.4	11
12	38	3	21	+ 6	44	0	0	0	SW	2.1	8	SW							F F	29.5	4.9	17.2	12
13	35	12	24	+ 9	41	0	0	0	SSW	2.3	7	NNW							F F	28.0	12.9	20.5	13
14	40	11	26	+ 11	39	T	T	0	WSW	4.3	17	WSW						F	F F	34.0	12.2	23.1	14
15	40	14	27	+ 12	38	0	0	0	W	1.7	6	NNE						F	F F	33.0	15.7	24.4	15
16	41	9	25	+ 10	40	0	0	0	N	1.3	6	SW							F F	33.8	10.3	22.1	16
17	42	6	24	+ 9	41	0	0	0	WSW	1.9	12	SSW							F F	33.0	6.9	20.0	17
18	43	5	24	+ 9	41	0	0	0	WSW	3.8	13	NNE							F F	33.5	6.0	19.8	18
19	36	1	19	+ 4	46	0	0	0	NNE	2.4	5	NNW							F F	27.4	3.3	15.4	19
20	44	1	23	+ 8	42	0	0	0	WSW	1.2	4	NNW							F F	32.1	2.7	17.4	20
21	41	- 2	20	+ 4	45	0	0	0	NNE	1.5	4	NNE							F F	27.5	-0.2	13.7	21
22	39	- 1	19	+ 3	46	0	0	0	WNW	1.8	5	N							F F	28.0	-0.3	13.9	22
23	36	- 3	17	+ 1	48	0	0	0	NNE	2.6	7	NNE							F F	29.0	-1.1	14.0	23
24	41	- 1	20	+ 4	45	0	0	0	N	1.9	6	N							F F	30.9	-0.2	15.4	24
25	36	9	23	+ 7	42	0	0	0	N	2.7	8	NE							F F	29.3	10.3	19.8	25
26	25	1	13	- 3	52	0	0	0	ENE	8.0	15	ENE							F F	18.8	3.0	10.9	26
27	31	-12	10	- 7	55	0	0	0	NNE	5.3	13	NNE							F F	20.4	-10.2	5.1	27
28	29	-10	10	- 7	55	0	0	0	WNW	3.3	9	SSW							F F	21.2	-8.6	6.3	28
29	36	- 4	16	- 1	49	0	0	0	SSW	4.1	15	SW							F F	28.0	-3.3	12.4	29
30	47	25	36	+ 19	29	T	T	0	SSW	7.1	17	S							F F	37.0	23.3	30.2	30
31	40	26	33	+ 15	32	T	0	0	SSW	7.7	19	SW							F M	36.9	24.3	30.6	31
Sum	1125	84	—	—	—	T	T	—	—	96.5	—	—		—		—	—	—		868.5	121.1	—	Sum
Avg	36.3	2.7	—	—	—	—	—	—	—	3.1	Fastest	Dir.	Possible	%		—	—	—		28.0	3.9	16.0	Avg.
										Misc.	# 19	SW			—	—	—	—					Misc.

T in columns 7, 8, 9 and in the Hourly Precipitation table indicates an amount too small to measure.

TEMPERATURE: (°F)
Average monthly 19.5
Departure from normal + 3.8
Highest 47 on 30
Lowest -12 on 27
Number of days with –
Max. 32° or below 9
Max. 90° or above 0
Min. 32° or below 31
Min. 0° or below 13

HEATING DEGREE DAYS (base 65°):
Total this month 1404
Departure from normal - 124
Seasonal total (since July 1) 4778
Seasonal departure from normal - 213

BAROMETRIC PRESSURE (In.)
Avg. station (elev. 4939 *feet, m. s. l.) 25.238 4/
Highest sea level 30.81 on 3
Lowest sea level 30.15 on 31

PRECIPITATION: (In.)
Total for the month T 1/
Departure from normal - 0.66
Greatest in 24 hours T on 14,30,31
Snow, Sleet–
Total for the month T 2/
Greatest in 24 hours T on 14, 30
Greatest depth on ground T on 8 3/
Dates of – Hail none
Sleet none Glaze none

Symbols used in columns 18-19
A – Hail
BS – Blowing snow
DL – Distant lightning
D – Dust
E – Sleet
F – Fog
H – Haze
K – Smoke
L – Drizzle
N – Sand
R – Rain
S – Snow
T – Thunderstorm
ZL – Freezing drizzle
ZR – Freezing rain

*When this elevation differs from the present station elevation this level was selected to permit comparison of data for a longer period of homogeneous record.

Occurred during the hour ending 8:30PM the 31st. Peak Gust for the month. SW 32 MPH at 8:18PM the 31st.
ø Occurrences based on best estimates from outside sources between the hours of 4:30PM and 8:00AM. ‡ Code State of Ground: M – moist, F – frozen, Sl – ice, snow or melting snow covering less than 1/2 of ground. 1/ The driest, 2/ the least amount of snow, and 4/ the highest monthly average station pressure, for any month of January for Period of Record 1950–1961.
3/ The last of several occurrences.

HOURLY PRECIPITATION (In.)

Date	A. M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	P. M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	Date
1																									1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
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27																									27
28																									28
29																									29
30	T	T	T		T	T	T	T																	30
31												T	T	T	T	T	T								31

Known errors found in this issue will be published in later issues.
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USCOMM-WB-Asheville 2/5/61 - 2500

FIGURE A.1
CENTRAL FACILITIES AREA

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU

LOCAL CLIMATOLOGICAL DATA

IDAHO FALLS 42 NW, IDAHO
C/O USAEC, BOX 2108
JANUARY 1961

Latitude 43° 50′ N. Longitude 112° 41′ W. Elevation (ground) 4790 ft. Mountain Standard time used

Date	Temperature (°F) Maximum	Minimum	Average	Departure from normal	Degree days (base 65°)	Precipitation Total (Water equivalent) (In.)	Snow, Sleet (In.)	Snow, Sleet, or Ice on ground at (In.)	Wind Prevailing direction	Average speed (m. p. h.)	Maximum Hourly Average Speed (m. p. h.)	Direction	Sunshine Total (hours and minutes)	Percent of possible	Sky cover Sunrise to sunset (tenths)	Midnight to midnight (tenths)	Thunderstorm or distant lightning	Weather restricting visibility to ¼ mile or less					Date
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	23	- 6	9	- 4	56	0			NNE	3.0	8	NNE											1
2	20	-13	4	- 9	61	T			N	2.0	5	N											2
3	25	- 4	11	- 2	54	0			NNW	2.8	5	ENE											3
4	26	-16	5	- 7	60	0			NE	1.9	5	NW											4
5	28	-10	9	- 3	56	0			NE	0.7	4	N											5
6	32	- 5	14	+ 2	51	0			NNE	1.7	6	NNE											6
7	40	4	22	+10	43	0			NNE	2.1	6	NE											7
8	38	2	20	+ 8	45	0			NNE	2.3	9	NNE											8
9	36	7	22	+10	43	0			NNW	2.3	5	NNE											9
10	33	- 3	15	+ 3	50	0			N	3.9	5	NE											10
11	39	12	26	+14	39	0			NNW	1.8	5	NNW											11
12	35	3	19	+ 7	46	0			SSW	2.0	6	N											12
13	32	7	20	+ 9	45	0			S	2.3	6	NNE											13
14	36	14	25	+14	40	0			SSW	3.6	9	SSE											14
15	37	10	24	+13	41	0			NE	3.0	7	NE											15
16	40	12	26	+14	39	0			N	1.3	6	N											16
17	39	5	22	+10	43	0			WNW	1.8	6	NW											17
18	42	5	24	+12	41	0			ENE	4.0	12	NE											18
19	35	- 3	16	+ 4	49	0			ENE	3.0	6	N											19
20	40	- 3	19	+ 7	46	0			N	2.3	6	N											20
21	38	- 6	16	+ 4	49	0			NNW	2.1	6	NNW											21
22	37	- 4	17	+ 5	48	0			NNW	2.7	5	N											22
23	38	-10	14	+ 2	51	0			NNE	2.0	6	NNW											23
24	40	- 5	18	+ 5	47	0			NW	1.7	5	NE											24
25	38	6	22	+ 9	43	0			ENE	3.7	13	NE											25
26	25	- 7	9	- 4	56	0			E	4.4	14	E											26
27	29	-20	5	- 8	60	0			ESE	2.9	6	NNW											27
28	26	-13	7	- 7	58	0			NNE	3.5	8	NNE											28
29	31	- 4	14	0	51	0			NW	2.4	7	NE											29
30	47	25	36	+22	29	T			S	8.0	23	SSW											30
31	40	20	30	+16	35	T			S	8.3	24	S											31
Sum	1065	0	—	—	—	T	—	—	—	89.5	—	—		—		—	—	—					Sum
Avg	34.4	0	—	—	—	—	—	—	—	2.9	Fastest	Dir.	Possible	%		—	—	—					Avg.
										Misc.	# 24	S			—	—	—	—					Misc.

T in columns 7, 8, 9 and in the Hourly Precipitation table indicates an amount too small to measure.

TEMPERATURE: (°F)

Average monthly 17.2
Departure from normal + 4.9
Highest 47 on 30 2/
Lowest - 20 on 27
Number of days with —
Max. 32° or below 11
Max. 90° or above 0
Min. 32° or below 31
Min. 0° or below 17

HEATING DEGREE DAYS (base 65°):

Total this month 1475
Departure from normal - 159
Seasonal total (since July 1) 4995
Seasonal departure from normal - 244

BAROMETRIC PRESSURE (In.)

Avg. station (elev. *feet, m. s. l.)
Highest sea level on
Lowest sea level on

PRECIPITATION: (In.)

Total for the month T 1/
Departure from normal - 0.53
Greatest in 24 hours T on 2, 30, 31
Snow, Sleet—
Total for the month
Greatest in 24 hours on
Greatest depth on ground on
Dates of — Hail
Sleet Glaze

Symbols used in columns 18-19

A = Hail
BS = Blowing snow
DL = Distant lightning
D = Dust
E = Sleet
F = Fog
H = Haze
K = Smoke
L = Drizzle
N = Sand
R = Rain
S = Snow
T = Thunderstorm
ZL = Freezing drizzle
ZR = Freezing rain

*When this elevation differs from the present station elevation this level was selected to permit comparison of data for a longer period of homogeneous record.

Occurred during the hour ending 6:30PM the 31st.

1/ The driest, and 2/ the highest temperature ever recorded, for any month of January for Period of Record 1950-1961.

HOURLY PRECIPITATION (In.)

Date	A. M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	P. M. Hour ending at 1	2	3	4	5	6	7	8	9	10	11	12	Date
1																									1
2								T	T	T	T	T	T	T	T										2
3																									3
4																									4
5																									5
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26																									26
27																									27
28																									28
29																									29
30			T	T	T	T	T																		30
31												T	T	T	T	T									31

Known errors found in this issue will be published in later issues.

FIGURE A.2
ANP AREA

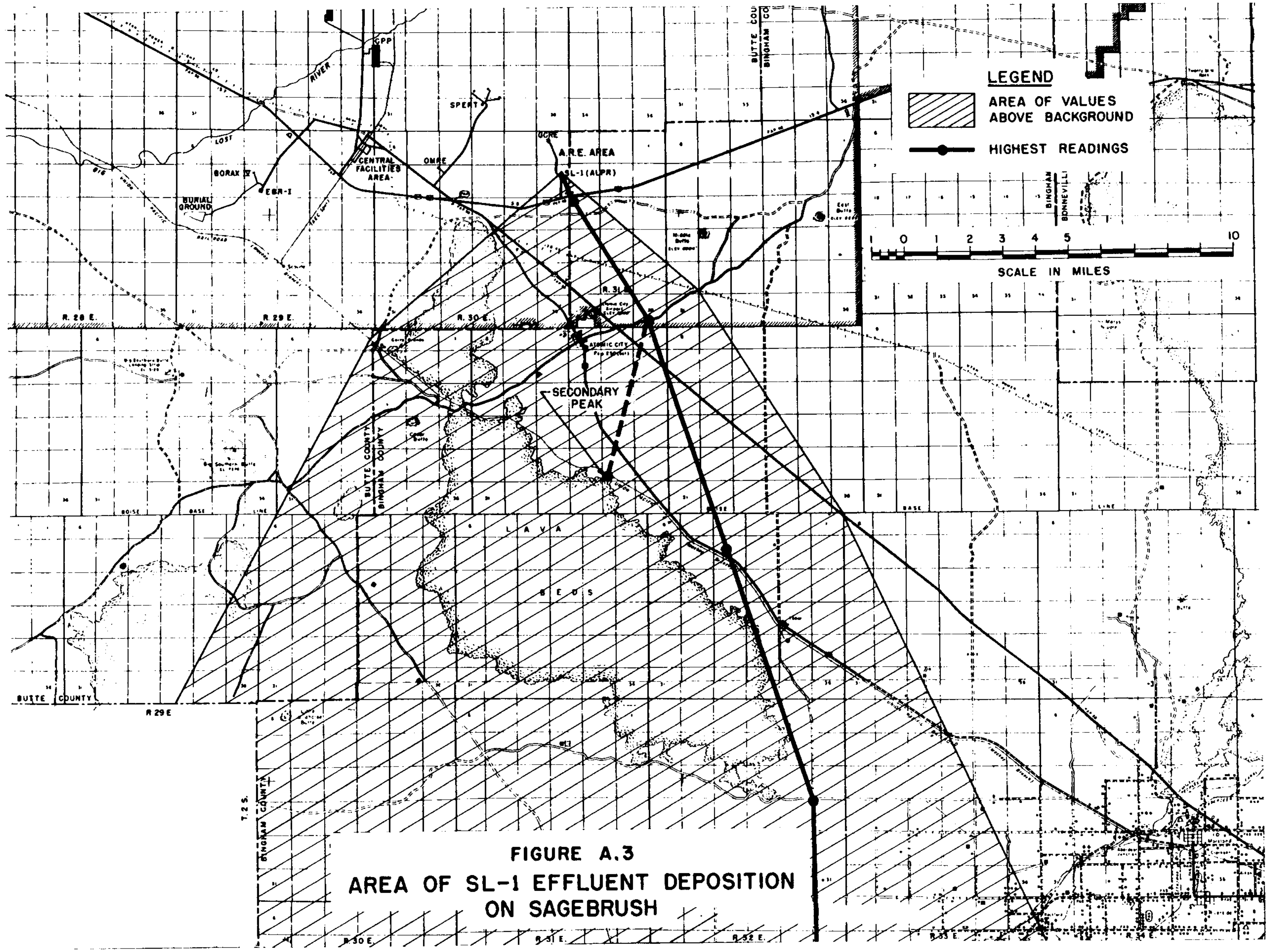


FIGURE A.3
AREA OF SL-1 EFFLUENT DEPOSITION ON SAGEBRUSH

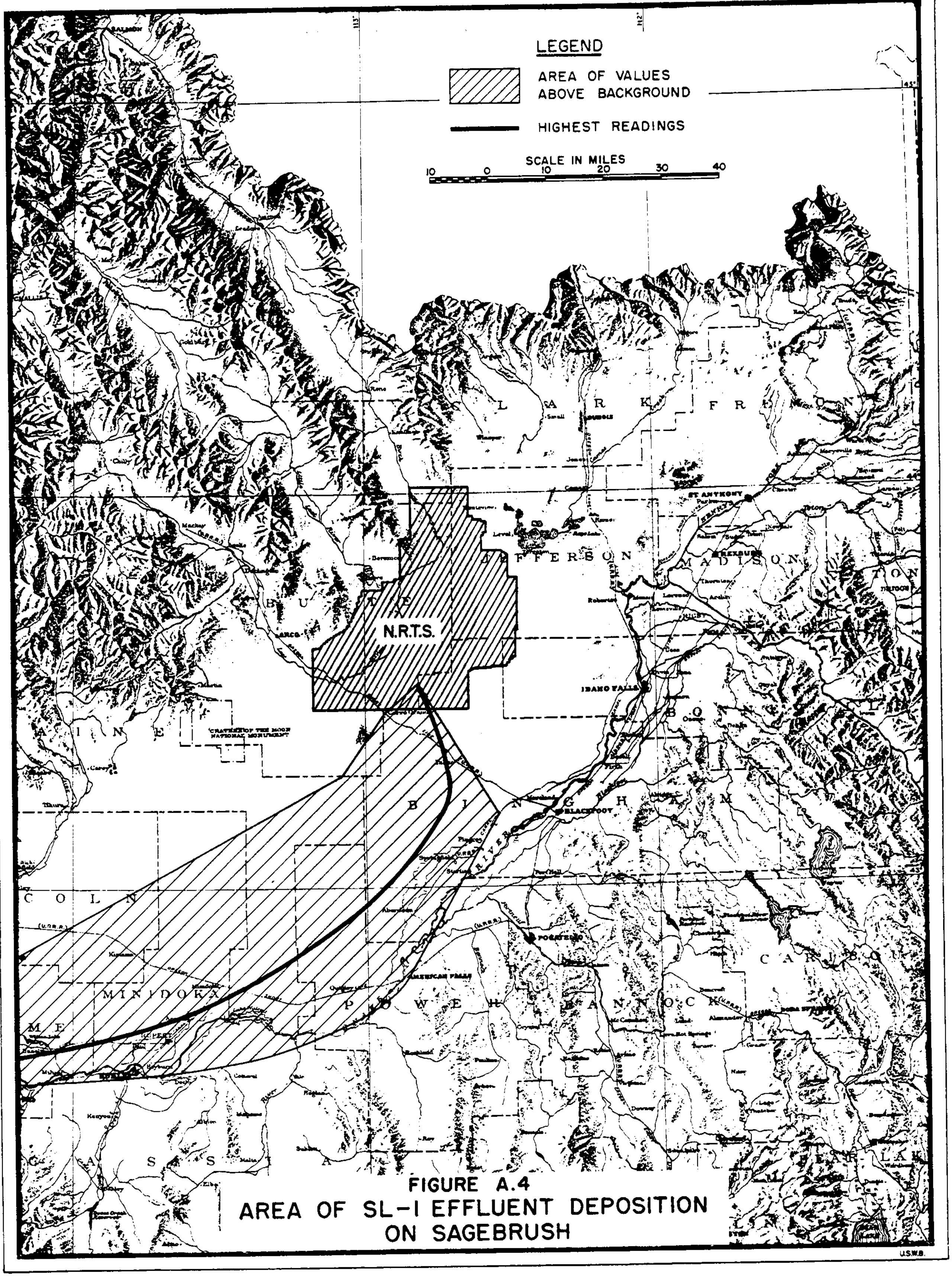


FIGURE A.4
AREA OF SL-1 EFFLUENT DEPOSITION
ON SAGEBRUSH

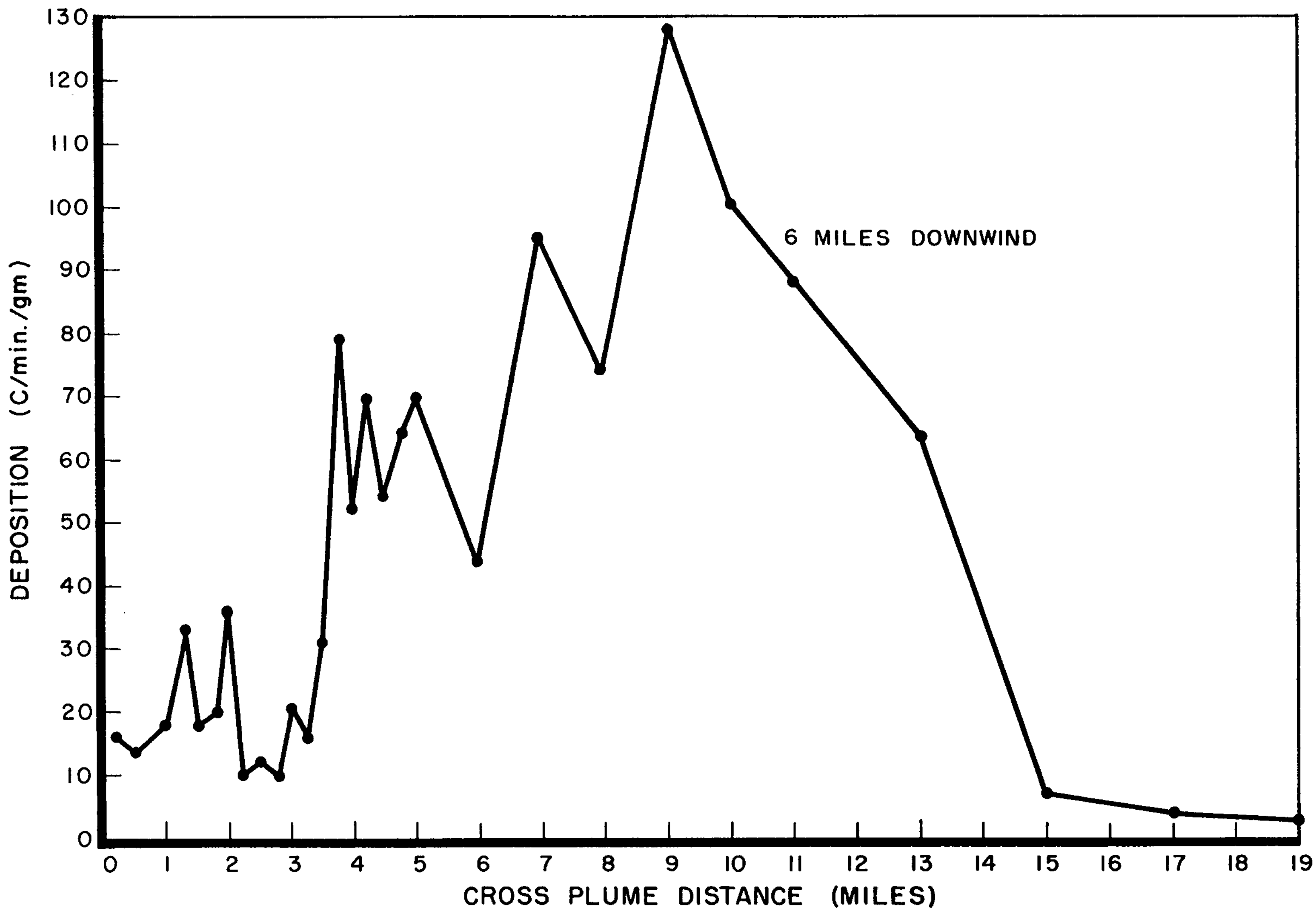


FIGURE A.5

DEPOSITION SURVEY ALONG HIGHWAY No. 26

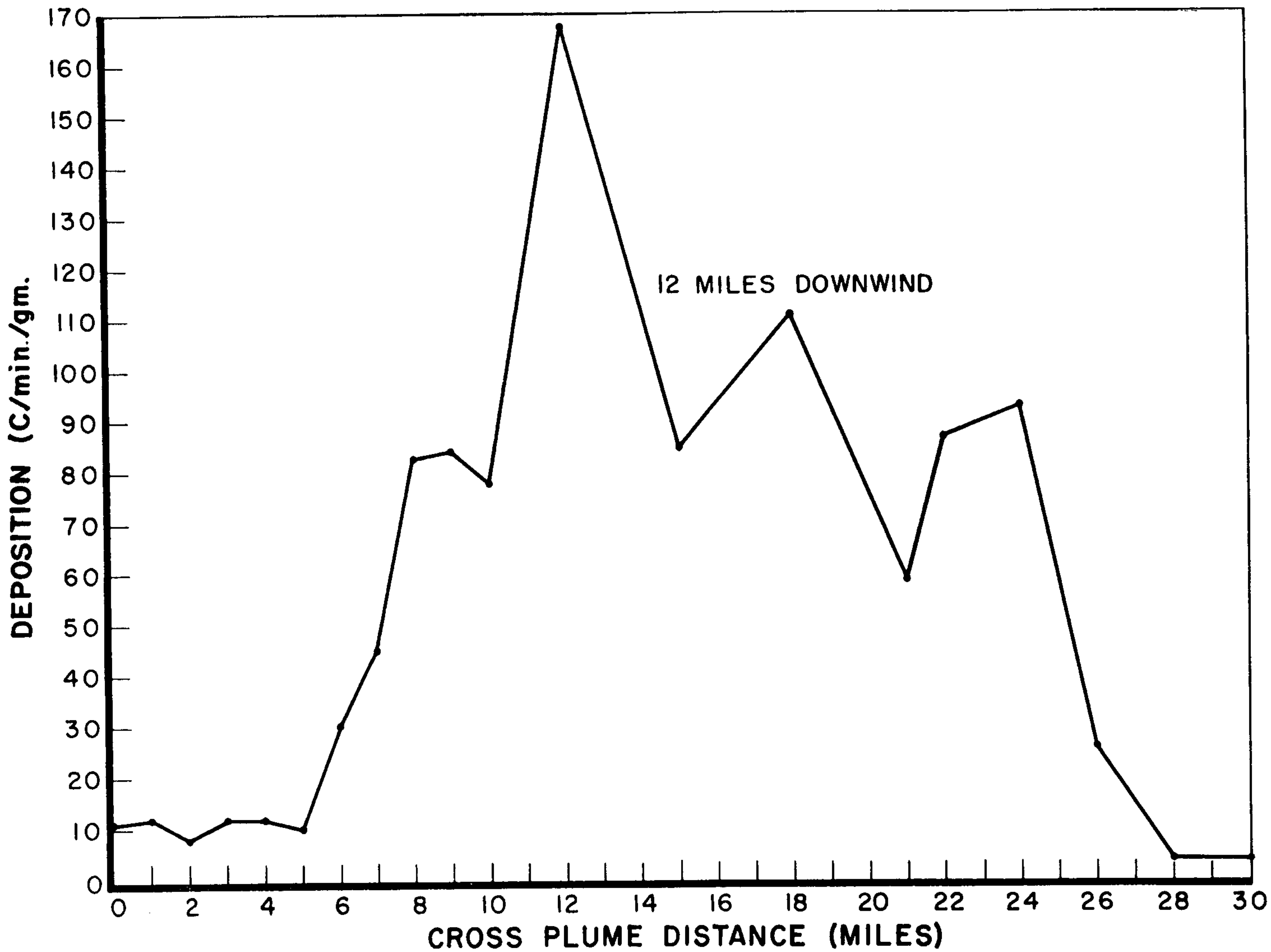


FIGURE A.6
DEPOSITION SURVEY ALONG RAILROAD TRACKS

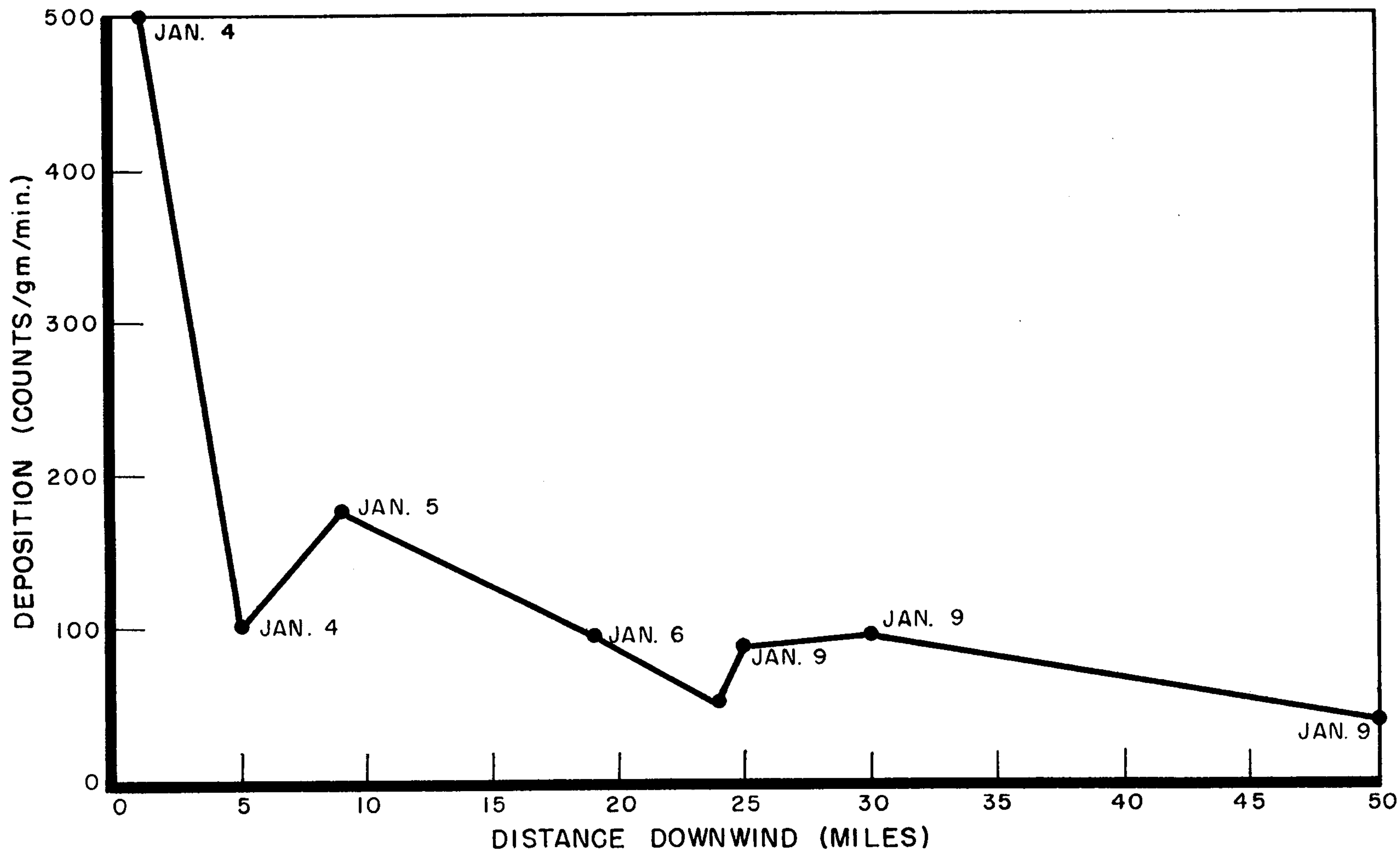


FIGURE A.7

DECREASE OF DEPOSITION ON SAGEBRUSH IN PLUME PEAK (HIGHEST READING) WITH DISTANCE

APPENDIX B

ANALYTICAL REPORT

I. METHOD OF ANALYSIS USED ON SAMPLES ARISING OUT OF SL-1 INCIDENT

A. General Statement on Procedures

A 256-channel pulse height analyzer utilizing a 3"x3" thallium-activated sodium iodide crystal was employed widely throughout all analytical work to identify the contaminants present and to determine the extent of decontamination required and which particular activity must be removed.

The general philosophy applied to all SL-1 samples was to continue decontamination procedures until either a clear and unequivocal gamma spectrum of the activity being determined was obtained or until no activity of any kind remained. The quantitative determination of the isolated activity was then made from the photo peak of the gamma spectrum and was corroborated by total counting in a gamma well crystal, when this was possible. In some cases, decontamination was continued only far enough to eliminate all interference with the photo peak of a desired activity. Before identification of the radioactive isotope was considered absolutely positive, its gamma spectrum should agree with the energies known to be characteristic of that nuclide, the activity should be shown to follow the chemistry of the suspected element, and, where possible, it should have the proper rate of decay as indicated by its half-life. All of the analyses on SL-1 samples have successfully met two or three of the criteria, and identification of each individual isotope is felt to be certain beyond any reasonable doubt.

The analytical procedures described do not necessarily represent perfected procedures that would be used again in exactly the form presented. They are the actual procedures used on the SL-1 samples because of the specific decontaminations required as indicated by gamma spectroscopy.

In addition to the general philosophies mentioned above, specific comments with respect to each particular analysis is listed below.

B. Analysis for Copper

A watch band buckle was first decontaminated by dissolving part of the buckle in concentrated nitric acid. A clear spectrum of Copper 64 was obtained on the remainder of the solid buckle, and a quantitative value was obtained from the photo peak. To prove unequivocally that the activity measured was in fact Copper 64, the buckle was dissolved in perchloric acid and the copper removed by precipitation as the sulfide using thioacetamide. Nearly an identical activity was obtained on the separated copper.

C. Analysis for Gold

A section of a gold ring was partially decontaminated by dissolving the outside layers in aqua regia. The remaining part of the ring was dissolved in aqua regia, evaporated with concentrated hydrochloric acid and the gold reprecipitated as the element with sulfur dioxide. The elemental gold was weighed as such so that neutron flux could be calculated. The activity of Gold 198 was determined both from the photo peak of a gamma spectrum and by total counting in a well crystal. Essentially identical results were obtained.

D. Analysis for Phosphorus

The sulfur pellet from the NAD dosimeter was burned off, carrier phosphorus added and the aluminum foil was dissolved using hydrochloric and nitric acid. Zirconium phosphate was precipitated from a 2 normal perchloric acid solution. The precipitate was dissolved in hydrofluoric acid and the phosphorus reprecipitated as the phosphomolybdate. This precipitate was dissolved, and the phosphorus precipitated as magnesium ammonium phosphate from an ammoniacal solution containing citric acid.

E. Analysis for Sodium

The samples of blood and liver to be analyzed for Sodium 24 were completely wet ashed with nitric and sulfuric acids. 100 ml. of blood and 1500 grams of whole liver were used. When wet ashing was complete, sodium sulfate was added to the sulfuric acid solution and a pyrosulfate fusion was made to solubilize anhydrous ferric sulfate and any refractory materials that may have been present in the sample. The melt was dissolved in water and three successive precipitations were made with sodium hydroxide to remove the main radioactive products such as cerium, zirconium, barium (as sulfate) etc. As an example of the extreme decontamination required, it is interesting to note that the first hydroxide precipitate from the blood sample registered 1 R/hr at contact by a Cutie Pie with the window open.

The solution was further decontaminated from cesium and potassium by repeated precipitations with sodium tetraphenylboron and from ruthenium by reduction with magnesium powder. The final solution was almost saturated with salts from so many separations and was counted for twenty minutes on a gamma spectrophotometer.

F. Analysis for Zirconium

A sample of highly radioactive cloth was dissolved in nitric and sulfuric acids and a pyrosulfate fusion made to dissolve refractory zirconium oxide. The zirconium was separated by two ammonium hydroxide precipitations followed by three lanthanum fluoride precipitations. The zirconium was precipitated from the fluoride solution as barium fluozirconate which was reprecipitated three times. Niobium carrier was added to the solution of the zirconium precipitate after which the solution was allowed to stand for about two half-lives of the 74-minute niobium daughter. At the end of this time, barium fluozirconate was again precipitated twice and niobium precipitated from the filtrate with tannic acid after buffering the solution with ammonium acetate.

G. Analysis for Strontium

The metallic appearing sample taken from the clothing of the first two victims and which was reading 24 R/hr at 1 foot was dissolved. Strontium carrier was added, and a sodium carbonate precipitation was made. After dissolving the precipitate in nitric acid, strontium nitrate was precipitated twice from fuming nitric acid. A barium carrier was added and three successive barium chromate scavenges were made to separate the barium isotopes. Yttrium hydroxide was precipitated from the filtrate after addition of the yttrium carrier. After allowing a growth time of one half-life of the fifty-minute Yttrium 91 daughter, yttrium carrier was again added and a yttrium hydroxide precipitated. The precipitate was dissolved in concentrated nitric acid, the yttrium extracted into tributyl phosphate, back extracted into water and precipitated as an oxalate. Identification and determination of Yttrium 91 was made from the gamma photo peak. Strontium 90 in soils and urine was determined by a conventional procedure involving precipitation of strontium as the nitrate from fuming nitric acid and extraction of the Yttrium 90 daughter into tributyl phosphate.

H. Analysis for Chromium

A stainless steel gasket was decontaminated from the bulk of the activity (ea. 50 R/hr.) by boiling with concentrated nitric acid and decanting. The clean steel was dissolved in boiling 72% perchloric acid and a cobalt carrier was added. The oxidized chromium was volatilized with gaseous hydrogen chloride as chromyl chloride. The chromium fraction was reduced with hydrogen peroxide, evaporated down to fuming perchloric acid and the chromium removed from cold 72% perchloric acid as insoluble chromium trioxide. The chromium trioxide was redissolved in water, the pH adjusted with acetic acid-acetate buffer and the hexavalent chromium precipitated as barium chromate. After weighing to determine the quantity of chromium present, the barium chromate was redissolved in perchloric acid and a chromium trioxide was reprecipitated from the cold concentrated acid. Identification and determination was completed by both gamma spectroscopy and total counting in the well counter.

I. Analysis for Cobalt

The residual solution left in the distilling flask after volutalization of the chromium as described in H above was evaporated to remove as much perchloric acid as possible. The solution was made about 9M in hydrochloric acid, and the solution extracted repeatedly with amyl acetate until no further yellow iron color was visible in the organic extract. The solution was evaporated to a small volume to remove most of the hydrochloric acid. After dilution with water to about 50 ml., five grams of sodium thiocyanate was added, and the solution was extracted repeatedly with methyl isobutyl ketone to extract the cobalt thiocyanate complex. After washing the extract and evaporation to dryness, residual organic material was removed by treating with nitric and sulphuric acids. The cobalt was dissolved in a little water, the solution neutralized with potassium hydroxide and reacidified with glacial acetic acid. The cobalt was then precipitated as potassium cobaltinitrite by addition of several grams of potassium nitrite. The precipitate was filtered and analyzed by both gamma spectroscopy and total counting in a well crystal.

J. Analysis for Iodine

Urine samples and air samples generally contained so much iodine activity that quantitative numbers could be obtained unambiguously by total gamma counting in a well counter, after positive identification had been obtained by gamma spectroscopy. In those cases in which this was not true, iodine numbers were taken from the photo peak.

II. ANALYTICAL INDICATIONS OF A NUCLEAR EXCURSION IN THE SL-1 REACTOR

The determination that the SL-1 Reactor Incident involved criticality was made in a number of ways. The basic assumptions and constants for the calculated values presented below are listed in Table B.1.

A. Analysis of Nuclear Accident Dosimeter

A nuclear accident dosimeter (NAD # 270) had been placed on the inside of the outside wall of the access stairway at some time prior to the incident. This dosimeter was positioned about 22-1/2 ft. from the vertical center line through the reactor core and about 19-1/2 ft. above the center of the core. The dosimeter contained bare and cadmium-covered gold foil, a sulfur pellet, fission foils of U^{238}, Np^{237}, and Pu^{239}, as well as chemical dosimeters for the measurement of gamma-radiation dose.

The gold foils were analyzed for Au^{198}, an isotope that is produced by exposing Au^{197} to a neutron flux. Gold-198 was found and identified both from its gamma decay curve and its gamma spectrum. Its gamma spectrum was determined on a 256-channel gamma-ray spectrometer. The activities of the bare foil and the cadmium-covered foil were of 2.6×10^3 and 1.8×10^3 dis/min respectively corrected for decay. These gold foils were compared with identical foils exposed to neutrons from a standard polonium-beryllium source with a paraffin moderator. A thermal-neutron dose of 1.2×10^8 neutrons/cm^2 was calculated from the difference between the disintegrations per minute from the two NAD foils. During the shutdown that started on December 23, 1960, the NAD had been removed and parts encapsulated to prevent the spread of materials contained in the dosimeter in case of damage. The NAD was replaced on December 30, 1960, but the gold foils were not counted during the maintenance; consequently, some of the activation noted after the incident may have been present prior to December 23, 1960.

Sulfur undergoes an (n, p) reaction forming p^{32} with neutrons of about 2.5 Mev or more. The sulfur pellet in NAD-270 was subjected to a chemical process to isolate and purify phosphorus. The presence of p^{32} could not be positively identified and, therefore, it is unlikely that a significant number of neutrons with energies greater than 2.5 Mev were in the neutron spectrum at the location of this NAD.

The fission foils of U^{238}, Pu^{239}, and Np^{237} from NAD-270 showed no activity above background at the time of counting (about 19 hrs. after exposure). This is not surprising since the analysis for fission products in these foils should be made shortly after exposure to neutrons to obtain good results.

B. Analysis of Brass Screw

A cigarette lighter and a brass zipper pull and button were removed from the clothing of the first victim recovered. The brass screw from the lighter was analyzed for Cu^{64}, which would be produced by neutron activation of Cu^{63}. Copper-64 was found and identified by its characteristic gamma spectrum. It was calculated that the screw had been exposed to a thermal neutron dose of 9.3×10^9 neutrons/cm^2. The button and zipper pull were so highly contaminated with aged fission products that Cu^{64} could not be identified even after several attempts at decontamination. Decontamination was not sufficient to allow identification of Cu^{64} in the presence of the remaining fission products.

C. Analysis of Brass Buckle

A brass pin from the film-badge case and a brass watch-band buckle were recovered from the second victim. These were analyzed, and in each case Cu^{64} was found and identified through its characteristic gamma spectrum. The 0.51-Mev gamma radiation from the buckle was further shown to result from Cu^{64} by determination of the presence of annihilation radiation by gamma-gamma coincidence measurements at 180° and 90° and by comparison with Cu^{64} samples prepared in the Materials Testing Reactor (MTR). One-half of the buckle was chemically treated to separate the copper from other elements. The separated Copper 64 was observed to decay with a half-life of approximately 10 hr., giving additional proof of Cu^{64}. Chemical determination of the copper content of the sample indicated 85 per cent copper. On the basis of the total copper and the disintegrations per minute, a neutron dose of 2.1×10^{10} neutrons/cm^2 was calculated. The Cu^{64} content of the brass pin was too small for quantitative analysis and flux determinations.

D. Analysis of Gold Ring

A gold ring removed from the third victim was thoroughly cleaned. A small section of it was dissolved and chemically treated to separate it from all interfering contaminants. A gamma spectrum showed the presence of only Au^{198} in the purified gold portion. This portion, when counted in a well counter previously calibrated for Au^{198}, gave a total activity of 1.0×10^5 dis/min corrected for decay per 0.274 g of gold in the sample. A thermal neutron dose of 9.0×10^9 neutrons/cm^2 was calculated for the time of the incident, assuming all of the neutrons were thermal neutrons with an average path of 20 mils in 68 wt. per cent gold. If some of the neutrons were not thermal, but had energies in the resonance region, their probability of capture is higher than the probability of thermal capture. Therefore, the value 9.0×10^9 neutrons/cm^2 calculated for thermal neutrons is a maximum value.

E. Analysis of Copper Wire

Copper wire and screws from the reactor operating room telephone located on the steel wall girder near the door to the covered stairway showed no Cu^{64} activity. This lack of any detectable activity may be explained by the fact that more than 99.5 per cent of any Cu^{64} activity produced would have decayed away by the time of sample recovery and analysis.

F. Analysis of Stainless Steel Gasket

A 15 gm piece of steel from the flexitallic gasket (stainless steel with about 18 per cent chromium and 8 per cent nickel) was dissolved, and the cobalt and chromium fractions were separated chemically and isolated from interfering elements. Cobalt-58 formed by an (n, p) reaction with Ni^{58} was identified in the cobalt portion by its characteristic gamma spectrum. A fast-neutron dose of 1.5×10^{11} neutrons/cm^2 was calculated from the 1.3×10^3 dis/min corrected for decay due to the Co^{58} in the 15 gm steel sample. Although the effective threshold for the (n, p) reaction is about 4 Mev, the fast neutron dose calculation is for the entire fission neutron spectrum, although many of these neutrons are clearly below the threshold of Ni^{58} (n, p) Co^{58} reaction. Chromium-51 in the isolated chromium fraction was identified by its gamma spectrum. A thermal neutron dose of 8×10^9 neutrons/cm^2 was calculated from the Cr^{51} activity of 3.1×10^3 dis/min corrected for decay per 15 gm of steel. These give a good indication of the fast and thermal flux at the top of the reactor since at the time of the accident the flexitallic gasket was located in one of the ports on the reactor head. The gasket had been newly installed after the reactor had been shut down.

G. Analysis of Blood

No positive determination of any Na^{24} in the blood from the first victim or the livers from the first two victims could be made. Since natural sodium has a low neutron cross section and since the Na^{24} resulting from neutron activation of natural sodium would have decayed through 6 half-lives in the blood and through 13 half-lives in the liver before the analyses could be made, the lack of positive identification of Na^{24} is not surprising.

H. Analysis of Material from Victims' Clothing

Clothing from the first and second victims was taken to the MTR hot cell. Very small pieces of rock or gravel (probably from the SL-1 reactor shield) and metal were shaken from the clothing. These pieces were separated by the manipulator fingers and sent to the analytical laboratory at the CPP for dissolution and isotopic and quantitative analyses. The uranium in the sample from the coveralls of the third victim and the uranium from metal and rock from the clothing of the first and second victims is as follows:

Uranium from material shaken from clothing of the first and second victims		Uranium in the coveralls from the third victim
34 μg uranium in metal sample	19.5 μg uranium in rock sample	
14.9 per cent burn-up (calc.)	32.6 per cent burn-up (calc.)	11.2 per cent burnup (calc.)

In order to calculate the burnup of U^{235} in the samples, an isotopic analyses was performed for U^{234}, U^{235}, U^{236}, and U^{238}. While a high percentage of residual U^{238} was found in the rock sample, it was believed that the uranium in the rock, undoubtedly, was contaminated with uranium of lower enrichment. Since the amount of uranium recovered was extremely small, the contamination could easily have resulted from minute quantities of lower enrichment uranium remaining on the manipulator fingers from previous work. The calculated burnup was impossibly high for highly enriched uranium and, therefore, could not be representative of uranium from an SL-1 fuel element. The uranium from the metal sample and from the coveralls from the third victim had U^{235} burnups that are about what would be expected from the SL-1 fuel. The isotopic differences between these samples are possibly due to fuel pieces which had been located in different parts of the core, or to the limits of detecting isotopic differences between samples, or to contamination as described above.

The samples shaken from the clothing of the first and second victims (metallic and gravel appearing material with readings of 25 R/hr gamma and 20 R/hr gamma, respectively, at a distance of 1 ft.) were also analyzed for Sr^{91}. Since Strontium 91 has a half-life of 9.7 hours no significant inventory of this isotope would have remained from operation of the reactor prior to the incident. Any Strontium 91 present must then have been produced during the excursion. About 60% of the Strontium 91 has a gaseous precursor, Krypton 91, and may or may not have undergone fractionation from the uranium fuel during the nuclear excursion. The metallic sample was dissolved, and a chemical separation of strontium made from the solution. Yttrium 91m was allowed to grow from the Strontium 91 for one half life, separated, and determined by gamma spectrum, assuming that 47% of the decay of Strontium 91 gives rise to Yttrium 91m. The activity of the Strontium 91 calculated at the time of the incident was 7.4×10^3 disintegrations per minute per microgram of uranium. From this activity and the ratio of uranium in the sample to total uranium in the reactor, a total of 1.5×10^{18} fissions was calculated for the incident, assuming no loss of the gaseous parent. This calculation also assumes that the

Sr^{91}-Y^{91} sample is representative of the average of uranium undergoing fission during the incident. Strontium 91 was also identified from the rock sample using the same technique. With the same Sr^{91}-Y^{91} data, the total number of fissions occurring were calculated on the basis of Sr^{90} in the sample and Sr^{90} calculated to be present in the entire reactor. A value of 2.0 X 10^{18} fissions was obtained in this calculation. An attempt was made to analyze a sample of clothing from the third victim for Zr^{97} since the 17 hour half life of this isotope precludes any large inventory from reactor operation prior to the incident. Because of the overwhelming high levels of aged fission product contamination, particularly Zr^{95}-Nb^{95}, the Zr^{97} was not identified. Similarly attempts were made to analyze for Ce^{143}, and again the presence of long lived cesium isotopes prevented Ce^{143} determination.

I. Analysis of GCRE Contamination

The GCRE change room was used for decontaminating personnel who had entered the SL-1 Reactor Building just after the incident. Thus fission products were transported from SL-1 Area on the clothing and shoes of these personnel.

A smear sample was taken in the GCRE change room and analyzed for gross fission products and uranium. Barium and La^{140}, zirconium and Nb^{95}, Cs^{134}, and uranium were identified.

J. Analysis of Air Filters

A filter from an MSA 2133 air sampler (this type filter removes small airborne particles from the air) in the SL-1 Control Room was analyzed for gross fission products. Barium and La^{140}, zirconium and Nb^{95}, Cs^{134}, Cs^{137}, Ce^{141}, and I^{131} were identified by their gamma spectra.

An air sample was also taken outside the SL-1 building by an MSA 2133 air sampler. A chemical separation was made to isolate iodine from other airborne material. Iodine-131 and -133 were identified on the separated iodine fraction by their gamma spectrum. Iodine-133 could not be determined quantitatively, but the presence of this short-lived isotope indicates recent nuclear activity.

A 450-ml sample of air from a point half way up the SL-1 Reactor Building access stairway was collected. The radioactivity of this sample was very low, and no isotope identification could be made.

K. Gross Gamma Activity at the SL-1 Reactor Building

A chemical dosimeter from NAD #270, which was removed from the top of the SL-1 access stairway 13 hours after the incident, was analyzed for total gamma dose. The dosimeter contains tetrachloroethylene and an aqueous color indicator solution. Under gamma irradiation the tetrachloroethylene breaks down to hydrogen chloride and hydrocarbons. The color change in the indicator resulting from the hydrogen chloride is a measure of the gamma dose and is evaluated with a spectrophotometer. A gamma dose of 840 R was indicated for the 13-hour period (an average of 65 R/hr).

In the operation to recover the third victim, a stretcher was fastened to the end of a crane's boom. Hurst dosimeters (NAD's) containing chemical units were attached to the stretcher. NAD 237 and NAD 262 were located 6 and 14 foot respectively from the vertical center line through the reactor during the recovery operations, which took about 9 hours. The gamma doses indicated for the 9-hour period were 3900 R and 2000 R respectively (an average of 222 to 433 R/hr).

The gold foils in NAD 237 and NAD 262 (positions described above) were analyzed for Au^{198}. No Au^{198} could be detected. A number of film badges containing indium foil as the neutron detector were attached to the boom and the stretcher. No 54 min. In^{116} was detected in these foils. From the period of time the boom was in the reactor room, the period of time between its removal and the counting of the foils, and the sensitivity of the counting apparatus, a steady flux of about 1×10^3 neutrons/cm^2 sec was observed.

A tabulation of the analytical results obtained as a result of the SL-1 incident can be found in Table B.2.

TABLE B.1

ASSUMPTIONS MADE IN CALCULATIONS OF THE NUCLEAR EXCURSION IN THE SL-1 REACTOR

1. The parameters for converting cpm to absolute dpm when counting with a scintillation spectrometer are those given by R. L. Heath, in "Scintillation Spectrometry, Gamma - Ray Spectrum Catalogue", IDO-16408.

2. Copper 64 was assumed to come from activation of Copper 63 which represented 69.0% of the copper in the sample. Copper 64 was determined from gamma spectrum assuming that 60% of the Copper 64 decays by positron emission leading to 0.51 mev gamma. The fraction of copper in the samples was determined by CPP as 59% on the cigarette lighter screw and 76% on the watch band buckle. A cross section of 4.1 barns was used for calculation of the neutron dose.

3. Gold 198 was assumed to come from the activation of Gold 197 which represented 100% of the gold in the sample. Gold 198 was determined from gamma spectrum and by gamma counting. In calculating Gold 198 activity from the gamma spectrum a 100% yield of 0.41 mev gamma per disintegration was assumed. A cross section of 98 barns was assumed for thermal neutron activation of Gold 197.

4. Chromium 51 was assumed to come from the activation of Chromium 50 which represents 4.4% of the chromium in the sample. Chromium 51 was determined from gamma spectrum assuming that 9% of the Chromium 51 disintegrations produce a 0.32 mev gamma. The gasket material was assumed to contain 18% chromium. A cross section of 16 barns was assumed for thermal neutron activation of Chromium 50.

5. Cobalt 58 was assumed to come from the activation of Nickel 58 which represents 68.0% of the nickel in the sample. Cobalt 58 was determined from gamma spectrum assuming that 100% of the Cobalt 58 disintegrations produce a 0.80 mev gamma. The gasket material was assumed to contain 8% nickel. A cross section of 91 millibarns was assumed for Nickel 58 in these calculations and is so weighted to take into account the entire fission neutron spectrum.

6. Strontium 91 was determined from a gamma spectrum of Yttrium 91m milked from the separated strontium fraction. In calculating the activity of Strontium 91, 96% of the Yttrium 91m disintegrations was assumed to produce a 0.51 mev gamma. The yield of Yttrium 91m from Strontium 91 was assumed to be 47%. In estimating the number of fissions produced a total uranium loading of 14 kilograms was assumed and the uranium content of the actual sample as reported by CPP was used in the calculations.

TABLE B.2

Tabulation of Samples and Analytical Results

SAMPLES TAKEN FROM SL-1 FOLLOWING INCIDENT FOR INDUCED ACTIVITY MEASUREMENT

Sample Description	Time of Analysis Date	Hour	Analyzed For	General Statement	Identification By	Data d/m	Remarks	Thermal Neutron Neutrons/cm^2 2100/1/3/61
Cigarette lighter screw taken from first victim	1/4/61	1900	Copper 64	Copper 64 found	Gamma spectra			9.3×10^9
Brass pin from film badge case recovered from second victim	1/5/61	0300	Copper 64	Copper 64 found	Gamma spectra			
Brass watch band buckle from second victim	1/5/61	0100	Copper 64	Copper 64 found	Gamma spectra Copper chemistry Decay curve		(total sample) (1/2 sample used)	1.8×10^{10} 2.1×10^{10}
Copper wire and screws from control room telephone	1/7/61		Copper 64	None found				
NAD dosimeter taken from SL-1 (No. 270) position at top of access stairway	1/4/61	1100						
(1) Bare gold foil	1/4/61	1100	Gold 198	Gold 198 found	Gamma spectra Decay curve	2.2×10^3		1.2×10^8
(2) Cadmium covered gold foil	1/4/61	1100	Gold 198	Gold 198 found	Gamma spectra	1.5×10^3		
(3) Sulfur pellet approx. 20 grams	1/12/61	1530	Phosphorus 32	Contaminated: Phosphorus separation made		3.6 ± 4.2		
(4) U-238, Pu-239, Np-237 fission foils	1/4/61	1600		No activity above background at time of counting				

Sample Description	Time of Analysis Date	Hour	Analyzed For	General Statement	Identification By	Data d/m	Remarks	Thermal Neutron Neutrons/cm^2 2100/1/3/61
(5) Chemical dosimeters for gamma dose	1/8/61	2200	Gamma dose		Cary spectro-photometer		Gamma dose: 840 Roentgens (IDO) 850 Roentgens (EGG)	
100 ml blood taken from first victim	1/7/61	2200	Sodium 24	No sodium 24 identified	Gamma spectrum	< 5 d/m/ml		
Gold ring taken from third victim	1/10/61	1800	Gold 198	Gold 198 found	Gamma spectra	1.9×10^4 d/m	On 0.472 grams ring at 1830 1/10/61. 0.066 inch thick, 0.194 inch wide, 0.308 inch long.	9×10^9
Zipper pull and button from clothing of first victim	1/4/61	1200	Copper 64	None identified: highly contaminated with aged fission products				
Samples shaken from clothing of first two victims. Dissolved by group at CPP and aliquot furnished for analysis								
(1) Metallic appearing sample (25 R/hr at 1 foot)	1/6/61		Uranium	Mass spectro by CPP,		3.4 micro-grams per ml.		
	1/6/61	0430	Strontium 91 On 10 ml aliquot	Strontium 91 identified and estimate made	Spectra on yttrium 91m milked from strontium fraction	2.5×10^4 d/m/ml $\pm$ 50% at 2100/1/3/61	1.5×10^{18} fissions	
(2) Rock and Gravel sample (20 R/hr at 1 foot)	1/6/61		Uranium	Mass spectro by CPP		3.9 micro-grams per ml		
	1/6/61		Strontium 91 on 5 ml aliquot	Strontium 91 identified	Spectra on yttrium 91m milked from strontium fraction			

Sample Description	Time of Analysis Date	Hour	Analyzed For	General Statement	Identification By	Data d/m	Remarks	Thermal Neutron Neutrons/cm^2 2100/1/3/61
Clothing sample from third victim recovered. Dissolved at CPP.	1/10/61		Zirconium 97	No zirconium 97 identified				
Liver from first victim recovered (1200 grams)	1/11/61	2330	Sodium 24	No sodium 24 identified	Gamma spectra	<0.4 d/m/g		
			Sodium 23		Flame photometer		1.15 mg/g	
Liver from second victim recovered (1570 grams)	1/11/61	2350	Sodium 24	No sodium 24 identified	Gamma spectra	<0.3 d/m/g		
			Sodium 23		Flame photometer		0.95 mg/g	
Flexitallic gasket from SL-1 Reactor	1/19/61	1200	Cobalt 58	Cobalt 58 found	Gamma spectra Cobalt chemistry		1.1×10^3 d/m/15 grams steel (nominally 18% chromium, 8% nickel)	2.5×10^{11}* (calculated by Phillips Petroleum Company
	1/20/61	0830	Chromium 51	Chromium 51 found	Gamma spectra Chromium chemistry		2.0×10^3 d/m15 grams steel (nominally 18% chromium, 8% nickel)	8×10^9 (calculated by Phillips Petroleum Company

* Fast neutrons.
Threshold at about 4 Mev for Ni-58 (n,p) Co 58.
Cross section taken as 90 millibarns.

Sample Description	Time of Analysis Date	Hour	Analyzed For	General Statement	Identification By	Remarks	Neutrons/cm^2 2100/1/3/61
Mass assay of uranium from coveralls from third victim						U-234 1.02% U-235 90.93% U-236 2.06% U-238 5.99%	
Mass assay of uranium from metal from clothing of victims						U-234 0.88% U-235 90.0 % U-236 2.73% U-238 6.39%	

MATERIALS TAKEN INTO SL-1 FOLLOWING INCIDENT FOR INDUCED ACTIVITY MEASUREMENT

Sample Description	Time of Analysis Date	Hour	Analyzed For	General Statement	Identification By	Remarks
Indium foils from neutron detectors in film badges placed on boom and net used to recover third victim	1/9/61	0735	Indium 116	No activity found	Gross gamma counting	Detection limit is 1.2×10^5 neutrons/cm^2 for instantaneous burst, assuming no build-up time and no decay time following irradiation
(1) Gold foils	1/9/61	0520	Gold 198	No activity found	Gross gamma counting	
(2) Chemical dosimeter from NAD 237	1/10/61	1400	Gamma dose			2000 roentgens (IDO)) 1700 roentgens (EGG)) In reactor compartment ca. 9 hours
(3) Chemical dosimeter from NAD 262	1/10/61	1400	Gamma dose			3900 roentgens (IDO)) 4000 roentgens (EGG)) In reactor compartment ca. 9 hours

MISCELLANEOUS SAMPLES CHECKED SPECTRALLY FOR MAJOR FISSION PRODUCT IDENTIFICATION

Sample Description	Time of Analysis Date	Time of Analysis Hour	Analyzed For	General Statement	Identification By	Remarks
Smear from GCRE change room	1/4/61		Gross fission products, U		Gamma spectra	Barium-lanthanum 140, zirconium-niobium 95, cesium 134, and uranium
Square of cloth from second victim removed	1/4/61	2250	Gross fission products	Gross fission products found	Gamma spectra	
Air sample on MSA 2133 paper taken in SL-1 control room	1/5/61	2000	Gross fission products		Gamma spectra	Barium-lanthanum 140, zirconium-niobium 95, cesium 134, cesium 137, cerium 141, cerium 144, and iodine 131
450 ml of air from SL-1 half way up access stairway, collected by gas sampler	1/5/61	0530		Very low activity; no identification made		
Air sample taken outside entrance to SL-1 Administration Building on MSA 2133	1/6/61	1230	Iodine isotopes		Chemical separation and gamma spectra	Iodine 131 and 133 identified on separated iodine fraction. Unable to determine iodine 133 quantitatively.

APPENDIX C

USE OF TELEVISION

Due to the 600 to 1000 R/hr radiation rates which were encountered in the SL-1 Reactor operating room, it was determined shortly after the incident that a television system installed in this area would possibly minimize personnel exposure.

In an attempt to assist in the recovery of the third victim and to obtain information about the conditions which existed in the reactor operating room, television equipment available at the National Reactor Testing Station (NRTS) was obtained. This equipment was positioned in the reactor operating room, but due to several unfortunate events the effort had to be discontinued.

Later, television was utilized to penetrate into the SL-1 Reactor to determine the extent of damage done to the core and, in addition, to ascertain whether any water existed in the reactor pressure vessel. Since all of this work had to be undertaken on a remote control basis, a mock-up was made of the SL-1 Reactor pressure vessel, pressure vessel head, and portions of the reactor operating room. The mock-up allowed those personnel who were to be involved in the actual operations to practice the approved procedures which were to be used in the operation.

In order to describe the role that television played in connection with the SL-1 disaster, this report has been divided into four parts: (1) the preparation for entry, (2) equipment utilization, (3) practice operations, and (4) actual operations.

Preparation For Entry. Upon arrival of Combustion Engineering, Inc., officials at the SL-1 Area shortly after the incident, plans were initiated for rescue operations. After two victims had been removed from the reactor operating room, it was believed that television could be of assistance in the recovery operation for the third victim, in determining the water level, if any, in the core, and in ascertaining the approximate condition of the core.

For all television entries subsequent to those made between January 4 - 8, CEI prepared and submitted written plans and procedures of the operation for IDO approval. During the period from January 4 - 8, because of the emergency nature of the situation, television entries were conducted in accordance with verbal agreements between IDO and CEI officials; these general procedures had been approved at a meeting of both parties on January 4.

All television entries began at the SL-1 Control Point, which had been established near the junction of Highway 20 and Fillmore Boulevard shortly after the incident. Personnel who were to participate in the operation were briefed on the health physics and operational procedures of the mission. In addition, the amount of time which would be spent on the mission and the evacuation procedure were covered.

All personnel about to enter the controlled area were equipped with the following anti-contamination outfit:

a. 2 pair coveralls
b. 2 pair gloves
c. 2 pair shoe covers
d. 1 head covering
e. full face mask

In order to protect the individual from airborne contamination, all openings and fastenings on the anti-c-clothing were covered with masking tape. Each person was issued a film badge and a self reading dosimeter upon entry into the controlled area, and a log was kept of all personnel entering and departing the controlled area to insure that all exposures were properly recorded.

A health physicist accompanied each television entry group and monitored the area in which the group was working. Upon expiration of the approved time limit, the health physicist instructed the group to depart from the SL-1 Area; also, the health physicist was responsible for evacuating the personnel in the area in case of a sudden increase in the radiation levels around the SL-1 Reactor Building.

Transportation between the Control Point and the SL-1 Area was furnished by the Austin-Western Crane, the television truck, and shuttle cars which were permanently assigned to the controlled area.

Prior to each television entry after January 8, it was necessary to have a crew composed of six - eight men enter the SL-1 Area in order to remove the canvas covers from the freight doorway of the SL-1 Reactor Building. After the television operation was completed, the crew again entered the SL-1 Area and replaced the canvas doorway cover. While the crew is not mentioned in future entries, exposures received by these men have been included in the total dosage chargeable to each of the television penetrations.

After each television penetration had been completed, all participants proceeded to the decontamination trailer located at the Control Point. As the personnel entered the decontamination trailer, they removed the outer shoe covers and deposited them in a receptacle positioned outside the trailer door. Upon entering the trailer, the personnel were assisted in removing their mask, gloves, and outer coveralls by a health physicist. The personnel then stepped into an intermediate area where another health physicist monitored them for contamination and assisted them in removing the remainder of their anti-c-clothing. If the person was found free of contamination, he was released to the "Clear Area" and the Control Point proper. In most cases, where a person's clothing or skin was found to be contaminated, health physics personnel at the Control Point were able to remove the contamination.

Equipment Utilization. In the television entries made through January 4 - 8, standard television equipment available from NRTS facilities was used. Because a radiation browning of the camera lenses was experienced, a new camera equipped with a vidicon tube and face shield made of fused quartz was obtained. Inasmuch as similar fused quartz equipment had been subjected in laboratory tests to an extremely high radiation field for an extended period of time with no browning and negligible affect on picture quality and resolution, it was believed that this type of equipment would prove satisfactory. Also procured was a fused cerium lens which had been subjected in testing to a field of 4×10^5R for a period of 250 hours with no adverse effects. For the television entries of January 3, 4, 27, and 28, and February 7, the following television equipment was utilized in addition to those radiation resistant items mentioned above:

1 Kintel Monitor - Receiver, Model No. DRN-14R
1 Kintel Camera, Model No. 1986-C
1 Kintel Control Unit, Model No. 1986-ACU
2 Dage Monitors, Standard, with remote focus control
1 Dage Camera, Standard
1 Conrac Receiver, 14 inch

Cables used with the Kintel system were manufactured specifically for use with the Kintel equipment, which was an experimental television system undergoing field testing by Sandia Corporation, Albuquerque, New Mexico, at the time of the incident. (It had been planned to send the Kintel equipment to NRTS for further testing at the Materials Testing Reactor facility after completion of the tests in New Mexico.) Cables used for the Dage and Conrac equipment were standard television cables. The Dage equipment was furnished by the Oak Ridge National Laboratory and the Conrac receiver was provided by the Special Power Excursion Reactor Test (SPERT) facility, NRTS.

In the entries on March 16-17, the Kintel camera, referred to above was used in addition to the following items:

2 Kintel Monitors, Model No. 1988-14R
1 Kintel Control Unit, Model No. 1988-DCU

The Kintel 1988 series equipment operated with a sweep of 729 lines as against 525 lines for the Kintel 1986 and DRN equipment. This increase in the number of lines provided a sharper picture and thereby enabled clear motion pictures to be taken directly from the monitor screen. No synchronization circuitry was needed between the television monitor and the motion picture camera since there were no moving objects in the reactor core.

A movable Austin-Western crane was used for all television entries subsequent to January 8. Heavy lead shielding was strategically located on the forward end of the crane to protect personnel from radiation. For the entries made on January 27 and 28, a fixed beam was mounted on the end of the crane's boom. On the forward end of the beam were mounted stationary pulleys used for dropping a light and a television camera through the ports in the reactor pressure vessel head. Approximately six foot from the forward end of the beam, a television camera was mounted so that the area could be scanned through which the dropable television camera would be moved. The fixed television camera transmitted its video signal to a remote monitor receiver where a monitor operator relayed the information, as to the position of the dropable camera, to the person operating the television camera control cables. Forward of the fixed camera two flood lights were installed to illuminate the entire field of operations in front of the beams. Several film badges and neutron threshold devices were attached to the underside of the beam in an attempt to record the radiation levels over the reactor head.

While it was possible to maneuver the movable crane into a position such that the end of the fixed beam was over the reactor head, it was an awkward and rather time consuming operation. Also, the sudden starts and stops of the crane caused unwanted vibrations to be imposed upon the television camera. To overcome these undesirable features, the fixed beam was replaced by a movable beam which could be positioned in or out by a hand crank winch mounted behind the crane's operator cab. Thus the crane could be positioned in an approximate location, and then the beam could be smoothly maneuvered over the reactor head. The movable beam had the same equipment attached to it as had the fixed beam and was used in the entries made on February 3, 4, and 7.

For the entries made on March 16 - 17, the movable beam and equipment with the exception of the fixed television camera were utilized. In these entries, a television monitor was mounted on the crane so that the television-camera-control cableman could view where he was placing the television camera without direction from the remote monitor located in the television control truck.

To house the television monitoring equipment and to provide a darkened area in which motion pictures could be taken of the television monitor, a ½ ton pick-up truck was obtained. In the bed of the truck was installed a bench which held the television monitors and controls. A canvas cover was positioned over the top of the truck bed to a height of six feet for weather protection and to eliminate all light. The truck was used in entries on January 27 and 28, and on February 3 and 4.

In order to offer better weather protection for the equipment, a ½ ton multi-passenger "carry-all" was modified and used as the television control truck for all entries subsequent to February 5. Rear seats were removed from the vehicle, windows behind the driver's seat were blacked out, and a light proof partition was placed between the driver's compartment and the rear portion of the vehicle. Electrical receptacles, electric lights, constant voltage transformers, and a television monitor bench were installed in the rear of the vehicle.

A mock-up of the SL-1 Reactor pressure vessel, pressure vessel head, and that area of the operating floor between the freight doorways and the pressure vessel head, was constructed on and around a fireman's training tower located near Fire Station No. 1 at the Central Facilities Area. Obstacles such as shield blocks, etc., actually on the reactor operating room floor and pressure vessel head were duplicated on the mock-up. The unit was very effective in emulating the circumstances which would be encountered during the remote entries into the reactor operating room. The mock-up was later modified to include a light-proof replica of the entire pressure vessel, head, and core.

An observation tower was constructed of sectionalized staging at the Control Point and towed by a trailer to the SL-1 Area, where it was installed just outside the northwest corner of the SL-1 fence. The observation platform of the tower was approximately thirty feet above the ground and afforded a partial view of the reactor operating room.

Communications were maintained with the Control Point and the SL-1 Administration Building by telephone. U. S. Army radio sets, AN/PRC-6, and AN/PRC-10, were used as a back-up to the telephone system during some entries.

Communication between the television monitor equipment operator and the television camera control cable operator was maintained by sound power telephones installed in the "Comfo" face masks.

Arm and hand signals were used by spotters on the observation tower to direct the crane crew in positioning the crane and boom at the reactor freight doors.

Motion pictures of the television monitor screens were taken with a 16 mm Bell & Howell Camera (KS-10 Camera Set). Still pictures of the monitor screens were taken by several different types of standard still cameras. It was found that no special motion picture camera equipment was required to take motion pictures of the television monitor screens.

Training. As soon as the mock-up was completed, crane crews, television technicians, television camera cable operators, spotters, and electricians were assembled and briefed on the proposed operation which was to be simulated.

Under the direction of CEI officials, several practice runs were performed before each television entry into the SL-1 Area. Two CEI engineers and four military personnel were trained in positioning the television camera and light into the reactor vessel. Several crane crews and crane spotters were trained to operate the crane and boom, while the television technicians and electricians practiced techniques on proper lighting and picture control.

After each entry in the SL-1 Reactor operating room, where difficulties were encountered, the problems would be analyzed and a solution to the problem would be worked out on the mock-up prior to the next television entry into the controlled area.

Use of Television Equipment - January 4-8. During a meeting of IDO and CEI personnel held on January 4, at about 10:00 a.m., it was suggested that television equipment be installed in the SL-1 Reactor Building for the purpose of remotely observing the building's interior and assisting in efforts to recover the third victim. Originally, the television camera was to be placed on a crane's boom and extended over the operating floor and, if possible, the reactor vessel. Two CEI personnel were assigned to make the arrangements for the television equipment and the crane. Later that same day, a crane and television equipment were obtained from the Phillips Petroleum Company, NRTS. The crane was studied to determine how it could best be outfitted for opening the freight doors of the Reactor Building and where to mount the television camera.

On January 5, crane operators were obtained from the H. K. Ferguson Company, NRTS, and the fabrication of an extension boom began at the Phillips Petroleum Company Machine and Welding Shop. This boom was fabricated from a 3-inch pipe and was approximately 20 foot long. The cab of the crane was covered with 1" of lead to shield the operator and a telephone head-set was installed for communication between the crane operator and the television monitor observer. The procurement of additional equipment, heavy duty power cords, instrument cushions, tape, etc., was also completed. The H. K. Ferguson Company fabricated a wedge to open the freight doors of the Reactor Building. This wedge was welded to the point sheave on the crane's jib and proved to be a satisfactory tool. At about 6:00 p.m., the television equipment from Phillips Petroleum Company's SPERT Area arrived at the SL-1 Control Point. A Kintel television camera was installed on the crane at the SL-1 Control Point. This television system gave poor results because of fluctuations in the power supply from the portable generators; other than this, the system appeared to operate satisfactorily.

At 8:00 a.m. on January 6, the television operations and entry with the crane were halted by a CEI official until advice from Phillips Petroleum Company's SPERT television technicians could be obtained. Based on their advice, it was decided by CEI to mount the television camera on a tripod which would be carried onto the reactor operating floor (see Figure C.1). Power would be furnished from receptacles in the SL-1 Administration Building; in addition, the television monitors and controls would be set up in the SL-1 Administration Building. Approximately 230 feet of cable would be used between the television camera and the control system and television monitors.

The Kintel camera, when mounted on the tripod, was equipped with the following remote controls: pan-and-tilt, change of lenses (wide angle, telephoto and standard), and focus. With these adjustments the camera was best suited for use in the recovery operation by positioning it on the reactor floor.

The personnel involved in placing the television system into operation were divided into two groups. The first group remained within the SL-1 Support Facilities Building to prepare the system for placement on the reactor floor and for testing after placement had been made. The second group carried and positioned the camera on the reactor operating room floor.

At 9:25 p.m. the first group, composed of five men and a health physicist, entered the SL-1 Support Facilities Building with the television equipment. The system was initially set up in an area of low radiation (20-40 MR/hr). After the operational test of the equipment was performed, a floodlight was clamped to a roll of masking tape, and this assembly was taped to the television camera with electrician's tape. The power lead for the lamp was taped to the camera cable. Communication by telephone was established between the SL-1 Administration Building and the Control Point. Personnel at the Control Point were informed that the television camera would be ready for placement by the time the second group arrived at the SL-1 Area.

While the second group was enroute, two men carried the television camera and cables to the bottom of the stairway leading to the reactor operating room. A wire to tie the cable at the head of the stairs was taped to the cable about 20 feet from the television camera. The rest of the cable was "snaked" down the hall to provide slack for the television camera crew.

The second television camera crew, composed of three men and a health physicist, arrived at the SL-1 Area about 10:00 p.m. and proceeded to the SL-1 office area for rebriefing. Immediately following this rebriefing, two men carried the television camera onto the operating floor. A radiation monitor was moved from within the stair-well to the outer edge and the cable was tied with the wire provided to prevent the cable weight from toppling the television camera. Upon leaving the reactor room, a telephone was pulled from a wall in order to obtain a copper sample, which had been requested by Idaho Operations Office. Three persons had assisted with the cable during this operation. One person was at the bottom of the stairway, another opposite the engine room, and a third in the machine shop area. The health physicist for the television camera crew remained at the bottom of the stairs to monitor and time the crew who proceeded into the reactor operating room. The time for the television camera placement was about 55 seconds, after which the second group returned to the Control Point. The first group returned to the SL-1 Administration Building to test the television system.

While testing the television system, it was determined that everything seemed to be operating normally except the focus mechanism of the camera. The pan-and-tilt system functioned satisfactorily and it was possible to change the lens. The picture obtained on the television monitor had no definition until the television camera was turned toward the Motor Control Center where a satisfactory picture was obtained. The focus could not be adjusted.

After some preliminary trouble-shooting, it was decided that the defect might be in the camera or the cable connections to the camera. It was also thought that the tape might be preventing the focus system from adjusting properly. At 10:50 p.m. this group returned to the Control Point for consultations.

By 12:00 midnight it was decided that the most likely reason for the failure of the television camera's focus mechanism was interference by the tape which had been placed around the case. The protective case was open at the bottom and the camera chassis moved during focusing. It was decided to cut the tape and pull it free at each side of the protective case to allow the camera chassis to move.

The total radiation dose received by the ten people who participated in this operation was 6365 mr.

At 12:47 a.m. on January 7, a CEI employee entered the SL-1 Area to proceed into the reactor operating room in order to cut the tape on the television camera and to place some indium foils on the reactor pressure vessel head. He was accompanied to the bottom of the stairs by an IDO employee who acted as health physicist for the entry. The two men returned to the Control Point at 12:55 a.m. The CEI employee informed personnel at the Control Point that he believed he had partially severed a wire when he had cut the tape free from the camera.

Also at 12:47 a.m., four persons entered the SL-1 Administration Building to observe the results of the efforts to repair the television system. At 1:05 a.m. a CEI official reported that the television system operated momentarily after the tape was removed from the focusing mechanism. A malfunction still existed, however; and at 1:50 a.m. the television repair crew returned from the SL-1 Administration Building and advised that the television camera should be returned from the reactor operating room to the SL-1 Administration Building for additional repair.

At 6:00 a.m. three military men proceeded to the reactor operating room to remove the television camera to the SL-1 Administration Building. One person carried the camera while another assisted by handling the cable. The third man entered the reactor operating room to turn off the two main circuit breakers which supply power to the bridge crane in order to eliminate a potential electrical shock hazard for subsequent operations. The health physicist for the group remained at the base of the covered stairway while the group proceeded up the stairs and into the reactor operating room. The party returned to the Control Point at 6:10 a.m. At 8:50 a.m. five men entered the SL-1 Administration Building to repair the television system. The camera and contaminated cable were moved from the control room to the machine shop to enable the men to work for a longer period of time. There the tripod and cables were disconnected from the camera. The camera was then taken to the Assistant Supervisor's Office (Building 602) where the crew remained for approximately one hour attempting repairs. During this period they checked the camera preamplifier assembly and cabling, but the trouble was not located.

Another attempt was made to repair the television system at 1:00 p.m. This group consisted of five personnel who remained in the SL-1 Area until 3:20 p.m. During this period, a complete maintenance check of the entire television system was performed. This included the testing of all tubes and the checking of all adjustments and calibrations. The conclusion was that the trouble must be either radiation browning of the lens or failure of the vidicon scanning tube. The latter could not be checked and there was no replacement part available.

At 2:55 p.m. an official of the General Electric Company was contacted and agreed to try to provide a second television system with 300 feet of cable to replace the existing unit. As a result, no further entries were made to repair the Kintel system.

The total radiation dose received by the thirteen people who participated in this operation was 9395 mr.

By 4:40 a.m. on January 8, a military crew had arrived at the Control Point to transport the second television onto the operating floor.

At 5:05 a.m. the second camera arrived from the General Electric Company. This second camera was different from the previously used Kintel camera. It was basically a fixed camera, i.e., it did not have the remote-controlled pan-and-tilt, lens and focus changing mechanisms. The camera's four-lens system required manual adjustment. Also, this second television camera had some lead shielding around it, which the Kintel camera did not feature, and weighed about seventy pounds. To mount this camera on the tripod would increase the total weight of the unit to approximately 110 lbs., which was heavier and larger than the Kintel unit.

The briefing of the crews started at 5:19 a.m., and by 7:10 a.m. the first crew was suiting up for the check out of the camera system.

At 8:00 a.m. seven people entered the SL-1 Administration Building to install and check out the new television system. The camera was found to be functioning properly. It was thought that this camera would not need any additional light source because of the satisfactory quality of the picture that was received from a relatively dark area. An investigation was made of the tripod and mount used for the first camera, to determine just how the camera was to be installed. It was determined that a mounting plate was needed to adapt the previous mount to the larger camera. After the mounting plate was fabricated, the camera was clamped to the plate with "C" clamps to determine whether the drive motors would aim the camera. It was found that the camera was much too heavy and its weight overpowered the drive motors so that it slowly tipped to a position with the lens toward the floor. The only way the camera could be mounted on the tripod was in a fixed position. This required exact placement on the reactor floor in order for the television camera to view the area of interest.

Originally, it was intended to tape the new camera cable to the cable that had already been used. This old cable supplied power to the drive motors. Since the drive motors would not be used, this old cable was pulled into the mechanics work area. The cable was found to be highly contaminated. The Control Point was contacted and informed of the problems encountered. The group was advised to return to the Control Point for further discussions. At 8:50 a.m. the group left the SL-1 Area for the Control Point.

After discussing the problem, it was decided by CEI officials at 9:30 a.m. not to utilize the tripod, but to position the television camera on top of the shield block that was resting on the tophat (laminated top shield) and to use the wide angle lens. It was anticipated that this plan would allow the television system to be used during the recovery operations and, specifically, assist the personnel in properly positioning the stretcher.

At 10:00 a.m. CEI requested that General Electric personnel familiar with this camera assist in preparing it for placement on the reactor operating floor. The actual placement of the camera was to be performed by military personnel.

At 11:05 a.m. CEI notified the Control Point that the proposed position of the camera would provide the best view to assist in the effort to recover the third victim.

A briefing was held at 12:40 p.m. with IDO, CEI, and military personnel concerning camera preparation and placement. The camera was to be set on wide-angle display, and the focus was to be adjusted before the camera was taken onto the reactor floor.

Three men entered the SL-1 Administration Building at 1:08 p.m. to prepare the camera for installation. At 1:15 p.m. an IDO employee entered the SL-1 Area to act as health physicist. The crew experienced some difficulty in removing the cover which housed the lens system. This had to be accomplished in order to set the camera for wide-angle viewing. The operation was finally completed by removing the glass face plate and reaching in to change the lens. The work was finished by

1:46 p.m. and the television camera was ready for placement on the reactor operating floor.

The camera was positioned on the reactor operating floor by three military personnel at about 1:50 p.m. They returned to the Control Point by 1:55 p.m.

A telephone call from the SL-1 Administration Building by the health physicist at 1:56 p.m. informed Control Point officials that the camera had been successfully positioned; however, only the extremities of the victim were visible at the top of the screen.

At 2:05 p.m. the remaining television crew returned to the Control Point.

At 5:00 p.m. three persons entered the SL-1 Administration Building to observe the televised recovery operation.

At 5:12 p.m. CEI reported that the television picture was not clear. The picture displayed on the monitor was becoming darker and darker; possibly, this darkness was caused by radiation browning of the lenses. By 5:15 p.m. the picture had almost completely disappeared. The television system, therefore, was abandoned with all power left on. It was decided to leave the power on because of radiation damage. Gamma radiation has less effect on the vidicon tube in the camera if the power is left on; five days later the power was turned off.

The total radiation dose received by the 16 people who participated in this operation was 6100 mr.

Use of Television Equipment -- January 27. After the television crew had completed practice on the SL-1 mock-up (see Figure C.2), a team composed of fourteen men entered the SL-1 Area at 5:40 p.m. to obtain television pictures of the core and pressure vessel. Prior to the entry IDO officials had approved "Procedure EP-RO-9, subject: Procedure for taking Television Pictures in the SL-1 Tank," submitted by CEI on January 26.

Inside the SL-1 Area the television camera equipment was checked and found to be operable. The crane was then moved into position in front of the SL-1 Reactor Building, and upon direction of the spotter located on the observation tower, the beam was lined up with the monorail "I" beam which was located over the reactor operating room floor. The crane was moved forward to a predetermined position which would allow the end of the beam to be positioned directly over the reactor pressure vessel head, (see Figure C.3). During this operation, two photographers accompanied by a health physicist obtained motion pictures of the entry from the observation tower (see Figure C.4).

As soon as the crane had been positioned, the television truck entered the SL-1 Area to a point west of the pump house. The truck was parked at this location for the remainder of the operation. Television and communication cables were connected as the beam proceeded into the reactor operating room. While the beam was being positioned, the camera encountered a radiation hazard warning tape which had been placed around the reactor head area by the crew that had worked in that area prior to the incident. In order to move the camera beyond the tape, the camera was moved back and forth by rapidly changing directions of the beam. Finally the tape broke, but the camera continued in an arc and apparently encountered a bare electrical wire, as an electrical arcing was observed by observers on the observation tower. The operation was terminated, at this point, as darkness prevented the observers from determining the extent of damage, if any, that had been done to the equipment. All personnel departed the area and left the equipment in place with the camera positioned over the reactor head.

The total radiation dose received by the fourteen people who participated in this entry operation, plus the six people who were in direct support of it, was 4980 mr.

Use of Television Equipment - January 28. Since the crane and television equipment had been left in place overnight, there was no positioning work to be accomplished when the operation crew entered the SL-1 Area at 11:00 a.m. The camera was checked and found to be operating properly, although it had remained in a very high radiation field for over twenty hours.

The camera was successfully dropped through nozzle #8, but could not penetrate the pressure vessel head because the guide wires became caught around the camera shield. The light was not able to penetrate the pressure vessel, but was positioned over various ports in an attempt to flash light the interior of the tank. Because of insufficient illumination inside the pressure vessel, the operation was terminated and personnel departed from the area. All equipment was removed except the television connecting cables.

The total radiation doses received by the thirty people who participated in this operation was 8225 mr.

Use of Television Equipment - February 3. As the fixed beam crane proved to be unsatisfactory for the previous operations, it was replaced by the moveable beam (see Figure C.5). Pulleys, lights, and a television camera were mounted on the end of the beam and training was conducted at the Central Facilities SL-1 mock-up on February 1. During the training program, a snow storm developed and sufficient snow was deposited on the television cables and connectors to cause them to short out. A full day was required to dry out and replace the shorted connectors, delaying the entry attempt that had been planned for February 2 to February 3.

Because it was feared that the television cables left on the ground in the SL-1 Area may have been shorted out from the snow, a crew of fifteen men entered the SL-1 Area on February 3, with electrical equipment to check out the cables. Because the cables were found to be shorted, the planned television entry was postponed until the cables were repaired.

The crew departed from the Control Point with the television cables to perform the maintenance that was necessary. Inasmuch as the cables could not be repaired prior to darkness, operations for the day were suspended.

The total radiation dose received by the fifteen people who participated in this operation was 775 mr.

Use of Television Equipment - February 4. After checking out all television equipment at the Control Point, a crew of eighteen men entered the SL-1 Area with the crane, television equipment and motion picture camera. The crane was positioned and the moveable beam was in process of being positioned into the reactor operating room when water, which had collected from melting snow located on the top of the canvas positioned over the television truck, leaked through and saturated the circuitry of the Kintel control unit. This resulted in the cancellation of the television penetration for the day.

All personnel and equipment withdrew to the Control Point where it was determined that the Kintel control unit could not be dried out in time for another penetration attempt. Activities were suspended for the day after preliminary decontamination of the television equipment was accomplished.

The total radiation dose received by the eighteen people who participated in this operation, plus the ten people who were in direct support of it, was 5575 mr.

Use of Television Equipment - February 7. A crew of thirteen men entered the SL-1 Area with the crane and television equipment at 3:20 p.m., and successfully positioned the crane and dropped the camera into nozzle #8 of the pressure vessel head. The interior of the pressure vessel was illuminated by dropping the light through the tops of nozzles #1, 7, 8, and 9. Because the television camera had been jarred after leaving the Control Point, it was badly out of focus. While a view of the core was obtained, it was of such poor quality and definition that observers could not recognize the items that appeared on the monitor screen. Pictures were taken of the monitor screens, but due to the focusing problem these photos were of little value in determining the condition of the core.

The crew departed for the control point with the equipment and the days operation was terminated.

The total radiation dose received by the thirteen people who participated directly in this operation, in addition to fourteen personnel who participated as laborers and observers was 7515 mr.

Use of Television Equipment - March 16. A television penetration was made into the SL-1 Reactor operating room using a control unit and monitor with a sweep of 729 lines as against 525 lines used on the previous entries. For this entry, a monitor was mounted on the Austin-Western crane in such a position that the camera-cable operator could watch the progress of the camera as it entered the pressure vessel. Another monitor was placed in the television truck with a 16 mm motion picture camera trained on it to record the television pictures on film.

The television penetration was successful, and the television monitors showed great detail; however, due to a malfunction of the motion picture camera shutter no movies were obtained. Several still photographs showing fair detail were obtained.

As it was not known at that time that the motion picture camera had not recorded the television pictures, the crane and television equipment was returned to the Control Point and the operation was terminated. The total radiation dose received by the twenty nine people who participated in this operation was 2400 mr.

Use of Television Equipment - March 17. At the recommendation of the IDO Control Unit a television penetration into the reactor pressure vessel was made with the same equipment as was used on the previous day's entry. The penetration was completely successful, and motion pictures were obtained. The television camera was manipulated by wires in the pressure vessel, and about 50% of the core was viewed.

As a precaution against a recurrence of the failure of the motion picture camera, the television camera remained in the pressure vessel while the motion picture film was processed. This was done so that additional motion pictures could be taken, if necessary. The first motion pictures taken were not entirely adequate because only half of the television monitor was photographed. Additional motion pictures were taken while the television camera was being withdrawn from the pressure vessel. These pictures were satisfactory and showed the general condition of the reactor core. After the operation was completed, the motion pictures were reviewed and the operation was declared a success.

The total radiation dose received by the twenty people who participated in this entry operation was 2330 mr.

Summary. Although the time and effort spent on these eight missions was considerable as compared to the objectives achieved, it is believed that valuable information was obtained from the latest entries, thereby, making the operations worthwhile.

It is quite evident that in the disaster preplanning for a reactor plant, ample consideration should be directed towards determining whether a television system should be installed as a part of a network to assist in disaster operations should a nuclear incident occur.

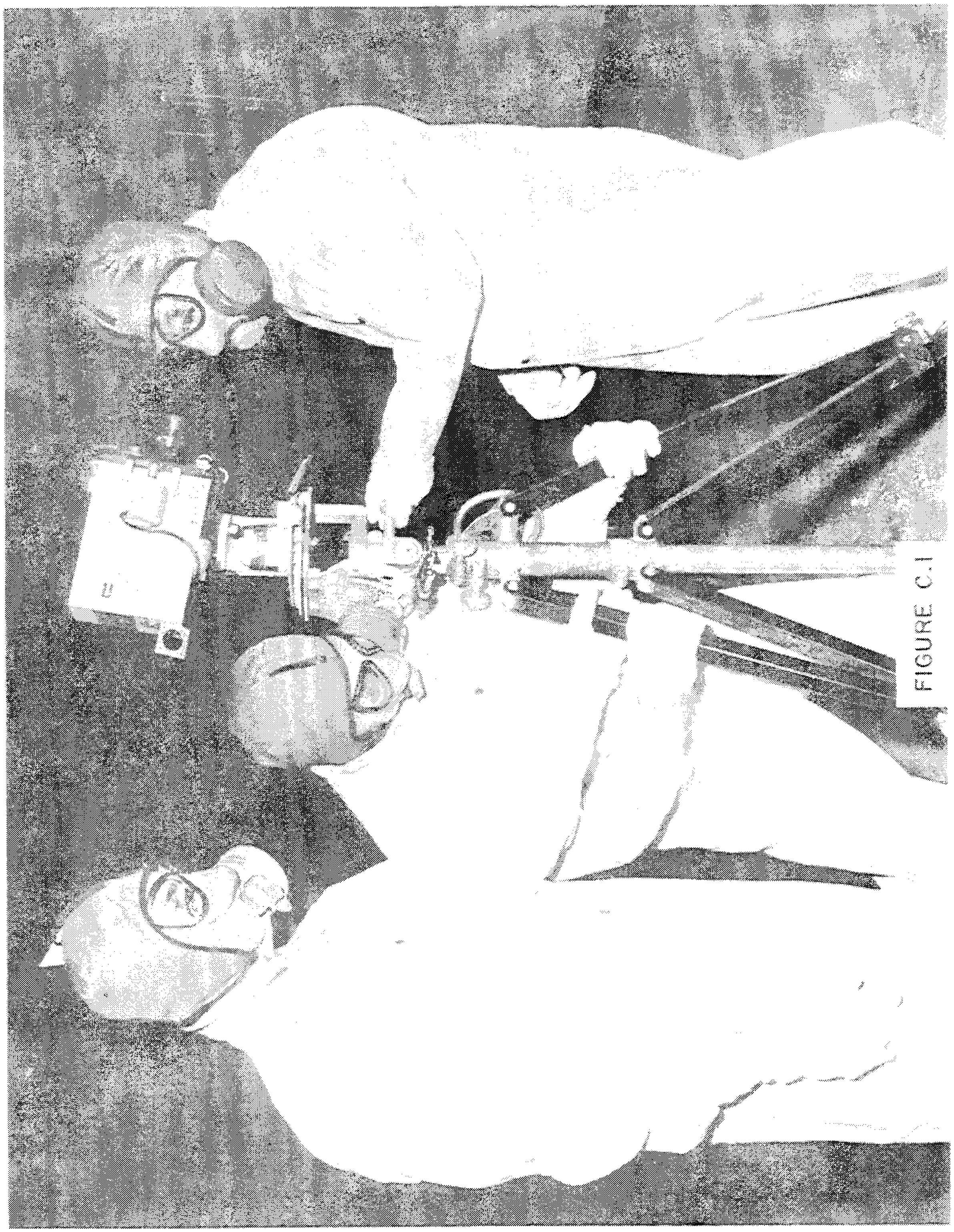


FIGURE C.1

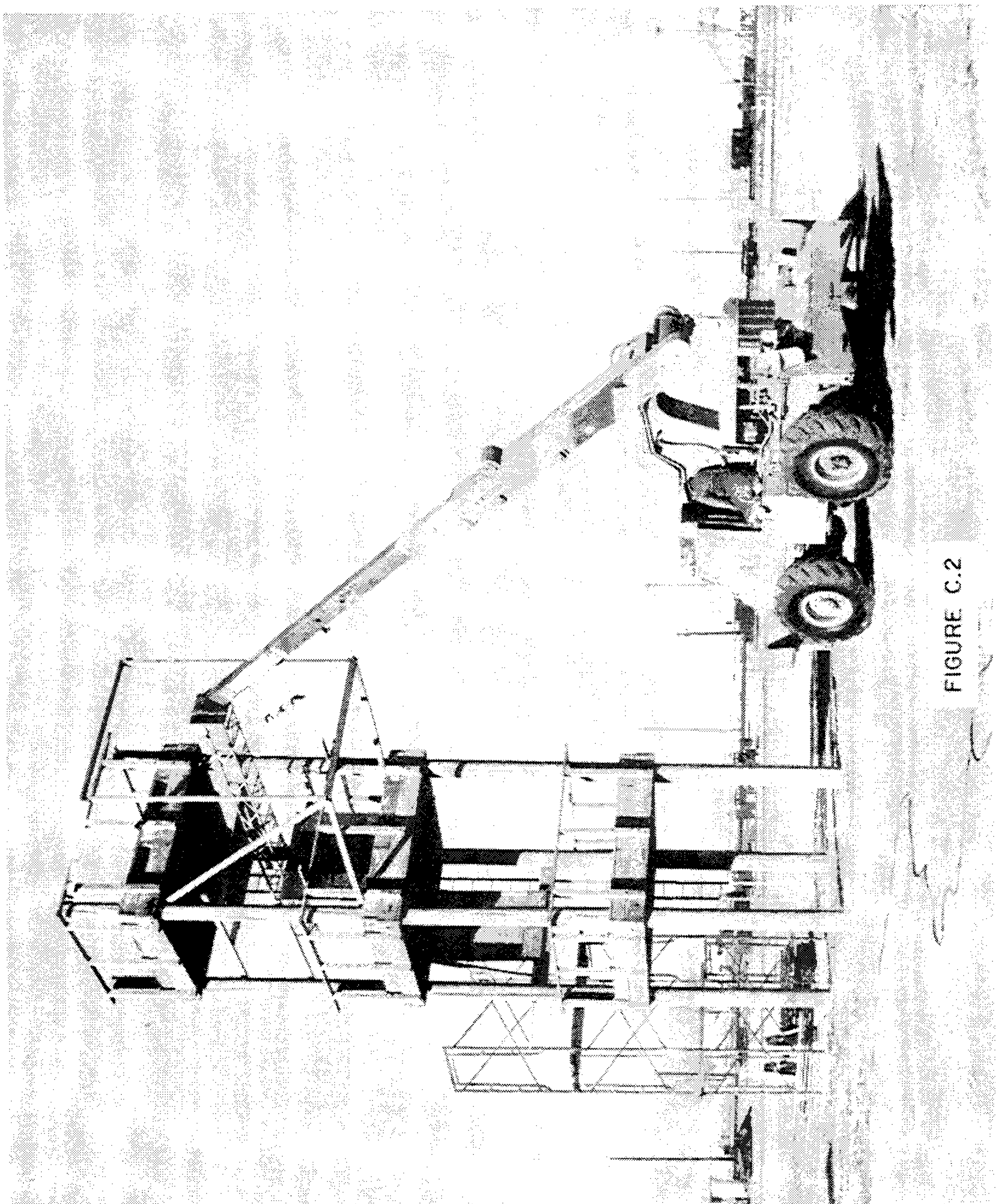


FIGURE C.2

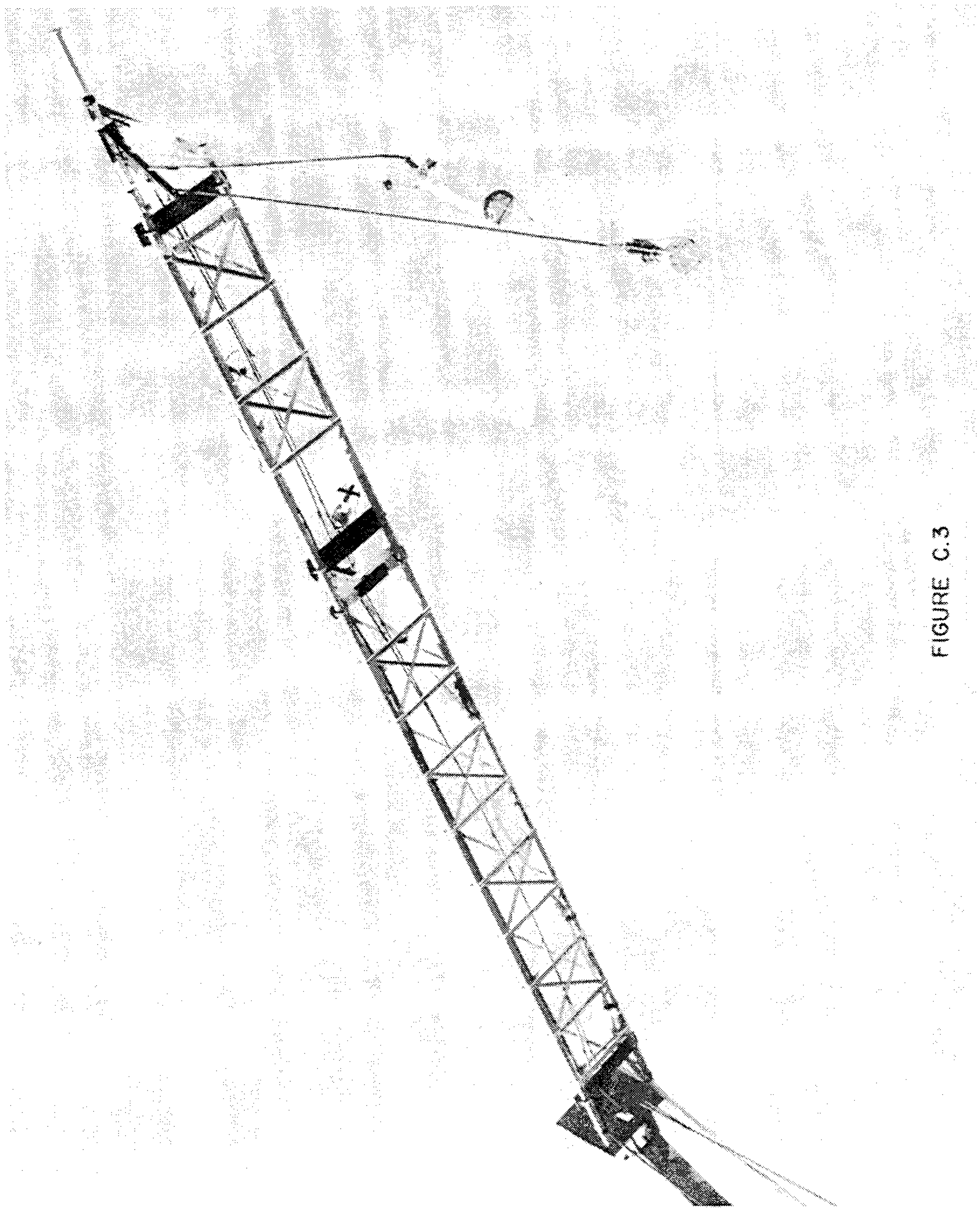


FIGURE C.3

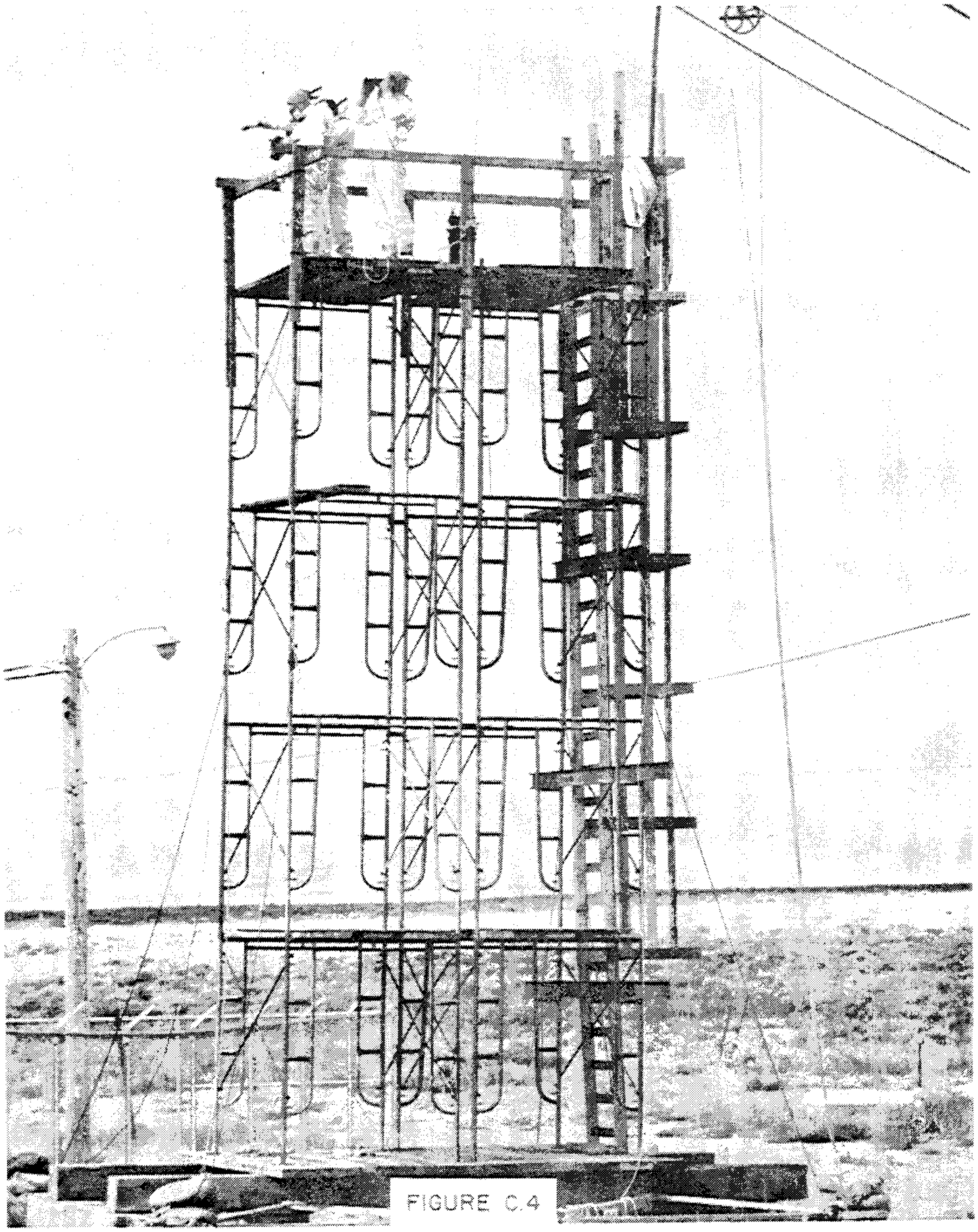


FIGURE C.4

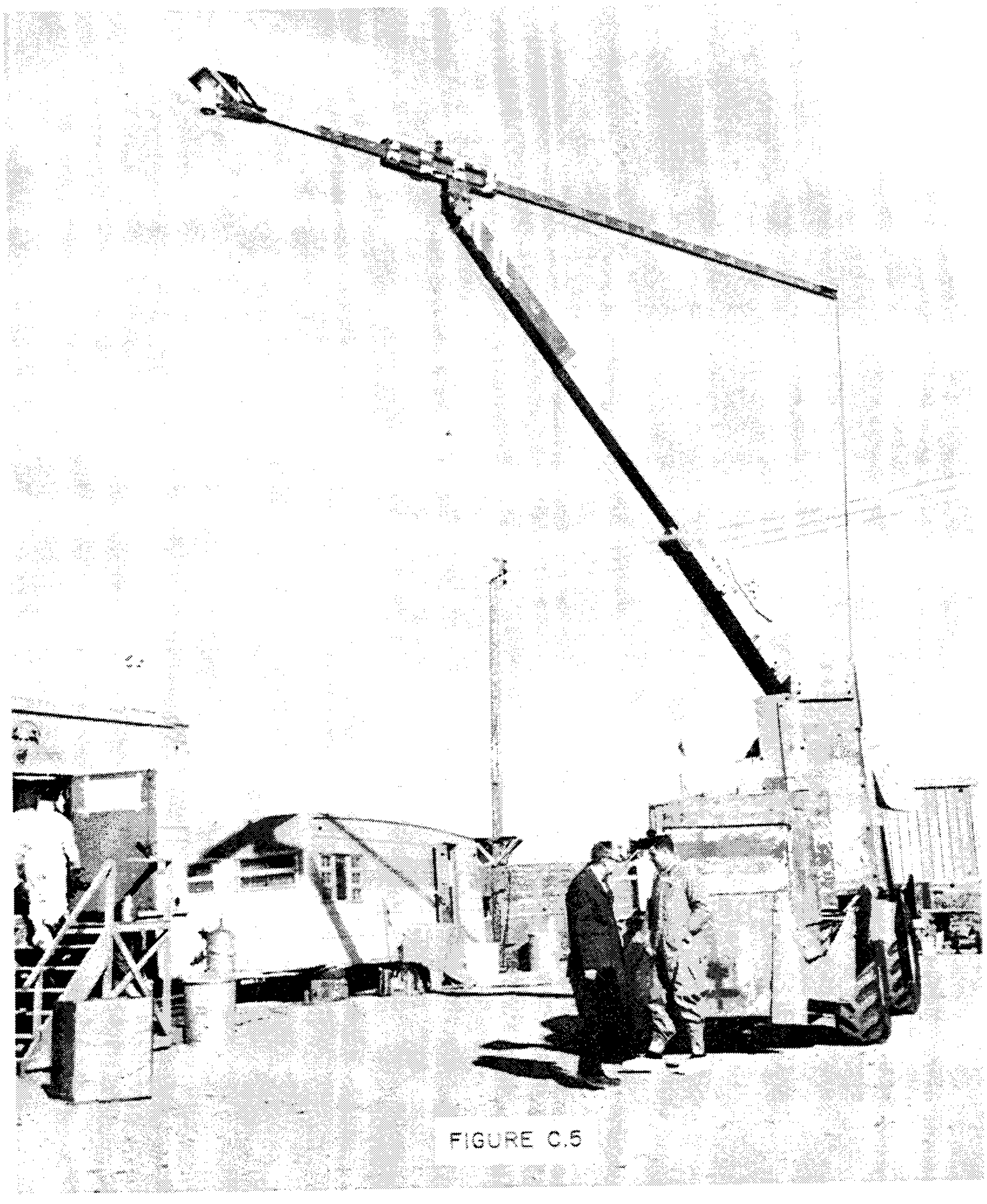


FIGURE C.5

APPENDIX D

ADT ALARM SYSTEM

In general, the American District Telegraph Company (ADT) alarm system, as utilized at the National Reactor Testing Station, consists of a device or sensor, a transmitter, a local recorder, and a receiver-recorder. The device (alarm box) or sensor either closes or opens an electrical circuit, causing activation of the alarm transmitter. The alarm signal is transmitted to a local recorder where it is recorded and date-time stamped; the signal is simultaneously transmitted to the Central Facilities Fire Station No. 1, Security Communications Room, and to Fire Station No. 2 and 3. In each case, the signal is recorded and date-time stamped by the receiver-recorder. At the SL-1 Area, each fire alarm box has a separate code and all the automatic heat detectors within a single system have a single code. For example, all the sensors in a particular building are on one system and an alarm code from this system would indicate a fire within that building. This system aids the IDO Fire Department in determining a fire location prior to their departure from the fire station.

The SL-1 has six fire alarm codes. Four of these codes are from manual fire alarm boxes located in the support facilities building, reactor building, training building, and administration building. The other two codes are in automatic heat detector systems in the reactor building and the support facilities building.

A secondary system of signals is incorporated in the ADT alarm system and is known as Supervisor's Signals. These signals are only relayed to the Central Facilities Fire Station No. 1.

Following is a list of the alarm codes and Supervisor's Signals from the SL-1.

	CODE	LOCATION
SL-1	1-1-2	Support Facilities Building (manual alarm box)
	1-2-1	Support Facilities Building (heat actuated device)
	1-1-3	Reactor Building (manual alarm box)
	1-2-2	Reactor Building (heat actuated device)
	1-1-4	Training Building (manual alarm box)
	1-3-1	South door of Administrative Building (manual alarm box)
	1-1-1-2	50,000 gallon water storage tank level
	1-1-1-3	Tamper and Gong Panel (opening ADT control panel door)

The three digit codes denote alarms and the four digit codes are supervisor signals. However, incorporated into the system is a trouble signal from the heat actuated device systems, which transmits a single signal or code when there is trouble in the system. Upon an actual alarm, the alarm code is repeated three times in the case of heat actuated devices, and five times from a manual alarm box.

The sensing elements utilized in the reactor operating room at SL-1 were of one type. The principle of operation was the utilization of two metals with different expansion co-efficients. The sensors have two silver contacts mounted on, but electrically insulated from, two curved struts that have a low expansion co-efficient. This assembly is mounted under compression in a tubular stainless steel shell having a high co-efficient of expansion.

Temperature changes cause the shell of the sensor to expand or contract, exerting magnified motion to the contacts, which close when the surrounding air reaches the temperature for which the unit is set. The shell is the basic temperature sensitive part and is always in contact with the surrounding air.

The seven sensing units mounted on the overhead approximately nine feet above the reactor operating floor were factory adjusted to alarm at 140°F.

A sketch of the sensing elements is shown in Figure D.1 and the location of the sensors above the SL-1 reactor operating room floor is shown in Figure D.2. Four sensing units of the ADT system are located in the condenser fanloft directly above the reactor operating floor. These sensing units are mounted on the ceiling and are located inside the airlock chamber, above the circulating air fan inlet and exhaust, and above the air mixing chamber. Initially, the sensors above the operating floor and in the fanloft had the same alarm point. Because several false fire alarms were experienced due to the higher normal operating temperatures in the fanloft, the sensors located there were replaced with devices which actuated at 225°F.

The ADT transmitter, located in the SL-1 Support Facilities Building, is an electrically tripped device with a spring driven clock mechanism. On alarm, a code wheel turns and actuates spring contact which close the circuitry to the ADT recorder. The alarm is then recorded locally and simultaneously transmitted to the fire station as stated above. Rewinding of the mechanism is necessary after each alarm.

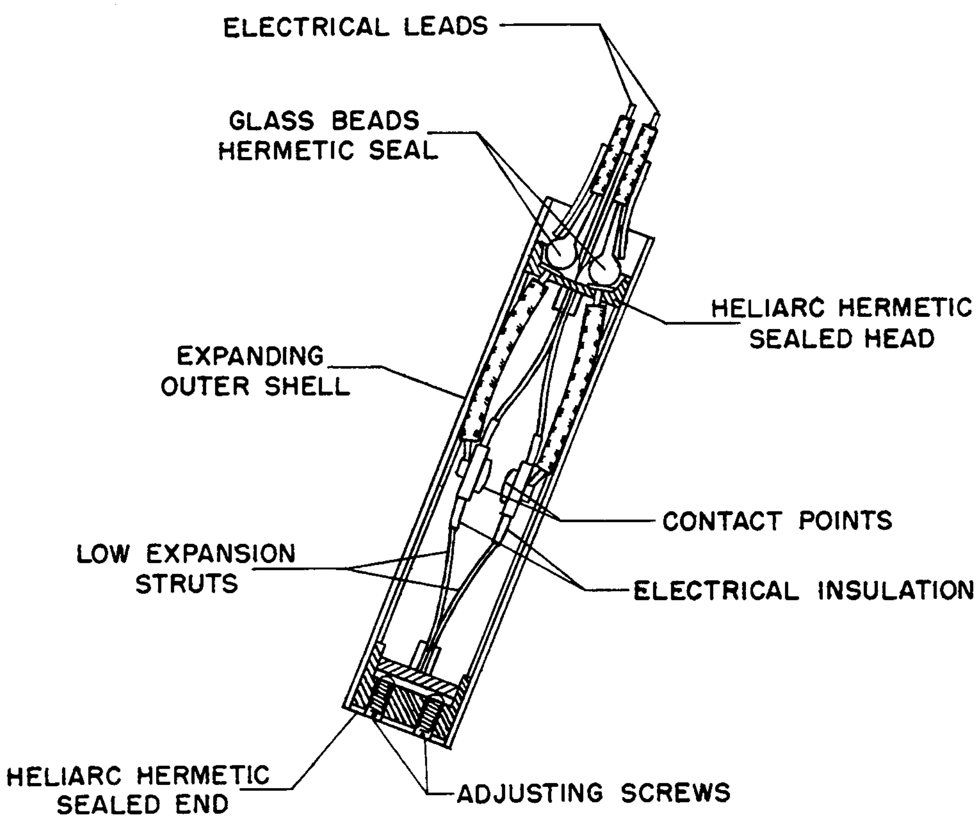
At 9:01 p.m. on January 3, 1961, a Code 1-2-2 was received by the Central Facilities Fire Station No. 1. This code indicated a fire in the Reactor Building at SL-1 Area and, as a result, the IDO Fire Department responded immediately to the alarm.

There was no Supervisor's Signal prior to the receipt of the Code 1-2-2 alarm; and since January 3, there have been Supervisor's Signals received from the SL-1 ADT System. These signals, subsequent to January 3, pertained to the 50,000 gallon water storage tank level and indicated that portions of this system were still operable. The alarm mechanism was rewound on February 9, 1961.

The last fire inspection conducted at SL-1 Area prior to the Incident was on December 7, 1960, and the inspection report indicated that all manual and automatic alarms were in proper working condition. During this inspection, several of the sensing units located above the operating floor were checked for actuation by subjecting them to the beam of a heat lamp.

There is no way the ADT system at the SL-1 could alarm under a pressure surge or shock unless there was damage to a sensor causing a short circuit across the normally open contacts in the sensor. A total of eleven automatic heat detectors are utilized in the SL-1 Reactor Building Alarm System and it would be difficult to determine which individual sensor caused the alarm unless one or more are damaged.

ADT ALARM UNIT
PRINCIPLE OF OPERATION



THE TWO FINE SILVER CONTACTS ARE MOUNTED ON, BUT ELECTRICALLY INSULATED FROM, TWO CURVED STRUTS THAT HAVE A LOW EXPANSION COEFFICIENT. THIS ASSEMBLY IS MOUNTED UNDER COMPRESSION IN A TUBULAR STAINLESS STEEL SHELL HAVING A HIGH COEFFICIENT OF EXPANSION.

TEMPERATURE CHANGES CAUSE THE SHELL TO EXPAND OR CONTRACT – EXERTING MAGNIFIED MOTION TO THE CONTACTS WHICH CLOSE THE INSTANT THE SURROUNDING AIR REACHES THE TEMPERATURE FOR WHICH THE UNIT IS SET REGARDLESS OF THE RATE OF AIR TEMPERATURE RISE. THE SHELL IS THE BASIC TEMPERATURE SENSITIVE PART ... ALWAYS IN CONTACT WITH THE SURROUNDING AIR.

FIGURE D.1

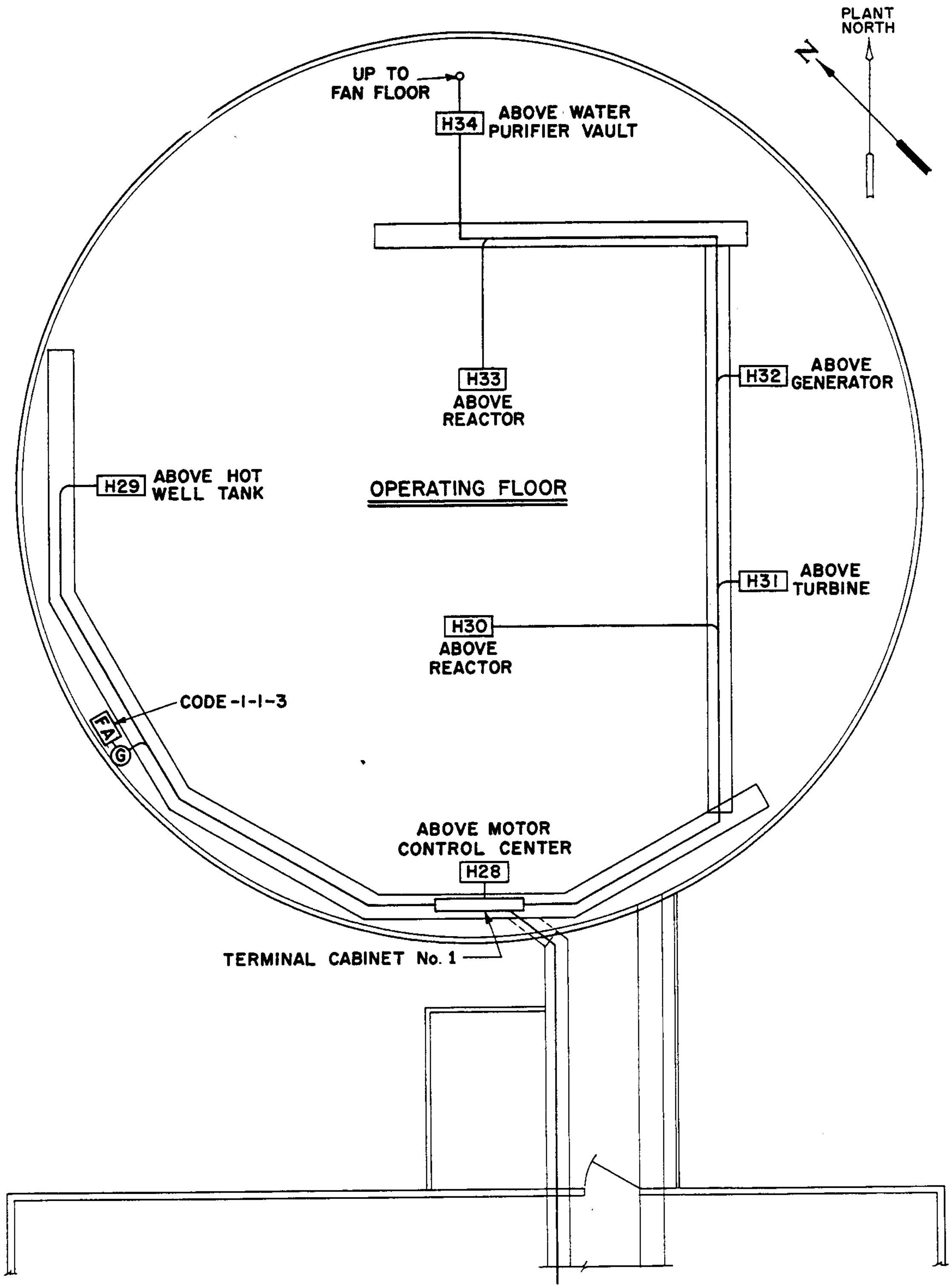


FIGURE D.2

LOCATION OF ADT SENSORS OVER SL-1 REACTOR

APPENDIX E

REPORT OF IDO SECURITY DIVISION

The IDO Security Division participated as both an enforcement and service organization during the recent disaster operation at the SL-1 Area of the National Reactor Testing Station (NRTS). The functions and responsibilities of the Security Division were many and varied following the incident, and ranged from those duties normally associated as a security function to those efforts similar to security but requiring a considerable increase in manpower. In addition, the Security Division performed a multitude of tasks which would normally not be associated with security but which were delegated or assumed because of the emergency nature of the situation.

On January 3, 1961, between 5:23 and 5:42 p.m. a Security Patrolman checked the SL-1 Area and found conditions to be in order. The next scheduled security check was to take place at about 10:00 p.m.

Later, two patrol duty officers and a utility patrolman on duty at 9:01 p.m. responded with the AEC-IDO Fire Department to the SL-1 fire alarm. This is a routine procedure since Security personnel normally establish road blocks and effect traffic controls to assist the Fire Department in their duties at a fire scene. The Fire Department had a key to the SL-1 Guard House, but not to the SL-1 Vehicle Gate and would normally have resorted to their bolt cutters in order to gain access into the area.

In this instance, the Security personnel arrived with the fire truck and expedited entry by opening the guard house and vehicle gate. For sometime, the SL-1 Area has been under security administrative control which precludes a guard assignment at the area. Instead, all fence-line entry points were secured, and access was permitted when a reactor operator on duty in the area met the visitor at the guard house. An intercom system which connected the guard house and the control room was utilized to request entrance. Security, of course, possessed access to the area at all times. The patrol duty officers also provided a G.M. and Jordan Radector radiation instrument to the Fire Department personnel so that a double check of the radiation levels could be performed.

As the seriousness of the situation became evident, the IDO Communications Section of the patrol force placed emergency procedures into effect. In addition to the assignment of additional personnel to the Section to handle the increased workload, the inter-net radio tie was effected to permit a central control of all radio communications. This permitted the IDO Manager and members of his staff, who had convened at the IDO Headquarters Building, to have direct communications with the SL-1 Control Point and other NRTS areas, transportation facilities, health and safety operations, and the Fire Department, regardless of the radio net normally used by each. Radio communication was the only available means to direct recovery actions at the SL-1 Control Point, or by which to receive information from that location, until a telephone circuit was installed from the AREA Hot Cell Facility. The recordings made at the Communications Section of the inter-net radio tie were transcribed by the Security Division for the information record of the investigation and advisory committees. Two handi-talki portable radio units (Motorola Model 123AC-1001AM and General Electric Model H.F. 31WL) were also furnished the Manager's staff as an emergency measure to replace, if necessary, the fixed station "B" used by the group throughout the disaster.

Radio communications were also established with a health and safety monitoring plane, which was airborne early on the morning of January 4, and several times since. All communications from this plane were included on the inter-net tie and in the subsequent recordings and transcripts.

The communications personnel assisted in recalling off-duty patrol personnel to duty as requested by the Security staff members who were with the Manager's group assembled for recovery actions.

Communications personnel also made an all station "Secode" broadcast which alerted all NRTS areas of the disaster. This broadcast enabled personnel at other NRTS facilities to prepare for possible emergency actions at their site, as a result of potential health and safety problems, and to determine the amount of assistance which could be extended to personnel at the SL-1 Area.

The total inter-net tie remained in effect for four days after the disaster, and then a partial reduction was effected. A tie, however, between net "A" (Security) and net "C" (Health and Safety) continued during normal work hours until January 27.

The local FBI was notified by the Security Division as soon as a disaster was declared and was provided with all information known at that time. Follow-up contacts have been made to keep them informed of the situation.

As the recovery program was developed on the night of January 3, additional patrol personnel were recalled to duty at the Site and the Headquarters Building in Idaho Falls, or were held over from the preceding relief to perform numerous tasks. These included such duties as:

a. Furnishing transportation from the SL-1 Control Point to the decontamination areas for personnel involved in the initial and subsequent reactor area entries;

b. Delivering an ambulance from the fire station to the SL-1 Control Point;

c. Providing transportation to and from the SL-1 Control Point, Central Facilities Area Dispensary, Cafeteria and the Chemical Processing Plant (CPP):

d. Arranging for and delivering special items from the heavy equipment shops, machine shops, and warehouse as their need became evident (the majority of these items consisted of airpacks, oxygen bottles and health physics clothing and devices);

e. Providing numerous courier trips between the NRTS, SL-1 Control Point and the IDO Headquarters Building, Idaho Falls, and vice versa (these trips involved transportation for personnel as well as to deliver charts, records, pictures, etc., and supplies required on an emergency basis);

f. Providing pickup and delivery services for official personnel between the Idaho Falls Airport, downtown hotels and the Headquarters Building; and

g. Making arrangements for the emergency procurement of motor pool vehicles to be used in the recovery operation.

The need for radiological personnel was extensive and immediate after the disaster. Patrol personnel accepted certain monitoring responsibilities immediately after initial recovery actions were initiated. These patrol people completed a monitor of Highway 20 eastward from the SL-1 Area to a point north of Atomic City, and Highway 26 from Atomic City to the Lost River Bridge on the west side of the NRTS. Subsequent radiation monitoring was made on a periodic basis at the SL-1 Control Point and at various security patrolled points around the SL-1 Area; other locations and roadways (burial ground, etc.) were surveyed as requested by the Staff Duty Officer and Health and Safety officials to determine any change in the radiation levels. Personnel monitoring was also performed by Security employees on January 3 and 4, 1961.

In addition to the monitoring services, the Security Division made numerous radiological escorts between the SL-1 Area, CPP Area, burial ground and the Idaho Falls Airport. Radiological escorts between SL-1 and CPP required special traffic controls, and on one occasion complete control over a portion of Highway 20 and NRTS roadways was obtained from 2:44 to 3:04 p.m. on January 10, 1961.

Additional personnel were assigned to assure adequate controls in order to prevent unauthorized persons from accidentally or purposely gaining access to the SL-1 Area. These controls included establishing (1) a new control point on the Pole Line Road now used for access to the GCRE and ML-1 Areas and (2) a post at the SL-1 Control Point at Fillmore and Highway 20 to enforce health and safety access restrictions. Two additional patrols were established as buffer protection outside the SL-1 Area in order to prevent penetration, and on the night of the disaster and the day following, one additional patrol was placed on Highway 20, on each side of the SL-1 Control Point, to keep traffic moving and prevent congestion which could hamper recovery actions.

Additional patrol assignments were made to personnel at the Headquarters Building in Idaho Falls to provide courier service and driver service to the NRTS, airport and hotels as previously noted. These persons also ran innumerable errands for the Control Unit and other officials involved with the disaster, including such things as delivery of news releases to the local newspapers and radio stations, purchasing items such as recording tapes, file cabinet keys, etc. The rooms used by the investigation and advisory groups were secured when not occupied, and an access control was established by Security. Keys were retained at the patrol island desk and issued only to authorized persons, and custodial personnel were escorted into the rooms to assure that evidence, files, etc., were not disturbed.

Patrol personnel were further assigned to guard the Albuquerque Operations Office airplane after a cask shipment of radioactive samples was loaded. The guard assignment continued until the pilot assumed responsibility the following morning. The guards additionally provided the necessary escort of uncleared personnel while within the Headquarters Building, the requirement for which was increased many times over normal because of the influx of visitors. The patrol force also established controls at certain buildings in the Central Facilities Area and other areas of the NRTS to assure that only those persons specifically authorized could have entry. This involved either guards posted at those locations or special locks and seals checked on a period basis.

To relieve the visitor problem as much as possible, special emergency identification and clearance procedures were initiated for the many AEC, contractor and DOD visitors, the majority of whom arrived within a few days after the disaster. These procedures minimized the confusion and delay for the visitor's access to the Headquarters Building and areas of the NRTS. This required numerous priority teletype and telephone messages to other AEC offices and, in some instances, accepting verbal confirmation of visit and clearance status from other than security offices pending written confirmation from an authorized source.

At the SL-1 Area a special identification device unique to that area was initiated and furnished for use by personnel involved in the recovery action. The procedures for its use and the issuance and recovery formalities were coordinated by the Security Division with the IDO Health and Safety Division and later with Combustion Engineering, Inc. These devices permitted better personnel control during the initial recovery action phases of the disaster and allowed those in control to readily identify those officially involved in the operations.

The need for qualified radiological trained personnel continued, and members of the patrol's Communications and Courier Sections were assigned to the IDO Health and Safety Division on a temporary basis to assist at the SL-1 Control Point. Their duties included time-keeping responsibilities for personnel entering the SL-1 Reactor Building, monitoring personnel, assisting with the special health and safety clothing, briefing personnel, obtaining and recording radiological readings, etc.

Also, security personnel were assigned to the Manager's staff to act as liaison with the Security Division and other personnel involved in the recovery actions. These personnel maintained the Security Division operational logs and made numerous radio and telephone contacts to coordinate the many phases of the activities for a satisfactory completion. In addition, Security personnel were responsible for such items as the recall to duty of the telephone and teletype personnel shortly after the disaster occurred, making arrangements for the telephone lines from the AREA Hot Cell to the SL-1 Control Point, etc.

As the need became evident for an around-the-clock control center at the IDO Headquarters Building to coordinate the numerous phases of the recovery effort between the Control Unit and the various groups at the NRTS, a Staff Duty Officer system was established within the Security Division. This officer represented IDO in all coordinations when the Manager's Control Unit was not assembled.

The Duty Officer maintained a record of all requests, notes and actions and kept a record of the key IDO and contractor personnel to assure that they could be reached at any time. He also contacted them when it was necessary to approve actions or access which they alone could authorize and, in general, enforce the special controls of the Manager's Control Unit. The persons who were assigned the Staff Duty Officer responsibilities were familiar with all phases of the operation and were qualified to act as necessary. In conjunction with this, a patrol supervisor officer was on duty during all hours at the NRTS to coordinate the instructions of the Staff Duty Officer.

As the recovery operations progressed and it became possible to photograph the inside of the reactor building, the necessity for a positive control of photographs became evident. The Security Division assumed this responsibility and established an accountability system and a procedure to assure that only authorized persons could have access to them. This involved obtaining all negatives (including those improperly exposed, damaged, etc.) regardless of who took them (three different contractor photographers were involved at three different times), all prints (including scrap and imperfect copies), the polaroid prints and their paper negatives (the latter were either turned in or accounted for as destroyed) and the color transparencies.

In addition, several photographs of the different investigating and advisory groups at the Headquarters Building were taken at the Manager's request by Security personnel in the absence of regular AEC or contractor staff photographers. Further, a Division employee operated a motion picture projector for the Technical Advisory Committee to review SL-1 movies.

The Security Division also established and enforced a photography policy for newspaper and television photographers at the NRTS to assure that only authorized persons were obtaining pictures and to assure the health and safety of the photographers within the restrictions imposed by the Health and Safety Division regulations.

Numerous other services were provided during the initial phases of the recovery program and many continue at this time; these included:

a. Coordinating a microphone and tape recorder setup for the AEC Investigation Board;

b. Investigating and reporting two unauthorized airflights over the SL-1 Area on January 6 (this involved a personal interview with the pilots and their passengers at the Idaho Falls Airport and impounding their planes until the IDO Health and Safety Division could monitor the aircraft for possible radiation hazards);

c. Preparing a brief comprehensive security history of the SL-1 Area;

d. Furnishing binoculars to the SL-1 Control Point and to the pilot of the Health and Safety monitoring plane - also providing a file repository for the library committee compiling a record of the disaster; and

e. Furnishing map information of the air miles involved between the SL-1 Area and the other NRTS areas, etc.

This summary report of the IDO Security Division's participation during the SL-1 Incident does not include a number of special courier or monitoring operations, etc., since this would at best be only an approximation at this time. The report simply represents an overall view of the basic services performed by the Security Division.

APPENDIX F

REPORT OF CHEMICAL PROCESSING PLANT PARTICIPATION

Chemical Processing Plant (CPP) Personnel were first made aware of a possible incident at the SL-1 when members of Phillips' Security were informed that a fire alarm had been received from the SL-1 Area. This alarm sounded at 9:01 p.m. on January 3, 1961. Early health physics assistance was requested through pre-planning at 9:02 p.m. by the IDO Fire Department.

After the severity of the situation at the SL-1 became known, a broadcast was made over the National Reactor Testing Station (NRTS) radio network requesting additional health physics personnel and equipment. In response to this request, a CPP Health Physicist was dispatched to the SL-1 Area. Also, during the early hours following the incident, CPP personnel furnished to the SL-1 Area many pieces of radiological survey equipment, in addition to anti-contamination clothing and Scott Air-Paks.

Following the recovery operation for victim No. 1, many persons at the SL-1 Area were found to be contaminated. As a result, arrangements were made by IDO officials to have primary personnel decontamination efforts take place at the Gas Cooled Reactor Experiment (GCRE) Facility, and secondary decontamination efforts take place at the CPP, as well as the Central Facilities Dispensary. CPP provided not only a decontamination facility, but supplied health physics personnel to survey the contaminated people and to assist, if necessary, in the decontamination.

Later, the CPP Decontamination Room was prepared for receipt of the first victim to be removed from the operating floor of the SL-1 Reactor Building. When the preparation had been completed, the room was inspected by IDO Officials and declared acceptable for decontamination work to be undertaken on the victim.

Upon arrival of the first victim at the decontamination room, CPP health physics personnel monitored all phases of the decontamination operation, and surveyed those people involved in the task. Throughout the activities which took place at the CPP regarding the work undertaken on the first victim, CPP personnel performed a variety of duties from personnel monitoring and surveying to providing the proper equipment for body decontamination.

In order to prevent IDO personnel from receiving a high radiation exposure while attempting to decontaminate the body, CPP personnel suspended a lead sheet (3' x 4' x 1/4") from a hoist and positioned the lead sheet near the body to act as a shield. The workers performed their duties behind this lead shield, insofar as was possible, throughout the decontamination operation. After the decontamination effort was suspended, CPP personnel were responsible for storing the victim and taking radiation readings throughout the day and night, with the plan that possibly a radioactive decay curve could be obtained. The data obtained proved to be quite erratic and a decay plot could not be made.

Transportation and decontamination of the bodies resulted in the contamination of many areas and much equipment at the CPP. Therefore, it was necessary for CPP personnel to spend many hours in establishing radiation zones and in decontaminating efforts.

In addition to providing those services stated above, CPP health physics personnel monitored the Los Alamos Scientific Laboratory (LASL) Pathology Team in their undertakings at the CPP Decontamination Room. A log of exposures was maintained by the CPP health physics staff and CPP also provided radiation protection equipment for the autopsy operations. During the performance of the autopsies, it was determined that several pieces of special equipment were necessary to perform certain tasks. This equipment, which was immediately fabricated by CPP Special Maintenance, allowed LASL members, who performed the autopsies, to work at as great a distance from the victim as was practical.

After the autopsies were completed by the LASL team, CPP personnel began decontamination of the area where the work had been performed. During this time, it was noted that contamination was being spread from the decontamination room. The extent of contamination was ascertained and confined by roping off the area. CPP health physics personnel also performed a radiological survey for alpha contamination on the ambulance, which was utilized to transport victims one and two from the SL-1 Area; no alpha contamination was found.

Next, CPP personnel monitored the work performed regarding the preparation of the victims for burial and assisted in transferring the burial vaults from CPP to the Central Facilities Area.

Approximately six to eight man-days were required to clean up the CPP area contaminated during the operation conducted in the course of the incident aftermath.

APPENDIX G

U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE MANUAL

Volume: 2000 Security
Part : 2400 Physical Security

ID-2400-3-01
Sec

ID CHAPTER 2400-3 AIRFLIGHT RESTRICTED AREA - NRTS

2400-3-01 Purpose and Scope

A continuous restricted airflight area has been established over the National Reactor Testing Station by the Federal Aviation Agency to minimize the risk to life and property (14 CFR Part 608, as amended by 26 F. R. 870 et seq, Jan. 28, 1961). This chapter outlines the flight controls to be observed and procedures to be followed by anyone finding it necessary to fly over the NRTS below 20,000 feet mean sea level.

2400-3-02 Responsibilities

021 The requester of a proposed airflight will be responsible for completing Form ID-83, "Request for Authorization for Airflight over NRTS", attached as ID Appendix 2400-3-021 (the number of copies required is noted on the form) and submitting them to the Director, Security Division, at least twenty-four hours in advance of the proposed flight. In the event of an emergency, the requester may obtain verbal airflight approval from the Director, Security Division, or his designated alternate with the understanding that Form ID-83 be submitted no later than the next work day following the verbal request. Emergency flight requests during other than normal work hours may be coordinated with the Senior Patrol Duty Officer by telephoning Idaho Falls, JA 2-4400, extension 2347. The Duty Officer will act for the Director, Security Division, in these instances. The requester must also assure himself that the pilot, observers, or other interested personnel are familiar with the provisions governing airflights over the NRTS. The requester must further notify the Director, Security Division, when an approved flight has been cancelled for any reason.

022 The Director, Security Division, shall give final approval of all airflights over the NRTS and will make distribution of the completed copies of Form ID-83 in accordance with the distribution indicated on the form. Prior to granting airflight approval, the Security Division will contact the U. S. Weather Bureau on weather conditions; the Health and Safety Division on radiation or other safety hazards, and for approval for exceptions to any of the flight control conditions noted in Section 04 of this Chapter; and the Federal Aviation Agency (FAA) to advise them

of the proposed flight. The Security Division shall also be responsible for cancelling approved flights prior to departure when unsafe or adverse conditions are made known. The Director, Security Division, shall further be responsible for the preparation of the annual "Utilization Report" for the IDO Manager's signature for submission to the Director, Bureau of Air Traffic Management, Federal Aviation Agency, Washington 25, D. C. The requirements for this report are outlined in 14 CFR 608.13 and 15 as amended by 26 F. R. 872, Jan. 28, 1961.

023 The Health and Safety Division shall advise the Director, Security Division, of: (1) any special precautionary measures that are necessary because of test or operational activities at the NRTS; (2) when special radio communications are required because of NRTS activities; (3) approved exceptions to the outlined flight control conditions noted in Section 04 of this Chapter; and (4) hazards or operational conditions or any other safety factor that would prevent a safe flight. If, after a flight has been approved, an unsafe condition arises before the scheduled flight departure, the Site Survey Branch, Health and Safety Division, shall immediately notify the Director, Security Division, who will advise the requester. During nonregular work hours the AEC Patrol Communications Dispatcher (telephone JA 2-4400, extension 2345) shall be notified of unsafe airflight conditions for requester notification. Should an unsafe condition arise after the plane is in flight, the Security Division will contact the FAA Communications and request that the plane be contacted by radio. The flight will be discontinued or specific instructions given as appropriate. If the requester or pilot cancels the flight after it has been approved, the Security Division shall be notified immediately at JA 2-6640, extension 255, or the Security Patrol's Communication Dispatcher as above noted.

2400-3-03 Airflight Restricted Area

The Federal Aviation Agency designated Restricted Area is noted on the attached ID Appendix 2400-3-03. Flights above 20,000 feet mean sea level are not included in these restrictions.

2400-3-04 Flight Control Conditions

All FAA Regulations shall be observed during flights over the NRTS; and, in addition, the following local regulations and restrictions shall be observed.

041 Airflight time over the NRTS shall be only during the period from one hour after sunrise to one hour before sunset.

042 Visibility minimums shall be equal to or better than those specified for visual contact flight:

a. one plane - 1,000 feet ceiling and three miles visibility
b. Two planes - 2,000 feet ceiling and three miles visibility
c. Ground fog shall be considered as zero ceiling

043 The altitude minimum permitted at any time shall be 500 feet. When two planes are flying over the same area of the NRTS at the same time, one plane shall occupy the air space between 500 feet and 1,000 feet; the second plane shall occupy the air space above 1,500 feet, and these understandings must be approved in advance. Planes must maintain a 500 foot minimum altitude above weather blimps.

044 The horizontal minimums are as follows:

a. A plane flying at an altitude between 500 feet and 1,000 feet shall maintain a horizontal minimum of not less than 500 feet from plant areas.

b. A plane flying at an altitude of 1,000 feet or above shall avoid flying directly over plant areas.

c. A plane flying at any altitude below 2,000 feet shall maintain a minimum horizontal distance of 1,000 feet from a tethered balloon or blimp.

045 When wind velocity at ground level is between 30 and 40 miles per hour, the minimum flying altitude shall be 800 feet. An approved flight shall be canceled, and a proposed flight shall not be approved when wind velocity exceeds 40 miles per hour.

046 Radio Communications

a. No plane may be authorized for an NRTS flight without two-way radio communications with the Idaho Falls FAA station. The plane receiver must be "on" to this frequency at all times while over the NRTS so that safety hazards or other conditions not known at the time of flight departure may be avoided by the aircraft.

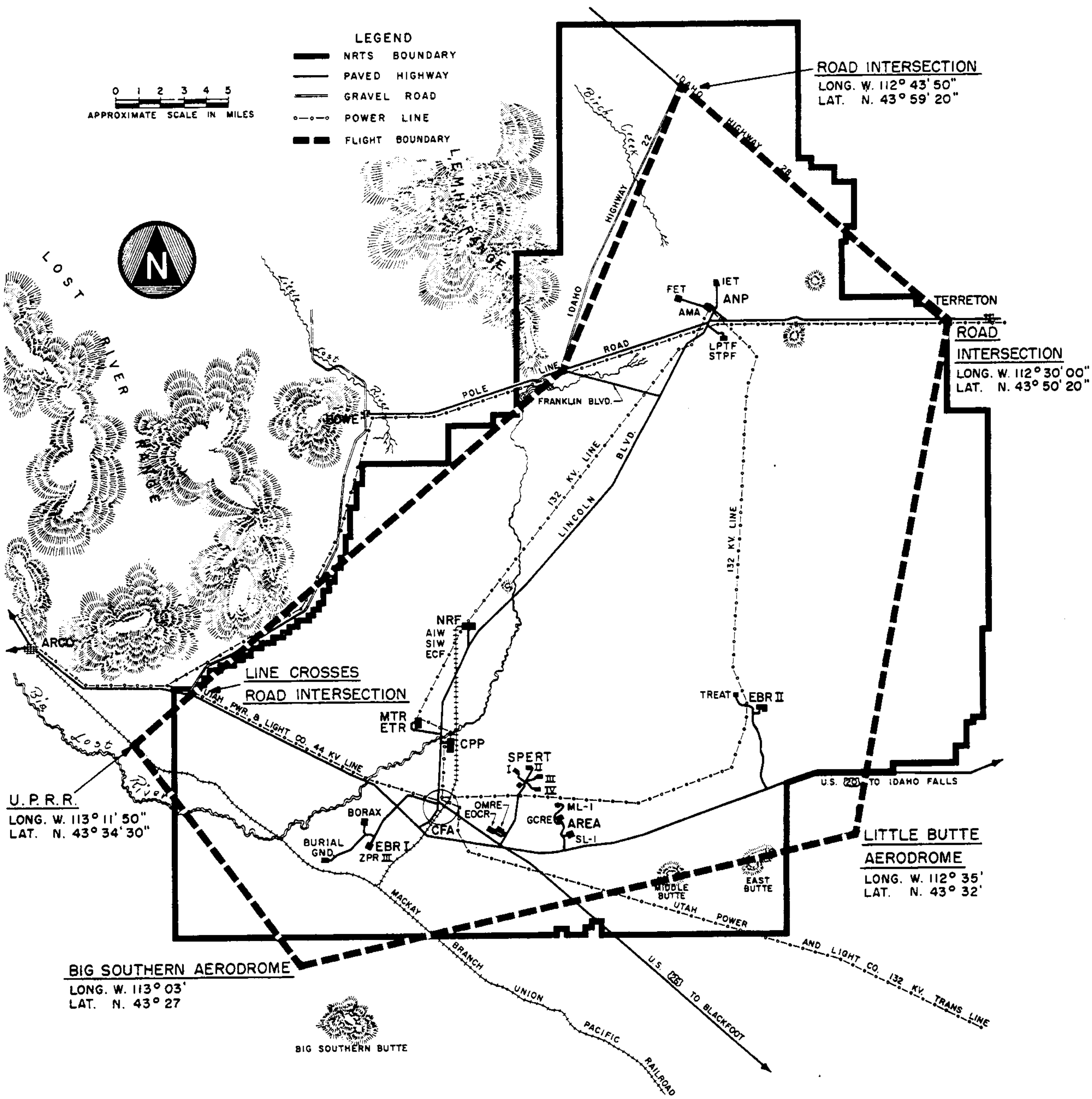
b. Special radio equipment may additionally be required for certain health physics monitoring flights, etc., to provide direct contact from the plane to the NRTS radio net. The radio units and operating instructions will be provided by the Health and Safety Division when they are necessary. These radios operate on net "C"; and when they are provided, the pilot should contact the CFA Patrol Dispatcher after take-off to advise of the estimated time of arrival over the NRTS and to verify the control conditions.

047 Emergency landings due to loss of power or fire in flight shall be at the pilot's discretion. Landings for all other conditions shall be made at fields adjacent to the NRTS. For detailed information on emergency landing fields refer to ID Appendix 2400-3-047A through E. (Note: Appendixes A through E were taken from the 1958 publication "Idaho Airport Facilities" which is issued by the State Department of Aeronautics and are subject to change.)

048 Deviations or exceptions to the provisions of this Chapter must be noted on the Form ID-83 and shall be subject to the approval of the Director, Health and Safety Division. The flights by or for the Predatory Game Control and Utah Power and Light Company will not require specific exception approvals providing only open terrain is involved; open terrain must exclude operating or construction areas as well as any location having structural towers erected for weather or other sampling data equipment even though their locations are well removed from plant areas. Such flights are not to include AEC or contractor personnel. Exceptions or deviations in conflict with FAA Regulations governing air-flights will not be approved.

2400-3-05 Violations

Noncompliance with the provisions of this Chapter may be cause for filing a violation report with the Federal Aviation Agency and denial of further flight privileges over the NRTS.



FLIGHT RESTRICTION MAP

NATIONAL REACTOR TESTING STATION
U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE

Form ID-83
(Revised 9/58)

U. S. ATOMIC ENERGY COMMISSION

Idaho Operations Office

DATE ....

REQUEST FOR AUTHORIZATION FOR AIRFLIGHT OVER NRTS

Authorization is requested for the following persons to fly over the National Reactor Testing Station (give full name and designation, as: Pilot, Observer, etc.):

....

....

Date of Flight .... Time of Flight - From .... to ....

Reason for Flight ....

....

Aircraft Identification, (make, type, color, identifying numbers, etc.) ....

....

Areas to be involved ....

....

Acknowledgment: The pilot is familiar with ID Manual Part 2400-3, "Airflight Restricted Area, NRTS," and agrees to comply therewith. Exceptions to the outlined controls are:

....

....

....

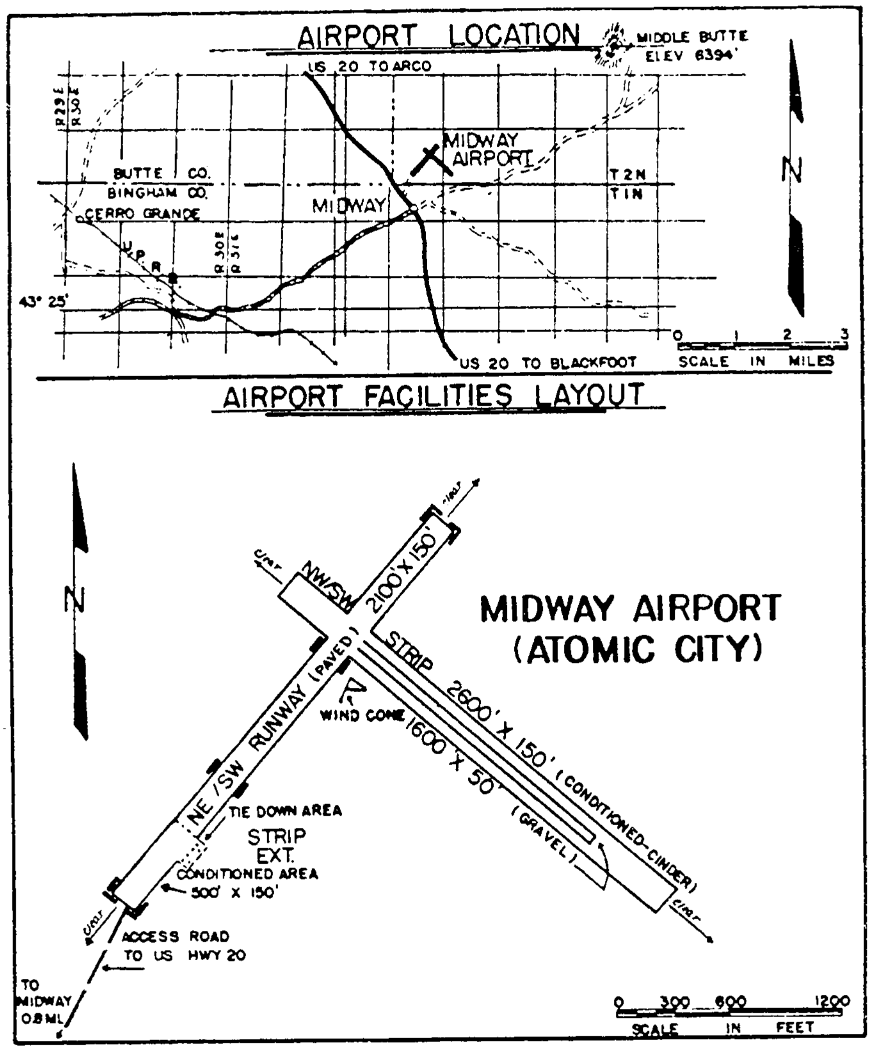
Name of Contact - H & S Division — Signature of Requester

.... Approved ....

Name of Contact - Weather Bureau — Director, Security Division, Idaho Operations Office

Distribution:
Copy 1 - Pilot
Copy 2 - CAA
Copies 3 & 4 - Security Division
Copy 5 - Health & Safety Division
Copy 6 - Requester

MIDWAY | **State of Idaho (Em. Field)**



AIRPORT DATA

Lat: 43° 28′ **Long:** 112° 48′

Elev: 5000′

Traffic Pattern: Standard left hand

From City: 25 Mi. SE Arco—½ Mi. N of Atomic City

Manager: State of Idaho Department of Aeronautics

Runway Surface: Surfaced

Lighted: No

Markers: Yes

FACILITIES

Aircraft Maintenance: No

Fuel: No

Storage: T.D.O.

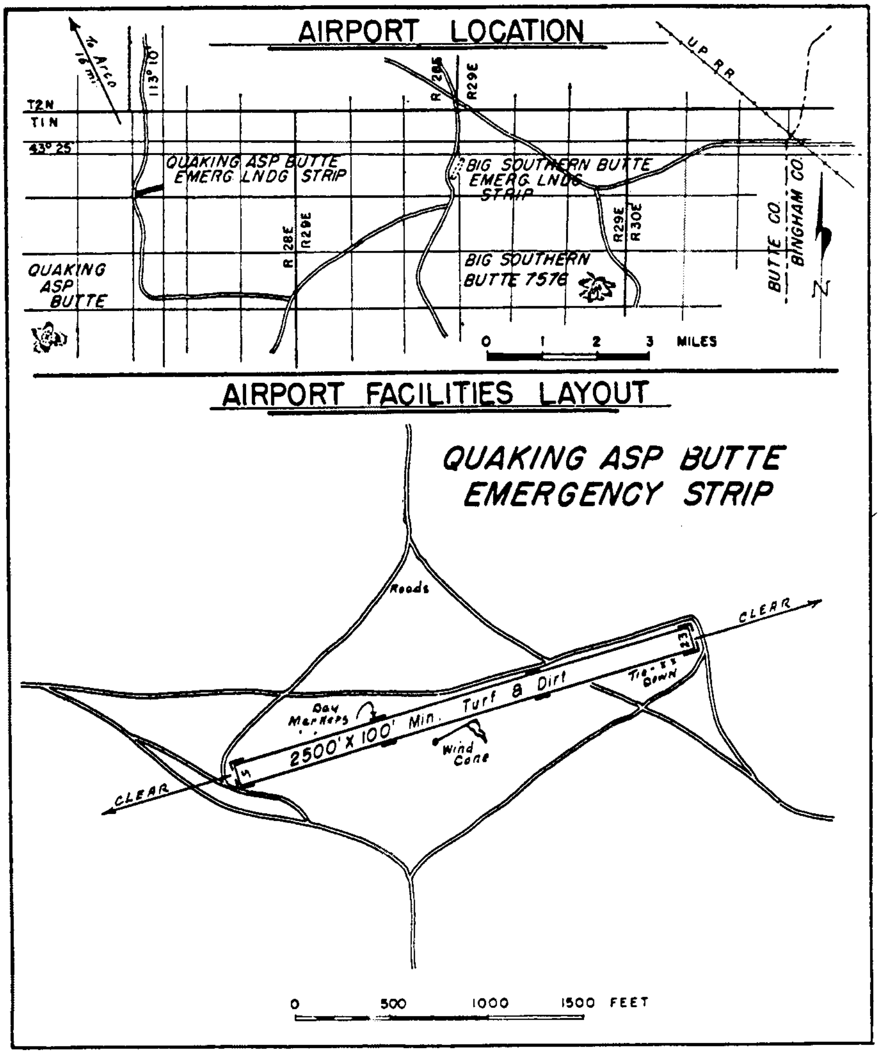
Cafe: ¼ Mi.

Airline Service: No

Remarks: Emergency landing strip —supervised by State of Idaho.

State of Idaho (Em. Field)

QUAKING ASPEN BUTTE



AIRPORT DATA

Lat: 43° 26′ **Long:** 113° 13′

Elev: 5250′

Traffic Pattern: Standard left hand

From City: 14 Mi. SSE of Arco

Manager: State of Idaho Department of Aeronautics

Runway Surface: Dirt and Sod

Lighted: No

Markers: Yes

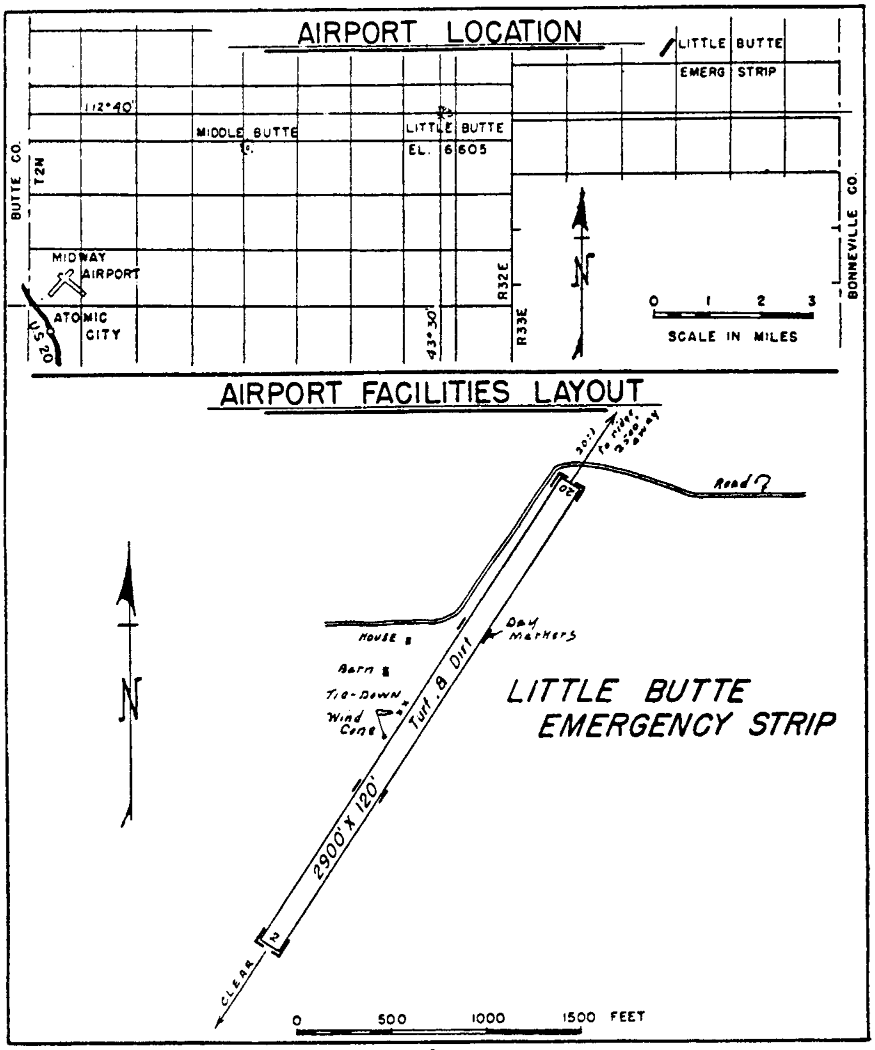
FACILITIES

Aircraft Maintenance: No

Fuel: No

Remarks: Located in the Craters of the Moon lava desert as an emergency facility to airmen crossing the 7000 sq. mi. of lava and desolation. Equipped with windsock, markers and tie-downs. 10 Mi. W of Big Southern Butte. Recommend airmen stay with aircraft if strip used in emergency. No snow removal voids winter use during excessive snow periods.

LITTLE BUTTE **State of Idaho (Em. Field)**



AIRPORT DATA

Lat: 42° 31′ **Long:** 112° 35′

Elev: 5380′

Traffic Pattern: Standard left hand

From City: 14 Mi. ENE of Atomic City

Manager: State of Idaho Department of Aeronautics

Runway Surface: Dirt and sod

Lighted: No

Markers: Yes

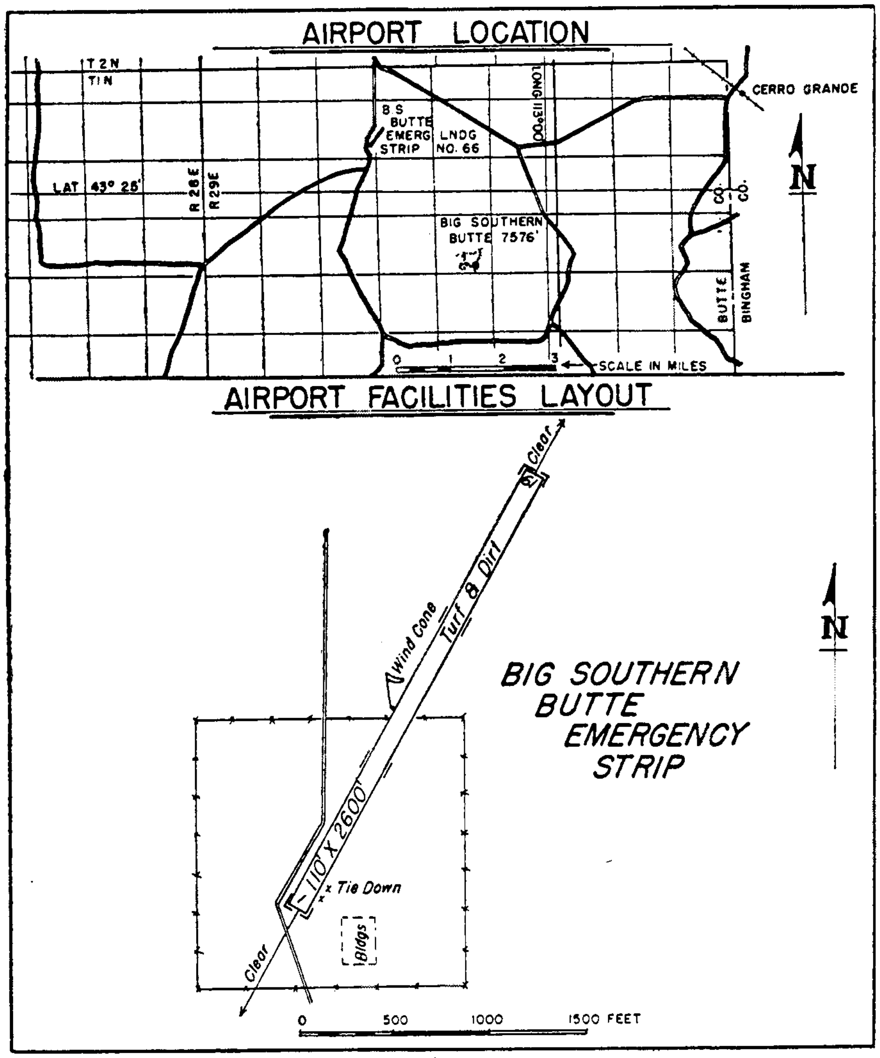
FACILITIES

Aircraft Maintenance: No

Fuel: No

Remarks: Located near SE corner of AEC danger area as an emergency facility to airmen crossing the 7000 sq. mi. of lava and desolation. Equipped with windsock, markers and tie-downs. In NE quadrant and adjacent to Little Butte. Buildings adjoining strip—recommend airmen stay with aircraft if landing strip used in emergency. No snow removal voids winter use during excessive snow periods.

BIG SOUTHERN BUTTE **State of Idaho (Em. Field)**



AIRPORT DATA

Lat: 43° 26′ **Long:** 113° 03′

Elev: 5120′ est.

Traffic Pattern: Standard left hand

From City: 18 Mi. SE of Arco

Manager: State of Idaho Department of Aeronautics

Runway Surface: Dirt and sod

Lighted: No

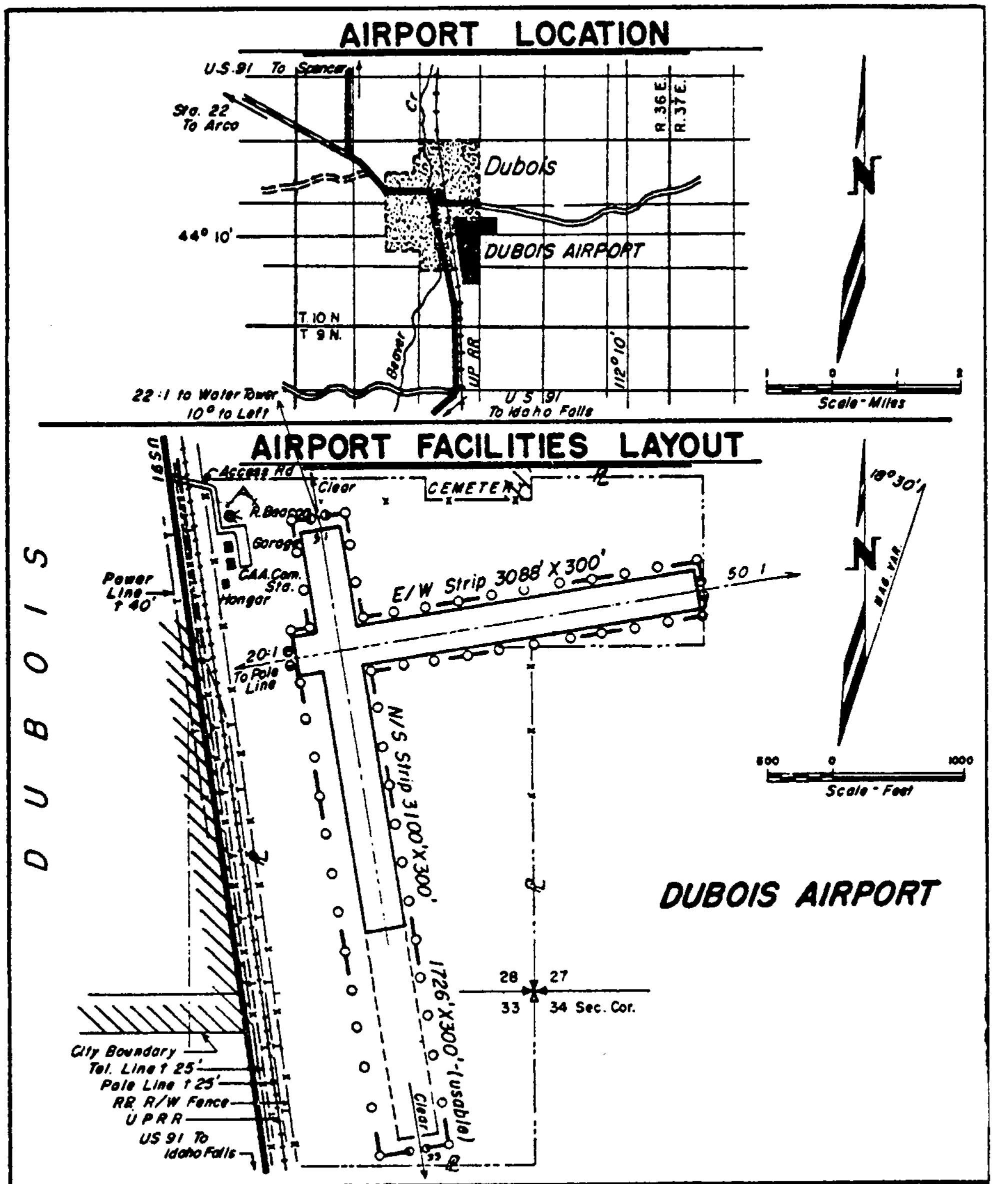
Markers: Yes

FACILITIES

Aircraft Maintenance: No

Remarks: Located in the Craters of the Moon lava desert as an emergency facility to airmen crossing the 7000 sq. mi. area of lava and desolation. Equipped with windsock, markers and tie-downs. Directly North and adjacent to Big Southern Butte. Recommend airmen stay with aircraft is used in emergency. No snow removal voids winter operation during excessive snow periods.

Dubois Municipal Airport **DUBOIS**



AIRPORT DATA

Lat: 44° 10′ **Long:** 112° 13′

Elev: 5123′

Traffic Pattern: Standard left hand

From City: .8 Mi. SSE

Operator: None-

Manager: Orson Rasmussen

Runway Surface: Dirt and gravel

Lighted: Yes

Markers: Yes

FACILITIES

Aircraft Maintenance: No

Fuel: No

Storage: T.D.O.

Cafe: ½ mile

Charter: No

Airline Service: No

CAA Communications:
DBS 388 kcs—116.9 mcs

Remarks: Phone Frontier 4-5560. Cafe in town.