REPORT OF THE SANTA SUSANA FIELD LABORATORY ADVISORY PANEL

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Dedication

THIS REPORT IS DEDICATED TO THE MEMORY OF

DR. ALICE STEWART

LONGTIME MEMBER OF THE SSFL ADVISORY PANEL
PIONEER IN THE FIELD OF RADIATION EPIDEMIOLOGY
AND
FRIEND OF THE COMMUNITY
SURROUNDING IN THE SANTA SUSANA FIELD LABORATORY

ORIGINS OF THE SSFL ADVISORY PANEL, PAST PANEL SSFL STUDIES, & ACKNOWLEDGMENTS

CREATION OF THE PANEL AND ITS ORIGINAL SSFL WORKER STUDIES

In 1989, press reports revealed an internal U.S. Department of Energy (DOE) study that found widespread radioactive and chemical contamination at the Santa Susana Field Laboratory. These disclosures triggered extensive concern among residents of nearby communities. In 1991, a study conducted the year before by the California Department of Health Services (DHS) came to light; that study had detected an elevated incidence of bladder cancers in census tracts in Los Angeles County closest to SSFL. Concerned by what they perceived as the belated disclosure of the DHS study, three members of the California State Assembly who represented the nearby communities -- then-Assembly members Terry Friedman (D), Richard Katz (D), and Cathie Wright (R) – held a hearing on the matter and pressed for comprehensive independent studies.

The legislators, responding to community calls for independent health studies in the wake of revelations about the site, arranged for the establishment of the Santa Susana Field Laboratory Advisory Panel, to consist of independent experts from around the country (and one from Britain) as well as community representatives. The legislators directed that the initial studies should be of the workers, as they were likely to have higher exposures than the pubic and, if there were no evidence of adverse effects on them, the community could be reassured as to their own likely risks. If, on the other hand, the workers were found to have experienced cancers or other health impacts associated with their radioactive or chemical exposures at the site, then the Panel would move to a second phase, examining potential community impacts and the feasibility of offsite epidemiological studies.

The legislators were instrumental in obtaining funding from the U.S. Department of Energy for the Panel's epidemiological study of the SSFL workers while assuring independence of the Panel from DOE, other agencies, and Rocketdyne. The Panel selected a team of researchers from the UCLA School of Public Health, supplemented by consultants from other institutions, to perform the occupational study, and provided oversight of the team's work. The UCLA team performing the health study of SSFL workers under Panel oversight consisted of Drs. Hal Morgenstern (now at the University of Michigan), Beate Ritz, John Froines, and Bambi Young.

The UCLA researchers' radiation study[1] was released in 1997 and found that exposure of SSFL workers to external radiation was associated with an elevated rate of dying from cancers of the blood and lymph systems and from lung cancer; death rates for all cancers and for "radiosensitive" solid cancers were found to increase as external radiation dose increased; and exposure to internal radiation emitters similarly resulted in increased rates of dying from cancers of blood and lymph systems and cancers of the upper aero-digestive tract. The researchers found these effects arising from doses well below those permitted by current regulations. They found radiation risks about 6-8 times higher than those generally extrapolated from A-bomb survivor data, and they found that cancer rates were impacted more by radiation that workers received at older than at younger ages.

The study of the rocket test workers was released in 1999[2]. The UCLA team found positive associations between exposures to chemicals used at the rocket test stands, particularly hydrazine, and the rates of dying from cancers of the lung, blood and lymph system, and bladder and kidney.

The two UCLA studies of the SSFL workers, performed under Panel auspices, and the reports of the Panel regarding both studies, are available at the Panel website, http://www.ssflpanel.org, as are the new studies of potential offsite contamination and health effects now being released by the Panel.

CONTINUATION OF THE PANEL AND SUPPORT FOR THE NEW OFFSITE/COMMUNITY IMPACTS STUDIES

The legislators who established the Panel had directed – and the Panel had committed to the community – that if the worker studies came back with positive findings, the Panel would turn its attention to studying potential impacts on the community, including the feasibility of performing an epidemiological study. Therefore, upon release of the UCLA study of the radiation workers in 1997 and of the rocket testing workers in 1999, the Panel's work was re-directed to studying possible offsite effects/community impacts of SSFL. Senators Dianne Feinstein (D) and Barbara Boxer (D) and Representative Elton Gallegly (R) were instrumental in efforts to obtain continuing federal support for the Panel's follow-on studies. DOE declined to directly fund the continued work of the Panel, so alternative sources funding were obtained.

Senator Sheila Kuehl (D), with support of then-Senator Cathie Wright (R), arranged for funding from the California legislature for the Panel's second phase of work. Those funds were provided through the California Environmental Protection Agency (CAL-EPA). Senator Kuehl and her staff have been tireless in assisting the Panel in its work.

Additionally, the Panel obtained indirect DOE funding via the Citizens' Monitoring and Technical Assistance Fund (www.mtafund.org). As part of a 1998 court settlement between the U.S. Department of Energy and 39 plaintiffs (nonprofit peace and environmental groups around the country), DOE established a $6.25 million Citizens' Monitoring and Technical Assessment Fund (MTA Fund) to provide money to non-profit, non-governmental organizations and Federally recognized tribal governments working on issues related to the nuclear weapons complex. The Fund was established to help those groups procure technical and scientific assistance to perform technical and scientific reviews and analyses of environmental management activities at DOE sites. Although the funds derive from DOE, the agency has no say in the selection of grantees, which is done through an independent MTA Fund board.

The Panel gratefully acknowledges the funding sources for these studies. The statements and conclusions in this report and in the Panel's consultants' reports, however, represent those of the authors and not of any funding entity.

The Panel's work has been conducted in part by a team of consultants, prominent experts in fields of reactor accident analysis, atmospheric transport of contaminants, hydrology and geology. The Panel expresses its gratitude for the hard work performed by this dedicated group of experts. This Panel Report attempts to summarize their primary findings and draw conclusions therefrom; although based on the consultants' reports, however, the Panel alone is responsible for this Report.

The Panel wishes to express its particular gratitude to community residents near the SSFL site who called for independent health and environmental studies, worked vigorously to get the Panel established and funded, helped set priorities for work, and provided the Panel with critical information and insights that only people who are "on the ground" can provide. This study is truly community-initiated and community-informed.

A BRIEF HISTORY OF THE SANTA SUSANA FIELD LABORATORY

THE SELECTION OF THE SITE

The Santa Susana Field Laboratory consists of 2850 acres of land in eastern Ventura County, bordering Los Angeles County, about 30 miles northwest of downtown Los Angeles, between Simi and the San Fernando Valleys. SSFL is located atop the Simi Hills overlooking Simi Valley to the north, Chatsworth, West Hills, and Canoga Park to the east, Woodland Hills and Thousand Oaks to the south, and Moorpark to the west. Initially intended as a remote field laboratory for work too dangerous to conduct in more populated areas, there now are approximately 150,000 residing within five miles of the site and more than half a million within ten miles.[3]

The facility is divided into four areas (Areas I, II, III, and IV). The first three engaged in rocket and missile testing and munitions development; Area IV focused on nuclear reactor development and "Star Wars" laser work. The rocket testing facility was established in the late 1948 by North American Aviation (the predecessor to Rocketdyne), and the site was selected for nuclear work shortly thereafter by the Atomics International Division of North American Aviation.

Safety considerations appear to have been subordinated to other interests from the outset. In 1949, North American Aviation prepared for the U.S. Atomic Energy Commission (AEC) an evaluation of potential sites for a reactor development facility in the general Los Angeles area.[4] Candidate sites in Southern California were evaluated based on safety factors associated with meteorological and hydrologic features of the locations, and were ranked accordingly. Santa Susana was ranked 5th out of 6 sites evaluated for meteorological appropriateness, in part because of nighttime drainage of potentially contaminated air "into the San Fernando Valley." It was additionally ranked near the bottom of the sites considered because "convergence of Santa Clara and San Fernando currents at this point makes daytime condition uncertain." As seen in the analysis by Panel consultant Dr. Jan Beyea, the complex terrain in the SSFL area indeed leads to large uncertainties in evaluating the potential off-site dispersion of airborne contaminants. Potential hydrologic problems were summarily reviewed. The siting review concluded that underground water "would flow into the San Fernando Valley water basins."

Despite the problems identified by their own review, the AEC and North American Aviation ended up choosing SSFL as the site for its reactor testing facility. In overriding the safety concerns identified, they seem to have been guided by convenience. A table at the beginning of the AEC survey of potential reactor sites compared the "actual driving time and distances" from UCLA and other universities participating in the project, noting that it would be highly desirable if the commute from LA universities to the site were kept short. In this regard, SSFL did very well compared to other sites with fewer identified safety problems. Furthermore, North American Aviation already owned land at SSFL for rocket testing. So, despite the safety problems identified and the low ranking on safety characteristics of the site, SSFL was chosen.

SAFETY CONDITIONS FOR SITE QUICKLY RELAXED

In selecting SSFL as the site for an AEC reactor testing facility, it was presumed that the power and size of any test reactor constructed there would be restricted to 1000 kilowatts (thermal). Relying on AEC siting criteria at the time that related power level to the size of a controlled exclusion area required around such a reactor and the minimum distance to any populated area, the analysts concluded that it would be safe to operate reactors up to 1000 kw at the site. That formula is

$$R = 0.01 \sqrt{k}$$

where "R equals the radius in miles of the controlled area and K equals the maximum power level of the reactor in kilowatts."[5] If the reactor power were no greater than 1000 kw, then an area with a radius of about a third of a mile on all sides of the reactor would have to be "fenced and guarded," and the nearest population concentration should be at least one mile away, according to the AEC site review. "Care must be taken to select an area where prospects for population growth in the near future are not anticipated." Despite the clear prospects for population growth in the area, SSFL was nonetheless selected, and a few years later, the SRE reactor was constructed, with a power twenty times higher than the maximum presumed in the siting selection as safe, given the site characteristics.

At 20,000 kilowatts, the SRE's exclusion area – fenced and guarded and controlled so no one other than SSFL employees could enter the area – would by the above formula have had to be 1.4 miles. Yet it was constructed right up against the SSFL northern boundary, with essentially no exclusion area to its north. (The Arness Ranch and Brandeis Bardin Camp Institute abutted the SRE area.)[6] And, given the assumptions in the original siting consideration, a 20,000 kilowatt reactor should have been located about four and a half miles from the nearest population concentration, despite Simi Valley being considerably closer. The AEC would on occasion permit reactor siting that didn't meet these criteria if a containment structure (the thick concrete domes that surround modern reactors) were included in the reactor design, to reduce the potential for release of radioactivity to the environment in case of accident, but the SRE was built without any containment structure. The potential implications of the decision not to require a containment are considered in David Lochbaum's study of the SRE accident conducted for the Panel.

A HISTORY OF ACCIDENTS, SPILLS, AND RELEASES

Over its lifetime, Area IV of SSFL was home to:

- ten reactors
- numerous "critical" facilities (a kind of low-power reactor)
- a plutonium fuel fabrication facility
- a uranium carbide fuel fabrication facility
- a "hot lab" (purportedly the largest in the country) for remotely cutting up irradiated nuclear fuel shipped in from around the country from other AEC/DOE nuclear facilities

- and a sodium burn pit, in which sodium-coated objects were burned in open-air pits

At least four of the reactors suffered accidents:

- the AE6 reactor experienced a release of fission gases in March of 1959[7]
- the SRE experienced a power excursion and partial meltdown in July 1959[8]
- the SNAP8ER in 1964 experienced damage to 80% of its fuel[9]
- the SNAP8DR in 1969 experienced similar damage to a third of its fuel[10]

In addition, the Hot Lab suffered a number of fires involving radioactive materials. For example, in 1957, a fire in the Hot Cell "got out of control and not only spread contamination but damaged some equipment. . . . Because such *massive contamination* was not anticipated, the planned logistics of cleanup were not adequate for the situation."[11] Another radioactive fire occurred in 1971, involving combustible primary reactor coolant (NaK) contaminated with mixed fission products.[12]

Radioactively and chemically contaminated items were not supposed to be burned in the Area IV burnpit. Nonetheless, such items were burned there for decades, causing extensive contamination of soil and groundwater and offsite migration in surface water runoff.[13]

The accident history of the site is poorly understood, given the limited amount of disclosure that has occurred to date. For example, virtually no information has been disclosed by DOE or Rocketdyne about the accident history of what may be the most dangerous operation at the site – the plutonium fuel fabrication facility. Elevated plutonium concentrations have been detected in soil outside the facility, but its record of incidents remains publicly unknown.

Approximately 30,000 rocket tests have been conducted at the other areas of SSFL, using a variety of fuels. Approximately a million gallons of TCE, a toxic solvent, were used to wash off rocket test stands, with roughly half that amount estimated to have entered the soil and groundwater. Dozens of toxic chemicals have been found in soil, groundwater, or surface water at the site.[14]

A History of Secrecy

Throughout its history the facility has shrouded its environmental problems behind a wall of secrecy. Revelations about accidents, spills, and releases have come reluctantly, often involuntarily, and frequently decades after the fact.

Perhaps the clearest example is the SRE partial meltdown in 1959, one of the most serious nuclear accidents of its time. A third of the core experienced melting; power had risen uncontrollably, nearly tripling in less than eight seconds; radiation monitors went off scale; coolant channels had been blocked, causing fuel temperatures to rise above the level that resulted in fuel elements losing their integrity and release large amounts of radioactivity into the coolant; and radioactive gases were intentionally vented into the atmosphere for weeks after the accident.[15]

The power excursion occurred on July 13. After a difficult shutdown and inability to find the cause of the problems, the reactor was started up again and ran until July 26, when it was discovered fuel had melted and was severely damaged. Yet no press release or other public announcement occurred until August 29, 47 days after the power excursion and 34 days after the event that the press release claimed it was announcing, the discovery on July 26 of "a parted fuel element." The Atomic Energy Commission (AEC)/Atomics International (AI) press statement, issued nearly five weeks after the event, began:

> During inspection of fuel elements on July 26 at the Sodium Reactor Experiment, operated for the Atomic Energy Commission at Santa Susana, California by Atomics International, a division of North American Aviation, Inc., *a parted fuel element was observed.*
>
> *The fuel element damage is not an indication of unsafe reactor conditions. No release of radioactive materials to the plant or its environs occurred* and operating personnel were not exposed to harmful conditions. The occurrence is important from a technical standpoint and a detailed study is under way to determine the precise cause of the damage.
>
> (emphasis added)

The press release appears to have been misleading. The problem identified was not merely that a fuel element had "parted" – it was that the fuel elements had experienced melting and release of radioactivity. It was not merely a single element, but a third of the core. The damage was precisely an indication of unsafe reactor conditions, as found by the highly critical AEC review of the accident[16]:

> [S]o many difficulties were encountered that, at least in retrospect, it is quite clear that the reactor should have been shut down and the problems solved properly. Continuing to run in the face of a known Tetralin leak, repeated scrams, equipment failures, rising radioactivity releases, and unexplained transient effects is difficult to justify. Such emphasis on continued operation can and often does have serious effects on safety and can create an atmosphere leading to serious accidents. It is dangerous, as well as being false economy, to run a reactor that clearly is not functioning as it was designed to function.

Furthermore, both AI and AEC knew already that radioactive materials had been released to the plant – there were high radiation readings in the reactor room and clear indications of a large amount of fission products had been released to the coolant. And they both knew that radioactive materials had been released to the environment—they were intentionally venting radioactive gases for weeks.

The true story of a partial meltdown of a reactor, without containment structure, in the Los Angeles area – what should have been one of the biggest stories of the period – was buried, as apparently intended by the AEC and AI. To the Panel's knowledge, only one paper picked up the release (the *Valley Greensheet*), running only a tiny paragraph repeating the release's claim of a parted fuel element and no indications of unsafe operating conditions.

The true story remained for all intents and purposes secret from the public for two more decades, until researchers for public interest organizations came across the underlying internal AI/AEC technical reports about the accident and released the information to the news media.

As disappointing as was the lack of candor about the SRE partial meltdown, the AEC and AI conduct with regards the other accidents and releases at the site was no better. As far as the Panel has been able to determine, no information was released to the public regarding the SNAP8ER fuel damage events in 1964 or the similar accident in 1969 with the SNP8DR reactor. Additionally, no public announcements were made about the Hot Cell radioactive fires.

This lack of candor, extending to this day, makes characterization of the potential health impacts of past accidents and releases extremely difficult. One simply does not know with confidence what accidents and releases have not been disclosed, nor what information about the ones we do know of also has not been revealed.

THE HISTORY OF SECRECY EXTENDED THROUGHOUT THE AEC/DOE NUCLEAR COMPLEX

The lack of candor about environmental problems was not unique to SSFL. Virtually the entire nuclear complex under the AEC and its successor agency, DOE, operated similarly. The AEC evolved out of the Manhattan Project, and secrecy became part of the agency culture extending far beyond any need to protect military secrets. Both AEC and thereafter DOE have been widely criticized as viewing their activities as above and exempt from the environmental laws and regulations required of all other institutions.

This was especially true of epidemiological studies by AEC/DOE of nuclear workers. Researchers who found adverse affects among the exposed workers were removed from their posts, had their grants cancelled and their access to their own data restricted, and pressured to not publish their findings.[17]

Huge releases of radioactivity, such as the "green runs" at Hanford, were kept secret for decades. Problems with leaking high level waste tanks migrating towards the Columbia River, releases of uranium at Fernald, problems with the reprocessing canyons at Savannah River – all these were kept tightly under wrap for decades.

Until 1986. The Chernobyl accident, about which the Soviet leadership initially dissembled, revealed a similar pattern in the U.S., and just as it led to an opening of light and disclosure in the USSR, light was shined onto previously hidden problems within the U.S. nuclear complex. During the accident, DOE assured Congress that no similar problem could occur in this country because this country had no unlicensed, uncontained graphite reactors. However, Congress quickly learned that wasn't the case. Indeed, DOE itself had such reactors, particularly the "N-Reactor" at Hanford – graphite moderated, unlicensed, and with no containment structure. The House

Interior Committee asked a team of experts to inspect the N-reactor – the first independent review – which identified serious safety problems.[18] These findings were soon confirmed by reviews by the National Academy of Sciences, which also found similar problems at DOE's Savannah River facility.

A new Energy Secretary, Admiral James Watkins, came to office pledging to change the safety and secrecy culture at DOE, bringing it in to the modern era of environmental compliance and transparency. Reviews of the safety and environmental practices of the entire DOE nuclear complex were initiated, which, in 1989, resulted in the review of SSFL by DOE contractor James Werner. It was the disclosure of the widespread contamination found by Werner that triggered the public concern about SSFL that led to the formation of this independent Panel.

Similarly, Admiral Watkins, recognizing the lack of credibility of and conflicts-of-interest associated with the DOE-sponsored epidemiological studies of its activities, committed to the creation of independent research about possible cancer induction from DOE nuclear operations. This too contributed to the creation of the Panel, which was to perform studies at arms length from DOE and its contractors in order to increase the confidence that workers, neighbors, the scientific community and the general public would place in study findings.. This resulted in the worker studies by the UCLA team under SSFL Panel auspices, which found increased cancer death rates associated with occupational exposures.[19] The positive findings of health impacts in the SSFL worker studies by UCLA has led to Phase II of the Panel's work, assessment of potential offsite impacts.

THE CURRENT STUDIES

THE PROBLEMS OF RELIANCE ON ROCKETDYNE DATA AND THE REFUSAL OF ROCKETDYNE AND DOE TO DISCLOSE CRITICAL INFORMATION

Performing an accurate assessment of potential impacts of accidents, spills, and releases from SSFL requires full access to information and high confidence in the reliability of that information. The Panel has been hindered in both regards.

There are serious questions regarding the reliability of information Rocketdyne does report. The misleading nature of the SRE accident press release discussed above is a case in point. Equally troubling is significant evidence that measurements reported may not be accurate. This is perhaps best illustrated by the findings of EPA investigator Gregg Dempsey.

The disclosures in the Werner DOE contractor report in 1989 of widespread contamination described above led to the U.S. Environmental Protection Agency getting involved in the site for the first time. EPA radiation expert Dempsey was sent to SSFL to inspect its radiation monitoring program. Dempsey found that Rocketdyne had been washing vegetation samples (which had the effect of washing off surface radioactivity) before monitoring them; heating to a high temperature both vegetation and soil samples (which had the effect of driving off volatile radionuclides); inappropriately subtracting an arbitrary value from actual radiation levels measured by dosimeters (which had the effect of inappropriately lowering measured radiation amounts); and numerous other problems.

EPA's Dempsey concluded that it is "clear to me that Rocketdyne does not have a good 'handle' on where radiation has been inadvertently or intentionally dumped onsite." He also concluded, "*the SSFL sampling, placement of sample locations, and analyses cannot guarantee that past actions have not caused offsite impacts. If the environmental program stays uncorrected, SSFL cannot guarantee that unforseen or undetected problems onsite will not impact the offsite environment in the future*."[20] (emphasis added) He later raised additional questions about Rocketdyne's practice of filtering radioactivity out of its water samples before measuring them, and throwing away the filters without measuring the radioactivity filtered out.[21]

In our review of a large number of Atomics International/Rocketdyne documents, serious questions about the reliability of assertions, measurements, and conclusory statements have arisen. We have had to attempt to independently assess these where we can; and where we cannot, incorporate some consideration of uncertainties.

In addition to the accuracy of what we have been able to see has been the reluctance of Rocketdyne and DOE to disclose public records essential to an accurate assessment of potential offsite impacts of their activities. Perhaps the best example has to do with our unsuccessful, repeated requests for meteorological data from the site, particularly from the time of the SRE partial meltdown.

To model atmospheric transport of radioactivity from that accident, identify high and low exposed populations (critical to making epidemiological studies feasible), and estimate population doses and consequent health effects, knowing the meteorological conditions at the time of the release is critical. **In the course of our investigations, we discovered that Atomics International had a meteorological station on top of the SRE at the time of the accident. We requested that Rocketdyne provide us with the weather data. Rocketdyne declined, asserting that the information was proprietary – a trade secret. Which way the wind was blowing nearly fifty years ago obviously is not a business secret. As discussed in Beyea's report to the Panel, withholding of weather data suggests the possibility that Rockedyne has something to hide regarding the implications for environmental releases and exposure of off-site populations.**

We subsequently submitted Freedom of Information Act (FOIA) requests to the Department of Energy for the data. DOE denied the FOIA requests – for half-century-old meteorological records. Under DOE FOIA rules, contractor records are considered government records and are to be released, yet DOE refused.

Numerous other requests for information were similarly frustrated. These are public records, documents created for the government using taxpayer funds. They are important in determining risks to the public. Yet they were suppressed. Occasionally, after having had difficulty in obtaining the records, we would have to ask a legislator to intervene and attempt to get the needed documents. But DOE and Rocketdyne actively resisted public disclosure of the records of safety problems at SSFL.

Perhaps the most troubling refusal of disclosure has to do with a computerized electronic database Rocketdyne has assembled of all of its records of accidents, releases, and other environmental matters at SSFL. These records were made available to lawyers for parties to a lawsuit against Rocketdyne but on condition that a large fraction of them be declared confidential, even though they related to environmental releases decades ago. Because the documents asserted to be confidential could not be segregated in the database from those not so asserted, the entire searchable database is off-limits to researchers, agencies, and the public. This is the case even though the documents were all produced pursuant to government contract, paid for by the taxpayer, and are important to understanding potential impacts on public health and the environment.

To members of the potentially affected community, such energetic efforts to prevent disclosure may well say something about that which is being hidden. To our Panel, it has reduced our confidence in the degree to which claims made by Rocketdyne and DOE can, in and of themselves, be relied upon without verification.

THE ISSUES ADDRESSED

These studies were initiated by the local community, which played an active role in determining priorities among the questions to be explored. The Panel held a number of community meetings, at which feedback was provided about what should be focused on given limited resources.

1. <u>The SRE Accident Sequence and Possible Radioactivity Releases</u>

It was felt that the SRE accident should be independently assessed. The reactor, at 20 MWth, was the largest that operated at SSFL.[22] The partial meltdown was arguably the most serious reactor accident publicly known to have occurred at the site. Other facilities – notably the plutonium fuel fabrication facility, or the Hot Laboratory (which handled highly irradiated reactor fuel from much larger reactors shipped in from the AEC/DOE nuclear complex) might possibly have had larger impacts, but virtually nothing about their accident history is publicly known. A critical review of AI claims about the SRE accident and radiation releases from the accident appeared important.

2. <u>Dose Estimation from the SRE Partial Meltdown</u>

Given the above, modeling atmospheric transport from the SRE accident could help bound potential offsite health impacts from radioactive releases at the site. If a bounding case resulted in no cancers estimated, then the public could be relieved and there would be no need for an epidemiological study of cancers caused by off-site releases from the SRE accident. Rocketdyne has claimed there could be no offsite effects from the accident given the size of the reactor; traditional dispersion models could determine the validity of that assertion. On the other hand, if estimated doses were large enough to predict that cancer would result in downwind populations, that would help people put the matter in perspective and could warrant consideration of the feasibility of an epidemiological study to identify excess cancers in exposed compared to unexposed populations.

3. <u>The Potential for Contamination in Soil at the Site Migrating into Groundwater & the Case of the Area IV Burnpit</u>

We heard from a number of community members concerned about the potential for radioactive and chemical contamination known to exist in the soil at SSFL migrating downward by rainfall percolation and polluting further the groundwater. They were particularly desirous of an independent assessment of claims by Rocketdyne that the direction of moisture movement in soil at SSFL is upward, not downward, so that groundwater cannot be affected by the soil contamination. This argument was raised specifically in Rocketdyne's successful objections to capping the sodium burnpit in Area IV, asserting that there was no need for a plastic cap to prevent moisture from infiltrating and driving contaminants further into the aquifer. This issue has taken on more importance since the similar plans were proposed for the Area I burnpit.

4. <u>The Potential for Contamination in Soil at the Site Migrating via Surface Water Offsite and Contaminating Groundwater in Simi Valley and Elsewhere</u>

Other community members wished to have analyzed the risk of surface runoff carrying contaminants offsite. Some were concerned about wells in Simi; others about potential exposure pathways on the Los Angeles County side. Perchlorate migration was of particular concern, both in and of itself and as a marker for other less rapidly mobile contaminants that might follow.

5. <u>The Potential for Contaminated Groundwater at the Site to Migrate</u>

Rocketdyne has argued that there is no risk from contaminated groundwater migration and that it need not clean up the groundwater contamination on site because earthquake faults and fine-grained geologic units prevent the contaminated groundwater from moving. Rocketdyne has also argued it shouldn't have to clean up the contamination by such toxins as TCE because it claims the TCE is confined in the rock matrix and cannot migrate. A number of community members wished an independent evaluation of these claims and of the potential risk of contaminated groundwater migration.

In short, the Panel has been asked to evaluate several potential pathways for offsite migration of SSFL contaminants: airborne releases from reactor accidents; contamination in soil migrating into groundwater; contamination in soil migrating offsite via surface runoff; and contaminated groundwater migrating offsite. In the studies by our consultants being released now, and our evaluation of the issues raised in those reports, we have tried to address those questions posed by the community.

We have also included a paper by community members describing the history of events involving Rocketdyne and how they affected people living in the shadow of SSFL. Their insights and reactions provide a very human face to these otherwise technical matters, and show how secrecy has created mistrust and distress for people concerned about the safety of their families.

In the discussion below, we briefly summarize the findings of the consultants' reports on these matters and draw conclusions therefrom. The full texts of the reports are available on the Panel's website, at http://www.ssflpanel.org .

1. *AN ASSESSMENT OF POTENTIAL PATHWAYS FOR RELEASE OF GASEOUS RADIOACTIVITY FOLLOWING FUEL DAMAGE DURING RUN 14 AT THE SODIUM REACTOR EXPERIMENT* BY DAVID A. LOCHBAUM

David Lochbaum is Nuclear Safety Engineer for the Union of Concerned Scientists. Independent of UCS, Lochbaum performed a study for the Panel of the SRE accident and the potential pathways for release of radioactivity from it. Rocketdyne claims that no radioactivity, with the possible exception of noble gases, was released to the environment in the accident. Lochbaum concludes to the contrary that as much as 30% of the most worrisome of the radionuclides, iodine-131 and cesium-137, may have been released, with a best estimate of 15% of each. Lochbaum summarizes his report as follows:

> The Sodium Reactor Experiment (SRE) experienced extensive fuel damage during power run 14 in July 1959. Thirteen of forty-three fuel elements in the SRE reactor core failed due to overheating when the cooling flow provided by liquid sodium was blocked or partially blocked by tetralin that had leaked into the primary sodium loop during prior power runs. Fission products were released from the damaged fuel into the primary sodium loop. Some of the fission products leaked from the primary sodium loop into the high bay area, a region inside the building housing the SRE reactor. Other fission products flowed with the helium cover gas over the liquid sodium in the reactor pool to gaseous storage tanks. Fission products from the high bay area and from the gaseous storage tanks were processed through the filters of a ventilation system and discharged to the atmosphere.
>
> Scant and disconnected data prevented a quantitative assessment of what got out when. A qualitative assessment, relying on experience from the subsequent fuel damage experienced at another sodium-cooled reactor, Fermi-I, and on results from experimental studies was performed to estimate the amount of radioiodine and cesium reaching the environment following the July 1959 accident at SRE.
>
> Based upon the fraction of the reactor core damaged (30 percent), the analytical value for fraction of radioiodine and cesium release from damaged fuel (10 percent), and an empirical value for effectiveness of the

> hold-up and filter performance of the ventilation system (10 percent), it was concluded that the fraction of the total cesium inventory within the SRE reactor core at the time of the July 1959 accident reaching the environment ranged from 0.3 percent to 30 percent and the associated release fraction for radioiodine ranged ranged between 3 percent and 30 percent. Balancing factors which drive the release fraction towards the upper bound and factors driving the release fractions towards the lower bounds yields the conclusion that it is reasonable to assume a release fraction of 15 percent is likely closer to the actual release fraction than is either end point.

Lochbaum's bounding estimated release fraction of 30% would equal approximately 13,000 curies of iodine-131 and 2600 curies of cesium-137, based on the inventories and power history asserted by Atomics International. (A curie is that amount of radioactivity that emits 37 billion disintegrations per second.) His best estimate of 15% release would thus mean 6500 curies of iodine-131 and 1300 curies of cesium-137 were released. By contrast, the official estimate for the Three Mile Island accident is 17 curies of I-131 and no cesium released. Although the TMI reactor was about 100 times larger than the SRE, it had a containment structure whereas SRE had none, and the official position is that virtually all radioactivity stayed inside containment.

As will be discussed below, one must take into account the possibility that the reported power history at SRE is inaccurate, given the remarkable purported coincidence that the accident occurred during a run about ten times lower in power than most previous runs. This would affect the radiodine inventory roughly tenfold but have inconsequential effects on the cesium, given its longer half-life.

Lochbaum's release estimates will be translated into potential health effects as we discuss Jan Beyea's study, below.

2. *FEASIBILITY OF DEVELOPING EXPOSURE MARKERS FOR USE IN EPIDEMIOLOGIC STUDIES OF RADIOACTIVE EMISSIONS FROM THE SANTA SUSANA FIELD LABORATORY* BY JAN BEYEA, PH.D.

Dr. Beyea is a physicist who specializes in modeling atmospheric releases of radioactivity from nuclear reactor accidents.

Given the lack of reliable data about the SRE releases, and the refusal of Rocketdyne to provide even meteorological data from the time of the accident, Dr. Beyea modeled the SRE releases by taking a real nuclear accident about which a good deal is known – the Windscale accident in England in 1957 – and transposing it onto the site and demographic conditions of Santa Susana in 1959. He addressed a range of potential radioactive releases, focusing on radioactive iodine and cesium, the two radionuclides of greatest health concern. In the absence of weather data withheld by Rocketdyne, he made calculations for different directions and speed of winds at SSFL during the accident, factors that would have made a significant impact on where any radioactive releases from the accident would have traveled. Based on the expert opinions available, Beyea's best estimates of iodine-131 releases are between 1500 and 4000 Ci, with a five percent likelihood that the releases were as low as zero or higher than

10,000 Ci. These values can be compared to official estimate of 17 Ci released from the Three Mile Island accident. Beyea's best estimate of the cesium-137 release is about 400 Ci, with possible releases spanning the range of 0 to several thousand Ci.

Beyea then estimated the total radiation doses that would have been delivered to people living within 100 km of SSFL. For iodine, doses to the thyroid, where iodine concentrates following inhalation or injestion, were estimated. Cesium, which settles to the ground emits gamma radiation that is similar to x-rays, delivers doses to the whole body. Beyea's best estimate of the total thyroid dose is 65,000 person-rem, with a five percent likelihood that the dose was zero or greater than 276,000. The best estimate of whole body dose from cesium is 75,000 person-rem, with a five percent likelihood that the dose is zero or greater than 360,000.

Beyea next estimated the number of cancers that would have been caused by these levels of radiation. His best estimate – the average of simulations conducted under varying assumptions about the magnitude of the releases and the wind speed and direction – is about 260 cancers, with a 95% confidence range of 0 – 1800 cancers.

DISCUSSION BY PANEL

Most radiation risk estimates – the values used to predict the numbers of cancers that will occur following exposure to ionizing radiation – are based on studies of survivors of the atomic attacks on Hiroshima and Nagasaki. The UCLA study of SSFL workers for the risk of radiation-induced cancer to be 6-8 times higher than presumed from the A-bomb survivor data. Alice Stewart, the British radiation epidemiologist who was a member of the SSFL Advisory Panel until her death in 2002, long theorized that the A-bomb data significantly understated true effects because of the "healthy survivor" effect: only people who survived the acute effects of radiation and poor public health conditions after the bombings survived to become part of the cancer studies that began five years after the bombings. Furthermore, she argued, the selection was greater for survivors exposed to higher radiation levels, and greater for the very young and the very old who are more susceptible to environmental hazards. Stewart argued that one reason that the effect of in utero radiation exposure on childhood cancer was not seen in the A-bomb studies is selective survival. Any dose-related selective survival of A-bomb survivors who were less susceptible to radiation would tend to bias estimates of radiation risk towards lower values. The radiation risk estimates from the National Academy of Sciences Committee on the Biological Effects of Ionizing radiation, released in 2005, are based on A-bomb survivor studies.

Current agency assumptions further reduce risk estimates by a dose and dose-rate effectiveness factor (DDREF) of 2, so the UCLA study of SSFL workers could be the equivalent of 12-16 times current official risk estimates. Studies of Oak Ridge workers produced risk estimates approximately 5 times higher than estimates from A-bomb data, or ten times current regulatory estimates that assume a DDREF, depending on exposure age. The Canadian radiation workers study found an effect 7-8 times that of the A-bomb studies, and studies of Hanford workers have found higher radiation risks than A-bomb survivors studies, depending on exposure age. The largest occupational radiation study ever conducted, including nuclear workers from 15 countries, estimated risks approximately 6 times higher than current regulatory assumptions. A large study of people from the area of the Mayak nuclear weapons facility found a similarly larger effect of radiation.

It is the best judgment of the Panel that a dose-response relationship about an order of magnitude higher than currently assumed by regulatory agencies is a more appropriate assumption, based on the number of studies that estimate higher values than agencies today presume for regulatory purposes, and based on limitations of the A-bomb and occupational studies.

There is also the unresolved matter of the strangely low reported power for the SRE run in which the accident occurred. AI reports the previous two runs as generating about ten times the power as the ill-fated run. Indeed, all but one of the previous 13 runs were considerably higher in power than Run 14. While it is possible that AI got lucky and the accident occurred while the power was low, and therefore the inventory of short-lived radionuclides such as I-131 was also low, we cannot discount the possibility that AI hasn't correctly reported the power and inventory during the accident. If Run 14 power levels were similar to levels of the previous two runs, this would push the radioiodine consequence estimate up by an order of magnitude.

In conclusion, the upper bound release fractions estimates of both Beyea and Lochbaum result in mean cancer estimates in the hundreds to thousands, depending on the dose-response ratio employed. Were Rocketdyne to disclose information so far denied the public, or were thorough measurements of offsite areas, local and distant, could be performed to allow back-calculation of 1959 releases, both Lochbaum and Beyea's central estimates might change.

The Panel concludes that the reactor was not so small, and the accident so minor, that health effects in the surrounding population are not possible. The bounding release of a significant fraction of the volatile radionuclides in the core could have resulted in hundreds to thousands of cancers. It may have been much less.

At the same time, the reader must be reminded that these cancers, if they occurred, would have been amidst a population of several million people and over a time period of many decades (life time of residents exposed to the 1959 releases or to cesium remaining in soil). Dr. Beyea's analysis concludes that much of the population dose could have been delivered at significant distances from the site – such as Los Angeles – where many more people live than live nearby. Although the estimated individual doses, and cancer risks, are smaller at greater distances, the total number of cancers produced are larger due to the population size. The ability of epidemiological studies to identify these cancers, if they exist, in a population that large, is limited, given the uncertainty about where the exposures occurred and the great mobility in the population.

3. AN ANALYSIS OF THE DESIGN AND PERFORMANCE OF THE CLAY CAP USED TO CONTROL GROUNDWATER RECHARGE INTO THE FRACTURED BEDROCK BENEATH THE FORMER SODIUM BURN PIT (FSDF) AT THE BOEING-ROCKETDYNE SANTA SUSANA FIELD LABORATORY BY WILLIAM BIANCHI, PH.D.

Dr. Bianchi is a soil physicist, the former Director of the Groundwater Research Field Station, Agricultural Research Service, Soils and Water Division, U.S. Department of Agriculture, Fresno, California. His paper examines claims associated with the decision not to cap the former sodium burn pit.

The sodium burn pit was an open-air location for burning reactor components contaminated with sodium. SSFL focused on development of reactors utilizing liquid sodium coolant. Sodium burns in the presence of air or water. Reactor components that had residual sodium on them were taken to the burn pit, placed in water pools, and left to react for several days. No radioactively or chemically contaminated items were to be placed there; but this restriction was violated over many years, leaving the soil in the burn pit area contaminated with various radioactive and chemical constituents. Groundwater beneath the site also became contaminated.

As an "interim measure," Rocketdyne excavated the contaminated soil down to bedrock. The critical question then became what to do to prevent the contaminants that had already migrated into the fractures in the bedrock from migrating further and contaminating groundwater more.

The California Department of Toxic Substances Control (DTSC) project manager for SSFL insisted upon a Resource Conservation and Recovery Act (RCRA)-compliant synthetic cap being placed atop the clean fill that was to replace the excavated soil. This plastic cap was designed to prevent rainfall from infiltrating into the fill and carrying contaminants further into the fractures in the bedrock.

Boeing resisted employing a RCRA-compliant cap. DTSC reversed the prior decision, and permitted the interim measure to go forward without use of a synthetic cap. Instead, a special clay soil would be employed and native vegetation grown atop it. It was argued that the clay would be impermeable and the vegetation would cause the flux of moisture in the soil to be upward. In fact the special clay cap material turned out to be SSFL soil from near the burn pit. As a condition of the interim measure, an infiltration monitoring program was established, involving the emplacement and maintenance of devices in the soil fill designed to detect moisture movement. If the theory put forward by Boeing were correct, no moisture should reach the detection devices.

Dr. Bianchi has conducted an examination of these issues, including a review of the annual infiltration monitoring reports. The Panel has requested of DTSC any analysis or evaluation it has conducted of those reports, but we have received no response.

Dr. Bianchi's findings are as follows: First of all, the supposed impermeable clay material is not impermeable at all. It's measured characteristics, as reported in the burn pit interim measures documentation, places it in the silty clay to silty clay loam soil class with water transmitting properties in the class of a poor aquifer, not in the impervious range. The laboratory soil particle size analysis indicates it would not be capable of preventing percolation of rainfall into the crack matrix of the bedrock and thus would not eliminate further downward mobilization of pollutants.

Second, the annual infiltration monitoring reports show that moisture is reaching the detection devices in the fill, which were supposed to remain dry if the fill overburden were performing as advertised.

Third, his experience and the data show the likelihood of fast pathways for water migration that the detectors are unlikely to measure. For example, tree and plant cover roots will cause measurement bias and increase in infiltration over time.

Fourth, Boeing's explanation for why the detectors are seeing water when it was predicted they wouldn't – that rainfall from the area surrounding the burnpit is causing movement of water in the aquifer thus bringing water into the fill – even if true, this is troubling. It means that the fill overburden with vegetation isn't performing as advertised and moisture is continuing to move into the system and carry pollutants further into the fractured bedrock and aquifer. That is what one is trying to prevent.

Dr. Bianchi concludes that Boeing's own data demonstrates that the interim measure for the Area IV burn pit has failed, that moisture is moving through the system and is capable of further mobilizing the pollutants below.

The argument that onsite SSFL soil, with vegetation, prevents rainfall infiltration and thus pollutants can't migrate into groundwater seems demonstrably untrue, particularly in light of these data. If soil and vegetation at SSFL prevented rainfall infiltration, there wouldn't be groundwater at SSFL in the first place – it has to be recharged by infiltration. Secondly, if SSFL soil and vegetation prevented infiltration and thus prevented soil contamination from migrating into the groundwater, there wouldn't be groundwater contamination at SSFL, and there is a great deal.

It is concluded that the existing data strongly support the potential for contamination in the bedrock beneath the burn pit and in the soil over the general area migrating into the groundwater, and indicate that the decision not to provide a RCRA-compliant cap at the Area IV burn pit has not worked as advertised. The proposal to not cap the Area I burn pit is called into question by these data as well.

4. *Migration of SSFL Perchlorate Contamination Offsite* by Ali Tabidian, Ph.D.

Dr. Tabidian is Chair of the Department of Geological Sciences at the California State University at Northridge. He has examined the prospect for transport of contaminants, particularly perchlorate, at SSFL offsite via surface water runoff.

Perchlorate is a component of rocket fuel and was used in large amounts at SSFL. Nearly a ton alone was disposed of by open-air burning in the Area I burn pit. Significant concentrations of perchlorate remain in soil and groundwater at SSFL. It is extremely soluble, and migrates rapidly with water. It is toxic, disrupting thyroid function in adults and interfering with development in the young. Because of its rapid migration, it also provides important indications of the potential pathways by which other, slower-moving contaminants may follow the leading edge of perchlorate transport.

At the beginning of this study, more than five years ago, Dr. Tabidian predicted that surface water pathways could have allowed perchlorate to migrate off siteSSFL in runoff, travel to Simi Valley, percolate into groundwater, and contaminate Simi Valley wells. Perchlorate was initially found in a dewatering well in the eastern part of Simi Valley; subsequent tests found, as Dr. Tabidian had predicted, perchlorate in many more wells. Approximately a quarter of tested wells tested positive for perchlorate.

Dr. Tabidian's model is that perchlorate migrated off the SSFL site via surface water runoff, over the hard rock of the mountain, until it reached the alluvium of the Valley floor. There it migrated via the Arroyo Simi and percolated into the groundwater beneath and near the Arroyo, which is where the perchlorate has in fact been showing up.

Dr. Tabidian conducted extensive analyses of the history of groundwater level fluctuations in Simi Valley, influenced by water usage, which initially caused a significant drop in water level. Later, imported water was brought in to Simi to supplement groundwater use, reducing extraction, and water levels began to rise again. This pattern helps explain the distribution of perchlorate. Dozens of violations of Rocketdyne's NPDES permit in recent years, including for perchlorate, indicate numerous pathways for contaminated surface runoff to offsite areas.

Dr. Tabidian examined the alternative explanations for the Simi perchlorate contamination put forward by Rocketdyne. These include possible use of Chilean fertilizer, which contains perchlorate; fireworks; and flares. A careful analysis of each claim demonstrated that none are likely. EPA has found that 99% of fertilizers contain no perchlorate, and if fertilizer were the cause, one would find perchlorate in all wells, not just the ones along the pathway predicted by Tabidian if it were coming from SSFL. Similarly, fireworks and flares are ubiquitous; if they were the source, virtually all water sources would be contaminated with perchlorate. Again, the distribution in Simi argues against a general source such as flares and fireworks. The only known major user of perchlorate is SSFL; the site has extensive perchlorate contamination; it is on a mountaintop which drains towards Simi; and the pathway of such drainage would result in the pattern of perchlorate contamination found in Simi.

Similarly, Dr. Tabidian examined the finding of perchlorate in Dayton Canyon and the alternative explanations put forward. Dayton Creek begins at SSFL in Happy Valley, which was significantly contaminated with perchlorate, and travels downstream through the Dayton Canyon property found also to be contaminated with perchlorate. Again, SSFL is the only known major user of perchlorate; it had contaminated the headwaters of Dayton Creek, upstream of where the perchlorate in Dayton Canyon was found. Although other explanations are possible, SSFL remains the likely cause of this contamination as well.

Perchlorate may, Dr. Tabidian has said, be viewed as the canary in the mine, as it moves faster than many of the other contaminants at SSFL. The pathways indicated by perchlorate detections offsite thus may indicate pathways for other contaminants as well.

5. GEOLOGIC FEATURES AND THEIR POTENTIAL EFFECTS ON CONTAMINANT MIGRATION, SANTA SUSANA FIELD LABORATORY BY HOWARD WILSHIRE, PH.D.

Dr. Wilshire spent his career as a research geologist at the United States Geological Survey. The Panel asked him to examine the geology of the SSFL site and in particular, evaluate claims by Rocketdyne that contaminated groundwater at the facility could not migrate because of earthquake faults and fine-grained units that would act as barriers to groundwater movement.

Dr. Wilshire summarizes his study as follows:

> The Santa Susana Field Laboratory (SSFL) site is located on the upper part of a small mountain range, and flanked by populated areas at lower elevations. The SSFL's operations have led to widespread, heavy contamination of soils, rock, and groundwater at the site. Central questions are whether the contamination has been, or can be, contained on-site, and the possibility of polluting local water supplies for surrounding communities. This report focuses on the geologic evidence for on-site containment of pollutants, and is based largely on reports commissioned by Rocketdyne and publications in the open literature based on those studies.[1] Many of these reports contend that natural geologic barriers prevent off-site migration of contaminants in groundwater. The geologic features proposed to constitute aquitards--barriers that greatly retard the movement of groundwater--include faults, and fine-grained sedimentary rocks that are interleaved with more porous and permeable sandstones.
>
> My review of the Rocketdyne consultants' reports reveals that the preponderance of evidence in those reports contradicts the conclusion that most of the faults and fine-grained units are aquitards. A big weakness in the Rocketdyne consultants' hypothesis is the inferior quality and quantity of field-derived information about the physical character of these features. Both the fault zones and fine-grained rocks are more susceptible to erosion than the coarser-grained sandstones that crop out prominently on the SSFL, and so are not as well exposed. But the descriptions of existing outcrops and other exposures, as well as the data in numerous well logs, directly contradict claims that the faults and fine-grained units are barriers to groundwater migration.
>
> All of the reports I reviewed suppose that rainwater moves to the water table mainly through fractures in hard rock lying beneath surficial sediments. Movement of groundwater below the water table also takes place in fractures rather than through the body of the rock, as would be

> expected for layers of very porous and permeable unfractured aquifer rocks. All rock types at the site are fractured, including fine-grained layers. Most of the faults comprise zones of open fractures along with some occasionally occupied by finely-ground rock gouge, which could locally impede groundwater movement. Fractures in fault zones and those cutting fine-grained units show evidence of circulation of meteoric water, that is water of recent atmospheric origin. Thus, the evidence strongly favors transmission of water, with or without contaminants, preferentially through many fractures rather than by percolation through the body of the rock. The fractures associated with faults and in fine-grained units are just as capable of transmitting water as fractured sandstone.
>
> I conclude that Rocketdyne's model of compartmentalized groundwater units bounded by faults and fine-grained units, which are supposed to prevent contaminated groundwater from moving to surrounding areas, is not supported by the preponderance of evidence and cannot be considered viable. The presence of faults and fine-grained rock units on the SSFL site does not eliminate the possibility for off-site subsurface contaminant migration.

Rocketdyne has argued that there is no risk of movement of contaminated groundwater at and from SSFL and that there is no need for the company to have to clean it up. That position is based in part on the claims discussed above by Dr. Wilshire and at length in his study. Rocketdyne has also argued that TCE and perchlorate are held up in the rock matrix of the sandstone at SSFL and thus cannot move. A recent study by a UCLA team disputes that assertion as well.[23] Dr. Thomas C. Harmon, now at UC Merced, experimentally tried to get TCE into the rock matrix of a sample of SSFL sandstone; very little was absorbed. He concluded that "there is potential for long-term exposure to TCE if contaminated groundwater will come into contact with human and ecological receptors."

In short, the large amount of toxic material contaminating groundwater at SSFL, some of which has moved offsite, poses a long-term problem. The geological features of the site do not prevent the migration of the contaminated groundwater.

6. *LOSS OF INNOCENCE* BY DAWN KOWALSKI, HOLLY HUFF, MARIE MASON, AND BARBARA JOHNSON

The SSFL Panel's work was initiated by local concerned community members, who supported and guided the project all along the way. In addition to technical studies by scientists, the Panel wanted a paper by the real experts about many of the human impacts of living near SSFL. Dawn Kowalski, Holly Huff, Marie Mason, and Barbara Johnson have lived much of their lives in the shadow of the site. Their children have played in the streams that drain off the mountain. They breathe the air the blows across it. And they have lived with the uncertainties, with the frustrations of dealing with the operator of the site and the agencies that are supposed to protect them from it.

Their paper, as the title indicates, documents their self-described loss of innocence through the years of dealing with SSFL. And yet, the best measures available for providing protection from possible future health impacts associated with continued contamination from SSFL come from a concerned, committed, educated, and persistent community.

These studies were triggered by the community, and we hope they will be helpful to the community.

CONCLUSION

This report and the individual reports associated with it are being issued in draft so that the community and other interested parties may comment on them before being finalized. All of the reports are available at http://www.ssflpanel.org, as is information as to how to submit comments. The Panel will take those comments into account before issuing its final conclusions.

ENDNOTES

[1] H. Morgenstern, J. Froines, B. Ritz, and B. Young, *Epidemiological Study to Determine Possible Adverse Effects to Rocketdyne/Atomics International Workers from Exposure to Ionizing Radiation,* June 1997; posted at http://www.ssflpanel.org; B. Ritz, H. Morgenstern, J. Froines, and B. Young, "Effects of Exposure to External Ionizing Radiation on Cancer Mortality in Nuclear Workers Monitored for Radiation at Rocketdyne/Atomics International," *Am. J. Ind. Med.* **35**, 21-31 (1999); B. Ritz, H. Morgenstern, D. Crawford-Brown and B. Young, "The Effects of Internal Radiation Exposure on Cancer Mortality in Nuclear Workers at Rocketdyne/Atomics International," *Environ. Health Perspect.* **108**, 743-751 (2000), available at http://www.ehponline.org/members/2000/108p743-751ritz/ritz-full.html (accessed last 10/1/06); H. Morgenstern and B. Ritz, "Effects of Radiation and Chemical Exposures on Cancer Mortality Among Rocketdyne Workers: A Review of Three Cohort Studies," *Occup. Med.* **16**, 219-237 (2001).

[2] H. Morgenstern, J. Froines, B. Ritz, and B. Young, *Epidemiologic Study to Determine Possible Adverse Effects to Rocketdyne/Atomics International Workers from Exposure to Selected Chemicals,* January 1999, available at http://www.ssflpanel.org .

[3] Boeing, Site Environmental Report for Calendar Year 2005, September 2006, p. 5-22; based on 2000 figures.

[4] NAA-SR-30, *General Reactor Site Survey of the Los Angeles Area,* U.S. Atomic Energy Commission, June 1, 1949.

[5] *ibid.*, p. 10

[6] Many years later, when contamination was found on the Brandeis property and a lawsuit ensued, Rocketdyne as part of the settlement purchase some of the contaminated land, which is now a buffer zone. However, even today that buffer extends far less than 1.4 miles from the reactor area.

[7] NAA-SR-MEMO 3757, *Release of Fission Gas from the AE-6 Reactor*

[8] NAA-SR-5898, *Analysis of SRE Power Excursion;* NAA-SR-4488, *Fuel Element Damage;* Thompson and Beckerley, USAEC, *The Technology of Nuclear Reactor Safety*

[9] NAA-SR-MEMO-12210 *SNAP8 Experimental Reactor Fuel Element Behavior: Atomics International Task Force Review;* NAA-SR-12029, *Postoperation Evaluation of Fuel Elements from the SNAP8 Experimental Reactor*

[10] AI-AEC-13003, *Findings of the SNAP 8 Developmental Reactor (S8DR) Post-Test Examination*

[11] NAA-SR-1941, Sodium Graphite Reactor, Quarterly Progress Report, January-March 1957, emphasis added

[12] Rockwell International, *Nuclear Operations at Rockwell's Santa Susana Field Laboratory – A Factual Perspective*, September 6, 1991

[13] McLaren/Hart Environmental Engineering Corporation, *Multi-Media Sampling Report for the Brandeis-Bardin Institute and the Santa Monica Mountains Conservancy, Volume I, Final Report*, March 10, 1993.

[14] California Department of Toxic Substances RFI data; Boeing NPDES Quarterly Monitoring Reports

[15] For a detailed description of the SRE accident, see the study prepared for the Panel by David Lochbaum, *An Assessment of Potential Pathways for Release of Gaseous Radioactivity Following Fuel Damage During Run 14 at the Sodium Reactor Experiment*, available at the Panel's website, http://ww.ssflpanel.org

[16] T. J. Thompson and J. G. Beckerley, *The Technology of Nuclear Reactor Safety*, prepared under the auspices of the US Atomic Energy Commission, 1964, emphasis added.

[17] See, e.g., the study of this sad history in H. Jack Geiger, David Rush, and David Michaels, *Dead Reckoning: A Critical Review of the Department of Energy's Epidemiologic Research*, a Report by the Physicians Task Force on the Health Risks of Nuclear Weapons Production, Physicians for Social Responsibility, Washington, DC 1992. (Two of the authors, Drs. Geiger and Michaels, took turns serving as co-chairs of the SSFL Panel. Dr. Michaels subsequently served as DOE Assistant Secretary for Environment, Safety and Health.) Also see, Wilkinson, GS. Seven years in search of alpha. **Epidemiology** 1999;10:340-344

[18] See testimony of James C. Warf, Daniel Hirsch, and W. Jackson Davis, in *N-Reactor at Hanford Reservation, Washington: Safety and Environmental Concerns*, Oversight Hearings before the Subcommittee on General Oversight, Northwest Power, and Forest Management of the Committee on Interior and Insular Affairs, House of Representatives, May 19, 1986.

[19] We note that Rocketdyne, the DOE contractor at SSFL, shortly after release of the independent UCLA studies, hired a contractor to perform a study for Rocketdyne. Because of the Rocketdyne sponsorship, this was widely viewed as of questionable independence and likely to produce a pre-ordained outcome. The Rocketdyne study, as expected, concluded Rocketdyne's activities had not harmed its workers. Serious methodological problems with the study led to conclusions at variance with those of the independent UCLA group.

[20] Gregg Dempsey, Office of Radiation Programs, US EPA, *Site Visit to Santa Susana Field Laboratory Operated by Rockwell/Rocketdyne*, July 28, 1989

[21] Dempsey presentation before SSFL InterAgency Work Group, March 16 2005.

[22] However, in the course of this research, we learned that Atomics International claimed that at the time of the SRE accident, it was operating only at $1/20^{th}$ of full power. As discussed elsewhere in this report, the Panel is not confident in this assertion. But if true, it is possible that the radioiodine release from the two SNAP reactor accidents might have been larger than the SRE event. The SNAP reactors were about the power that AI claims SRE was running at when the partial meltdown occurred; the SNAP accidents occurred over many months, providing a long period for continued radioactivity release; and the fraction of fuel damaged was, for the SNAP8DR, equal to, and for the SNAP8ER two and a half times greater than at SRE.

[23] Yoram Cohen et al., *The Potential for Offsite Exposures Associated with Santa Susana Field Laboratory, Ventura County, California,* Report Prepared by the Center for Environmental Risk Reduction, UCLA, February 2006.