Sodium Reactor Experiment

July 2004

SRE History

Sodium Reactor Experiment - 1956

Sodium Reactor Experiment (1958)

Why Did We Build the Sodium Reactor Experiment (SRE) ?

- Development of the “next generation” commercial nuclear power plant to supersede boiling water reactors (BWRs) and pressurized water reactors (PWRs)
- Enhanced efficiency and safety of low pressure sodium coolant over high pressure water
- Precursor to sodium cooled fast reactor designs of the 1970s and 1980s
- In 1985 the SRE was designated by the ANS as a National Nuclear Landmark

SRE Made National Nuclear Landmark In November 1985

AI's Nuclear Research was Openly Publicized in the Media

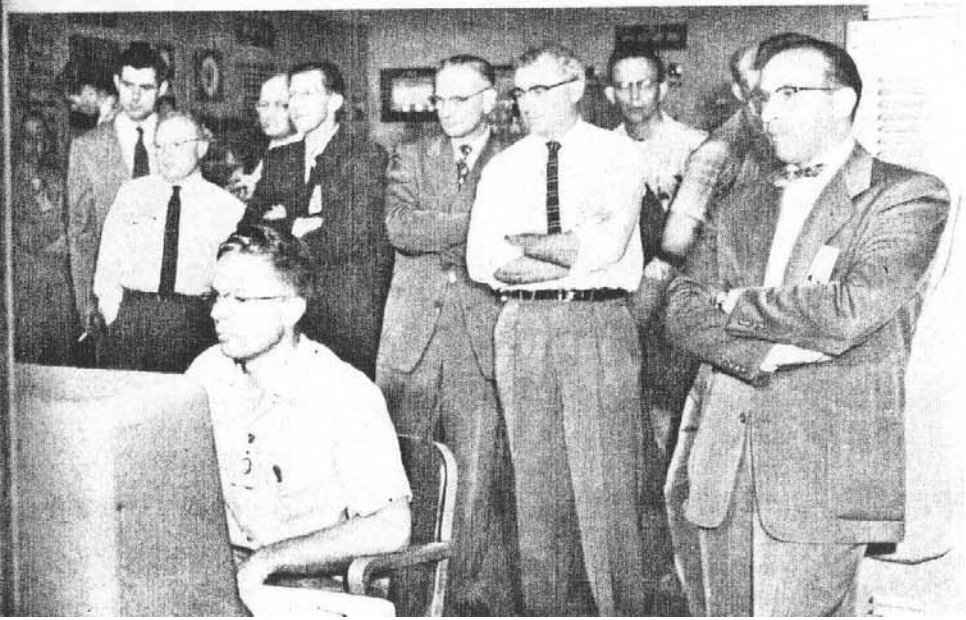
- TV – Ed Murrow Show – Nuclear power for Moorpark – November 12, 1957 – Televised November 24, 1957
- TV – Science show –Schoolgirl toured the Canoga facility and SSFL - Shown the SRE and Hot Lab - 1958
- Numerous teacher and student tours of SSFL in the 1960s
- Internal NAA SkyWriter newspaper covered all nuclear programs including SRE
  - Employees free to take home, and show friends and neighbors

SRE Goes Critical April 25, 1957

VALLEY Skywriter

VOL. XVII, No. 18 NORTH AMERICAN AVIATION, INC. MAY 3, 1957

SRE BEGINS SUSTAINING CHAIN REACTION



AI Reactor First of Thermal Type to Reach Critical Stage

On April 25 self-sustaining nuclear fission was achieved in the Sodium Reactor Experiment, the atomic power reactor developed for the Atomic Energy Commission by Atomics International, the AEC announced this week.

The Sodium Reactor Experiment (SRE) is the first sodium-cooled "thermal" reactor to produce a sustained nuclear chain reaction. The SRE uses neutrons moderated with graphite to sustain the fission process, and liquid sodium is circulated through the reactor core to remove heat produced by the atomic fission.

Design Aim

During the initial start-up test the reactor operated at a power level of about one kilowatt of heat. No electricity was generated. The design capacity of the

AEC Chairman Lights Moorpark – Nov. 12, 1957

Skywriter

NORTH AMERICAN AVIATION, INC. NOVEMBER 22, 1957

CS INTERNATIONAL'S SRE DEDICATED

—When Lewis L. Strauss, chairman of AEC, threw switch last week, SRE electric arc shown at left was produced from power furnished by the SRE.

Experimental Power Reactor Officially Goes 'On-Stream'

Over 250 federal government and local officials and representatives of the nation's press witnessed the official dedication of the AI Sodium Reactor Experiment last week, with Adm. Lewis L. Strauss, chairman of the Atomic Energy Commission, throwing the switch to place the reactor and electrical power plant "on stream".

Chairman Strauss, in his dedicatory address, pointed out that the SRE and the electrical kilowatts flowing from it into the grid of the Southern California Edison Co. not only was an experiment to provide important technical data on the sodium graphite reactor concept, but also that the reactor was capable of immediate and practical application for producing electricity.

California Tribute

"It seems altogether fitting to me that the first commercial use of atomic power should occur in this great state, where so many of man's fundamental nuclear discoveries have been made," Strauss said.

After reviewing the AEC's experimental program, the chairman detailed future plans for the organic moderated and cooled reactor developed by Atomics International, telling of the full-scale demonstration plant to be built for the Consumers Power District of Nebraska.

"Great Hopes"

"The Commission and its reactor experts have great hopes for the sodium-graphite concept of power reactors," the speaker declared. "Before construction of the Nebraska plant is completed, sometime in 1962 or 1963, we look to this experimental reactor to have further enriched our store of reactor technology."

Strauss predicted that by the mid-1960s there will be some 18 or 20 nuclear power plants serving homes and industries across the nation.

In addition to Adm. Strauss, present from AEC were W. Kenneth Davis, director, Division of Reactor Development; Harold A. Fidler, manager, San Francisco Operations Office; A. P. Pollman, manager, Southern California Area Office; Rod Southwick and Phil Jacques, AEC public information officers; Everett Holles, special assistant to the chairman; and other AEC

(Continued on Page 2, Column 4)

SRE Televised on Ed Murrow “See It Now” Show – November 24, 1957

SEE IT NOW—Cameraman Leo Rossi films demonstration of atomically-generated arc used in SRE dedication for showing on Edward R. Murrow "See It Now" TV program next Sunday on Channel 2. AI Cameraman Hal Williams, second from right, also films demonstratio park, in Simi Valley, will be included Town was cut off normal "juice" by Edi

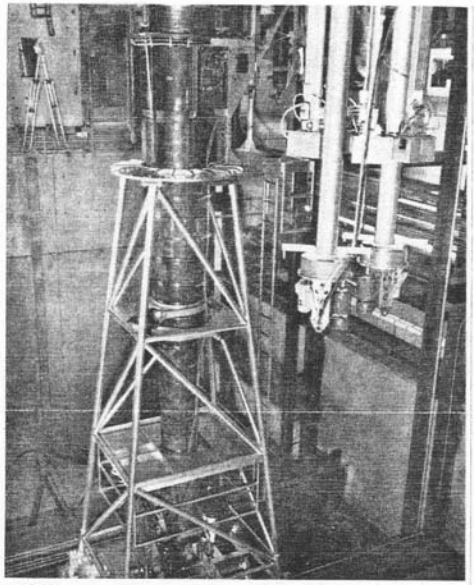
TV Show Sunday to Include Shots Filmed at SRE

Filmed scenes of Atomics International's Sodium Reactor Experiment (SRE)—including shots of the reactor control room, the reactor building and the top of the reactor core—are scheduled for showing on the Edward R. Murrow television program, "See It Now", this Sunday at 5 p.m. on Channel 2.

Columbia Broadcasting System cameramen made the film for Murrow's show, which will feature atomic energy projects in the United States and abroad. An interview with Lewis L. Strauss, chairman of the Atomic Energy Commission, was filmed for the program.

Moorpark Lighting

Also planned for the show were scenes of the lighting of the Simi Valley town of Moorpark. On Tuesday evening last week the "See It Now" camera crew pointed their lenses at the community of 1146 people as Southern California Edison Co. engineers "blacked out" the town for about 20 seconds. A switch was then closed and about 1000 kw. of electricity generated by Edison from heat produced in the SRE lighted Moorpark homes and industries.



BIRD'S EYE VIEW—CBS Director Arthur Morse, left, chose fuel handling cask as vantage point for cameras to film SRE for "See It Now" TV show, which is to be telecast next Sunday.

Classified Ads

FOR SALE—

North American's current backlog of unfilled orders amounts to $581,000,000, the said, has a greater technical and production capability than ever before, and intends to con-

Rocketdyne
Propulsion & Power

BOEING

SRE Reaches 20 megawatts – May 21, 1958

SRE RUN EXCEEDS DESIGN POWER LEV

The Sodium Reactor Experiment reached and exceeded its design power level of 20,000 kilowatts of heat Wednesday night following a scheduled series of low power tests of the reactor core systems and components. During power runs to date, 21,000 kilowatts of heat has been achieved.

Heat from the nuclear power plant, built and operated by AI for the AEC, is used by Southern California Edison to generate electricity. About 6000 kilowatts of electricity can be produced from the reactor heat.

Located in the Santa Susana mts., the SRE has as its major objective the development of technical data for designing, building and operating full scale nuclear plants for the production of economic electrical

Experience gained from the SRE i used by Atomics International in its opment work for the 75,000 net kilowatt central station nuclear powe to be built by the Atomic Energy C sion for the Consumers Public Pow trict of Nebraska.

VALLEY Skywriter

VOL. XVIII, No. 21 NORTH AMERICAN AVIATION, INC. MAY 23, 1958

Junior High Girl Tours SRE Shown on Channel 13 TV Science Show – May, 1958

TV SCIENCE—Richard P. Johnson, AI, explains Lab Reactor to Doreen Melendy, top science student at Eliot Jr. High, Altadena, and Al Renner, Eliot science teacher, during filming for TV show to be seen May 22 at 4:30 p.m. on Channel 13.

Teachers Visit SSFL – July 1965

TAKING NOTES — Bill Littleton, left, using an engineering model, explains operation of SRE to group of teachers. Right photo, educator from L.A. City Schools' Teachers Workshop tries out remote manipulator in AI Hot Cell. Above, Ray Conner, left, points out SRE safety rod columns to teachers.

North American Hosts Five-Day Series of Workshops for Teachers

Fifty-five Los Angeles City School teachers visited AI last week as part of NAA's fourth Teachers' Workshop aimed at providing educators with an insight into the aerospace and nuclear industry.

Conducted at the request of the school system, the workshop's purpose was to give teachers an overview of the industry. The group also toured other NAA divisions.

This marks the first year that AI has served as host for the teachers for an entire day.

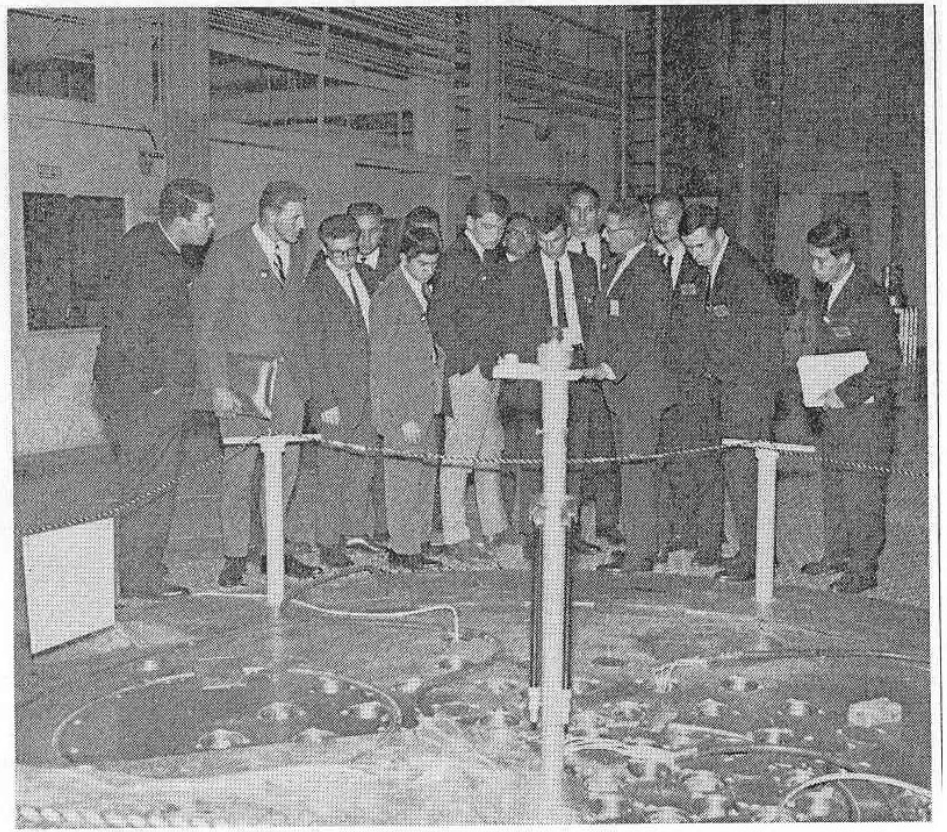
Donald J. Vest, Training, said "It is our hope that we will provide them with an experience which will assist them to do a better job of inspiring, assisting, guiding and teaching their students presently and in the future.

"We further hope," he continued, "to provide these educa-

presented a talk on careers in atomic energy to close the morning session.

In the afternoon, the teachers were briefed by Bob Dickinson, General Administration, on power reactors and watched a film on the subject.

Students Tour SRE – December, 1965



SRE TOUR — Business students from Fresno State College are briefed on operation of Sodium Reactor Experiment by Dutch Sturtevant, of Atomics International, on Santa Su tour.

Fresno College Students Tour Division Facilities

Fifteen students from Fresno State College toured AI's Santa Susana facilities last week and were briefed on the division's SNAP nuclear reactor and central station power accomplishments.

The students were all members of Alpha Kappa Psi, a business fraternity.

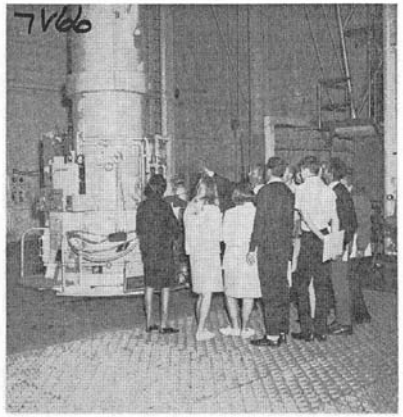
Roger D. Moeller, director of Special Programs at AI, spoke to the group on the role of government in nuclear energy, private investment needed to enter the atomic power field, and the early history and present state of the industry.

Afterward, the students departed for Santa Susana to tour the Sodium Reactor Experiment and the Sodium Components Test Installation.

Students, Teachers Visit SSFL – February 1966

ATOMICS INTERNATIONAL
Skywriter

VOL. XXVI, No. 4 NORTH AMERICAN AVIATION, INC. FEBRUARY 25, 1966



EDISON DAY — Sylmar High School students get a chance to operate remote control manipulators in Components Development Hot Cell during "Science Youth Day" tour of Nuclear Field Laboratory. At right, Granada Hills High students are shown fuel handling machine operation.

AI Hosts 360 Science Students, Teachers

Schools Participate in Tour of NFL's Major Facilities

Atomics International was host for more than 360 science students and teachers from 12 San Fernando Valley and Ventura County high schools last Saturday, a part of the annual Atomic Energy Commission observance of "Science Youth Day" which commemorates the 119th anniversary of Thomas A. Edison's birth.

The one-day field trip was planned in conjunction with the Los Angeles City School system. Outstanding science students were selected by the faculty members of each school to participate in the 2½-hour program held in the Nuclear Field Laboratory in the Santa Susana Mts.

Film Seen

Tours of the NFL's major facilities followed preliminary briefings and the showing of "SNAPSHOT", a color film depicting the SNAP 10A launch. The students visited the Sodium Reactor Experiment, here and abroad, to become interested in careers as scientists and engineers.

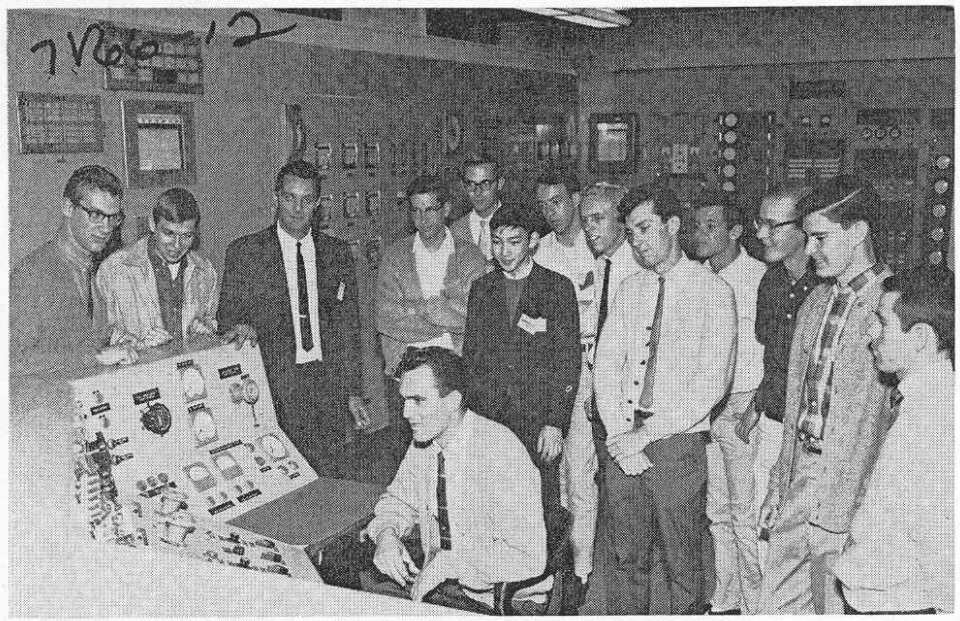
Each year more than 300 U.S. corporations and other organizations help sponsor programs involving some 200,000 young science students and teachers.

Pointing out that more than 42,000 high school science pupils and teachers will have joined with the AEC since 1957 in commemorating the date of Edison's birth, Dr. Glenn T. Seaborg, chairman of the AEC, said:

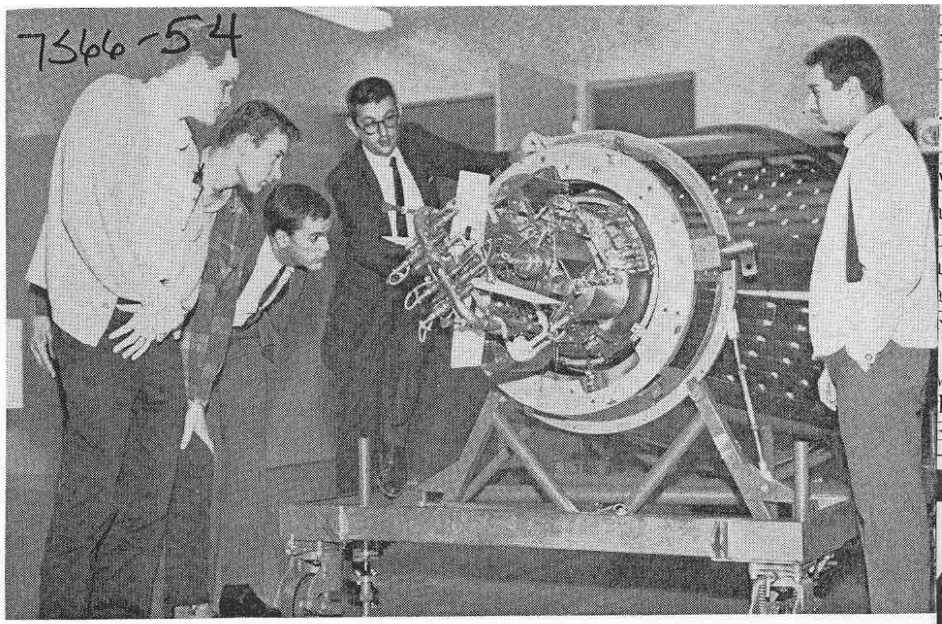
Important Need

"I am delighted that AEC field offices and our contractors throughout the United

Students View SRE and SNAP 10A – March, 1966



FUTURE ENGINEERS — Engineering students from Valley State College view control console of Sodium Reactor Experiment during recent tour of



Nuclear Field Lab. At right, Felix Owen of AI, second from right, explain how the SNAP 10A nuclear reactor system operated in space to the student

Students Visit SSFL – March 1966

il Skywriter MARCH 11, 1966 Page Three

STUDENTS CELEBRATE SCIENCE YOUTH DAY WITH TOUR

SCIENCE YOUTH DAY — Joel V. Levy, manager, AEC Canoga Park Area Office, talks with high school science students on Thomas A. Edison's life. At right, William E. Krupp, left, demonstrates how Hot Lab remote control manipulators work to Canoga Park and Taft high school students. Students were on tour of Nuclear Field Laboratory located in Santa Susana Mts.

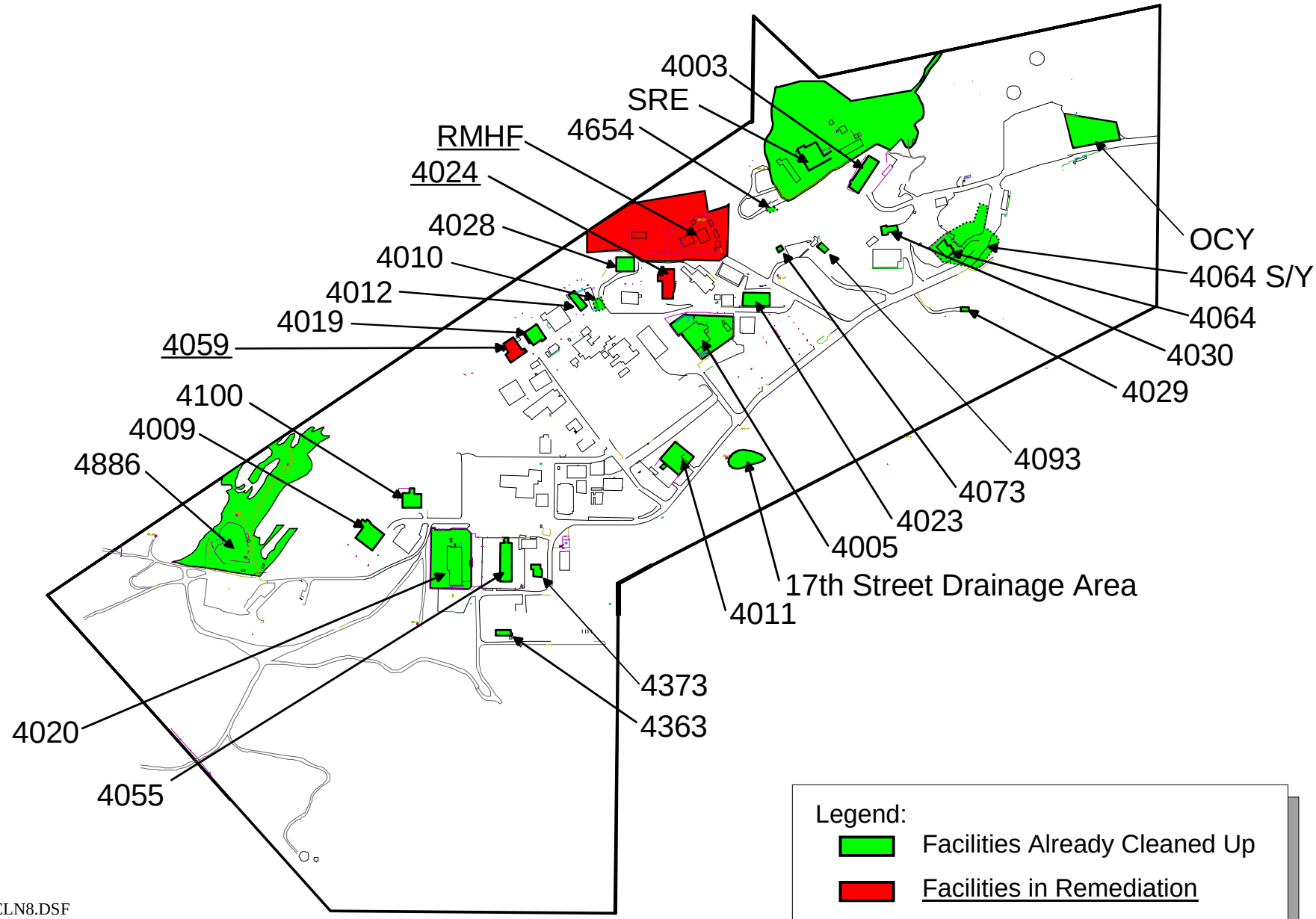
AT THE SRE — Amos Schooler, left, explains the functions of the Sodium Reactor Experiment to Francis Polytechnic students using a scale model of the plant. In the right picture, Allen C. Smith, left, discusses the purpose of the SRE's fuel loading face with students from Granada Hills. Students visited the laboratory in celebration of Science Youth Day.

SRE Design

Construction & Operational Schedule

• Design began	June 1954
• Construction Began	April 1955
• Construction completed	February 1957
• First critical	April 1957
• Full Power	May 1958
• Core damage accident	July 1959
• Restarted	September 1960
• Shutdown	February 1964

Santa Susana Field Laboratory (SSFL) Area IV Radiological Facility Status



A4CLN8.DSF
3/23/99

Sodium Reactor Experiment (1958)

SRE Complex Plan

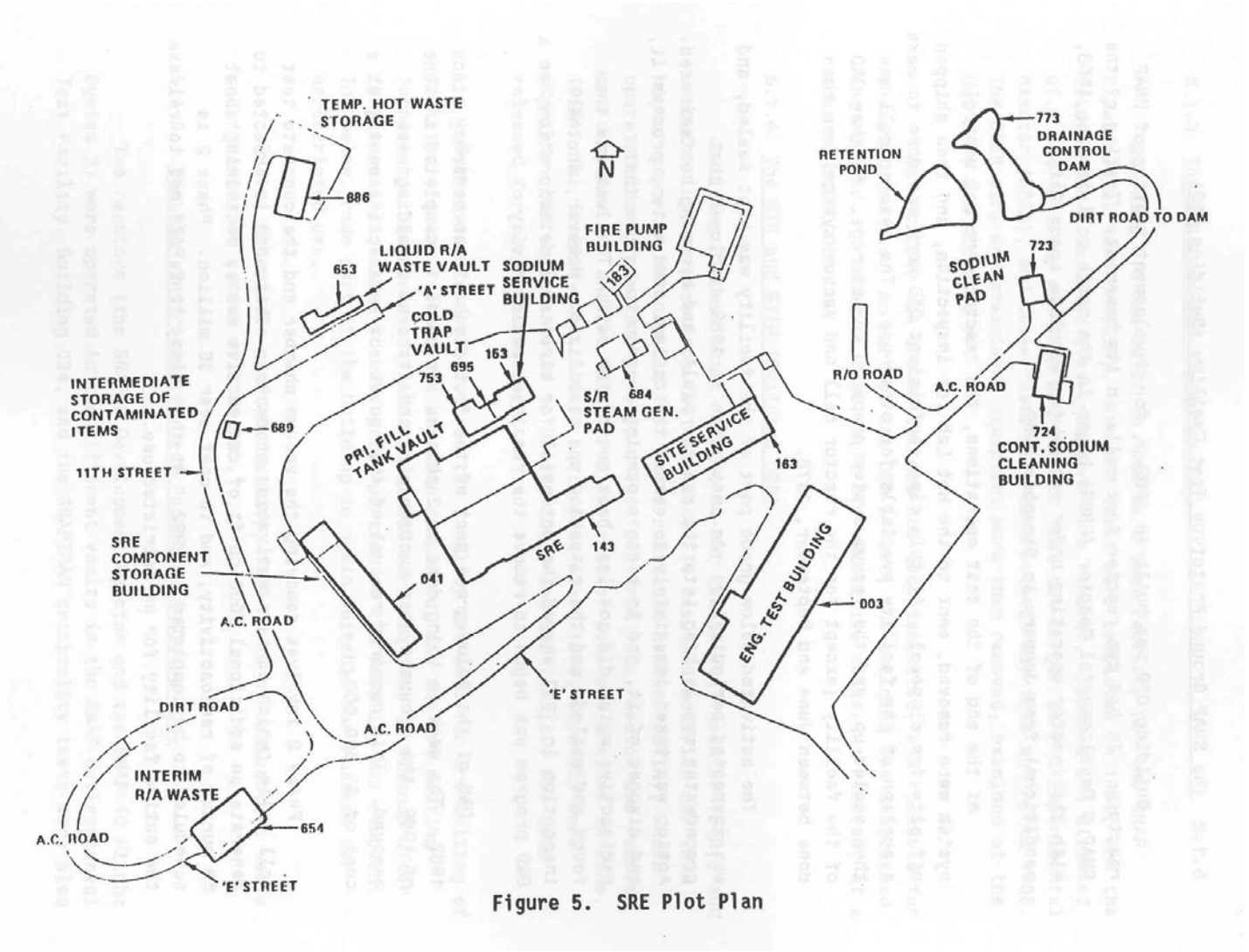


Figure 5. SRE Plot Plan

SRE Refueling Head

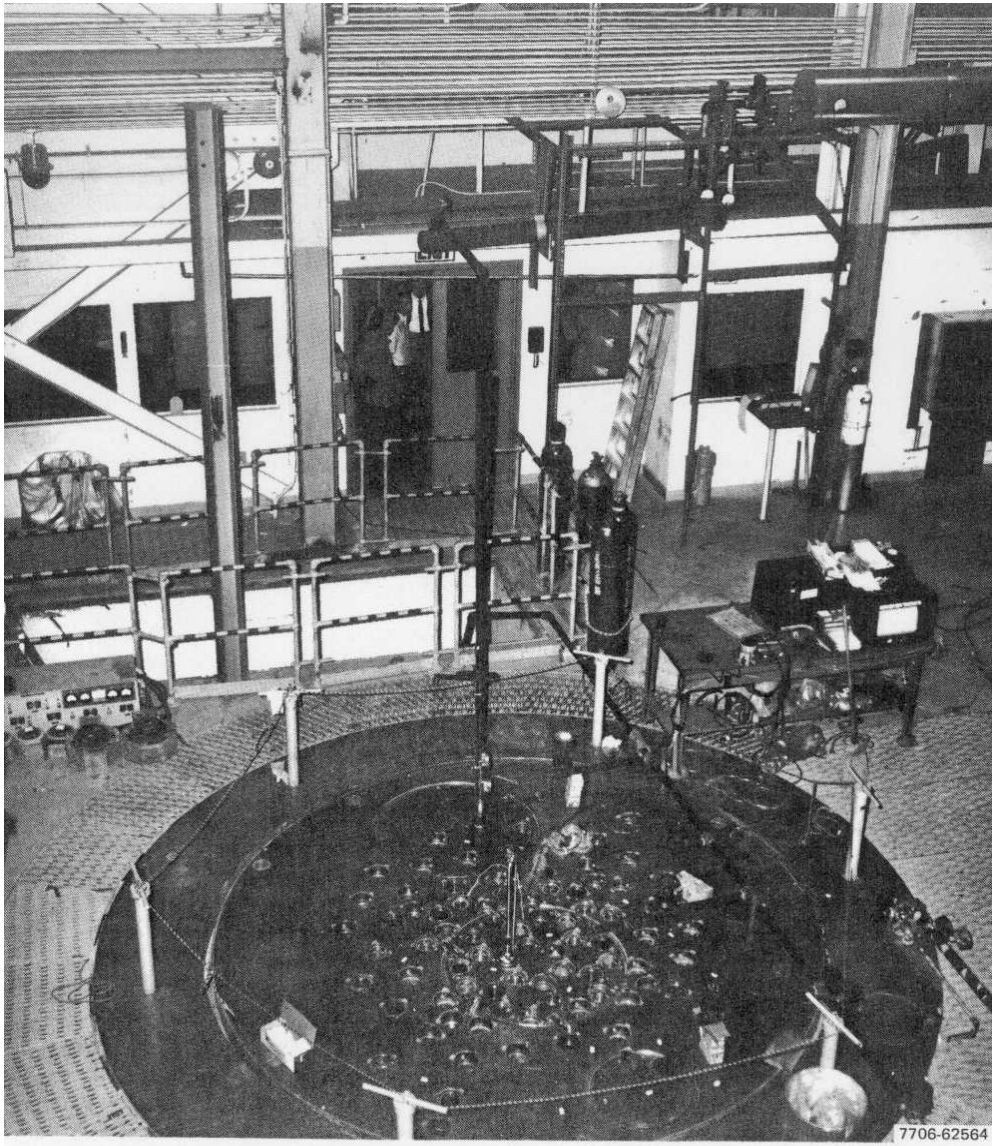


Figure 16. Reactor Passivation Piping During Installation

SRE Engineering Design

• Fuel	Enriched uranium metal
• Fuel cladding	Stainless Steel
• Moderator	Graphite
• Primary coolant	Sodium
• Secondary coolant	Sodium
• Electrical plant	Steam powered turbine
• Design Power level	20 megawatts (thermal)
• Electrical power generated	37 million kilowatt-hrs
• Operated	27,000 hours

SRE Layout

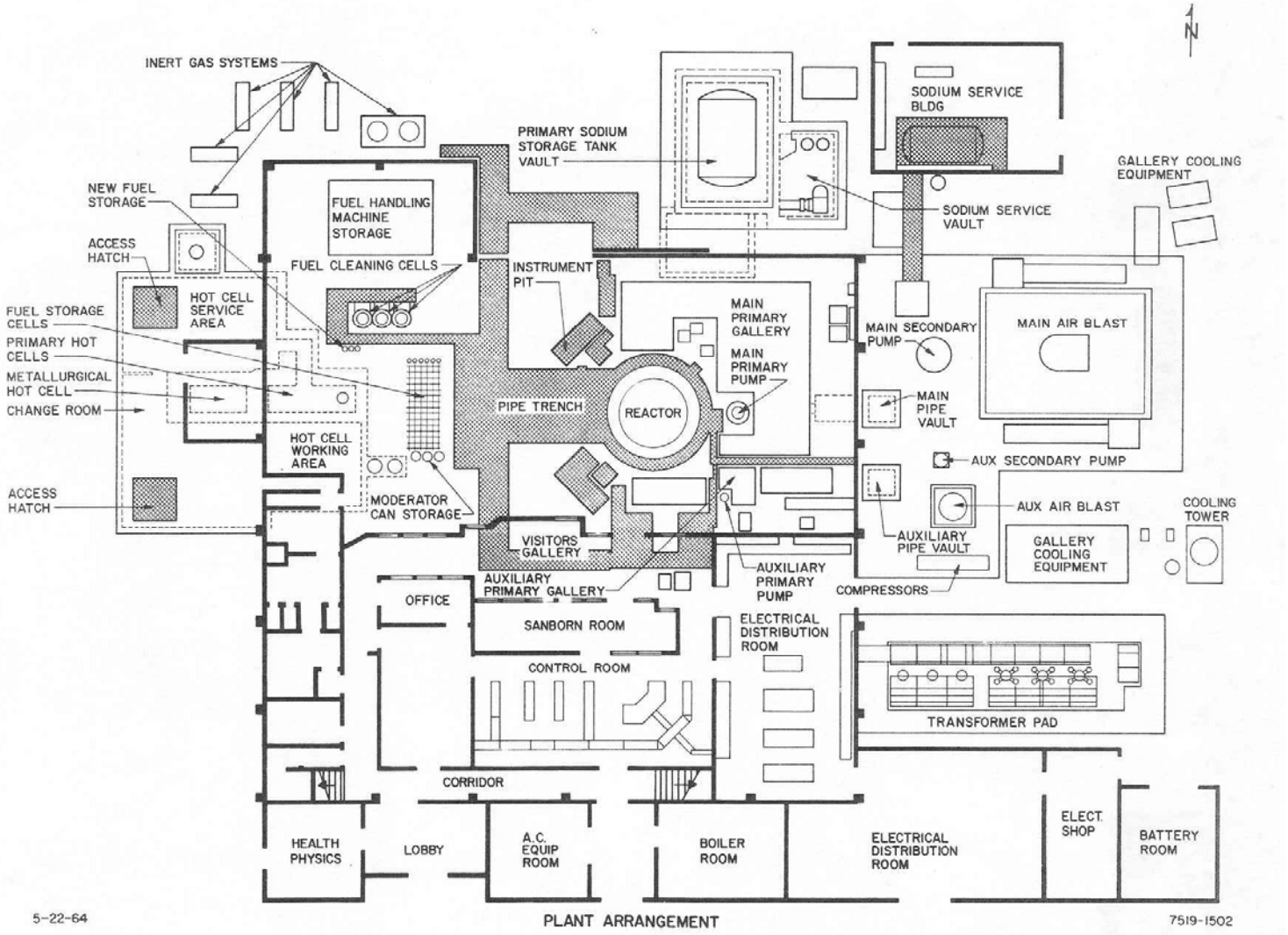


Figure 3. Building Layout

SRE Cooling System

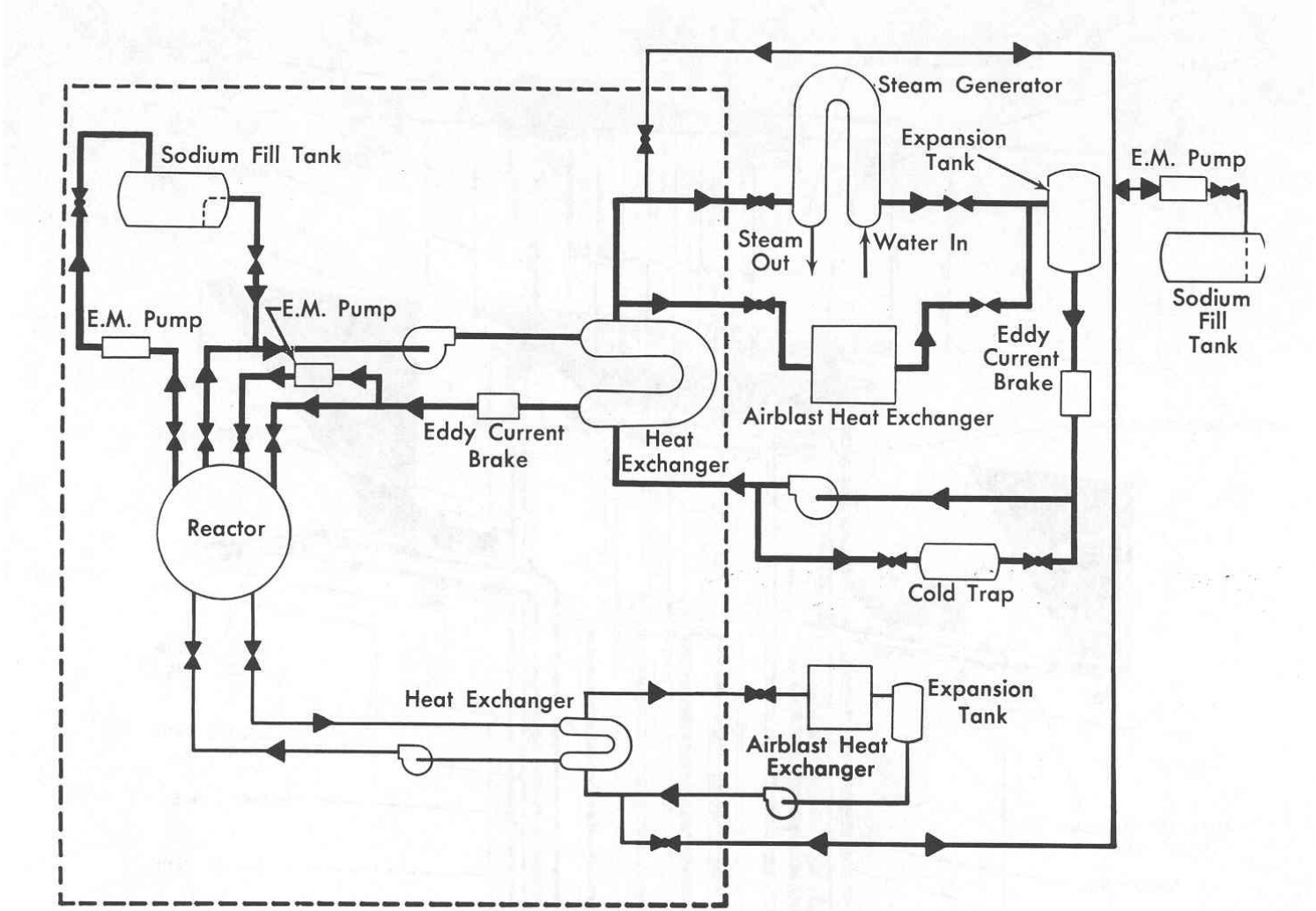


Figure 2. SRE Cooling System

SRE Cutaway

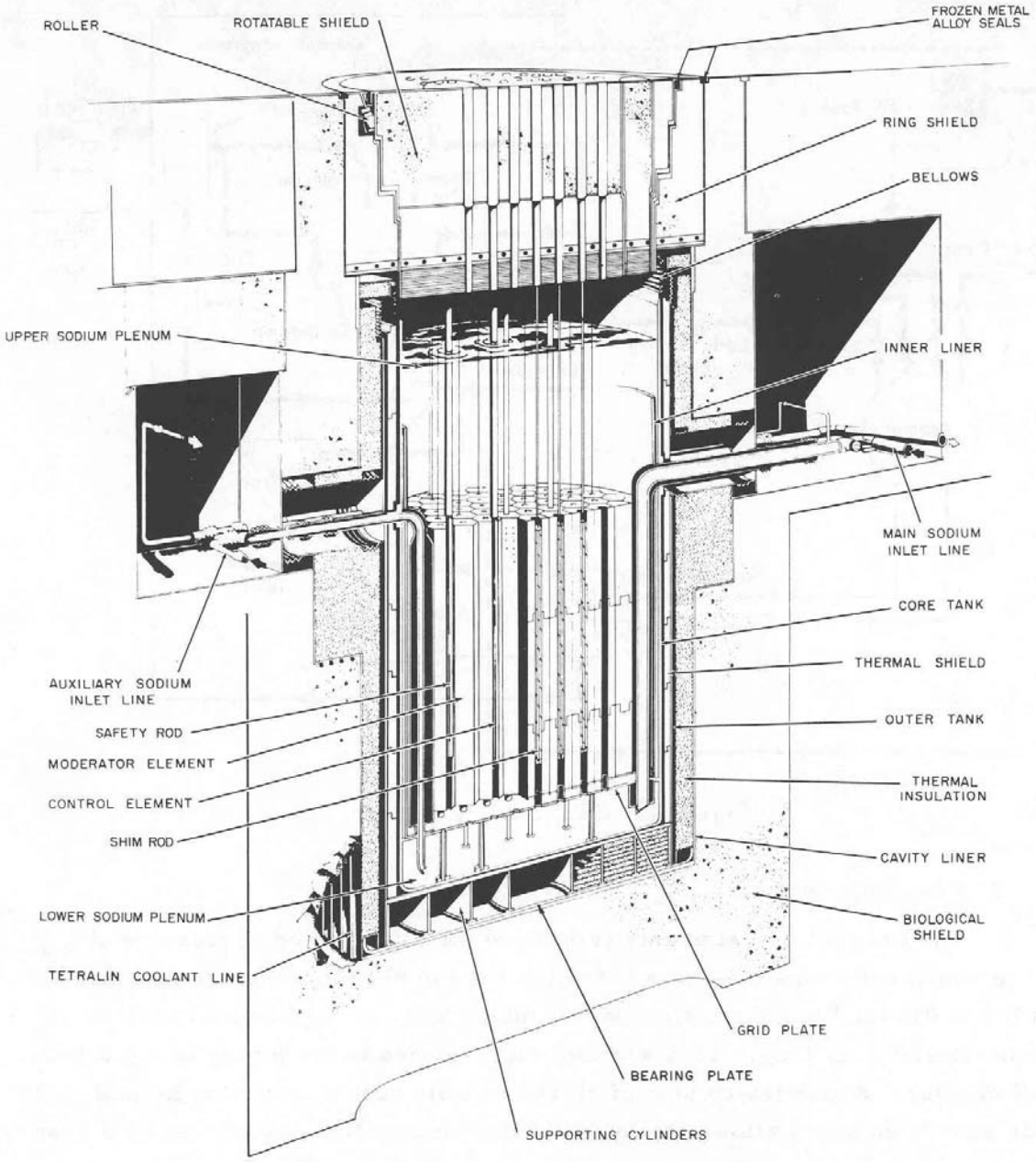


Figure 1. Cutaway View of SRE Reactor

SRE Accident

SRE Accident – July 1959

- Tetralin pump bearing coolant leaked into primary sodium coolant
- Tetralin residue blocked inlet coolant orifices
- Cladding in 13 of 43 fuel assemblies melted
- Solid uranium fuel did not melt but collapsed to bottom of pressure vessel
- Pressure vessel remained intact and fuel continued to be cooled by sodium coolant.
- Some contamination of building interior occurred due to leaks in vessel penetrations
- Fuel was removed, declad in the Hot Lab, and shipped offsite
- 55,000 pounds of primary contaminated sodium was drained and shipped to Hanford
- A new core and new sodium coolant was loaded and the reactor continued operation from 1960 until 1964

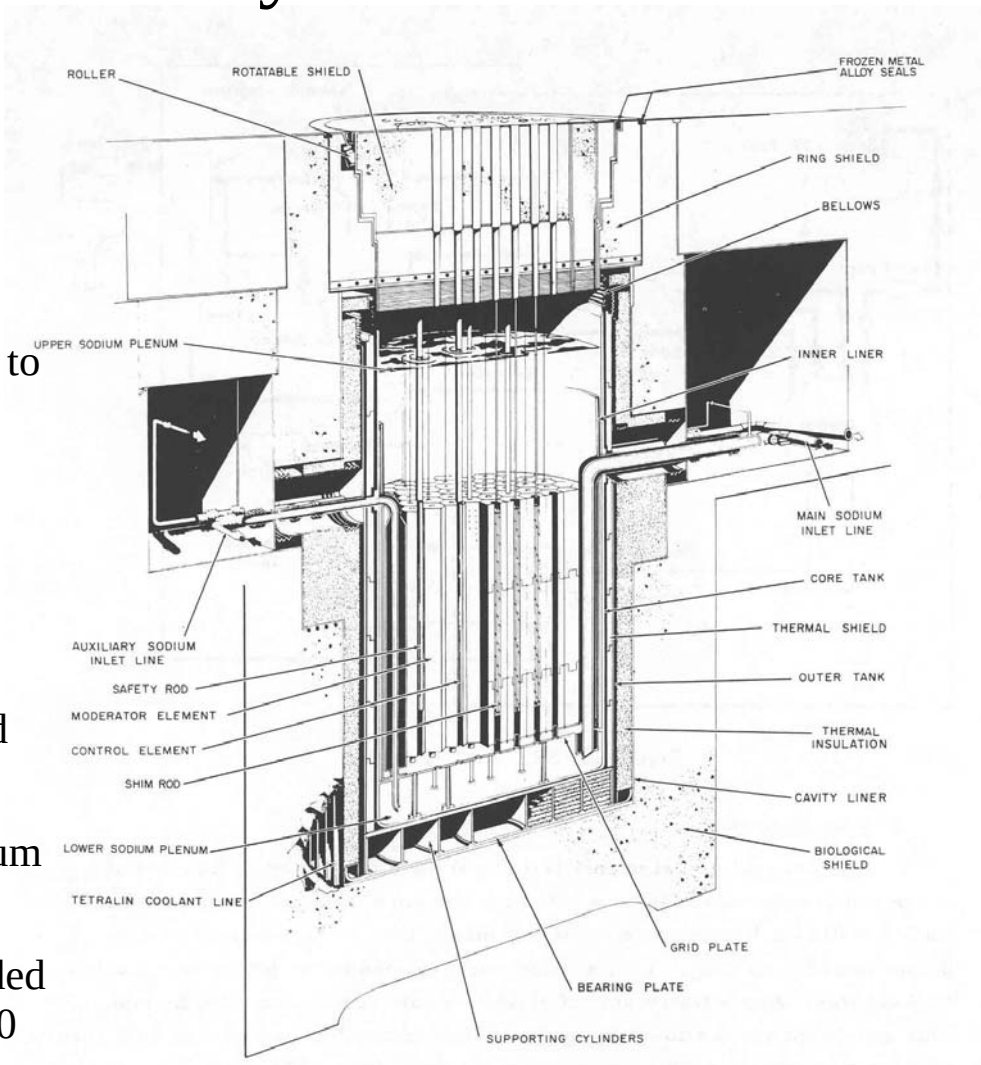


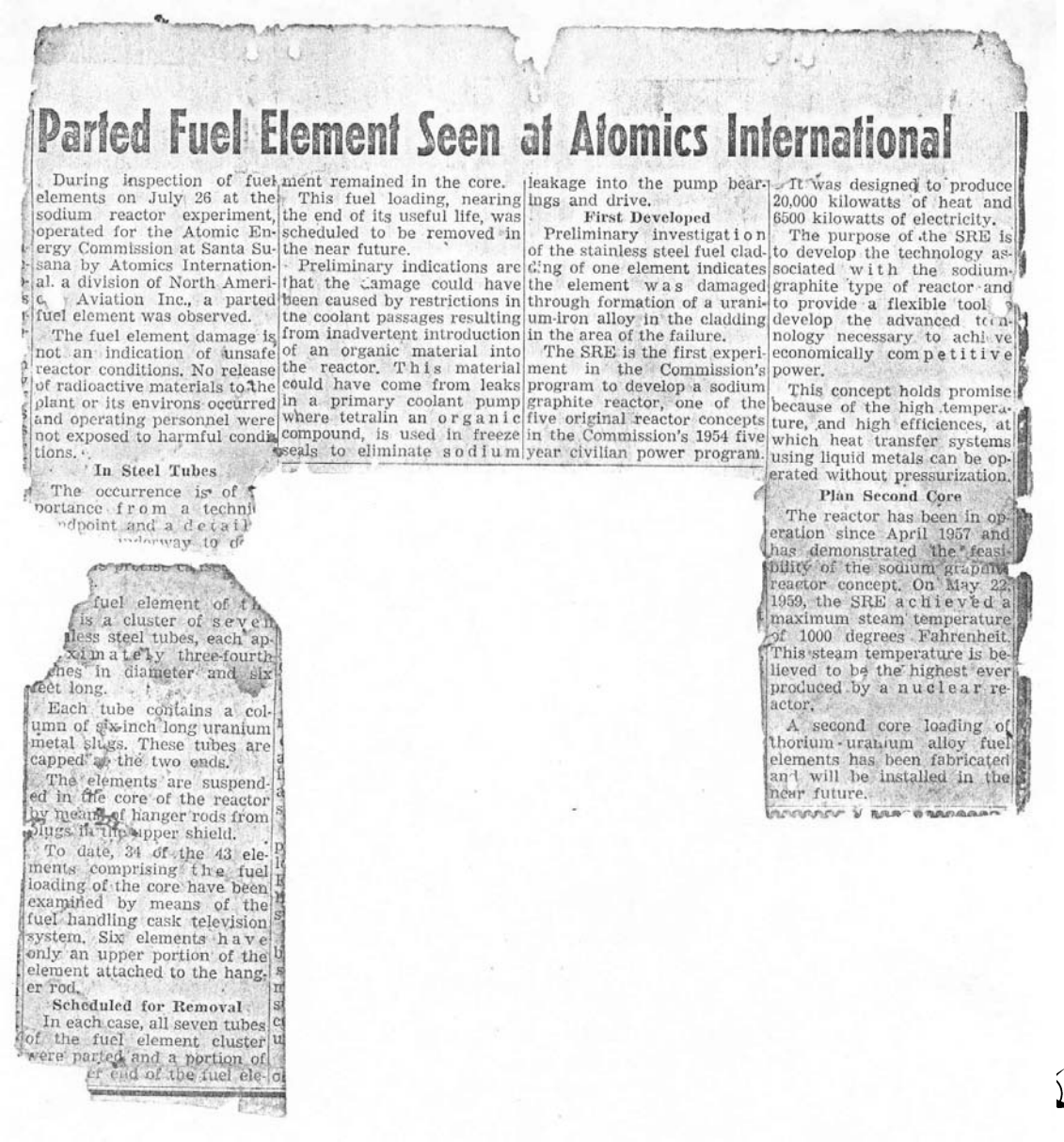
Figure 1. Cutaway View of SRE Reactor

SRE Accident
Occupational and Environmental Impact

- No radworkers exceeded federal exposure limits
- 28 curies of Xe-133 and Kr-85 gas was released from the hold-up tank in controlled conditions and in low concentrations that met federal airborne limits
- If the wind was blowing directly to the nearest resident in Susana Knolls, the exposure would be 0.018 millirem
- Soil, vegetation, and water sampling at the time did not indicate any increase in environmental radioactivity
- Subsequent off-site soil sampling in 1992-94 did not observe any contamination in the vicinity of SRE
- 115 soil samples taken on-site at the SRE location show only low levels of cesium-137 below the soil cleanup guidelines

Valley Green Sheet – August 31, 1959

AI's press release on the SRE accident was not very explicit or informative



Parted Fuel Element Seen at Atomics International

During inspection of fuel elements on July 26 at the sodium reactor experiment, operated for the Atomic Energy Commission at Santa Susana by Atomics International, a division of North American Aviation Inc., a parted fuel element was observed.

The fuel element damage is not an indication of unsafe reactor conditions. No release of radioactive materials to the plant or its environs occurred and operating personnel were not exposed to harmful conditions.

In Steel Tubes

The occurrence is of importance from a technical viewpoint and a detailed [illegible] underway to determine [illegible]

fuel element of the [illegible] is a cluster of seven [illegible]less steel tubes, each approximately three-fourths [illegible]nches in diameter and six feet long.

Each tube contains a column of six-inch long uranium metal slugs. These tubes are capped at the two ends.

The elements are suspended in the core of the reactor by means of hanger rods from plugs in the upper shield.

To date, 34 of the 43 elements comprising the fuel loading of the core have been examined by means of the fuel handling cask television system. Six elements have only an upper portion of the element attached to the hanger rod.

Scheduled for Removal

In each case, all seven tubes of the fuel element cluster were parted and a portion of [illegible]er end of the fuel element remained in the core.

This fuel loading, nearing the end of its useful life, was scheduled to be removed in the near future.

Preliminary indications are that the damage could have been caused by restrictions in the coolant passages resulting from inadvertent introduction of an organic material into the reactor. This material could have come from leaks in a primary coolant pump where tetralin an organic compound, is used in freeze seals to eliminate sodium leakage into the pump bearings and drive.

First Developed

Preliminary investigation of the stainless steel fuel cladding of one element indicates the element was damaged through formation of a uranium-iron alloy in the cladding in the area of the failure.

The SRE is the first experiment in the Commission's program to develop a sodium graphite reactor, one of the five original reactor concepts in the Commission's 1954 five year civilian power program.

It was designed to produce 20,000 kilowatts of heat and 6500 kilowatts of electricity.

The purpose of the SRE is to develop the technology associated with the sodium-graphite type of reactor and to provide a flexible tool to develop the advanced technology necessary to achieve economically competitive power.

This concept holds promise because of the high temperature, and high efficiences, at which heat transfer systems using liquid metals can be operated without pressurization.

Plan Second Core

The reactor has been in operation since April 1957 and has demonstrated the feasibility of the sodium graphite reactor concept. On May 22, 1959, the SRE achieved a maximum steam temperature of 1000 degrees Fahrenheit. This steam temperature is believed to be the highest ever produced by a nuclear reactor.

A second core loading of thorium-uranium alloy fuel elements has been fabricated and will be installed in the near future.

SRE Remediation

SRE Remediation

- Fuel and sodium removed 1967
- Decontaminated and decommissioned (D&D) 1974 - 1983
- ESG Final Status Surveys 1978 - 1983
- ANL Verification Surveys 1979 - 1984
- Released for unrestricted use by DOE 1985

SRE Release Documentation

- EXG-DOE-13367 (DOE-SF-4), “Sodium Reactor Experiment Decommissioning Environmental Evaluation Report”, February 23, 1982.
- ESG-DOE-13403, “Sodium Reactor Experiment Decommissioning Final Report” August 15, 1983
- N704TI990027 through N704TI990039, “Radiological Survey Results – Release to Unrestricted Use - SRE” 1978-83
- DOE/EV-0005/46 (ANL-OHS/HP-84-101), “Post Remedial Action Survey Report for the Sodium Reactor Experiment Facility.” February 1984

SRE Excavation - July 1979

SRE Excavation - July 1979

Biological Shield - August 1979

SRE Excavation - August 1979

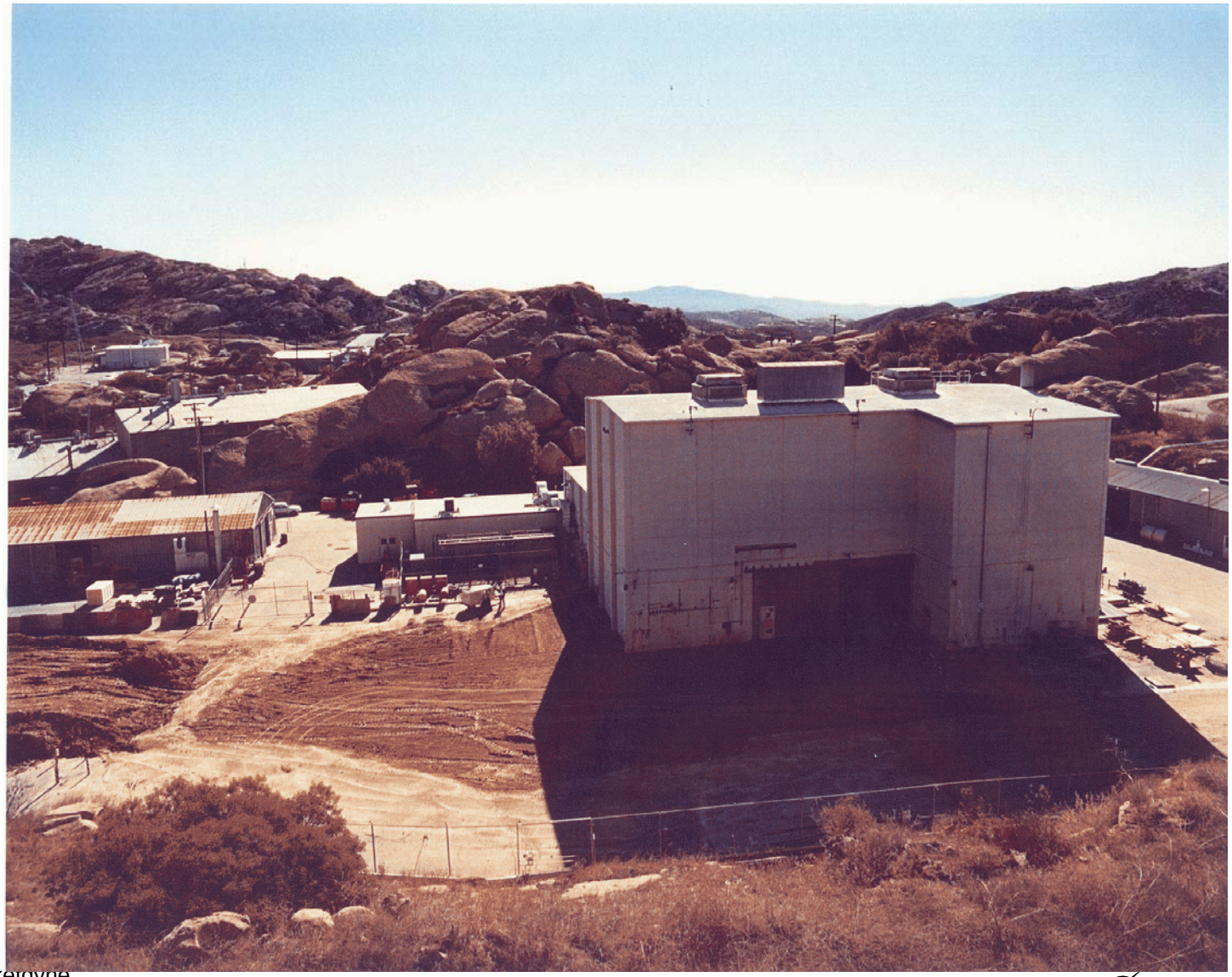
SRE Pond Excavation – August 1979

SRE Excavation – January 1980

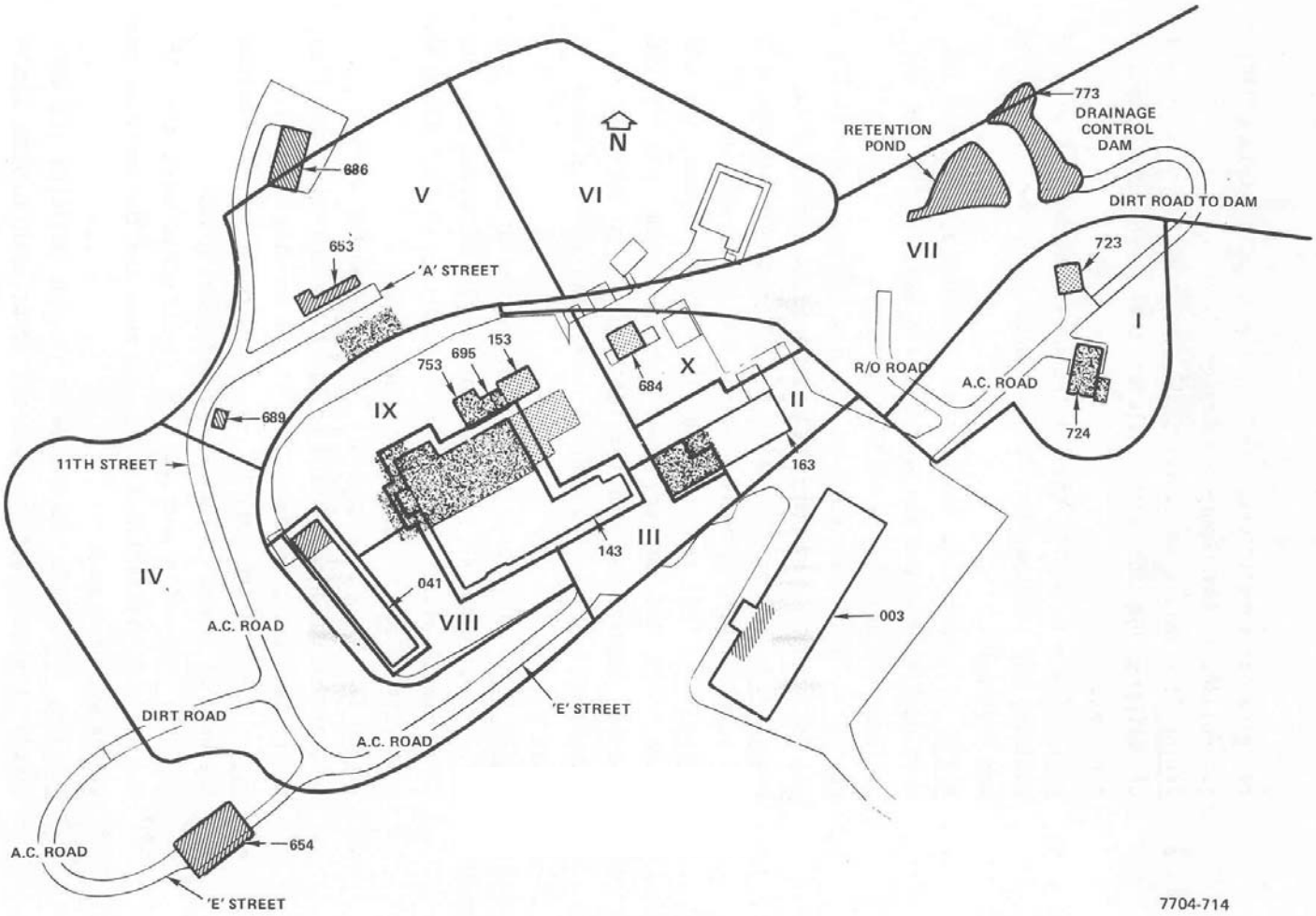
SRE Excavation – December 1980

SRE Excavation – December 1980

Post Excavation ~1981



SRE Radiological Survey Areas 1978-83



ESG-DOE-13403
173

Figure 81. Radiological Survey Regions

SRE Soil Sampling Locations

Rockwell 1978-83

ANL & Rockwell 1979-82

Rockwell 1995 Area IV Survey

Boeing Leachfield Excavation 2000

DHS & Boeing 2001

Boeing 2001

Boeing 2002

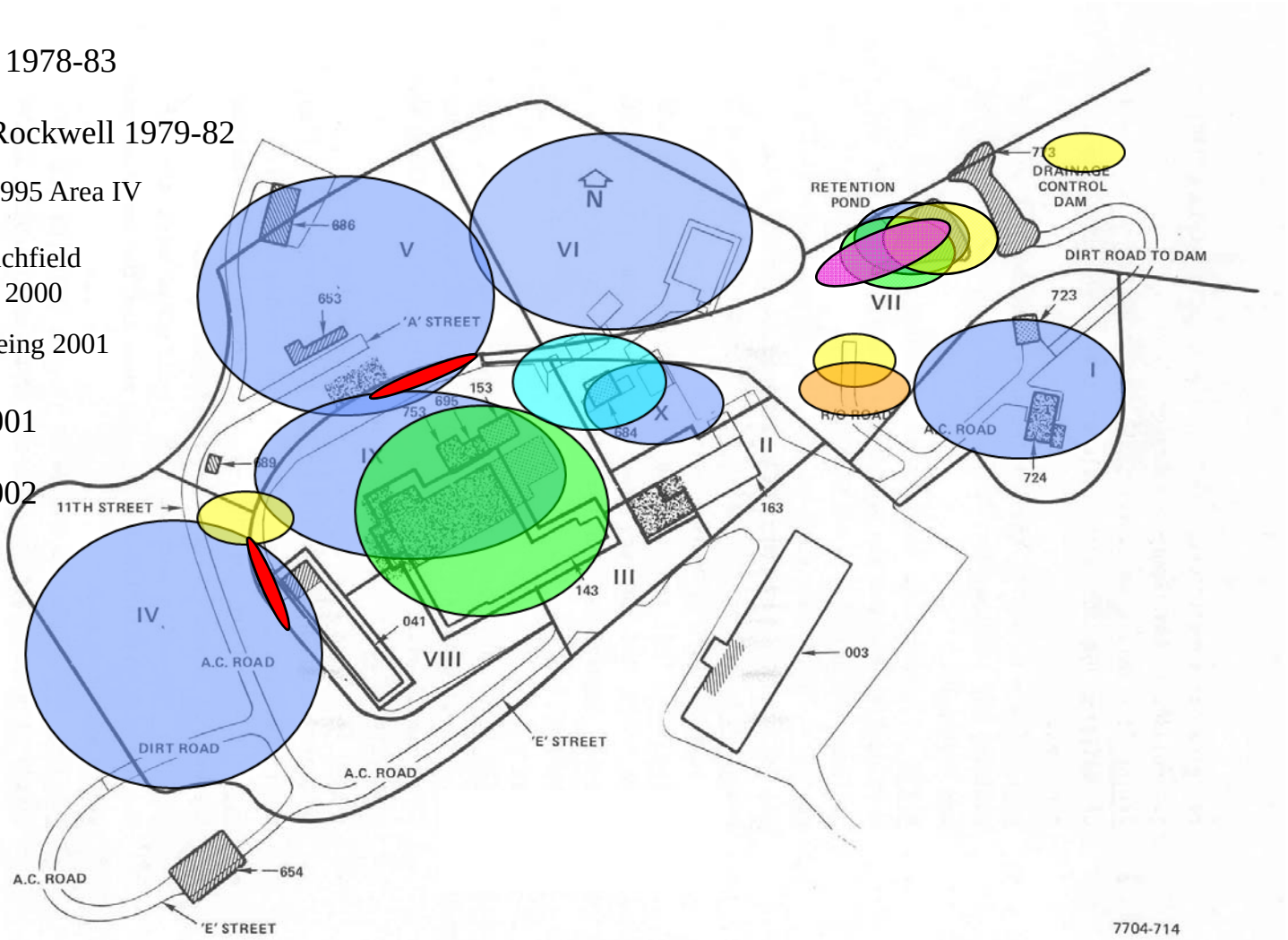


Figure 81. Radiological Survey Regions

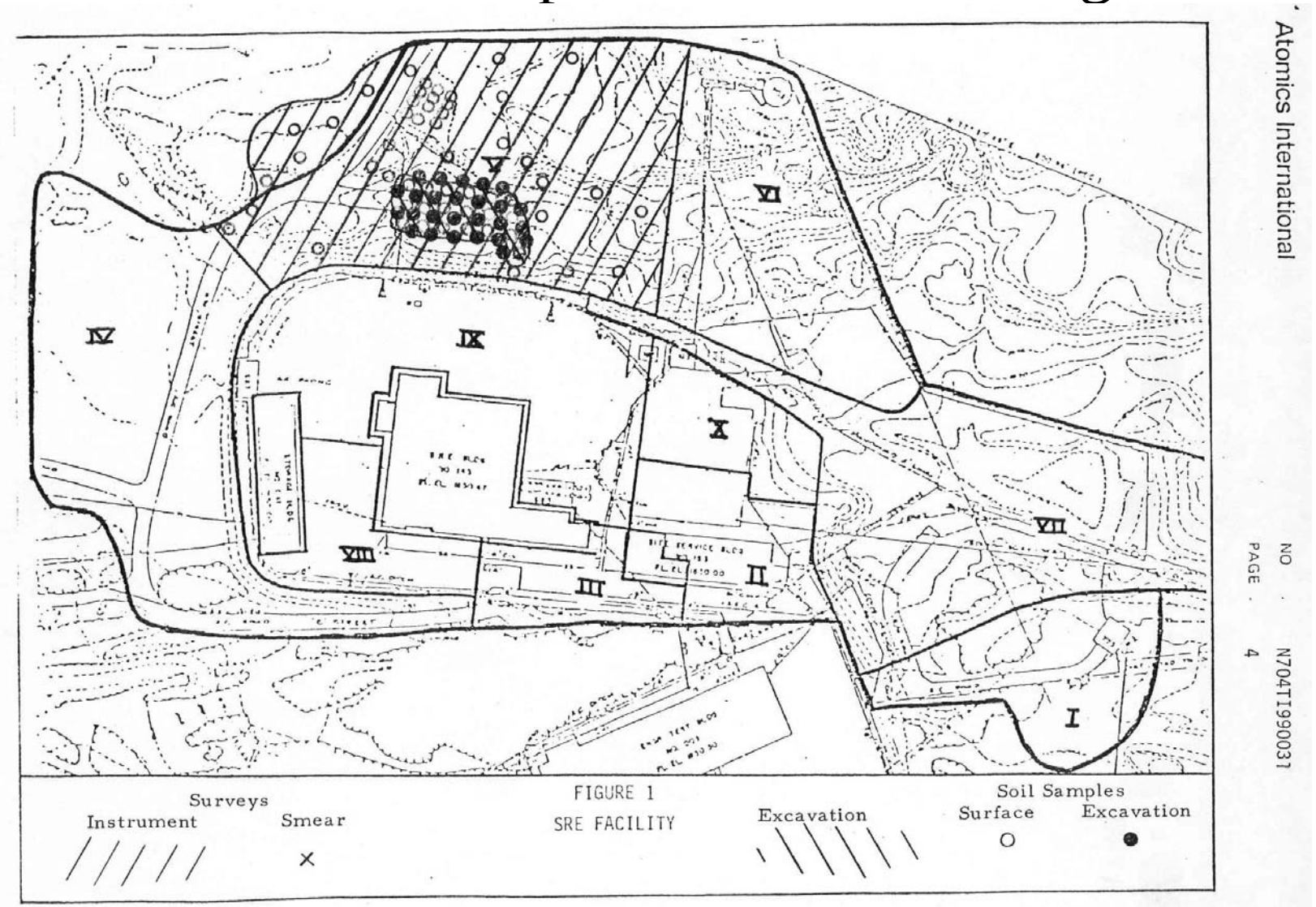
Gross Beta Results for SRE Soil

Region	Date	No. samples	Gross Beta Range (pCi/g)
I	1978	27	16 - 45
II	N/A	0	N/A
III	N/A	0	N/A
IV	1978	34	9.4 - 80
V	1978	22 + 42	6.6 - 49
VI	1978	18	Maximum 32 Average 22
VII	1983	Approx 100	12 - 90 Average 29
VIII	N/A	0	N/A
IX	1983	108	Maximum 98 Average 33
X	1983	25	Maximum 28 Average 25
Building 143	1983	?	Maximum 96 Average 51

Post Remedial Soil Sampling

Survey	Date	Location	Number samples	Cesium-137 (pCi/g)	Analytes
ANL samples taken as part of the Final Status and Verification Surveys	1981	Sub-building excavation and pond	60	<MDA – 3.1	Gamma emitting radionuclides, uranium, Sr-90
Samples taken during Area IV survey	1995	Pond, leachfield & bldg	8	<MDA – 2.4	Gamma emitting radionuclides, H-3, Sr-90, uranium, thorium, plutonium
Samples taken under septic tank and leachfield	2000	Septic tank, leachfield	11	<MDA – 0.65	Gamma emitting radionuclides
Boeing samples taken at mercury soil area	July 2001	Mercury soil	8	<MDA – 0,25	Gamma emitting radionuclides
DHS samples taken at mercury soil area	July 2001	Mercury soil	8	<MDA – 0.33	Gamma emitting radionuclides, uranium, thorium, gross α/β
Post-excavation samples taken in north & west trench	July 2001	North & west trench	8	<MDA – 1.2	Gamma emitting radionuclides
Samples taken from pond and pond drainage	Sept 2002	Pond & pond drainage	12	<MDA – 2.6	Gamma emitting radionuclides

Rockwell Soil Sample Locations in Region V

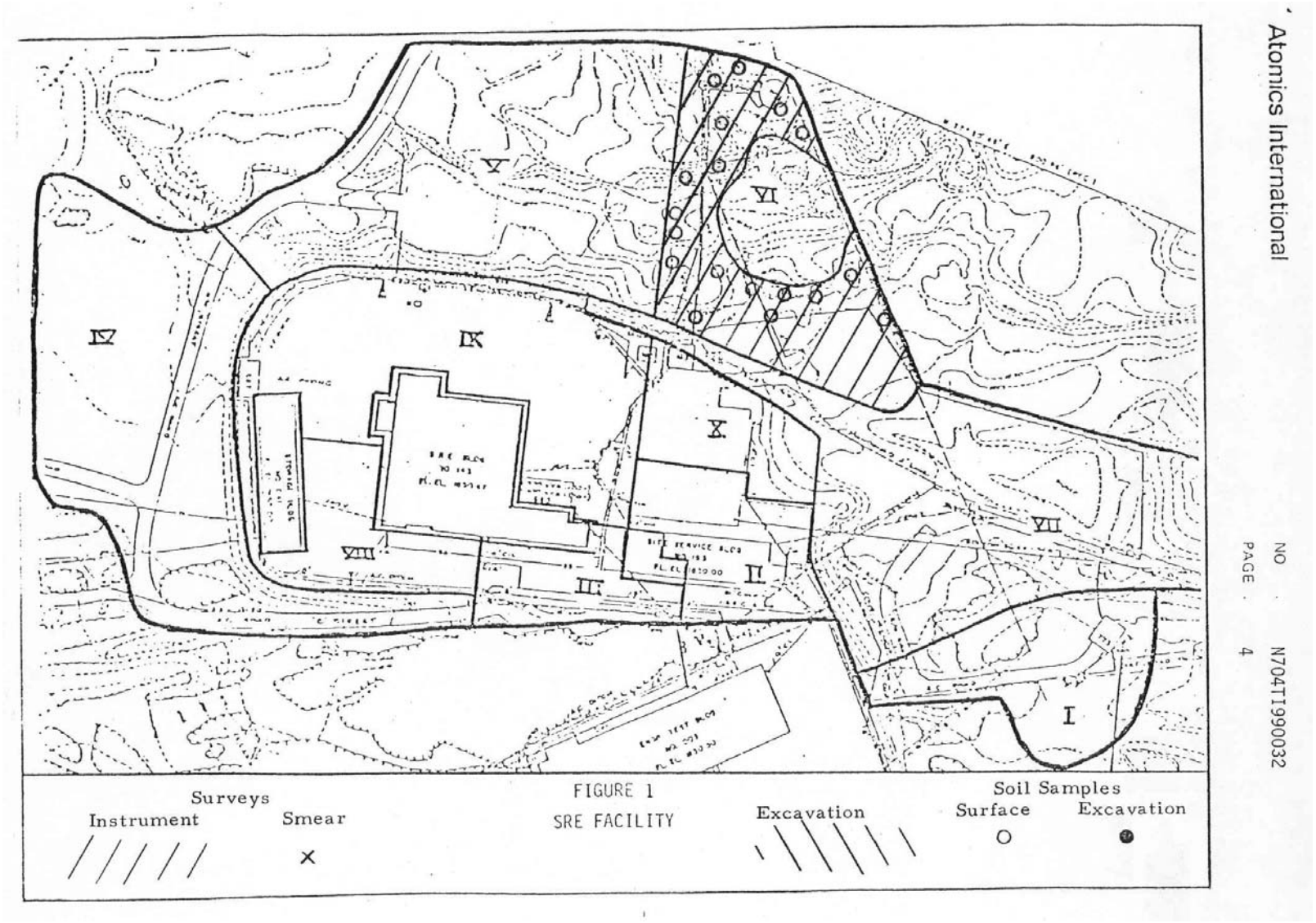


Atomics International

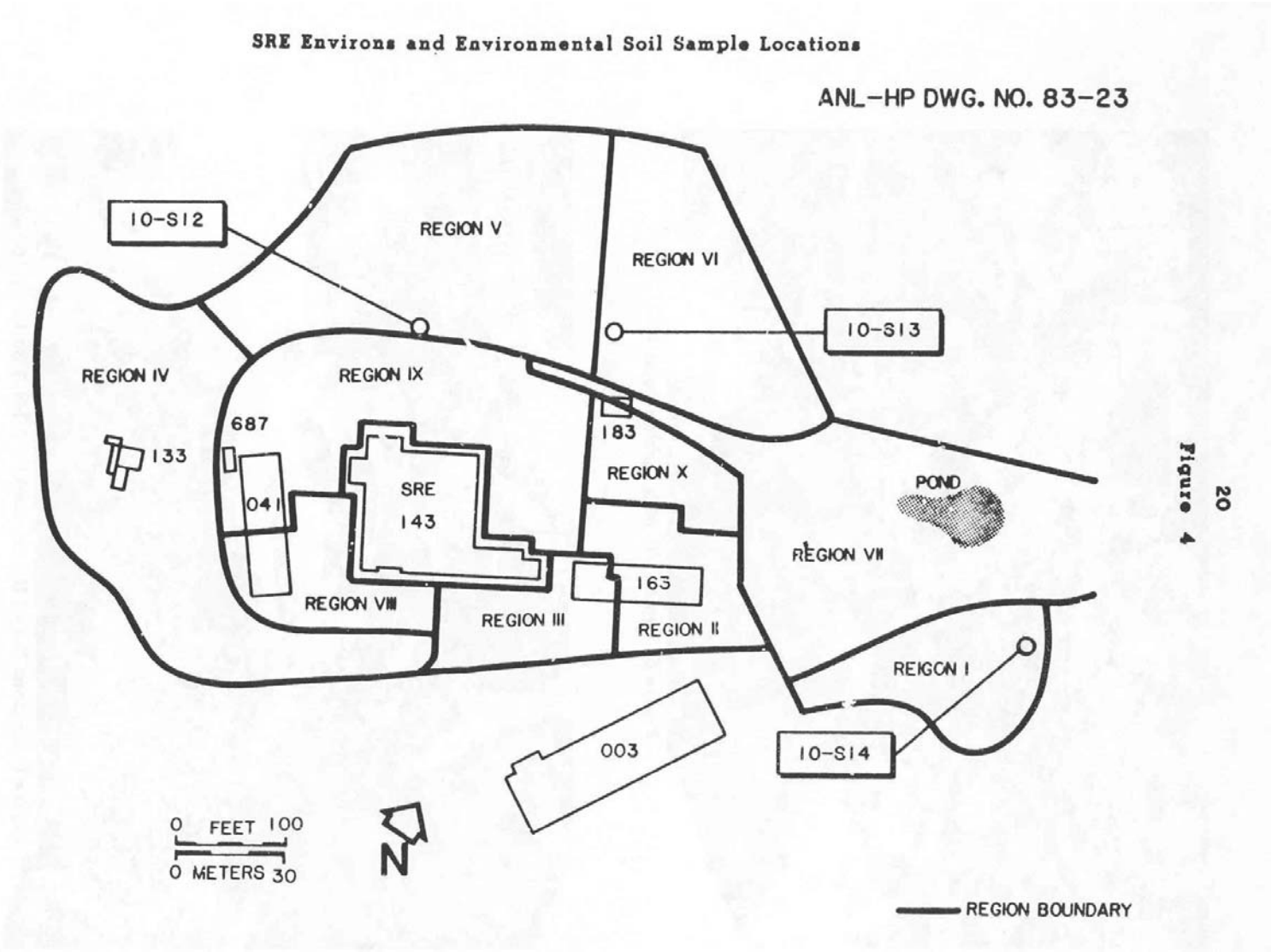
NO . N704TI990031

PAGE . 4

Rockwell Soil Sample Locations in Region VI



ANL Soil Sample Locations – 1979-82



ANL Soil Sample Locations – 1979-82

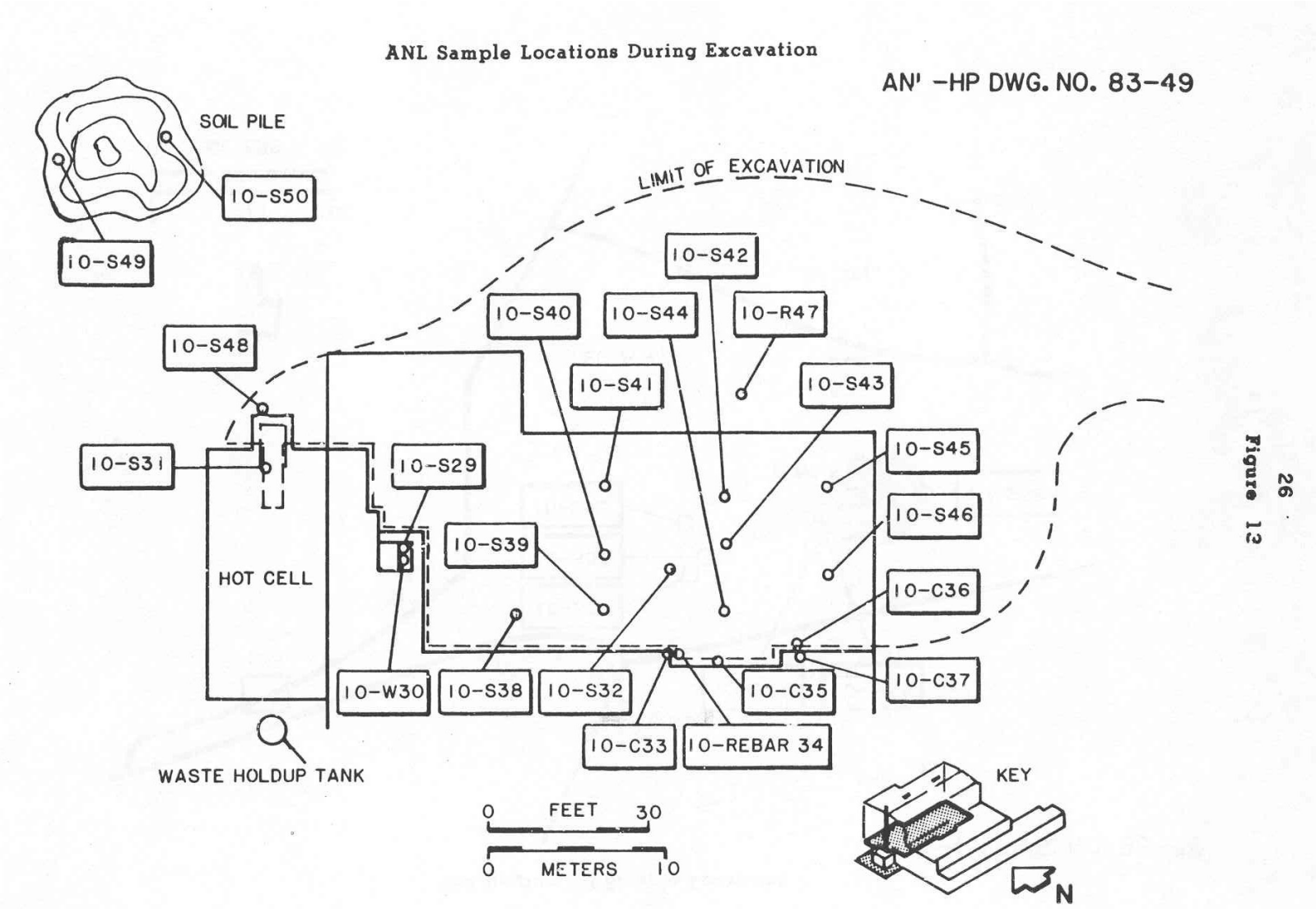


Figure 13

Rockwell Soil Sample Locations – 1979-82

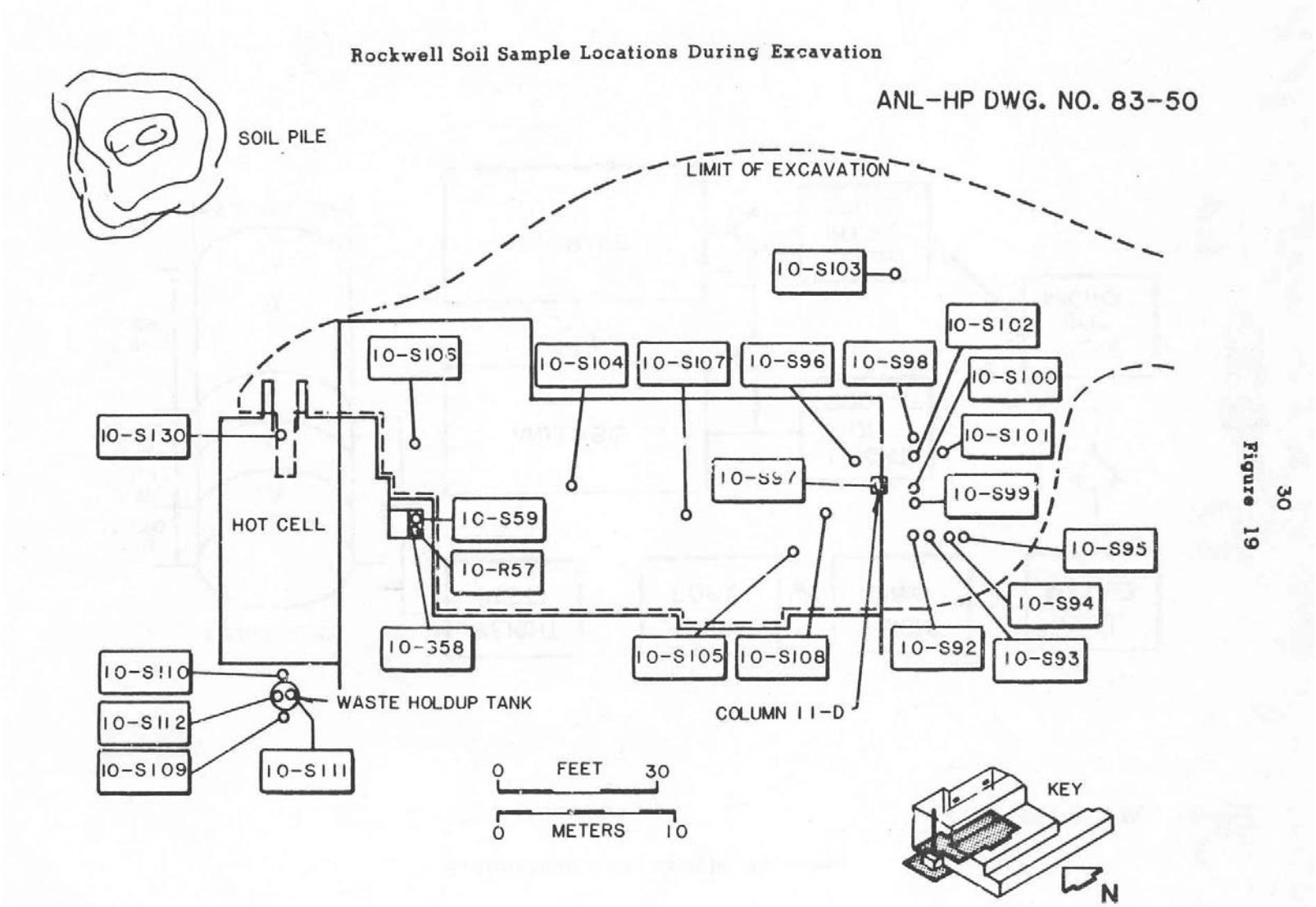


Figure 19

ANL Soil Sample Locations (SRE Pond)

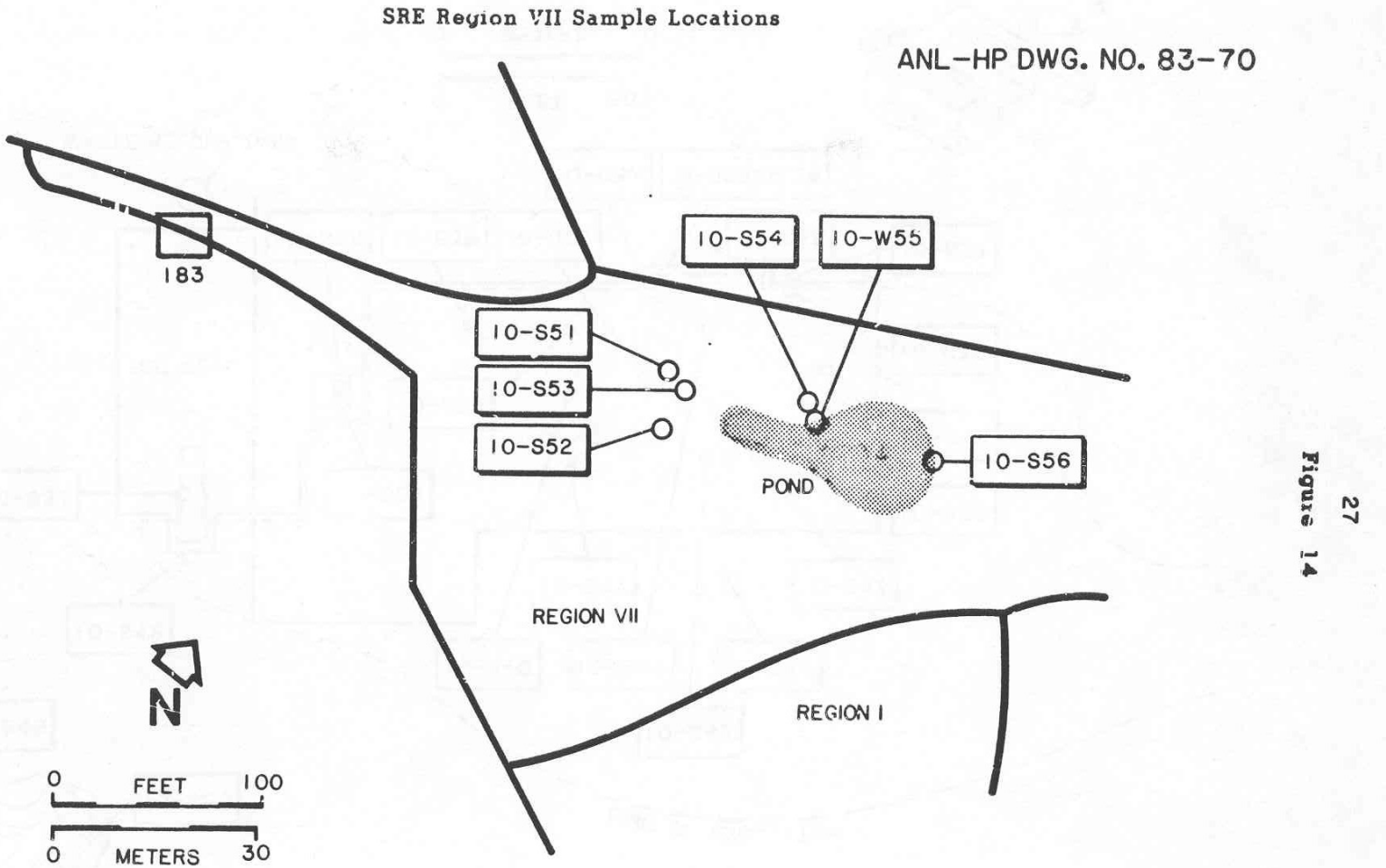


Figure 14

27

SRE Cleanup Standards

Media	SRE Cleanup Standard	Today's Standard
Surface total alpha	100 dpm/100 cm^2	100 dpm/100 cm^2 (for Pu) 1,000 dpm/100 cm^2 (for Th) 5,000 dpm/100 cm^2 (for U)
Surface removable alpha	20 dpm/100 cm^2	20 dpm/100 cm^2 (for Pu) 200 dpm/100 cm^2 (for Th) 1,000 dpm/100 cm^2 (for U)
Surface total beta	0.1 mrad/hr at 1 cm	1,000 dpm/100 cm^2 (for Sr-90) 5,000 dpm/100 cm^2
Surface removable beta	100 dpm/100 cm^2	200 dpm/100 cm^2 (for Sr-90) 1,000 dpm/100 cm^2 (for mixed fission products)
Soil Near surface Below 3 m	 100 pCi/g gross beta 1,000 pCi/g gross beta	 Isotope specific limits
Concrete Rubble	100 pCi/g	

2001 Sampling at SRE North & West Trench

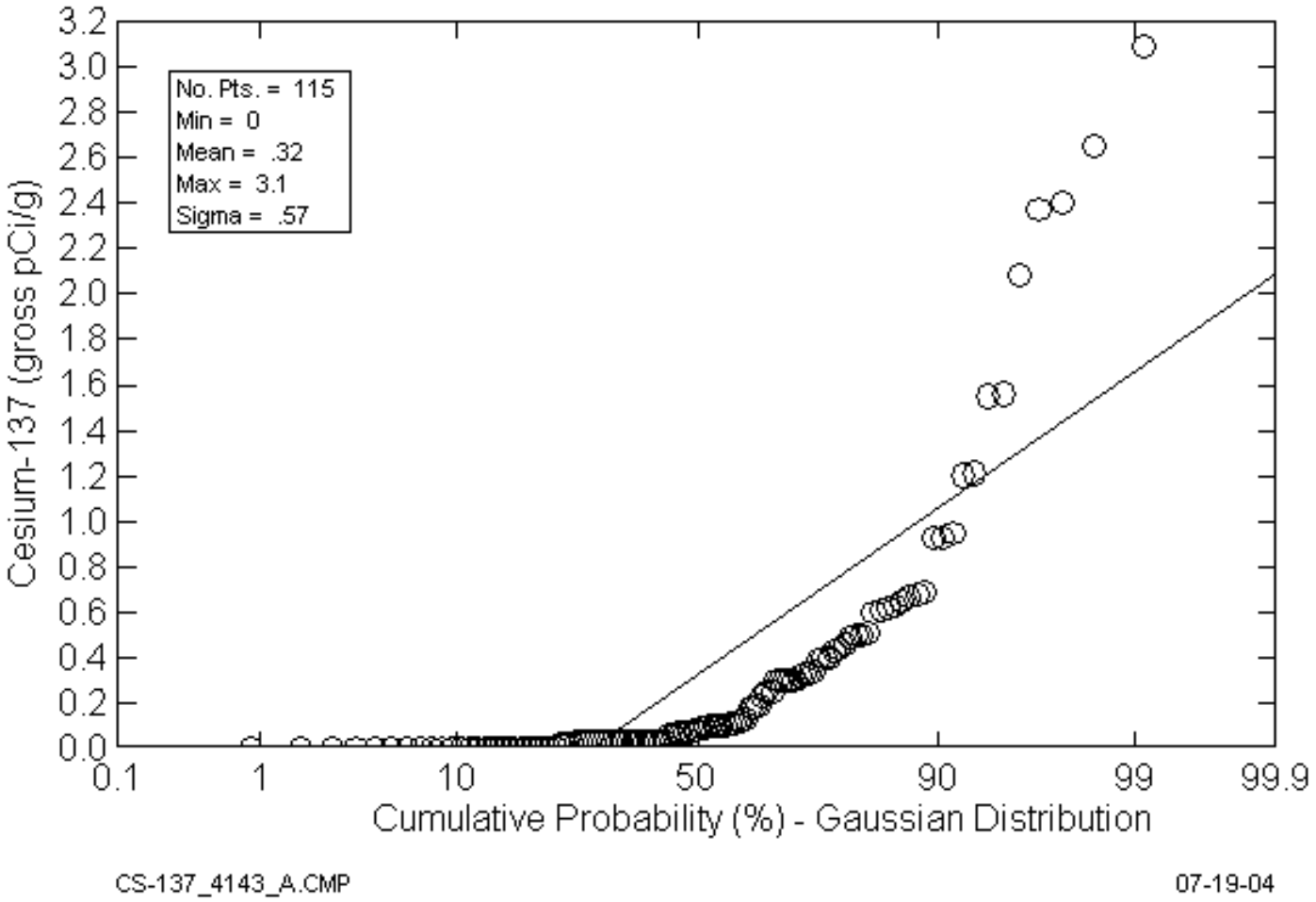
North Trench	Cs-137 (pCi/g)		West Trench	Cs-137 (pCi/g)
Pre-excavation	<MDA		Pre-excavation	<MDA
Pre-excavation	0.3		Pre-excavation	0.2
Pre-excavation	0.5		Pre-excavation	1.2
Pre-excavation	0.6		Pre-excavation	2.8
Pre-excavation	1.1		Pre-excavation	2.9
Pre-excavation	1.9		Pre-excavation	4.5
Pre-excavation	2		Pre-excavation	5.7
Pre-excavation	2.1		Pre-excavation	5.9
Pre-excavation	2.2		Pre-excavation	6.3
Pre-excavation	2.6		Pre-excavation	8.9
Pre-excavation	3.6		Pre-excavation	9.1
Pre-excavation	17.7		Pre-excavation	9.4
Pre-excavation	30.3			
Post-excavation	1.2		Post-remedial	0.5
Post-excavation	<MDA		Post-remedial	0.4
Post-excavation	<MDA		Post-remedial	0.1
Post-excavation	<MDA		Post-remedial	0.3

Exceeds DCGL

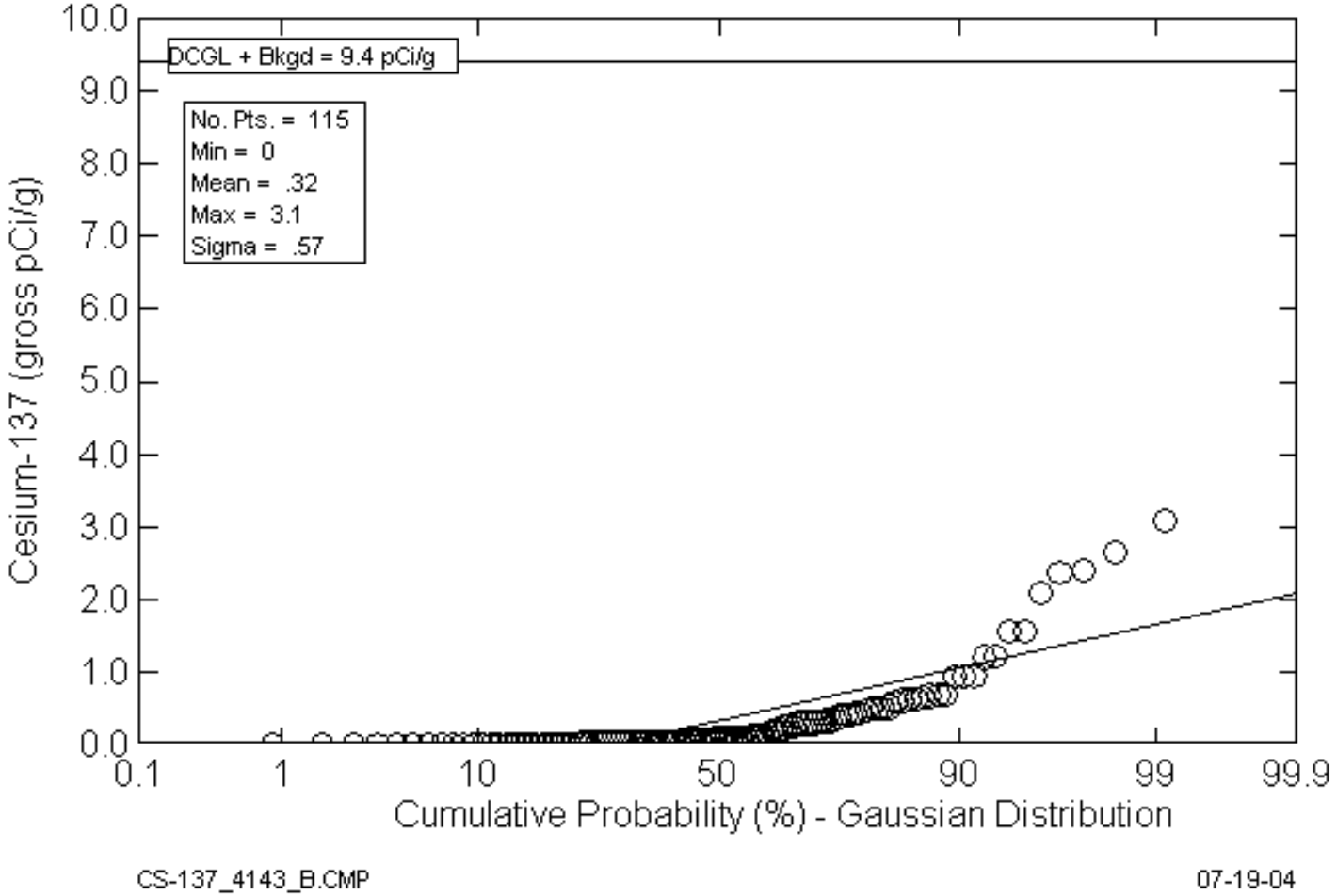
Less than DCGL

Compilation of Post-Remedial Cesium Data for SRE

Cesium-137 in SRE Post Remedial Soil Samples



Cesium-137 in SRE Post Remedial Soil Samples

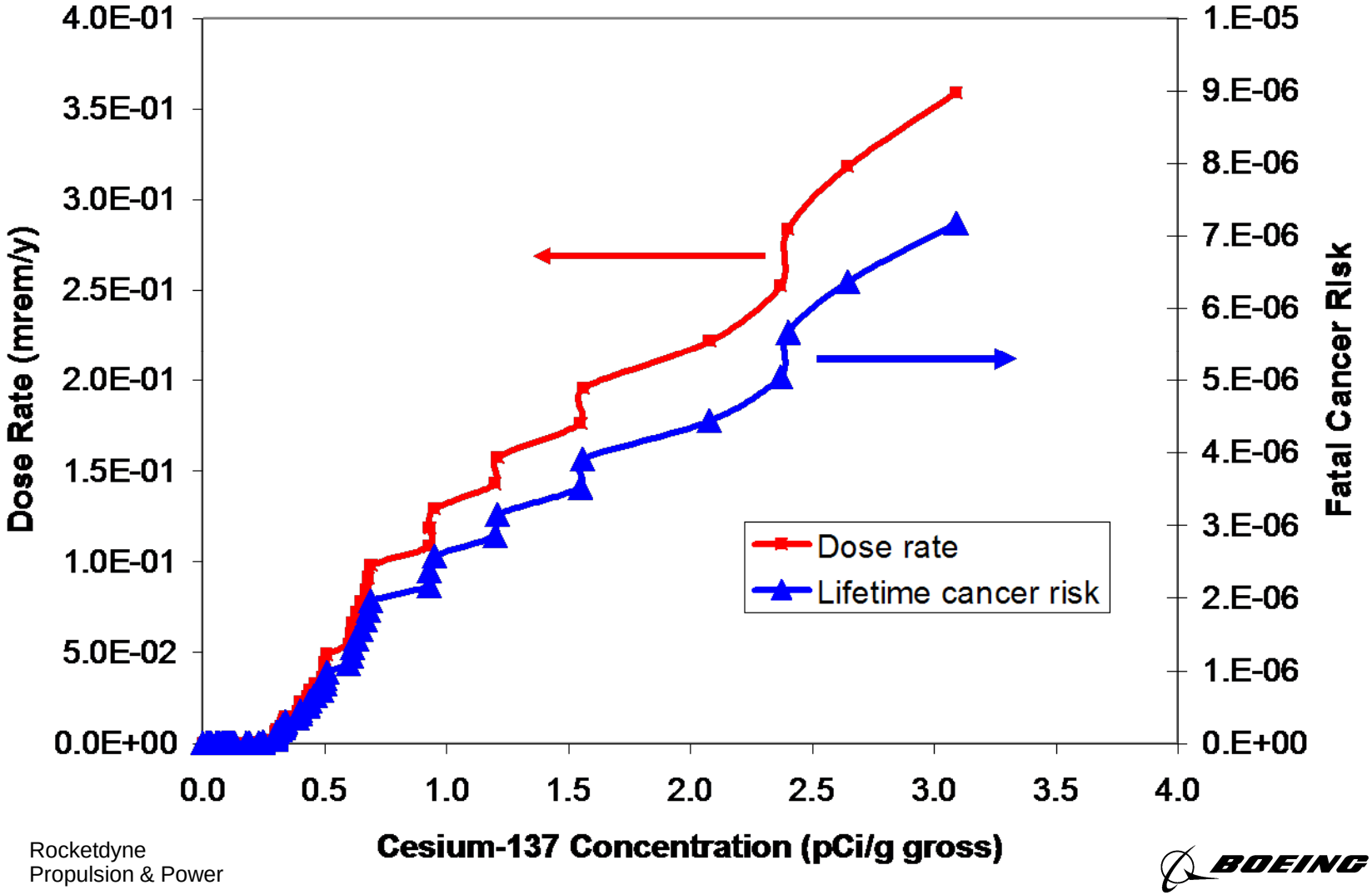


Cesium-137 Statistics Summary

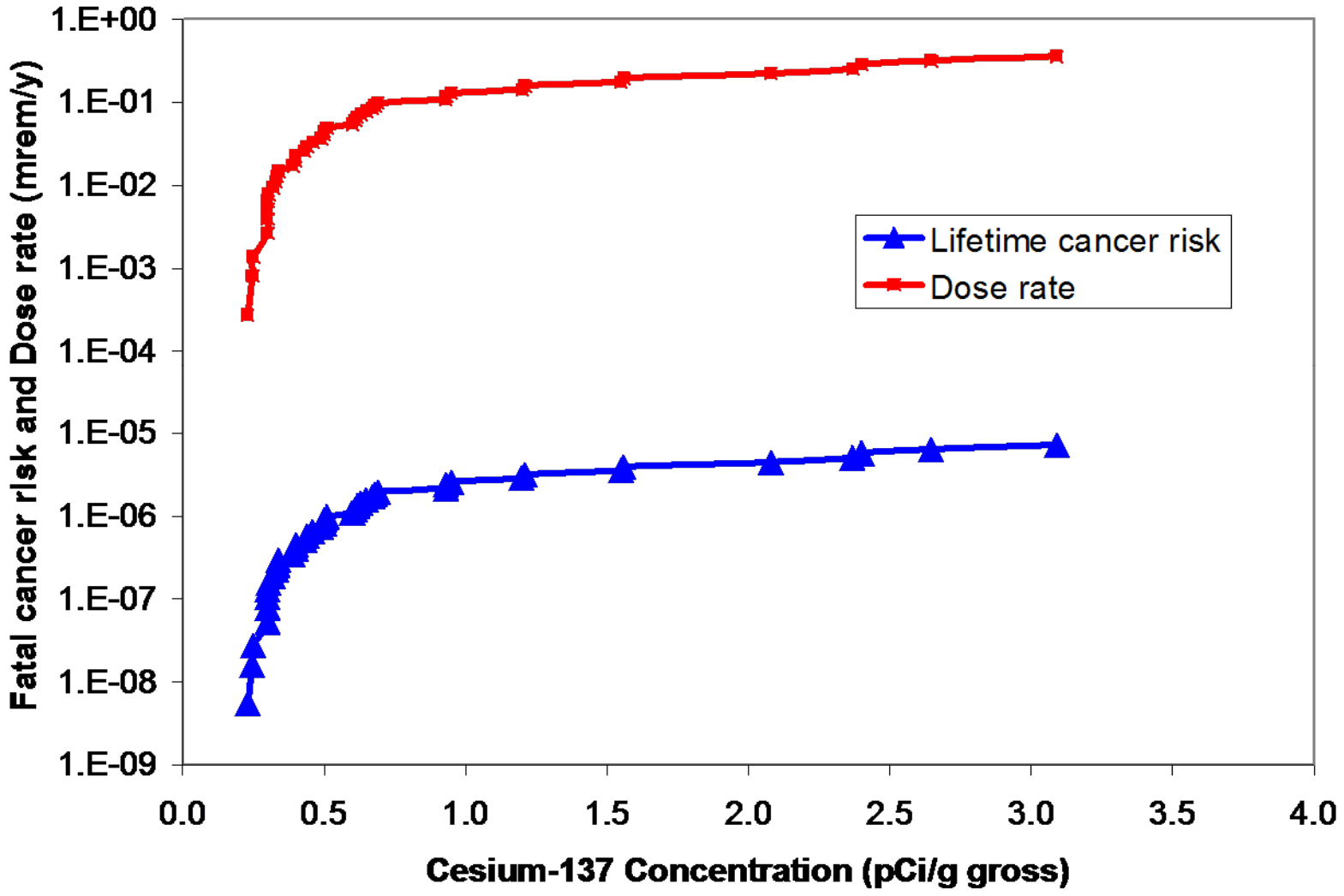
- Minimum 0 pCi/g (gross)
- Maximum 3.1 pCi/g (gross)
- Mean 0.31 pCi/g (gross)
- Background 0.21 pCi/g (95^{th} percentile)
- Cleanup standard 9.2 pCi/g (net)
- Net = Gross – Background
- Mean Theoretical Risk* 7.2×10^{-6} (net)
- Mean Dose 0.36 mrem/y (net)

* Assuming the linear no threshold model of radiation risk is valid at dose rate 1000 times less that background radiation levels

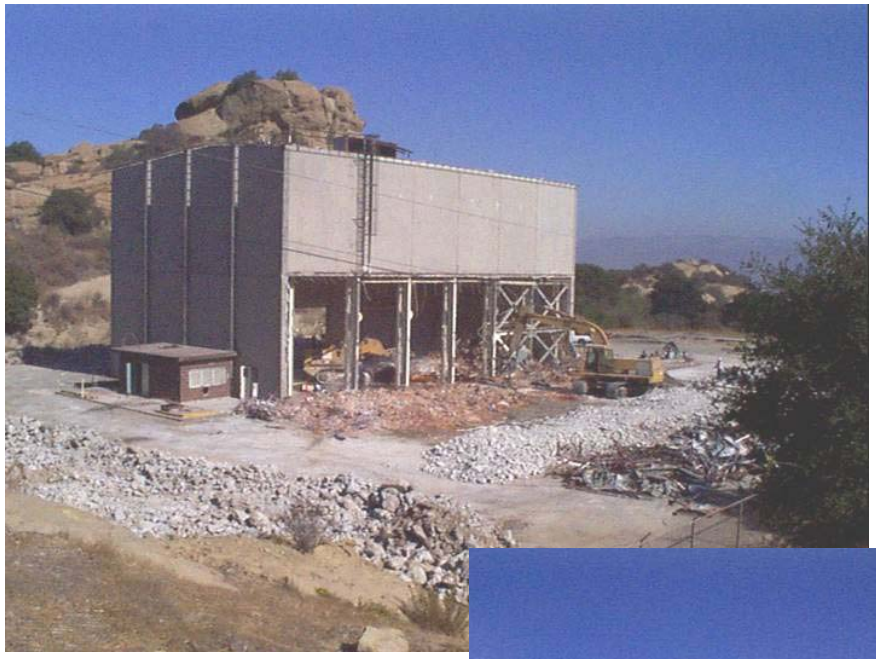
Dose and Theoretical Risk from Cesium-137 at the Sodium Reactor Experiment



Dose and Theoretical Risk from Cesium-137 at the Sodium Reactor Experiment



Demolition of the Sodium Reactor Experiment (1999)



SRE Location – December 2003

What Next?

- All post remedial soil sampling has demonstrated that
  - residual contamination is well below cleanup standards
  - the site meets CERCLA standards
- Additional wells will be sunk to investigate if SRE has impacted groundwater