Working Draft

ISSUES MATRIX FOR THE SANTA SUSANA SEC PETITION AND NIOSH EVALUATION REPORT

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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 and 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 National Institute for Occupational Safety and Health (NIOSH) SEC Petition Evaluation Report (ER) for said petition. Subsequently, during the meeting of the Board held in Augusta, Georgia, on December 18, 2008, SC&A was directed by the Board to perform the "full" review of the SSFL SEC Petitition-00093 and the NIOSH SEC Petition ER.

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.

The most recent SEC Petitions (the Mallinckrodt Chemical Company in St. Louis, Missouri; the Vitro Manufacturing facility in Canonsburg, Pennsylvania; and the Metallurgy Collaboratory in Chicago, Illinois) have included "all" employees present during a given time rather than the narrower class of those employees who were monitored. It is unclear why NIOSH has proposed a narrower addition to the SEC class in this case.

This matrix contains an issues list for the Santa Susana SEC Petition. It is based on an assessment of the following:

- The NIOSH ER dated February 6, 2008
- The Santa Susana SEC Petition SEC-00093
- SC&A's Site Profile Review
- A review of relevant documents

SANTA SUSANA SEC ISSUES MATRIX – DRAFT PRELIMINARY SC&A ASSESSMENT

No.	Issue	SC&A's Understanding of the NIOSH ER Position	SC&A Initial Review/NIOSH RESPONSE
1	The Sodium Reactor Experiment (SRE) Incident and Release of Core Gases. (Petitioner Issue)	TBD-2 (ORAUT 2006a) contains a discussion of the SRE coolant failure in Section 2.2.1.1.2 and in Table 2-6. Based on their review of claims in NIOSH OCAS Claims Tracking System (NOCTS), NIOSH concluded that personnel monitoring exists for members of the proposed class (both internal 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 exist. 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.	The potential that all staff may not have been adequately monitored combined with the seriousness of this event suggests that it may be necessary to develop an incident-specific exposure model or conclude that exposures cannot be properly evaluated. Section 2.2.1.1.2 of TBD-2 provides very little information on the incident, and does not discuss any potential exposure information to workers. 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. 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 response: All technical reports and memos available though due diligence data capture were reviewed when evaluating the SRE incident (there are currently 82 documents in the SRDB that are related to SRE operations and/or the incident in 1959). The section of the SEC evaluation report addressing the petitioner concern was specifically related to reports detailing the release estimates, which are cited in the evaluation report. Specific technical reports can be found in the SRDB and include among others: - Hart – Distribution of fission product contamination in the SRE, 1962, NAA-SR-6890 - SRE fuel element damage, final report, 1961, NAA-SR-4488 (suppl) - SRE fuel damage interim report, 1959, NAA-SR-4488 NIOSH is currently proceeding with the development of internal and external coworker models, which can be applied to workers, who are thought to have been exposed during the incident and/or cleanup thereof. NIOSH is also pursuing an independent review of the different release estimates available, to determine the most scientifically defensible release scenario and therefore the extent and the necessity of an exposure model for on-site workers. The revised TBD will contain additional detail of the incident and potential exposure implications. **2014 Update: None – issue closed on 4/20/2010 (pg. 47 of transcript)**

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2	Radiation Badges: This issue was based on a Tiger Team report indicating "inadequate radiation badges." (Petitioner Issue)	NIOSH's response to this issue is captured in the following statement: *The Tiger Team Report cited by the petitioner does not state that 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 1998]. *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 the ER.*	SC&A concurs with NIOSH's response, assuming the petitioner was not referring to some other concern than the adequacy of the badges. **NIOSH response:** **no response needed** **2014 Update: None. Issue closed.**
3	Tritium Plumes: Workers may have been exposed to drinking water contaminated with tritium. (Petitioner Issue)	NIOSH states that tritium has never been detected (>1,000 pCi/l) in any of the water supply wells. NIOSH also asserts that the primary supply wells (WS-5, WS-6, WS-12, and WS-13) were in Areas I, II, and III; 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 with the highest tritium concentration. NIOSH maintains that this well has never been used for potable water and is downgradient of the tritium source (Building 4010). According to the NIOSH ER, the	The 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 in the monitoring wells reaching 117,000 pCi/l. Potential tritium concentrations in the wells should be reassessed, given this information. NIOSH response *(please note that this is the information initially to be presented in a NIOSH White paper, however, NIOSH felt that this matter could be dealt with more efficiently by instead including the information in its entirety in the issues matrix)*: NIOSH did not claim that the sampling well (RD-34A) used as a basis for the bounding calculations was the one with the highest concentration ever found.

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		mean concentration of tritium in WS-7 has been 2,940 pCi/l since 1991. Through some modeling of migration and decay assumptions, NIOSH concluded that workers could have consumed water with 30,000 pCi/l of tritium in the 1950s and 1960s.	Well RD-34A was selected because it is downgradient of Building 4010 (the source of the tritium) and because tritium has been constantly detected there since 1991. NIOSH did not intend to use the highest concentration found on site. The information in the cited environmental reports was included in NIOSH's evaluation of the mean concentration in well RD-34A. A reference to 117,000 pCi/L is found in the Site Environmental Report for Calendar Year 2006, which also states that this highest level was found in well RD-95 in 2005. This well is to the west of and closer to the assumed source in Building 4010. The only drinking water source in Area IV, WS-07, is east-northeast of this building. Sampling well RD-34A is in the general direction of this well. Since this assessment, Site Environmental Report for Calendar Year 2007 has been issued. Data for sampling wells that are in the general direction of WS-07 were reviewed (RD-17, RD-27, RD-30, RD-63, RD-85, RD-86). Other than RD-34A, there was only one other well with a positive result, RD-63 at 350 pCi/L on 02/16/06. Two samples taken in 2007 were below the detection level for this well. Based on this information, NIOSH concludes that the choice of well RD-34A provides the best data for a bounding estimate. See the following references for more detail including maps of the area and location of the plume and the former drinking water wells: • The Boeing Company, 2008, Site Environmental Report for Calendar Year 2007, DOE Operations at The Boeing Company, Santa Susana Field Laboratory, Area IV, September • Haley & Aldrich, 2007, Analysis of Potential for Tritium in Water Supply at SSFL, PowerPoint slide presentation, undated, SRDB 41888 **2014 Update: Closed** **A revision to the environmental TBD includes potential intakes of tritium by workers. The document is awaiting approval pending final approval of the external coworker model. Issue was closed on 4/20/2010 (pg. 56 of transcript).**

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4	Uranium Fires: The petitioner refers to numerous uranium fires, cites two incidents of a sodium explosion, and expresses concern that monitoring was lacking regarding facility incidents. (Petitioner Issue)	NIOSH has concluded that there are data available for the various uranium fires that would allow dose estimates to be bounded.	SC&A reviewed over 40 Radiological Safety Incident Reports specific to uranium fires. These reports include information on uranium quantities, mixtures and enrichment levels, causal factors contributing to the fires, air and surface sampling data prior to decontamination, and details on personnel involved, including monitoring procedures (e.g. bioassay, nasal smears) and whether personnel were exposed or wearing protective gear. Therefore, SC&A is in agreement with the conclusions of NIOSH that bounding dose estimates are possible regarding uranium fire incidents (Alexander 1967a, b, c, and d; Badger 1960 and 1961; Begley 1976; Harrison 1986; 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 1964a, b and c; Stephenson 1961, 1962, 1963a and 1963b; Weber 1963; Young 1960 and 1965). Lack of monitoring for workers involved in facility incidents is discussed further in this document (see SRE, Issue #1; Sodium Disposal Facility, Issue #6; and SC&A Issue #3). NIOSH response: No NIOSH response needed, some of this issue addressed later **2014 Update – Closed**
5	Air Monitoring: The petitioner maintains that air monitoring was insufficient. (Petitioner Issue)	NIOSH has concurred that there is a lack of air monitoring for the period at SSFL-Area IV prior to 1958, which impacts the feasibility of accurately estimating internal radiation doses for the proposed worker class during that time period. After 1958, dose reconstructions were primarily based on bioassay data. TBD-4 (ORAUT 2007) provides guidance for assigning occupational environmental doses for Area IV, Downey, Canoga, and De Soto sites of SSFL from 1954 to 1999. 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 unsubstantiated assumptions that	SC&A concurs with conclusions made by NIOSH regarding insufficient air monitoring prior to 1958. SC&A questions the post-1958 data and/unsubstantiated assumptions that were applied in order to reconstruct occupational environmental doses, due to insufficient environmental monitoring and data limitations. 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. SC&A does not believe that NIOSH has clearly demonstrated a correlation between the bioassay data and the potential exposures to specific radionuclides after 1958. NIOSH response: Please see response 4.5-1 from TBD issues matrix. In general internal monitoring is documented starting in 1958, but the number of people monitored

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		were used to derive annual external dose estimates for a **restricted** number of facilities. Environmental inhalation intakes were calculated using facility stack emission data, and included annual gross alpha/beta concentrations at the stack point of release. This data was adjusted by a reduction factor of 0.01 to account for decreased intake due to contribution from multiple, widely spaced facilities; atmospheric dispersion of stack effluent and building wake effects. Stack emission data varied by facility, but covered most years between 1971 and 1999. In addition, stack emission data were used to characterize radionuclides for the period 1988–1999 and extrapolated to cover all years.	is small at first, but is steadily increasing until 1962, which seems in accordance with the scope of operations at the site. NIOSH found no evidence that internal monitoring data was incomplete or poorly documented, but the data from the earlier years is more limited. This issue will be further evaluated in the determination of the feasibility of the internal coworker model. Furthermore, SC&A asserts that stack emissions data are not an adequate method to assess onsite worker exposures in areas with buildings or in facilities that include outdoor operations with contaminated materials, such as the Burn Pit. NIOSH response: NIOSH is currently in the process of reviewing the ambient intake approach and is also pursuing the development of a coworker model for internal and external exposures, which rely on external film badge/TLD data and internal bioassay data. **2014 Update: Open.** **Additional information obtained from new reference materials was added to the environmental TBD. The added stack release information and external environmental monitoring information significantly modified the previous guidance on ambient external dose and inhalation intakes.** **An analysis was added addressing the potential intake of tritium in groundwater by workers.** **An internal coworker model based on internal monitoring has been completed for the entire non-SEC operations period.**
6	The Sodium Disposal Facility (also known as the Sodium Burn Pit): This facility was not adequately monitored and/or records are missing. (Petitioner Issue)	NIOSH concludes that while there may have been radiological contamination at the Sodium Burn Pit, the following details are presented suggesting low exposures and the ability to bound dose estimates: • Radiological contaminant levels were estimated to be no greater than 56 pCi/g; radionuclides of concern were cesium-137, thorium, and strontium. Cs-137 was also found in the lower collecting pond.	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 have been considered for internal monitoring. The Sodium Burn Pit was not expected to result in radiation exposures and was not routinely monitored. 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 ascertain the exposures that could have been incurred.

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		• The Sodium Burn Pit was located in open air discontinuously occupied and not considered to be an operations area. • In the ER, NIOSH asserts that radiological exposures were unlikely; due to the explosive nature of the reactions taking place, safety precautions regarding chemical exposures were instituted at this facility from its inception. • After radiological contamination was discovered, radiation surveys and soil samples were conducted from 1978 through 1983. • Actual bioassay results and associated monitoring program data were available and included worst-case scenarios for the proposed worker class.	Worker exposures may have included a complex mixture of highly enriched uranium, actinides, MFPs, and various activation products, including large amounts of Na-24. NIOSH response *(please note that this is the information initially to be presented in a NIOSH White paper, however, NIOSH felt that this matter could be dealt with more efficiently by instead including the information in its entirety in the issues matrix)*: Since the presentation of the Evaluation Report to the Advisory Board, NIOSH has been pursuing the bioassay data needed for an internal dose coworker study. The data were collected and analyzed by an independent contractor to produce an epidemiology study. The main obstacle to obtaining the data has been the concern over protecting the worker's privacy right. Assuming that NIOSH will be successful in obtaining these data, it would be used to assign doses to workers at the burn pit who may have been unmonitored. NIOSH believes that this would be favorable to claimants for the following reasons: • The area was open and unconfined, so airborne concentrations would have been lower than in fixed facilities. • Potentially violent reactions were known about and expected. Explosive safety would have prevented close contact with the hazardous materials during such reactions, regardless of whether the workers suspected radioactive contamination or not. • Exposures were intermittent. • The radioactive contamination found at the burn pit is known from soil samples to consist of low levels of fission products, principally Cs-137. NIOSH has published a method in ORAUT-OTIB-0054 to determine the mixture of radionuclides present given a gross urinalysis (such as in the example cited by SC&A). The sodium burn pit operations were non-routine activities, since it was only used for intermittent sodium disposal. From claimant data, it appears that personnel at the burn pit often consisted of firemen, who tended to be included in the radiation worker group, based on interviews with an HP expert and a fireman.

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			Regarding the SC&A concern about the validity of environmental data expressed in the ER review: Environmental soil concentration data are not used for dose reconstructions at SSFL since internal and external dosimetry data are available. The issues with the EPA and the methods used for environmental data are not directly applicable here. TBD-5 does not address internal exposures to unmonitored workers, since that is discussed in TBD-4 (environmental TBD). Na-24 is produced by neutron activation in the primary coolant loop of the sodium reactor, and was a known (short lived, 15 hr half life) external radiation hazard. The sodium burn pit was inadvertently contaminated with fission products but the radioactivity levels found there do not lead to the conclusion that it was used to routinely dispose of large amounts of primary loop sodium. The chemical hazard posed by Na reacting with water would require safety measures to prevent inhalation of Na vapor, which is a chemical hazard. **2014 Update: Open.** **Internal coworker model was completed; external coworker model was completely revised and is in approval stages. Those models can be used to assign any unmonitored dose from SSFL facility operations.**
7	Other Issue #1: Identification of workers with blank radiation exposure record sheets in their file. (Petitioner Issue) **NIOSH comment: actually not a petitioner issue, but a NIOSH identified issue**	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 other reviews (Boice et al. 2006a and Boice et al. 2006b).	SC&A acknowledges this practice, based on a review of two studies conducted by Boice et al. (2006a, 2006b) and site interviews. The reports substantiate the use of 'blue cards,' also known as Kardex cards, that were used to identify Rocketdyne (AI) employees. These cards included employee name, Social Security numbers, employee serial numbers, hiring date, birthdate, complete job history (e.g., occupational title, occupational code, pay type, department, and dates of job change or termination). While it is recognized that individuals were required to have a film badge upon entering a controlled area, there is insufficient information available in the cited reports to conclude this occurred all the time. SC&A interviewed several former employees about their work at SSFL. Some of the workers do not recall being issued a badge when they were working in or passing through a radiological area.

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			NIOSH response: Generally a radiation badge was issued for a worker routinely working in an area with an exposure potential. Workers passing through a controlled area would not necessarily be considered as such, but based on claimant data, visitor badges were issued to some non-routine workers in a controlled area. NIOSH has completed the external coworker model, which will be used to assign doses for workers who are determined to fall into this category. **2014 Update: Open.** **Revised external coworker model is in the completion stages. This can be used to assign unmonitored dose to workers**.
8	Other Issue #2: Monitoring of firemen from other sites who were involved with fires or other events at SSFL. (Petitioner Issue) **NIOSH comment: actually not a petitioner issue, but a NIOSH identified issue**	NIOSH asserts that firemen wore film badges when working in areas with the potential for radiological exposures. One person interviewed mentioned that firemen consistently wore badges; 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 questions the adequacy and availability of monitoring records for firemen, particularly in reference to facility incidents, such as fires in the Sodium Burn Pit. Since little or no monitoring existed for these incidents, SC&A questions the process for concluding that the existing records are bounding and applicable to reconstructing actual source terms. NIOSH response: Fires in the sodium burn pit were not considered incidents per se, since they were planned activities occurring on an as-need basis. See response to the sodium burn pit issue (No 6). **2014 Update: Open.** **No additional information to add. Coworker models can be used to assign any unmonitored dose. Incidents can be assessed on an individual basis.**

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9	SC&A Issue #1: Which areas (Area IV, Canoga Park, De Soto, and Downey) should be considered in the SEC petition and when did operations begin at these facilities (coverage dates)?	There are three other operations addressed in the site profile—the Canoga Park, De Soto, and Downey locations. NIOSH considers these facilities as individual covered areas and does not include them in the SEC Petition-00093. The dates of operation of all the facilities are not consistent within the Site Profile documents or the ER.	Facilities and their initial coverage dates need to be defined more clearly for SSFL. A review of SEC Petition-00093 and relevant support documents elucidated referential discrepancies: • 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*. • 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. 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. • If coverage is limited to Area IV, the initial date of coverage is presented in the TBDs as 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. 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. Given the above, we believe NIOSH should re-assess the SEC Petition as applicable only to Area IV at SSFL and define coverage dates as necessary. NIOSH response: Per SEC rule 83.13 a petition is submitted by a petitioner who indicates on his petition for which class of workers and which site he/she is petitioning for. The petitioner's intent is clarified in a consult call and follow up letter. Per 42 CFR Part 83.9(c)(1)(i) a single petition can only represent a single site, but a petitioner is free to submit a petition for any site where he/she has verified employment. This was discussed with the petitioner during the consult call (OSA 103548) and it was the petitioner's intent to submit a petition for a class of workers who worked in all area of Area IV of the Santa Susana Field Laboratory, which is the class that was evaluated by NIOSH as outlined in the SEC ER The evaluation report covers Area IV of the Santa Susana Field Laboratory, with coverage start date in 1955 as outlined in class definition on the first page. Coverage dates are not determined by NIOSH, and some preliminary research into facility operation start date at Area IV SSFL, did not indicate that radiological operations started before that date Regarding coverage dates: Figure 4.5.3-1 (originally from Sapere and Boeing, 2005*) shows that only 2 facilities were in use pre-1955: the SRE and the KEWB facility, both listed

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10	SC&A Issue #2 Adequacy of the internal monitoring program, pre-and post-January 1, 1959. Main Concerns: (1) Incomplete bioassay dataset and insufficient correlation of bioassay data to specific radionuclides (2) Missing radionuclides (3) Difficulties with uranium bioassay methods (4) No internal coworker model or source term data (5) Erroneous data interpretation	(1) NIOSH identified 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). Two sources (NIOSH 2008, ORAUT 2006c) state that there is sufficient bioassay and other supporting data available after 1959 to establish an upper bound for uranium, mixed fission products (MFPs), Po-210, plutonium, SR-90, tritium, and thorium. (2) NIOSH maintains 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. Fission products were monitored for 49% of the workers. (not sure where this comes from) (3) 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 (ORAUT 2006b) discusses the two independent methods used to assess uranium in urine; the fluorometric method identifies uranium concentrations, while the radiometric method assesses the gross alpha/beta energies. (4) 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*	(1) For the period post-1959, SC&A does not believe that these sources (NIOSH 2008, ORAUT 2006c) have clearly demonstrated a correlation between the available bioassay data to specific radionuclides. A brief review of claimant files illustrates that monitoring was not routine for all radiation workers. Detection limits for 1975–1988 are unavailable, and Table 5-9 in TBD-5 containing solubility type and fraction of activity is incomplete. Furthermore, though the number of bioassays increased significantly in the 1965 to 1970 timeframe, there were still deficiencies with respect to the full range of different radionuclides to which workers were exposed. NIOSH response: Over the course of operations, on average 47 % of radiation workers were monitored internally, but not all of them on a routine basis. A revision of the TBD will include a discussion on the exposure potential and the available data. (2) 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. 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 cannot be confirmed due to uranium monitoring limitations. NIOSH response: Uranium bioassay was conducted from the start of the routine program. U-233 was present as fuel in the Advanced Epithermal Thorium Reactor (AETR) which, in spite of its name, was a critical test assembly unlikely to result in internal exposures of U-233**.** (3) The TBD does not clarify whether urine samples prior to 1961 were analyzed by both Uranium Fluorometric (UF) **and** Uranium Radiometric (UR) methods. Beginning in 1962, the type of urinalysis methods used was usually specified. NIOSH response: the capacity for both analyses methods was present since the start up of the bioassay program, although the majority of the 1958-1961

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		ETEC. (5) TBD-5 has several occasions where data interpretation is not complete.	results available in claimant files were for radiometric uranium. The assumption presented in the report that the early uranium urinalyses were limited to fluorometric analyses is not valid, as supported by documentation such as SRDB Ref ID 39919, which describes the uranium electrodepositing and counting method and also lists some early U and GB results from 1958; SRDB Ref ID 1959 also shows that radiometric and fluorometric analysis capability were planned. (4) NIOSH asserts that an internal coworker model is unnecessary, and does not address the use of a coworker model for unmonitored individuals. In many cases, the dose reconstruction reports rely on guidance developed for internal dosimetry based non-SSFL site data that may not accurately reflect conditions at SSFL. NIOSH should make use of the data that Boeing appears to have to see if they are sufficient to estimate dose. There is no way to tell whether the doses in the Boeing spreadsheet would qualify as bounding doses (or more accurate than that) under 42 CFR 83. Due to the magnitude of such an investigation, SC&A did not perform such an assessment, but we believe that NIOSH will need to perform this assessment in order to support the conclusions and recommendations in the ER. NIOSH response: NIOSH has been pursuing the development of an internal coworker model, using the computerized data bases containing complete bioassay monitoring results are available from the earlier epidemiological study by Boice et al. (2006). This effort is on-going and has been hampered by site funding issues. (5) See our review of TBD-5 for specific comments on data interpretation issues. NIOSH response: please see TBD issues matrix responses for TBD-5 **2014 Update: Open** **The internal coworker model was completed after the personnel dosimetry database was received from Boeing. NIOSH has dismissed database related to the Boice study and completed its own data entry effort, which**

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			ensures that no data were missed. Data were analyzed and are presented in the internal coworker model OTIB-0080.
11	SC&A Issue #3: Lack of information related to the potential exposures associated with facility "incidents" (e.g. Sodium Reactor Experiment and Sodium Burn Pit).	The NIOSH ER does not include substantive details regarding potential SSFL personnel exposures resulting from facility incidents.	Atomics International prepared two reports on the SRE 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: • *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

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			statement was not provided in the report, and the number of personnel exposed was also not presented.] The final report (AI 1961) contains information related to potential worker exposure. Examples include the following: • *This report discusses the distribution and management of the fission products during the recovery operations. During the recovery effort the objectives 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. NIOSH response: NIOSH has used information from these reports for dose reconstruction when it was relevant for a given claim. Additional guidance will be added to the revised TBD. Not all incidents are typically discussed in a TBD, even though the SRE incident should be addressed – see earlier response to this issue 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*

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			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. SC&A concludes that there is a lack of information concerning facility incidents that had significant potential for internal and/or external exposure to personnel. NIOSH response: NIOSH does not use source term or environmental data for DR approaches for this site, since personal internal and external monitoring data are available. Coworker doses can be assigned if a worker was not monitored but should have been. **2014 Update: Open.** **Coworker models have been completed and can be used to assign doses to unmonitored workers who should have been monitored for exposures. Incident information is assessed on an individual claim basis and information such as presented in the SRE incident reports are incorporated in individual dose reconstructions if needed for claim completion.**
12	SC&A Issue #4: Lack of information on environmental exposures.	(1) TBD-4 (ORAUT 2007) 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. 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. (2) 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,	(1) 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. For example, nuclear reactor programs were essentially phased out in the early 1970s. NIOSH response: TBD-4 is currently undergoing review to include additional information that was collected during the SEC research. The approach regarding stack data back-extrapolation will be reviewed for the revision of TBD-4. (2) 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.

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		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.	More recent Boeing reports (Boeing 2003, 2004, 2005, and 2006) have documented tritium concentrations approaching 117,000 pCi/L in the monitoring wells. This issue should be re-evaluated to determine if this exposure route can be assessed. NIOSH response: see tritium in groundwater issue (No. 3) **2014 Update: Open.** **The environmental TBD was revised to include updated information. The TBD is in draft status pending issue resolution related to the external coworker model.**
13	SC&A Issue #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). Main concerns: (1) No external coworker model (2) Workers were unlikely to have been monitored for thermal neutrons (3) Dosimeter response to low-energy photons	NIOSH maintains in the ER that information on ambient environmental external dose is unavailable for 1955 through 1965, but did exist for the mid-1970s and forward. Baseline doses above background for Area IV were estimated using the available data, and are given as 20 mrem/year for 1955–1965. For the RMDF, a facility-specific dose was estimated to be 80 mrem/year, and during SRE operations, a facility dose of 40 mrem/year was applied to Building 4143. NIOSH concludes that "the ambient environmental method does not support a bounding external exposure evaluation method for the timeframe evaluated [in the ER], in support of radiological dose reconstructions for the proposed worker class. However, the available ambient environmental data can be used to bound the external ambient doses for unmonitored workers during the evaluation period." TBD-6 (2006c) 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	(1) It appears that individuals may have been unknowingly exposed to radiation. An October 22, 1962, memorandum from F.H. Badger[1] 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, an April 1991 Tiger Team Assessment (DOE 1991), questioned the external radiation dosimetry program, stating,"In 1989 and 1990, extremity doses were not added in to exposure records or reported to the Radiation Exposure Information Reporting System (REIRS)." In general, monitoring of SSFL employees appeared to be somewhat indiscriminate; radiation workers may or may not have worn badges, and non-radiation workers could conceivably have incurred external exposures. Identification of job titles may yield potential exposure information upon which a dose reconstruction is based and subsequently linked to a coworker model. This issue is relevant to the SEC petition limitation of employees who "were monitored." SC&A concludes that NIOSH must re-assess the SEC petition limitation. NIOSH response:

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

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		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. *(1)* The ER affirms: "Further research and development of a co-worker data set has not been performed by NIOSH because a dosimetry data deficiency has not been identified for the proposed worker class timeframe. In the case that a co-worker study is deemed necessary, NIOSH believes that sufficient data exist to support a co-worker study and dose reconstruction approach." (2) 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). (3) 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.	The SEC proposed class definition will be reassessed in light of new information regarding potentially unmonitored workers. An external coworker model has been completed and is in stages of final revision. (2) 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 track analysis of **thermal** neutrons. 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. NIOSH (from TBD issues matrix 4.6-2 and 4.6-3): While the above statement is correct it has very limited impact on DR other than to make any result more claimant favorable. Neutron spectra measurements done in similar facilities have found doses resulting from neutrons < 100 keV to be, at most, less than 5% of the total neutron doses. (See ORAUT-TKBS-0003). While we do not have neutron spectra for the Area IV facilities we do have spectral data for other similar facilities (Y-12, Hanford, SRS) and the correction factors given in the SSFL Site Profile are bounded by them. Neutron exposures are most likely associated with operations of the higher-energy D-T Accelerators and would be reasonably recorded by NTA film. The option to assign a neutron dose using the recorded photon dose for each worker and an appropriately selected neutron-to-photon dose ratio is also available. The issue is still being investigate with the on-going TBD review. (3) No specific information on source term is provided. Furthermore, there is no consideration for dose from skin contamination incidents.

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			NIOSH response: The issues regarding the energy dependence of early film dosimeters have been resolved on various site profiles. This is not an SEC issue. **2014 Update: Open.** **SSFL neutron-to-photon survey data were reviewed and a neutron/photon ratio approach developed. This was presented in a white paper sent to the work group in June 2010. Internal NIOSH issue resolution continues. Detailed guidance will be incorporated into the TBD once all issues have been resolved.**

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