vowed an instant reply to *Il Saggiatore* when it appeared in Rome. He goes on to suggest that, although the questions in the document were phrased in a way that clearly implied they were meant to be a denunciation, nothing was done at the time, partly because the Jesuits were in a relatively weak position in the Church. But the charges were resurrected in the early 1630's, during the height of Europe's Thirty Years War, when Urban VIII was coming under pressure to shift his allegiance from France (which had sided with Protestant Germany and Sweden) to Spain, and the Jesuits were using this to try to return to power.

In line with this interpretation, Redondi then raises the possibility that a special commission set up by the Pope under Cardinal Francesco Barberini to examine complaints made with the support of the Jesuits against Galileo's newly published *Il Dialogo* had been instructed to frame the charges of heresy in a way that would do the least overall damage. He also says that this tactic was accepted by Galileo during a famous closed-door meeting with Barberini, after which Galileo dropped his initial defiant stand and agreed to plead guilty to the lesser charge of defending Copernicus' ideas.

This novel interpretation of a thoroughly studied event has encountered many critics. Some have focused their attacks on the newly discovered document. The Society of Jesus in Rome, for example, has produced a letter written by Grassi in the same year, but in a very different handwriting, to dispute that he was the author of the charges (Redondi now says that the document could be a copy made by an assistant). Others argue that the document, which is unsigned apart from the initial "G," could have been a standard inquiry with little legal significance.

Redondi himself argues that, even if his data are weak, his interpretation of the events surrounding the trial remains new and significant. "Galileo's trial was a political process, like all the great affairs of state," he said in a recent interview. "The movement [towards liberalization] was suddenly stopped by political and military dangers at the top of the Church; this crisis was the external key to the personal issue faced by Galileo."

William Shea of McGill University agrees that Redondi's approach to understanding Galileo in the context of his period remains important. "Redondi writes about this is the way that people produce new theories about the Kennedy assassination," he says. "Many scholars feel that some of his ideas are far-fetched; but the book does for the first time compel us to ask certain questions about Galileo that we have not asked before." ■ **DAVID DICKSON**

The Buried Cost of the Savannah River Plant

Once-secret documents reveal a history of problems at the South Carolina plant where 33 million gallons of military nuclear waste sit in steel tanks

FEDERAL officials are beginning to cope with the pollution left behind by the 40-year-old nuclear weapons program, but they are not wildly enthusiastic about the work that lies ahead.

It will cost over $1 billion to repackage liquid defense wastes alone. The first major effort, which began 3 years ago at the Savannah River Plant (SRP) near Aiken, South Carolina—producer of most of the nation's bomb material—will take until the next century to complete. Other cleanup campaigns are getting started at the defense nuclear complex in Hanford, Washington, the retired Y-12 enrichment plant in Oak Ridge, Tennessee, and sites in California, Colorado, and Ohio.

These and other remedial programs will crowd the budget at the parent agency, the Department of Energy (DOE), pushing aside regular defense projects. They will spark regional fights over where to store the waste canisters. And they have caused worries about the new pollution that will arise when tanks and seepage basins are disturbed. The agenda is so unappealing that even national leaders seem ready to cut and run.

For example, the Senate Armed Services Committee recently proposed a retreat. It cut more than $81 million from DOE projects that would control ongoing thermal and chemical pollution at DOE's nuclear weapons plants, preferring to spend the money on real defense programs, such as new weapons R&D. The cuts may be restored when the DOE appropriation reaches the floor of Congress, but the committee vote shows that the senators, like others, are reluctant to spend defense money on something as unmilitary as the environment.

However, there are dangers in hesitating, as a new report on the Savannah River Plant points out. A 110-page paper (see box), released on 23 July by the Environmental Policy Institute (EPI), criticizes the managers of this plant for their neglect of health and safety in the past. EPI claims that the government is allowing a 300-square-mile corner of South Carolina to become a "national sacrifice area" for the weapons program, a zone whose soil and water will remain toxic for longer than humans have kept records.

The authors, EPI staffer Robert Alvarez and consultant Arjun Mahkijani, reviewed a data bank of 14,000 incidents recorded between 1953 and 1982 by employees of the E. I. du Pont de Nemours & Company, the manager of the Savannah River Plant. EPI and others filed legal actions and Freedom of Information appeals over the last 5 years

Savannah River tank farm. *The plant holds 70% of U.S. high-level defense waste.*

Down on the Sludge Farm

The Environmental Policy Institute's report on the Savannah River Plant (SRP), "Deadly Crop in the Tank Farm," attacks the plant's official safety studies as lacking credibility. Citing a safety data bank that covers 33 years of operation, the authors claim that standards at SRP are far below those at civilian plants. Some points in the critique follow, along with SRP responses:

■ Shoddy record keeping between 1953 and 1982 makes the data on equipment and human failures invalid for calculating future risks. EPI found that the average number of incidents reported each year jumped from four in the early 1950's to 1800 in the 1980's. Because problems at the plant did not increase 450%, this discrepancy means that many events were omitted from the early record.

William Durant of SRP confirms that reporting standards did change, explaining that until 1977 detailed logbook entries were not included in the data bank. But he believes that "all significant incidents" have been used in estimating risks.

■ The incident data bank contains only sketchy reports of workers' exposure to radiation. Although 300 cases are recorded in SRP's 33-year history, 75% of them appeared in the last 6 years. EPI estimates that 1000 early incidents have been omitted. The record contains no information on workers' lifetime exposure as a result of ingesting or inhaling radioactive particles.

SRP officials respond that the plant maintains a "comprehensive" program that tracks all individual exposures on a weekly basis. These records are kept in the private files of the health protection department, not in the incident data bank.

■ Some problems are ignored in risk estimates, even though they are discussed in other SRP records. For example, EPI claims that corrosion pits on the newer tanks, which in one case penetrated one-third of the width of a tank wall, are neglected in the data bank and in risk estimates.

SRP official William Stevens said that some older tanks have suffered from "stress cracking" and that "we are getting out of those." Four of the 24 old tanks have been emptied, and four more are due to be drained by the end of the year. The others will have to await the beginning of the glassification program.

■ Plutonium wastes could "go critical" if normal plant processes are disrupted, generating more volatile radioactive isotopes, EPI claims. This possibility is not reflected in risk calculations.

This scenario is "extremely incredible," SRP officials say, because the concentration of plutonium in the waste is strictly controlled at the point of production and could never go above one-tenth of what is needed to achieve a critical mass. Before that could happen, sensors in the tanks would signal an alarm.

■ Major discrepancies can be found in records on plutonium inventory and tank leaks, according to the critics. EPI makes much of the fact that the reported level of plutonium-238 in the tanks jumped inexplicably from 300,000 curies in a 1978 report to 1 million curies in 1980.

SRP officials say that the 1978 figure may reflect a much earlier inventory. The increase cited in 1980 was genuine and not a statistical error. Today the inventory of plutonium-238 is even larger: it stands at 1.5 million curies.

■ Leaks and routine dumping have already damaged the local environment severely, and some chemicals have migrated into the ground water. For example, about 50% of the radioactive tritium dumped into one basin (half-life of 12 years) will eventually make its way into a nearby creek. Strontium-90 (half-life 29 years) and toxic compounds such as mercury, trichloroethylene (TCE), and polychlorinated biphenyls (PCB's) are also moving through the ground water.

According to SRP, the unlined pits used as temporary waste dumps will be closed by 1988. SRP also plans to remove pollutants in the soil around one pit.

■ Contaminants will continue to move into the ground water even under a new permanent waste disposal program, according to EPI. Some of the salts now in tanks will be mixed with concrete to make saltcrete, a new solid that will be buried on site. Because it will contain long-lived isotopes such as technetium-99 (half-life 210,000 years) and iodine-129 (half-life 17 million years), it is fair to assume that the radiation will be carried into local streams and down the Savannah River.

Stevens of SRP says that the undesirable isotopes will be "released very slowly" so as not to violate drinking water standards. ■ **E.M.**

to obtain the data. Having studied the foot-thick file, Mahkijani claims that the data keeping at Savannah River was sloppy and the approach to risk estimation biased. It is "statistical folly," he says, to rest any assurance of public safety on this file, "because essential data are missing."

The Savannah River site holds about 70% of the nation's military high-level nuclear waste by curie content (837 million curies), accumulated since the first reactor began running in 1953. Most of it lies in 33 million gallons of liquid, salt, and sludge stored in 51 underground tanks. The older, single-walled tanks began leaking a decade ago and are being phased out rapidly. The 27 newer, double-lined tanks also have problems, but will be emptied on a slower schedule.

An expensive plan launched in 1983 calls for all the tanks to be drained and the contents separated into sludge and liquid, with the sludge being made into borosilicate glass, beginning around 1990. The glass is to be poured into stainless steel drums and buried "out West," as a DOE official says. Exactly where out West is not known, but DOE has three candidate sites (in Washington, Nevada, and Texas) under review (*Science*, 11 October 1985, p. 150). The liquid and salt wastes (containing less intensely radioactive but long-lived isotopes) will be made into "saltcrete," a radioactive form of concrete, for burial on site.

The reason for beginning the national cleanup at this plant is that its tanks sit above shallow waters that drain into the Savannah River and atop a deep formation known as the Tuscaloosa aquifer. The Tuscaloosa is a major source of drinking water that runs through South Carolina, Georgia, northern Florida, and Alabama. The plant also lies 100 miles from the highest shock zone of the great Charleston earthquake of 1886. Local shock intensity in the SRP area in 1886 may have been VII or VIII on the modified Mercalli scale, which goes up to XII. There is no reason to assume that a big quake could not hit again. EPI says that the buildings and tanks at the plant are not hard enough to withstand severe seismic shock (Mercalli IX).

SRP's own safety analysis assumes that if the tanks broke open in a worst-possible quake (Mercalli XII), 90% of the radioactive isotopes would be trapped in the soil and about 10% would be released into surface waters. Even granting these assumptions and ignoring the potential for solvents to mobilize more of the waste, EPI argues, the spill would cause tens to hundreds of thousands of excess cancer cases and devastate an uncalculated amount of property.

The EPI report does not analyze the 3-year-old effort to drain the tanks, although it

does say that not enough R&D has been done to prepare for it. Alvarez thinks the borosilicate glassification program is ill-conceived. He fears that future accidents may cause the project to lose public support and die. If so, the waste may never be removed. Instead, Alvarez prefers a more expensive approach, one used on a small scale at DOE's nuclear laboratory in Idaho, where wastes are made into a powder through calcining. This powder will be converted later into a solid or glass form. Alvarez concedes it would be vastly more expensive to follow this route, and he notes that it would create a greater volume of waste.

Other critics of DOE have praised the agency and du Pont for their first steps in cleaning up Savannah River, while at the same time denouncing DOE's record of stalling. One critic, Dan Reicher of the Natural Resources Defense Council (NRDC), says: "Things are changing. Large amounts of money are being spent, but there is still a concern that DOE is operating outside of federal laws and regulations."

The NRDC has been in court since the mid-1970's, trying to impose civilian standards on DOE weapons facilities. It sued to have DOE file an environmental impact statement on its plan to restart the mothballed L-reactor at Savannah River. NRDC won that case in 1982. Then NRDC sued to enforce a cleanup of the Y-12 plant at Oak Ridge, where millions of pounds of mercury were dumped. NRDC won again in 1983. Meanwhile, DOE insisted that it did not have to comply with all elements of the new toxic dump laws (the Resource Conservation and Recovery Act of 1976 and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980) because it was a self-regulating defense agency. NRDC argued that the agency did have to comply and won in federal court in 1984. DOE did not appeal. Now state officials and environmentalists are getting down to finer details in their talks with DOE on just what it means to abide by civilian standards. The arguments are becoming denser and more legalistic and may lead to new lawsuits over the proper method of cleaning the site.

From the late 1970's until 1983 DOE resisted change in court, but it rapidly lost support in Congress for its obstinacy. The agency finally was compelled to take action on the festering problem at Savannah River. Under intense pressure from the House, DOE agreed in 1983 to begin the present cleanup and glassification project that is meant to clear the site by the end of the century. DOE now wishes to be judged on this effort, and not on the historical record. ■ ELIOT MARSHALL

Petersdorf to Head Medical Colleges

Academic medicine must face up to the need for some real changes in research and education

On 1 September, Robert G. Petersdorf will leave the University of California at San Diego, where he has been dean of the medical school since 1981, to become president of the Association of American Medical Colleges, the Washington-based institution that Petersdorf calls the "Chamber of Commerce" of academic medicine. He succeeds John A. D. Cooper (AAMC president for 17 years) at a time when academic medicine feels itself beleaguered.

Robert Petersdorf: *Not all medical schools need to do research.*

Three years ago Petersdorf summed up his view of the situation when he wrote, "The establishment that is responsible for medical education is again under attack for overproducing physicians, for glutting the country with specialists, and for operating a system of medical education that is anachronistic and not responsive to societal needs." Not one to buy the simplistic view that the serious issues in medical care can all be laid at academic medicine's door, he nonetheless went on to state, "I contend that unless we make some changes in the way we operate our academic enterprise in education, research, and health care, we may be heading for disaster—a disaster that is largely of our own making."*

The AAMC is a membership organization (all 127 of the nation's medical schools belong), that is known in Washington as a strong defender of the academic status quo. Petersdorf, 60, is something of an iconoclast, very much a member of the inner sanctum but one whose blunt challenges of the medical establishment set him apart from his brethren. In an interview with *Science*, he acknowledged that many of the things he has said and written during the past several years have put him "toward the left of the establishment, if that is the progressive side," and said that as AAMC president and spokesman he may have to "keep still" when it comes to some of his personal views unless he can achieve the goal of bringing his colleagues in academic medicine around to his thinking. "A leader," he says, "cannot lead if he is too far ahead of his flock."

But in recent speeches and articles Petersdorf has left a trail that plainly indicates some of the directions in which he thinks academic medicine should go and which problems it should tackle.

The rising costs of health care, driven in part by a physician surplus and a huge corps of high-priced medical specialists, has become something of a national obsession, a real issue but one that is easy to satirize. "In the communities with which I am familiar," Petersdorf has wryly written, "there are few echocardiograms in search of a cardiologist to read them, there is only a rare belch wanting a gastroenterologist, and there is not a single even slightly plugged coronary that does not have three specialists waiting in the wings." The blame, he says, lies squarely with academic medicine itself for a failure to limit residency and fellowship subspecialty training programs.

A couple of years ago, he made a startling and unpopular suggestion: reduce specialty training by limiting the number of years that residencies and fellowships are supported by the current system of subsidy with revenue from the care of hospital patients. At present, the system supports new doctors

*Robert G. Petersdorf, "Is the Establishment Defensible?" *The New England Journal of Medicine*, **309**, 1053 (1983).