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ADVISORY BOARD ON

RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

Review of the Santa Susana Field Laboratory (SSFL) Area IV Special Exposure Cohort (SEC) Petition-00093 and the NIOSH SEC Petition Evaluation Report

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Review of the Santa Susana Field Laboratory (SSFL)-Area IV Special Exposure Cohort (SEC) Petition-00093 and the NIOSH SEC Petition Evaluation Report	Page 2 of 54
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TABLE OF CONTENT

ABBREVIATIONS AND ACRONYMS

ABRWH or the Board	Advisory Board on Radiation and Worker Health
AEC	Atomic Energy Commission
AERD	Atomic Energy Research Development
AWE	Atomic Weapons Employer
AI	Atomics International
ATR	Advanced Test Reactor
BE	Beryllium
CFR	Code of Federal Regulations
Ci	Curie
cpm	Counts per minute
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOELAP	Department of Energy Laboratory Accreditation Program
dpm	Disintegrations per minute
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
EPA	Environmental Protection Agency
ER	Evaluation Report
ETEC	Energy Technology Engineering Center
EU	Enriched Uranium
FR	*Federal Register*
FWSP	Federal Work Study Program
HEPA	High Efficiency Particulate Air
HHS	Health and Human Services
ISF	Interim Storage Facility
keV	Kilo Electron Volt
L	Liter
LMEC	Liquid Metal Engineering Center
LMFBR	Liquid Metal Fast-Breeder Reactor
LMIC	Liquid Metal Information Center
LMR	Liquid Metal Reactor

MDA	Minimum Detectable Activity
MDL	Minimum Detection Limit
MeV	Mega Electron Volt
MFP	Mixed Fission Product
mL	Milliliter
MPBB	Maximum Possible Body Burden
Mr	Millirem
NAA	North American Aviation
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH OCAS Claims Tracking System
NSEC	Nuclear Science and Engineering Corporation
NTA	Neutron Track Emulsion Type A
OCAS	Office of Compensation Analysis and Support
ORAU	Oak Ridge Associated Universities
ORAUT	Oak Ridge Associated Universities Team
pCi	pico Curie
r	Rem
R&D	Research and Development
REIRS	Radiation Exposure Information Reporting System
Rem	roentgen equivalent man
RI	Rockwell International
RMDF	Radioactive Material Disposal Facility
RSRMS	Radiation Safety Records Management System
SC&A, Inc.	S. Cohen and Associates
SEC	Special Exposure Cohort
SRDB	Site Research Database
SRE	Sodium Reactor Experiment
SNAP	Systems for Nuclear Auxiliary Power
SSFL	Santa Susana Field Laboratory
TBD	Technical Basis Document
UCLA	University of California Los Angeles
UF	Uranium Fluoride

UR	Uranium Radiometric
W	Watt
WB	Whole Body

1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE OF SEC REVIEW

During the meeting of the Advisory Board on Radiation and Worker Health (the Board) held in Redondo Beach, California, on September 4, 2008, S. Cohen & Associates (SC&A) was directed by the Board to perform a "paper" review of the Santa Susana Field Laboratory (SSFL) Special Exposure Cohort (SEC) Petition-00093 and the NIOSH SEC Petition Evaluation Report (ER) for said petition.

The scope of this review addresses specific issues of concern raised in the petition and NIOSH's response to these concerns, as given in the ER. SC&A reviewed hundreds of documents that were considered relevant to the petition. Documents reviewed include the following:

- Documents that were referenced and/or enclosed in the petition
- Documents referenced/cited in the ER and site profile
- Documents contained in the NIOSH Site Research Query Database

The purpose of this review is to provide the Board with an independent assessment of issues and concerns that surround the petition and NIOSH's response and proposed methods for accommodating these issues/concerns. Findings identified in our review are expected to provide the Board with a **preliminary** overview of potential issues that may impact the feasibility of dose assessment. Following a formal, multi-step resolution process, any unresolved findings may then be used by the Board for determining whether radiation doses can be estimated with sufficient accuracy, as defined in 42 CFR §83.13(c)(1). In addition, since this review was limited to a paper study, there will likely be a need to follow up this report with a site visit, interviews with claimants and petitioners, and the retrieval and review of additional documents, in accordance with Board-approved procedures for the review of SEC petitions and associated evaluation reports. It is for this reason that this report is referred to as "preliminary" and as a "paper study."

1.2 TECHNICAL APPROACH AND REVIEW CRITERIA

The approach used by SC&A to perform this review follows the protocols described in the draft report prepared by SC&A entitled, *Board Procedures for Review of Special Exposure Cohort Petitions and Petition Evaluation Reports,* Revision 1 (SC&A 2006a), and the *Report to the Working Group on Special Exposure Cohort Petition Review* (SC&A 2006b). The latter is a set of draft guidelines prepared by a Board-designated working group for evaluation of SEC petitions performed by NIOSH and the Board. The former is a set of draft procedures prepared by SC&A and approved by the Board for use by SC&A on an interim basis (ABRWH 2006, p. 132). The procedures are designed to help ensure compliance with Title 42, Part 83, of the *Code of Federal Regulations* (42 CFR 83) and implement the guidelines provided in the report of the working group.

Key review criteria identified in the report of the working group include the following:

- Timeliness
- Fairness
- Understandability
- Consistency
- Credibility and validity of the dataset, including pedigree of the data, methods used to acquire the data, relationship to other sources of information, and internal consistency
- Representativeness and completeness of the exposure data with respect to the area of the facility, the time period of exposure, the types of workers, and processes covered by the data

The working group guidelines also recommend that NIOSH include in its SEC evaluation a demonstration that it is feasible to reconstruct individual doses for the cohort, including sample dose reconstructions.

SC&A's implementation of the SEC Review process includes the following steps:

(1) Conduct a critical review of the petition and relevant reports, as well as documents and data that are enclosed and/or referenced in the petition/reports.

(2) Identify additional issues/concerns that emerged from SC&A's document review, which are independent of those stated in the petition.

(3) As part of the SEC review, develop a preliminary technical position for issues identified in the petition, as well as SC&A's independent findings.

SC&A's draft report with its preliminary findings will subsequently undergo a multi-step resolution process, including interviews with site workers and others who can provide insights into the issues of concern. Resolution includes a transparent review and discussion of draft findings with members of the Board's working group, petitioners, claimants, and interested members of the public. This resolution process is intended to ensure that each finding is evaluated on its technical basis in a fair and impartial manner. A final report will then be issued to the full Board for deliberation and a final recommendation.

1.3 ORGANIZATION OF THE REPORT

Following this introduction, Section 2.0 of this report provides summary data contained in the SSFL Site Profile. The site profile specifies relevant background information and methods to be used by NIOSH for the reconstruction of internal and external doses, and includes brief site profile summaries of materials and quantities processed, facility descriptions, and proposed methods for dose reconstruction.

Section 3.0 of this report summarizes specific concerns and issues raised in the SEC Petition-00093, as well as NIOSH's ER of the petition. In the ER, NIOSH provided responses to the petition's concerns, along with the conclusion that dose reconstruction is not feasible for SSFL workers for the years 1955 through 1958.

As a result of our review of the petition, NIOSH's evaluation of the petition, the SSFL Site Profile, and other documents, SC&A identified a total of five major findings (that in some cases are supported by more detailed findings), which are cited in Section 4.0 of this report. A discussion is provided for each finding that serves to explain the technical basis for our concern.

- Subsection 4.1: Which areas (Area IV, Canoga Park, DeSoto, and Downey) should be considered in the SEC Petition and when did operations begin at Area IV

- Subsection 4.2: Concern whether the internal monitoring program was sufficiently robust to estimate exposures before and after January 1, 1959

- Subsection 4.3: Lack of information related to the potential exposures associated with facility "incidents" (Sodium Reactor Experiment, Sodium Burn Pit, etc.)

- Subsection 4.4: Lack of information on the environmental exposures (surrogate data, drinking water, etc.)

- Subsection 4.5: Justification for assignment of external dose estimates is not provided and there is no coworker model for external exposures (personnel records are also of concern)

Section 5.0 provides concluding comments regarding the impacts of our findings on dose reconstruction for SSFL workers.

2.0 KEY INFORMATION AND DATA PRESENTED IN THE SSFL SITE PROFILE

The most current site profile for the Santa Susana Field Laboratory (SSFL) consists of six Technical Basis Documents (TBDs) that were issued at various times (see References for specific dates). These TBDs will be referenced throughout this report and include the following:

- ORAUT-TKBS-0038-1: Introduction
- ORAUT-TKBS-0038-2: Site Description
- ORAUT-TKBS-0038-3: Occupational Medical Dose
- ORAUT-TKBS-0038-4: Occupational Environmental Dose
- ORAUT-TKBS-0038-5: Occupational Internal Dose
- ORAUT-TKBS-0038-6: Occupational External Dose

Throughout this report, individual TBDs are referenced simply by number. For example, ORAUT-TKBS-0038-1 will be identified as TBD-1. Collectively, the six TBDs of the site profile are intended to provide core information, data, and guidance that are intended to assist in the dose reconstruction of individual workers who may have been exposed to internal and external occupational radiation at SSFL as stated in ORAUT-TKBS-0038-1:

> *. . . The purpose of this document is to provide a site profile that contains technical basis information for evaluation of the total occupational dose for EEOICPA claimants who were employed at the Atomics International (AI) facility as described above.*

2.1 PRINCIPAL OPERATIONS

SSFL consists of a total of 2,850 acres and is located in the Simi Hills of Ventura County, approximately 30 miles northwest of downtown Los Angeles, California. Based on ownership and operations, SSFL is divided into four administrative and operational portions—Area I, Area II, Area III, and Area IV. DOE operations are conducted in a 290-acre westernmost administrative and operational portion designated as Area IV.

SSFL was initially established in 1947 by North American Aviation (NAA) to meet the requirements for a field test laboratory to static-fire large rocket engines; however, it also met NAA’s need for a nuclear research facility. As a result, Area IV was established in 1953 at SSFL as a nuclear research and development (R&D) facility. Since then, SSFL has housed both nuclear development and rocket development groups, although in distinct and separate locations. Atomic Energy Research Development (AERD) also conducted operations in SSFL-Area IV. In December 1955, the nuclear development and rocket development groups were transformed into separate divisions—Atomics International (AI) and Rocketdyne.

Two distinct AI groups were housed in Area IV and supported by DOE. One focused on development of civilian nuclear power, and the other was a center of excellence for research and testing of non-nuclear components related to liquid metals. These two groups were referred to as AI and Liquid Metal Engineering Center (LMEC), respectively. Nuclear R&D activities in

Area IV increased rapidly from 1953 into the late 1960s, and then began to decline. AI was eventually merged into Rocketdyne in 1984 as a result of this decline.

The LMEC was created in 1966 as a government-owned and contractor-operated organization; its purpose was to provide development and non-nuclear testing of Liquid Metal Reactor (LMR) components and to establish the Liquid Metal Information Center (LMIC) for the Atomic Energy Commission's (AEC's) Liquid Metal Fast-Breeder Reactor (LMFBR) program. The LMEC was renamed Energy Technology Engineering Center (ETEC) in 1978 to reflect DOE's desire to broaden its mission beyond the LMFBR program.

Several corporate mergers and organizational changes occurred over the years. In 1967, NAA merged with Rockwell Standard to become North American Rockwell. In 1973, the corporate name changed to Rockwell International (RI). Rockwell International with AI and Rocketdyne continued to exist as independent divisions until 1984, when AI was absorbed by the Rocketdyne division. The Boeing Company purchased RI in 1996, and Rocketdyne is now a division of Boeing.

Before the remaining research activities ended in 1998, three primary types of operations were conducted at Area IV: (1) development and testing of nuclear reactors, (2) nuclear support operations, and (3) non-nuclear energy R&D.

2.2 DEVELOPMENT AND TESTING OF NUCLEAR REACTORS

Between 1953 and 1980, several nuclear reactors were built, tested, and operated in Area IV. These included both nuclear reactors and critical test assemblies. Nuclear reactor programs focused on the development and operation of homogeneous water boiler-type reactors, sodium-cooled graphite-moderated reactors, and uranium-zirconium hydride reactors.

2.2.1 Homogeneous Water Boiler Reactors

The water boiler reactors were operated in Buildings 4073 and 4093. The water boiler reactors used a 93% enriched uranyl sulfate solution held in a critical configuration in a spherical vessel. Rather than actually boil, the neutron and gamma flux caused radiolytic decomposition of water into hydrogen and oxygen in the form of tiny bubbles, which gave the impression of boiling. Area IV contained two water boiler reactors.

2.2.2 Sodium-Cooled Graphite-Moderated Reactors

The Sodium Reactor Experiment (SRE) facility consisted of 12 structures, including the reactor building, office buildings, and support structures. Eight structures were directly involved in operations with radioactive materials:

(1) Reactor Building (Building 4143)
(2) Component Storage Building (Building 4041)
(3) Temporary Hot Waste Storage Building (Building 4686)
(4) Site Service Building (Building 4163)

(5) Cold Trap Vault (Building 4695)
(6) Liquid Radioactive Waste Vault (Building 4653)
(7) Interim Radioactive Waste Storage Area (Area 4654)
(8) Intermediate Contaminated Storage Area (Area 4689)

2.2.3 Systems for Nuclear Auxiliary Power Reactors

The Systems for Nuclear Auxiliary Power (SNAP) program operated from 1956 to 1971 to support the development and testing of small reactors designed to provide power for research missions in space. The SNAP reactors were uranium-zirconium hydride reactors that used fully enriched (93%) uranium dispersed in fuel rods containing zirconium hydride. Seven SNAP reactors were tested and operated in Buildings 4010, 4024, 4028, and 4059.

2.3 CRITICAL TEST FACILITIES

Several programs used critical test facilities (i.e., low-power reactors) in Area IV. Use of these low-power reactors began in 1954, and continued until 1974. The critical test facilities included SNAP development test facilities, which were housed in Buildings 4373, 4012, 4019, and 4024. Critical test facilities supporting the development of civilian nuclear power included Buildings 4009 and 4100.

2.4 NUCLEAR SUPPORT OPERATIONS

Starting in 1956, several operations were conducted in Area IV to support nuclear programs. These included the manufacture, management, and disassembly of fuel for reactor operations, as well as the operation of nuclear waste management facilities for offsite disposal.

2.4.1 Reactor Fuel Manufacturing

As part of the nuclear reactor development work performed for the government, three different reactor fuel manufacturing operations occurred at the SSFL in Buildings 4003, 4055, and 4064. The first operation was the assembly of fuel elements for the SRE, the second was a plutonium fuel manufacturing facility, and the third was a uranium carbide fuel pilot plant. There was also a Fuel Storage Facility, used to store the Special Nuclear Materials (enriched uranium and plutonium) used to make the fuels.

2.4.2 Disassembly and Examination of Reactors and Used Reactor Fuel Assemblies

During reactor test operations, it was often necessary to examine reactor fuel assemblies and other test specimens to determine how they were performing. This involved handling and examining highly radioactive items, for which the Hot Lab operated in Building 4020 from 1959 to 1990. The Hot Lab was a 16,000-ft^2 facility containing four large hot cells with remote manipulators and cranes, a mock-up area, an operating area, and decontamination areas. Construction was completed in 1959, and the facility was used until 1990.

2.4.3 Fabrication, Use, and Storage of Radioactive Sources

Operations at SSFL required many instruments for detecting and measuring radioactivity, and these instruments were calibrated periodically using known quantities and types of radioactivity called sources, which were sealed containers that included small measured quantities of radioisotopes. Sources were also used for some forms of radiography, irradiation testing, and other applications. Sources were manufactured in the Hot Lab at SSFL, and used in various facilities at SSFL and elsewhere. Approximately 140,000 Ci of radioactive material (primarily Pm-147) were fabricated into sources at the Hot Lab. They were stored in secured locations and used under carefully controlled conditions.

2.4.4 Preparation of Radioactive Material for Disposal

The operation of nuclear reactors generates radioactive waste and other radioactive material that must be disposed of offsite. Other operations at the SSFL (fuel fabrication, reactor and fuel examination, etc.) also generated radioactive waste. Radioactive waste was prepared for disposal at the Radioactive Material Disposal Facility (RMDF) with support at the Interim Storage Facility (ISF) in Building 4654.

2.4.5 Research on Reprocessing Used Reactor Fuel

The Hot Cave in the Engineering Test Building supported licensing of nuclear fuel reprocessing. The used fuel assemblies from nuclear reactors contain unused fissionable material, fissionable transuranic products (mainly plutonium), and fission products. Rockwell developed a process to make a partial separation of used fuel, removing part of the fission products so that the material could be used again as reactor fuel. The experiments used up to one kilogram quantities of unirradiated uranium and thorium, and up to 100-g quantities of highly irradiated materials.

2.4.6 Operation of Particle Accelerators

Rockwell operated a Van de Graaff generator in Building 4030, bombarding tritium targets with deuterons to produce neutrons. A second Van de Graaff generator was operated for neutron activation of materials.

2.4.7 Research Using Radioisotopes

Some of the research at the SSFL required the use of special radioisotopes. For these tests, small quantities of specially prepared radioisotopes were brought to the SSFL, used in laboratories under carefully controlled conditions, and then either returned to the vendor or stored safely when reuse was required.

2.4.8 Miscellaneous Operations

Two of the facilities at SSFL, the Conservation Yard and the Sodium Disposal Facility (also referred to as sodium burn pit), were not intended for use with radioactive materials, but both were inadvertently contaminated. The site profile states that both areas have been remediated and that no residual contamination has been detected.

2.5 OTHER RELEVANT FACILITIES

There are three other operations that are addressed in the site profile; the Downey facility, the Canoga Park facility, and the De Soto facility. Each of these facilities is described below. NIOSH considers these facilities as individual covered areas and does not include them in SEC Petition-00093. This issue will be further reviewed below.

2.5.1 Downey

The Downey facility, located in Downey, California, included AEC-funded activities performed in a small portion of a large building from 1947–1955. The AEC activities included mainly paper studies, R&D, and engineering studies. The R&D activities involved the use of a 2-MeV Van de Graaff generator, a small-scale radiochemical laboratory, a neutron counting room, and a construction area with a small 0.5 W teaching reactor.

2.5.2 Canoga Park

Activities at the Canoga Park, California, facility occurred in the Vanowen Building from approximately 1954–1960. Activities that had been performed at the Downey facility were moved to the Canoga Park facility at the end of 1955. The primary activities performed at the Vanowen Building included design, development, and operation of small aqueous fuel reactors; fuel development; and radiochemistry, and beryllium machining is believed to have occurred.

2.5.3 De Soto

Radiological operations occurred at the De Soto facility from 1959 to the mid-1990s. Nuclear fuel material and other radioactive materials were used in Buildings 101 and 104 (referred to as 001 and 004, respectively, prior to 1984) from 1959–1983. Building 104 was used at a much-reduced level until the mid-1990s. The nuclear operations conducted in these buildings included the Advanced Test Reactor (ATR) fuel fabrication and supporting activities; a Gamma Radiation Facility; and a mass spectroscopy (Helium Laboratory).

2.6 RADIONUCLIDES OF CONCERN

Workers at SSFL were engaged in many process operations and maintenance activities that had the potential for external and internal exposures to a host of radionuclides shown in Table 2-3 of TBD-2.

3.0 OVERVIEW OF THE SEC PETITION-00093 AND NIOSH'S EVALUATION REPORT

3.1 SEC PETITION-00093

SEC Petition-00093 qualified on October 19, 2007. The petition requested that NIOSH consider the following class: "All employees who worked in all areas of SSFL-Area IV during the time period from 1955 to the present (which incorporated the post-1987 remediation period)."

The petition provided information and affidavit statements in support of the petitioner's belief that accurate dose reconstruction over time is impossible for the SSFL-Area IV workers in question. NIOSH deemed the following information and affidavit statements sufficient to qualify SEC-00093 for evaluation:

> *As identified in Item F.1 of the SEC-00093 Form B and discussed in the July 30, 2007 call, the petitioner discussed the sodium burn pit, the lack of internal monitoring data, and indicated that no records were kept. The petitioner also discussed a Tiger Team report indicating that the report detailed "inadequate air monitoring" and that "no internal monitoring was done."*

The information and statements regarding the lack of pre-1959 internal monitoring data qualified the petition for further consideration by NIOSH, the Advisory Board on Radiation and Worker Health, and the Department of Health and Human Services. NIOSH determined that the time period from 1955 to 1965 should qualify for the purposes of the SEC petition evaluation, which includes the employment period in the original SEC-00093 petition.

Additional or more specific information that was included in the petition, but not mentioned above, includes the following:

- Faulty HEPA filters associated with the radiation storage buildings
- Improper dosimeter badges
- No record of radionuclides released during the partial meltdown of the SRE
- Evidence of spills incompletely documented
- Monitoring wells placed upgradient of the site
- No soil or water sampling for tritium and a general lack of characterization of the site
- Radiological survey showing tons of radioactive waste stored in boxes by Building 143—high levels of Cs-137 and Co-60

A summary of the key elements defined in SEC-00093 include the following:

- <u>Issue #1: SRE Incident and Release of Core Gases</u>. The basis for this issue being identified was a concern that monitoring records do not exist for this incident and that there was a release of core gases.

- Issue #2: Radiation Badges. This issue was based on a Tiger Team report indicating "inadequate radiation badges."

- Issue #3: Tritium Plumes. The petitioner was concerned that there may have been employee exposure to the tritium plumes through the consumption of drinking water.

- Issue #4: Uranium Fires. The petitioner references many uranium fires and cites two incidents of a sodium explosion, and it appears to express concern that there was insufficient or no monitoring associated with these and similar incidents.

- Issue #5: Air Monitoring. The petitioner was concerned that there was insufficient air monitoring, and NIOSH agrees with this prior to 1958.

- Issue #6: The Sodium Burn Pit. The concern with the pit is that there was no monitoring of the pit and no records were maintained.

3.2 SEC PETITION EVALUATION REPORT

On February 6, 2008, NIOSH issued its SEC Petition Evaluation Report (ER) for SEC-00093. Section 1.0 of the ER states that this report evaluated ". . . the feasibility of reconstructing doses for **all** employees who worked in any area of Santa Susana Field Laboratory-Area IV during the time period from January 1, 1955 to December 31, 1965 . . ." [Emphasis added.]

Under 42 CFR § 83.13(c)(1), the feasibility to reconstruct doses includes the following:

> *. . . radiation doses [that] can be estimated with sufficient accuracy if NIOSH has established that it has access to sufficient information to estimate* ***maximum radiation dose*** *for* ***every type of cancer*** *for which radiation doses are reconstructed, that could have been incurred in plausible circumstances by any member of the class, or if NIOSH has established that it has access to sufficient information to estimate the radiation dose of members of the class more precisely than an estimate of the maximum radiation dose.* [Emphasis added.]

The ER responded to specific concerns and issues raised in the SEC Petition, as summarized above in Section 3.1, and concluded the following:

> *. . . Based on its full research, NIOSH modified the petitioner-requested class to define a single class of employees for which NIOSH cannot estimate radiation doses with sufficient accuracy. The NIOSH-proposed class includes all employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors and subcontractors* ***who were monitored*** *while working in any area of Area IV of the Santa Susana Field Laboratory for a number of work days aggregating at least 250 work days from January 1, 1955 through December 31, 1958, or in combination with work days within the parameters established for one or more other classes of employees in the SEC.* [Emphasis added.]

The ER (p. 11) states the "NIOSH-proposed class includes all employees who were monitored or should have been monitored for internal radiological exposures while working in all areas of Area IV."

While the original petition requested that all employees be considered, NIOSH has restricted the employees included in the class to either those who were monitored or should have been monitored. This inconsistency needs to be addressed and further instruction should be provided as to who is covered.

Furthermore, the actual proposed addition to the class restricts the addition to those employees who were actually monitored, rather than to the potentially broader class of those "who were monitored or should have been monitored." NIOSH normally includes this broader definition in its SEC class additions, and it is unclear why NIOSH has proposed a narrower addition to the SEC class in this case. Specifically, while the practice of issuing badges to workers who entered controlled areas is documented for the most part, the issue of environmental doses and doses due to exposure to the sodium burn pit and other areas outside buildings needs to be taken into account in the class definition.

Data and information employed by NIOSH in its evaluation are cited in Section 4.0 of the ER. The recommendation to approve the SEC status of this modified class was based on NIOSH's conclusion that it could not estimate internal exposures with sufficient accuracy during the period from 1955 through 1958 (which is a period NIOSH has stated as having limited internal monitoring data). NIOSH states that this timeframe corresponds with the date after which an established bioassay program existed at SSFL and after which sufficient internal monitoring has been identified.

Sections 5.0 and 6.0 of the ER provide summary descriptions of SSFL processes, SSFL monitoring practices, and available monitoring data. These data closely parallel information contained in the six TBDs that define the SSFL Site Profile and provide the technical basis for Section 7.0 of the ER.

While Sections 7.1, 7.2, and 7.3 of the ER address the generic feasibility of internal and external dose reconstruction for SSFL workers, Section 7.4 addresses specific issues and concerns identified in the SEC petition, as summarized below.

3.3 NIOSH'S RESPONSE TO MAJOR ISSUES RAISED IN SEC-00093

3.3.1 Responses to Six Issues Identified in the SEC Petition and During Discussions with the Petitioner

Response to Issue #1: SRE Incident and Release of Core Gases

NIOSH states that several documents were reviewed in the preparation of the ER (Lochbaum 2006; Hart 1962) beyond what was reviewed as part of the site profile. It should be noted that there are at least two key documents (AI 1959 and 1961) that were prepared related to this incident that were not reviewed as part of the site profile or ER.

NIOSH concludes the following based on the reports reviewed:

> *Although there is not a consensus on the exact amount of gaseous radioactive materials released to the environment following the incident, all pertinent scientific reports conclude that a significant amount of fission products were released into the primary sodium coolant, with a percentage of that inventory being released to the reactor's cover system, and subsequently released into the atmosphere through reactor building vent systems and from gaseous storage tanks. The type and range of releases to the environment following the fuel damage run from less than 1 Ci of iodine-131 (Christian, 2005) to a conservative upper bound estimate of approximately 3000 Ci of iodine-131 (Lochbaum, 2006). Based on documented stack releases during the incident, AI concluded that since no iodine-131 was detected in cover gas, only about 28 Ci of the noble gases krypton-85 and xenon-133 were released from the stacks to the environment (Rutherford, 2005).*

Based on their review of claims in NOCTS, NIOSH concluded that personnel monitoring exists for members of the proposed class (both internal monitoring and external monitoring) during the timeframe of the SRE event. NIOSH also notes that some air monitoring measurements from the reactor area and stack monitoring also exist.

Section 4.4.2 of this report presents our concerns related to the robustness of the internal monitoring of staff who may have worked in the SRE area. The potential that all staff may not have been properly monitored, combined with the seriousness of this event, suggests that it may be necessary to develop an exposure model for this incident or conclude that exposures cannot be properly evaluated.

<u>Response to Issue #2: Radiation Badges</u>

NIOSH's response to this issue is captured in the following statement:

> *The Tiger Team Report cited by the petitioner does not state that the dosimeters were inadequate, but that they were not Department of Energy Laboratory Accreditation Program (DOELAP) accredited, and it specifically focuses on the D&D period versus the period being evaluated in this report. As it relates to the program being discussed in the Tiger Team report, it was common practice (and is noted as an option in Section 7 of the DOELAP Administrative Standard DOE-STD-1111-98) for smaller programs to be exempted from DOELAP accreditation, contingent upon using a National Voluntary Laboratory Accreditation Program (NVLAP)-accredited commercial service (DOE, 2006). However, this is pertinent only beginning in 1986 when the DOELAP requirements were implemented. Therefore, as discussed previously, the period cited in the petition is after the period of the evaluation and does not impact this evaluation report.*

We concur with NIOSH's response, assuming the petitioner was not referring to some other concern than the adequacy of the badges. As noted, SC&A has not interviewed the petitioners for this preliminary report.

Response to Issue #3: Tritium Plumes

NIOSH states that tritium has never been detected (>1,000 pCi/l) in any of the water supply wells. They further state that the primary supply wells (WS-5, WS-6, WS-12, and WS-13) were in Areas I, II, and III at SSFL, while one well (WS-7) was in Area IV and contributed a small percentage of the water supply. NIOSH has proposed to bound this exposure by assuming that workers consumed water from a shallow monitoring well that has had the highest tritium concentration. NIOSH points out that this well has never been a source of drinking water and is downgradient of the source of tritium (Building 4010). NIOSH also stated in the evaluation report that since 1991, the mean concentration of tritium in this well has been 2,940 pCi/l. Through some modeling and migration and decay assumptions, NIOSH concluded that workers could have consumed water with 30,000 pCi/l of tritium in the 1950s and 1960s.

The above assumptions seem to be claimant favorable, except for the fact that more recent Boeing reports (Boeing 2003, 2004, 2005, and 2006) have documented tritium concentrations as high as 117,000 pCi/l in the monitoring wells (not the drinking water wells). Therefore, the above modeling should be reviewed in light of this more recent information. Concentrations for the period January 1, 1959, to December 31, 1965, need to be provided or inferred by a scientifically defensible method in order to estimate tritium dose for this period.

Response to Issue #4: Uranium Fires

NIOSH has concluded that there are data available for the various uranium fires that would allow dose estimates to be bounded and, based on our review of this information (Alexander 1967a, b, c, and d; Badger 1960 and 1961; Begley 1976; Klostermann 1961; Loba 1959, 1960, 1961a, 1961b, 1962, and 1970; Oldfield 1961; Mooers 1959a and 1959b, 1960, and 1961 a, b and c; Owens 1978; Rudkin 1964 a, b and c; Stephenson 1961, 1962, 1963a, and 1963b; Weber 1963; Young 1960 and 1965), we concur with this conclusion.

Response to Issue #5: Air Monitoring

NIOSH has concurred that there is a lack of area air monitoring for the period at SSFL-Area IV prior to 1958, which impacts the feasibility of estimating internal radiation doses with sufficient accuracy for the proposed worker class during that time period. After 1958, NIOSH will base its dose reconstructions primarily on bioassay data.

Our discussion on the adequacy of the bioassay program prior to and after January 1, 1959, is presented below in Section 4.3

Response to Issue #6: The Sodium Burn Pit

NIOSH concludes that while there may have been radiological contamination at the Sodium Burn Pit, the following facts appear to support a low exposure and ability to bound dose estimates:

- It appears contaminant levels were low (56 pCi/g maximum) related to radioactive contamination (principally cesium-137), and that contaminants were primarily in the lower pond.
- Contamination was not identified in areas outside the ponds.
- The Sodium Burn Pit was an outdoor area not continuously occupied, nor continuously used.
- Because the pit was not an operations area, exposures for individuals that may have intermittently occupied the Sodium Burn Pit would have been lower than exposures for individuals who performed operations work with source materials that were delivered to this location.
- Radiological exposure controls were in place (e.g., workers were required to maintain a safe distance from the pits, including lined and unlined pits/ponds), because of the violent reactions that could occur if sodium or potassium made contact with the water.
- Bioassay results were available for affected and/or associated members of the proposed class, including worst-case exposure scenarios for the proposed worker class.

This issue is discussed in Section 4.3.

3.3.2 Other Issues

Two other issues were identified by NIOSH in preparing the ER. The first issue dealt with the identification of workers with blank radiation exposure record sheets in their file (a sheet with no entries). The second issue dealt with the monitoring of firemen from other sites who got involved with fires or events at SSFL Area IV.

Response to "Other" Issue #1

NIOSH discovered through an interview with a current Radiation Safety Officer at SSFL that all individuals were issued a blank record sheet in his/her file called a "blue card." If an individual entered into a "controlled" area, they were required to have a film badge and any exposure was entered into their file. This practice was corroborated by NIOSH through random personnel record reviews and through other reviews (Boice et al. 2006a and Boice et al. 2006b).

SC&A acknowledges this practice.

<u>Response to "Other" Issue #2</u>

NIOSH learned through interviews and reviews of dosimetry information that firemen typically wore film badges when working in areas with the potential for radiological exposures. One person interviewed mentioned that firemen wore badges at all times. However, one fireman did not have monitoring records in his file. The SEC Petition ER concludes the following:

> *As previously discussed and stated, the availability of personnel records for monitored individuals supports NIOSH's ability to reconstruct dose with sufficient accuracy for those proposed worker class members. Because the available data also includes a representation of the maximum potential exposures (a bounding exposure scenario) for the proposed worker class, NIOSH contends that this supports the ability to bound the associated dose for all members of the proposed worker class, including dose associated with the exposure scenarios presented by/for these firemen.*

SC&A is in agreement with the above statements.

3.4 NIOSH'S CONCLUSIONS

The ER concluded that, based on the limited pre-1959 internal monitoring data and associated program or source information, there is insufficient information to support establishing a bounding internal exposure scenario for the proposed worker class that worked in Area IV of the SSFL from 1955 through 1958. NIOSH has identified post-1958 radiological internal monitoring program data and the original monitoring data for individuals working in the highest-exposure areas at Area IV, and therefore has concluded that doses can be bounded for the class evaluated for the period from 1959 through 1965.

4.0 PRELIMINARY FINDINGS ASSOCIATED WITH THE SEC PETITION

4.1 OVERVIEW

This section of the SEC review process identifies discrete issues of concern that may adversely affect the ability to estimate SSFL worker exposures. Findings presented below are grouped as follows:

- Section 4.1: Which areas (Area IV, Canoga Park, DeSoto, and Downey) should be considered in the SEC Petition and when did operations begin at Area IV

- Section 4.2: Concern whether the internal monitoring program was sufficiently robust to estimate exposures before and after January 1, 1959

- Section 4.3: Lack of information related to the facility "incidents" (SRE, Sodium Burn Pit, etc.)

- Section 4.4: Lack of information on the environmental exposures (surrogate data, drinking water, etc.)

- Section 4.5: Justification for assignment of external dose estimates is not provided, and there is no coworker model for external exposures (personnel records are also of concern)

4.2 AREAS CONSIDERED IN THE SEC PETITION AND COVERAGE DATES

4.2.1 Areas Addressed by Petition

The petitioner submitted SEC Petition Form B to the NIOSH Office of Compensation Analysis and Support (OCAS) on June 22, 2007. The petition referenced the employer as Atomics International, and the following locations were noted as being relevant to the petition:

- SSFL Buildings 059, 010, and 143
- DeSoto 101
- The Burn Pit
- Santa Susana Field Laboratory

However, the petitioner submitted a revised Form B on November 16, 2007, in which the specific SSFL buildings, DeSoto 101, and Burn Pit were removed from the list of locations. It appears the petitioner was asked to remove these other operations, since the petition should focus on the DOE facility or AWE facility ("covered" facility) at which the class worked as per 42 CFR Part 83.9(c)(1)(i).

Periodically, DOE publishes a list of facilities "covered" under EEOICPA. The latest publication of these sites was on August 23, 2004 [Federal Register/Vol. 69, No. 162/Monday, August 23, 2004 (pp. 51825-51831)]. There are two sites shown on this list that could apply to the facilities covered in the site profile; Atomics International in Los Angeles County, which is shown as a BE DOE (Beryllium and DOE) facility, and Energy Technology Engineering Center (ETEC), Santa Susana, Area IV. There are no listings for the associated facilities operated by AI in Canoga Park, De Soto, or Downey.

DOE has developed a database of the covered sites, which is accessible through the web site, http://www.hss.energy.gov/healthsafety/FWSP/Advocacy/faclist/findfacility.cfm. This database includes the following "covered" facilities:

- Area IV of the Santa Susana Field Laboratory, which is shown as a DOE facility with the operator, North American Aviation (NAA).

- Atomics International (shown as Beryllium Vendor and with the locations of Los Angeles and Ventura Counties) and includes, but is not necessarily limited to, the following locations; Area IV of the SSFL, portions of the Downey facility, the Vanowen Building at the Canoga facility, and the De Soto facility. The description notes that the AI Division of NAA is a statutory beryllium vendor under the EEOICPA, but that the company also worked with radioactive materials under contract with the Atomic Energy Commission (AEC) at numerous locations. (It should be noted, as stated above, that the AI site is shown as a BE DOE facility in the most recent *Federal Register* notice).

- Canoga Avenue Facility, which is shown as a DOE facility with the operator, NAA.

- De Soto Avenue Facility, which is shown as a DOE facility with the operator, NAA.

- Downey Facility, which is shown as a DOE facility with the operator, NAA.

Therefore, the list of covered sites in the DOE database is not consistent with the list of covered sites identified in the August 23, 2004, *Federal Registe*r.

The nomenclature related to these facilities is further confused by the document titles of the six Technical Basis Documents (TBDs) identified below, where various facility names are used in the titles.

- ORAUT-TKBS-0038-1, *Technical Basis Document: Atomics International – Introduction*, Rev. 01 (ORAUT 2006a)
- ORAUT-TKBS-0038-2, *Technical Basis Document: Energy Technology Engineering Center – Site Description*, Rev. 00 (ORAUT 2006b)
- ORAUT-TKBS-0038-3, *Technical Basis Document: Atomics International – Occupational Medical Dose*, Vol. 3, Rev. 00 (Atomics International TBD, 2006a, ORAUT 2006c)
- ORAUT-TKBS-0038-4, *Technical Basis Document: Area IV of the Santa Susana Field Laboratory, the Canoga Avenue Facility (Vanowen Building), the Downey Facility, and the De Soto Avenue Facility (sometimes referred to as the Energy Technology*

Engineering Center [ETEC] or Atomics International) – Occupational Environmental Dose, Rev. 01 (ORAUT 2007)

- ORAUT-TKBS-0038-5, *Technical Basis Document: Energy Technology Engineering Center – Occupational Internal Dose*, Rev. 00 (ORAUT 2006d)
- ORAUT-TKBS-0038-6, *Technical Basis Document: Atomics International – Occupational External Dosimetry*, Rev. 01 (ORAUT 2006e)

The TBDs focus on Area IV of the Santa Susana Field Laboratory, but also address the Canoga, Downey, and De Soto facilities. Dose reconstructions that are prepared for employees of AI include work conducted at all four of these facilities. It is noted above that the AI Division of NAA operated all four of these facilities, and their internal and external dose monitoring programs were the same for all the facilities.

In addition, TBD-1 (p. 6) states, "The name Atomics International (AI) is used to represent all [all meaning the four facilities; Area IV, Downey, Canoga Avenue, and De Soto Avenue] of them unless more specific location information is warranted." Therefore, when the petition refers to the facility as AI and it is shown as a covered DOE facility, it is easy to understand why there would be some confusion as to what locations are covered.

Given the above, we believe NIOSH should re-assess the SEC Petition being only applicable to Area IV at SSFL.

4.2.2 Coverage Dates

The initial date of coverage is dependent on whether all four facilities are covered in the petition, or if just Area IV of SSFL is covered.

If all four facilities are covered in the petition, the initial year of coverage should be 1947 or 1948. TBD-2 (p. 9) states, "The SSFL was initially established by North American Aviation (NAA) in 1947 to meet the requirements for a field test laboratory to static-fire large rocket engines, but it also met the NAA's need for a nuclear research facility." The first year of coverage shown for the Downey facility in the DOE database is 1948, which is also noted as the first year of coverage in TBD-1 (ORAUT 2006a) (p. 6). TBD-2 (p. 27) discusses AEC-funded activities taking place at Downey between 1948 and 1955.

If only Area IV of SSFL is covered in the petition, it is not clear whether the initial date of coverage is 1953, 1954, or 1955. The initial date of coverage for Area IV is shown as 1955 in 42 CFR Part 83.9 and the DOE "covered facilities" database. However, there are conflicting references in the TBDs as to when operations began at Area IV. TBD-2 (p. 9) states, "Area IV was established at the SSFL in 1953 as a nuclear research and development facility." Later in this same document on the same page, it is stated that "Nuclear R&D activities in Area IV increased rapidly from 1953 into the late 1960s, then declined." Figure 2-3 in TBD-2 also shows that Area IV was established in 1953 to provide nuclear-related research. TBD-2 (p. 13) states, "Between 1954 and 1980, several nuclear reactors were built, tested, and operated in Area IV."

Given the above, we believe NIOSH should re-assess the time periods of interest to the SEC Petition.

4.3 ADEQUACY OF THE INTERNAL MONITORING PROGRAM

4.3.1 Overview of Internal Monitoring Program

SC&A evaluated internal monitoring data from 136 claimant files with dose reconstruction overviews. Our evaluation included identifying the number of workers that were monitored in a given year. The results of this evaluation are presented graphically below. The percentage of workers monitored and the total number monitored are shown in Figures 4.3.1-1 and 4.3.1-2 for the period of 1955–1995 and 1956–1966, respectively.[1] The conclusions we have drawn in evaluating this information are presented below.

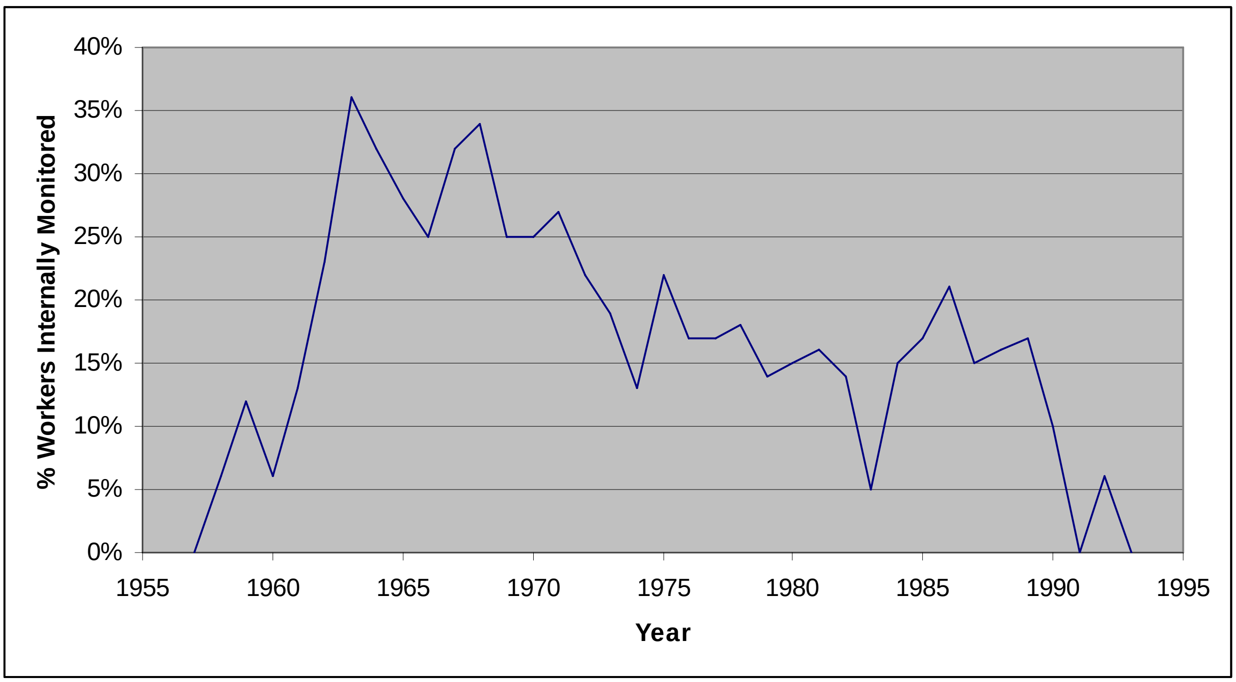

Figure 4.3.1-1: Percentage of Workers Monitored, 1955–1995

[1] Figures showing the actual number of workers internally monitored were redacted given Privacy Act concerns.

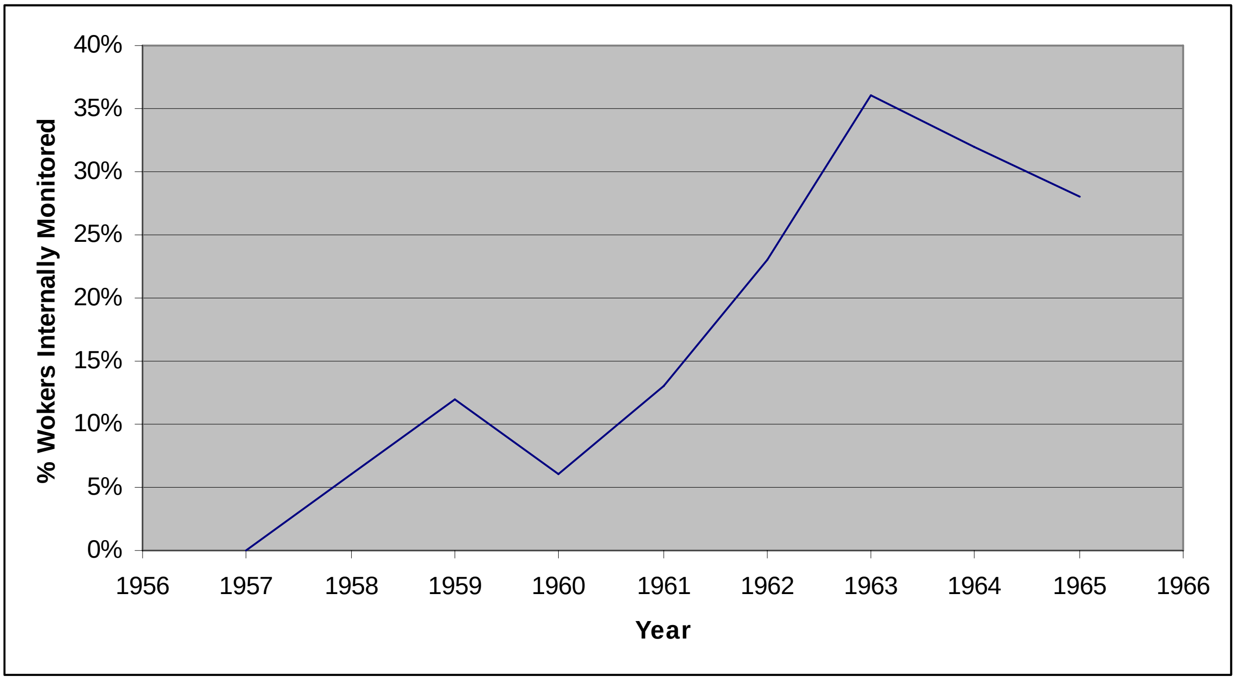

Figure 4.3.1-2: Percentage of Workers Monitored Internally from 1956–1966

4.3.1.1 1948–1958

TBD-5 describes the internal dosimetry (bioassay) program at SSFL, with key excerpts presented below. As part of the ER, NIOSH located personal and area monitoring data in the NIOSH Site Research Database (SRDB) and in its NIOSH OCAS Claims Tracking System (NOCTS), which have been used to estimate doses to individual employees in the proposed class. NIOSH identified only limited amounts of internal personnel monitoring data for pre-1959 exposures, which is consistent with its finding that an SSFL routine bioassay program was not initiated until August 1958 (Kellehar 1966).

The figures above indicate that there was essentially no internal monitoring taking place prior to 1959, which is consistent with NIOSH's findings in the SEC ER.

4.3.1.2 1959–1965

Entry into the bioassay program was based on job assignment, but monitoring procedures were generally invariable across occupations. However, firefighters appeared to be monitored more frequently than other workers. By the early 1960s, the bioassay program "normally" consisted of urinalysis for personnel whose work assignments involved "potential exposure to radioactive materials." The frequency of sampling during the 1960s was slightly higher than in any other time period and varied from one to four per year, depending on the nature of the employee's work, past exposure history, etc. Special bioassay sampling, consisting of more frequent urine testing, was in place very early (1960), but "only when gross internal contamination" was suspected (Hart 1979).

The figures above indicate that while the number of personnel that were internally monitored was increasing during this period, it was not until roughly 1963 when the percentage of workers monitored "somewhat" stabilized above 25%. Hence, there is some question whether the bioassay data collected and analyzed from 1959 through 1963 was sufficient for internal dose reconstruction or to develop a coworker model for internal dose reconstruction.

4.3.1.3 1966–2004

In 1970, standards for bioassay sampling were published (Staszesky 1970). Work in areas where unencapsulated radioactive material was present required baseline and termination urine samples. A new baseline could be required for a change in job assignment. For new operations, a "pilot" bioassay program consisting of weekly urine samples could be required until a pattern was established. Regular work in these areas required a quarterly routine urine sample, but monthly samples could be required in a case of high exposure potential. Periodic fecal samples and in-vivo counts could also be required. Employees who periodically performed work in these areas were subject to semiannual urine samples. Personnel who frequently entered these areas, but did not perform hands-on work, such as project engineers, industrial engineers, etc., provided annual routine urine samples.

SC&A has observed no cases where workers had a significant increase in the monitoring frequency after 1970. This is consistent with the data, which show that overall internal monitoring frequencies did not change over time (Figures 4.3.1.3-1 and 4.3.1.3-2).
By the mid-1970s, the definition of who was included in the routine bioassay monitoring program had changed to "personnel whose work assignments potentially expose them to respirable-sized radioactive aerosols" (Hart 1979). By the late 1980s, the criterion was "personnel whose work assignments potentially expose them to radioactive aerosols" (Tuttle 1989). Quarterly urine sampling was the norm through the 1980s (Hart 1979, 1980a, 1980b, and 1980c; Eggleston 1983 and 1984; Tuttle 1985, 1986a, 1986b, 1986c, 1988a, 1988b, and 1989).

In the mid-1970s, fecal sampling was used, but "only when gross internal contamination" was suspected (Hart 1979). Using the concept of a Maximum Possible Body Burden (MPBB), an excretion rate was determined by radionuclide that would indicate that one MPBB had been received. For several years prior to 1968, the policy was to restrict employees from work in potential airborne areas until their body burden was less than 25% of the MPBB (Alexander 1968a). Starting in January 1968, ETEC imposed a restriction from work in areas with potential airborne exposure (or in some cases, from all radiation areas) if the bioassay results indicated the receipt of 50% or more of the MPBB. The restriction remained in place until two consecutive bioassay samples indicated that the remaining deposition was less than 25% of the MPBB (Staszesky 1970).

The figures above indicate that the internal monitoring seems to have stabilized during this period and decreased in later years as operations ceased.

4.3.2 Monitoring for Internal Exposure of SSFL Workers was Incomplete and Poorly Documented for Most Years of Facility Operation

In Section 5.2 (p. 10) of TBD-5, the evaluation of the SSFL internal monitoring program is prefaced with the following statement:

> *Early 1960s AI documents describe* ***all*** *the elements of a* ***comprehensive*** *radiation safety program, including a laboratory with bioassay capability. …* [Emphasis added.]

This statement, however, was tempered by numerous admissions in subsequent sections of the TBD. A sampling of statements suggesting deficiencies and data limitations include the following:

Page 13:

> *Specific radionuclides* ***could*** *be determined "where required" (Lang 1960).* ***Some*** *detail has been found on early urinalysis methods. In addition to the in-house laboratory capability, bioassay services were contracted to the following vendors:* [Eight vendors are listed.]
>
> *…Information on the periods during which ETEC used these laboratories was* ***not*** *found.* [Emphasis added.]

In addition to the eight contract laboratories, ETEC had its own **in-house** laboratory, which analyzed urine for uranium content by fluorometric method. Exposure to uranium may have existed in various states of enrichment up to 93%.

Page 14:

> *Due to its higher specific activity, EU activity* ***could*** *be determined by counting….*
>
> *No specific information on sensitivities for the* ***in-house*** *laboratory was obtained….* [Emphasis added.]

Page 15 (Regarding thorium):

> *No details of early thorium analyses were recovered…*

Page 15 (Urinalyses for period 1967–1974):

> ***Partial*** *documentation on bioassay methods from 1967 through 1974 was found. …These documents are* ***believed*** *to refer to services offered by UST* [one of the eight contract laboratories]. [Emphasis added.]

Page 17 (Urinalysis for period 1975–1988):

*The following analytical methods were taken from a series of annual reports…. The measurement "type" in parentheses appears in many personnel bioassay records. The detection limits should have improved over the years. However, a listing was **not** found.* … [Emphasis added.]

Page 18 (On the method for analyzing mixed fission products):

*Mixed fission products were precipitated from a **basic** oxalate media. … Alkali metals such as ^{137}Cs did **not** precipitate. In addition, **volatile** fission products such as 1-131 were **lost**.* … [Emphasis added.]

Page 19 (On in-vitro methods for individual radionuclides):

*Although fecal sampling was mentioned as both a routine and a special bioassay method in site documents, **little** detail has been found about the analytical methods used.* … [Emphasis added.]

Page 20 (On the use of whole-body counting for monitoring workers):

*… whole-body counting for fission or activation products was apparently **not** part of the routine bioassay program at ETEC. Between 1975 and 1988, only 25 counts on 25 individuals were summarized in annual reports. …All WBCs were reported positive for ^{137}Cs. Ten counts were performed in 1977 and 15 were performed in 1979.* [Emphasis added.]

Page 20/21 (On the use of chest counting):

*In 1967, the first chest (lung) counts for uranium using a medical system were performed at UCLA. The 186-keV gamma ray from the decay of ^{235}U was used to quantify the amount of EU in the lung … Calibration of this system was **crude**;…* [Emphasis added.]

Starting in 1968, Helgeson Nuclear Services provided lung counting services. … The results were reported in milligrams of ^{235}U ± 2 sigma…

By 1977, two 5-in.-diameter, thin-window phoswich detectors were used, … [to detect U-235]

(SC&A notes that all chest measurements only quantified the amount or the activity of U-235. Without a firm understanding of the level of enrichment, the more important contribution of U-234 to total alpha activity cannot be determined.)

Page 25 (On solubility type, fraction activity, and particle size per facility):

> *In the absence of any measurements or studies, NIOSH guidance requires the use of default **solubility classes** and particle size values from the International Commission on Radiological Protection. … With one exception, facility-specific solubility and particle size data for ETEC has **not** been found. Activity fractions were **not** available with the exception of those for limited fuel fabrication operations. … Table 5-9 lists* [recommended/default] *this information* (emphasis added). [Our review of Table 5-9 indicates that to date, (1) a solubility class has not been assigned to all radionuclides, (2) activity fractions are lacking for several facilities, (3) activity fractions are based on inappropriate data, and (4) activity fractions fail to identify select radionuclides (e.g., Na-24, radioiodines)].

4.3.3 Insufficient Correlation between Bioassay Data and Potential Exposures to Specific Radionuclides

Two sources (NIOSH 2008, ORAUT 2006e) state that there is sufficient bioassay and other supporting data available for 1959 and beyond to establish an upper bound for uranium, mixed fission products (MFPs), Po-210, plutonium, SR-90, tritium, and thorium. Of the 37 internal monitoring records available to SC&A, 78% were monitored for uranium, 62% for mixed fission products, 0% for polonium, 24% for plutonium, 5% for strontium, 14% for tritium, and 0% for thorium.

SC&A does not believe that these sources have clearly demonstrated a correlation between the bioassay data available and the potential exposures to specific radionuclides. They have not clearly defined for which workers each of the procedures were conducted, including gross alpha and gross beta. From a brief review of claimant files, it appears that monitoring was not routine for all workers handling radioactive material. Furthermore, detection limits for 1975–1988 are unavailable, and Table 5-9 in TBD-5 containing solubility type and fraction of activity is incomplete in many cases. Hence, it appears that there were significant limitations in the bioassay program in 1959, and perhaps for a few years beyond 1959.

4.3.4 Missing Radionuclides in Bioassay Data

The site profile indicates that bioassay data were available for gross alpha, gross beta, uranium, fission products, plutonium, thorium, Po-210, Sr-90, H-3, P-32, S-35, C-14, Pm-147, americium, and curium. Of the 37 internal monitoring records available to SC&A, the vast majority of monitoring was for uranium and mixed fission products; 78% and 62%, respectively. Fission products were monitored for 49% of the workers. Only a few monitoring records exist for the following radionuclides: 8% for cesium, 3% for beryllium, 3% for mercury, 3% for potassium, 0% for polonium, 24% for plutonium, 5% for strontium, 14% for tritium, and 0% for thorium. Potential exposure to radionuclides such as U-233 and U-234 could have occurred during these operations, but it may not be possible to determine this, given the limitations of uranium monitoring (see below).

4.3.5 No Coworker Model

The site profile has not cited an internal coworker model as necessary, and the document does not address the use of a coworker model for those individuals potentially exposed but not monitored. A review of some of the claimant files indicates that some workers, who it appears should have been monitored, were not monitored, and those workers who were monitored were not monitored on a routine basis. In many cases, the dose reconstruction reports rely on guidance that has been developed for internal dose determinations based on other site information, rather than relying on site information. A coworker model would allow for more precise determinations of the doses the SSFL workers received. It is unclear whether there are data for coworker models for all the relevant radionuclides, especially for the early years through 1961/1962.

4.3.6 Lack of Source Term Data

TBD-5 states the following:

> *Without bioassay or air sample data, the last resort is determination of airborne concentrations using source term evaluations (NIOSH 2002, p. 19). Data on the amount of dispersible material available does not appear to be available for ETEC.*

4.3.7 NIOSH's Interpretation of Reported Values by the Contract Laboratory Nuclear Science and Engineering Corp. (NSEC) may not be Correct

Section 5.3.1.2 (page 14) of TBD-5 attempts to clarify data reported by NSEC related to urinalyses for gross alpha, gross beta, and MFPs:

> ***Gross Alpha***
> *Shepard (1959) gave a minimum measurable concentration of 7.5 dpm/L for gross alpha counting. NSEC gave its minimum measurable concentration as 0.2 cpm/mL (NSEC 1957). It is* ***assumed*** *that this is a* ***typographical error*** *and 0.2* ***dpm****/mL was* ***intended****.* [Emphasis added.]
>
> ***Gross Beta***
> *Shepard (1959) gave a minimum measurable concentration of 75 dpm/L for gross beta counting. NSEC gave its minimum measurable concentration as 1.0 cpm/mL (NSEC 1957). It is* ***assumed*** *that this is a* ***typographical error*** *and 1.0 dpm/mL was intended.* [Emphasis added.]
>
> ***Mixed Fission Products***
> *… for beta activity with an approximate minimum detectable amount (MDA) of 60 dpm/****sample*** [is assumed] *(ORAU 2004, p. 27) … NSEC gave its minimum measurable concentration as 2.0* ***cpm****/mL (NSEC 1957). It is* ***assumed*** *that this is a* ***typographical error*** *and 2.0 dpm/mL was intended.* [Emphasis added.]

The unsupported assumption that in all three cases a "typographical error" was, in fact, made may not be correct, given the discrepancies between the values reported by NSEC relative to those of Shepard:

	Shepard 1959	NSEC
Gross alpha	7.5 dpm/l	0.2 cpm/ml or **200 cpm/l**
Gross beta	75 dpm/l	1 cpm/ml or **1,000 cpm/l**
MFP	60 dpm/l	2 cpm/ml or **2,000 cpm/l**

If, in fact, the NSEC data were correctly reported in the units of cpm/ml, and adjusted for yield(s) and counting efficiencies, MDA values (redefined in dpm/l) are likely to more than double. Such large differences are hard to explain and raise questions about the credibility of bioassay data provided by contract laboratories as a whole. Since this concern applies to the time period post-1958, it brings into question NIOSH's ability to perform internal dose reconstructions post-1958. This issue needs further investigation.

4.3.8 Potential Difficulties Associated with Uranium Bioassay Data

Uranium at SSFL to which workers may have been exposed existed in various degrees of enrichment (i.e., 2% to 93%). Section 5.3 of TBD-5 discusses the two independent methods used to assess uranium in urine; the fluorometric method only identifies uranium concentrations in ug/ml, while the radiometric method assesses the gross alpha activity in dpm/l. Given the potentially wide range of specific activities of uranium defined by fluorometric urine data, all fluorometrically analyzed urine would also require a **concurrent** radiometric evaluation of that sample in order for these data to be useful to dose reconstruction.

From information contained in Section 5.3 of the TBD, it is unclear whether urine samples were consistently analyzed by both fluorometric **and** radiometric methods. This is particularly evident from the internal monitoring records pre-1961, where there appears to be no distinction made between the types of urinalysis methods used. From 1961–1962, there was a transition period where uranium in general was monitored, as well as Uranium Radiometric (UR) and Uranium Fluoride (UF). After 1962, the type of urinalysis methods used was usually specified.

It is **not** unreasonable to assume that for the early years, concern for the chemical toxicity of uranium may have limited urine bioassay to the fluorometric method. If this assumption is true, the absence of concurrent radiometric analysis of urine samples would severely limit the value of early fluorometric data.

Thus, in the event that a fluorometric urine bioassay cannot be matched with a concurrent radiometric analysis, a claimant-favorable default value should be used that defines the enrichment level of uranium. NIOSH should further explore this issue, as it might apply to the post-1958 time period.

4.3.9 There are Unanswered Questions Regarding the Completeness and Quality of Personnel Exposure Records

In Section 5.2 of the TBD, the following statements appear:
Page 10:

> *…AI established health and safety files on each employee that contained radiation exposure records, injury records, and other "pertinent" data (Lang undated, 1960). Today, personnel radiation exposure records are in the Radiation Safety Records Management System (RSRMS), which encompasses about* ***170 file cabinets***. [Emphasis added.]

Page 12:

> *The bioassay records in the individual files generally consist of:*
>
> - *Individual Personnel Keysort Cards (Figure B-2, Attachment B), which were used to track the type, frequency, and week of sample collection. … The forms can be* ***difficult to read due to the quality of the copies****, and dose reconstructors should refer to the forms listed below for urine and fecal data. This form* ***might*** *be the* ***only*** *place* ***in vivo*** [?] *data are listed.* [Emphasis added.]

Section 5.7 (page 23):

> *The bioassay results from ETEC and its predecessor organizations are* ***apparently not*** *available in a computerized format. The units used to report the results are* ***generally*** *included in the hard-copy reports. …* [Emphasis added.]

Section 5.8 (page 23):

> ***No codes*** *have been found* [for excreta samples]. …

These statements suggest that (1) all personnel records currently exist in hardcopy form only, and (2) records may be of poor quality, difficult to interpret, and incomplete.

SC&A concludes that the use of these records for dose reconstruction will require a comprehensive assessment regarding the quality and completeness of records contained in the 170 file cabinets, and requires guidance to dose reconstructors for their interpretation/use.

4.3.10 Use of SSFL Site Survey Data/Source Term cannot be Regarded as Useful Surrogate Data for Bioassay Data in Dose Reconstruction

In the absence of an individual's in-vitro/in-vivo bioassay data, the TBD provides the following information and guidance to dose reconstructors:

Section 5.11 (page 26):

> *If bioassay data are **not** adequate to evaluate an individual's internal doses, dose reconstructors can use workplace monitoring data (NIOSH 2002). The following types of workplace data **might** be available for ETEC: breathing zone air samples, general area air samples, and surface contamination surveys. However, **these data are not likely to be in individual exposure records**. Data on respirator use are **not** likely to be available … resuspension factors are **not** likely to be available.* [Emphasis added.]

Section 5.12 (page 30):

> *Without bioassay or air sample data, the last resort is determination of airborne concentrations using **source term** evaluations (NIOSH 2002, p. 19). Data on the amount of dispersible material available does **not** appear to be available for ETEC.* [Emphasis added.]

This "guidance" is deficient and places an unrealistic responsibility on the dose reconstructor because, at a minimum, the dose reconstructor will need to make judgments regarding (1) how to use general air sampling data when breathing zone data are not available or limited, and (2) what resuspension factors should be assigned. It is important that additional guidance be provided that ensures that claimant-favorable assumptions are applied in a consistent manner.

4.4 LACK OF INFORMATION WITH CERTAIN FACILITY INCIDENTS

4.4.1 Overview

Table 2-6 in TBD-2 presents major site incidents that had significant potential for internal or external exposure to personnel. The two primary incidents of concern are the SRE and the Sodium Burn Pit.

4.4.2 Sodium Reactor Experiment Coolant Failure

TBD-2 contains a discussion of the SRE coolant failure in Section 2.2.1.1.2 and in Table 2-6. Section 2.2.1.1.2 provides very little information on the incident, and does not discuss any potential exposure information. Table 2-6 (30 pages after Section 2.2.1.1.2) provides more detail on the incident, but does not provide any worker exposure information. There is information in Table 2-6 about exposure being negligible for nearby residents (a maximum theoretical calculated dose of 0.06 rem to someone living in Susana Knolls, the nearest residential area at the time), but does not present exposure information for workers.

Based on our review of claimant files, it does not appear that all workers who should have been monitored were monitored. NIOSH (Hughes 2008) provided SC&A with a spreadsheet containing information on claimants who worked at Area IV in 1959, and whether they were internally or externally monitored. The key finding from this spreadsheet (the spreadsheet cannot be provided given Privacy Act concerns) is that 42% of those claimants, who were "radiation workers", were not internally monitored while all radiation workers were externally monitored.[2] If these radiation workers did indeed work in the SRE area, the lack of internal monitoring would be a concern, given the program was supposed to be fully functional in 1959.

Atomics International prepared two reports on this incident; a report titled *SRE Fuel Element Damage, An Interim Report (NAA-SR-4488)—November 15, 1959* (AI 1959), and a second report titled, *SRE Fuel Element Damage, Final Report (NAA-SR-4488 (suppl)—1961* (AI 1961).

The interim report (AI 1959) contains important information related to this incident that is not in the site profile. Examples of this information include the following:

- *During this occasion, specifically, in October 1958, the maximum radiation levels in the general area of the moderator coolant pump were reported to be about 50 Mr/hr (October 14). Below shield blocks 1 and 2, the radiation level was about 21 mr/hr (on October 11).* (p. IV-C-9)
- *Radiation levels measured on April 18, 1959 varied from 50 to 420 mr/hr. …Additional measurements made 5 days later (a total of 17 days after shutdown) indicated no significant decay*. (p. IV-C-10) [Table IV-C-6 includes radiation levels in the Gamma Facility on various dates in August, September, and October of 1959. The measured radiation levels peaked on August 12 (2.9 r/hr) and decreased to 0.7 r/hr on October 5.]
- *Cold trapping was started during run 14. However, radiation measurements could not start until August 8 (due to the radiation hazard from the high radiation levels of Na^{24}), at which time the dose rate, extrapolated to near the surface, was about 70 r/hr. It is possible that initial cold-trap dose rates, had they been measured, would have yielded significantly higher values.* (p. IV-C-12) [The radiation rates at the cold trap, shown in Table IV-C-7, range from 63 r/hr on August 8, 1959, to 50 r/hr, with a peak of 81 r/hr on August 13.]
- *Following the termination of run 14, the fuel handling cask was used to inspect the fuel elements in the reactor. … Operations directed towards removal of these slugs resulted in occasional radiation levels as high as 1000 r/hr at 1 ft. from the slugs. However, the maximum total exposure received by operations personnel during these cask operations did not exceed 1 rem in a single week.* (p. IV-C-22). [The basis for this last statement was not provided in the report, and the number of personnel exposed was also not presented.]

The final report (AI 1961) also contains information related to potential worker exposure. Examples of this information include the following:

- *This report discusses the distribution and management of the fission products during the recovery operations. During the recovery effort the objectives*

[2] Percentages rather than absolute numbers have been provided given Privacy Act concerns.

were: (1) To limit personnel exposure to an average dosage rate of 1.25 rem/quarter (5 rem/yr). (p. III-19)

- *Throughout the recovery effort the radiation exposure to each individual was limited to less than 5 rem/yr. It was occasionally necessary to permit the weekly exposure for some key individuals to reach 600 mrem per week, in which case the individual was not exposed to radiation during the following week. Such exposures required a special permit, and only 30 permits were issued. For the 150 persons directly involved in the work, the average exposure was 2 rem/yr.*

This information is pertinent to reconstructing both external and internal exposures associated with this incident.

4.4.3 The Sodium Burn Pit

The sodium burn pit was built to clean nonradioactive metallic sodium and NaK from various scrap test components. Contamination was identified in the sodium burn pit in 1978, at which time monitoring of the area began and continued until 1983. Prior to 1978, no radioactivity was expected in this area, thus raising questions whether individuals involved in these activities would be considered for internal monitoring. It is unclear when the radioactive contamination was introduced to the burn pit or how far back in time the potential exposure to radiation exists. Given the violent nature of the operation, it would be expected that this operation would have generated an airborne hazard. Since the sodium burn pit was not expected to result in radiation exposures, there was no routine monitoring. But this does not mean that routine exposure can be ruled out. Additional information should be gathered on this site to demonstrate that unmonitored workers are not likely to have received sufficient dose to be of concern, or a model should be developed to bound the exposures that could have been received.

The TBD also does not consider exposure to contaminated soil that has resulted from spills and other incidental releases. For example, a review by a U.S. Environmental Protection Agency (EPA) official in 1989 (Dempsey 1989) identified Building 064, the Special Nuclear Materials Storage Area, that had been contaminated as a result of a spill. This EPA official also had concerns about the validity of some, if not all, of their environmental data:

> *In the Rocketdyne procedure, soils are heated in a muffle furnace for 8 hours at 500^{o}C. Several problems were identified: first, this temperature is sufficient to volatilize most man-made radionuclides of concern, including cesium-137 and strontium-90. Second, from the Rocketdyne procedure, soil is sieved through a coors crucible to obtain uniform particle size…. This procedure is a screening method at best and is not an accurate quantitative procedure.*

TBD-5 does not specifically address radiological incidents that may have resulted in internal exposures to workers' that were unmonitored.

Based on information provided in TBD-5, it is unclear (1) whether workers exposed during these early incidents were adequately monitored for internal exposure, and (2) if workers were, in fact, monitored, whether their exposure records exist. A particular concern involves the potential exposures associated with the SRE. Worker exposures may have included a complex mixture of highly enriched uranium, actinides, MFPs, and various activation products, including large amounts of Na-24.

4.5 LACK OF INFORMATION ON THE ENVIRONMENTAL EXPOSURES

4.5.1 Overview

Occupational environmental dose refers to radiation exposures received by workers while onsite but outside the SSFL facilities from facility discharges to the atmosphere, ambient external radiation originating in the facilities, and inadvertent ingestion of site-generated radionuclides. The environmental monitoring program was established at Area IV in May 1954, before construction of the first radiological facility, with emphasis on soil, vegetation, and water sampling.

TBD-4 provides guidance and data for assigning occupational environmental doses for Area IV, and the Downey, Canoga, and De Soto sites that make up SSFL, for all years, starting with 1954 through 1999. Due to insufficient environmental monitoring/data limitations, the TBD relied on the following data and applied the following assumptions in order to provide the dose reconstructor the means to estimate inhalation intakes that are radionuclide-specific and for all years of facility operations.

> *Average annual gross alpha/gross beta concentrations in facility stack emissions were the basis for estimating potential worker environmental* ***inhalation*** *intakes. Most of the available SSFL* ***stack*** *emission data include annual average gross alpha and gross beta concentrations at the* ***stack point of release****. Years with data vary by facility, but gross alpha/gross beta concentration information is available for* ***most*** *years between* ***1971*** *and* ***1999****. …*
>
> *…Identification of* ***specific radionuclides*** *released from various facilities in stack emissions are available … from* ***1988*** *to* ***1999*** *and were used to characterize radionuclide emissions for* ***all*** *years. …*
>
> *…In years where data were not available, stack concentrations were assumed to be the* ***average yearly*** *gross alpha and gross beta concentrations in stack effluents from years* ***1971*** *to* ***1999,*** *for which data were available.*
>
> *…Furthermore, the average percentage that each identified radionuclide contributed to the gross alpha or gross beta concentration determined from* ***1988*** *to* ***1999*** *data was applied to each of these years to make radionuclide-specific stack concentration estimates….*

> *…Because the stack effluent concentrations were at the point of release, a further **reduction factor** of **0.01** was taken to account for the lessened overall intake due to contribution from multiple, widely spaced facilities; atmospheric dispersion of stack effluent over the course of a year's exposure; and building wake effects.* [Emphasis added.]

4.5.2 Surrogate Use of the Time-integrated Average Yearly Gross Alpha/Gross Beta Stack Emission Corresponding to Years 1971 to 1999

The surrogate use of the time-integrated average yearly gross alpha/gross beta stack emissions corresponding to years 1971 to 1999 (when stack measurements were taken) is likely to underestimate stack emissions for years 1954 through 1970. SC&A's conclusion is supported by the steady reduction in facility operations over time, as illustrated in Figure 4.5.2-1. For example, nuclear reactor programs were essentially phased out in the early 1970s.

Sections 4.6.4, 4.6.5, and 4.6.6 of TBD-4 acknowledge the lack of external dose rate monitoring data prior to 1974, and provide unsupported/unreferenced assumptions that were used to derive annual external dose estimates for a **restricted** number of facilities, as given in Table 4-4 of the TBD.

4.5.3 Exposure to Onsite Water Supply Wells

The SEC ER states that onsite water supply wells were the primary water source from 1949 to 1964, which differs from Section 4.7 of TBD-4, which states, "Potable water is not a source of occupational radioactive material at SSFL, because the SSFL facilities used either bottled water from an off-site vendor (Moore et al. 1962) or the city water supply." In addition, other references (Winzer 1980 and 1981; Curphey 1983) indicate that well water was a source of drinking water into the 1980s.

Although the ER stated that the drinking water supply wells did not have elevated levels of tritium (>1,000 pCi/l) (concern with tritium given current tritium plume on site), the ER has tried to bound any contamination that may have existed onsite by assuming the onsite supply wells were contaminated with tritium at a concentration of 30,000 pCi/l. More recent Boeing reports (Boeing 2003, 2004, 2005, and 2006) have documented tritium concentrations as high as 117,000 pCi/L in the monitoring wells (not the drinking water wells). Therefore, this issue should be re-evaluated to determine if this exposure route can be properly assessed in earlier years, and if so, how to assess this exposure.

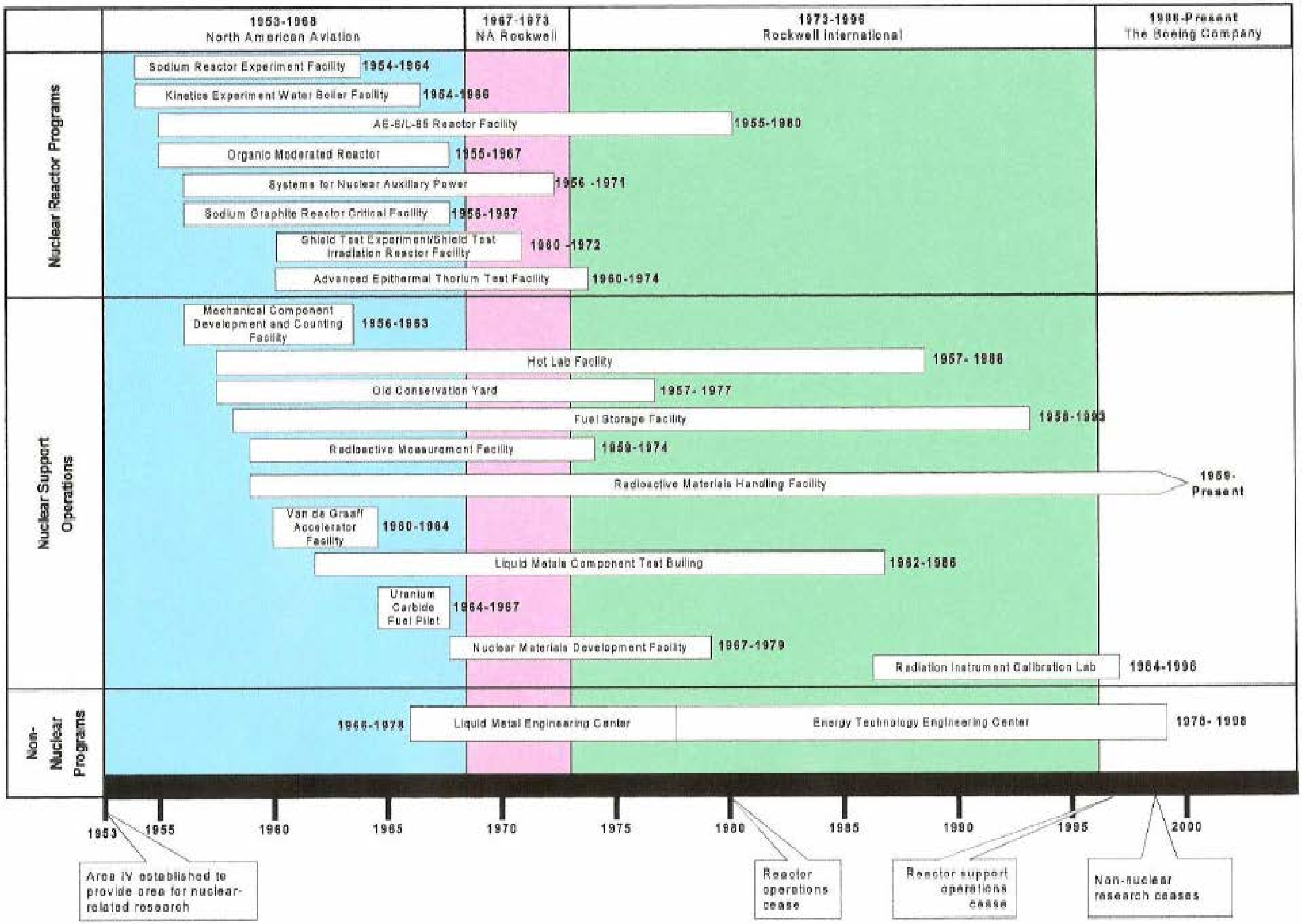

Figure 4.5.3-1: Summary of Area IV Activities

4.6 ASSIGNMENT OF EXTERNAL DOSE

TBD-6 contains documentation to assist in the evaluation of occupational external doses from processes that occurred at SSFL. An objective of this document is to provide supporting technical data using claimant-favorable assumptions to evaluate occupational external doses that can be reasonably associated with worker radiation exposures. This document addresses the evaluation of unmonitored and monitored worker exposure, missed dose, and the bias and uncertainty associated with the monitoring of external dose.

4.6.1 No Coworker Model

TBD-6 has not cited an external coworker model approach as necessary, and the document does not address the use of a coworker model for those individuals potentially exposed but not monitored. It appears that individuals may have been unknowingly exposed. An October 22, 1962, memorandum from F.H. Badger[3] to the Health and Safety File regarding "Health and Safety Observations at RMDF" states that, "Routine smear surveys have repeatedly revealed significant contamination or radiation dose rates in areas usually thought to be free of radioactive material." One of the examples provided was a 4 Rad/hr capsule lying in an area thought to be uncontaminated.

In addition, in an April 1991 Tiger Team Assessment, the DOE noted several issues with the external radiation dosimetry program. The report, as an example, noted that "In 1989 and 1990, extremity doses were not added in to exposure records or reported to the Radiation Exposure Information Reporting System (REIRS)."

Based on the poor track record of badging employees appropriately, the conclusion of no monitoring being equal to no work in a radiation area does not seem to be justified. The dose reconstructor should be able to look at a job title and determine potential exposure, and then be linked to a coworker model. This issue is also relevant to how NIOSH has defined the SEC from 1955 to 1958, which at present does not include employees who "should have been monitored," but is limited to employees who were monitored. This SC&A conclusion indicates a need for NIOSH to revisit the limitation.

4.6.2 Workers Were Unlikely to Have Been Monitored for Thermal Neutrons

As stated in Section 6.2 of TBD-6, "…Both fast and **thermal** neutrons were **measured** and **recorded** as whole-body (WB) dose in rem" (emphasis added). This statement is contradicted in Section 6.4, where it states, "…It is assumed that the dose recorded was the result of **fast** neutron exposure" (emphasis added).

The second statement is likely to be correct, since the common practice at DOE facilities was to assess NTA film for tracks produced by proton recoil. It is unlikely that NTA dosimeters were modified and calibrated for tract analysis of **thermal** neutrons. [Tracks in emulsions exposed to

[3] F.H. Badger was employed by Atomics International. His title was Analyst, Health Physics, Senior Health and Safety Operations.

thermal neutrons may be produced by nitrogen in the gelatin that captures a thermal neutron and releases a 0.58 MeV proton–N^{14}(n, p) C^{14}.]

In the absence of empirical data involving neutron spectra for reactors and Pu fuel storage facilities, the lack of dosimeter calibration methods, and the relative insensitivity of NTA film to neutrons with less than 500 keV (or as much as 1 MeV), there remains an undefined level of uncertainty for recorded neutron doses. Therefore, the use of Y-12 data as surrogate values may not be appropriate.

TBD-6 assumes that the NTA film effectively measured all neutron exposure received at AI, and does not consider correction factors for the insensitivity of NTA to neutrons at energies below 500 keV. Actual neutron energy spectrum data are limited to a few facilities (i.e., SRE). There is no discussion of neutron-to-photon ratios in the site profile; however, it is mentioned as an option for calculating thermal neutron exposure in the ER report.

4.6.3 Dosimeter Response to Low-Energy Photons

TBD-6 does not discuss issues associated with the response of dosimeters to low-energy photons. There are statements to the effect that the dosimeter was similar in design to the Hanford dosimeter. The Hanford dosimeter applied a correction factor for exposure of plutonium facility workers to compensate for badge shortcomings. The ER indicates there are source term data available to bound low-energy photon dose; however, no specific information on source term is provided. Furthermore, there is no consideration for dose from skin contamination incidents.

5.0 CONCLUSIONS

After a thorough review of SEC Petition-00093 and the large number of relevant/support documents, it is still unclear as to which of the four facilities should be covered in the petition and the initial year of coverage, which is dependent on whether all four facilities are covered in the petition or if it is just Area IV of SSFL that is covered. The list of covered sites in the DOE database is not consistent with the list of covered sites identified in the August 23, 2004, *Federal Register*. If only Area IV of SSFL is covered in the petition, it is not clear whether the initial date of coverage is 1953, 1954, or 1955. If it is determined that all four facilities will be included in the SEC Petition, the initial coverage date will need to be changed to 1947 or 1948. NIOSH and DOE should make this decision, based on further research.

SC&A agrees with the findings in the SEC ER that the internal monitoring program was insufficiently robust to estimate exposures before January 1, 1959. Only limited amounts of internal personnel monitoring data for pre-1959 exposures were identified, which is consistent with NIOSH's findings that an SSFL routine bioassay program was not initiated until August 1958 (Kellehar 1966). Our review of the percentage of workers being monitored for internal exposure indicates that the percentage continued to increase after 1959, until it plateaued several years later. A determination needs to be made by NIOSH on whether the percentage of workers who were monitored in the several years after 1958 indicates a fully functioning internal monitoring program.

In addition, monitoring for internal exposure of SSFL workers was incomplete and poorly documented for most years of facility operation. These deficiencies and data limitations are stated throughout sections of the TBD. For 1959 and beyond, SC&A does not believe that NIOSH has clearly demonstrated a correlation between the bioassay data available and the potential exposures to specific radionuclides.

There is a lack of information concerning two major facility incidents that had significant potential for internal or external exposure to personnel; the SRE coolant failure and the sodium burn pit. TBD-5 does not specifically address radiological incidents that may have resulted in internal exposures to workers' that were unmonitored and, based on our review of claimant files, it does not appear that all workers who should have been badged were indeed badged. As noted, the poor track record of badging employees appropriately indicates a need for NIOSH to revisit the limitation for its proposed addition to the SEC class only to employees who were monitored. The information in TBD-5 is unclear as to whether workers exposed during these early incidents were adequately monitored for internal exposure and, if workers were monitored, whether their exposure records exist.

SC&A questions the data and unsupported/unreferenced assumptions that were applied in order to reconstruct occupational environmental doses, due to insufficient environmental monitoring and data limitations. This includes inhalation intake estimates that are radionuclide-specific and the surrogate use of the time-integrated average yearly gross alpha/gross beta stack emissions corresponding to years 1971 thru 1999, which likely underestimate stack emissions for years 1954 through 1970. There are also conflicting reports concerning the exposure to onsite water supply wells. This issue should be re-evaluated to determine if this exposure route can be properly assessed in earlier years and, if so, how to assess this exposure.

In the absence of empirical data involving neutron spectra for reactors and Pu fuel storage facilities, the lack of dosimeter calibration methods, and the relative insensitivity of NTA film to neutrons with less than 500 keV, there remains an undefined level of uncertainty for recorded neutron doses. Therefore, the use of Y-12 data as surrogate values may not be appropriate. There is no discussion of neutron-to-photon ratios in the site profile; however, it is mentioned as an option for calculating thermal neutron exposure in the ER report. The ER indicates there are source term data available to bound low-energy photon dose; however, no specific information on source terms is provided. Furthermore, there is no consideration for dose from skin contamination incidents. Additional work is needed in this area to either better define the likely neutron dose or provide a plausible bound for the dose.

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APPENDIX A: PETITIONER/WORKER INTERVIEW

To be provided at a later date.