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Laka digitizes books and magazines from the international movement against nuclear power.

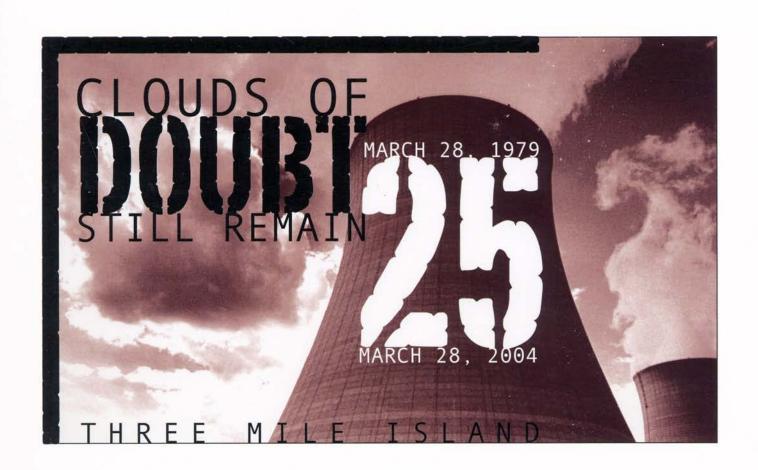
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Laka plays with, amongst others things, its information services, an important role in the Dutch anti-nuclear movement.

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Three Mile Island 25th Anniversary Observance

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March, 2004

Hello,

2004 marks the 25th anniversary of the beginning of the accident at Three Mile Island. While we won't be celebrating the anniversary of the accident, we will observe it in an appropriate manner. Nevertheless, we in central Pennsylvania have reason to celebrate.

Central Pennsylvanians, through Three Mile Island Alert and through other individual and collective efforts, have made the world a safer place. Thanks to our continuous vigilance and determination, we can point to many advances in the last 25 years.

- Training for nuclear plant operators has been improved;
- Emergency training for first responders has been improved;
- Communication between plant operators and all levels of government has been improved;
- Security around the plants has been strengthened;
- •We have a state-of-the-art monitoring system in place around both of south central Pennsylvania's nuclear power facilities (TMI & Peach Bottom);
- •Those in and around nuclear plants have been provided with potassium iodide tablets;
- Evacuation plans have been improved and now include day care facilities and pre-schools;
- •The lessons learned from TMI have been shared and implemented world wide;
- •We have on-going dialog with the plant operators and the Nuclear Regulatory Commission;
- •We have championed the development of alternative and renewable energy sources; and,
- •There has not been a single order for a commercial nuclear power plant in the United States in the last 25 years.

Still, clouds of doubt remain and we must remain vigilant. A restructured electric generating industry is short-changing our communities and schools on their fair share of taxes; funds established to finance the decommissioning of these aging plants are under funded; there's still no repository for nuclear waste and each operating nuclear plant is a dangerous waste site; the industry, thanks to a nuclear-friendly administration in Washington, is 33-0 in approvals of license renewals; though an inherently dangerous technology, nuclear power still has champions in Washington; health issues will persist for generations to come; and under Pennsylvania's \$9 billion industry restructuring, consumers have paid and are still paying billions in "stranded" costs to bail out the industry. While we have accomplished much, much remains to be done before we put an end to our nuclear nightmare.

If you are in central Pennsylvania covering the 25th anniversary, we invite you to attend the events listed on the enclosed calendar of events and to contact us with any questions you might have about TMIA or our mission. If you are attending our press luncheon or community dinner, please RSVP.

Sincerely,

Eric J. Epstein, Chair Three Mile Island Alert



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A Brief, Organizational History of Three Mile Island

Three Mile Island Unit 1 (TMI-1) came on line in September 1974 at a cost of \$400 million. Legal intervention was conducted by the Environmental Coalition on Nuclear Power (ECNP) based in State College.

Three Mile Island Unit 2 (TMI-2) came on line in December 1978, and was grossly over budget and behind schedule. Legal intervention was conducted by the ECNP and Three Mile Island Alert (TMIA).

The plant had been on-line for just 90 days, or 1/120 of its expected operating life, before the March, 1979, accident. One billion dollars was spent to defuel the facility. Three months of nuclear power production at TMI-2 has cost close to \$2 billion dollars in construction and cleanup bills; or the equivalent of more than \$10.6 million for every day TMI-2 produced electricity. The above-mentioned costs do not include nuclear decontamination and decommissioning or restoring the site to Greenfield status.

At the time of the Accident in March 1979, TMI 1 and 2 were owned by three utilities operating in two states: Metropolitan Edison (Met Ed) (50%), Jersey Central Power & Light (25%) and Pennsylvania Electric (25%). The companies were organized under the General Public Utilities holding company umbrella. The operator of both plants was Met Ed.

1980, The Susquehanna Valley Alliance, based in Lancaster, successfully prevented Met Ed from dumping 700,000 gallons of radioactive water into the Susquehanna River.

On March 25, 1980, Met Ed, blamed the plant's designer, Babcock & Wilcox (B&W) for the TMI accident, sued B&W for \$500 million. GPU also filed an unsuccessful \$4 billion lawsuit against the NRC. GPU alleged that the NRC's negligence contributed to the TMI accident.

June-July, 1980, for 11 days, Met Ed illegally vented 43,000 curies of radioactive Krypton-85 (10-year half-life; beta and gamma) and other radioactive gasses into the environment without having scrubbers in place.

In September, 1980, Met Ed renamed itself GPU Nuclear in a bid to dissociate itself from itself.

On July 17, 1998 - AmerGen Energy (British Energy and Exelon) announced that it reached an Agreement with GPU to purchase TMI-1 for \$100 million. The proposed sale included \$23 million for the reactor, and \$77 million, payable over five years, for the nuclear fuel. (See Dec. 20, 1999 for follow-up information, and September 5, 2002, re TMI resale.)

December 20, 1999, TMI's license was transferred from GPU Nuclear to AmerGen. TMI-2, which remains a GPU possession, in placed in Post-Defueling Monitored Storage in 1992. GPU contracts with AmerGen to maintain a skeletal staff presence at TMI-2. (See July 17, 1998.)

August 8, 2000 - FirstEnergy Corporation proposed a \$4.5 billion takeover and merger of GPU.

November, 2001 - TMI-2 was formally transferred from GPU Nuclear to FirstEnergy.

September 5, 2002 - Exelon announced that it was putting its 50% share of AmerGen up for sale. British Energy's share is also up for sale. British Energy, which is bankrupt, owns the other 50% of AmerGen, and includes the following nuclear power plants: Clinton, Oyster Creek and Three Mile Island. The reported price tag is anywhere from \$340 to \$600 million

December 23, 2003 – British Energy (BE) completed the sale of its 50% Amergen interest to Exelon Generation after receiving shareholder approval of the deal on December 22.

At the time of the sale, BE had an offer on the table from FPL. However, its AmerGen partner, Exelon, held rights of first refusal if the BE share came up for sale.

-more-



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As expected, BE received about \$277-million(US) prior to various adjustments. BE said it would pay a break fee of \$8.29-million to FPL Group, following termination of the original sale agreement between BE and FPL after Exelon exercised its right of first refusal and matched FPL's offer to become the sole owner of the AmerGen plants. BE said it would use around 94-million pounds of the AmerGen sale proceeds to pay off all the outstanding money borrowed from the British government under an emergency credit facility. The remaining cash will be used for general working capital and collateral purposes, it said.

What's Wrong With the NRC's 2004 Fact Sheet on the TMI Accident?

Published by Three Mile Island Alert - March 2004

"The main feedwater pumps stopped running, caused by either a mechanical or electrical failure, which prevented the steam generators from removing heat."

The problems did not start with the feedwater pumps, trouble began in the condensate polisher system. The NRC reported this in 1979 but states that they don't need to know the exact cause of the condensate polisher valve's failure. No one knows why the accident began to this day.

"Signals available to the operator failed to show that the valve was still open... In addition, there was no clear signal that the pilot-operated relief valve was open."

Because TMI had been falsifying reactor leak rates to the NRC in the weeks leading to the accident, operators had learned to ignore the most obvious sign that the PORV had stuck open and that coolant was being lost through this pathway. The high temperature reading at the PORV drain line was a clear indication that coolant was escaping. But, operators had become accustomed to this anomaly because of the criminal falsification which allowed this condition to exist for several weeks.

It should be noted that if the company had operated lawfully, the plant would have been shutdown for repairs and there would have been no accident on March 28th 1979.

It is also noteworthy that NRC inspectors at TMI during the weeks before the accident failed to find or note the reactor coolant leak. Later, the company pleaded "no contest" to federal charges of criminal falsifications

On May 22 1979, former control room operator Harold W. Hartman, Jr. tells the NRC investigators that Metropolitan Edison- General Public Utilities had been falsifying primary-coolant, leak rate data for months prior to the accident. At least two members of management were aware of the practice. NRC investigators do not follow-up or report the allegations to the commission.

On February 29, 1984, a plea bargain between the Department of Justice and Met Ed settled the Unit 2 leak rate falsification case. Met Ed pleaded guilty to one count, and no contest to six counts of an 11 count indictment.

"In a worst-case accident, the melting of nuclear fuel would lead to a breach of the walls of the containment building and release massive quantities of radiation to the environment. But this did not occur as a result of the Three Mile Island accident."

It was only by luck that the reactor walls were not breached. The industry conjectured that voids in the coolant prevented molten fuel from burning through the reactor walls. It is not known if these voids will form to prevent a total meltdown in future accidents. Fifteen million curies of radiation is a "massive quantity."

"The accident caught federal and state authorities off-guard."

State officials had no means to measure radiation at the scene. They had to take field samples and return to their laboratories. This was not an effective way to acquire real-time data or collect data on gaseous releases. Their data collection abilities were insufficient to determine release rates. The NRC no longer monitors radioactive releases at reactor sites.



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"They did not know that the core had melted, but they immediately took steps to try to gain control of the reactor and ensure adequate cooling to the core."

Reactor core measurements taken during the first morning showed that fuel might have melted. This data was cast aside because operators believed it was not possible and therefore erroneous. During the first day, the NRC in fact distanced itself from the company by stating it did not tell them how to run their plant and that they were overseers of regulatory matters. Initially, the NRC was more interested in hiding from responsibility than offering advice to the company.

"Helicopters hired by TMI's owner, General Public Utilities Nuclear, and the Department of Energy were sampling radioactivity in the atmosphere above the plant by midday. A team from the Brookhaven National Laboratory was also sent to assist in radiation monitoring."

By mid-morning, citizens (many who had not heard about the accident) were reporting a metallic taste in their mouths. Because the reactor had been leaking for several weeks, the reactor drain tank was full and a pathway to the environs had already been created by valves aligned to handle the leaking coolant and facilitate the falsification of the leak rates.

Additionally, at the time of the accident, GPU reported that radiation monitors went off-scale, filters were clogged and other monitoring devices "disappeared." Therefore, we do not know how much radiation escaped undetected into the atmosphere. Still, the Columbia Study found *increased cancer incidence*, including lung cancer, from 1975-1985.

"In an atmosphere of growing uncertainty about the condition of the plant, the governor of Pennsylvania, Richard L. Thornburgh, consulted with the NRC about evacuating the population near the plant. Eventually, he and NRC Chairman Joseph Hendrie agreed that it would be prudent for those members of society most vulnerable to radiation to evacuate the area. Thornburgh announced that he was advising pregnant women and pre-school-age children within a 5-mile radius of the plant to leave the area."

The NRC's agreed upon conditions of a reactor which would require evacuation of nearby communities had already been met two days earlier on Wednesday the 28th. Governor Thornburgh complained often about the conflicting and confusing data coming from the plant and the NRC.

"....even though it led to no deaths or injuries to plant workers or members of the nearby community."

In August 1996, a study by the University of North Carolina-Chapel Hill, authored by Dr. Steven Wing, reviewed the Susser-Hatch study (Columbia University; 1991). Dr. Wing reported that "...there were reports of erythema, hair loss, vomiting, and pet death near TMI at the time of the accident... Accident doses were positively associated with cancer incidence. Associations were largest for leukemia, intermediate for lung cancer, and smallest for all cancers combined... Inhaled radionuclide contamination could differentially impact lung cancers, which show a clear dose-related increase." o

Findings from the re-analysis of cancer incidence around Three Mile Island is consistent with the theory that radiation from the accident increased cancer in areas that were in the path of radioactive plumes. "This cancer increase would not be expected to occur over a short time in the general population unless doses were far higher than estimated by industry and government authorities," Wing said. "Rather, our findings support the allegation that the people who reported rashes, hair loss, vomiting and pet deaths after the accident were exposed to high level radiation and not only suffering from emotional stress."

Even under normal operating circumstances nuclear plants release radiation. The NRC acknowledged that 12 people are expected to die as a direct result of normal operation and releases for each commercial nuclear reactor that is granted a license extension of 20 years.

The admission came in a correction to its 1996 relicensing regulation, which was published in the Federal Register on July °30 1996. According to the Federal Register notice, each relicensing is expected to be responsible for the release of 14,800 person-rem of radiation during its 20-year life extension. The figure includes releases from the nuclear fuel chain that supports reactor operation, as well as from the reactors themselves. The NRC calculates that this level of radiation release spread over the population will cause 12 cancer deaths per reactor.

"But new concerns arose by the morning of Friday, March 30. A significant release of radiation from the plant's auxiliary building, performed to relieve pressure on the primary system and avoid curtailing the flow of coolant to the core, caused a great deal of confusion and consternation."

This was not by accident or design. The release was perpetrated by a lone operator acting on his own and without permission or consultation with anyone else. There were no regulatory repercussions resulting from his actions.

"Today, the TMI-2 reactor is permanently shut down and defueled, with the reactor coolant system drained, the radioactive water decontaminated and evaporated, radioactive waste shipped off-site to an appropriate disposal site, reactor fuel and core debris shipped off-site to a Department of Energy facility, and the remainder of the site being monitored."

The reactor was destroyed. No one knows how much fuel remains in the reactor core debris. Some estimates have placed it at 20 tons of uranium. Unit #2 is still releasing small amounts of radiation to the air and water.

"The accident was caused by a combination of personnel error, design deficiencies, and component failures."

Also add to the list: criminal activity, the NRC's failure to disseminate safety data, NRC inspection and enforcement failures, failure to fix problems noted by control room operators, sloppy control room housekeeping and economic gain placed above safety.

"Upgrading and strengthening of plant design and equipment requirements. This includes fire protection..."

A reactor safety division specifically created to spot problem trends in the wake of the TMI accident was abolished by NRC executives in 1999. According to the NRC's Office of Inspector General, only half of NRC employees feel it is safe to bring up new safety problems in 2003. One former NRC employee stated those who do have their careers harmed by NRC executives.

For more than a decade, the NRC was aware that the fire protection material Thermolag was defective and burned at the same rate as plywood. The NRC was aware that Thermolag's manufacturer has falsified test results yet did nothing to fix the problem. Finally the NRC asked TMI to remove Thermolag. Two years after that request, TMI was again asked to remove Thermolag. The NRC and TMI were very slow to act.

"Expansion of NRC's resident inspector program - first authorized in 1977 - whereby at least two inspectors live nearby and work exclusively at each plant in the U.S to provide daily surveillance of licensee adherence to NRC regulations..."

At Davis Besse, there was no chief inspector for a year. Inspectors find less than 2% of problems identified at the plants. The NRC has decreased total inspection man-hours in recent years.

"The installing of additional equipment by licensees to mitigate accident conditions, and monitor radiation levels and plant status..."

The NRC no longer monitors radiation at the plants. On many occasions, the communication lines from the control room computers to the NRC are found to be inoperable.

"Employment of major initiatives by licensees in early identification of important safety-related problems, and in collecting and assessing relevant data so lessons of experience can be shared and quickly acted upon..."

Oh, if this were only true. Drastic employee cutbacks and overburdened workers and engineers have little time and are reluctant to raise new safety issues. TMI Alert has learned of TMI employees who simply "up and quit" due to the excessive work load.

"July 1980 Approximately 43,000 curies of krypton were vented from the reactor building."

For 11 days, in June-July, 1980, Met Ed illegally vented 43,000 curies of radioactive Krypton-85 (beta and gamma; 10 year half life) and other radioactive gasses into the environment without having scrubbers in place. In November 1980, the United States Court of Appeals for the District of Columbia ruled that the krypton venting was **illegal**.

By 1993, TMI-2 evaporated 2.3 million gallons of accident generated radioactive generated water, including tritium a radioactive form of hydrogen (half life; 12.5 years), into the atmosphere despite legal objections from community-based organizations.

Postscript:

The NRC fails to point out that it had ignored for more than a year prior to the accident, a newly discovered safety problem which did occur at TMI. Voids in the coolant created by a poor design of piping caused reactor pumps to cavitate and vibrate violently. These vibrations threatened to destroy the pumps. The coolant pumps had to be turned off during the height of the accident.

The NRC's role in the accident is one of tacit permissiveness. This attitude of the industry was criticized by the President's Commission above all other factors. Three Mile Island Alert has observed that safety conditions and attitudes are returning to the level evidenced by the industry in 1979.

Many of the so called "permanent" changes have been downgraded since the time of their installation. The NRC inspectors have little confidence in the newly implemented regulatory process according to a January 2000 GAO investigation. The new regulatory process handcuffs the ability of inspectors to pursue safety problems at the plants. Unless a suspicious condition is deemed clearly dangerous, the new process doesn't allow the implementation of other than routine inspections.

The Davis Besse near miss is a prime example. The NRC did not have a resident inspector there for one year. Although there was clear evidence of a leaking reactor, the NRC initially denied possession of the "smoking gun" – a picture of the red crud which had formed on the outside of the reactor vessel. The NRC had in fact ignored the problem to allow the plant to continue operating.* Determining that something is clearly dangerous is apparently still a subjective skill at the NRC.

There are many outstanding safety issues identified by the NRC following the accident which have still not been corrected. One example is the vulnerability of electrical cables during an accident which can electrically short circuit. Another example is the PORV valve which released the coolant during the accident – it is still not rated as a "safety item."

Plain Dealer, 5/16/03

^{*}When nuclear regulators fixed blame for failing to notice that there was a hole in the lid of the Davis-Besse reactor in Ohio, they spent little time criticizing the role played by their new oversight rules.

Those rules, seeking to reduce overly burdensome regulations, in 2000 replaced the subjective, nit-picky set of guidelines that had governed power plant inspections for years.

But documents obtained by a watchdog group show that a special Nuclear Regulatory Commission task force last year had in fact intended to blame the new regulatory system in part for the slipshod inspections at Davis-Besse. Before the task force's report was complete, however, NRC staff had removed a section on the shortcomings of the NRC's new reactor oversight process.

The final report - an indictment on the agency and plant owner FirstEnergy Corp. - did list possible improvement to the oversight process. But it was far less sweeping and less critical than the earlier suggestions.

Fines & Penalties

October 25, 1979 - The NRC issued a Notice of Violation (NOV) for the accident to Met Ed and recommended the maximum fine permitted under law. \$155,000

March 25, 1980 - Met-GPU, blaming Babcock & Wilcox (the plants designer) for the TMI accident. GPU sues sue B&W for \$500 million.

On January 24, 1983 B&W and GPU settle out-of-court. Babcock & Wilcox Settlement resulted in modifications to plants; there were no damages paid. But a \$21 million contribution was made to the TMI-2 defueling program. \$21,000,000

July 22, 1983 - GPU is fined \$140,000 for submitting material false statements to the NRC in connection with the license certification of then TMI-2 Supervisor of operations who cheated on his license requalification exam in 1979. \$140,000

February 29, 1984 - A plea bargain between the Department of Justice and Met Ed settled the Unit-2 leak rate falsification case. Met Ed plead guilty to one count, and no contest to six counts of an 11 count indictment.

The Company also agreed to pay a \$45,000 fine, and establish a \$1 million dollar interest-bearing account to be used by the Pennsylvania Emergency Management Agency. The Settlement stipulated that the fines, emergency preparedness fund, and legal cost of the prosecution, would not be paid by GPU/Met Ed rate share holders. \$1,045,000

July 24-27, 1984 - During the 159-ton reactor head lift, which was delayed due to polar crane failure, GPU vented radioactive gases into the environment despite pledges by the Company and NRC that no radioactive releases would occur. GPU was fined \$40,000 by the NRC for this violation. \$40,000

August 12, 1985 - GPU and Bechtel were fined \$64,000 for cleanup worker allegations of safety violations first reported on March 22, 1983, \$64,000

January 13, 1990 - GPU was fined \$50,000 for excessive radiation exposure to a worker or for failing to enforce requirements protecting workers. \$50,000

July 31, 1990 - The NRC announced that an allegation that a shift supervisor on duty at Three Mile Unit-2 control room, during defueling operations in 1987, had sometimes slept on shift or had been otherwise inattentive to his duties, was true. Although some key members of the site management staff were aware of the sleeping problems and some actions were taken to correct it, it [sic] was not effectively corrected until utility corporate management became involved. The NRC staff proposes to fine GPU Nuclear, Inc. (GPUN) the company that operates the TMI site, \$50,000. The staff also

Notice of Violation to the former shift supervisor. \$50,000

October 14, 1997 - GPU agreed to pay a \$55,000 fine for violations identified by the NRC between November 1996 and May 1997 including inadequate implementation of the plant's emergency preparedness program. \$55,000

TOTAL: \$22,599,000



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Security

The Department of Homeland Security (DHS) asked the Nuclear Regulatory Commission to provide a list of nuclear plants which are most vulnerable to terrorist attack. Because the NRC did not respond in time, DHS made their own list of 30 plants. Three Mile Island is on the list. A September 2003 Government Accounting Office Report concluded that the NRC does not currently have the ability to assess and oversee its security programs.

TMIA's Entrance Guard Petition for Rulemaking is Stonewalled by the NRC

For more than two years, the Nuclear Regulatory Commission has tabled a TMIA petition for rulemaking that would create a requirement for entrance guards. The failure to issue a ruling in a timely manner is inexcusable. The most likely explanation for the delay is that the NRC does not agree that entrance guards are needed and would rather leave the matter unresolved than reap the bad publicity from rejecting the rule. An NRC official tells TMIA that they are "still working on it." The petition was filed on September 12, 2001 as originally planned in response to Exelon's removal of the guard post earlier that year.

For more information and a link to the petition see:

http://www.tmia.com/security/noguards.html

It All Started at TMI

The nation first learned of security problems at nuclear plants at TMI. In the spring of 1975 when two conscientious security guards took the problems to their bosses who not only ignored their concerns, but pressured the pair to resign. They were told that they could not be assured of their safety when returning to work. The threat forced the two to seek employment elsewhere.

The two guards took their problems to Ralph Nader. Soon, Nader described security as a "sham" and a threat to national security at a press conference in Washington DC and called for a congressional investigation. Two years later, the Government Accounting Office agreed with the men and found that security was "inadequate at best."

1993 Intrusion Reveals Poor Security

Another emergency at TMI on February 7, 1993, demonstrated security weaknesses at all US nuclear plants. The apprehension started when a 31-year-old man suffering from depression drove his mother's 1984 Plymouth station wagon into the guarded entrance at Three Mile Island, crashed through the protected area fence and then through a roll-up door. The car stopped 63 feet inside the turbine building.

He exited the car, descended a ladder and hid in the darkened belly of the condenser pit. It was so dark that guards put off performing a thorough search until brighter flashlights were made available. In the meantime, the plant continued operating at full power while the control room staff carefully watched the gauges and alarms for any changes that would indicate sabotage

Guards assumed defensive positions to protect some of the more vulnerable equipment and hid in spots where they could see strategic portions of the enormous turbine building. All access doors were locked by computer control; yet, the NRC knew this would only slow down an intruder armed with a satchel charge by fifteen seconds. Locking the control room doors had the unfortunate effect of delaying calls for offsite responders. In fact, the control room shift foreman informed some responders to standby at home because of the inability to move about the plant.

Four hours later the intruder was found curled up in a fetal position and seemed unaware of his surroundings. He was arrested, charged with four felonies, including "risking a catastrophe," and then hospitalized for psychiatric observation. The intruder was not hostile and the only damage to plant systems resulted from the car's striking equipment in a place and manner which did not directly threaten public safety.

Two years passed before the NRC ruled that vehicle barriers should be installed at all power reactors.



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Aircraft Threat

The "bottom line" is nuclear plants are no better protected from aircraft attacks than they were prior to 9/11. TMIA has video of former NRC Chairman Ivan Selin stating that a small airplane would not need explosives to cause troublesome damage, potentially leading to a meltdown.

In 1993, TMI Alert presented video to the NRC showing how an aircraft could be used to attack a nuclear plant. The video showed how easy it was to identify each building from the air.

TMI Alert is recommending the Phalanx Close-In Weapon be deployed at Three Mile Island. The Phalanx Close-In Weapon System is a rapid-fire, computer-controlled, radar-guided gun system designed to defeat a wide range of air threats. The system would be deployed by the Department of Homeland Security and manned by highly trained military personnel. It is the only practical measure which offers such sophisticated around-the-clock protection and avoids the problems associated with surface to air missiles. TMI Alert believes that the Phalanx air defense system is cheaper, safer and more reliable than any other active system.

The computerized radar system can determine if an aircraft's flight path termination point is at the reactor site. If such a determination is made, operating personnel can verify the approaching threat and destroy it shortly before striking the plant. The system would be ideal to use next to a busy airport because of its advanced analysis capabilities which can determine a real threat from a passing, disoriented, or troubled aircraft. The Phalanx could be deployed immediately.

It is also possible to construct aircraft barriers around vital buildings. (Please see the conceptual drawings by MIT scientist Theodore Postal attached.)

On October 17th 2001, an e-mail threat from Al Qaeda operatives in Spain stated that Three Mile Island would be hit with an explosive laden plane later that evening. The threat said someone working at the plant would also disable the cooling system.

Three F-16 fighters were scrambled to orbit the plant. The airspace around Harrisburg was shutdown for nearly four hours. The threat was determined to be not credible and airspace was reopened.

The public was not made aware of these events until later. Local officials were also left in the dark and were angered by the lack of communication needed for emergency preparedness.

For more information see:

http://www.tmia.com/security/airplane.html

Vehicle Bombs

TMI voluntarily installed vehicle barriers in 1993 following the intrusion. But TMIA had been critical of the setback distances of those barriers from vital systems. TMI tripled its setback distance for proper security checks of incoming vehicles following the September 11th attacks. The new setback distance is still not sufficient to protect against a large bomb.

The force of the Oklahoma City bomb blast damaged 324 surrounding buildings, overturned automobiles, touched off car fires, and blew out windows and doors in a 50-block area. News reports indicated the explosion was felt 55 miles from the site and registered 6.0 on the Richter scale. Foundations were cracked over a four block area. The Oklahoma City bomb is categorized as a medium sized bomb by terrorist experts.

There are two shock waves produced by a truck bomb - the air wave and the ground wave. The earthquake-proofing measures of reactor coolant pipes can be overwhelmed by a large truck bomb resulting in a devastating failure. The lateral accelerations propagated through the ground from a truck bomb far exceed those produced during the peak magnitude of an earthquake. This shock wave can cause a large break Loss of Coolant Accident by virtue of the rapid jolt where pipes do not have time to flex and act in a forgiving manner as they were designed to do during an earthquake.

In the event of a large truck bomb attack detonated a thousand feet away from the reactor, the reactor building will most likely continue standing, but the pipes inside can rupture. Any water pipe which breaks also becomes a potential water jet which could produce the unwanted consequence of an electrical short circuit. Oil pipes used to cool reactor pumps can rupture and potentially start fires if they have in effect become a blowtorch as burning oil under pressure is sprayed from the fracture. There are other safety systems pipes which can rupture and cause explosions which we are not comfortable disclosing publicly.

TMI Alert's Recommendations

- •Extend the setback distances to 1100 feet
- •Keep vehicle barriers closed at the entrances at all times
- •Perform bomb checks before a vehicle comes within 1100 feet of vital systems (At TMI, vehicles should be checked before crossing the bridge to the island.)
- ·Install blast deflection shields where needed

for more information see:

http://www.tmia.com/security/truck.html

Boat Exclusion Zones

There are two primary concerns regarding water-borne attacks, using a boat as a bomb delivery vehicle or as a commando transport vehicle. TMI alert has lobbied for boat exclusion zones since 1993. TMI Alert presented a full report on TMI's water craft vulnerabilities to Governor Ed Rendell last fall. (The report is available to the media from TMI Alert by special request.)

The US Coast Guard acting under the Department of Homeland Security created permanent exclusion zones at the Peach Bottom and Three Mile Island nuclear plants in 2003.

The exclusion zone at TMI is insufficient because there are no water craft barriers in place to prevent intrusion. The only advantage to the zone is that guards will not have to watch multiple recreational boaters which could previously enter those waters. Any boat which enters the zone will now receive special attention by guards and possible response from local, state or federal authorities.

The exclusion zone at TMI should be extended to surround the northern end of Three Mile Island where the plant is located. Water craft denial barriers must be installed. The US Coast Guard should patrol the waterways at Three Mile Island as it does at some other nuclear plants.

For more information see:

http://www.tmia.com/security/boat.html

Commando Attacks

There are many shortcomings with guard requirements. Most notable is the insufficient size of the guard force. During the 1990s, nuclear plants cut back their guard forces by approximately 20 percent. When the industry increased the size by about 33 percent following the 9-11 attacks, the net gain from ten years earlier is only one or two guards per shift. Although the exact number of guards is kept secret, we can conclude that there are about 12 or 13 guards on duty per shift at TMI.

Because guards take up defensive positions during a commando attack, there are no guards actively attempting to apprehend intruders. During Operation Safeguards Response Evaluation drills in the 1990s, guards failed nearly half (48%) of security drills. In one case a lone individual simulated causing a meltdown. The defensive strategies have proven ineffective.

Current requirements assume a small number of attackers enter the plant from one location. Current guard forces are insufficient to repel 19 attackers (the number of 9-11 hijackers).

A successful commando attack can occur in less than two minutes. The addition of a second fence and concertina wire at TMI are a definite improvement. But even with this addition, only 10-15 seconds of additional response time is gained. Locked reactor building doors represent only a 15 second delay to attackers carrying satchel charges. Guards may be faced with advanced weapons such as rocket propelled grenades and plastic explosives. These weapons were used in a prison breakout in France last year.

In 1993, TMI Alert presented testimony to the U.S. Senate and the U.S. Nuclear Regulatory Commission on the use of public records to plan a nuclear plant attack.

Using publicly available records one can:

- •Develop a fool-proof plan which could, with relative ease, overwhelm a security force and cause irreversible and catastrophic damage.
- Determine size and strength of the security force
- ·Where the force is likely to be posted
- ·Methods of gaining access to plants and buildings
- ·Sabotage targets and priorities
- Technological designs to prevent sabotage (some make sabotage easier)
- ·Sabotage tools and devices
- Methods of disrupting communications

Three Mile Island Alert's Recommendations

- •The NRC must triple the number of guards currently protecting our nuclear plants
- ·Guards must be better trained
- ·Guards must not be compelled to work excessive overtime
- ·Guards must receive better pay
- ·Guards must have heavy weapons to match intruders firepower
- ·Guards must be deployed in multiple layers
- Some guards must be dedicated to apprehending intruders
- ·Guards must patrol the owner controlled area

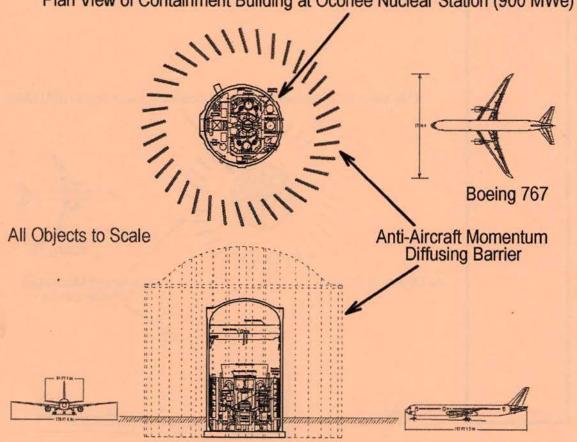
For more information see:

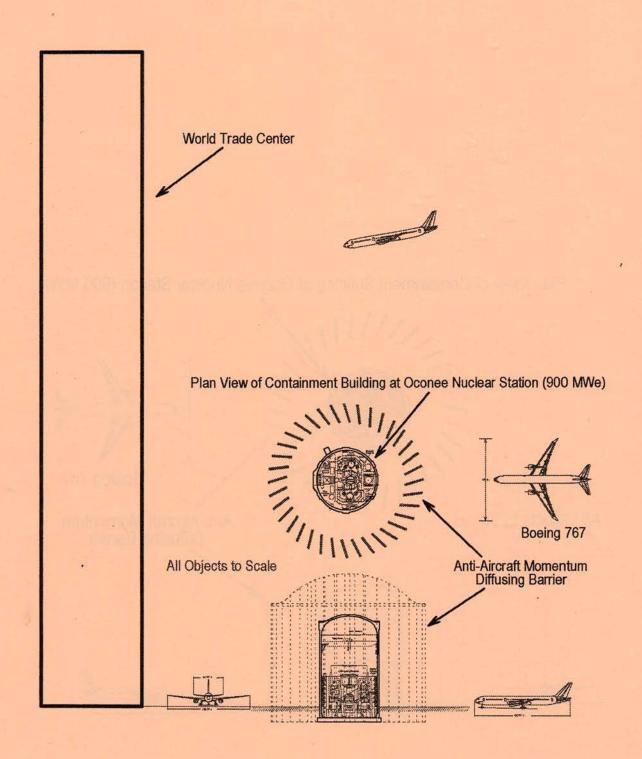
http://www.tmia.com/security/commando.html

For a complete list of TMI Alert's recommendations see:

http://www.tmia.com/security/rec.html

Plan View of Containment Building at Oconee Nuclear Station (900 MWe)







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All About The Clock

The NRC: What, me worry?

by Daniel Hirsch

The question immediately arose on September 11 and has persisted: As horrific as the terrorist attacks were, what might have happened if the terrorists who seized jumbo jets and used them as weapons against the World Trade Center and the Pentagon had aimed them at nuclear power plants instead? And if more attacks are likely, as government officials have said, are nuclear facilities on the terrorist target list?

The Sunday Times of London reported in October that some intelligence assessments suggest that the intended target of the fourth plane, the one downed in Pennsylvania, was a nuclear power reactor. The plane had descended much too soon for Washington to be its intended destination, these assessments indicate, suggesting that the true target may have been one of several nuclear plants in its flight path, with the single still-operating unit at Three Mile Island seeming the most likely. This assessment cannot be confirmed, of course. But if it is correct, we owe even more to those brave passengers who succeeded, at the cost of their own lives, in bringing the plane down before it reached its intended target.

Misleading statements

Immediately after the September 11 attacks, the U.S. Nuclear Regulatory Commission (NRC) and the nuclear industry issued statements asserting that U.S. reactor containments were designed to withstand the crash of a fully loaded jumbo jet. Within days, both had to recant and admit that the opposite was the case. Just hours after the terrorist attacks, NRC spokesperson Breck Henderson said U.S. nuclear plants were safe because "containment structures are designed to withstand the impact of a 747."

Ten days later he admitted that "the initial cut we had on that was misleading." In a formal statement, the agency conceded that it "did not specifically contemplate attacks by aircraft such as Boeing 757s and 767s, and nuclear power plants were not designed to withstand such crashes." A similar pattern of assurance followed by retraction characterized the behavior of public relations personnel for a number of specific nuclear sites.

Early on, however, David Kyd, spokesperson for the International Atomic Energy Agency (IAEA), was quoted as saying that most nuclear plants, built during the 1960s and 1970s, were designed to withstand only accidental, glancing impacts from the smaller aircraft used at the time. "If you postulate the risk of a jumbo jet full of fuel, it is clear that their design was not conceived to withstand such an impact," he said. In reporting Kyd's comments, the Associated Press quoted an unnamed U.S. government official to the effect that a direct hit at high speed by a modern jumbo jet "could create a Chernobyl situation."

The press has focused on the vulnerability of reactor containment buildings to airborne attack. But there are also "soft targets" outside containment, and their protection is critical to preventing radioactive release. Excessive emphasis on the risk of air attack obscures the far larger and more frightening possibility of ground assault or the threat from insiders. Security at the nation's nuclear

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plants has been grossly inadequate for decades, and the nuclear industry and its captive regulatory agency, the NRC, have refused to do anything about it—both before and after September 11.

1,000 times more

A typical nuclear power plant contains within its core about 1,000 times the long-lived radioactivity released by the Hiroshima bomb. The spent fuel pools at nuclear power plants typically contain some multiple of that—several Chernobyls' worth (see "What About the Spent Fuel?" page 45).

Any analogy with the dropping of a bomb is imperfect, of course, because much of the destruction caused by an atomic bomb comes from blast effects, and the damage caused by a terrorist attack on a nuclear plant would stem almost exclusively from the release of radioactivity. However, the potential casualties from an atomic attack and those resulting from using conventional explosives to produce a radiological release from a nuclear facility would be surprisingly similar. For example, the NRC estimated years ago that a meltdown at one of the San Onofre reactors in Southern California could produce 130,000 "prompt" fatalities, 300,000 latent cancers, and 600,000 genetic defects. Analyses for other reactors performed by Sandia National Laboratories for the NRC estimated damages up to \$314 billion in 1980 dollars (the equivalent of about \$700 billion today).

Because there is an immense amount of radioactivity at a reactor, and because the fuel must be constantly cooled to prevent it from melting and releasing that radioactivity, it is not difficult to understand why nuclear facilities might be a tempting target. As Bennett Ramberg pointed out in 1984 in his seminal book on the subject, *Nuclear Power Plants as Weapons for the Enemy: An Unrecognized Military Peril*, any country that possesses nuclear energy facilities gives its adversaries a quasi-nuclear capability to use against it. Conventional explosives—a truck bomb, for example—could cause a massive radiological release, with terrorists turning their adversaries' own technology against them. And just as simple box-cutters were used to convert U.S. jumbo jets into guided missiles, conventional means could turn U.S. nuclear plants into radiological weapons. The need to protect nuclear facilities against terrorist attack should be obvious.

Minimal protection

Yet for decades, NRC regulations have required only minimal security. Fifteen years ago in the March 1986 *Bulletin* ("Protecting Reactors from Terrorists"), two colleagues and I warned even then that terrorist trends were rendering the NRC security rules inadequate. But with only a single, partial exception, the agency's primary security regulations are unchanged from a quarter century ago. And despite September 11—when the NRC's assumptions crumbled at the moment the Twin Towers fell—both the industry and the agency that regulates it continue to resist making any significant improvement to dismally inadequate and outmoded security regulations.

We reported in 1986—and it is still the case today—that NRC regulations require nuclear reactor operators to protect against no more than a single insider and/or three external attackers, acting as a single team, wielding no more than hand-held automatic weapons.

Security personnel at power reactors are not required to be prepared for:

- more than three intruders;
- more than one team of attackers using coordinated tactics;
- more than one insider;
- · weapons greater than hand-held automatic weapons;
- attack by boat or plane; or
- any attack by "enemies of the United States," whether governments or individuals.

For years, reactor sites were not even required to provide protection against truck bombs. But after a decade of efforts by the Committee to Bridge the Gap and the Nuclear Control Institute to get the agency to strengthen security and repeated refusals by the NRC to require greater protection, the 1993 World Trade Center bombing and an intrusion event at Three Mile Island finally propelled the agency to amend the rules. But the truck bomb rule is still a concern because of the limited size of the explosion that operators must protect against. It apparently requires protection against truck bombs of roughly the size used at the World Trade Center in 1993, but not the larger quantities of explosives that have been used in similar attacks since then. The NRC is behind the curve, "fighting the last war" rather than protecting against threats that can materialize without warning.

To deal with the limited threat that the NRC does recognize—called the "design basis threat" (DBT)—the agency requires a nuclear power plant to be guarded by a total of five individuals. It may seem incomprehensible in today's world that targets capable of producing tens or hundreds of thousands of casualties and hundreds of billions of dollars of damage are protected by a mere five guards, but that is the minimum the NRC mandates.

The events of September 11'demonstrated the inadequacy of the agency's quarter-century-old security rules. There were 19 terrorists on the planes, and possibly additional participants in the conspiracy—far in excess of the three external attackers the NRC envisages. They acted as four coordinated teams, but the NRC rule requires the nuclear industry to guard against only a single team. They used jumbo jets filled with jet fuel as their weapons, far more lethal than the hand-carried automatic weapons and explosives contemplated in the regulation. They were very sophisticated, training for months to fly big jets, and willing to die—a level of motivation and capability far beyond that upon which the NRC rules are predicated.

None of the details of the agency's DBT are secret. With a single exception discussed below, they can all be found in the Code of Federal Regulations, available in most libraries and on the Internet. Any potential adversary can immediately learn that the required security arrangements that protect these high-value targets are inadequate.

Three external attackers . . .

The only aspect of the DBT that is not explicitly stated in the Code is the famous number "three"—the maximum number of external attackers against which reactor owners must provide protection. The Code indicates that reactors must be protected against an attack by "several" intruders, and that "several" is less than the number required to operate as more than one team. This is enough to give a pretty clear indication of exactly how small the DBT is, but other publicly available documents make it clear that "several" means three.

The number was publicly revealed as a consequence of the licensing hearings for the Diablo Canyon nuclear plant in California in the early 1980s. The Governor of California was a party in the hearings, in which the adequacy of security at the plant was a key issue. The state's security experts testified that a dozen attackers was a credible number to safeguard against. But the utility, Pacific Gas & Electric (PG&E), and the NRC staff argued that irrespective of any threat that might exist, NRC requirements were far more modest. The precise number in the DBT became a key issue in the hearings.

The NRC's Atomic Safety and Licensing Appeal Board decided in favor of PG&E and the NRC staff, expressly ruling on how many attackers a reactor operator is required to protect against. The ruling was not immediately published on the theory that it contained sensitive information. The specific number for the DBT, according to the Diablo decision, was withdrawn at the last minute from the published regulations and replaced with "several," not for any security reason, but because the commission thought it would have trouble explaining to the public why it was requiring a lesser level of protection against sabotage for reactors than against theft at non-reactor sites. This remains the case today—NRC nervousness about public discussion of the DBT of three external attackers is not motivated by a security concern, but by fear of embarrassment were it widely known that it only required reactors be capable of protecting against no more than a trivial terrorist challenge.

The Governor of California, however, asked that an expurgated version of the decision be published, and the agency agreed. When the "sanitized" Appeal Board decision was released, the actual

number had been deleted. But ironically, the remaining text explained what "several" meant, and other underlying documents cited in the text—which had been publicly released—gave away the actual number.

The Appeal Board ruling cited a number of NRC documents it relied on in concluding that the DBT should be limited to three attackers. And although the ruling was redacted, all of the underlying documents were available in the NRC's public reading room. Those documents, the "SECY Memoranda," are the agency's actual decision documents on adopting the rule. Over and over again the SECY Memoranda state that the DBT in the rule is "an external threat of one to three persons armed with pistols, shotguns, or rifles (including automatic weapons), and who may be assisted by an insider (employee or unescorted person)." This is the so-called "three-and-one" threat described in publicly available NRC documents.

The Appeal Board decision discloses some of the rationale for settling on three external attackers.

First, the board states, power plants by rule are not required to protect against more than one team of attackers—only fuel-cycle facilities with weapons-grade material must do that. Because the minimum number of attackers who could operate as more than one team is obviously four, three is the maximum number of attackers who cannot act as more than one team.

. . . and five guards

Second, and perhaps most astonishingly, the Appeal Board discloses how the regulation's minimum force of five guards was derived:

"A response force ratio (i.e., ratio of guards to attackers) must be equal to 1 [1 to 1] to protect power reactors. The report [the NRC staff report that formed the basis for the numerical determination for the design basis threat] then states: 'Given the above response force ratio modified by a measure of conservatism, the minimum number of guards available for response to an assault may be determined. Therefore, for the presently specified threat, the minimum number of guards available for response at a nuclear power plant is judged to be 5'" (emphasis added).

The Appeal Board decision went on to indicate that the "presently specified threat" referred to was the external threat (of three) along with a single insider capable of participating in a violent attack. This three-and-one threat created a maximum total of four attackers. A 1:1 ratio of guards to attackers would require only four guards. But modifying the ratio "by a measure of conservatism" (giving the guards a one-person advantage) resulted in the regulations requiring a minimum of five guards.

(The actual regulation mentions a "nominal" number of 10 guards, with a minimum of five. But the Diablo decision and underlying documents indicate that this "nominal" number was employed to "camouflag[e] the exact threat.")

Thus, the NRC security regulations, unchanged except to require protection against small-sized truck bombs, require operators to protect against an attack by three outsiders, perhaps aided by one insider, with no team-maneuvering tactics, no attack by boat or air, and minimal hand-held weapons.

This rule made little sense when it was first adopted, and it makes even less today. The September 11 attacks—with at least 19 attackers, four times as many teams, and a level of sophistication far beyond that contemplated by the agency—blew away the NRC's security regulations. Yet those regulations remain unchanged.

Seventeen years of trying

For 17 years, my group, the Committee to Bridge the Gap, joined by the Nuclear Control Institute, has worked quietly behind the scenes in a largely futile effort to convince the NRC to upgrade its security requirements. With one partial exception, the truck bomb rule, we have failed.

In 1984, in the wake of truck bombings in the Middle East, the NRC staff decided to consider requiring protection against truck bombs at U.S. power reactors. It commissioned Sandia National

Laboratories to study the vulnerability of plants to truck bomb attacks. The results were frightening—small truck bombs could cause "unacceptable damage to vital reactor systems," and larger truck bombs could have the same effect, even if detonated off site, because the exclusion zone surrounding many facilities is small. Inexplicably, after the study was conducted, the agency dropped the idea of a truck bomb rule.

In 1985, the Committee to Bridge the Gap testified before the Safeguards and Security Subcommittee of the NRC Advisory Committee on Reactor Safeguards, pointing to data showing increasing terrorist capabilities and actions, urging the agency to upgrade the regulations to deal with larger attacking forces and with truck bombs. The response was unenthusiastic, with many subcommittee members indicating that there were so many ways to destroy a reactor that, if you protected against truck bombs, you'd have to protect against all those other vulnerabilities as well.

Over the next few years, both the Committee to Bridge the Gap and the Nuclear Control Institute continued to push the NRC to upgrade security regulations, to no avail. In 1991, at the time of the war with Iraq and the prospect of terrorist attacks against U.S. targets, we formally petitioned the NRC to upgrade its regulations. In addition to urging protection against truck bombs, the petition called for a new DBT with 20 external attackers (ironic in light of the 19 terrorists on the planes on September 11) capable of operating as two or more teams, with weapons and explosives more significant than hand-held rifles. The NRC denied the petition, ruling that "there has been no change in the domestic threat since the design basis threat was adopted that would justify a change."

Finally, after the truck bomb attack on the World Trade Center in 1993 and an event at Three Mile Island in which an intruder drove a station wagon through the perimeter and into the turbine building, where he stayed for hours while security tried to figure out if he had a bomb, the NRC adopted a new rule requiring some measure of protection against truck bombs. However, the rule may not be sufficient to protect against truck bombs of the size that have been used since 1993.

The rest of the DBT remains unaltered, despite the NRC's promises in 1994 that in a second phase it would consider upgrading the rest of the security regulations.

In fact, a number of actions have weakened security. For example, in 1996 the NRC issued Generic Letter 96-02, "Reconsideration of Nuclear Power Plant Security Requirements Associated with an Internal Threat." It permitted "reductions in unnecessary or marginally effective security measures," granting licensees the option, for instance, to keep "doors to vital areas . . . unlocked."

One counterterrorism program, killed

In late 1998, I received a plain manila envelope in the mail. Inside were documents indicating that the NRC had recently terminated its only counterterrorism program, called the Operational Safeguards Response Evaluation program, (OSRE). The program evaluated nuclear plant security by undertaking mock terrorist attacks—"black hat" force-on-force exercises. The documents contained astonishing information: Given six months advance warning, including the date on which the security test would occur, plants prepared by increasing their guard force by as much as 80 percent. Even so, security failed the tests. In nearly half of the tests conducted at the the country's reactors, mock terrorists penetrated security and reached at least one "target set" that, had the intruders been actual terrorists, could have resulted in a meltdown and massive radioactivity release.

This failure rate is extraordinary. No terrorist group is going to give notice six months in advance of when and where it intends to attack. And these tests were against the existing DBT—against only three intruders.

Other publicly available NRC documents from the early 1990s indicate that in an OSRE test at the Peach Bottom reactor, it took only 17 seconds for the mock terrorists to penetrate the perimeter fence and breach the access control barrier. It took intruders 18 seconds at San Onofre, 30 seconds at Duane Arnold, and 45 seconds at Maine Yankee.

And what was the response to this dismal failure rate? The NRC killed the program—there could be no more failures if there were no more tests.

My organization passed the OSRE documents along to the *Los Angeles Times*, which ran a major story about the program's termination. The agency was sufficiently embarrassed that a couple of days later Shirley Jackson, then NRC chair, reinstated the program. Since then, however, the industry and the agency have worked together to gut the tests. Earlier this year, the NRC approved the industry's proposed self-evaluation program that would replace NRC-run force-on-force tests. Companies failing the independent tests are now able to test themselves! The problems inherent in self-regulation should be obvious.

After September 11

Our two organizations have persisted in so-far-fruitless attempts to get the DBT upgraded. Last year, we met with NRC Chairman Richard Meserve, trying once again to get the NRC to fix gaping security problems. Nothing came of the meeting. As we were leaving, Meserve said we should feel free to see him again, adding something to the effect that he meets with industry "all the time," and there is no reason he can't meet with public groups from time to time as well. (And indeed, as we left we saw a number of industry lobbyists sitting outside his office waiting to go in.)

After September 11, we wrote to Chairman Meserve, urging him to recommend that the National Guard be called out to protect all the nation's reactors, that air defenses be deployed to protect them, and that employees and contractor personnel be thoroughly re-vetted.

We also asked the NRC to upgrade its security regulations immediately to protect against attacks involving greater numbers, operating as multiple teams, with more than one insider; require a strong two-person rule and other enhanced measures to protect against insiders; require protection against a truck bomb as big as a large truck can carry; require protections against boat and airplane attacks; require full security protection of spent fuel storage pools and dry cask storage, including after reactor closure; and that the Operational Safeguards Response Evaluation program be reinstated and expanded.

The NRC response was business as usual. The agency is continually reviewing the DBT, we were told, just as we have been told for the last 17 years.

But no improvements were promised and none has been made. Both the Committee to Bridge the Gap and the Nuclear Control Institute have decided that after years of quiet work it is time to go public about these problems. It is clear that the United States has sophisticated adversaries out there and everything we know is available to them as well. The only people not taking the danger seriously are the ones who should be required to do something about it—the nuclear industry and the agency that is supposed to regulate it.

All the NRC has done in the wake of the attacks on the World Trade Center and the Pentagon is to recommend—not even require—that licensees go to a higher state of alert within their existing security system and within the existing DBT. A no-fly-zone excluded small planes from flying near power reactors, but after a week that restriction was lifted. The federal government has failed to call out the National Guard—although in the absence of federal action, some governors have taken that step on their own. The NRC and the industry strongly oppose legislation introduced by Sens. Harry Reid, Hillary Clinton, Jim Jeffords, Joe Lieberman, and Cong. Ed Markey that would have required the agency to upgrade security regulations.

In 1981, the NRC and industry argued against the Governor of California's contention in the Diablo case that there should be protection against up to a dozen terrorists, saying such an attack wasn't credible. In 1991, the NRC and industry argued against our rulemaking petition that the DBT be increased from three to 20 external attackers operating as several teams, against asserting that there was no evidence there could ever be an attack of more than three as a single team. Protections against attacks by boats, large truck bombs, or from the air remain beyond the design threat. On September 11, 19 attackers in four teams using planes caused the worst terrorist event in U.S. history. Yet the NRC and industry refuse to upgrade the DBT regulations to a level consistent with the now-evident threat.

The industry's response is shocking. Rather than conceding the vulnerability of its facilities and the need to upgrade security, at a press conference on September 25 a spokesman for the Nuclear

Energy Institute took the extraordinary stand that greater security isn't required because Chernobyl wasn't that bad.

Why does the industry continue to ignore the need to protect its facilities? First, more security means more expense, and its every instinct is to avoid current expenses. Second, if it admits its reactors are vulnerable, the industry's dream of a nuclear renaissance is diminished.

Having received a big boost from the Cheney energy plan, the industry had been hoping to build new reactors, supposedly of the new pebble-bed design. In order to save money, these "passively safe" reactors would be built without a containment structure. In addition, they are made of graphite, which burns readily, as evidenced by Chernobyl and the earlier Windscale accident in Britain. As poorly resistant to terrorism as today's reactors are, pebble-bed reactors would be far worse. Furthermore, the industry-Cheney proposals involve a revival of the idea of reprocessing spent fuel to separate plutonium, which would then be used in civil reactors, creating a massive additional risk that terrorists might acquire nuclear weapons materials from poorly guarded civilian power plants. The nuclear industry hopes that its post–September 11 problems will go away, without having to upgrade security.

And why has the NRC not imposed upgraded security requirements? Put bluntly, the NRC is arguably the most captured regulatory agency in the federal government, a creature of the industry it is intended to regulate. Efforts to separate its promotional and regulatory functions, which led to the breakup of the Atomic Energy Commission in the mid-1970s, have failed utterly. The NRC's principal interest is in assisting the industry, keeping regulatory burdens and expenses to a bare minimum, and helping to jumpstart the nuclear enterprise.

But the risk of terrorist attack at one or more nuclear plants is simply too great to allow this failed agency and the industry it allegedly regulates to continue to ignore the need to provide reasonable protection. The industry's short-term economic or political concerns pale in comparison to the damage that would occur if attackers turn the nation's reactors into radiological weapons.

Daniel Hirsch is president of the Committee to Bridge the Gap, a Los Angeles- based nuclear policy organization.

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TMI's Health Effects: What We Know

The most fundamental and critical issues surrounding the accident at Three Mile Island are the adverse health effects and the unresolved questions of dose. The facts are that people have experienced radiation symptoms and have suffered adverse health effects. Some have died and more will as a result of the accident.

Unfortunately, the lie that not enough radiation was released to cause harm has been told so often by the Nuclear Regulatory Commission, GPU, and others, it has become part of the "official science." Many of us, as "human dosimeters," unaware of the accident, reported radiation symptoms during the accident, but the authorities responsible for protecting our health and safety refused to look into our allegations. They omitted evidence of dose limit violations and they never fined TMI owner Metropolitan Edison (Met-Ed) for overdosing the public. They misrepresented one radiation monitor as having remained "on-scale" during the accident when it did not. And they shamelessly prohibited conclusions of any health damage, when in fact there were.

What we know:

There is no doubt adverse health effects occurred as a result of the accident at Three Mile Island. A study by Dr. Steve Wing of the University of North Carolina has verified increased cancer incidence around TMI. Wing also states in his reanalysis of the Columbia University study, that Columbia found positive results but interpreted them as negative. In fact, all the studies conducted by Columbia and the Pennsylvania Department of Health have shown increases in adverse pregnancy outcomes as well as cancers, despite their conclusions to the contrary.

We have found that official studies pertaining to the TMI nuclear accident are intentionally misleading reports funded in whole or in part by state and federal governments, Met-Ed/GPU, and the nuclear industry. Even Columbia University's Study was paid via the TMI Public Health Fund and needed approval by federal Judge Sylvia Rambo and Met-Ed's lawyers. Their "official scientists" will tell you TMI did not cause adverse pregnancy outcomes or cancer increases because "not enough radiation escaped." They might tell you there were increases in some health effects caused by stress; smoking, drinking or taking tranquilizers; population increases; or due to radon or some other environmental problem. The fact is their scientists falsely concluded radiation doses were too low to cause any harm and, thereby, completely exonerated TMI as the cause.

The facts are that people have suffered adverse health effects, some have died and more will as a result of the accident. But don't take our word for it. Read the studies and see the underlying data. The press releases have been and continue to be misleading.

Central Pennsylvanians trying to cope with the accident at TMI and its aftermath agree with official government scientists on one thing: TMI-2 has generated a lot more stress than electricity. The worry and uncertainty surrounding the accident persists to this day. The effects of stress on health are widely documented. Worries about cancer, birth defects, the possibility of another accident, all stress the body's neurochemistry and can affect the functioning of the nervous system, hormone levels, and immunological response. Virtually every study conducted agrees that there are increased levels of stress and that stress has deleterious effects on our health.

This is one aspect of the accident on which there is unanimity. Unfortunately, central Pennsylvanians don't buy the findings of "official" studies on the health results of Three Mile Island. Conversely, the officials demonstrate no interest in solid evidence collected by "un-official" scientists and lay people.

All the major, officially-sanctioned health studies following the accident (funded by state and federal government, Met-Ed/GPU and the nuclear industry, and the TMI Health Fund) rely upon one radiation monitor which was, in fact, misrepresented by the President's Commission Report and the NRC's Special Inquiry Group. These reports fraudulently report that the HP-R-3236 monitor remained "on scale" during the accident which, in fact, did not. All these studies have as their basic assumption that not enough radiation escaped during the accident to harm anyone.

Put yourself in the shoes of a TMI neighbor and consider the following:



or visit our website at http://www/tmia.com

. www.loke.org

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- •The recommended chromosome studies were not done on workers or residents because the official doses were declared too low and, therefore, would not yield useful information. Meanwhile, University of North Carolina epidemiologis Steven Wing contends chromosomal damage has been found in TMI-area residents.
- •The Pa. Dept. of Health admitted to only one occurence of neo-natal hypothyroidism within ten miles of the plant, but discounted 19 additional cases further downwind. When the Department refused to alert the public to the neonatal hypothyroidism, former Secretary of Health Gordon MacLeod, asked a reporter to look into the matter. After an early morning phone call from a panicked Dr. Tokuhata of the Dept. of Health, Dr. MacLeod wrote: "... several concerned Health Department employees have called me repeatedly to complain that abnormal health data were not being made available to the public." In his American Journal of Public Health (AJPH) article (Vol. 72, No. 3, March, 1982), MacLeod also writes that "... there was an omission of 88 infant deaths from Department of Health data" and that the "neonatal mortality rate more than doubled after the accident."
- •During the first two quarters of 1978, the neonatal mortality rate within a 10 mile radius of TMI was 8.6 and 7.6 per 1,000 live births respectively. During the first quarter of 1979, following the start-up of Unit 1, the rate jumped to 17.2; it increased to 19.3 in the quarter following the accident and returned to 7.8 and 9.3 respectively in the last two quarters of 1979.
- •Increases in adverse health effects were also found by Penn State professor, Dr. Winston Richards. "Infant mortality for Dauphin County while average in 1978 becomes significantly above average in 1980. Death from leukemia while average in 1979 is very close to above average in 1980, and deaths from cancer for ages 45-64 while average for 1978 become decidedly significantly above average for 1980."
- •Resident infant deaths due to Sudden Infant Death Syndrome show huge increases in Pennsylvania after the start-up of TMI in 1974 and another large increase after the accident. In an unrelated study, a British pathologist found babies that died of SIDS had a three-fold increase of "eosinophils" in lung tissue. Local people had "persistently elevated eosinophils" and there were "very high eosinophil counts" in animals after the TMI accident. Dr. Leaser states this could be a precursor to leukemia.
- •The Health Department's official cancer study was released in the fall of 1985 claiming they found no increases in incidences of cancer within a 20 mile radius of TMI caused by the accident. Shortly thereafter, the Sunday Patriot-News exposed the Health Department's obfuscation and their contrived results. The Pa. Department of Health had "included 28,610 people" who lived beyond the five mile radius of the plant as living within five miles, and, another 122,000 people who live farther than 10 miles from the plant were included in the population of those living within 10 miles, which substantially diluted any cancer rates.
- •A study by the University of North Carolina exposed how "official science" obfuscated what the people around TMI have always known: there was offsite radiation, there were radiation sickness symptoms, and now there are adverse health effects.

The University of North Carolina study found "... there were reports of erythema, hair loss, vomiting, and pet death near TMI at the time of the accident ..." "Accident doses were positively associated with cancer incidence. Associations were largest for leukemia, intermediate for lung cancer, and smallest for all cancers combined." "Inhaled radionuclide contamination could differentially impact lung cancers, which show a clear dose-related increase." While "official" studies found problems, they concluded TMI wasn't the cause. The UNC study says in official studies "... positive results have been interpreted as negative ..."

Columbia's AJPH article of June 1991, actually shows there was more than a doubling of all observed new cancers after the accident at TMI — including lymphoma, leukemia, lung, colon and the hormonal category of breast, endometrium, ovary, prostate and testis. For leukemia and lung cancers in the 6-12 km distance, the number observed was almost four times greater and in the 0-6 km distance colon cancer was exactly four times greater. Their paper on cancer in proximity to the plant finds "a statistically significant relationship between incidence rates after the accident and residential proximity to the plant." So stress can be blamed for cancer, but radiation cannot.

•Millersville University Study, James W. Fenwick, Assoc. Prof., biostatistician: Fenwick found in early 1998 that "Cancer rates in Lancaster County appear to be on the rise." Reporting statistically significant increases of prostate and urinary/bladder cancers in men; increases in kidney/renal, pelvis and ovarian cancers in women; and small increases in the rate of thyroid cancers in both men and women.

Litigation: 25 Years - The Miscarriage of Justice That Won't End

At the time of the 20th anniversary, there were personal injury lawsuits pending for more than 2,000 plaintiffs. These were recently dropped when the U.S. Third Circuit Court of Appeals refused to hear an appeal on Judge Sylvia Rambo's decision granting TMI defendants a summary dismissal. The last round of personal injury lawsuits representing almost 2,000 plaintiffs was recently dropped by their attorneys, based on the U.S. Third Circuit Court of Appeals refusal to hear an appeal on the judge's decision granting TMI defendants a summary dismissal. The attorneys chose not to appeal the judge's decision to the Supreme Court. In this case the controlling hands of Federal District Judge Sylvia Rambo threw out most of the plaintiffs' expert witnesses, as she decided the issues of fact that belonged instead before a jury. This is the legacy of Three Mile Island 25 years later; victims continue to wait for justice.

In 1985, Met-Ed's insurance pool paid more than \$3.9 million dollars for out-of-court settlements of personal injury lawsuits, many involving children. The largest settlement, over one million dollars, was for a child born with Down's Syndrome. State law requires certain legal matters involving children to be made public; had it not been for the children's settlements, we may never have learned of this or other cases settled because stipulations incorporated into the settlement agreements prohibited plaintiffs from discussing their settlements. Funds from the \$560,000,000 Price-Anderson Act insurance pool paid these settlements.

Lawsuits not involving personal injury, such as the class action for property loss, evacuation losses and expenses for individuals, corporations and governmental agencies and municipalities were settled some time ago. In 1982, after Judge Rambo dismissed two suits seeking reimbursement for costs of emergency services provided during the accident, the U.S. Circuit Court of Appeals reinstated the cases which resulted in settlements of \$250,000 to the Commonwealth of Pennsylvania and \$225,000 to the municipalities. "Temporary evacuation, which lasted less than two weeks for most evacuees, caused short term economic loss of approximately \$90 million to individuals and local communities "

To date, public records show GPU and the nuclear industry has paid out at least \$50 million to plaintiffs from TMI-related suits brought against them.



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- •Lee Survey, Jane Lee, Unpublished Report: Mrs. Lee, voluntarily surveyed 409 families in a small development within five miles north, northwest of TMI, in one of the areas where the Pa. Department of Health refused to conduct an investigation. Since the accident Lee documented 23 cancer deaths, 45 living cancers, 53 benign tumors, 31 miscarriages, stillbirths and deformities, and 204 cases of respiratory problems. The "metallic taste" was reported by 98 people interviewed. So, yes, 25 years later the concern continues.
- •Aamodt Study, Marjorie M. Aamodt, Intervenor in the TMI proceedings: A "Voluntary Community Health Survey" was undertaken by a group of local residents led by Mrs. Aamodt. Two survey areas were canvassed where people reported "radiation symptoms" during the accident; a third area seven to eight miles away on a hill was chosen as a control. The unexpected results of the study compiled and analyzed by Mrs. Aamodt showed a 600% cancer death rate increase for all three areas, with the control group revealing health damage also. This data was verified by members of the TMI Public Health Fund and it was learned through a Freedom of Information Act Request that Dr. Glyn Caldwell of the Center for Disease Control wrote, "I do agree if all deaths the were confirmed by medical records, then this would be a statistically significant increase." The deaths have been confirmed.
- •The President's Commission Report is cited most often to refute radiation exposure as causing any health damage to the two million people living within the fifty mile radius of the plant; stating at most, only one cancer death would be expected. But this report, which misrepresented a critical radiation monitor as remaining on-scale during the entire accident from which questionable low doses were derived, is the root cause of the cover-up/controversy.
- •Admiral Rickover himself ". . . said that the report, if published in its entirety, would have destroyed the civilian nuclear power industry, because the accident at Three Mile Island was infinitely more dangerous than was ever made public." He admitted persuading President Jimmy Carter ". . . to publish the report only in a highly 'diluted' form." (7-18-86 Notarized Affidavit by Jane Rickover.)

The Accident Continues: Individual Stories from TMI

Symptoms reported during the accident were real. Thousands of people called the Governor's hot-line and TMIA's telephone log listed a full range of radiation symptoms. The burning or irritation of eyes, nose and throat, reddening of skin, breathing difficulties, headaches and joint aches, menstrual irregularities as well as nausea, vomiting, diarrhea and subsequent hair loss - were the precursors of the nightmare to come. A letter by Harrisburg Mayor Stephen Reed, then a member of the State House of Representatives, asked the NRC why they refused to look into these effects. The NRC's Harold Denton issued the now classic response - still echoed today - that not enough radiation escaped to cause any of the effects reported.

- •Living on the west bank of the Susquehanna River, Bill Whittock was startled by the roar of the steam blowing out of TMI around 4:00 a.m. Bill had the metallic taste, developed skin cancer, and now his wife has breast cancer. They were plaintiffs in the consolidated personal injury lawsuit until dropped by the attorneys. Bill died of cancer.
- •While preparing to milk the cows, Marie Holowka of Zions View, was engulfed by strange blue air, choked, and could hardly breathe. She fell to the ground, was sick for days. Many of her cows died after the accident and the Guinea fowl eggs would not hatch. Marie developed a thyroid problem, breast cancer, and later cancer around her heart. Marie died of cancer.
- •Louise Hardison had many problems after the accident. Goats, chickens, cats and rabbits died on her farm across the road from TMI. Stillborn lambs and some rabbits were deformed they didn't have all their legs. Louise has also died. Her farm was sold and mutated dandelions still grow in the unfarmed pasture.
- •On a hill eight miles northwest of TMI, dentists Klein and Malchodi found all the dental X-ray films taken of their patients' teeth those first two days were fogged or banded. They taped new film on the front door for the next week and found nothing wrong with those so they concluded they got their highest doses on the first two days.
- •Ruth and Clair Hoover both had the metallic taste in their mouths, they saw "white fallout" and had little red spots on their arms. After the accident they lost seven cows and 12 calves, their St. Bernard dog, and their pony. Ruth developed reproductive problems and Clair was diagnosed with an inoperable brain tumor. They had already received settlement in the first round of lawsuits in 1985, prior to Clair's diagnosis of the brain tumor. Ruth's problems appeared to be similar to those reproductive problems in their cattle.
- •Fran Cain, who still lives across the river from the cooling towers at TMI, had the metallic taste and later that year a poodle puppy was born with no eyes. She received a settlement in the first lawsuit.
- •Darla & Bill Peters had that bitter metallic taste so strong they couldn't drink enough water to get rid



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- of it. They had burnt skin and noses, and Bill got blisters on his nose and lips. Their dog and cats and kittens died. Later he found enough dead birds to fill a hydraulic bucket half full of dead birds. Bill died during his deposition for the lawsuit. One of the attorneys said, "It's OK, because we still have Darla."
- •Charlie Conley's cows died, the hop toads disappeared, as did the bumble bees that pollinated his clover. The cooling tower drift from the plant would drift over his trees and at times the leaves would turn black desiccated. Many trees just died about five years ago. So did Charlie.
- •On Herb Myers' farm in New Cumberland, the sheep would not dilate during birthing to deliver their young. Some time later a stillborn double-headed calf was born and the vet told Herb to have it stuffed and mounted, which he did. Herb died of thyroid cancer shortly after the 10th anniversary of the accident. His family did not sue.
- •"A wave of hot air" engulfed Jean Trimmer as she leaned over her porch railing calling for her cat. Shortly thereafter, her skin tingled and started to itch and later her skin appeared reddened "like a week at the beach." She got tiny white bumps on her skin and her beautiful black hair started falling out. When her hair grew back, it had white hairs growing in a salt and pepper effect. Jean developed a rare kidney illness.
- •During the evacuation, Nurse Becky Mease's baby had projectile vomiting and severe diarrhea. The hospital in Ocean City said it could be radiation poisoning and suggested she have her car checked for contamination. She did. It was, and so was her purse. Later, her child developed cataracts and other health problems.
- •Debbie Baker just found out she was pregnant. She lived in the vicinity of the dentist office with the fogged film. Debbie's son Bradley, was born with Down's Syndrome. The lawsuit on his behalf was settled out-of-court and was the largest made public, for over one million dollars. Debbie is one of the co-founders of the citizens' radiation monitoring networks around TMI.
- Dr. Steve Wing of the University of North Carolina says, "The cancer findings, along with studies of animals, plants and chromosomal damage in Three Mile Island area residents, all point to much higher radiation levels than were previously reported. If you say that there was no high radiation, then you are left with higher cancer rates downwind of the plume that are otherwise unexplainable. Our findings support the allegation that the people who reported rashes, hair loss, vomiting and pet deaths after the accident were exposed to a high level radiation and not only suffering from emotional stress."

The accident at Three Mile Island was not a one day or one week disaster. TMI burped and vented their poisons upon us during the accident and through the years of clean-up. The symptoms were real. We did not imagine the metallic taste.



Radiation and Public Health Project

Joseph J. Mangano, MPH, MBA, National Coordinator 786 Carroll Street, Brooklyn, NY 11215 718-857-9825 www.radiation.org Directors
Jay M. Gould, PhD
Jane S. Gould, MA
Ernest J. Sternglass, PhD
William McDonnell, MA
Joseph Mangano, MPH
MBA

LOCAL CHILD DEATHS, CANCERS SOAR AFTER THREE MILE ISLAND ACCIDENT, RATES REMAIN HIGH FOR NEXT TWO DECADES

Middletown PA, March 27, 2004 - Death rates for local infants and children soared in the first two years after the Three Mile Island nuclear reactor meltdown according to a new analysis released today, the eve of the accident's 25th anniversary.

In 1979-80, the mortality rate in infants in the four closest downwind counties was 9% higher than in 1977-78, compared to declines of 5% in Pennsylvania and 8% in the U.S. The rate in Dauphin County, site of Three Mile Island soared 37% (81 to 119 deaths).

Moreover, the number of deaths in Greater Harrisburg rose 25% for age 0-1, 23% for age 1-14, and 7% for age 15-24 in the same two-year period. Deaths for other adults declined during this time, except for the very elderly (up 17% for persons age 85 and over).

"These data suggest strongly that the 1979 meltdown immediately harmed the local population, especially the youngest, and very elderly, who are most vulnerable to the toxic effects of radiation," says Joseph Mangano, National Coordinator of the New York research group Radiation and Public Health Project (RPHP). Mangano adds that these data have never before been discussed publicly by health officials. "Much work remains to fully understand the toll from Three Mile Island," he says.

Long-term effects were also presented by Mangano. Cancer death rates among children younger than ten years old in downwind counties were 24% below the U.S. rate in the 1970s (before the accident), but have been 30% higher after the accident.

All 1979-2000 death rates for children and adolescents under age 25 in downwind counties are consistently higher than those in upwind counties, both for cancer and for all causes. Downwind counties near Three Mile Island include Dauphin, Lancaster, Lebanon, and York, while upwind counties include Adams, Cumberland, and Perry.

Mangano stated that measuring in-body radiation levels is a helpful way of advancing the research on Three Mile Island. RPHP has recently measured levels of radioactive Strontium-90 in 4000 baby teeth. In four medical journal articles, high and rising levels near nuclear reactors were found, plus high levels in teeth of children with cancer.

Advisory Board Rosalie Bertell, PhD, GNSH Samuel Epstein, MD

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EFFECTS OF THREE MILE ISLAND RADIOACTIVE EMISSIONS ON THE HEALTH OF THE LOCAL POPULATION

A. Short Term Effects - Deaths 1977-78 vs 1979-80)

1. Infant Mortality (Deaths Under One Year)

	Deaths	< 1 Year	Live Bir	ths	Death	s/1000	
Area	1977-78	1979-80	1977-78 1	979-80	1977-7	8 1979-8	0 % Ch.
Dauphin County	81	119	6095	6538	13.29	18.20	+36.9**
Downwind Counties	331	378	27587	28972	12.00	13.05	+ 8.8*
Upwind Counties	75	76	6877	7347	10.91	10.34	- 5.2
Other Pennsylvania	3840	3744	271493	280369	14.14	13.35	- 5.6
United States	92920	91191	6659911	7106656	13.95	12.83	- 8.0

^{* =} significant at p<.03; ** = significant at p<.003; all differences of <.05 are significant

2. Total Deaths by Age, Harrisburg Area

	Total Death	Total Deaths		
Age	1977-78	1979-80	% Ch.	
0-1	138	173	+25.4 p<.04	
1-14	62	76	+22.6	
15-24	134	143	+ 6.7	
25-34	137	132	- 3.6	
35-44	203	196	- 3.4	
45-54	585	553	- 5.5	
55-64	1246	1210	- 2.9	
65-74	1949	1983	+ 1.7	
75-84	2103	2181	+ 3.7	
85+	1318	1551	+17.7 p<.0001	

3. Total Cancer Cases, Area Under 10 Miles from Three Mile Island

	Total Cance		
Type of Cancer	1975-79	1981-85	% Ch.
All	1722	2831	+ 64.4
All (Age 0-24)	34	47	+ 38.2
Hodgkin's Disease	22	24	+ 9.1
Leukemia	28	54	+ 92.9
Lung	194	440	+126.8
Non-Hodgkin's Lymphoma	67	91	+ 35.8

B. Long Term Effects - Disease and Death Rates After 1979

1. Childhood Deaths by Age, Whites, 1979-2000, Downwind vs. Upwind Counties

Cancer Deaths Age	Deatl	ns Population	Rate/100,000	% Higher
0-9 Downwind	149	3,140,994	4.74	+32.1 p<.02
0-9 Upwind	31	863,418	3.59	
10-19 Downwind	139	3,213,895	4.32	+17.2
10-19 Upwind	37	1,002,791	3.69	
20-24 Downwind	116	1,629,789	7.12	+12.9
20-24 Upwind	34	539,460	6.30	

Deaths, All Causes (Excluding Accidents, Homicide, Suicide)

Age	Death	s Population	Rate/100,000	% Higher	
0-1 Downwind	2469	316,553	780.0	+10.7 p<.00	01
0-1 Upwind	576	81,769	704.4		
1-9 Downwind	497	2,824,441	17.6	+12.8 p<.00	6
1-9 Upwind	122	781,649	15.6		
10-19 Downwind	410	3,213,895	12.8	+21.8 p<.00	05
10-19 Upwind	105	1,002,791	10.5		
20-24 Downwind	349	1,629,789	21.4	+28.4 p<.00	02
20-24 Upwind	90	539,460	16.7	444	

2. Childhood Cancer Deaths, Before and After 1979 Accident, Downwind Counties

Age	Deaths % Above/Below U.S.		
0-9, 1970-79	58	- 24.3	
0-9, 1980-00	128	+30.4 p<.0001	
10-19, 1970-79	79	- 7.6	
10-19, 1980-00	128	+ 0.1	
0-19, Dauphin	63	+33.7	
0-19, Lancaster	105	+13.9	
0-19, York	71	+ 1.8	
0-19, Lebanon	38	+64.8 p<.04	

3. Childhood Cancer Incidence, Age 0-19, 1990-99

Age	Cases	Rate/100,000	% +/- U.	S.
0-19, Downwind	592	18.28	+14.0%	p<.03
0-19, Upwind	154	17.35	+ 8.2%	
Dauphin	132	20.69	+29.0%	p<.05
Lancaster	222	16.85	+ 5.0%	
Lebanon	67	21.35	+33.1%	
York	171	17.63	+ 9.9%	

 Cancer Deaths, Dauphin/Lancaster/York Counties Compared to the U.S. Before and After Three Mile Island Opening Cancers Especially Sensitive to Radiation Age 65 and over (age 60 and over from 1950-74)

	% +/- U.S. (N	No.Deaths)	
Type of Cancer	1950-74	1980-00	% Ch.
Breast (Females)	+ 9 (1731)	+15 (2403)	+ 6* p<.06
Hodgkin's Disease	- 13 (108)	- 9 (52)	+ 4
Leukemia	- 7 (731)	+ 6 (1183)	+15* p<.002
Multiple Myeloma	- 6 (227)	+ 3 (619)	+ 9
Non-Hodgkin's Lymphoma	+12 (557)	+18 (1356)	+ 6
Thyroid	- 14 (72)	+31 (91)	+45* p<.007

Notes: Dauphin County is the site of Three Mile Island. Dauphin and Lancaster, Lebanon, and York Counties represent the closest downwind counties. Adams, Cumberland, and Perry Counties represent the closest upwind counties.

Harrisburg area = Standard Metropolitan Statistical Area (Dauphin, Cumberland, Perry Counties)

Cancer cases under 10 miles from Three Mile Island from Pennsylvania Cancer Registry, in Hatch M et al., Cancer near the Three Mile Island. . . American Journal of Epidemiology, September 1990. 132 (3);397-412.

Health: Science for Sale: TMI and the University of Pittsburgh

by Eric Joseph Epstein

The University of Pittsburgh's most recent "health study," released on Halloween, is essentially a recitation of discredited protocol and disputed data. Re-released on October 31, 2002, the Study actually acknowledged an increase in lymphatic and blood cancers among men. However, as in previous University of Pittsburgh Studies conducted by the same group of researchers (Evelynn Talbott et al; 2000),1 this survey relied on government and nuclear industry sponsored "health studies" which were completed in the early 1980s. These studies were based on inaccurate dose projections, did not factor data only available in 1985 regarding the severity and conditions of the partial-core meltdown at Three Mile Island Unit-2,2 and did not factor the prevailing weather conditions and wind patters in March-April, 1979.

Nor did any of these studies evaluate the health impact to members of our community who participated in the defueling of Three Mile Island. In fact, General Public Utilities chose not to maintain a health or cancer registry, despite the fact, that from 1979-1989, 5,000 clean-up workers received "measurable doses" of radiation exposure.3 (3)

Moreover, the University of Pittsburgh's Study relied heavily on the much maligned Pennsylvania Department of Health's seventeen year-old survey released in September, 1985. That Study's protocol was ridiculed and criticized by epidemiologists at Harvard (Dr. George Hutchison), and Penn State (Dr. Robert A Hultquist) for "diluting" increases in cancer by "expanding" the population base to include people living outside of ten-mile study-zone.4

A great deal of radiation was indeed released by the partial core melt at TMI. The President's Commission estimated about 15 million curies of radiation were released into the atmosphere. A review of dose assessments, conducted by Dr. Jan Beyea, (National Audubon Society; 1984)5 estimated that from 276 to 63,000 person-rem were delivered to the general population within 50 miles of TMI. More recently, David Lochbaum of the Union of Concern Scientists, estimated between 40 million curies and 100 million curies escaped during the accident.

For 11 days, in June-July, 1980, Met Ed illegally vented 43,000 curies of radioactive Krypton-85 (beta and gamma; 10 year half life) and other radioactive gasses into the environment without having scrubbers in place.6

And by 1993, TMI-2 evaporated 2.3 million gallons of accident generated radioactive generated water, including tritium (a radioactive form of hydrogen with a half life of 12.5 years), into the atmosphere despite legal objections from communitybased organizations.7

The plant's owners, co-defendants, and insurers have paid more than \$80 million in health, economic and evacuation claims, including a \$1.1 million settlement for a baby born with Down's Syndrome.8 In June 2000, the United States Supreme Court remanded 1,990 unsettled health suits from the TMI-accident back to Federal Court. (GPU v. Abrams; Dolan v. GPU).9

In August 1996, a study by the University of North Carolina-Chapel Hill, authored by Dr. Steven Wing, reviewed the Susser-Hatch study (Columbia University; 1991). Dr. Wing reported that "...there were reports of erythmea, hair loss, vomiting, and pet death near TMI at the time of the accident...Accident doses were positively associated with cancer incidence. Associations were largest for leukemia, intermediate for lung cancer, and smallest for all cancers combined...Inhaled radionuclide contamination could differentially impact lung cancers, which show a clear dose-related increase."10

Today, TMI-2 remains a high level radioactive waste in the middle of the Susquehanna River. There was no decommissioning fund established for TMI at the time of the accident. The site of the nation's worst commercial nuclear accident has not been decontaminated or decommissioned. There has not been a human entry in the basement of the reactor building since March, 1979.11

See reverse for footnotes



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End Notes

- 1. Environment Health Perspectives, June, 2000.
- 2. On November 6, 1984, research conducted by the Department of Energy on reactor damage during the accident, indicates temperatures may have reached in excess of 4,800 degrees. In October 1985, removal of damaged fuel from TMI-2 began.
- 3. On April 11, 1984, William Pennsyl settled out-of-court two days before an administrative law judge was scheduled to hear his case relating to GPU's refusal to allow Pennsyl to wear a respirator during cleanup activities.
- By 1986, TMI-2 defueling work force peaks at 2,000, but by 1989, after ten years of defueling activities, 5,000 TMI workers have received "measurable doses" of radiation exposure.
- 4. Pennsylvania's TMI study clouded by survey method doubts, Frank Lynch, "Sunday Patriot-News", Front Page, Harrisburg, PA, October 6, 1985.
- 5. Study available from the TMI Public Health Fund, 16223 Locust Street, Philadelphia, PA 19103, 215-875-3926.
- 6. In November, 1980, the United States Court of Appeals for the District of Columbia ruled that the krypton venting (June-July, 1980) was illegal.
- 7. In 1980, the Susquehanna Valley Alliance, based in Lancaster, successfully prevented GPU/Met Ed from dumping 700,000 gallons of radioactive water into the Susquehanna River. Ten years later, in December 1990, despite legal objections by TMI Alert and the Susquehanna Valley Alliance, GPU began evaporating 2.3 million gallons of accident-generated radioactive water (AGW).
- By August, 1993, evaporation of 2.3 million gallons of AGW was completed more than six months behind schedule. The evaporator was disassembled and removed from the site. And on October 28, 1993, according to the Pennsylvania Department of Environmental Resources, the total activity during evaporation was 658 curies of tritium or 1 to 1.3 MR dose to the public.
- 8. By 1985, TMI had paid at least \$14 million for out-of-court settlements of personal injury lawsuits. The largest settlement was for a child born with Down's Syndrome. Most of the cases were "sealed," and only those cases involving "minors" are published as prescribed by the rules and regulations of Pennsylvania's Orphan's Court.
- 9. On June 12, 2000, the United States Supreme Court, without comment, rejected an appeal by GPU to throw out 1,990 health suits. On May 2, 2001, the Third Circuit Court ruled that "new theories" to support medical claims against Three Mile Island will not be allowed.
- 10. New Study Shows Higher Cancer Rate near Three Mile Island Nuclear Power Reactor Meltdown. Researchers at University of North Carolina at Chapel Hill have published, in the journal Environmental Health Perspectives (February 24, 1997), a re-evaluation of the health effects near Three Mile Island. They have found chromosomal damage and higher cancer rates than previously reported, suggesting radiation levels were higher than official estimates. Copies of the study may be requested at: 919-541-3345.
- 11. December, 1993, GPU placed TMI-2 in Post-Defueling Monitored Storage. On October 17, 2001, due to a "credible threat" against Three Mile Island, the Harrisburg and Lancaster airports were closed for four hours, air travel was restricted in a 20-mile radius, and fighter jets were scrambled around TMI.

Ethics and Environmental Health | Mini-Monograph

Objectivity and Ethics in Environmental Health Science

Steve Wing

Department of Epidemiology, School of Public Health, University of North Carolina, Chapel Hill, North Carolina, USA

During the past several decades, philosophers of science and scientists themselves have become increasingly aware of the complex ways in which scientific knowledge is shaped by its social context. This awareness has called into question traditional notions of objectivity. Working scientists need an understanding of their own practice that avoids the naïve myth that science can become objective by avoiding social influences as well as the reductionist view that its content is determined simply by economic interests. A nuanced perspective on this process can improve research ethics and increase the capacity of science to contribute to equitable public policy, especially in areas such as environmental and occupational health, which have direct implications for profits, regulation, legal responsibility, and social justice. I discuss research into health effects of the 1979 accident at Three Mile Island near Harrisburg, Pennsylvania, USA, as an example of how scientific explanations are shaped by social concepts, norms, and preconceptions. I describe how a scientific practice that developed under the influence of medical and nuclear physics interacted with observations made by exposed community members to affect research questions, the interpretation of evidence, inferences about biological mechanisms in disease causation, and the use of evidence in litigation. By considering the history and philosophy of their disciplines, practicing researchers can increase the rigor, objectivity, and social responsibility of environmental health science. Key words: cancer, chance, dose reconstruction, environmental justice, epidemiology, ionizing radiation, research ethics, significance testing, Three Mile Island. Environ Health Perspect 111:1809-1818 (2003). doi:10.1289/ehp.6200 available via http://dx.doi.org/ [Online 19 June 2003]

In politics, policy, and law, science has emerged as an alternative to folk traditions, religion, and superstition as a way to understand and manipulate the material world. The value and prestige of the sciences derive not only from their erudition, explanatory power, and applied technology but from their perceived objectivity. A common view among scientists and lay persons alike is that scientific objectivity is a consequence of standardized methods of quantitative observation and experimentation. The scientific method, by removing subjectivity and social influence, yields knowledge that is ostensibly trustworthy and objective.

Despite the persistence of this view, historians, philosophers, and scientists themselves have shown that it does not provide an adequate account of the production of scientific knowledge (Harding 1991; Holtzman 1981; Hubbard 1990; Kuhn 1970). There are several reasons why method cannot remove social influences from science. First, the content and methods of science are formed in relation to answering questions or testing hypotheses that are socially embedded. Second, scientific explanation requires language, concepts, and models that are cultural products. Although all sciences expend considerable effort to rationalize concepts and terminology, these tools of inquiry are inevitably shaped and transformed by historical forces. Therefore, scientists cannot even see the world, much less provide explanations of its workings, without a socially formed perspective. Ironically, the belief that science could attain

objectivity through independence from social forces places science in the role of a religion's omniscient God (Harding 1991). The illogic of the naïve view of-scientific objectivity has been described in physics, genetics, and epidemiology, as well as in mathematics and statistics (Armstrong 1999; Hubbard 1990; Keller 1992, 1995; Kuhn 1970; Levins 1979; Levins and Lewontin 1985).

The reluctance of scientists to acknowledge the shaping of their work by social forces and their ongoing avowal of science as value-free can be viewed as a self-serving argument against public oversight (Keller 1995). However, even among scientists who accept an ethic of social responsibility, attempts to salvage naïve objectivity persist because the alternative is perceived to be a judgmental relativism in which there is no basis for adjudicating competing claims. Such relativism is anathema to the most basic assumptions of science: that a real world exists independent of human cognition, and that theories and hypotheses about that world can be tested by controlled methods of observation and experimentation. A logical alternative to both judgmental relativism and naïve objectivity is "strong objectivity," an objectivity attained through revealing, rather than concealing, the cultural content and social forces that are embedded in science (Harding 1991). To practice strong objectivity, scientists must consider not only the technical aspects of their discipline, but must also take into account its history, conceptual foundations, preconceptions, taboos, and the social forces that shape its content and application. This requires scientists to distinguish truth, in the form of statements about the world made by people, from reality, the world itself (Hubbard 1990; Rorty 1989), and to be self-critical about the ways scientists create truths and facts in relation to the real world that they study.

This article explores how a contextual research practice can improve the rigor, ethics, and social responsibility of environmental health science. I use as a case example research on cancer incidence after the 1979 nuclear accident at Three Mile Island (TMI) near Harrisburg, Pennsylvania, USA. I consider how unarticulated cultural views about the reliability of assumptions and evidence shaped the framing of questions, the design of research, and the interpretation of findings in the scientific literature as well as in the courtroom.

Accident at Three Mile Island

Three Mile Island is in the Susquehanna River about 16 km (10 miles) from Harrisburg, the capital of Pennsylvania, where the Susquehanna cuts across parallel ranges of hills that rise hundreds of meters above the river. Several smaller towns are located along the river near to TMI (Figure 1). Dairy and other farms are common in the area, which has a strong agricultural tradition (Figure 2).

At 4:00 A.M. on 28 March 1979, a series of events began that led to a loss of control of the nuclear chain reaction in the TMI Unit 2 reactor. For several days it was not clear how or when the reactor could be shut down. Uncontrolled releases of radioactivity to the environment began shortly after 4:00 A.M. on 28 March. Within hours, radiation monitors at the plant went off-scale because radiation

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Address correspondence to S. Wing, Dept. of Epidemiology, 2101F McGavran-Greenberg Hall, School of Public Health, CB#7435, University of North Carolina, Chapel Hill, NC 27599 USA. Telephone: (919) 966-7416. Fax: (919) 966-2089. E-mail: steve_wing@unc.edu

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levels exceeded the instruments' measurement capacity (Macleod 1981). Although thermoluminescent dosimeters were placed off-site on 30 March, there were large angular gaps between the monitors (Beyea 1985). As a result, there was little information about early releases and poor capacity to detect narrow plumes with low dispersion. At the time the region was experiencing unusually balmy temperatures and low winds as an upper-level cold air mass kept lower-level warm air from rising—ideal conditions for trapping radioactive emissions (Steinacker and Vergeiner 2002). Xenon-133 from TMI was detected in Albany, New York (Wahlen et al. 1980).

The possibility that a hydrogen explosion in the reactor containment or a meltdown of the reactor core would result in high-level radiation exposures generated great fear and anxiety among officials and the public (Del Tredici 1980; Gray and Rosen 1982). Lack of knowledge about details of the plant's condition, lack of experience with this type of situation, and nonfunctional radiation monitors gave rise to conflicting reports about the severity of the accident and its threat to the public. The Nuclear Regulatory Commission (NRC) reported a reading of 3,000 millirads per hour taken above the plant on 29 March (NRC 1979b). About 5-6% of people within 5 miles of the plant left during the first 2 days of the accident. After Governor Thornburgh's 30 March order to evacuate pregnant women and children from the 5-mile area, nearly 50% of residents left (Houts and Goldhaber 1981).

On 1 April, the hydrogen gas bubble began to dissipate, and concerns of imminent danger diminished. Industry and government representatives assured the public that only small quantities of radiation had been released and that exposures were far below levels that could affect health. The NRC and a presidential commission released reports indicating that the maximum possible off-site radiation dose was

less than average annual background levels (NRC 1979a; President's Commission on the Accident at Three Mile Island 1979).

The official position that high-level radiation exposures were impossible was questioned by hundreds of local residents who reported metallic taste, erythema, nausea, vomiting, diarrhea, hair loss, deaths of pets and farm and wild animals, and damage to plants (Del Tredici 1980; Molholt 1985; Osborn 1996; Three Mile Island Alert 1999). Many of these phenomena could be caused by radiation; however, the maximum possible dose was officially reported to be orders of magnitude less than the dose needed to produce acute symptoms. Residents were told that their symptoms were due to stress. People who pressed their concerns about radiation were treated as though they had psychologic problems.

Epidemiology of the Accident

Health studies at TMI began to be planned soon after the immediate danger had ended. In June 1979, the Pennsylvania Department of Health, working with the Centers for Disease Control and the U.S. Census Bureau, conducted a special census of residents living within 5 miles of TMI (Goldhaber et al. 1983c). The University of Pittsburgh's Department of Radiation Health provided estimates of radiation doses for 5-mile area residents "for educational, public relations and defensive epidemiology purposes" (Gur et al. 1983). The demographics of evacuation (Goldhaber et al. 1983a), medical care use, and spontaneous abortion (Goldhaber et al. 1983b) were studied. Many studies of stress have been published, making the 1979 accident at TMI one of the best-studied cases of psychologic response to disaster and evacuation (Baum 1990; Baum et al. 1983, 1993; Cleary and Houts 1984; Cornely and Bromet 1986; Davidson et al. 1987; Dew and Bromet

1993; Dew et al. 1987a, 1987b; Fabrikant 1983; Gatchel et al. 1985; Houts et al. 1991; Houts and Goldhaber 1981; McKinnon et al. 1989; Prince-Embury and Rooney 1988; Schaeffer and Baum 1984).

Few studies took on the topic of radiation exposures. Ionizing radiation is considered to be one of the best-understood carcinogens, and scientists asserted that doses at TMI had been too low to produce any observable effects on cancer. Population dose estimates and quantitative cancer risk estimates based on studies of the survivors of the atomic bombing of Hiroshima and Nagasaki yielded a prediction of, at most, one accident-related cancer death in the lifetimes of the population in the 50-mile area (Hatch et al. 1990). Therefore, there was no scientific reason to study health effects of radiation.

Yet, concerns persisted that some areas near TMI had been exposed to high radiation levels during the accident. In 1984 Carl Johnson, former Director of Health in Jefferson County, Colorado, site of the Rocky Flats nuclear weapons plant, spoke at a public meeting at the Pennsylvania State University-Harrisburg campus in Middletown, Pennsylvania. He described reports of symptoms consistent with high-level radiation exposure that had been experienced during the accident in several hilltop neighborhoods near TMI (Johnson C. Unpublished data). Johnson's description piqued the interest of Marjorie Aamodt, an experimental psychologist by training, who, with her husband, Norman Aamodt, an engineer, had been participating in hearings regarding the restart of TMI Unit 1.

In the spring of 1984, Marjorie Aamodt initiated a household survey in three hilltop communities with a total population of about 450 people. All three neighborhoods had unobstructed views of TMI at distances of between 3 and 8 miles (Aamodt and Aamodt 1984). Two of the communities were areas

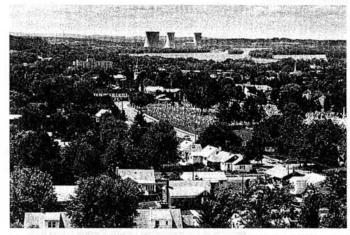


Figure 1. View of TMI from the roof of an apartment building in Middletown, Pennsylvania, 19 July 1979. Photograph copyright of Robert Del Tredici (Del Tredici 1980) and used with permission.

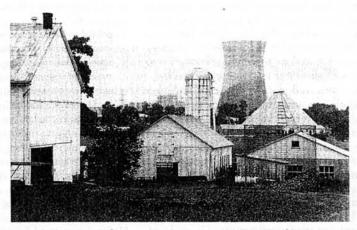


Figure 2. Farm in Londonderry Township near TMI, 4 July 1979. Photograph copyright Robert Del Tredici (Del Tredici 1980) and used with permission.

that Dr. Johnson had identified. Using a structured questionnaire designed with input from Dr. Johnson, Ms. Aamodt and several volunteers interviewed residents about symptoms and diseases experienced during and after the accident. They obtained descriptions of metallic taste, nausea, vomiting, hair loss, and erythema, almost all from people who had been out-of-doors, as well as information on the occurrences of cancers, cardiovascular diseases, reproductive problems, dermatologic conditions, and ruptured/collapsed organs. Residents reported 19 cancer deaths during 1980-1984, compared with an expected number of 2.6. In June 1984, the Aamodts submitted a report to the NRC proceeding on the competency of the utility to conduct surveillance of radiation releases (Aamodt and Aamodt 1984).

The Aamodt survey soon came to the attention of the TMI Public Health Fund. The Fund, financed by the nuclear industry and administered by the Federal District Court in Harrisburg, had been created in 1981 as part of a settlement for economic losses from the accident. Scientific advisors to the Fund verified several aspects of the Aamodt study, including the ascertainment of cancer deaths and calculation of expected deaths, and recommended a more comprehensive study of cancer in the TMI area. The Fund chose a team led by Mervin Susser, a highly renowned epidemiologist from Columbia University, New York, New York, to design and conduct the cancer study. The Columbia investigators proposed an innovative design that avoided several common problems that can lead to ambiguous results in environmental epidemiology (Hatch et al. 1990).

Because concerns about cancer among both patients and physicians could have resulted in earlier detection of cancer and cause higher incidence rates as an artifact of publicity, the Columbia group did not compare TMI area residents to an unexposed control group from another area. Rather, they divided the 10-mile area into small study blocks, each of which was assigned an accident dose based on a state-of-the-art dispersion model that considered release estimates, meteorologic, and topographic data (Beyea and Hatch 1999). Dose estimates for the 69 study blocks varied by more than three orders of magnitude. This permitted a comparison of cancer rates along a continuum from low to high exposure areas, all of which had a similar potential for early detection of cancer. Although the accident occurred in 1979, incident cancer cases were identified for the period 1975-1985, making it possible to evaluate the variation in cancer rates that existed in the area both before and after the accident. This design feature was important because cancer rates show significant geographic variability, and it would have been a mistake to attribute high cancer rates in a more exposed area to accident emissions if rates there were already higher prior to the accident. Population counts according to age and gender for each year from 1975 to 1985 were derived from census data. The Columbia design permitted an evaluation of the relationship between estimated accident dose and cancer incidence for the population within 10 miles of TMI, with adjustment (control) for preaccident variation in cancer incidence. Estimation of doseresponse relationships with adjustment for differences in risk between the exposure groups prior to exposure is rarely possible in environmental epidemiology.

Two publications by Columbia investigators describe cancer incidence in relation to the TMI accident (Hatch et al. 1990, 1991). Hatch et al. (1990) reported positive associations between accident doses and non-Hodgkin's lymphoma, lung cancer, and all cancers combined. Leukemia, analyzed separately for children and adults, was also positively associated with accident dose. However, these estimates lacked statistical precision because of small numbers (54 cases at all ages combined). The authors reasoned that results did not "provide convincing evidence" that TMI radiation releases had influenced cancer in the area. Among the considerations weighing against a causal interpretation were

the lack of effects on the cancers believed to be most radiosensitive and the indeterminate effects on children . . . the low estimates of radiation exposure and the brief interval since exposure occurred.

They continued,

Pending a demonstration that very low dose gamma radiation can act as a tumor promoter or the identification of another late-stage carcinogen in the effluent stream, an effect of plant emissions in producing the unusual patterns of lung cancer and non-Hodgkin's lymphoma appears unlikely, and alternative explanations need to be considered.

One alternative explanation was considered in a second report (Hatch et al. 1991). Using distance from TMI as the measure of psychologic stress, Hatch et al. considered the hypothesis that increased cancer rates after the accident were caused by stress. Findings were equivocal because of the speculative nature of the mechanism of cancer promotion by stress-induced neuroendocrine dysfunction as well as lack of a specific measure of stress.

Reanalysis of the Cancer Incidence Study

By the time the Columbia studies were published, a lawsuit alleging health damages from radiation released in the TMI accident had been under way for several years. Approximately 2,000 plaintiffs argued that emissions of radioactive gases during the

accident were much larger than had been stated by industry and government officials; meteorologic conditions and hilly terrain had caused the radioactive gases to disperse in narrow plumes; and these intense plumes had exposed small areas of the surrounding countryside to high radiation doses, resulting in health impacts including cancer (Merwin et al. 2001). Marjorie and Norman Aamodt were consulting for plaintiffs' attorneys and asked to meet with me to discuss the litigation. They provided documents including their health survey, sworn affidavits from TMI neighbors, analyses of local mortality records, scientific articles, government reports, and letters and memoranda from scientists and government officials suggesting that radiation releases and doses from the accident had been substantial. They asked me to provide epidemiologic support for the plaintiffs in the suit.

lawsuit. Although I had not thoroughly studied the TMI accident, I knew that allegations of high radiation doses at TMI were considered by mainstream radiation scientists to be a product of radiation phobia or efforts to extort money from a blameless industry. Years of collaboration with epidemiologists and health physicists aligned with the U.S. Department of Energy (DOE) Health and Mortality Study had familiarized me with a culture in which concerned workers and community members, as well as scientists who claimed there was evi-

I was wary of becoming involved in the

dence of health effects of low-level radiation, were viewed as threats to the nuclear industry (Morgan 1992). Taking the plaintiffs' allegations seriously enough to become involved in any professional capacity might expose me to ostracism and loss of scientific credibility.

However, I was impressed with the intelligence and humanity of the Aamodts and with their thoughtful compilation of evidence. As in all research of this type, important measurements of interest had not been made, case reports, statistical observations, and related records were not entirely consistent, and mechanisms for some putative effects were uncertain. Nevertheless, their scenario of higher-than-reported doses did not seem implausible. My reaction to the Aamodts' work was not only a function of evidence suggestive of high releases; it was also a function of a willingness to consider the possibility that official conclusions might be in need of revision.

My personal experience, as well as study of the history and current practices of radiation epidemiology, had led me to adopt a skeptical attitude toward official assumptions and logic. On a small scale, our collaborative team engaged in the DOE Health and Mortality Studies had been assured repeatedly by industry and federal officials that no records existed that could account for a gap

we had found in annual radiation dose records. However, shortly after publication of our report that the existing workers' badge readings were related to their cancer mortality (Wing et al. 1991), over 14,000 radiation records that we had been seeking for more than 2 years were provided to us (Wing et al. 1994). On a larger scale, major radioactive releases from nuclear weapons sites had been concealed from the public for decades (Thomas 2001); government-funded scientists had conducted human radiation experimentation without informed consent (Advisory Committee on Human Radiation Experiments 1995; McCally et al. 1994); risks to workers and the public had been withheld because of concerns about litigation and loss of public support for the nuclear industry (Advisory Committee on Human Radiation Experiments 1995; Makhijani et al. 1995; Office of Technology Assessment 1991; Sterling 1980); and epidemiologists who deviated from status quo views about radiation and health had lost funding and suffered professionally (Greenberg 1991; Lyon 1999; Morgan 1992; Stewart and Kneale 1991; Thomas 2001; Wilkinson 1999). At the scale of the scientific culture itself, there had long been a lack of nuanced scientific logic in the deference given by radiation epidemiologists to quantitative estimates of radiation risks based on the world's most studied radiationexposed population, the Japanese A-bomb survivors (Stewart 2000; Wing et al. 1999).

Given these facts, it seemed possible that the full story about radiation releases, doses, and health effects from the TMI accident had yet to emerge. Although I had never previously participated in litigation, I was aware that some of my colleagues had provided testimony for the defendants in radiation cases. Knowing that the defendants in the TMI case had many experienced experts at their disposal and that it was difficult for plaintiffs to find help, I agreed to examine epidemiologic data related to the case.

One of the first tasks I undertook was a review of published studies on "mass hysteria," a medical term for outbreaks of psychogenic illness with no physical etiology (Brodsky 1988; Donnell et al. 1989; Faust and Brilliant 1981; Hefez 1985; Simon et al. 1990; Small and Borus 1987). There is no doubt that the TMI accident had created high stress, even panic nor is there any doubt that stress can produce physical symptoms. Although some symptoms reported by TMI area residentsnausea and vomiting, for instance-are commonly reported in the literature on outbreaks of psychogenic symptoms, other symptoms, most notably metallic taste and hair loss, are not. Furthermore, one hallmark of mass psychogenic illness is that it occurs in public places where people witness the symptoms of

others. At TMI most symptoms were reported by people who had not been in public, some of whom said they had not even heard about the accident at the time of their symptoms. Thus, although it seemed plausible that some psychosomatic illness would have occurred at TMI, most reports did not fit the classic scenario of mass psychogenic illness. Nonhuman occurrences were obviously not psychogenic, although reports could have resulted from increased vigilance or altered perception due to the accident. I did not attempt to validate independently cases of unusual mortalities or abnormalities in animals and plants, and lack of ongoing systematic surveillance precluded comparisons with baseline (preaccident) rates; however, the detail and quality of observation left me unable to dismiss these reports.

The Aamodts were interested in further examination of cancer incidence data assembled by Columbia. The Columbia investigators had not acknowledged the possibility that community members' symptoms might have been a sign of significant amounts of radiation. They assumed from the beginning that accident doses were below average background levels, and they did not analyze data for the hilltop communities in the 1984 health survey. The plaintiffs' legal team asked me to reanalyze the Columbia cancer incidence data to check whether study block boundaries had been constructed in a way that might have obscured clusters and to evaluate whether excess cancers may have occurred in areas where there had been reports of acute symptoms and other unusual phenomena.

Although skepticism about the Columbia study was understandable, the study was, in principle, well designed, and I knew that the investigators were highly respected. However, recognizing that there were several potentially interesting omissions from the published results, I agreed to conduct reanalyses if the data could be released through the court. The court decided not to disclose the locations of residence of cancer cases on the grounds that this would violate patient confidentiality; however, the court did direct that we be given, for each study block, a) dose estimates, b) numbers of cases of specific types of cancer, c) population counts, and d) average levels of education, income, and population density. Estimates of doses from gamma radiation for each study block were given in relative units that ranged from 0 to 1,666. The values were not assigned a unit of measurement (e.g., Sv or rem) but were calculated on a ratio scale such that a value of 10 was twice that of 5, and a value of 1,000 was twice that of 500 (Hatch et al. 1990).

We considered different primary hypotheses and used a primary analytical method different from the one used by the original investigators (Wing et al. 1997c). Because ionizing radiation

is a mutagen related to most if not all malignancies, and because higher doses of radiation can lead to immune suppression and promotion of initiated cancers, we considered all cancer as one primary outcome. We examined lung cancer because beta-emitting radioactive gases in the accident plumes could have produced higher doses to the lung than to other organs. We considered leukemia, including chronic lymphocytic leukemia (which had been omitted in the Columbia reports) because studies of high-dose radiation have shown that leukemia is more radiation sensitive and appears sooner after exposures than solid tumors. Although leukemia was a primary outcome of the Columbia study, incidence among children and adults had been analyzed separately, reducing an already small sample size. More important, the childhood cancer analyses considered children conceived after the accident as exposed, potentially diluting any differences in cancer incidence between exposed and unexposed children. Finally, we used baseline (preaccident) cancer rates rather than socioeconomic status variables (education, income, and population density) as the primary method to control for potentially confounding differences in other cancer risk factors between more- and less-exposed populations within the 10-mile area (Wing et al. 1997c).

Our analyses corrected for two problems that had affected the Columbia results. One of their published analyses included duplicate case counts that we were able to eliminate from the reanalysis. In addition, the original preaccident period was defined as 1975–1979. However, case ascertainment for 1975 was incomplete. This led to an underestimation of cancer incidence in the preaccident period and an overestimate of the increase in cancer following the accident. To correct this problem, we redefined the preaccident period as 1976–1979 (Wing et al. 1997b, 1997c).

We found positive relationships between accident dose estimates and cancer rates for all three categories of cancer. The slope of the dose-response estimates was largest for leukemia, intermediate for lung cancer, and smallest for all cancers. Estimates were larger for cancers that occurred in 1984-1985 (a 5-year lag) than for cancers that occurred in 1981-1985 (a 2-year lag), and they were larger when statistical adjustments were made for differences in socioeconomic status between areas of low and high dose. Lung cancer showed the most consistent dose-response relationship across levels of dose. Figure 3 shows dose estimates in relation to lung cancer rates, based on the 440 cases diagnosed in the 10-mile area during 1981-1985, adjusted for preaccident variation in lung cancer incidence, but not for socioeconomic status. The height of the bars represents the difference between the observed numbers of cases at each dose

level and the number that would have occurred if each area had experienced the average lung cancer rates of the 10-mile area population as a whole.

Epidemiologic Evidence in Court

Scientific rigor and objectivity have a special value in courts of law, which specify rules for deciding what constitutes scientific evidence and whether scientific evidence is reliable and therefore admissible at trial. Since 1993, the standards for admissibility of scientific evidence in federal courts have been based on the U.S. Supreme Court's ruling in Daubert v. Merrell Dow Pharmaceuticals, Inc. (1993). Judges decide whether expert testimony can be considered in litigation based on criteria expounded in Daubert, other cases, and in the Federal Rules of Evidence:

- 1) there is a testable hypothesis
- 2) the methodology has been subjected to peer review
- the results have an acceptable "known or potential rate of error"
- standards are used to control the reliability of the methodology
- there is adequate support and acceptance of the methodology by a scientific community
- the testimony relies on facts or data used by other experts in the discipline
- the expert's professional qualifications are adequate
- 8) the methods have the potential to be used for purposes outside the courtroom (Merwin et al. 2001)

Exclusion of evidence that does not meet these standards is intended to protect juries from being exposed to untrustworthy scientific testimony.

Our reanalysis of the TMI cancer incidence data was submitted to the District Court for the Middle District of Pennsylvania in support of the plaintiff's allegations. My testimony about relationships between estimated doses and cancer incidence in the 10-mile area was being used as evidence that significant exposure had occurred, not as evidence that a particular plaintiff's cancer was caused by radiation. The defendants argued that our study was unreliable and that the judge should exclude it from trial on grounds that it did not satisfy the Daubert criteria.

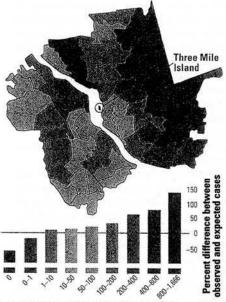
The court considered the admissibility of our reanalysis based on our report describing the study's hypotheses, design, materials, analytical methods, results, and conclusions; transcripts of depositions conducted by defense attorneys; the defendants' motions in limine (to suppress); plaintiffs' responses to defendants; reports on our study prepared by defendants' experts; my affidavits responding to questions from the judge; and testimony by the defense experts and me at an in limine

hearing. The court's evaluations of each of the criteria are summarized in Table 1. Defendants did not challenge the first Daubert criterion, and the judge found that "the cancer incidence study methodology consists of a testable hypothesis" (TMI Litigation Cases Consolidated II 1996a).

Under the second criterion the court considered whether the methodology used to produce the results had been peer reviewed. The Columbia team's papers, and therefore the basic study design and data collection, had been peer reviewed and was recognized by the court. Part of our study was a replication of the original analyses showing that we could apply the same statistical methods to produce the same results. In other analyses we applied the same statistical method to corrected data using different controlling (or adjustment) factors corresponding to the before-after design of the study. Despite these facts, the judge, noting that "Aside from Wing's 'unadorned assertions' that the methodologies have been subject to peer review, Plaintiffs have presented no evidence of this fact," ruled, "This factor will weigh against the admission of the proffered testimony" (TMI Litigation Cases Consolidated II 1996a).

The court made two rulings on the issue of the third criterion, the known or potential rate of error (TMI Litigation Cases Consolidated II 1996a, 1996b). Because of a lack of understanding of how to interpret the standard errors of the dose-response regression coefficients provided in our report, the court initially deferred its decision on the "rate of error." However, the first ruling cited defendants' argument that the findings could have been "ascribable to chance as well as to any real association with accident emissions" on the basis of 95% confidence limits around our estimates of dose response for all cancer (in the models that omitted socioeconomic status) and leukemia (in models with and without socioeconomic status) (Wing et al. 1997c), which, defendants noted, included the null value of no effect (TMI Litigation Cases Consolidated II 1996b). The court then cited defendants' experts as claiming that lung cancer "has never been identified with radiation exposure as an isolated effect," implying that lung cancer was the only type of cancer that showed a dose effect, and also cited their claim that there was not sufficient latency for lung cancer to appear after the accident. In its second ruling on the rate of error, the court accepted the defendants' claims that minimum latency for lung cancer was known to be 10 years (TMI Litigation Cases Consolidated II 1996b). Below I discuss this juxtaposition of argument about statistical testing and the state of knowledge about cancer latency and radiosensitivity. However, in its second ruling, the court did not exclude evidence from our study on rate of error grounds.

The court next considered whether there were standards controlling the operation of our technique. Although seemingly impressed with our quality control procedures, which led us to identify biases associated with double-counting of cancer cases and an undercount in 1975, the court found fault with what the defendants cited as our failure to conduct analyses of incidence of "the types of cancers known to be radiogenic" and of cancer deaths. Our failure to conduct these analyses balanced against the quality control procedures in the court's evaluation of our standards of control. The court ruled, "This factor will not weigh against the admission of the proffered testimony" (TMI Litigation Cases Consolidated II 1996a).



Radiation doses resulting from the 1979 nuclear accident (relative units of radiation)

Figure 3. Radiation emissions and incidence of lung cancer, 1981–1985, in the TMI 10-mile area. Figure adapted from Dalrymple (1997).

Table 1. Consideration of admissibility of evidence from the reanalyses of cancer incidence in the TMI 10-mile area, District Court for the Middle District of Pennsylvania.

Criterion for admission		Weight in consideration of admission
	Testable hypothesis	For
2. 1	Peer-reviewed methodology	Against
	Known or potential rate of error	Neither for nor against
4.	Standards are used to control reliability	Neither for nor against
5. 3	Support and acceptance of methodology	Neither for nor against
6. 1	Relies on facts or data used by other experts	Against
7. 1	Professional qualifications	For
	Potential for use outside	
	the courtroom	For

On the fifth criterion, the court found that the principle of reanalysis was generally accepted, and it attributed to defendants the claim that "the statistical technique employed by Wing is generally accepted in the scientific community" (TMI Litigation Cases Consolidated II 1996a). The latter point is ironic given the court's decision that lack of peer review of the methodology weighed against admissibility. However, the court agreed with defendants that the methodology was problematic "because it produces conclusions at odds with what is generally known and accepted about cancer latency periods" (TMI Litigation Cases Consolidated II 1996a). This factor, like the standards of control, did not weigh against admission of the testimony.

Regarding our reliance on facts or data used by other experts, the court found, "In many ways Wing's cancer incidence study closely resembles a standard and reliable epidemiologic reanalysis. Yet in one important way it does not. Wing's reanalysis produces no conclusive findings" (TMI Litigation Cases Consolidated II 1996a). This lack of conclusiveness, according to the court, weighed against admission of our study. The court found that criteria seven and eight, professional qualifications and nonjudicial uses, weighed in favor of admissibility.

Deferring only the final decision on rate of error, which eventually was decided in favor of admissibility, the court weighed all the Daubert criteria to decide on admissibility of the reanalysis (TMI Litigation Cases Consolidated II 1996a). The ruling found our results on all cancer and leukemia to be admissible at trial. The lung cancer findings, including the regression analysis summarizing the dose response shown in Figure 3, were excluded based on defendants' arguments that radiation-induced lung cancer has a minimum latency of 10 years, and that the analyses were therefore irrelevant to the case.

Discussion

The TMI cancer incidence studies were conducted in the context of conflict between residents who believed they had been injured and officials who denied that such injuries were possible, as well as conflicts between scientists over the magnitude of radiation releases, the state of knowledge about radiation-induced cancer, and the meaning of evidence produced by the TMI cancer incidence studies. In the next section, I intend to show how the objectivity, rigor, and ethics of science can be increased by analyzing the influence of these conflicts on research assumptions, methods, and conclusions. I begin with a discussion of the court's reasoning on the admissibility of the reanalysis, focusing on Daubert criteria 1-3 and 5.

Testable hypotheses: collision of evidence and assumptions. The court found that our methodology did involve a testable hypothesis. Ironically, we argued that although the Columbia investigators designed a study with a testable hypothesis, they were unable to test it because of their assumptions. A testable hypothesis requires that evidence of the effect be interpretable as supporting the hypothesis. Support should be strengthened to the extent that the design and conduct of the study help rule out alternative explanations for the findings. However, the Columbia investigators clearly stated that the accident doses were known to be too low to produce the effects being hypothesized; the increased risk of cancer at the assumed maximum dose to a member of the public would have been less than one-half of 1% according to standard assumptions, clearly an excess too small to be detectable by epidemiologic methods (Wing et al. 1997c). We argued that a follow-up study of cancer mortality among adults in the TMI 5-mile area (Talbott et al. 2000, 2003) suffered from the same logical flaw: assumptions of low doses clearly precluded an interpretation of the positive dose-response relationships as supportive of the hypothesis under investigation (Wing and Richardson 2001).

If the testability of a hypothesis depends on assumptions as well as methodology, then an evaluation of the quality of a study must address the logic of key assumptions as well as the methodology. The assumption that the cancer risk of the maximally exposed person would increase by only 0.5% was supported by official reports. We addressed a testable hypothesis only because we considered the possibility that these reports could be wrong. Without that possibility, there would be no testable hypothesis. Our association with plaintiffs in the litigation introduced us to critical reevaluations of radiation monitoring, detailed case reports of symptoms (Aamodt and Aamodt 1984; Molholt 1985), biodosimetric studies of persons who reported symptoms at the time of the accident (Shevchenko 1996; Shevchenko and Snigiryova 1996), and meteorologic and environmental analyses (Field et al. 1981; Steinacker and Vergeiner 2002; Wahlen et al. 1980), as well as the court order that directed calculation of radiation doses for the Columbia study. The order prohibited "upper limit or worst case estimates of releases of radioactivity or population doses . . . [unless] such estimates would lead to a mathematical projection of less than 0.01 health effects," and further specified that "a technical analyst . . . designated by counsel for the Pools [nuclear industry insurers] concur on the nature and scope of the [dosimetry] projects" (Three Mile Island Litigation 1986). These court-imposed restrictions, which conditioned the input of the investigation (release estimates) on projections of its outcome (health effects), constitute a manipulation of research that was possible, in part, because of years of investigative complacency brought on by entrenched assumptions that precluded even consideration of the possibility of high releases. The requirement of prior concurrence by lawyers for the industry suggests that the industry's image and liability were more important than accuracy and full disclosure.

Peer review: normal science. Under Daubert, the court considers peer review of the methodology to be a factor in the admissibility of evidence. The court's decision that lack of peer review weighed against admissibility of our study was curious and internally contradictory for reasons noted above. In principle, peer review is one of several Daubert criteria that gives preference to normative scientific views under the debatable assumption that widely held beliefs are more reliable. Although peer review may catch obvious flaws or poor writing, it cannot ensure that findings are correct, or even that research is not fraudulent (Broad and Wade 1982). In areas where scientific research, professional meetings, fellowships, and journals are funded through organizations with interests in an established perspective, peer review by orthodox scientists may lead to rejection of studies whose results challenge established assumptions, even if their methodology is appropriate (Nussbaum 1998; Nussbaum and Köhnlein 1994).

Known or potential rate of error. This criterion of admissibility is intended to recognize that scientific studies make measurements to quantify phenomena, and that the accuracy of these measurements is an important criterion. For example, upon repeated measurements of identical samples, variability in a scale, assay, or other measurement device produces a distribution of results similar to the patterns of card combinations produced by well-shuffled decks. In the case of epidemiologic studies of exposure-disease relationships, the courts have taken statistical parameters such as standard errors, confidence limits, test statistics, and p-values to be indicators of this rate of error.

Our report provided information on sample size, goodness of fit, and standard errors of regression coefficients rather than p-values or 95% confidence intervals. Although confidence limits and p-values can be easily calculated from standard errors and likelihood ratio tests, they are commonly misinterpreted as reflecting a process of randomization in which there is an a priori probability distribution of results from repeated unbiased, well-controlled experiments distributed around the true parameter (Greenland 1990). In the absence of randomization or random sampling in the TMI cancer incidence study

of a total population, I argued that statistical evidence should be evaluated

in the context of the sensitivity of the findings to changes in assumptions and data, coherence of the evidence with other knowledge, the magnitude of associations, their consistency across groups, and temporal relationships of exposure and effect. (Wing 1995)

Although the court recognized literature recommending that the admissibility of evidence should not be determined solely on the basis of a significant p-value or a confidence interval excluding the null value of no statistical association, defendants specifically made that argument, and the court was uncertain about how to judge my less mathematical approach. The problem, according the judge, was that, "To the extent that the results are more likely the product of random error than a true causal relationship, the probative value of the study necessarily diminishes" (TMI Litigation Cases Consolidated II 1996a). I argued that random error was not the issue because randomization had not been employed.

The court's interpretation reflects confusion between the use of chance as a tool and the idea of chance as a force of nature. Chance as a tool is familiar in card games, random sampling, and random allocation, and can be created only by complete control over the materials being manipulated: cards, sampled units, or patients assigned to treatment. Under these conditions, probabilities of particular occurrences are defined because the materials can be ordered or mixed through a process (shuffling, randomization) that has been constructed to eliminate systematic influence on the order or assignment. Following the use of chance as a tool, longrun probabilities are determined if there is no bias in the conduct of the game or research.

Statistical testing in observational settings, including most epidemiology, occurs in studies of aspects of the real world, such as dose-response relationships, in which there have been no randomization and no random sampling. Under these conditions there is no a priori probability distribution because chance has not been used as a tool. Therefore, chance introduced through randomization is not a possible explanation of a result. What, then, do researchers (or courts) mean when they conclude from statistical tests that results are likely due to chance? They should not mean that some unknown factor is the cause, because other causes that create (or mask) the appearance of an association between exposures and outcomes are referred to as confounders (whether or not they have been measured). Rather, the concept of chance in observational research has been confused with its original interpretation in randomized studies: it is treated as a force of nature that functions as an alternative explanation to specific causes.

In its second ruling on the rate of error issue, the court quoted from the affidavit I prepared on this issue in which I attempted to explain why the strict application of statistical tests being advocated by defendants was increasingly recognized as inappropriate:

Abuse of significance testing in epidemiological research is now widely appreciated and discussed. The problem is clearly recognized by one of the defense's experts, K. Rothman, who wrote in an editorial introducing a paper on logical problems with statistical significance testing, "In a century in which science has revealed that molecules and atoms are mostly unoccupied space and that matter is energy anyway, we should be accustomed to having the substance of our scientific foundations dissolve into emptiness. In this issue [of the journal], Greenland perforates the foundations of statistical interpretations used by epidemiologists in just this way" (Rothman 1990). The problems with significance testing noted in the paper by Greenland (Greenland 1990) have been recognized for some time, but have been ignored in the interests of preserving a simple if fallacious method that was believed to result in the separation of conclusive, causal associations from those that are inconclusive or spurious. That method is the determination of the statistical significance of a finding. As noted by Rothman, "conventional statistics [p-values and confidence limits] have a strict interpretability in experiments with random assignment of exposures. The results of those experiments are nearly always dressed in the same statistical garb that was developed for and is applied to experimental studies. Greenland shows us that, despite our reliance on conventional statistics for interpreting our nonexperimental results, there is no basis for the interpretations usually given to these statistics in nonexperimental settings." [emphasis added]. This is because, in the absence of randomization of exposure in a fair experiment, it is not possible to distinguish the extent to which test statistics reflect bias or the exposure under investigation. (TMI Litigation Cases Consolidated II 1996b)

That a normative scientific practice used to distinguish causal from noncausal relationships-central not only to science but to its social and legal applications-could "dissolve into emptiness" should be disconcerting to those who count on science for objective and rational knowledge. Critical analysis of normal scientific practice can help to identify such emptiness before serious mistakes are made. In the TMI reanalysis we chose a contextual set of criteria to evaluate quantitative evidence because we did not believe that results could be a product of random error unless randomization had been introduced by design. If our primary quest had been small p-values, we would have used one-tailed tests (because our hypothesis was one-directional), emphasized results adjusted for socioeconomic status, and analyzed log-transformed doses, which, as noted by Mangano (Mangano 1997), would have better fit the data and produced smaller

Invocation of chance as a force of nature—a cause incapable of being further

analyzed—can discourage scientists from humility about the scientific enterprise as well as deeper mechanistic analysis (Gigerenzer et al. 1989). In the case of environmental health research, this may discourage the testing of hypotheses or use of methods with the greatest potential to implicate institutions that permit or produce pollution. An understanding of how chance as a tool has been conflated with chance as an explanatory force of nature could help to improve the practice and applications of science. However, even without a detailed understanding of that process, it is clear that current practice, although normative science, is inconsistent and illogical. Chance may have created an empire in the world of science (Hacking 1990), but its emperor has no clothes.

Basis of assumptions about radiogenic cancers and cancer latency. The court's ruling that our lung cancer findings were inadmissible at trial was based on defendants' claims that a) only lung cancer was statistically significantly related to accident dose estimates, b) lung cancer has never been found as the sole effect of radiation, and c) radiogenic lung cancer is known to have a minimum latency of 10 years. These arguments, repeated in the court's rulings under several Daubert criteria, especially the fifth, imply that dose-response relationships for leukemia and all cancer resulted from random error, and that the results for lung cancer must be due to some other error because they could not occur as a result of the hypothesized cause. Although the leukemia dose-response coefficients, based on 75 cases, were less precise than the lung cancer estimates, they were roughly 40% larger in magnitude, which would be consistent with studies showing steeper relationships for leukemia than for solid tumors after highdose radiation. Dose-response coefficients for all cancers were more precise but smaller in magnitude, which would be consistent with lower doses to organs other than the lung (Wing et al. 1997a, 1997c).

Our interest in lung cancer was based on the presence of radioactive gases, primarily xenon-133 and krypton-85, in the accident plumes. In addition to penetrating gamma radiation, these gases emit beta radiation, which has low penetration and therefore would have delivered direct doses selectively to exposed skin and respiratory tissues, which would be consistent with reports of erythema and putative impacts on plants as well as elevations in lung cancer. However, even if lung doses were substantial, no cancer effect would be seen in the incidence study if radiogenic lung cancer has a minimum latency of 10 years.

There have been no epidemiologic studies of the exposure of human populations to radioactive xenon and krypton gases.

Consequently, assumptions about the types and timing of cancers that could result must be based on inference from studies of other types of ionizing radiation. Defendants argued that the study of Japanese A-bomb survivors, upon which official estimates of radiation risks and latency have been based, proved that lung cancer has a 10-year minimum latency. In response, we noted that ionizing radiation can act as a promoter as well as an initiator of cancer (Doll 1978); that high doses can suppress immune function, which is associated with the appearance of secondary tumors within 2 years of radiotherapy (Appelbaum 1993); and that latencies of less than 5 years have been observed for miners exposed to radon (Hornung and Meinhardt 1987). A recent study of lung cancer among uranium miners found the best estimate of minimum latency to be less than 1 year (Langholz et al. 1999).

Epidemiologists often remain skeptical of estimates of dose-response relationships because of questions about possible confounding and measurement error. In the area of radiation health effects, however, the A-bomb survivor studies are widely used for risk estimation and have long functioned as a 'gold standard" for judging other epidemiologic evidence (BEIR V 1990). The A-bomb studies have this status despite being based on a select group of survivors that had to resist radiation, blast, and the aftermath of war to enter the study, and whose radiation doses were not measured but calculated based on a) estimates of radiation releases that have been repeatedly revised, and b) interviews whose accuracy depended on the survivors' memories and their trust of researchers connected with the U.S. military occupation forces (Lindee 1994; Stewart 2000; Wing et al. 1999). The status of the A-bomb studies as a gold standard has shaped the normative scientific culture, including peer review, research funding, and dismissal of conflicting evidence from other populations (Nussbaum and Köhnlein 1994; Wing et al. 1999). Critical analysis of the evolution of radiation epidemiology within the context of the military, medical, and industrial uses of ionizing radiation can help scientists reevaluate the A-bomb studies more objectively. Such an approach would help to increase the explanatory capacity of radiation health science and improve its applications in the courts, compensation programs, and public education (Wing and Richardson 2002).

Radiation versus stress as causal explanations. From their inception, epidemiologic studies of the TMI accident focused on stress. Although this was not specifically an issue in the court, it is central to the epidemiology and public relations of the accident. Citizens were told that symptoms similar to

those which are caused by radiation exposure were due to stress. Studies were designed to quantify health effects of stress in general, and specifically as an alternative explanation to radiation-induced cancer increases following the accident. An editorial commenting on the paper by Hatch et al. (1991) on stress and cancer suggested that the stress-cancer link might be used as grounds for not disclosing accidents to the public because the resulting stress would injure people (Janerich 1991). When radiation exposures were studied, discussion of findings focused on reasons why radiation effects may have been overestimated or spurious, ignoring plausible reasons why they may well have been underestimated (Hatch et al. 1990; Talbott et al. 2000; Wing and Richardson 2001). The Columbia investigators chose not to discuss dose misclassification and migration, for example, as reasons to expect underestimation of radiation effects (Hatch et al. 1990). In fact, they planned to consider the possibility of confounding bias in estimates of dose response only in the event that they found a positive radiation-cancer relationship (Susser 1997), despite the fact that such bias could also mask a true effect. The lack of attention to these standard interpretive issues can be understood in terms of the key role that assumptions play in evaluating the meaning of results (Wing et al. 1997b).

Despite differences in results between the Columbia studies and ours, both found evidence of impacts of the accident on cancer incidence. However, the evidence led us to different conclusions regarding both cause and biological mechanism. The Columbia group concluded that the evidence suggested stress as a cause, and stress-induced immune system depression as a mechanism. We concluded that the evidence suggested radiation as a cause, and promotion of cancer through late-stage "hits" in a multistage process of carcinogenesis, as well as radiation-induced immune system depression, as mechanisms. Keller described an analogous situation in which experimental observations on genetic mutations were redescribed and reinterpreted to produce different conclusions about causes and mechanisms (Keller 1992).

Conclusion: The Ethics of Strong Objectivity

Conflicts over responsibility for damage to health and the environment are increasingly common. They often involve disputes between actors, such as industries and governments, with the ability to make large impacts as well as sponsor research on those impacts, and communities that are most directly affected but that have little political power or capacity to conduct research to document their exposures or health conditions (Wing 2002). Affected communities may experience

these situations as examples of environmental injustice. Many rural people living near TMI had modest levels of formal schooling and little experience in being assertive with government and industry officials. Those that spoke out about their experiences of physical problems from the accident endured ridicule. The Aamodts were able to influence the TMI Public Health Fund's sponsored research on physical impacts of the accident by initiating their own survey, researching government records, and petitioning the NRC. Other residents who lived within the 10-mile area also conducted surveys, constructed disease maps, and documented damage to plants and animals (Osborn 1996; Three Mile Island Alert 1999). However, when health studies were undertaken through official channels, citizens who believed they had been affected by accident emissions and their supporters were not included in the framing of questions, study design, analysis, interpretation, or communication of results. The studies themselves were funded by the nuclear industry and conducted under court-ordered constraints, and a priori assumptions precluded interpretation of observations as support for the hypothesis under investigation.

The naïve approach to objectivity, represented in the Daubert criteria, contends that scientists can produce unbiased evidence by standing apart from legal conflicts and adhering to normative science. The problem with this position is that scientific questions and the details of specific working hypotheses emerge from conflicts, which also influence the assumptions that frame methodologies used to produce evidence and interpretations of the meaning of evidence. This process occurs at various scales, from decisions about how much to trust conflicting assertions regarding a specific event like the TMI accident, to the role of the A-bomb studies as a gold standard for evaluating evidence, to widespread conventions such as the confusion between chance as a tool and chance as a force of nature. Although science has strong rationalist traditions, it has also been shaped by perspectives of dominant gender, race, and class groups, excluding perspectives of groups with less power (Harding 1991; Holtzman 1981; Hubbard 1990; Levins 1979; Levins and Lewontin 1985). Pretending that there are no assumptions embedded in scientific methodology conceals and reinforces existing inequalities.

Strong objectivity demands that scientists critically evaluate how the knowledge they create is shaped at every point by historical social forces. Strong objectivity is therefore not a static feature of scientific knowledge that, once attained, becomes a property of that knowledge. It is an evolving process that is never finished, like scientific inquiry itself. Scientists should be trained to engage in careful reflection

about how the history of their discipline has affected their hypotheses, assumptions, and tools, and how their work, like the work of others before them, is shaped by contemporary forces (Armstrong 1999). This is essential as careful measurement and analysis for producing an objective science that will be maximally rigorous, rational, reliable in courts of law, and useful for improving the world. Strong objectivity is needed, not only for good science, but for ethical conduct of research.

Postscript

In December 1999, after summary dismissal of the TMI case by the District Court for the Middle District of Pennsylvania, the U.S. Third Circuit Court of Appeals found that the district court had erred in excluding our lung cancer findings (although the appeals court also ruled that the lung cancer findings would not change the outcome of the case). In December 2002, the circuit court declined to hear an appeal of Judge Rambo's second ruling granting summary dismissal. Attorneys representing 1,990 remaining plaintiffs in the TMI case declared they would take no further legal action (Associated Press 2002).

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Defueling TMI-2: A Litany of Problems

Three Mile Island Unit-2 was built at a cost to rate payers of \$700 million and had been on-line for just 90 days, or 1/120 of its expected operating life, when the March 1979 accident occurred. One billion dollars was spent to defuel the facility. Three months of nuclear power production at TMI-2 has cost close to \$2 billion dollars in construction and cleanup bills; or the equivalent of over \$10.6 million for every day TMI-2 produced electricity. The above mentioned costs do not include nuclear decontamination and decommissioning or restoring the site to "Greenfield" status.

At the time of the accident, TMI's owners had no monies put aside for decommissioning. General Public Utilities' (GPU) customers contributed three times as much for the defueling effort than the corporation that caused the disaster, \$246 to \$82 million. In January 1993 the Pa. Public Utility Commission (PUC) refused GPU's request to hand their customers the TMI-2 decommissioning bill estimated to be at least \$200 million. However, several months later, the PUC reversed itself and gave GPU permission to pass the cost of decontamination and decommissioning TMI-2 onto the rate payer. This decision to financially assess GPU rate payers for the accident was upheld by the Pennsylvania Supreme Court. In 1995, GPU hired a consultant to conduct a site-specific decommissioning study for TMI-2. The "retirement costs" for TMI-2 was estimated to be \$399 million for radiological decommissioning and \$34 million for non-radiological removal.

Although the plant is scheduled to be decontaminated and decommissioned in 2009, if GPU requests a five year extension on their license, these activities will not begin until 2014; fully 35 years after the accident.

Moreover, the cleanup of TMI-2 has been fraught with problems:

In July 1980, Met Ed (GPU) vented 43,000 curies of radioactive Krypton-85, and other radioactive gasses directly into the atmosphere. TMI-2 was designed to release approximately 770 curies of Krypton-85 a year. Four months later in November 1980, the United States Court of Appeals for the District of Columbia ruled that the krypton venting was illegal.

On August 12, 1982, cleanup worker William Pennsyl was fired for insisting he be allowed to wear a respirator while undressing men who entered highly radioactive areas. Pennsyl filed a complaint with the U.S. Department of Labor and, on April 11, 1984, settled out of court two days before an administrative law judge was scheduled to hear his case.

On March 22, 1983, TMI-2 senior-safety, start-up engineer Richard Parks publicly charged GPU and Bechtel Corporation with deliberately circumventing safety procedures, and harassing him and other workers for reporting safety violations. Parks filed a complaint with the U.S. Department of Labor. On August 12, 1985, GPU and Bechtel were fined \$64,000 for the incident by the Nuclear Regulatory Commission (NRC).

From July 24-27, 1984, during the reactor head lift, which was delayed due to brake failure on the polar crane, GPU vented radioactive gasses into the environment. The venting occurred despite pledges by GPU and the NRC that no radioactive releases would take place during the head lift operation. GPU was fined \$40,000 for the violation by the NRC.

In May 1987, a non-licensed plant employee was suspended after he was found sleeping in the radioactive waste control room. Two months later, ten employees working at TMI-1 and TMI-2 tested positive for drugs; eight individuals were suspended for 30 days without pay and one resigned. Thirty three people were arrested in all. Since March 1986, 16 employees tested positive for drugs at TMI.

On December 1, 1987, GPU announced the firing of a shift supervisor for sleeping on the job. Although the employee had a record of sleeping on the job dating back to the early 1980s, GPU did not issue a warning until October 1986. Edwin Stier, former director of the New Jersey Division of Criminal Justice, reported that 21 witnesses saw the shift supervisor asleep on the job.

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In December 1990, GPU began evaporating 2.3 million gallons of accident-generated radioactive water (AGW) into the atmosphere. In April-May 1991, the evaporator was shut down for most of this period so GPU could "rewrite the main operating procedure." A Notice of Violation was issued by the NRC. In January 1993, GPU "discovered" they failed to take periodic samples of approximately 221,000 gallons of AGW in the borated water storage tank. Evaporation was completed in August 1993, six months behind schedule.

In August 1993, Dr. Michio Kaku, Professor of Nuclear Physics, City University of New York, evaluated studies conducted or commissioned by GPU and the NRC on the amount of fuel left in TMI-2. Dr. Kaku concluded, "It appears that every few months, since 1990, a new estimate is made of core debris, often with little relationship to the previous estimate . . . estimates range from 608.8 kg to 1,322 kg . . . This is rather unsettling . . . The still unanswered questions are therefore: precisely how much uranium is left in the core, and how much uranium can collect in the bottom of the reactor to initiate re-criticality?"

TMIA: About Three Mile Island Alert

Three Mile Island Alert (TMIA) is a non-profit citizens' organization formed in 1977. Over the years, TMIA has been in the forefront, actively involved with many Three Mile Island-related issues including:

- •active intervener before the Nuclear Regulatory Commission (NRC) in hearings involving safety, technical and managerial issues;
- •monitoring and tracking chronic safety, technical and managerial problems at Unit-1 and Unit-2;
- tracking adverse health effects as a result of the TMI-2 accident and the normal operation of Unit-1 (since 1974);
- ·participating in two radiation monitoring networks;
- evaluating security problems at the Island; and,
- •providing information, research, and educational materials to the general public, the news media, scholars, and elected officials.

TMIA's achievements include:

- ·a landslide vote in a referendum against restarting Unit I after the accident:
- relief for ratepayers from accident-related expenses;
- ·creation of the TMI Health Fund;
- ·establishment of monitoring systems around the plant;
- successfully lobbying for vehicle barriers at nuclear plants;
- •the defeat of efforts to create a permanent low-level radioactive waste dump in Pennsylvania;
- successfully lobbying for potassium iodide stockpiling near nuclear facilities;
- getting day care centers and nursery schools included in evacuation plans;
- ·helping establish wind energy and other alternatives to nuclear power;
- successfully lobbying for vehicle barriers at nuclear plants;
- ·maintaining a regular dialog with the utility, state government, and municipal leaders;
- •staging of numerous rallies, meetings, conferences, fund raising events and the continuous publication of a regular newsletter; and,
- •a coordinating role for the many safe-energy groups and individuals who have done battle with the nuclear power establishment.

TMIA also serves as regional clearinghouse on a broad spectrum of issues relating to nuclear power production including problems at Peach Bottom-2 and -3, Susquehanna-1 and -2.

TMIA has enjoyed wide public and political support in its watchdog role. In the spring of 2003, TMIA was recognized by the Pennsylvania House and Senate, along with the City of Harrisburg, for TMIA's efforts on behalf of the community at TMIA's 25th anniversary.

TMIA's policy is formulated by a planning council which meets quarterly. TMIA meets regularly with the NRC and Pennsylvania Department of Environmental Protection to discuss issues and problems relating to TMI-1 and -2. The organization relies heavily on volunteers who staff the office, maintain our web site, and write, edit, and mail TMIA's newsletter. All of TMIA's funding comes from membership dues, private contributions, and fund raising events.

TMIA's office is open Monday through Friday from 10:00 am to 6:00 pm. Weekend visits are available by appointment. The public and all interested parties are encouraged to stop by or contact the group by phone or mail and to visit our web site at http://www.tmia.com.



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