UNITED STATES
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
SEQUOYAH FUELS CORPORATION	)	Docket No. 40-8027
Sequoyah Facility	)	License No. SUB-1010
I-40 and Highway 10	)	EA 90-158
Gore, Oklahoma 74435	)	

RESPONSE OF SEQUOYAH FUELS CORPORATION
TO THE NUCLEAR REGULATORY COMMISSION'S
NOVEMBER 5 DEMAND FOR INFORMATION

On August 22, 1990, Sequoyah Fuels Corporation (Sequoyah) notified Region IV of the U.S. Nuclear Regulatory Commission (NRC) about elevated levels of uranium that had been discovered in water seepage during the excavation of two underground storage tanks buried adjacent to the Solvent Extraction (SX) building at the company's facility in Gore, Oklahoma. Test results showing an elevated level of uranium had been available to some personnel at Sequoyah since August 7. Apparently concerned about what the agency regarded as a delay in notification as well as a perceived lack of sensitivity to the implications of elevated levels of uranium, the NRC has subsequently conducted extensive inspection activities in connection with the incident and Sequoyah's response to it. The NRC has broadened its examination into a wide-ranging

look at management performance and environmental and safety conditions at Sequoyah. The NRC's inspection activities have included an evaluation by an Augmented Inspection Team (AIT), which reported on the incident and Sequoyah's response on October 11. The NRC's Office of Investigations (OI) is also continuing to inquire into the circumstances surrounding the August 22 report.

On November 5, based on the data collected by NRC inspectors and investigators, the NRC issued a Demand for Information in connection with its on-going inspection activities. In a letter accompanying the Demand for Information, Hugh L. Thompson, Jr., Deputy Executive Director for Nuclear Materials Safety, Safeguards and Operations Support, wrote:

> While these NRC review activities have not been concluded, they have progressed to the point where NRC is concerned that certain aspects of the SFC safety and environmental programs are not operating in full accord with NRC requirements. Therefore, you are required to respond to the enclosed Demand for Information in accordance with the instructions provided therein. This information is necessary to determine whether to modify, suspend or revoke your NRC license, and/or whether to renew your license.

The Demand for Information asks Sequoyah to present within 5 days[1/] description of a program for

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1. The response to the Demand for Information was originally due on November 13. The NRC agreed to meet (continued...)

management oversight to assure the NRC that the facility is being operated effectively and safely "while management deficiencies and weaknesses in the permanent organization are being remedied." (Demand for Information, p. 24). The Demand for Information also asks Sequoyah to agree within 5 days to the concept of an independent comprehensive assessment of all management, staffing, health and safety procedures, and to set forth a plan for such assessment within 30 days. In addition to the information and plans sought, the Demand for Information also presents the NRC's findings and conclusions thus far -- in essence, an interim report -- which are sharply critical of Sequoyah's management and operations.

The August events compelled Sequoyah to engage in an intensive assessment of management and operations at the facility. This assessment has taken several forms. First, Sequoyah created an Interim Compliance Oversight Team (ICOT), led by Dr. Keith Asmussen of General Atomics. Second, Sequoyah hired a respected outside consultant, Dr. James Buckham, to conduct an independent critique of its response to the incidents and events of August. Third,

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1.(...continued)
with Sequoyah to discuss the Demand for Information and related issues on that date, and the meeting occurred at NRC Headquarters on November 13. At the close of the meeting, Sequoyah was given until November 20 to respond to the Demand for Information.

Sequoyah hired environmental consultants, Roberts/Schornick and Associates, Inc. (Schornick) to assist Sequoyah to develop and implement an ambitious and comprehensive plan for a facility-wide environmental assessment. Each of these teams identified steps it believed that Sequoyah's management should take. Sequoyah has committed, either formally or informally, to implement virtually all of these recommendations and to proceed with the environmental assessment proposed by Schornick.

Although Sequoyah is committed to the above program and agrees that its handling of the August situation fell short of the NRC's expectations in some respects, it does not believe that its activities either violated NRC regulations or its license or that the August events threatened worker safety, public health and safety or the environment. Procedures in place and the experience of the people involved at Sequoyah resulted in a solid margin of safety in the August situation and in subsequent incidents.

Sequoyah is striving to meet the NRC's expectations. It hopes that when the agency assesses the full record, the NRC will derive comfort, and regain confidence in Sequoyah's ability to conduct operations in a manner that protects the environment and the health and safety of workers and members of the public.

In this response to the NRC's Demand for Information, Sequoyah (i) presents its view of the incidents and conditions of concern to the NRC, and responds to issues raised in the AIT Report and the Demand for Information; (ii) agrees to the establishment of an oversight program, recommends an appropriate oversight team and discusses how the oversight team would function; and (iii) agrees to an independent management assessment, for which a detailed plan will be submitted according to the time schedule set forth by the NRC.

The Factual Background

General Atomics acquired the Sequoyah facility from Kerr-McGee two years ago. It found the facility to be plagued by a history of regulatory problems and a legacy of environmental problems from past operating practices. In the past two years, Sequoyah's new management has embarked on a program designed to improve management and deal with long-standing waste and environmental issues. In our view, actions taken by Sequoyah prior to August (described in detail below) have greatly strengthened the operations of the facility.

The incident which triggered NRC concern arose from the discovery of contaminated water in an open excavation immediately adjacent to the solvent extraction

(SX) building. The water was observed by workers excavating soil prior to constructing a reinforced concrete vault around two underground storage tanks. The tanks were being encased so that they would no longer be regulated as underground storage tanks under regulations promulgated by the Environmental Protection Agency, as adopted by the State of Oklahoma.

On August 2 when workers at the SX excavation identified some contaminated rocks (total volume, less than two gallons), Mike Nichols, Manager, Health, Safety, and Environment, ordered them collected and placed under waste control. Discolored water was first noticed in the excavation pit on August 4, and tests were ordered at that time. The test results came back on August 7, showing an elevated uranium level of 2.06 grams per liter (g/l). This level is above the restricted area MPC of 1.5 g/l, and significantly above Sequoyah's environmental action level for water of 225 ug/l. Additional tests were ordered and took place on August 6 and 7.[2/]

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2. The NRC has stated that, ". . . Mr. Lacey claims not to have known about any contamination in the excavation until approximately August 17." (Demand For Information, p.15). Mr. Lacey does not recall ever making such a claim. Mr. Lacey has stated that he did not know of high levels of uranium in water (in the grams per liter range) until August 17, when he discussed the matter with Mike Chilton. Mr. Lacey had heard of lower levels of uranium in water (20 mg/l) by August 6 or 7.

Steps began immediately to remedy the situation. Drumming of the water began on August 6. The seepage was briefly discussed at a staff meeting on August 7. Over the next few days, it was determined that a french drain and sump (which was already planned for relief of hydraulic pressure under the vault) would serve to recover seepage. The August 6 and 7 tests, which revealed elevated levels of uranium ranging from 1-8 g/l, were not immediately disseminated within Sequoyah and were not fully discussed by senior management until August 17.[3/] Management

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3. In support of their allegation that Lee Lacey knew about the potential for contamination in the excavation pit prior to the excavation, the NRC has stated:

> ...although Mr. Lacey did not attend a meeting with the Oklahoma Water Resources Board in late July 1990, he was aware that the potential for uranium contamination in the excavation pit had been discussed during that meeting since Ms. Couch, who had attended the meeting, stated that she briefed him on this issue.

(Demand For Information, p. 16).

This statement is inaccurate. On March 6, 1990, Mr. Lacey and Carol Couch met with Tom Springer of the Oklahoma Corporation Commission to discuss closure plans of the underground storage tank ("UST") system. On June 15, 1990, Sequoyah submitted to the Corporation Commission a letter stating that the company planned to begin excavation of the UST system around August 1, 1990. The Corporation Commission delegated regulating authority to the Oklahoma Water Resources Board ("OWRB") on June 19, 1990. On August 1, 1990, Ms. Couch notified OWRB that excavation had begun on the UST system. Sequoyah personnel did not meet with OWRB in July of 1990, and contamination

(continued...)

reached the conclusion that the results warranted informing the NRC, but that they did not require reporting under 10 C.F.R. § 20.403. On that basis, the decision was properly made to formulate a plan to initially assess the extent of migration, if any, and to confer with Reau Graves, President of Sequoyah, when he returned from vacation on August 21. Consistent with that decision, a drilling rig was located to begin the investigation, and the situation was communicated to the NRC on August 22, along with a brief description of Sequoyah's planned initial assessment actions.

I. The uranium levels uncovered in the excavation of the underground storage tanks were not reportable under 10 C.F.R. § 20.403, and posed no threat to workers, public health and safety or to the environment.

Sequoyah's decision to notify the NRC about the elevated levels that had been discovered was not required by law; communications with the NRC were undertaken because, at the NRC's suggestion, the company has tried to establish an informal relationship in which irregularities or significant incidents or conditions are communicated to the agency, even when there is no requirement that reporting take place. Sequoyah recognizes that the NRC's oversight function is furthered if licensees come forward

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3.(...continued)
issues were not discussed by Ms. Couch with OWRB or Mr. Lacey in July.

on an informal basis in unusual situations. The company also believes that such an approach is particularly appropriate given the troubled history of this facility prior to its purchase in November 1988 by General Atomics, and in light of the NRC's proposed rule on reporting of incidents set forth at 55 Fed. Reg. 19890 (May 14, 1990). Indeed, Sequoyah has communicated with the NRC on this basis several times prior to August 22.

As presently drafted, 10 C.F.R. § 20.403 requires immediate[4/] and 24 hour[5/] reporting of specific events

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4. A licensee shall immediately report any event that involves byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause:

   a. Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms of any individual to 375 rems or more of radiation; or

   b. The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II of this part; or

   c. A loss of one working week or more of the operation of any facilities affected; or

   d. Damage to property in excess of $2,000.

   10 C.F.R. §20.403(a).

5. A licensee is required to report within 24 hours any event that involves byproduct, source, or special nuclear material possessed by the licensee that may

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involving byproduct, source, or special nuclear material. Sequoyah management concluded that neither an immediate nor a 24 hour report was required because of the levels of uranium in water in the excavation.[5/] Mr. Lacey conferred

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5.(...continued)
have caused or threatens to cause:

a. Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

b. The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II; or

c. The loss of one day or more of the operation of any facilities affected; or

d. Damage to property in excess of $2,000.

10 C.F.R. § 20.403(b).

6. The NRC has criticized Mr. Lacey, asserting that "his reasons for not reporting to the NRC did not reference any of the reporting criteria." (See, e.g., Demand For Information, p. 17; AIT Report, p.12). This is not correct. Mr. Lacey told Mr. Vasquez that, on August 17, he concluded that the discovery of the elevated levels of uranium was not an "event," and that, in reviewing the reporting criteria, the only criterion which appeared remotely applicable seemed to be 20.403(b)(2):

> The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table III. . .

(continued...)

subsequently with Dr. Keith Asmussen, General Atomics Manager, Licensing, Safety, and Nuclear Compliance, and Laura Quintana, General Atomics Manager, Health Physics, and later with Dr. James Buckham, all of whom concurred with his interpretation that the situation was not reportable under 10 C.F.R. § 20.403.

In this case, potential exposure to uranium in water was several orders of magnitude less than the exposure thresholds noted in 10 C.F.R. §§ 20.401(a)(1) and (b)(1) for any part of the human body. A "release" of radioactive material did not occur; the water was in an excavation, well within the restricted area boundary. Monitor wells several hundred feet downgradient, but still within the restricted areas boundary, did not show elevated levels of uranium. Furthermore, to exceed the release concentration thresholds in Appendix B, Table II (45 mg/l), uranium levels in water would have had to been in excess of 225 g/l (in the case of an immediate report) or 22.5 g/l (in the case of a 24 hour report). The highest single level reported in the excavation was 8.2 g/l uranium, found in a test performed on August 6; the other samples taken

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Mr. Lacey stated to Mr. Vasquez that, since the liquid was contained within the excavation, well within the restricted area boundary, he did not believe a release had occurred.

between August 4 and 17 ranged between 1 and 4 g/l. This discovery did not result in the loss of operation of the facility because the facility was already in a shutdown phase for annual maintenance.[7] Moreover, Sequoyah did not suffer property damage in excess of $2,000. The cost of cleaning up a long-standing condition, whether at the time of decommission or before, should not be regarded as the kind of property damage covered by 10 C.F.R. § 20.403(b)(4).

The NRC has expressed concern about the time which elapsed between the time the tests were done and when they were communicated to management. Sequoyah has changed its procedures to ensure that test results are disseminated promptly and more widely within the organization.

Moreover, the AIT's statement that "no actions were taken to address the contamination concerns" after August 7 (AIT Report, p. 9) is not accurate. As noted above, Sequoyah personnel drummed water pumped from the excavation and modified a french drain to recover some of the contaminated water remaining below ground. While these

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7. Sequoyah believes that the discovery did not constitute an "event" of the sort contemplated by the regulation, which emphasizes accidents, releases and discharges. Rather, it represented the discovery of a condition that had apparently existed for some time, at least back to the mid-1980's, when the floor to the SX Building was rebuilt and reinforced. This basic conclusion---that this condition was not a reportable "event"---was also reached by Dr. Buckham in his evaluation of Sequoyah's entire response to the excavation area situation.

measures may not prove to recover all of the water, even the AIT has recognized that these steps will recover a "relatively large amount." (AIT Report, p. 21). Messrs. Lacey and Chilton immediately followed up on the elevated levels of uranium shown in the test results and determined that, while a report was not required under 10 C.F.R. § 20.403, the NRC should be informed of the situation. Mr. Lacey brought the analyses to Mr. Graves' attention upon his return from vacation and recommended that the matter be communicated to the NRC, which it was.

In addition, the NRC's statement that "No evaluation of the source of the uranium contaminating the water or the potential for release of contamination to unrestricted areas was performed" is also not accurate. (Demand For Information, p. 21). The experience of Sequoyah strongly indicated that the source of the contamination was past operations of the solvent extraction process. The ensuing investigation confirmed this. After developing an initial plan to assess the nature and extent of the problem, Sequoyah contacted the NRC the very next day and explained the situation as well as the company's plan to commence investigatory drilling. In fact, Carol Couch promptly located a drilling rig on August 22 and confirmed its availability the next day so that drilling could begin as early as August 27. Sequoyah's plan was

first to assure that migration of licensed material was limited to the immediate area. Given these and other steps taken by Sequoyah to characterize and mitigate the problem, the assertion that formation of the AIT was compelled by "an apparent lack of awareness as to the potential significance of the elevated concentrations of uranium" is gratuitous. (See, e.g., AIT Report, p. 2; Demand For Information, p. 5). In fact, the conduct of Sequoyah management and staff during this period reflects an awareness grounded in their site-specific experience working with and around uranium.

The AIT and Dr. Buckham, the independent consultant asked to evaluate this incident, have both identified weaknesses in Sequoyah's handling of this incident. They concluded that the response illustrated a lack of communication between different divisions within Sequoyah, arising from an overly compartmentalized view of responsibility. These factors came together in a process by which the test results were not adequately disseminated and shared within the facility. Sequoyah has instituted significant changes in response to these recommendations, which are discussed below.

While there were weaknesses in Sequoyah's handling of this situation, at no time did the elevated

levels of uranium pose any threat to public health and safety. As the AIT report notes:

- "The licensee control of personnel leaving the site, and surveys of equipment and personnel associated with the excavation, indicated that no contamination related to the excavation was allowed off-site."

- "Initial investigations of ground water in the vicinity of the solvent extraction building apparently indicate that contamination to date has not migrated off-site or come in contact with any aquifers that may be used by members of the public."

- "Backfill around pipelines and utility lines in the vicinity of the SX building has apparently served as conduits for the migration of liquids. The licensee has effectively eliminated these pathways by construction of barriers around the lines and installation of upgradient sumps to collect any liquid."

(AIT Report, pp. 20-21). The NRC November 6 press statement underscored the same point, noting that "there is no indication that off-site groundwater or drinking water have been affected."

The AIT found that Health and Safety technicians "provided continuous coverage throughout all phases of the work at the excavation." (AIT Report, p. 8). There is no doubt that Health & Safety personnel were focused intensively on the possibility that an explosion could result from a hexane leak. The AIT found, for example, that Health & Safety technicians carefully monitored each load of dirt being taken out of the excavation with an

explosive meter. Work was halted several times when the meter registered 20% of the Lower Explosive Limit. The AIT also noted that "as excavation activities progressed and after digging procedures were completed, the Health and Safety Department followed their confined space procedure and evaluated oxygen, toxic and explosive hazards during work in the excavation." (AIT Report, p. 8). Health & Safety personnel also directed their attention to taking precautions against falls by personnel who were working at heights of 10-15 feet.

In view of the dangers of a possible hexane explosion, it is logical that personnel focused their attention on the threat to health and safety which presented the highest risk. However, even with the emphasis on the danger of a hexane leak and normal industrial safety hazards, significant steps were taken to prevent any kind of problem that could have resulted from elevated level of uranium:

- When the crew visually discovered some pieces of uranium on the surface, the Manager of Health, Safety and Environment ordered them collected and removed from the site;
- Discolored water was tested immediately on August 4. When the first test result came back, Bob Keihn, the senior engineer on the project, ordered the water to be drummed;
- Health & Safety technicians took air samples on August 3 and 4, which did not show any unusual level of contamination;

- Many soil samples were taken;
- Health and Safety technicians monitored the pit with an alpha survey instrument prior to workers entering the pit;
- Although special urinanalysis of contract workers began on August 22, routine urine samples were taken from Sequoyah personnel working in the excavation prior to August 22; and
- The concrete forms used for the vault wall were carefully surveyed. Some forms were found to be contaminated with uranium. These were decontaminated by hydroblasting and then resurveyed again before release to the contractor.

Thus, as the AIT concluded, there was no danger to public health and safety from the water. There was certainly no basis for the NRC's statement to the public that Sequoyah had released into the groundwater 35,000 times the safe amount of uranium and implying that drinking water in the area might be endangered.[8/] Protecting public health and safety should be the highest priority of both the NRC and its licensees. However, fears that members of the public have about the facility are based on information that is not accurate. As Dr. Buckham concluded, "more damage has been done to the company's

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8. The NRC's public release of the comparison of the uranium concentrations found in the excavation inside the restricted area to the environmental action level of 225 ug/l was inappropriate. The correct comparison would have been to the restricted area MPC of 1.5 g/l natural uranium.

image by the content and format of the NRC announcement than by any SFC action."

II. The circumstances surrounding the sub-floor monitor were also not reportable under 10 C.F.R. §20.403 and posed no threat to public health and safety or to the environment.

NRC, Region IV, officials, as well as OI have also criticized Sequoyah for the manner in which senior officials responded after being informed that there had been historical problems with the floor in the Main Processing Building. On the morning of September 14, 1990, Lee Lacey contacted Bill Fisher at NRC, Region IV, to inform him of the discovery of uranium contaminated water (U=6.2 g/l) in a sub-floor monitor located underneath the Main Processing Building. Mr. Lacey first learned about the presence of the sub-floor monitor on Friday, August 31, 1990 when it was brought to his attention by a former Sequoyah employee after work in a local restaurant. Sequoyah generally, and Mr. Lacey in particular, have been criticized for failing to evaluate the purpose, contents and condition of this sub-floor monitor and inform the NRC of their findings prior to September 14. Sequoyah's position was to add this information to the list of items to be investigated in the short term. However, Sequoyah's failure to report the condition to the NRC earlier neither

violated the reporting requirements of 10 C.F.R. § 20.403 nor posed a hazard to public health and safety or to the environment. The delay also becomes more understandable given the other activities occupying Mr. Lacey and other Sequoyan personnel.

Shortly after hearing of the presence of the sub-floor monitor, Mr. Lacey followed up on the matter with Jim Mestepey and was informed that the sub-floor monitor had been there for several years. While recognizing that the matter should in the near future be evaluated out of concern that there might be contaminated material underneath the floor of the Main Process Building, Mr. Lacey concluded that the sub-floor monitor had been there for an extended period and did not pose any immediate problems. In addition, Mr. Lacey knew that Reau Graves had already notified the NRC about possible contamination under the Main Process Building on or about August 24, and had committed to investigating the matter upon completion of the SX investigation. Accordingly, it was not unreasonable for Mr. Lacey to focus his attention on the imminent concern of the NRC, namely the analysis of the SX excavation. During the evening following the exit interview on September 13, in which NRC officials stressed again the type of conditions about which they wanted to be notified and the need to bring forward information

regarding similar environmental problems due to past practices, Mr. Lacey decided that this was the type of issue that should be brought forward. As a full review of the circumstances makes clear, the timing of the reporting of the sub-floor monitor reflected a willingness to respond to Mr. Beach's statement during the exit interview. In no way did it represent an effort to delay informing the NRC until after restart.

On the morning of September 14, Sequoyah management inspected the sub-floor monitor, sampled its contents and questioned employees about its origin. After developing the available background information on the sub-floor monitor, and receiving the test result showing an elevated level of uranium (6.2 g/l) in the water, Sequoyah promptly communicated the matter to the NRC. Sequoyah believed the contamination beneath the building would be limited due to the nature of the process as conducted in the building and was a problem to be addressed at decommissioning. Less than one-fourth of the process building area contains "wet" process material.

The circumstances surrounding the sub-floor monitor, like those involved in the SX excavation, reflected a long standing condition. The sub-floor monitor was installed sometime in the mid-1970s. Since that time, it has been pumped when appropriate, with the contents

occasionally being analyzed and always being recycled.[9] The situation clearly did not cause or threaten to cause any of the scenarios outlined in 10 C.F.R. § 20.403(a) and (b). No one was exposed to radiation and there is no evidence of a "release" in excess of the thresholds indicated in either 10 C.F.R. §§ 20.403(a)(2) or (b)(2). The operation of the facility was unaffected by the discovery and no damage to property was sustained.

As evidenced by their Order Modifying License dated September 19, 1990 (the "Order"), the NRC is concerned that the ground water and environment in the plant's unrestricted area may have been tainted with uranium contaminated water seeping from beneath the Main Processing Building. Sequoyah has complied fully with the intent and letter of the Order and to date only one sample has revealed a uranium concentration in water in excess of the maximum permissible concentration ("MPC") of 45 mg/l in the unrestricted area. Follow-up analyses have shown considerably lower levels, and Sequoyah management now believes that the initial sample may have been an anomaly. Thus, the circumstances surrounding the sub-floor monitor never posed a hazard to public health and safety or to the

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9. Liquid is pumped from the subfloor monitor according to Sequoyah Facility Operating Procedure N-290-13, Revision #2: Plant Pond, Pit and Pad Pump-Out.

environment. In retrospect, however, the knowledge of the sub-floor monitor could have been communicated earlier. Sequoyah has, therefore, seized this opportunity to carefully examine conditions underneath the Main Processing Building and beyond, and used it to improve the safety and environmental sensitivity of plant operations.

III. The treatment provided to Sequoyah and contract employees satisfied the requirements of 10 C.F.R. Parts 19 and 20.

Of crucial concern to the NRC, and to Sequoyah, is the safety of workers at the facility, whether employed by Sequoyah or by a contractor. The NRC has stated that:

> ...contract workers were allowed to continue working in the excavation area without being informed either of the presence or uranium in the water or of the necessary precautions to take to minimize or eliminate the possibility of personnel or equipment contamination, as required by 10 C.F.R. Part 19.

(Demand For Information, pp.8-9). This assertion is inaccurate. Sequoyah management understands the concerns of employees working with or near radioactive material and respects their right to receive the instructions, notifications and reports provided for in the regulations. Before working at the SX excavation, all workers were shown how to monitor for elevated levels of uranium before exiting and either received radiological training, an orientation, or were escorted by trained personnel.

During the radiological training, which many workers received July 23, 1990, Sequoyah's Derrell Martin, Gary Barrett, Rick Callahan and Dave Nieto provided instruction on various topics including radiation, the facility process, general procedures (for personnel radiation exposure monitoring, access to restricted and controlled access areas, change room procedures, as well as health and safety precautions and requirements), the contingency plan, general safety/hazard communications, respirator protection and health physics. Mr. Callahan, Supervisor of Health Physics Technicians, explained radioactivity and the types of radiation, general safety measures for working with uranium, biological effects, exposure limits, the NRC regulations, as well as other related topics. Mr. Callahan specifically addressed the physical characteristics of uranium, biological effects of radiation and programs in place to measure internal and external exposure to radiation and asked the class to assist Sequoyah in making every reasonable effort to keep radiation exposures as low as reasonably achievable (ALARA).

The NRC's statement, that "routine controls were implemented at the change area and access points to the unrestricted area" (Demand For Information, p. 8), depicts only a partial picture of the radiological controls

implemented by Sequoyah. Health and Safety Technicians conducted radiological surveys of the SX excavation pit and vault, the surrounding area (including the road used to haul dirt to yellowcake storage), trucks, and each piece of equipment used during work. In cases where equipment or other items were found to be above background levels for uranium, or even suspected of being so, they were washed and resurveyed prior to release. These surveys all revealed acceptable levels of uranium.[10/]

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10. The NRC has stated that:

> ...at no time did Mr. Nichols or any other Licensee personnel from the Health, Safety, and Environmental department survey the earthen walls of the excavation or take note of the large section of yellow stained earth which was part of the excavation face immediately under the SX building. This readily apparent indication was not surveyed or otherwise evaluated until an NRC inspector requested that it be done on August 24, 1990. That survey identified radiation levels in local areas in excess of 6 mrad/hr.

(Demand For Information, p. 19).

As Sequoyah personnel explained to the NRC inspectors, the yellow stained material, which was part of the earthen area directly below the SX building, was in an area where dirt was constantly falling from it. The stain may or may not have been there for days before. The surveys of the excavation pit identified an area in the corner which read approximately 6 mr/hr. at the surface and background at about 18 inches from the surface.

The NRC has stated that it has information that suggests "a contract worker, who worked in these excavation activities, may have taken home contaminated equipment." (Demand For Information, p. 9). On November 16, Sequoyah management was informed that NRC inspector Vasquez and OI were investigating the possibility that Jim Smith, the contractor, had taken home contaminated equipment---rubber boots, canvas shoe covers, and gloves---and that contaminated dirt was found under the accelerator of his flat bed truck. Sequoyah employees, including Mike Nichols and Joe Bohannon, the new Quality Assurance engineer, joined Inspector Vasquez to review the contractor's allegations and conduct the appropriate surveys.

Because these specific allegations were presented to Sequoyah only last Friday, and we are still fully assessing the matter, Sequoyah respectfully requests the opportunity to further supplement the record if needed. Thus far, however, Sequoyah's investigation indicates that no equipment that went off-site exceeded permissible release limits. Sequoyah bases this finding on a thorough examination of the truck and the boots, shoe covers and clothing that were surveyed by Mike Nichols with the appropriate technique and instrumentation in the presence

of Inspector Vasquez and OI investigator Chapman, as well as Jim Smith.[11]

Although the uranium levels measured in the equipment and the truck have proven to be within Sequoyah's permissible release limits, no Sequoyah equipment, irrespective of contamination level, should have been found off-site. Both Sequoyah and the NRC must evaluate this incident in light of procedures followed by Sequoyah at its worksite. During work at the SX excavation, all vehicles were surveyed thoroughly upon leaving the facility. Surveys included the equipment in back, e.g., shovels, gas cans, boots, etc. During the surveys, when any contamination was found (which was always below Sequoyah release limits) the truck was cleaned to ALARA background levels. Statements by technicians involved clearly

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11. The discrepancy between the results obtained by Sequoyah and those obtained by Inspector Vasquez can be explained by the differences in instrumentation and technique. Mr. Vasquez did his examination with an instrument which he has stated was not the proper instrument for the detection and measurement of uranium contamination. Additionally, Mr. Vasquez stated that he did not know the efficiency factor of his instrument, that it could be 10% or it could be 40%. Apparently, the instrument was not properly calibrated. This explains the high and inaccurate findings that he made.

    In contrast, Sequoyah is satisfied that the technique and instrumentation used by Mr. Nichols were appropriate for the examination done, and the results obtained---that no permissible release levels were exceeded---were accurate.

indicate that Jim Smith's truck, like those of all others, was surveyed to assure that contamination did not leave the restricted area. The equipment at issue here was discovered under the seat of the truck, a place in which a survey would not have ordinarily been made.

Mr. Smith had received radiological training and had been previously employed by Sequoyah for 10 years. His knowledge of uranium and associated work rules is extensive. He is also familiar with the fact that contractors do not take equipment supplied to them, particularly anti-contamination clothing such as gloves, boots and shoe covers off the worksite. Despite his experience and awareness of Sequoyah policy, Mr. Smith still took these items off-site, in a way that made detection extremely unlikely despite the diligent survey efforts conducted by Sequoyah personnel. Under the circumstances, the responsibility for the equipment going off-site rests with the contractor, not with Sequoyah.[12/]

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12. It is worth noting that after the excavation work started, Mr. Smith actually discussed with Mike Nichols what would happen if his boots became contaminated. He was informed that they would either be cleaned to below release criteria or he would be given a new pair. A few days after that, Mr. Nichols was informed by the Health Physics Supervisor that Mr. Smith's boots showed elevated levels of uranium but that the levels were below release limits. The boots read approximately 1000 dpm/100 cm^2 fixed. The Health Physics Supervisor then cleaned them and released them back to Mr. Smith.

Sequoyah also conducted routine urinalyses of Sequoyah employees, and special urinalysis of contract workers, which showed results within acceptable limits. Routine testing of Sequoyah personnel was in place well before August 22, 1990. From August 1, 1990, to September 15, 1990, approximately 120 bioassay samples were collected from Sequoyah and contract personnel who worked in and around the excavation site. The AIT appropriately concluded that Sequoyah "surveyed individuals to the extent that site and contractor personnel were not over-exposed due to the contamination in the excavation." (AIT Report, p.23).

The two workers involved in moving aggregate rock, Jim Smith and E. Baldwin, were trained as radiological workers on July 23, 1990. The slightly elevated levels of uranium in their urine resulted from moving contaminated rock into the excavation pit. The fact that the rock was contaminated was discussed with Mr. Smith prior to starting, and proper radiological monitoring was instituted including lapel monitors, air sampling and urine samples. The slightly elevated levels observed in the workers urine were below Sequoyah administrative limits and did not require any work restrictions.

Sequoyah insisted that personnel working at the HX excavation wear radiological protective clothing

including coveralls or smocks, boots, hard hats and safety glasses while in the excavation area. On several occasions, Health and Safety Technicians reminded reluctant Smith & Smith workers of their obligation to wear protective attire and eyeware. At the end of each day, workers were required to shower and change clothes, and individuals were monitored for contamination.

Cognizant of the risks associated with hexane, as well as uranium, Sequoyah constantly monitored work at the site. In addition to conducting the radiological surveys discussed above, Health Physics personnel took air and soil samples. Test results consistently revealed uranium well below regulatory limits. These steps reflect the initiative and commitment to of Sequoyah's Health and Safety personnel.

The NRC has stated that:

> During a tour of the facility, NRC inspectors noted workers in the excavated pit and casually questioned SFC personnel as to why there was yellow water in the excavated pit since yellow water may be an indication of the presence of uranium...Although sample results were available in the process lab indicating significant levels of uranium in the water, Mr. Mestepey and Ms. Couch remained silent as to the source of water or the levels of contamination in the water. Although the inspectors did not pursue the matter further, they noted that the area was controlled in the fashion of a contaminated area since the area had been roped off with a step-off pad at the entry to the pit. However, Mr. Mestepey and Ms. Couch indicated to the inspectors that these controls were not because of contamination concerns, but because of explosion hazards

related to hexane and because of other industrial safety concerns.

(Demand For Information, p.6). It was in fact the case that these measures were not taken in response to contamination in the excavation. Rather, the area was roped off to prevent persons from falling into the pit and the step-off pad was placed to allow personnel to work on the tank tops without canvas shoe covers in order to reduce the risk of slips and falls.

Sequoyah also complied with the "as low as reasonably achievable" (ALARA) requirement of 10 C.F.R. Part 20. As the table below indicates, external exposures of persons working in and around the SX excavation are well within acceptable limits (1250 mrem) per calendar quarter:

WHOLE BODY EXPOSURES

	HIGH	LOW	AVERAGE TOTAL EXPOSURE FOR 6 WEEK PERIOD
Contractors (23 Total)	40 mrem (1 Person)	10 mrem or less (21 Personnel)	7.7 mrem
SFC Personnel (17 Total)	40 mrem (2 Personnel)	10 mrem or less (15 Personnel)	15.0 mrem

SKIN DOSES

	HIGH	LOW	AVERAGE TOTAL EXPOSURE FOR 6 WEEK PERIOD
Contractors	110 mrem (2 Personnel)	10 mrem or less (15 Personnel)	21.5 mrem
SFC Personnel	70 mrem (1 Person)	10 mrem or less (7 Personnel)	29.4 mrem

With regard to air sampling, of the 26 contractors and 17 Sequoyah personnel working in the excavation pit, the following data is available. Initially, 14 air samples were taken August 3 and 4. The highest MPC value was 0.2 MPC. These samples are extremely representative because they were taken during the actual digging of the dirt when the potential for airborne contamination was greatest. When the dirt was being extensively handled and moved to the yellowcake storage pad or placed in drums, approximately 300 lapel, high volume and low volume air samples were taken. With the exception of cases where contaminated drums were being handled, the air samples were all below MPC values and approximated background levels. After August 22, air monitoring in the excavation pit was renewed. These air samples were, as expected, also well below MPC values and approximated background levels.

Internal exposures were also well within the acceptable limit (1250 mrem). From August 8, 1990, to

September 15, 1990, approximately 120 bioassay samples were collected for 43 Sequoyah and contractor personnel who worked in and around the SX excavation site. The analyses results of samples taken from Sequoyah personnel from August 1, 1990, to September 15, 1990, were less than minimum detectable, and the only elevated urine samples were from personnel who were handling used yellowcake drums and the contaminated fill aggregate. Of the two Sequoyah and contractor personnel who did exhibit elevated urine samples, none was above the facility action level of two samples above 20 ug/l or 1 sample above 100 ug/l. In any case, the calculated exposure for all individuals is less than 1 mrem.

IV. Sequoyah has responded quickly and comprehensively to address the environmental problems revealed by these incidents.

Once the problem of contamination was uncovered, Sequoyah evaluated the extent of contamination with initiative, competence and extreme effort. As early as August 22, 1990, Sequoyah began making arrangements for a drilling rig so that, on August 27, 1990, soil borings around the SX building could be obtained to help determine the extent, if any, of subsurface contamination. Sequoyah also began excavation of underground utility lines as early

as August 30, 1990. During the SX excavation investigation, 15 potential migration pathways were identified and evaluated, and 10 migration barriers and 13 sampling and recovery sumps were installed over a seven day period. During the Main Process Building investigation, 9 potential pathways were identified and evaluated, 7 migration barriers and 8 sampling and recovery sumps were installed over a period of 16 days.

Sequoyah personnel did their utmost to review drawings, schedule crews, secure proper permits, obtain laboratory results, determine how to manage excavated materials and maintain appropriate documentation.[13/] At times, Sequoyah had three drilling rigs and two construction crews conducting trenching operations simultaneously. In fact, when a NRC geohydrologist reviewed Sequoyah's progress in early October, he was complimentary of the extent and professionalism of the investigatory efforts of Sequoyah. Sequoyah's

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13. Mike Nichols has been criticized by the NRC for his failure to include information regarding the SX excavation in the decommissioning file. (Demand For Information, p. 18). The decommissioning records are records to be used for decommissioning the facility in the future. It is unreasonable to expect that a complete set of records would be present in this file for a situation that is still being investigated and reviewed by NRC Region IV, OI and Sequoyah. The record concerning the SX excavation is expanding daily and is being maintained on an active file basis. As analyses become available and complete, they are being entered into the decommissioning file.

environmental consultant, Schornick, observed that the Main Process Building investigation, which the company undertook in 27 days, would normally be a 9 month effort. During this period, 32 shallow monitor wells were installed, 24 deep wells were installed, and 34 boreholes were drilled and sampled.

Throughout this process, Sequoyah was under the scrutiny of NRC Inspectors, many of whom offered valuable suggestions and direction. In some instances, however, NRC Inspectors steered investigation efforts away from those areas believed by Sequoyah to have potential for contamination, specifically, that area to the west and southwest of the Main Process Building, and did not appear to reflect an awareness of the daily monitoring and special project workload that is required for maintenance of the license, as well as state and federal permits.

On September 24, 1990, for example, the drill rig was set up over coreholes to the west of the Main Process Building when, at Inspector Vasquez's insistence, the rig was immediately moved to the area east of the facility. At the time, Sequoyah suggested that this would be the least likely area of migration of licensed material away from the process building, due to several factors: (1) predominant groundwater flow; (2) the eastern part of the building contains the dry process phase of the operation; and (3)

there are limited utilities that communicate with the wet process phase in this area. Similarly, it is probable that the majority of migration from the SX yard would be to the northwest. Any migration via underground pathways would be likely to occur to the northwest due to the sloping of utility lines.

The following actions also evidence Sequoyah's independent initiative to define problems, analyze conditions, propose solutions, and recommend actions:

- Hand augers in Laboratory tunnel to investigate potential contamination beneath the Floor;
- Limestone pile investigation;
- Combination Stream line investigation;
- Hand auger in the Denitration Sub-Floor Monitor to investigate potential contamination beneath the Floor;
- Employee interviews to locate potential areas of contamination;
- Prioritizing areas of concern and developing work plans for each;
- Installation of RCRA site equivalent monitor wells. Sequoyah installed 28 shale wells at the main process building and 24 sandstone wells. Sequoyah also installed 4 shale wells at the SX building, and as of November 9, 1990, has completed 4 sandstone wells;
- Sequoyah set forth a 9 month environmental investigation plan that normally would have been conducted over a 2 year time frame;
- Sequoyah expanded its sump and floor investigation to areas beyond the Main Process Building;

- Sequoyah environmental personnel have worked 7 days a week and up to 76 hours/week to complete these investigations while still maintaining and conducted normal routine and special projects;

- Sequoyah is in the process of upgrading its underdrain monitoring system by installing an automatic pumping unit at each basin having an underdrain monitoring system;

- Sequoyah is in the process of installing a $1,000,000 stormwater management plan;

- Sequoyah recently reviewed and did repairs to normal erosion and settling of soils around its lined pond area and the fluoride burial pits; and

- The ditch west of Pond 2 was upgraded with a french drain pumping system and then filled to prevent clean stormwater from becoming contaminated with nitrates from Pond 2 seepage.

V. Sequoyah management has instituted changes to remedy the problems noted by the AIT and Dr. Buckham.

Both Dr. Buckham and the AIT were critical of a variety of management failings at Sequoyah. Dr. Buckham found that employees needed to understand that their responsible attitude to chemical safety (which was the thrust of the NRC's 1986 accident investigation) must also apply to the concerns of the public, political and regulatory sectors, which are primarily sensitive to uranium and radiation issues. Significantly, too, Dr. Buckham was critical of the state of communications inside the company. Focusing on what he called "cultural problems related to responsiveness," he observed that Sequoyah

employees are reluctant to communicate observations or to ask questions and "to a greater extent than is desirable, do their work with a 'blinders-on' approach and hesitate to express concerns or get involved in 'other people's' business."

The AIT criticized the delay between the time when senior management discovered the test results on August 17 and when Sequoyah reported to the agency on August 22. They were also sharply critical of the failure of senior management to find out about the test results between August 6-7 and August 17, and to factor into the planning for the excavation the general awareness that some contamination might be encountered. The AIT paralleled Dr. Buckham's finding by noting that "the problem so stressed the organization that significant communication weaknesses between the various departments were exhibited." (Letter from A. Bill Beach to Sequoyah (October 11, 1990)). The AIT concluded that a focus on restart, and a number of other activities, "probably overshadowed" the elevated concentrations in the vault.

Sequoyah has responded to each of these identified weaknesses and has taken or committed to action to implement corrective measures. While Sequoyah believes that the facility faced an unusual confluence of circumstances unlikely to recur---preparing for restart,

dealing with a major excavation which posed health and safety hazards, preparing the NRC license renewal application, responding to the reportable incident of August 3---Sequoyah has responded aggressively to strengthen personnel and make management changes that will insure that such weaknesses do not recur under any foreseeable combination of circumstances.

On the personnel side:

- a Senior Health and Safety Technician has been promoted to Health Physics Supervisor to enable operational health physics and support functions to each have a supervisor;
- authority has been granted to hire two new Health and Safety Technicians to improve operational coverage;
- an additional environmental professional has been hired to provide greater resources and expertise, particularly in the hydrology area; and
- a position has been authorized and filled for a full time Quality Assurance Engineer.

Management reforms, in response to the useful suggestions in Dr. Buckham's report, have been similarly vigorous. Sequoyah procedures have been revised to require Design Change Authorization ("DCA") sign-off prior to initiating work on every project performed by outside contractors. Complete or near-complete project drawings will be made available to those signing the DCA, as applicable. A new written procedure covering safety-related aspects of excavations on the facility site has

been prepared. It includes specific provisions concerning sampling and analyses for uranium, and appropriate remedial steps and communications channels if uranium is encountered. Department managers will conduct special meetings with their employees to emphasize the importance of controlled and contained handling of uranium compounds. Sequoyah committed to give this area special emphasis in annual refresher courses and annual off-site supervisor conferences.

Sequoyah also agreed to modify its Serious Incident reporting system to include all occasions when a safety hazard or an environmental problem is encountered. In addition, Sequoyah accepted the recommendations that it should seek to establish an informal communication channel with NRC, Region IV, for advice on reporting and that it should begin instituting procedures to report in accordance with the NRC's proposed regulation, although the regulation has not yet taken effect.

Above all, Sequoyah has committed to breaking down the barriers to communication between departments that were illustrated by these incidents. In a memorandum to all personnel on October 12, Sequoyah President Reau Graves wrote:

> SFC is committed to improving communications, both with NRC and within the SFC organization itself. Management is working hard to establish and maintain good communications with NRC. You

> can help by promptly reporting accidents, incidents, near-misses, or environmental/ contamination concerns (such as the discovery on uncontained uranium, and/or contaminated soil or water) to your supervisor or manager, who will then relay that information to the proper people. I am also emphasizing the importance of good communications between SFC personnel in different work groups. We are all in this together. From a regulatory perspective, if one department has a serious problem, we all have a problem. I want to again strongly encourage constructive communications between all work groups at SFC. We will be further addressing these communications issues in special meeting with your department management, during annual refresher training, and at our supervisors' off-site conferences.

The NRC has stated that in part, Sequoyah's failures during this period appear to be the result of:

> A long-standing problem, carried over from the previous owner, of poor communication between organizational elements, up the management chain, and to the NRC. Present managers have not corrected this problem and appear to have contributed to it.

(Demand For Information, p. 22). Sequoyah disagrees with the assertion that present management has in some way exacerbated communication deficiencies since taking over the company in 1988. Sequoyah management is, in fact, proud of the improvements it has made in this area over the last two years. Sequoyah personnel, particularly Messrs. Lacey and Nichols, have worked to improve the company's relationship with the NRC so that even those significant situations which may not be reportable are nevertheless communicated to the agency.

In addition, management has endeavored to improve communications between Health, Safety Environment and Operations personnel. As noted above, Sequoyah admits that communication between departments could be improved and that the NRC could have been informed of certain findings earlier than they were, and for this reason has already implemented a number of steps aimed at addressing these deficiencies. In general, however, Sequoyah management has worked hard over the last two years improve internal and external communication, and believes its progress in this area has been substantial.

VI. The situation in August should not detract from improvements that have been made at Sequoyah since 1988.

The NRC knows well the history of this facility before its purchase by General Atomics in 1988. The tragic 1986 accident heightens the need for vigilant NRC oversight at this facility; public confidence requires nothing less. Additionally, long-standing problems needed to be addressed when General Atomics purchased the facility in November 1988, less than two years ago. The conditions revealed in the SX excavation illustrate those problems. As the AIT report documents, prior to 1985 "the floor of the SX Building was constructed of unprotected concrete"; "process solutions were routinely in direct contact with the concrete"; "corrosive acidic solutions were simply released

directly on to the floor"; "these practices resulted in extensive degradation of the floor", and the resulting elevated levels of uranium under the SX building. (AIT Report, p.6).

Similarly, the AIT found that leakage occurred because of an evaporator (taken out of service years ago), located just north of the SX building, characterized as "antiquated." The purpose of the evaporator was to increase the concentration of uranium in the solution tenfold, from 40 g/l to 400 g/l and it routinely leaked solution onto the unprotected pad where it stood. Chemical overflows also occurred because in past years a flange on the solvent dump tank was not placed on the tank access pipe correctly; apparently, licensee staff "knew the tank was full when liquid flowed out of the pipe . . . ." (Report of the AIT, pp. 6-8).[14] This condition was corrected in 1988.

In the past two years, management at Sequoyah, supported by General Atomics, has invested millions of

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14. The NRC has stated that, "Testimony from various SFC individuals to the NRC, and testimony from Mr. Lacey himself, indicated that he was aware as early as 1988 of the SX contamination problem." (Demand For Information, p. 16). This statement is misleading. Mr. Lacey was aware of the potential for soil contamination in the area of the SX building. Mr. Lacey certainly did not have sufficient information to lead him to suspect the magnitude of the "SX building contamination problem" as it came to light following the excavation.

dollars to counteract the damage, and cure the problems, left by the previous owners. Many areas of long standing environmental concerns have been addressed during the past 24 months. For example:

- A $1,000,000 project is underway to dam a natural drainage basin and construct a reservoir to capture and contain stormwater runoff from the plant site, excluding the process area. The reservoir will:
  - consolidate six (6) previous stormwater discharge points;
  - provide source of water for use in irrigating and recreation; and
  - provide a single point for sampling and discharge;
- A system designed to automatically pump liquids which might accumulate under lined impoundments is being installed on each of the lined ponds;
- A separate Environmental Laboratory has been established away from the main process area to provide specialized analyses of vegetation, soil, and water samples for environmental monitoring purposes;
- Many of the older redundant and poorly constructed wells located in and around the site have either been taken-out-of service and plugged, replaced, or reworked to provide more accurate environmental information;
- A planned program to reduce the acres of land committed to the process area has been underway and significant improvements have been made through initial efforts of simply moving fences in uncontaminated areas much closer to the work activity;
- A new system to significantly reduce the consumption of chlorofluorocarbons (CFC's) was installed. This system incorporates specially

designed valves to control fugitive emissions and a storage tank to allow draining of the R-11 refrigerant into an enclosed vessel for performing maintenance on the system and, thereby, reducing the loss of CFC to the atmosphere;

- Raffinate treatment was upgraded to improve by-product ammonium nitrate production rate and reduce personnel exposure;

- Powder transfer systems in Reduction-Hydroflourination were modified to reduce emissions; and

- The facility is presently in the process of covering three fertilizer ponds at a cost of approximately $200,000 to remove over 540,000 sq. ft. of rainfall collection surface area from adding to the inventory in the fertilizer ponds. This will enhance Sequoyah's ability to process Pond 2 liquids, and ultimately will allow completion of Pond 2 remediation at an earlier date than would otherwise have been possible.

Similarly, many plant upgrades and equipment modifications have been made to address specific safety concerns within the process area. For example:

- Pressure transmitters were installed in various critical tanks to prevent boil over or over pressurization;

- Heat sensing cables have been installed in various high temperature areas to alarm in the Control Room;

- Electrical speed controls have been added to conveyors to aid in the control of batch reaction to prevent boil over;

- Revalving and modifications to chemical storage tanks have been accomplished to minimize and contain liquids in the event of a line rupture or other failure;

- Stop buttons have been installed at strategic locations to shut down liquid lines if a system failure occurs;

- Many modifications and installations have been made to various ventilation, dust collection, filter and transfer systems throughout the plant to control airborne particulates and to mitigate equipment failures;

- Health and Safety technical staff has increased from 6 persons to 9 persons in order to provide improved coverage in the process area;

- Increased the health and safety monitoring program's portable survey instrumentation by a factor of 2 in order to accommodate the expanded health-physics program (from 27 instruments to 58 instruments);

- Various procedure changes and methods of operation have provided significant results, as follows:

  - Reduced the number of persons on work restrictions by 80%; and

  - Increased the coverage of health-physics personnel to the process areas which has resulted in the identification and elimination of many problem areas.

- A new gamma spectroscopy unit has been purchased and installed for in-house service which reduces the response time for evaluating samples, utilize computer technology to evaluate data and allows in-house radionuclide identification;

- Three computer based alpha/beta analyzers have been purchased and installed for analyzing radioactive samples; and

- The system for Flourine Cell electrolyte removal has been modified to reduce worker exposure to chemicals.

Major advances have also been made in the handling and disposal of solid waste. Sequoyah has:

- Constructed and placed into service a new $750,000 raffinate sludge dewatering/load-out facility to process and ship a 20-year backlog of accumulated sludge to an NRC approved site for reprocessing and recovery of the uranium. This new facility has treated and shipped approximately 20% of the backlog and processed all of the current generated sludge;

- Constructed and placed into service a new $70,000 decontamination building to sort, decontaminate and package low-level radioactive waste for disposal in a commercial waste disposal site. This facility and other waste minimization programs have reduced low-level radioactive waste shipments by 60%. This facility was instrumental in compacting and repacking approximately 700 drums of previously stored waste and shipment off-site to a NRC approved disposal facility;

- Eliminated the backlogged inventory of 52,000 contaminated drums by crushing the drums and shipping them off-site to a NRC approved disposal site. The 2-3 acres of land previously used to store the drums will be reclaimed, surveyed, and removed from the restricted area;

- Sorted decontaminated and removed approximately 300 tons of previously stored used equipment from a storage area;

- Purchased vehicles and initiated an in-house fleet to more efficiently utilize the by-product ammonium nitrate to fertilize company owned property; and

- Made significant progress toward remedial actions to long-standing problem waste issues as weather and regulatory guidance permits. For example, remediation of a 700' x 300' unlined pond was 95% complete prior to excessive rainfall accumulation in the spring of 1990. Blistered pond liners have been repaired and automatic underdrain samplers and pumps have been installed.

In all three areas---environmental, safety, and solid waste---Sequoyah initiated the vast majority of the steps taken; although some were influenced by regulatory

considerations, very few were directly driven by regulatory requirements. The far-reaching plan for environmental remediation outlined by Sequoyah and Schornick follows in the same pattern; it represents a commitment to deal with conditions and problems far beyond the situation which triggered NRC concern in the present investigation. We propose to do more than look at how to characterize the waste process stream flow so as to ascertain potential migratory release pathways. We are also looking in great detail at historical contamination which may have moved laterally as well as vertically to fully understand and remediate the conditions that were the legacy of the previous owner.

Plainly, much remains to be done---both in engineering terms and in management terms. Dr. Buckham's report, which gives Sequoyah due credit for significant progress, but points up the clear need for continued improvement, is probably a fair assessment. But Sequoyah would urge the agency to take full account of where this facility was just two years ago, and how far it has come, before taking any action that will jeopardize the hard-won gains that have been made.

VII. Sequoyah agrees to the establishment of a capable and experienced oversight team.

The Demand for Information suggests the creation of an independent oversight team of people experienced in dealing with plant operations at a nuclear fuel cycle facility like the Gore facility. The NRC believes that an oversight program is necessary over the next few months to ensure that the plant runs safely and effectively while the comprehensive management assessment is undertaken to discover what management or procedural changes are needed to improve Sequoyah's management.

Sequoyah realizes the depth of the NRC's concerns and agrees to the creation of an oversight program. We have certain concerns about the potential impact of an oversight program, as Reau Graves noted in the November 13 meeting at NRC headquarters. Sequoyah is in the process of strengthening its management by adding key personnel, integrating them into the management team and making certain key changes in management procedure to enhance communications between divisions and with the NRC. Under some circumstances, the presence of an oversight program could undercut regular management by superseding it; whatever the short-term benefits, this would be detrimental in the longer term. Moreover, it is also possible that the presence of an oversight program could adversely affect the management assessment that the NRC wants, and which

Sequoyah strongly endorses. In some cases, an oversight program and regular management can combine to the point that it becomes difficult to know what is being assessed: regular management, or regular management combined with the oversight program.

Although Sequoyah believes these are legitimate concerns, we believe that they can be accommodated, while still providing the expertise and oversight presence that the NRC wants. Experienced oversight personnel will recognize the potential problem, and treat it accordingly.

Sequoyah proposes utilizing members of the firm of PLG, Inc. (PLG) to implement its oversight program. As the NRC knows, PLG members are familiar with the Gore facility, having worked on the oversight program established in the aftermath of the 1986 accident. This familiarity with the facility would enable the PLG team to come in and do the job, with a minimum of training or lead time. At the same time, members of the PLG team have not spent significant time in the facility since General Atomics acquired it, so they will be capable of bringing a fresh perspective to what is needed to operate the facility and whether existing management is performing effectively.

The team envisioned would be expert in the management of radiation and chemical safety and environmental protection at regulated facilities similar to

Sequoyah's. Its proposal, which is attached in full as an Appendix, envisions one person on-site, full time, 8 hours per day, 7 days a week, with team members rotating out after a week. Daily reports will identify the activities, areas and procedures that received oversight and the observations made from that oversight. Weekly reports would summarize the daily reports and will identify items of safety, significance and outstanding actions items.

With PLG, Sequoyah would have an oversight team that was thoroughly familiar with the facility; the public would have an independent expert team with impressive credentials; the NRC can have a team who are well known to the agency for their extraordinary backgrounds in a range of positions touching the nuclear industry and the fuel cycle. Sequoyah believes that the initial agreed upon period for oversight should be 60 days. After the first 60 days, Sequoyah representatives, PLG team members and the NRC could meet and assess the situation, determining if the oversight should be extended, which areas to focus on, and what level of coverage is required. The need for continued oversight should be periodically reevaluated (perhaps monthly) until the time at which the NRC determines that continued oversight is not necessary.[15/]

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15. In addition to and separate from the oversight program, Sequoyah plans to continue using Dr. James

(continued...)

VIII. Sequoyah agrees to an impartial management assessment.

Sequoyah welcomes the NRC's suggestion for an impartial comprehensive management assessment. Sequoyah believes that any impartial comprehensive management assessment will find areas which need improvement, and we intend to benefit from the conclusions of the assessment. At the same time, if the management assessment reaches the general conclusion that our management is capable and continuing to grow stronger, it is Sequoyah's hope that the findings would give the NRC the basis for confidence now lacking, and a reason for discontinuing oversight, if oversight continues to be in effect. Sequoyah will submit the proposal for an impartial management assessment within the time period specified by the NRC.

15.(...continued)
Buckham as an advisor to senior management. Dr. Buckham's continuing familiarity with the facility and its personnel, and his extraordinary expertise in all aspects of operations of a nuclear fuel cycle facility makes him a great asset to successful management of Sequoyah.

Conclusion

Sequoyah would urge the agency to reach the following general conclusions:

1. The incidents investigated reflected a shortage of trained, technical personnel at a period of maximum stress on the facility, but they entailed no violations of law and posed no threat to workers, public health and safety or to the environment.

2. While improvements need to continue---both in management and in sensitivity to health, safety and environmental considerations, significant strides have been made by Sequoyah in the two years under current ownership.

3. The conditions revealed in the current investigation have been, and will be, a catalyst for positive change, as demonstrated by the ambitious plan of environmental characterization to which Sequoyah has committed.

4. That Sequoyah has responded positively to specific NRC concerns throughout the last few months, and has demonstrated a commitment to improve identified weaknesses.

Respectfully submitted,
SEQUOYAH FUELS CORPORATION

Nov. 20, 1990
Date

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APPENDIX

PLG-P452

Proposal

INDEPENDENT OVERSIGHT PROGRAM FOR THE SEQUOYAH FACILITY

Prepared for
SEQUOYAH FUELS CORPORATION
Gore, Oklahoma
November 16, 1990

PLG

ENGINEERS ■ APPLIED SCIENTISTS ■ MANAGEMENT CONSULTANTS

Newport Beach ■ CA
Washington ■ DC

1. INTRODUCTION

PLG, Inc., proposes to implement an independent oversight program at the Sequoyah Fuels Corporation (SFC) nuclear fuels processing facility in Gore, Oklahoma. Based on the Demand for Information issued by the U.S. Nuclear Regulatory Commission (NRC), we understand that SFC will establish an independent oversight team (IOT) composed of persons who are experienced in the management of radiation and chemical safety and environmental protection at regulated facilities similar to the Sequoyah facility in order to provide additional assurance to the NRC that its regulatory requirements are being satisfied during operation of the facility. In this regard, we are confident that PLG is ideally suited to provide the IOT. Consider the following qualifications:

- PLG, founded in 1956, is an independent engineering organization that provides support primarily to the nuclear, chemical, and aerospace industries.
- PLG is internationally recognized as a leader in the performance of safety and risk assessments of complex engineered systems, and in the application of specialty analyses such as dispersion modeling/consequence analysis, seismic analysis, and human reliability analysis. At the international level, PLG is also recognized for its extensive contribution to contemporary methods of risk and safety analysis. We provide both individual consulting services and teams for major analysis assignments.
- For 34 years, PLG has helped industry to meet both regulatory requirements and self-imposed safety and environmental goals. In addition, because our staff is largely composed of engineers and engineering managers with "hands-on" process and systems engineering experience, we are called on regularly to perform independent safety reviews of facility operations, practices and procedures.

Presented in the sections that follow is a description of the proposed approach to implementing an independent oversight program at the Sequoyah facility, a summary of the qualifications of the proposed oversight team, and a brief overview of PLG's relevant project experience.

1.1 WHY IS PLG BEST QUALIFIED TO PERFORM THE INDEPENDENT OVERSIGHT PROGRAM?

The ability of PLG to provide the independent oversight team is bolstered by three key assets: our direct knowledge of the Sequoyah facility management structure and operations, our nuclear fuel cycle engineering and analysis experience, and our national reputation in the risk and safety technology field.

1.1.1 Knowledge of the Sequoyah Facility

Following a major accident in 1986 at the Sequoyah facility, the NRC required that an IOT be established to oversee restart and operation of the facility. PLG was selected as that IOT

The principal activity of the IOT was to perform an ongoing independent audit of safety-related activities, thus providing assurance to plant management and the regulators that the plant would operate in accordance with the highest standards of safety and quality.

In addition, PLG performed a detailed review of the process design and operating procedures, and provided recommendations for mitigating potential hazards and improving overall plant safety. Beginning in late 1986, the PLG oversight team performed onsite, 24-hour surveillance of operational and maintenance activities for 12 months, followed by 6 months of single-shift-per-day surveillance. PLG continues today to perform 1-week, onsite, follow-up inspections on a quarterly basis. All findings and recommendations have been documented and presented to management on a monthly/quarterly basis. When major hazards or deficiencies in operations were identified, PLG immediately presented these concerns to management. Thus, no other independent firm can claim the same level of firsthand knowledge about the Sequoyah facility operations than PLG.

1.1.2 Nuclear Fuel Cycle Engineering and Analysis Experience

PLG's technical staff members have been employed in virtually all phases of the nuclear fuel cycle, including uranium procurement, processing, enrichment, and reprocessing; transport of spent nuclear fuel and radioactive materials; criticality and spent fuel analysis; and, of course, technical and management services supporting nuclear power plant design, construction, and operation. Their early experience included "hands-on" participation in the startup and operation of the Idaho Chemical Processing Plant. Today, PLG has become the leading independent risk assessment organization servicing the owners and operators of commercial nuclear power plants.

Added to the nuclear fuel cycle experience (including uranium and fuel processing) is the extensive use of PLG's risk assessment expertise by the chemical process industry and the nuclear weapons complex of the U.S. Department of energy (DOE). The chemical processes that we have analyzed cover a broad range and involve the handling of very large quantities of highly toxic and combustible materials.

Another area of experience that is very relevant to the oversight role relates to management analysis. PLG has performed some of the most comprehensive management assessments ever performed on technical facilities. Several of these are in the area of "management prudence" that is associated with the construction and operation of large nuclear power plant projects.

1.1.3 Reputation in the Safety and Risk Technology Field

While the thrust of our business is the solving of real engineering and risk- and safety-related problems, we have also had considerable success in being among the major thought leaders in the technology of safety and risk analysis. This impressive experience base is detailed in Section 4. It is appropriate to highlight here some examples of assignments that typify our national standing in the field. These examples are restricted to assignments that either are current or were completed within the past 2 years:

- Membership on a major chemical company's oversight committee relating to the design and operation of a rocket fuel production facility.
- Membership on a National Academy of Sciences committee overseeing the U.S. Army's chemical munitions disposal program.
- Membership on a high-level safety review committee overseeing the safety of numerous chemical and other facilities at a major DOE laboratory.

- Consultant to the DOE on the disposal and processing of high-level radioactive waste.
- Membership on a National Academy of Sciences committee overseeing the safety of the space shuttle.
- President of the National Society for Risk Analysis.

2. OVERSIGHT PROCESS

PLG proposes to establish an independent oversight program along the lines of the Independent Oversight Team (IOT) that PLG provided during restart of the Sequoyah facility following the January 1986 incident. The program would provide one onsite senior-level evaluator for 8 hours each day, 7 days per week, until the NRC agrees to termination of the oversight program. The evaluators will randomly vary the time of day that they are on site in order that observations can be made during different shifts.

To ensure complete responsiveness to the NRC requirements as well as to the needs of SFC, PLG will prepare a guidance document for use by all members of the oversight program. The document will specify the objectives of the oversight program; the organization of the oversight team and its responsibilities and authorities; the criteria for communicating with SFC, the NRC, and other organizations; and procedures for conducting daily evaluations and preparing daily and weekly reports. In addition to the primary responsibilities of daily evaluations and weekly reports, the team members will also assist the management appraisal activity on a time-available basis; i.e., if no impact on oversight activities is expected.

A schedule for site duty for team members will be prepared and submitted to SFC and the NRC. PLG proposes to post one team member onsite for a period of 7 days. On the 7th day of the member's tour, a replacement will arrive and will be briefed on the evaluations that transpired over the last week and those planned for the following week. Thus, every 7 days, there will be two team members onsite for 1 day. The oversight schedule will be updated when required by events such as team member illness. To ensure backup capability, PLG is submitting a list of six individuals in addition to the project manager. Upon termination of the oversight program, a complete record of the actual site duty schedule will be included in the oversight termination report.

Daily and weekly reports will be prepared by the onsite team members. The daily reports will identify the activities, areas, and procedures that received oversight and the observations resulting from the oversight. During the initial weeks of the oversight activity, the PLG project manager will prepare a list of activities, areas, and procedures that will be the focus of the oversight activities. This list will be developed from review of the NRC Demand for Information and discussions with SFC management. Items of safety significance will be separately identified in the daily reports. All items that are of immediate safety significance or that do not appear to meet NRC requirements will be brought to the attention of the President of SFC or his designee when found, in addition to being documented in the daily report. The daily report will also identify action items; e.g., special observations that need to be performed. The date and the person assigned action item followup will be identified.

Weekly reports will summarize the daily report and will identify items of safety, significance, and outstanding actions items. They also will identify any changes in the team site duty schedule. Each weekly report will be reviewed with the President of SFC or his designee prior to SFC submittal of the reports to the NRC.

When the NRC agrees to termination of the oversight effort, the PLG project manager will prepare a termination report. The report will summarize safety significant observations as well as the areas, activities, and procedures that were evaluated. Trends in safety performance and adherence to NRC regulatory requirements will be summarized, and

recommendations for follow-on activities by the SFC organization will be provided, if appropriate.

3. OVERSIGHT TEAM QUALIFICATIONS

PLG has assembled a team of experts with direct experience in the evaluation and management of large process and manufacturing facilities associated with the nuclear fuel cycle, nuclear defense programs, and chemical processing. Some of the highlights of the individual team member qualifications are as follows:

- The program director is a leading authority on quantitative risk analysis, having begun his career in the startup and early operation of a nuclear fuel reprocessing facility and being committed to independent and unbiased evaluations.
- The project manager is an authority on nuclear fuel cycle chemical processes and a proven top-level analyst of chemical and nuclear process plants.
- Essentially all members of the team have process plant experience or formal training in operations, design, analysis, or risk assessment.
- Most of the team members have extensive experience in making critical assessments of nuclear facility operating procedures, licensing requirements, technical specifications, radiation protection programs, quality assurance programs, and emergency response plans.
- Some team members have had important roles in the management analysis of large nuclear facilities.
- The team has been staffed to accommodate an operations perspective of the plant—many have "hands-on" experience with operations and heavy equipment.
- The team has been selected to ensure: (1) full compliance with the license, and (2) good operating practices whether licensing related or not. This latter quality is expected to result in both compliance and production dividends to the Sequoyah Fuels Corporation.

Dr. B. John Garrick, President of PLG, will serve as PLG project director, and will be responsible for ensuring that the products developed by the respective project teams reflect the same high standards of quality and objectiveness that are required of all PLG projects. Dr. Garrick is recognized as an international authority on risk and safety analysis of all phases of the nuclear fuel cycle, and has served on numerous independent safety review committees for the nuclear, chemical, and aerospace industries.

We propose Mr. Willard C. Gekler as the PLG project manager for this work. He was a senior-level member of the previous IOT activity at the Sequoyah facility. He has extensive experience in the analysis of radiation and chemical safety and environmental protection at regulated facilities that are similar to SFC.

The oversight team will be composed of personnel who also have such experience. In addition to Mr. Gekler, PLG proposes Henry W. Morton, Dr. Dennis C. Bley, Donald W. Latham, Dr. John G. Stampelos, Timothy J. McIntyre, Robert A. Dykes, and David A. Bidwell as members of the oversight team. Messrs. Morton, Stampelos, and McIntyre are all experienced members of the previous IOT at the Sequoyah facility.

The following is a summary of the qualifications of each oversight team member:

- **B. John Garrick, Ph.D. (Project Director)**
  - President and Chairman of PLG, Inc.
  - International authority in the development and implementation of quantitative methods of risk analysis, risk management, and reliability analysis.
  - Member of high-level safety review committee overseeing the safety of numerous chemical and other facilities at Idaho National Engineering Laboratory.
  - Ph.D., Engineering and Applied Science, 1968.
- **Willard C. (Bill) Gekler (Project Manager)**
  - Member of the PLG Independent Oversight Team during restart of Sequoyah Fuels Facility, 1986-1988.
  - Safety and reliability engineer with over 33 years of experience in the design and analysis of chemical process, engineering test, and nuclear facilities.
  - Project manager and/or principal investigator for numerous safety and risk assessments of large, complex production and experimental facilities, including nuclear power plants, nuclear processing facilities, chemical processes, and petroleum refineries.
  - Performed engineering design and analysis for nuclear and chemical facilities, including monitored retrievable storage systems, chemical agent disposal system, liquid sodium heat transfer test loops, and refinery modifications.
  - Petroleum Refining Engineering (PRE), 1954.
- **Henry W. Morton**
  - Member of PLG Independent Oversight Team during restart of Sequoyah Fuels Facility, 1986-1988.
  - Technical Consultant and Certified Health Physicist with extensive professional experience in nuclear health physics; radioactive waste management; environmental aspects of nuclear power, nuclear licensing, and nuclear criticality safety; and instrument and testing methods development.
  - Consultant evaluating radioactive waste systems and the environmental impact of nuclear reactor effluents.
  - Supervisor of Nuclear Criticality Safety and Licensing for reactor fuel reprocessing plant.
  - M.S., Environmental Science, 1972.
  - B.S., Nuclear Engineering, 1965.

- **Dennis C. Bley, Ph.D.**

  - Senior consultant with over 23 years experience in risk and reliability analysis of nuclear power plants, chemical processes, and space and defense systems.
  - Principal investigator of the PLG probabilistic risk assessment of the UF_6 handling processes at the Sequoyah facility.
  - Extensive experience in interfacing with the NRC on licensing and regulatory-related issues pertaining to all phases of the nuclear fuel cycle.
  - Ph.D., Nuclear Reactor Engineering, 1979.
  - B.S., Electrical Engineering, 1967.

- **Donald W. Latham**

  - Senior consultant with over 28 years experience in reliability, availability, and maintainability engineering for the electric power industry, with emphasis on nuclear power systems.
  - Direct working knowledge of the nuclear licensing and regulatory process as a result of 11 years with a nuclear utility and 13 years with reactor vendor and engineering firms.
  - Former Supervisor, Reliability and Quality Engineering, for San Diego Gas & Electric Company, responsible for implementing numerous programs for maintenance optimization, productivity improvement, and quality assurance for nuclear and fossil power plants.
  - Extensive experience in the development and management of training programs for reactor operators.
  - B.A., Physics, 1955.

- **John G. Stampelos, Ph.D.**

  - Member of PLG Independent Oversight Team during restart of Sequoyah Fuels Facility, 1986-1988.
  - Senior consultant with extensive experience in nuclear reactor operation, safety evaluation, and risk assessment.
  - Senior nuclear staff engineer on Nuclear Safety Oversight Committee for the President of United States.
  - Power plant watch officer in charge of 60 nuclear operators and maintenance personnel on the U.S.S. Enterprise.
  - Ph.D., Nuclear Engineering, 1979.
  - M.E., Nuclear Engineering, 1976.
  - B.S., Electrical Engineering, 1970.

- **Timothy J. McIntyre**

  - Member of PLG Independent Oversight Team during restart of Sequoyah Fuels Facility, 1986-1988.
  - Senior consultant providing onsite support in preparation of risk assessments at nuclear utilities.
  - Member of safety enhancement program team investigating severe accident management and emergency operating procedure implementation at nuclear power plant.
  - Principal engineer and analyst for various nuclear power plant risk assessments.
  - Director and instructor of U.S. Navy Advanced Electronics Theory School.
  - B.S., 1984.

- **Robert A. Dykes**

  - Senior consultant with more than 30 years of experience in the assessment, execution, and supervision of operation and maintenance of complex systems in a hazardous environment.
  - Commanded squadron of U.S. Navy ships.
  - Managed ship overhauls.
  - Organized and monitored qualification and certification programs for operations and maintenance of electronic, hydraulic power plant systems.
  - Qualified naval aviator.
  - M.S., Systems Management, 1987.
  - B.S., Environmental Science, 1958.

- **David A. Bidwell**

  - Consultant experienced in hazard determination, data analysis, and safety and risk assessments of nuclear facilities and chemical process plants.
  - Systems engineer responsible for operation of primary and secondary systems at 1,100-MWe nuclear power plant.
  - Coordinated plant operations with chemistry, engineering, and technical testing departments to support compliance with NRC license requirements.
  - B.S., Applied Physics, 1984.

Detailed resumes for each of the proposed project team members follow.

B. JOHN GARRICK

Summary

President and Chairman of PLG, Inc. A scientist, engineer, and international authority on quantitative risk analysis and risk management of technological systems. Over 35 years of direct experience in risk and safety assessment.

Experience

Experience includes research, operations, engineering and construction, teaching, and consulting. A leader in the development and implementation of quantitative methods of risk analysis, risk management, and reliability analysis in the fields of nuclear power, aerospace and chemical processing. Directed more than 30 major probabilistic risk assessments (PRA) in these three industries. Experience consists of 13 years at PLG (engineering, applied science, and management consulting), 18 years at Holmes & Narver, Inc. (technology, engineering, and construction), and 5 years with the U.S. Atomic Energy Commission. Served on numerous national and international scientific and technical committees and special panels for the National Academy of Sciences, International Atomic Energy Agency, Congressional Office of Technology Assessment, Accreditation Board for Engineering and Technology, and numerous other topic and company-specific committees and advisory panels. Over 200 publications in risk, reliability, and engineering technology.

Education

Ph.D., Engineering and Applied Science, University of California, Los Angeles, 1968
M.S., Engineering and Applied Science, University of California, Los Angeles, 1962
Diploma, Nuclear Reactor Technology, Oak Ridge School of Reactor Technology
B.S., Physics, Brigham Young University, 1952

Memberships, Licenses, and Honors

President, Society for Risk Analysis (an international professional society)
Past President, Los Angeles Maintainability Association
Fellow, Institute for the Advancement of Engineering
Founder, Southern California Chapter of the Society for Risk Analysis
Member, American Nuclear Society
B. John Garrick Fellowship, Massachusetts Institute of Technology
B. John Garrick Fellowship, University of California, Los Angeles
Adjunct Professor, University of California, Los Angeles
Registered Professional Engineer, State of California
Selected via National Competition To Attend Prestigious United States Atomic Energy Commission's Oak Ridge School of Reactor Technology To Do Graduate Work in Nuclear Science and Technology in 1954

WILLARD C. GEKLER

Summary

A chemical and nuclear engineer with 35 years of experience in analysis and design of chemical process, engineering test, and nuclear facilities. Partner and Senior Consultant, PLG. Currently leading probabilistic risk assessments (PRA) and performance improvement analysis for power facilities and chemical facilities.

Experience

Manager and investigator for probabilistic risk assessment of chemical process facilities. Lead investigator for RAM analyses and simulation studies of combined cycle power plants and cogeneration facilities. Managed probabilistic safety assessment for Nine Mile Point Unit 1 and availability engineering services for waste-fueled power plants. Lead investigator in study of safety criteria for spent fuel transport risk assessment methods. Managed integrated model for evaluation of safety, reliability, and economics at the Sequoyah Nuclear Plant. Manager of Quality Assurance for PLG. Instructor in AIChE chemical risk assessment short course and EPRI workshops on reliability-based preventive maintenance planning methods. Led development of availability data management system for geothermal power plant. Previously, at Holmes & Narver, Inc., positions ranged from engineer to technical director of Process and Energy Systems Division. Performed and managed engineering design and analysis for nuclear and chemical facilities. Facilities included monitored retrievable storage system, chemical agent disposal system, liquid sodium heat transfer test loops, and refinery modifications. Also, performed and led development and field testing of reliability monitoring program for safety systems in nuclear power plants. Process engineer for Mobil Oil Corporation and Esso Standard Oil Company performing research and development and field tests for new products and product quality improvement.

Education

Graduate Work, Nuclear Engineering, University of California, Los Angeles, 1960-1963
P.R.E. (Petroleum Refining Engineer), Colorado School of Mines, 1954
Short Course, Radioactive Waste Management for Nuclear Power Reactors, University of California, Los Angeles, 1975
Reactor Safety Course, United Kingdom Atomic Energy Authority, 1967
Systems Safety Analysis Course, University of Washington, 1965

Memberships, Licenses, and Honors

American Nuclear Society
The Society for Risk Analysis
Certified Reliability Engineer, American Society for Quality Control
American Institute of Chemical Engineers

HENRY W. MORTON

Educational Background

M.S., Environmental Science, University of Michigan, 1972
B.S., Nuclear Engineering, University of Tennessee, 1965

Employers and Experience

1984-Present Morton and Potter. Technical Consultant and Certified Health Physicist with over 19 years of professional experience in the nuclear field in health physics, radioactive waste management, environmental aspects of nuclear power, nuclear licensing, nuclear criticality safety, and instrument and testing methods development. Providing technical services in the preceding fields to nuclear utilities and nuclear fuel fabricators.

1982-1984 Independent consultant. Provided technical services in radiation protection and radioactive waste management to utilities operating nuclear power plants.

1976-1982 Nuclear Safety Associates. Partner and Technical Manager providing consultation to industry in the areas of radiation protection, radioactive waste management, environmental assessment, and regulatory affairs. Consulting activities included evaluation of radwaste systems and the environmental impact of reactor effluents, analysis of low-level waste management alternatives, consulting in health physics and radiation protection programs, managing radiation surveys, and representing industry in regulatory and licensing proceedings.

1969-1976 Nuclear Fuel Services. Supervisor of Nuclear Criticality Safety and Licensing at Nuclear Fuel Services' reactor fuels plant. Directed the criticality control program, prepared license applications and supporting safety analyses, audited the radiation protection programs, and coordinated licensing and compliance activities for the plant. Previously, as an Environmental Protection and Licensing Specialist at NFS' corporate office, performed analyses of nuclear criticality, shielding, environmental, and radiological safety and developed design bases for fuel reprocessing, fuel fabrication, and UF plants.

1965-1969 Union Carbide Corporation. Engineer at the Y-12 Plant in Oak Ridge, Tennessee, where he developed instrumentation and measurement methods and provided engineering services in health physics, chemical processing, and engineering design.

Memberships, Licenses, and Honors

Certified Health Physicist by the American Board of Health Physics
Certified Engineer-in-Training by the Tennessee State Board of Architectural and Engineering Examiners

DENNIS C. BLEY

Summary

Senior Consultant and Partner with PLG, Inc., with 23 years experience in reliability and availability analysis, plant modeling for risk assessment, decision analysis, and expert systems.

Experience

Has worked on probabilistic risk assessments (PRA) for many large engineered systems, including chemical facilities such as a uranium fuel conversion facility, a microelectronics fabrication facility, and an hydrofluoric acid plant. These studies examined the onsite and offsite risks resulting from equipment failure, human action, and external effects including earthquake, fire, and wind. Principal investigator for many of these studies and many smaller projects. Primary utility risk assessment witness during the 1983 Indian Point hearings before the Nuclear Regulatory Atomic Safety and Licensing Board—the only hearings ever to address the risk of an operating power plant. Performed and supervised analyses of electric power systems, electronic control systems, and plant mechanical systems. Member of Senior Consultant Group for the U.S. Nuclear Regulatory Commission (NRC). Member of the Oak Ridge Associated University Advisory Committee for the PRA training program. Has been a major contributor to other PLG projects, such as an expert system to assist nuclear power plant operators in diagnosing and responding to accidents, a work order scheduling system, a probabilistic cost-benefit analysis of steam turbine diagnostics, reliability analyses of plant systems for use in the licensing process, technical review of the California Office of Emergency Services Recommended Emergency Planning Zone Considerations, and technical review of several industry and U.S. Department of Energy risk assessments. Lecturer at PLG, University of California, Los Angeles, and Massachusetts Institute of Technology short courses in PRA and power plant availability.

Education

Ph.D., Nuclear Reactor Engineering, Massachusetts Institute of Technology, 1979
Courses in Nuclear Engineering and Computer Science, Cornell University, 1972-1974
U.S. Navy Nuclear Power Training Program and Officer Candidate School, 1967-1969
B.S.E.E., University of Cincinnati, 1967
Courses in Mathematics and Physics, Centre College of Kentucky, 1961-1963

Memberships, Licenses, and Honors

American Association for Artificial Intelligence
American Association for the Advancement of Science
American Nuclear Society
Association for Computing and Machinery
American Society for Testing and Materials
Eta Kappa Nu (National Electrical Engineering Honors Society)
Institute of Electrical and Electronics Engineers
Registered Nuclear Engineer, State of California
Sherman R. Knapp Fellowship (Northeast Utilities), 1975-1976
Sigma Xi (National Science Honors Society)
Sloan Research Trainee, 1974-1975
Society for Risk Assessment

Town Hall of California
World Affairs Council of Orange County
U.S. Naval Reserve, Commander, Field Officer in Technology Mobilization Program

DONALD W. LATHAM

Education

B.A., Physics, University of California, Santa Barbara, 1955
Graduate Study: Physics, New Mexico Highlands University; 1960-1961; Education, San Fernando State College, Northridge, California, 1956-1959

Employers and Experience

1987-Present PLG, Inc. Senior Consultant engaged in reliability, availability, and maintainability (RAM) engineering. Established a RAM reporting system for a utility's fossil generating units. Developed a method for reporting/assessing quality program deficiencies for a nuclear plant. Provided input on historical problems/solutions at combined-cycle plants for use in developing equipment specifications for future plants.

1976-1987 San Diego Gas & Electric Company. Supervisor, Reliability and Quality Engineering. Established and supervised programs to identify the causes of losses in availability of fossil power plants and to recommend fixes. Also responsible for programs to ensure optimized availability of new and modified plants. Assumed the responsibility for the allied field of quality assurance in November 1980. Organized and implemented the following programs: (1) vibration monitoring, (2) nondestructive testing, (3) drawing control, (4) predictive maintenance, (5) thermal imaging, (6) Heber Geothermal Project quality assurance, and (7) maintenance optimization.

Senior Nuclear Engineer and Reliability Program Coordinator. Coordinated the development and implementation of the Sundesert availability program.

1976 Consultant. Principal Client: Center for Nuclear Studies, Memphis State University. Related university capabilities to industry needs and assisted university in methods of developing training programs to meet the identified needs.

1974-1975 General Atomic Company. Manager, Training. Managed the development of training programs for operations staffs of future high temperature gas reactors. Developed plans for a training center and simulator.

1968-1974 Manager, Nuclear Training Services; Advisory Engineer (Business Development). Instituted development of Westinghouse Nuclear Training Center and simulator. Developed new, and modified existing, training programs to improve effectiveness while decreasing instructor time. Researched utility service needs for business opportunities.

1962-1968 Atomics International. Senior Physicist and Senior Site Representative. Physicist-in-charge of a research reactor. Represented the U.S. Atomic Energy Commission and Atomics International in closing U.S. participation in the heavy water moderated organic cooled reactor

program at the Whiteshell Nuclear Research Establishment, Manitoba, Canada.

Memberships, Licenses, and Honors

Electric Power Research Institute (EPRI) Nuclear Division Engineering and Operations Task Force; Nuclear Reliability and Maintenance Subcommittee; Fossil Plant Reliability and Performance Subcommittee; and National Data Subcommittee
Edison Electric Institute Availability Engineering Task Force
American Nuclear Society
American Society of Metals, International
Senior Reactor Operator, Atomics International
Registered Professional Nuclear Engineer, California
U. S. Atomic Energy Commission Q Clearances

JOHN G. STAMPELOS

Educational Background

Ph.D., Nuclear Engineering, University of Florida, Gainesville, 1979
M.E., Nuclear Engineering, University of Florida, Gainesville, 1976
B.S.E.E., U.S. Naval Academy, 1970
U.S. Nuclear Regulatory Commission PWR Simulator Refresher Course (Sequoyah Simulator), 1980
U.S. Naval Nuclear Ship Superintendent School, 1974
U.S. Naval Nuclear Power School, 1971

Employers and Experience

1982-Present PLG, Inc. Electrical and nuclear engineer involved in systems analysis; plant operator action analysis for plant safety assessments; development of interactive, user-friendly computer software (QUICKRAM); and the development of plant preventive and predictive maintenance programs. Participated in an assessment of risk in the transport of nuclear fuels. Lead investigator for systems analysis of Nine Mile Point Unit 1 (NMP-1) safety assessment. Analyzed NMP-I power plant procedures for conformance with technical specifications. Prepared systems analyses, human reliability analysis, and electric power recovery analysis for the Seabrook Station probabilistic risk assessment.

1980-1981 President's Nuclear Safety Oversight Committee, Washington, D.C., Senior Nuclear Staff Engineer.

1979-1980 U.S. Nuclear Regulatory Commission (NRC), Washington, D.C. Fellow to the Advisory Committee on Reactor Safeguards. Prepared independent analyses of various subjects in the field of nuclear power plant safety and nuclear waste storage. Assessed the NRC "Action Plan as a Result of the Accident of Three Mile Island Unit 2 Nuclear Generating Station." Reviewed generic nuclear reactor safety component test programs.

1975-1979 University of Florida. Graduate student.

1970-1975 U.S. Navy. Commissioned Officer. *USS Enterprise*, Power Plant Watch Officer. Supervised training of 60 nuclear operators and maintenance of all equipment in two (of four) main machinery rooms (main propulsion turbines, the ship turbine generator, and associated equipment) through overhauls and deployment. Assistant and Acting Senior Nuclear Ship Superintendent at Mare Island Naval Shipyard, responsible for scheduling and completion of major nuclear submarine overhaul, refueling, and power plant testing.

1970 Brookhaven National Laboratory. Guest research assistant.

Memberships, Licenses, and Honors

American Nuclear Society
Institute of Electrical and Electronic Engineers
Registered Professional Nuclear Engineer, Florida, 1977

TIMOTHY J. McINTYRE

Summary

A Senior Consultant specializing in safety analysis probabilistic risk assessments (PRA), availability improvement programs, and training activities. An engineer with 24 years of power plant operations and maintenance experience. Primary analysis experience in boiling water reactors. Principal investigator for the Fermi 2 PRA and Pilgrim Station Safety System Unavailability Monitoring Program.

Experience

Principal investigator for the Fermi 2 Level 1 PRA. Provided direct client exposure to PRA through training and analysis while working at client facilities. Trained and directed client PRA team in all technical aspects of a PRA. Principal investigator for the Pilgrim Station Safety System Unavailability Monitoring Program. Provided technical guidance to analysis team on the INPO Good Practice on Safety System Unavailability Monitoring Program. Principal investigator on the reliability and availability analysis of generator protection relay scheme upgrades of fossil unit generators for the Niagara Mohawk Power Corporation. Senior analyst for the Pilgrim Station Probabilistic Safety Assessment (PSPSA). Performed system and event analysis of boiling water reactor systems related to the PSPSA. Systems analyst on the Hatch plant integrated risk model and Three Mile Island, Unit 1, PRA. Training director for the Oyster Creek Nuclear Generating Station Generic Post-Maintenance Test Guide program. Analyst/investigator on the EPRI seismic margin program specializing in electrical and electronic component analysis and relay chatter. Representative on the Boston Edison Company Safety Enhancement Program to investigate safety improvements developed on the Pilgrim Station. Retired U. S. Navy Senior Chief Petty Officer.

Education

B.S., Southern Illinois University, Carbondale, 1984
Specialized training at the following U.S. Navy schools:
- Electronics Technical Basic and Advanced Theory Schools
- Naval Nuclear Power School, including Prototype Training
- Quality Assurance

Memberships, Licenses, and Honors

American Nuclear Society
Qualified as Senior Reactor Operator
Qualified as Naval Nuclear Power Prototype Instructor

ROBERT A. DYKES

Summary

A senior consultant and manager with more than 30 years of experience in the U.S. Navy, achieving rank as Captain with major responsibilities for planning, implementing and managing large complex projects.

Experience

Overview management responsibility for the overhaul of the nuclear vessel, *USS Enterprise*. Personally controlled the major activity, a $7-million project involving over 350 technical and nontechnical personnel. Took over responsibility after schedule slippage, and coordinated the work planning, layout of responsibilities, critical scheduling, manpower allocations, and contractor activities. Project was completed as originally scheduled. During this same period, other projects were added that had schedule slippages, and their schedules were also recovered through detailed planning and control. This was accomplished in spite of projects being done by others in the same location who were all competing for work space and manpower resources.

As a commanding officer in an amphibious squadron, was responsible for war planning, execution of exercises, planning and scheduling the overhaul of vessels, and training large numbers of personnel.

Personally managed the overhaul of the *USS St. Louis*, a large amphibious vessel. The overhaul was a $12-million project involving over 400 technical and nontechnical personnel. With development of an revised plan and rescheduling of critical milestones, completed the project early and with a savings of over $1 million.

Periodically organized and supervised action-oriented teams with personnel from up to 14 different organizations to work complex problems.

Was project manager for a computer-based logistics command and control system that allowed European commands to access distributed database in the U.S. to improve supply and intransit visibility of material. Coordinated and supported personnel from several organizations in both Europe and the U.S., achieving the rank of Captain with multiple command positions. A qualified naval aviator.

Education

M.S., Systems Management, University of Southern California, Los Angeles, 1987
B.S., State University of New York, College of Environmental Science and Forestry, 1958
Management Information Systems Certificate, University of Southern California, Los Angeles, 1986

Memberships, Licenses, and Honors

Naval Institute
National Defense Transportation Association
Association of Production and Inventory Control

DAVID A. BIDWELL

Summary

Consultant at PLG, Inc., with direct experience in hazard determination, data analysis, and safety assessments of nuclear facilities and chemical process plants. Direct experience in performing hazard and operability (HAZOP) studies.

Experience

Key technical contributor to Risk Management and Prevention Programs (RMPP) in support of the chemical process industry. Currently, a member of HAZOP team for the Unocal Science & Technology Division RMPP.

Formerly, a systems engineer for Southern California Edison Company, San Onofre Nuclear Generating Station. Responsible for the manipulation of both primary and secondary plant systems. Implemented appropriate actions as required by abnormal plant conditions. Integrated theoretical principles of power production including the nuclear reaction, and steam- and turbine-generator cycles. Coordinated plant operations with chemistry, engineering, and technical testing departments.

Education

B.S., Applied Physics, Columbia University, 1984

Memberships, Licenses, and Honors

Air Force, Army, and Navy ROTC Scholarships
New York State Regents Scholarship

4. PLG PROJECT EXPERIENCE

PLG's experience is presented here under the following major headings:

- Safety Assessments, Reviews, and Audits
- Process Plant Hazard Evaluation and Risk Assessment
- Transport and Fate of Chemicals in the Environment
- Transportation Risk Analysis
- Fire Risk Analysis
- Earthquake and Other External Hazards Evaluation
- Nuclear Plant Risk and Reliability Assessment
- Financial Risk Analysis of Construction Projects

4.1 SAFETY ASSESSMENTS, REVIEWS, AND AUDITS

Since its beginning, PLG has been called on regularly to conduct independent safety assessments, audits, and reviews of both the operation and the management of complex engineered systems. Our ability to perform an independent assessment and oversight function is based on two important assets. First, PLG has become one of the leading independent risk assessment organizations servicing the owners and operators of nuclear process facilities and nuclear power plants, petroleum and chemical facilities, and other complex systems. Second, our staff is composed mainly of engineers with direct experience in the design, management, and operation of the facilities we are asked to audit and review. Thus, the resulting expertise from this experience base covers the two most fundamental issues connected with facilities such as the Sequoyah facility: safety and management.

Presented below is a brief summary of the relevant projects.

- **Independent Oversight of Nuclear Fuel Conversion and Process Facility (Sequoyah Fuels Corporation).** Following a major accident at Sequoyah Fuels nuclear fuel processing plant in 1986, the U.S. Nuclear Regulatory Commission (NRC) required that an independent oversight team (IOT) be established to oversee restart and operation of the plant. PLG was selected to provide and manage the IOT. The principal activity of the IOT was to perform an ongoing audit that emphasized environmental, health, and safety-related activities, thus providing assurance to plant management and the regulators that the plant would operate in accordance with the highest standards of safety and quality. Oversight activities included the following:

  - Adequacy and accuracy of procedures.
  - Qualifications, training, commitment, adequacy, and capability of plant management and staff.
  - Adequacy of quality assurance program.
  - Adequacy of plant record keeping.
  - Surveillance walk-throughs.

- Review of and followup on plant incidents.
- Adherence to license conditions and NRC regulations.

For 12 months, the PLG oversight team performed onsite, 24-hour surveillance of operational and maintenance activities, followed by 6 months of single-shift-per-day surveillance. One-week, onsite, follow-up inspections continue to be performed by PLG on a quarterly basis. All findings and recommendations were documented and presented to management on a monthly/quarterly basis. When major hazards or deficiencies in operations were identified, PLG immediately presented these concerns to management.

- **Release Prevention Screening Assessment of Unocal Facilities (Unocal Corporation).** PLG and a major architect-engineering firm performed a screening-type risk assessment of Unocal's major refineries, an ammonia plant, and other chemical process facilities (a total of 28 facilities). The objectives were to (1) characterize the potential for releases of toxic chemicals and flammable gases into the atmosphere at these facilities, and (2) provide a quick summary assessment of measures that could prevent, mitigate, and respond to these releases. PLG and Unocal jointly developed a standard protocol that provided the basic structure for guiding the collection of data and information that were necessary to characterize the potential for releases as well as prevention/mitigation plans. Onsite assessments were then performed. The results were used in an evaluation of various aspects of release prevention controls and countermeasure plans being employed at the Unocal facilities.

- **Savannah River Plant Technical Support Services [U.S. Department of Energy (DOE)].** Under subcontract to a major architect-engineering firm, PLG is providing technical support services to the DOE Savannah River Restart Special Projects Office for the restart of the production reactors at that location. These services include using commercial experiences for the preparation of procedures and guidelines to be used by the DOE staff in its role of overviewing startup, operations, maintenance, and training activities by the operating contractor. Other services involve assisting the DOE in overview functions, including the review of startup test procedures, overview of testing activities, and evaluation of test results.

- **Safety Review of the DOE Feed Materials Production Center (FMPC) (U.S. Department of Energy).** PLG participated in the 1988 DOE review of the overall safety performance at the FMPC. This review included an assessment of the adequacy of follow-up actions taken by the contractor in response to a 1986 technical safety appraisal as well as the identification of key issues that required additional management action. The review covered all operational activities at the FMPC and supporting services such as training, emergency readiness, safety administration, radiological protection, industrial hygiene, occupational safety, and fire protection.

- **Safety Review of Y-12 (Weapons Materials Production) Facility at Oak Ridge National Laboratory (U.S. Department of Energy).** PLG participated in a follow-up safety review of the DOE weapon materials production facility at Oak Ridge. PLG staff was assigned responsibility to review operations, auxiliary activities, and experimental facilities. As part of this assignment, PLG performed a thorough safety review of a recently completed waste water pretreatment facility, including evaluation of both the physical and procedural safeguards implemented at that facility.

- **Triennial Review of Internal Safety Review Program (EG&G Idaho, Inc.)**. In compliance with the section of DOE Orders 5480.5 and 5480.6 concerning the requirements for internal safety reviews, EG&G performed a triennial review of the DOE-owned nuclear reactors and nuclear facilities operated by EG&G. Dr. B. John Garrick, President of PLG, served as chairman of an expert panel of three outside consultants who performed the triennial review. The evaluation resulted in a comprehensive list of 15 findings, conclusions, and recommendations for improvements regarding policies and procedures development and implementation, organizational effectiveness, and qualifications of current staffing.

- **Safety Assessment of Industrial Waste Water Pretreatment Facility (U.S. Department of Energy/Allied-Signal, Inc.)**. In accordance with DOE Order 5481.1B, PLG performed a safety assessment of the newly constructed wastewater facility at DOE's Kansas City Division plant. The primary objectives were to identify potential major risks posed by operation of the wastewater facility and to develop recommendations as to how plant management could mitigate these risks prior to or during initial startup and operation.

4.2 PROCESS PLANT HAZARD EVALUATION AND RISK ASSESSMENT

Accidental releases of hazardous chemicals can arise from a process plant itself or from storage areas onsite or nearby. PLG has developed extensive methodologies to identify sources of hazard and to address the various possible scenarios involving release of hazardous materials into the environment. Analyses performed by PLG have evaluated the sources of hazard, the likelihood of release, and the overall risk due to the potential impact of hazardous chemicals on the public and surrounding industrial activities. Examples of such evaluations and the clients for whom they were performed are presented below:

- **Hazard Evaluation and Risk Assessment of a Hydrofluoric Acid Storage and Distribution System (major petrochemical company)**. The analysis focused on the unloading operation of hydrofluoric acid trucks, external and internal hazards jeopardizing the integrity of the storage tank, the relief valve system, and the distribution piping. A top-down approach was followed for which a HAZOP-type of method was used first. From this method, the most hazardous conditions for which a full-scope risk assessment is performed were identified. The risk assessment involved modeling of human errors and system response to abnormal conditions (using fault trees and event trees) and evaluating component failure frequencies and human error rates. Also, as part of risk assessment, the potential release scenarios (source terms) were identified, and the evaporation, dispersion, and impact on the offsite populations were evaluated using probabilistic methods.

- **Safety Evaluation of Effluent Removal System (U.S. Department of Energy)**. A reliability and risk analysis was performed on a critical safety and containment system at a major DOE weapons plant. The results of the study were provided for use in modifying the design and operating procedures of the system.

- **Systems Safety Analysis for Glove Box Purge System (U.S. Department of Energy)**. A detailed systems safety analysis was performed to assess the failure frequency of two different purge system/glove box configurations at a major DOE weapons plant. Failure was defined as excessive overpressure or underpressure in the glove boxes resulting from purge system malfunctions. The purge system is used to sweep hazardous gases

from the glove boxes and to control glove box pressure. Hazardous gases may be released into the glove boxes by processes located in the boxes. The analysis used fault trees to model the various configurations and to provide the basis for the quantification of the glove box failure frequency attributable to the purge system. Major contributors to failure were identified in purge system equipment, operator actions, and in other systems supporting or interfacing with the glove box operations. The purge system was found to be a minor contributor to failure of the glove box containment function.

- **Evaluation of Chlorine Cylinders Failure Frequency (major chemical manufacturer)**. In this study, the failure modes of chlorine cylinders are identified. Cylinder failure incidents are reviewed, and failure frequencies are evaluated from industry-based and plant-specific data.

- **Chemical Plant Hazard Analysis (major chemical company)**. A pilot study was performed to demonstrate the applicability of risk analysis methods to a chemical facility. The analysis involved evaluating potentially hazardous operations and developing and quantitatively evaluating risk models on selected process units. A top-down approach was employed in which the most hazardous operations received more detailed attention. The offsite impact of potential releases was also included in the analysis.

- **Risk Management and Prevention Program for the Brea Chemicals Plant (Unocal Corporation)**. PLG and a major architect-engineering firm were selected by Unocal Chemical Division to develop and implement a Risk Management and Prevention Program (RMPP) for the Brea, California, plant. The plant, which receives anhydrous ammonia liquid and urea granules by rail and truck and produces a variety of agricultural fertilizers, is located in an area of commercial, light industrial, and residential land use. Acutely hazardous materials of concern include ammonia, chlorine, nitric acid, and sulfuric acid. Following development of an RMPP project plan, PLG supported Unocal in presenting the plan to the Administering Agency. HAZOP studies and dispersion modeling/consequence analysis were then performed as necessary for selected processes.

- **Risk Management and Prevention Program for the Science & Technology Division (Unocal Corporation)**. PLG and a major architect-engineering firm were selected to assist Unocal in developing and implementing an RMPP for the Science & Technology Division in Brea, California. Acutely hazardous materials at the facility include ammonia, hydrogen sulfide, and vinyl acetate monomer. PLG performed a detailed assessment of existing Unocal safety-related plans, procedures, and programs that satisfy California's statutory requirements and any requirements of the Administering Agency. HAZOP studies were performed, as necessary, for those systems/processes using AHMs, followed by dispersion modeling and consequence analysis. PLG also trained selected Unocal personnel at the Science & Technology Division in the use of hazard analysis and risk assessment methods to evaluate process safety, and assisted Unocal in using the results of the RMPP to further enhance the safety risk management process at the facility.

- **Central Ferry Transhipping Terminal Limited Environmental Impact Study (Unocal Corporation)**. PLG assisted Unocal in the conduct of a limited environmental impact study for the Central Ferry project. The project involved the transport of ammonia by barge on the Snake River from Unocal's Hedges Terminal in Kennewick, Washington, to the proposed Central Ferry Transhipping Terminal in the Palouse area of Washington state. Approximately 20,000 short tons of ammonia will be barged on one of two

Unocal-owned barges to Central Ferry and then offloaded at a rate of approximately 400 gallons per minute through a fully engineered hard pipe system in about 3 to 5 days.

The study was performed in two phases. In Phase 1 a quantitative risk assessment was performed to establish the likelihood and magnitude of potential releases to the aquatic environment. The releases from all credible events were modeled for aquatic dispersion and to determine the total impact on the aquatic environment in the Snake River. Phase 2 was a HAZOP study of Central Ferry operations. It included the vessel and operations performed on the vessel, systems and operations used to transfer ammonia to terminal storage, ammonia storage, truck loading, and aqua ammonia conversion. The HAZOP study assessed the overall safety of terminal operations, identified important accident scenarios, and provided suggestions for safety enhancement of terminal operations.

- **Comparative Analysis of Exposure Assessment Systems (Chemical Manufacturers Association)**. A comparative evaluation of existing exposure assessment methods was performed by PLG. This study involved identifying the salient aspects of the methods and their applicability to targeted chemicals and types of risk; e.g., accidental releases, occupational exposures, or consumer exposure through end-use products. Some of the aspects that were evaluated include the factors and criteria used in hazard determination, the weighting of these factors in determining hazard severity, the ease of using the exposure assessment methods, and the extent of method validation and testing.

- **Risk Assessment of a Butane Handling Facility (major chemical manufacturer)**. PLG has performed an assessment of the risk from handling and unloading rail tank cars of butane. This study involved fault tree and event tree analysis of the facility, the evaluation of equipment failure rates, and the evaluation of operator actions. Recommendations were made for facility modifications to reduce the risk.

- **Risk Assessment of a Holdup Tank Facility (in-house generic study)**. A complete risk analysis was performed for an unstable hazardous chemical in a holdup tank at a process facility. The study involved thorough investigations of hazard sources, accident scenarios, and accident frequency. It also involved an evaluation of potential clerical dispersion patterns, the number of people potentially affected by the release plume, the concentration above which unwanted health effects could occur, and the likelihood of these events. Modifications to the facility were proposed to reduce the release likelihood and the public health risk, given a release.

- **Hazardous Chemical and Transportation Risk Evaluation for Seabrook Station (Public Service Company of New Hampshire)**. PLG evaluated the potential for accidents at Seabrook Station due to industrial activities in the area. A wide variety of potentially hazardous conditions was evaluated. The particular events of interest included accidents leading to hazardous concentrations of toxic or flammable gases or vapors inside the control room. Various scenarios involving the release of hazardous materials into the environment were considered. Releases included those from large storage tanks in the area, tanker trucks passing by the plant, and a nearby natural gas pipeline.

- **Independent Plant Safety and Performance Evaluation (major petrochemical company)**. A team of experts performed a thorough onsite investigation of a manufacturing plant and recommended a list of measures to improve plant safety and availability. The investigation went beyond the hardware and included the management structure and operational style of the plant personnel.

- **Siting and Transportation Risk Study (major chemical manufacturer).** PLG performed a quantitative risk assessment for two unloading and two transportation modes for supplying hazardous acids to a chemical process facility. Results of the assessment were used by the manufacturer for both siting and design of the acid unloading and storage facilities.

- **Risk to a Nuclear Plant from Chemical Plant Operations (major electric utility company).** PLG performed an analysis to determine the contribution to the overall risk of a nuclear plant from numerous hazardous chemical sources in the area surrounding the plant. The analysis consisted of:

  - A detailed evaluation of the chemical hazards.
  - A description of the types of accidents by which each chemical could be released.
  - An evaluation of how the releases could propagate to the nuclear plant site.
  - A characterization of the mechanisms by which the releases, once they reach the plant, could affect plant operation.

  The hazard sources included chemical storage areas, process areas, transfer terminals, and transportation routes. Both toxic and other possible hazards were considered, but only the toxic hazards were found to have significant effects on plant operations.

- **Hazardous Chemical and Transportation Risk Evaluation for the Three Mile Island Nuclear Plant (GPU Nuclear Corporation).** PLG performed a comprehensive study of the potential hazard to personnel in the Three Mile Island Unit 1 (TMI-1) control room from any of more than 60 hazardous chemicals stored or transported near the plant. The analysis modeled both puff and continuous evaporation and dispersion and took chemical buoyancy and the effects on plant structures into account. For each chemical, the evaporation rate was determined as a function of time for a variety of temperatures and wind speeds. This information was used with data on the locations of the railroad track and plant structures, historical meteorological data, data on the frequency of chemical releases per tank car mile, and data on control room air flows to evaluate the expected frequency with which toxic chemical concentration limits in the control room would be exceeded.

- **Control Room Habitability Studies (several utilities).** PLG has performed several studies on the potential for accidental releases of toxic materials that may jeopardize control room habitability. The method used for these studies is similar to that described for the TMI-1 hazardous chemical study. Among the types of accidents evaluated were ruptures of onsite tanks of ammonium hydroxide and chlorine. Most plant modifications proposed by PLG based on these studies were implemented by the utility companies.

4.3 NUCLEAR PLANT RISK AND RELIABILITY ASSESSMENT

PLG is a recognized leader in the world in the application of decision theory and probabilistic safety assessment to the design and operation of nuclear facilities. This is evidenced by the large array of probabilistic risk assessments performed by PLG in the past 10 years. For example, PLG has been directly involved in 30 major nuclear plant probabilistic risk assessments. In all of these PRA projects except three, PLG was the lead PRA consultant

and performed most of the PRA analyses (see Table 4-1). Most importantly, each full-scope PRA performed by PLG has provided the client with an objective, quantitative analysis tool that may be used by the facility owner or operator to measure and manage the risk to public health, safety, and the facility.

In large-scale risk assessment projects, such as those for nuclear plants, PLG develops an integrated computer-based model of the plant. This model is then used to evaluate the overall response of the plant to equipment failures. These models are quantified using a comprehensive data base on failure frequencies, maintenance outages, and human error rates.

4.4 TRANSPORT AND FATE OF CHEMICALS IN THE ENVIRONMENT

PLG has provided environmental services to the nuclear and chemical process industries for more than 20 years. Examples of services performed by PLG are as presented below.

- **Meteorological Information and Dispersion Assessment System.** MIDAS is a fully integrated software package designed to assess the environmental and health impacts of both routine and accident-related atmospheric releases of hazardous materials. MIDAS produces estimates of plume location and intensity in real-time, historical, and simulation modes. Thus, MIDAS is used regularly by PLG to perform dose reconstruction and consequence analyses in support of nuclear and non-nuclear facility safety assessments. In addition, MIDAS uses a database management system and proven computational models to aid the plant manager, operators, and emergency planner at facilities handling hazardous materials to meet specific emergency planning and decision-making needs.

  MIDAS can use any of three atmospheric dispersion models. The PC-based system uses a standard straightline Gaussian model for estimating plume location on a near real-time basis. The standard model is a variable trajectory plume segment model that uses multiple input of meteorological and effluent data as well as forecast data to calculate plume location and concentration. It can account for the effects of local terrain and sea breeze (for areas near large bodies of water).

  The third model, a state-of-the-art particle-tracking model, provides the capability to compute three-dimensional windflow fields and to simulate dispersion of released material within these fields. This model can use all of the input of the variable trajectory model and the measurements from a SODAR (a radar sounding device used to measure meteorological parameters up to about 300 meters).

  In addition to being used in-house by PLG to perform hazardous material dose assessments, the MIDAS software package is currently licensed for use at 25 nuclear power plants and 24 chemical process facilities to support both dose reconstruction analyses and emergency planning activities, thus making MIDAS one of the most widely used dose assessment systems of its kind.

- **Quick Dense Gas Dispersion Model.** The Quick Dense Gas (QDG) program developed by PLG incorporates a model for the evaporation and dispersion of dense gases that operates on an IBM PC/AT-compatible personal computer. QDG incorporates a built-in evaporation model for liquid pools (composed of either pure chemicals or mixtures), which is based on mass and energy balance. It includes the effects of pool spreading, convective heat and mass transfer with the air, heat conduction with the ground, radiative

Table 4-1 (Page 1 of 3). Summary of PLG's Major PSA Projects

PSA Number	Plant Owner/Client	Plant with Separate PSA Model	Reactor Type	Reactor Vendor	Containment Type	PSA Scope			PSA Level		
						Detail	Internal Events	External Events	1	2	3
1	Kernkraftwerk Gösgen-Däniken AG	Gösgen	PWR	Siemens KWU	Free Standing Steel with Concrete Confinement	Full	X	X	X		
2	Baltimore Gas and Electric Company	Calvert Cliffs*	PWR	Combustion Engineering	Large, Dry	Focused	X		X	X	
3	Duquesne Light Company	Beaver Valley 1*	PWR	Westinghouse	Large, Dry Subatmospheric	Full	X	X	X	X	
4	Duquesne Light Company	Beaver Valley 2*	PWR	Westinghouse	Large, Dry Subatmospheric	Full	X	X	X	X	
5	Tennessee Valley Authority	Watts Bar	PWR	Westinghouse	Ice Condenser	Full	X		X	X	
6	Pacific Gas and Electric Company	Diablo Canyon 1	PWR	Westinghouse	Large, Dry	Full	X	X	X		
7	Houston Lighting & Power Company	South Texas Project 1	PWR	Westinghouse	Large, Dry	Full	X	X	X		
8	New Hampshire Yankee	Seabrook 1	PWR	Westinghouse	Large, Dry	Full	X	X	X	X	X
9	Commonwealth Edison Company	Zion 1	PWR	Westinghouse	Large, Dry	Full	X	X	X	X	X
10	New York Power Authority	Indian Point 3	PWR	Westinghouse	Large, Dry	Full	X	X	X	X	X
11A	Consolidated Edison Company	Indian Point 2	PWR	Westinghouse	Large, Dry	Full	X	X	X	X	X
11B	Consolidated Edison Company	Indian Point 2 Update	PWR	Westinghouse	Large, Dry	Full	X		X		
12A	Public Service Electric and Gas Company	Salem 1	PWR	Westinghouse	Large, Dry	Focused	X		X		
12B	Public Service Electric and Gas Company	Salem 1 and 2 Update	PWR	Westinghouse	Large, Dry	Full	X		X		

*This PSA performed to satisfy IPE requirements.

Table 4-1 (Page 2 of 3). Summary of PLG's Major PSA Projects

PSA Number	Plant Owner/Client	Plant with Separate PSA Model	Reactor Type	Reactor Vendor	Containment Type	PSA Scope			PSA Level		
						Detail	Internal Events	External Events	1	2	3
13	Tennessee Valley Authority/EPRI	Sequoyah 1	PWR	Westinghouse	Ice Condenser	Focused	X		X		
14	Northeast Switzerland Kraftwerke	Beznau	PWR	Westinghouse	Spherical Shell	Full	X	X	X		
15	Maine Yankee/YAEC	Maine Yankee*	PWR	Combustion Engineering	Large, Dry	Focused	X	X			X
16	GPU Nuclear Corporation	Three Mile Island 1	PWR	Babcock & Wilcox	Large, Dry	Full	X	X	X		
17	Tennessee Valley Authority	Bellefonte 1	PWR	Babcock & Wilcox	Large, Dry	Full	X	X	X	X	X
18	Consumers Power Company	Midland 1	PWR	Babcock & Wilcox	Large, Dry	Full	X	X	X	X	X
19	Duke Power Company/ EPRI	Oconee 1	PWR	Babcock & Wilcox	Large, Dry	Full	X	X	X	X	X
20A	GPU Nuclear Corporation	Oyster Creek	BWR	General Electric	Mark I	Full	X	X	X	X	X
20B	GPU Nuclear Corporation	Oyster Creek Update*	BWR	General Electric	Mark I	Full	X	X	X	X	
21	Bernische Kraftwerke AG	Mühleberg	BWR	General Electric	Mark I	Full	X	X	X	X	
22	Detroit Edison Company	Fermi 2	BWR	General Electric	Mark I	Full	X		X		
23	Boston Edison Company	Pilgrim	BWR	General Electric	Mark I	Full	X	X	X		
24	Southern Company Services	Hatch 1	BWR	General Electric	Mark I	Focused	X		X		
25	Niagara Mohawk Power Corporation	Nine Mile Point 1	BWR	General Electric	Mark I	Focused	X		X		

*This PSA performed to satisfy IPE requirements

Table 4-1 (Page 3 of 3). Summary of PLG's Major PSA Projects

PSA Number	Plant Owner/Client	Plant with Separate PSA Model	Reactor Type	Reactor Vendor	Containment Type	PSA Scope			PSA Level		
						Detail	Internal Events	External Events	1	2	3
26A	Tennessee Valley Authority	Browns Ferry 1	BWR	General Electric	Mark I	Full	X	X	X	X	X
26B	Tennessee Valley Authority	Browns Ferry 1 Update	BWR	General Electric	Mark I	Full	X	X	X		
27	Long Island Lighting	Shoreham	BWR	General Electric	Mark II	Full	X	X			X
28	Taiwan Power Company/ROCAEC	Kuosheng PSA Conversion	BWR	General Electric	Mark III	Full	X	X	X	X	X
29	DOE/Oak Ridge National Laboratory	High Flux Isotope Reactor	Research	Singmaster and Breyer	Confinement	Full	X	X	X	X	
30	DOE/Oak Ridge National Laboratory	Health Physics Research Reactor	Research	ORNL	Confinement	Focused	X	X	X		

*This PSA performed to satisfy IPE requirements.

heat exchange with the air, and solar heating. A separate module allows the modeling of vapor releases directly into the atmosphere. QDG is used by PLG to perform consequence analyses for facility and system safety assessments involving multicomponent heavy gases.

- **LPG Dispersion Calculations (Major Petroleum Company).** PLG is performing a dispersion assessment of a vapor/aerosol cloud resulting from an LPG release. The scope of work requires analysis of the extent and shape of the vapor/aerosol cloud resulting from client specified periods of LPG release. Results include contours of cloud concentrations at the upper and lower explosive limits as a function of time. The analysis is being performed using PLG's QDG program. The pseudo aerosol approach used for this assessment has been validated against hydrofluoric acid aerosol release tests. It incorporates releases rates, compositions, chemical properties, meteorological data, and a map showing terrain and other obstacles or structures downwind of the release.

- **Dispersion Modeling of Chemicals from Plant Stacks (several utilities).** PLG has modeled the dispersion of sulfur dioxide from the stacks of fossil fuel power plants. These models included terrain effects and pinpointed the locations of maximum ground concentrations of sulfur dioxide. The dispersion of hydrogen sulfide was also modeled by PLG.

- **Cooling Tower Plume Dispersion Modeling (several utilities).** PLG has developed computer models for assessing the environmental impact of a cooling tower operation. The programs model atmospheric dispersion and phase changes within the cooling tower plumes to assess visibility (fogging), salt drift (crop damage), icing, and sunlight reduction (shadowing).

- **Evaluation of Atmospheric Dispersion Models at the Three Mile Island Nuclear Plant (GPU Nuclear Corporation).** PLG performed experiments at Three Mile Island to determine atmospheric diffusion under low-wind-speed inversion conditions in the vicinity of plant structures and in the river valley. In these experiments, sulfur hexafluoride was released and the average concentrations were measured by collecting air samples at various locations. These samples were then analyzed to determine the amount of sulfur hexafluoride captured in each bottle, and the analysis was used to determine the average dispersion between the source and receptor. The study results indicated that wind meander plays a large role in dispersion under low-wind-speed inversion conditions.

- **Probabilistic Consequence Analyses for Risk Assessments (for several electric utilities).** In 1978, PLG developed the first consequence analysis tool for risk assessment that was responsive to site-specific conditions. That tool has since been applied to more than 10 plant sites. The CRACIT code, which enables probabilistic calculations of health effects for gas emissions, is the only model available that explicitly accommodates protective actions (e.g., evacuation times along realistic paths) and site and plant-specific features; e.g., variable plume trajectories. Time-dependent plume characteristics are determined from local sequential weather data to reflect the effects of terrain and sea breeze.

4.5 TRANSPORTATION RISK ANALYSIS

PLG's involvement in the analysis of risk associated with transporting hazardous materials can be traced back to 1968 when Dr. Garrick participated in evaluations of risk in the transport of hazardous chemicals and biological materials. That study resulted in a computerized decision methodology for assessing the risk per trip using different modes of transportation. Subsequently in 1974, this capability was used to evaluate routine exposures from the shipment of radioactive materials for the nuclear power industry. Since that time, PLG has remained active in the application of risk analysis to the transport of hazardous materials. Examples of PLG experience in this field are as follows:

- **A Manual for Performing Transportation Risk Assessment (Chemical Manufacturers Association).** A manual was developed for performing risk assessment for the transportation of acutely hazardous materials. This manual has been distributed industry wide among the distribution professionals, and seminars have been given about its use. The methodology is given through a set of data sheets on which the required data are identified, and polynomial equations are given for computing the evaporation and dispersion patterns and the fire and explosion effects. From these computations, the impact of a release on the public is estimated for different weather conditions. The final outcome of the methodology is a risk curve representing the number of people affected and the frequency of occurrence. The data sheets are now being computerized to facilitate their use.

- **Risk Management for Shipping Hazardous Materials (major chemical manufacturer).** In this study, the risks were assessed of transporting a hazardous material (which was both toxic and flammable) between two processing facilities. Several different transportation options were considered. Risk was evaluated for the frequency of an accident and the number of people potentially affected by either toxic or explosive effects of the chemical. This evaluation involved the enumeration of possible accident scenarios, the statistical analysis of accident data, and the evaluation of material behavior: transport in the environment, chance of ignition, and impact on surrounding population. Route and region-specific information was used for such parameters as rail quality, local demographics, and weather characteristics.

- **Spent Fuel Transportation Criteria (Electric Power Research Institute).** In this study (EPRI NP-3416), PLG assessed the margins and public risk inherent in using the transport cask design criteria defined by federal regulations. Objectives of the project included evaluating the equivalence between current regulatory test conditions and real or credible accidents and identifying the major contributors to high risk accident scenarios.

- **Proposed Regulations for Transportation of Fissile III and Other Radioactive Material (Southern California Edison Company).** PLG performed an analysis of the risk to the public from shipment of spent nuclear fuel over proposed routes from the three nuclear plant sites in California, and the results of the analysis were presented in testimony.

- **Transportation of Spent Nuclear Fuel from the Oconee Nuclear Station for Storage at the McGuire Nuclear Station (Duke Power Company).** PLG analyzed the risk to the public from transporting spent nuclear fuel between the Oconee and McGuire plants. Results of the analysis were presented as testimony before the Atomic Safety and Licensing Board.

- **Proposed Rule-Making on Transportation of Radioactive Materials and Spent Fuel (16 utility companies).** Performed a cost-benefit analysis to determine whether special trains should be required for shipment of spent fuel from nuclear power plants. Results were presented as testimony before the Interstate Commerce Commission.

- **Severe Accident Frequency Data for the Definition of Bounding Environments for Transportation Packages (U.S. Nuclear Regulatory Commission).** This work was performed in support of a project addressing possible changes in packaging standards from those embodied in 10CFR71. The PLG study is included as Appendix H in the NRC report, NUREG/CR-3499.

- **Draft Environmental Impact Statement (U.S. Department of Energy).** PLG performed a review of the transportation-related section of the Draft Environmental Impact Statement in cooperation with LeBoeuf, Lamb, Leiby & MacRae. The scope of this review includes local and national costs, risks of spent fuel transportation, the RADTRAN II computer code, and compliance with the Nuclear Waste Policy Act and the Repository Siting Guidelines.

- **Risk Model for the Transport of Hazardous Materials (U.S. Army).** PLG personnel developed a computerized risk model to enable the client to evaluate the changes in risk resulting from changes in materials, routing, or container design for transport of hazardous biological and chemical materials. Risk was evaluated for selected health effects per trip. Data bases were established for accident rates by carrier type, population density, atmospheric dispersion, and the frequency of container system equipment failures.

- **Testimony in the Area of Transportation Risk (miscellaneous).** Dr. Garrick was asked to testify before the Interstate Commerce Commission hearings on a proposed rule authorizing special train service for spent fuel transport. This testimony was prepared in cooperation with LeBoeuf, Lamb, Leiby & MacRae and presented in Docket 36325 in July 1976.

  Testimony on transportation of nuclear fuel and radioactive materials was also developed and presented by Dr. Garrick in connection with the Sundesert Nuclear plant. These proceedings were before the State Energy Resources Conservation and Development Commission of the State of California in November 1976. This testimony was prepared with the law firm of Lowenstein, Newman, Reis & Axelrad and presented in Docket 76-NOI-2, dated November 11, 1976.

4.6 FIRE RISK ANALYSIS

PLG is in the forefront of fire analysis methodology development. The methods used today for probabilistic fire analysis have been developed by members of the PLG staff. Our methods integrate statistical analysis of fire occurrence data, fire propagation analysis (e.g., phenomenology and heat transfer analysis), fire detection and suppression analysis, and plant safety analysis.

For complicated arrangements of combustibles and equipment sensitive to heat, the computer code COMPBRN is used. It can model the temporal behavior of a fire as it propagates and the thermal response of the equipment. The computed quantities include

flame height, heat generation rate, heat impingement rate, component surface temperatures, and hot gas layer thickness and temperature (for fires within a room).

In parallel with fire propagation analysis, fire detection and suppression analyses are also performed. These analyses can be used to determine the time required to detect and suppress a fire. Specific consideration is given to the fire protection systems in the area and the historical evidence on similar events. The likelihood of severe consequences is then determined by comparing the fire propagation time with the calculated detection and suppression time.

Examples of PLG fire analysis include:

- **Fire Frequency of PCB Transformers (major environmental services company).** The PCB-filled transformers were analyzed to identify the potential scenarios for major releases. The frequency of fires involving PCB transformers that may lead to a release were estimated.

- **Comparative Risk Assessment of Askarel and Mineral Oil Transformers (major chemical manufacturer).** A comparative risk assessment was performed to quantitatively evaluate the decision made in the 1930s to replace electrical distribution transformers cooled and insulated by mineral oil with transformers cooled and insulated by Askarel (which contains PCBs). The assessment involved collection and analysis of data on transformer fires, fire propagation and suppression, and injuries and fatalities caused by building fires. The results of this study were submitted to the EPA and were referenced in the October 11, 1984, *Federal Register* discussion on the benefits of Askarel transformers.

- **Fire Risk Evaluations for Nuclear Power Plants (various utilities).** PLG has performed fire risk assessments for more than 10 nuclear plants. The results of these studies were used to identify potential plant modifications for fire prevention and mitigation.

4.7 EARTHQUAKE AND OTHER EXTERNAL HAZARDS EVALUATION

Hazards originating outside the plant boundaries must be part of an integrated plant risk model. Earthquakes, hurricanes, lightning, floods, explosions, and aircraft crashes are examples of such hazards. PLG systematically addresses these issues in its plant risk analysis projects. For more than 10 nuclear power plants, detailed analyses have been performed to identify these hazard sources and estimate their levels of contribution to overall plant risk.

PLG has pioneered the inclusion of these external hazard sources in probabilistic risk assessments. We have developed probabilistic methods and data specialized to many of these hazards. The analysis of external events consists of four major steps:

- E. ation of the peak hazard and its frequency of occurrence.

- Estimation of the damage to plant structures and equipment from the peak hazard.

- Estimation of the frequencies of the various accident scenarios that could result from damage to plant equipment.

- Comparison of these frequencies with those of other events.