REPORT OF JOHN R. FRAZIER, Ph.D.
Certified Health Physicist
November 4, 2006

I. INTRODUCTION

At the request of The Boeing Company, I have reviewed extensive information pertaining to the radiological aspects of an incident that occurred in 1959 involving the Sodium Reactor Experiment (SRE) at the Santa Susana Field Laboratory (SSFL). I have also been asked to review the October 5, 2006 reports of Dr. Jan Beyea (Beyea 2006) and David A. Lochbaum (Lochbaum 2006) to the SSFL Advisory Panel and provide my professional opinions regarding the scientific and technical content of those two reports.

In the following report, I present a summary of my qualifications to give opinions in this matter, the opinions that I have formed regarding the radiological issues associated with the 1959 SRE incident and the bases of those opinions, and the scientific and technical content of the reports of Dr. Beyea and Mr. Lochbaum.

II. QUALIFICATIONS

My qualifications are detailed in the attached Curriculum Vitae (Attachment A). My area of expertise is health physics. Health physics is the scientific discipline of measuring radiation and protecting people from the harmful effects caused by high doses of radiation. My academic degrees include a B.A. in physics, M.S. in physics, and Ph.D. in physics (with emphasis in health physics and radiation protection). I have over twenty-nine (29) years of professional experience in health physics, primarily in the areas of environmental radiation dose assessment and exposure pathways analysis, external and internal radiation dosimetry, environmental sampling and analysis, and radiation detection and measurement. I have received Comprehensive Certification by the American Board of Health Physics (ABHP) and am a member of the American Academy of Health Physics. The term "Certified Health Physicist" is a certification mark that may only be used by individuals who have received Comprehensive Certification by the ABHP. Certification in health physics by the ABHP is the same as professional certification by other recognized professional organizations, such as certification in diagnostic radiological physics by the American Board of Radiology. I am an elected member of the National Council on Radiation Protection and Measurements (NCRP) and a Fellow and Past-president of the Health Physics Society. I have extensive experience performing environmental exposure pathway analyses and radiation dose assessments for man-made radioactive material and naturally-occurring radioactive material. I have performed numerous assessments of radiation doses and human

health risks from real or hypothetical environmental and occupational exposures to a variety of radioactive materials in several physical and chemical forms. Those dose and risk assessments have included, but were not limited to, human exposures to fission products, activation products, and naturally-occurring radioactive material.

III. DOCUMENTS REVIEWED

Specific documents that I have reviewed pertaining to the radiological aspects of the 1959 SRE incident are listed in Attachment B. I have not listed the numerous general reference documents with which I am familiar (and on which I base many of my opinions) that pertain to the following topics: identities, amounts, and physical/chemical properties of radioactive material at nuclear reactor facilities; ventilation and air filtration systems used at nuclear facilities; environmental fate and transport modeling; sampling and analysis of radioactive material in environmental media; exposure pathways analysis and radiation dose assessments; and human health risk assessment and the bases and use of risk coefficients.

IV. 1959 SRE INCIDENT AT SSFL

After carefully reviewing the documents listed in Attachment B, I conclude that the following statements pertaining to radiological aspects of the 1959 SRE incident are true and accurate:

A. Potential radiological impacts of the 1959 SRE incident were assessed in a timely manner soon after the incident using actual measurement data and first-hand knowledge of those who were present at the time of the incident.

On July 29, 1959, only three days after the Sodium Reactor Experiment (SRE) was shut down at the end of power run 14, Atomics International formed an eight-member ad hoc Committee to assist in analysis of the problem within the reactor and determine the origin of the problem. The Committee was also charged with reviewing and advising on steps to remedy the problem and bring the reactor back into operation, including making recommendations for any necessary changes in operating procedures or reactor system to prevent occurrence of a similar problem. Reactor operations data were re-examined and evaluated. Metallurgical and chemical analyses of reactor components were performed. A radiological characterization of the coolant and gaseous activity was performed. After approximately three months of gathering and evaluating data pertaining to the incident, the Committee issued an interim report that described the origin, the nature and consequences of the damage the SRE fuel from the incident (AI 1959).

Throughout the following year, a more detailed evaluation of individual components of the reactor was performed. The sodium coolant was drained and a detailed analysis was

performed to determine the amounts of insoluble contaminants and fission products in the coolant. Fuel elements were removed and inspected. The reactor was surveyed and cleaned. Damaged moderator assemblies were removed and replaced. Piping and equipment were also cleaned. Additionally, detailed metallurgical, chemical, or radiological examinations were performed of the fuel, moderator cans and other components of the reactor. In 1961, the Committee completed its investigations and issued its final report that revised and supplemented its interim report (AI 1961).

B. The assessments of potential radiological impacts that were made following the incident showed that there were no radiological hazards to the environment.

The 1959 interim report by the ad hoc Committee prepared soon after the incident concluded that "no radiological hazard was present to the reactor environs." (AI 1959 at p. I-2). The 1961 final report of the ad hoc Committee described their investigation and presented conclusions regarding the causes and consequences of the fuel element damage (AI 1961). Radiological conditions in the surrounding environment were monitored during the investigation of the incident and the 1961 report noted that "[c]ontinued routine monitoring of soil, vegetation, water, and air revealed no increase in background radiation levels." (AI 1961 at p. III-21) The final report also concluded that:

> "In spite of the cladding failure to 13 fuel elements and the release to the primary coolant of several thousands of curies of fission product activity, no radiological hazard was presented to the reactor environs."

The Committee performed a final review of the causes and effects of the fuel damage, the modifications that were made in the reactor system, and the changes in operating procedures and management. Based on that review the Committee recommended approval for operation and the SRE was returned to operation on September 7, 1960.

C. The identities, locations, and amounts of fission products in the sodium coolant, cover gas system, and other components of the primary system were studied extensively soon after the incident.

An assessment of the locations and amounts of fission product contamination in the SRE was performed soon after the incident. Fission product release and distribution data were compiled during the time between the incident in July 1959 and the restart of the reactor in September 1960. The report of that study was prepared by R.S. Hart of Atomics International and issued on March 1, 1962 (AI 1962). Several of the conclusions of that report are significant.

For example, the report noted that only isotopes of xenon (Xe) and krypton (Kr) were found in the cover gas (helium) (AI 1962). The assessment also found that a carbonaceous particulate material in the sodium effectively scavenged fission products from the sodium. In addition, it was found that "[t]he cold trap in the primary system was effective in removing fission product contamination" from the sodium (AI 1962). The design and operation of the reactor was such that "[a]lthough 5,000 to 10,000 curies of fission product activity was unexpectedly released to the primary sodium coolant system, no radiological emergency of any nature occurred" (AI 1962). The limited amount of fission products released into the sodium coolant during the incident and the effectiveness of the coolant cleanup components combined to allow continued use of the same sodium that was in the reactor during the incident (AI 1962).

D. Studies of the radioactivity released from the SRE reactor during the 1959 incident, including measurements of radioactive material in and around the reactor, show that only inert (noble) gases (isotopes of krypton and xenon) were released during the incident and that no radioiodine or radiocesium was released to the environment.

The only transport pathway for radioactive material (fission products) from the SRE reactor fuel to the offsite environment initiated with release from the fuel into the sodium coolant, followed by release from the coolant into the helium gas that covered the coolant. Measurements of the identities and amounts of fission products in the sodium coolant and in the helium gas following the 1959 incident showed that although numerous fission products were within the sodium coolant only isotopes of the inert (noble) gases krypton and xenon were present in the helium cover gas (AI 1961; AI 1962). The measurements made in 1959 and thereafter clearly show that the sodium coolant retained the fission products except for the noble gases krypton and xenon that were released into the helium cover gas. Most of the krypton and xenon was contained in storage tanks and held until it underwent radioactive decay, but some of these inert gases escaped into the offsite environment. The potential radiation dose from the released krypton and xenon was a small fraction of the radiation dose that is received from natural background radiation in any day.

E. There were multiple components of the SRE that contributed to containment of radioactive material within the SRE facility. At commercial power reactors (light-water reactors), the reactor building is a containment pressure vessel that encloses the reactor and many related components and is necessary for containing high pressure gas releases that might occur during an accident in those reactors. Because the fundamental design of the SRE prevents generation of high volumes of gas (i.e., steam) during routine operations or during incidents (such as the 1959 incident), it was unnecessary for the reactor building at the SRE to be a containment pressure vessel.

The SRE reactor building was not designed as a containment pressure vessel, because the maximum credible accident that could have occurred at the SRE would not cause a release a high volume of gas (such as steam) that would require pressure containment. The SRE was designed to retain gases at about atmospheric pressure and reduce leakage of potentially contaminated gases from the facility to the environment by maintaining the reactor building at a pressure slightly lower than the outdoor air (i.e., it was maintained at slight negative pressure). Containment of radioactive material at the SRE was assured through multiple components that were integral part of the reactor design. The components that contain radioactive material within the SRE reactor and its associated structures include the fuel, fuel elements, cavity liner and cover shields, sodium coolant, helium gas cover of the coolant, nitrogen gas cover of other components, reactor building, shielded gas storage vaults, gas storage tanks, and exhaust air filtration systems. The absence of any releases of radioactivity other than the inert gases krypton and xenon from the SRE reactor during the 1959 incident confirmed the SRE contained radioactive material as it was designed.

F. Over the 47 years since the SRE incident additional assessments of offsite releases and/or radiation doses to offsite personnel have been made and <u>none</u> of the assessments based on actual SSFL-specific measurement data have changed or modified the conclusion of the 1961 final report that "no radiological hazard to offsite persons was present."

Although assessments of offsite releases and radiation doses to offsite personnel from the 1959 SRE incident have been performed in recent years in association with litigation related to the SSFL, all of the assessments that used site-specific measurement data reached the same conclusion as the 1961 final report (AI 1961) that the 1959 SRE incident did not produce any radiological hazard to offsite persons. Other assessments I have reviewed of releases of radioactive material from the 1959 SRE incident have in my opinion ignored the science and experimental facts pertaining to the design and operation of the SRE and the measurements following the 1959 SRE incident, and base their assessments on speculative theories that are unsupported by science or measurement data.

G. Concentrations of radioactive cesium in surface soil have been measured at numerous locations surrounding the SRE site since the incident in 1959. The results of those soil measurements show that there are no areas in the vicinity of the SRE site having radioactive cesium greater than amounts due to fallout from atmospheric weapons testing. Measurements of radioactive cesium in soil in the environs of the SRE do not indicate or suggest in any way that radioactive cesium was released to the environment during the 1959 incident.

If there had been a release of significant quantities of radioactive cesium to the air as a consequence of the 1959 SRE incident there would have been (and would continue to be) elevated concentrations of radioactive cesium in surface soil in the vicinity of the SRE site, with the highest concentrations near the site boundary and concentrations decreasing with increasing distance from the site. Soil sampling at the SRE site and in the surrounding areas was performed after the 1959 incident, with no elevated concentrations of radioactive cesium being present in those samples (AI 1961). Additional soil sampling and radiation measurement studies have been performed in the environs of the SRE throughout the intervening years since the incident and none of the data from those studies indicate any radioactive cesium greater than amounts due to fallout from atmospheric weapons testing (EGG 1979; McLaren 1993; McLaren 1995; Hamilton 1997; Ogden 1998; USEPA 1998a; USEPA 1998b; and QST 1999).

H. Because there were no releases of radioactive cesium or radioactive iodine from the SRE to the offsite environment during the 1959 incident there were no radiation doses or adverse health risks from those materials to anyone offsite.

Assessments of exposure pathways, radiation doses, and cancer risks to offsite individuals from radioactive cesium and radioactive iodine released offsite as a consequence of the 1959 SRE incident should conclude necessarily that there were no offsite radiation doses and no increased health risks from those materials from the incident. Simply stated, with no releases of those radioactive materials offsite there was no offsite exposure, dose, or cancer risk from them.

V. OCTOBER 5, 2006 REPORT OF JAN BEYEA, Ph.D.

The report of Jan Beyea, Ph.D., to the SSFL Advisory Panel, dated October 5, 2006, includes numerous statements unrelated to science, engineering, or the technical aspects of assessing offsite exposures, doses, and human health risks from the 1959 SRE incident (Beyea 2006). I have prepared the following comments and conclusions regarding the specific sections of Dr. Beyea's report pertaining to radioactive materials releases, transport and offsite dose calculations, and human health risk assessment. It is important to note at the beginning of this section that Dr. Beyea states in his report "… the estimates in this report are limited to scoping calculations that carry a wide range of uncertainty, complicating their use for estimation of statistical power." (Beyea 2006 at p. 4).

A. Release Estimates

Dr. Beyea bases his determination of the amount of radioactive material released during the 1959 SRE incident on his own method of comparing release estimates prepared previously by

five (5) individuals or organizations, giving a weight to each of those estimates that he somehow determines. This method of determining the most accurate value of any parameter is without scientific basis or merit. He selects release estimates from individuals or organizations without examining the basis, assumptions, and limitations of each of those estimates. He admits that his selection of the release estimates is non-random (Beyea 2006). However, a review of the origin of the release estimates shows that his selection is in fact biased toward the estimates of the greatest amount of radioactive material released from the site. Those estimates of large releases are based on flawed and unsupportable assumptions regarding the fundamental science of the SRE design and operation. Moreover, the estimates of large releases ignore the detailed release estimates made soon after the incident using actual site-specific measurement data and first-hand knowledge of those who were present at the time of the incident.

From the results of the release estimates that he selects, Dr. Beyea presents his mathematical "analysis" in which he calculates the "statistical parameters" associated with the combined estimate. This attempt to lend technical credibility to his release estimate is disingenuous, without scientific basis, and blatantly misleading. Through application of his own method for estimating the amount of radioiodine released to the offsite environment, he arrives at an estimate of from 0 to several thousand curies released to the offsite environment due to the 1959 SRE event.

The scientific approach that Dr. Beyea should have used to determine releases from the SRE site is the accepted method whereby the "source term" for releases to offsite areas is determined from site-specific measurement data (if available) or through calculations based on relevant, site-specific parameters. This accepted method provides deterministic values of the identities, amounts, and concentrations of radioactive material released during an event. This accepted method is that which was used in the release calculations soon after the 1959 SRE incident (AI 1961). This scientific method for determining the source term for the 1959 SRE incident was also used by defense experts (Christian 2005; Daniel 2005) in the recent litigation pertaining to the SSFL [O'Connor v. Boeing]. The approach used by Christian and Daniel for determining the "source term" for the 1959 event incorporated site-specific facility design parameters, operations history, and measurement data obtained during and following the event. The results of Christian's detailed analyses of the event based on extensive theoretical and measurement data show that radioiodine was retained in the reactor and was not released to the offsite environment (Christian 2005).

Beyea also applies his method for estimating the amount of radioactive cesium (specifically cesium-137) released to the offsite environment from the 1959 SRE event. He arrives at an estimate of from 24 curies to 2,400 curies released to the offsite environment due to the 1959 SRE event (Beyea 2006). A release of such large amounts of cesium-137, if indeed it

had occurred, would have been detected at the time of the event in measurements of radioactivity in the helium cover gas and other components of the SRE, in environmental samples following the event, and in surface soil in the area surrounding the SSFL even today. The presence of quantities of cesium-137 that would indicate a release to the atmosphere was not observed in any of the relevant measurements and analyses at the time of the event or in the years that followed. The absence of elevated levels of cesium-137 in surface soil in the environs of the SRE site is discussed in Section IV.G.

B. Dose Estimates

In Chapter 3 and Appendix 2 of his report, Dr. Beyea presents the methodology and results of his calculations of radiation doses from iodine-131 and cesium-137 from the 1959 SRE incident. He uses radionuclide fate, transport, and dispersion models and parameters that overestimate offsite concentrations. He then assumes exposure assessment pathways and parameter values that overestimate offsite doses (Beyea 2006 at Appendix 2). He presents tables of thyroid doses to offsite residents that are based on offsite releases of 10,000 curies and 20,000 curies of iodine 131 – hypothetical amounts that are unrealistically high and unsupported by the data. (As noted in preceding sections of this report, assessments performed soon after the 1959 SRE event showed that there was no release of radioiodine to offsite areas.) Even with the very large activity Dr. Beyea uses as input to his offsite dose calculations for various distances, the individual thyroid doses to members of the public that he calculates are comparable to the annual dose that one receives in a year from natural background radiation sources in California – a small radiation dose.

Dr. Beyea's tables of radiation doses from cesium-137 are based on releases of 300 curies and 600 curies to offsite areas from the 1959 SRE incident. As noted previously in this report, such large releases of cesium-137 did not occur, were not indicated by measurements at the time, and are not indicated by soil sampling data even today. Although Dr. Beyea uses release estimates of a large quantity of cesium-137 to calculate the offsite doses from cesium-137, the resultant annual radiation dose from cesium-137 that he calculates is less than the dose each resident of the U.S. receives from natural background radiation sources.

Based on his own calculations of releases of radioiodine and radioactive cesium from the 1959 SRE incident, Dr. Beyea calculates offsite radiation doses that are within the range of natural background radiation doses in the U.S. As noted previously in this report, there was no radioiodine or radioactive cesium released offsite and, hence, there would have been no offsite radiation doses to anyone from radioiodine or radioactive cesium from the 1959 SRE incident.

C. Projected Health Effects

The key to Beyea's assessment of potential health effects is his calculation of collective (population) doses. He first calculates a radiation dose (in the radiation dose unit rem) for hypothetical persons (with undefined population and exposure characteristics) within each of 96 specific geographic areas (sectors) from the SRE site boundary to beyond 100 kilometers (approximately 62 miles) from the site. He then multiplies each sector-specific dose by the total population within that sector (as of 1960) to calculate the collective dose (person-rem) for each sector. Finally, he adds the collective doses for all 96 sectors to arrive at the population dose that he uses to assess a number of cancers that he claims would be due to the 1959 SRE event.

As noted in the preceding section, the radiation doses that Dr. Beyea calculates are very low, especially for locations more distant from the SRE site. However, the populations in many of those distant sectors are very large. Therefore, even though the doses he calculates are very low (within the variations of natural background doses), the collective (population) dose that he calculates appears to be very large because he includes distant locations having very large populations with very low doses. It is only through such calculations of multiplying very small doses (fractions of rem) by very large populations that he can arrive at large values of collective doses (person-rem).

The preeminent international radiation protection organization, the International Commission on Radiological Protection [ICRP], reports that the method of multiplying very low doses by very large populations to calculate and interpret collective dose (the very method used by Dr. Beyea) is inappropriate and is not a valid predictor of adverse health effects from very small doses (such as the doses calculated by Dr. Beyea). The ICRP notes that collective dose is not intended as a tool for epidemiologic risk assessment and it is therefore inappropriate to use it in risk projections based on epidemiologic studies.

As noted in the preceding section, Dr. Beyea calculates very low doses to offsite individuals as a consequence of the 1959 SRE incident, even though he incorporates assumptions of large release quantities and environmental exposure assessment parameters that maximize his calculated doses. Several organizations have addressed the inappropriateness of calculating health risks at such low doses. For example, the Health Physics Society (the 6,000-member professional organization of radiation safety professionals) issued a Position Statement in 1996 (revised in 2004) entitled "Radiation Risk in Perspective" (HPS 2004). The following is an excerpt from that statement.

> "In accordance with current knowledge of radiation health risks, the Health Physics Society recommends against quantitative estimation of health risks below an individual dose of 5 rem in one year or a lifetime dose of 10 rem above that received from natural sources. Doses from natural background radiation in the United States average about 0.3 rem per year. A dose of 5 rem will be

> accumulated in the first 17 years of life and about 25 rem in a lifetime of 80 years. Estimation of health risk associated with radiation doses that are of similar magnitude as those received from natural sources should be strictly qualitative and encompass a range of hypothetical health outcomes, including the possibility of no adverse health efects at such low levels." (HPS 2004)

The radiation doses calculated by Dr. Beyea are less than the doses received from natural background radiation sources. Hence, Dr. Beyea's quantitative calculation of health risks from those doses cannot be supported by the science and, in fact, adverse health risks from such low doses may actually be zero.

VI. OCTOBER 5, 2006 REPORT OF DAVID A. LOCHBAUM

The report of David A. Lochbaum, prepared for the SSFL Advisory Panel, dated October 5, 2006, presents his estimates of the amounts of gaseous radioactivity, especially radioiodine and cesium that was released to the offsite environment from the 1959 SRE event (Lochbaum 2006). I have reviewed Mr. Lochbaum's report and have the following comments and conclusions regarding that report.

A. Gaseous Fission Products That Escaped from the Fuel

Although Mr. Lochbaum is correct in stating that gaseous fission products escaped from the reactor core into the sodium coolant and that some of that gas passed into the helium cover gas or into the high bay area and was released offsite, he fails to note that those gaseous fission products were limited to radioactive isotopes of krypton and xenon. He ignores the measurement data obtained following the 1959 SRE incident that showed that of the fission products present in the reactor core or the sodium coolant, only the inert (noble) gases krypton and xenon escaped into the helium cover gas or the high bay area. Instead, Mr. Lochbaum uses data from another reactor incident, at Fermi I in 1966, to speculate that the amount of gaseous fission products released from the SRE fuel elements into the sodium coolant was significantly higher than the amount released in the Fermi I incident and that the gaseous fission products that were released from the sodium coolant contained large amounts of radioiodine and cesium (Lochbaum 2006 at pp. 14-15). The principal basis for his opinion in this regard is the difference between radiation readings at the two facilities. There can be numerous causes of such differences between readings (e.g., differences in quantities measured, differences in the type and location of the detectors at the two facilities, differences in the range and calibration of those detectors, etc.) that are unrelated to Mr. Lochbaum's conclusion that the SRE event released radioiodine and cesium to the environment.

B. Fraction of Radionuclide Inventory Released Offsite

Mr. Lochbaum notes that noble gases (krypton and xenon) are released relatively quickly from the fuel into the sodium coolant and that because of their very low solubility in sodium they pass rapidly from the sodium coolant into gas space (Lochbaum 2006 at p. 16). However, he fails to note the indisputable scientific facts that radioiodine and cesium are released from the fuel much slower than noble gases are released and the radioiodine and cesium interact with the sodium coolant very efficiently to prevent their escape into any gas space (such as into the helium cover gas). These differences in reactor release rates and retention fractions in the sodium coolant are the very reasons that only krypton and xenon escaped during the 1959 SRE incident and that radioiodine and cesium were not released from the SRE reactor into the offsite environment.

Mr. Lochbaum states that "the data do not permit a quantitative analysis and prompt a turn to a qualitative assessment." (Lochbaum 2006 at p.15). However, he proceeds to calculate (quantitatively) a range of release fractions. He then uses his own "balancing factors" to conclude that a value of 15 % was closer to the actual release fraction for each of those radionuclides (Lochbaum 2006).

C. Consequences of Lochbaum's Release Estimates

If the amount of cesium (specifically cesium-137) indicated by Mr. Lochbaum's calculations had actually been released offsite as a consequence of the 1959 SRE incident, there would have been (and would continue to be) measurable quantities of cesium-137 in the surface soil on and around the SRE site. However, concentrations of cesium-137 in soil have been measured at various times at numerous locations in the environs of the SRE site and none of those samples had concentrations of cesium-137 above the range of soil concentrations due to global fallout from atmospheric weapons testing. Environmental monitoring data clearly show that releases of cesium-137 from the site as claimed by Mr. Lochbaum never occurred.

Prepared and submitted by:

John R. Frazier, Ph.D.
Certified Health Physicist

ATTACHMENT A
CURRICULUM VITAE OF JOHN R. FRAZIER

JOHN R. FRAZIER, Ph.D., CHP

Professional Qualifications

Dr. Frazier has over 29 years of health physics experience in external and internal dosimetry, environmental dose assessment, radiation risk assessment, radiation spectroscopy, health physics training, bioassay, radiation detection and measurement, and radiological site characterization. Numerous federal agencies including the Nuclear Regulatory Commission (NRC), Environmental Protection Agency (EPA), U.S. Department of Agriculture (USDA), U.S. Department of Defense (DOD), and U.S. Department of Justice (DOJ) have sought his advice on a wide range of health physics and radiation protection topics from operational health physics program design to environmental radiation dose and risk assessments. He has also served as a consultant to private companies and individuals on numerous health physics issues. He is an elected member of the National Council on Radiation Protection and Measurements (NCRP). Dr. Frazier has made presentations on introductory and advanced health physics and radiation protection topics for professional society meetings, student groups, and public interest forums. His publications are in the areas of fundamental interactions of radiation with matter, radiation detection instrumentation, radiological site assessments, and external and internal radiation dosimetry.

Education

Ph.D., Physics, University of Tennessee, Knoxville, Tennessee; 1978.

M.S., Physics, University of Tennessee, Knoxville, Tennessee; 1973.

B.A., Physics, Berea College, Berea, Kentucky; 1970.

Registrations/Certifications

Certification by the American Board of Health Physics in 1981; recertified through 2009.

Experience and Background

2004 - *Present* *Independent Health Physics Consultant*

Dr. Frazier provides consultation services on a wide range of radiation protection issues for private companies, government agencies, and individuals. His principal areas of expertise are internal and external radiation exposure assessments, environmental radiation dose and radiological risk assessments from occupational

and environmental exposures, and evaluations and assessments of all aspects of operational health physics programs.

1993 - 2004 ***Senior Radiological Scientist, Auxier & Associates, Inc., Knoxville, Tennessee.***

Dr. Frazier served as senior consultant on radiation protection issues for private companies and government agencies. He performed assessments of internal and external radiation exposures, environmental radiation doses and radiological risks from occupational and environmental exposures. He also performed evaluations and assessments of all aspects of operational health physics programs. Dr. Frazier served as technical advisor to organizations that performed environmental radiological assessments and risk assessments and that provided occupational radiation protection services in government and industry.

1986 - 1993 ***Senior Radiological Scientist, Nuclear Sciences, IT Corporation, Knoxville, Tennessee.***

Dr. Frazier served as senior radiological scientist and technical manager of the health physics consulting group within IT. He was responsible for health physics professional services provided by IT for federal, state, and local agencies, contractors, and private companies. These services included development of all aspects of the health physics programs for nuclear facilities, technical assessments and evaluations of existing health physics programs, and environmental and occupational radiation dose assessments. He served as technical advisor and task manager for radiological aspects of remedial investigations and feasibility studies (RI/FSs). He also served as manager and technical director for specific projects in areas that included design and implementation of environmental monitoring and sampling programs, assessment of operational health physics programs, and radiation dose and risk assessments for occupational exposures and environmental releases. Previous responsibilities included serving as senior technical consultant for upgrading Environmental Health and Safety Programs at the Department of Energy Rocky Flats Plant, Oak Ridge National Laboratory, and the Oak Ridge Y-12 Plant.

1980 - 1986 ***Health Physicist, Oak Ridge Associated Universities, Oak Ridge, Tennessee.***

Dr. Frazier developed and coordinated Oak Ridge Associated Universities (ORAU) health physics training programs. He taught health physics and radiation protection courses for several hundred students each year at ORAU Professional Training Programs. He developed new lectures, laboratory exercises, and training materials for health physics training for the Nuclear Regulatory Commission, Department of Energy, and corporate clients. In addition to his training responsibilities, Dr. Frazier served as division health physicist for the Manpower Education, Research, and Training Division of ORAU. He served as technical consultant to federal and state agencies, other training institutions, and ORAU clientele on environmental, health and safety issues. He evaluated radiation measurement and radiation protection instrumentation equipment.

1978 - 1980 ***Chief Radiation Physics Section, Bureau of Radiological Health, Rockville, Maryland.***

Dr. Frazier supervised research and support activities of a staff of seven health physics professionals and technicians. He planned and implemented radiation research projects pertaining to ionizing radiation detection/ measurement. He scheduled personnel requirements in accordance with the scope of such projects. He coordinated support for external radiation dosimetry by the Radiation Physics Section for all other branches in the Division of Electronic Products. He supervised and performed multi-point calibrations of radiation detection/ measurement instruments per month. Dr. Frazier also assisted in planning radiation dosimetric surveys of large numbers and types of ionizing radiation sources to reduce population exposure. He coordinated environmental radiation dosimetry for extended geographical areas using external radiation dosimeters.

1977- 1980 ***Research Physicist, Bureau of Radiological Health, Rockville, Maryland.***

Dr. Frazier calibrated X-ray detection/measurement instruments. He maintained radiation calibration secondary standards traceable to the National Bureau of Standards. He evaluated new X-Ray detection/measurement instruments with radio-frequency fields under controlled environmental conditions and a wide range of ionizing radiation fields. He also developed external radiation dosimetry techniques with both active and passive dosimeters.

Awards/Activities

Fellow, Health Physics Society, 2000
Elda E. Anderson Award, Health Physics Society, 1988
Senior Technical Associate, IT Corporation, 1988
Distinguished Technical Associate, IT Corporation, 1990
National Council on Radiation Protection and Measurements (NCRP)
Council Member, 2002-2008
Scientific Committee 46, 1999-2006
Scientific Committee 2-1, 2004-2006

Professional Affiliations

Health Physics Society
(Plenary Membership since 1981; President, 2002-3; President-Elect, 2001-2; Board of Directors, 1992-5; Treasurer-Elect, 1997-8; Treasurer, 1998-2000)
American Academy of Health Physics (Secretary, 1996-1997, Director, 1998)
East Tennessee Chapter of the Health Physics Society (Past President)
International Radiation Protection Association (Plenary Membership)

Publications

Dr. Frazier has prepared or contributed to over 100 reports and publications in the fields of health physics and environmental science.

List of Publications

Frazier, J. R., "Negative Ion Resonances in the Fluorobenzenes and Biphenyl" Ph.D. Dissertation, University of Tennessee, Knoxville, Tennessee, 1978.

Frazier, J. R., "Low-Energy Electron Interactions with Organic Molecules: Negative Ion States of Fluorobenzenes," Journal of Chemical Physics, Vol. 69, No. 3807, 1978.

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Frazier, J. R., "A Dosimetry System for Evaluating Chest X-Ray Exposures," HEW Publication (FDA) 79-I 107, 1979.

Film Badge Dosimetry in Atmospheric Nuclear Tests, National Academy Press, Washington, D.C., 1989.

ATTACHMENT B
LIST OF DOCUMENTS

List of Documents Reviewed

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(AI 1961) Atomics International, "SRE Fuel Element Damage – Final Report", NAA-SR-4488 (suppl), 1961.

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(Christian 2005) Jerry D. Christian, Ph.D., "Chemical Behavior of Iodine-131 during SRE Fuel Element Damage in July 1959 Response to Plaintiffs' Expert Witness Arjun Makhijani", May 26, 2005.

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