producers, chairs the Senate's subcommittee on federal energy regulation. He told a group of reporters on 16 September that the major difference he sees between President Carter and Ronald Reagan is in their choice of rhetoric. Reagan says what the energy producers like to hear, and Carter blasts Big Oil. But, Johnston said, the record shows that the Carter Administration has helped, or allowed others to help, the industry free itself of controls imposed by previous administrations.

Johnston continued: "When I go down in my state, I see virtually none of the independent oil producers for Carter. Here is Carter, who has put in the Natural Gas Policy Act [ending two decades of federal price controls] and deregulated crude oil; we've gotten higher drilling rig counts, more dollars being spent, more activity, more profits being made by oil people than ever before. But do they like Carter? Oh no, they hate him because of his rhetoric." Johnston's conclusion: Although a Reagan Administration might use more pleasing language, it wouldn't be able to do much more for the industry than is being done already.

—Eliot Marshall

Debate over Waste Imperils 3-Mile Cleanup

Lack of disposal facilities for radioactive material could make the decontamination effort impossible

The cleanup on Three Mile Island represents a challenge unlike any the nuclear industry and its governmental patrons and overseers have ever faced before. If all goes well, decontaminating the unit 2 reactor, the containment building, and other facilities will continue over 5 years and will require more than 2000 workers, immense amounts of material, and, at a minimum, the expenditure of a half billion dollars (even if the damaged reactor is not returned to service).

But if things go badly, schedules will be disrupted, costs will escalate, and the job will not get done. It now appears that the cleanup is in trouble. It is threatened by political hang-ups in radioactive waste disposal, hang-ups which could severely embarrass both the nuclear industry and its patron, the Department of Energy (DOE).

Although the unit 2 reactor was brought to a "cold shutdown" within days after the accident occurred on 28 March 1979, no one will feel easy about the situation on Three Mile Island until the damaged core has been removed. "I think we've clearly got the situation in hand, but the probability of deterioration is not zero," says Robert C. Arnold, the General Public Utilities (GPU) official in charge of the cleanup. "We need to get on with the cleanup so that we can do more than just baby-sit the core."

The cleanup is a task of extraordinary proportions. During the accident more than 300,000 gallons of water contaminated with fission products overflowed into the auxiliary and fuel handling buildings from the primary coolant system, and nearly 700,000 gallons of coolant water with a half million curies of radioactivity poured into the containment building sump. Also, some 43,000 curies of krypton-85, a long-lived gaseous fission product, escaped from the reactor vessel and dispersed within the containment building. The contamination of this building was pervasive: the sump, the walls, the ceiling, and all equipment are still dangerously radioactive, even if in most cases the radioactivity is only on the surface and is removable. Moreover, the core suffered severe damage, and, although temperatures inside the core never reached levels high enough to melt the fuel itself, much of the fuel cladding is believed to have melted.

Luther J. Carter Photo

Cleaning up Three Mile Island

Shipping cask for hauling Three Mile Island radioactive waste. In background are vaults for wastes that require heavy shielding.

Every step in the cleanup must be taken in a highly sensitive political and regulatory environment. Yet major steps have been taken. A "demineralizer," or ion exchange filtration unit, was installed last year with the Nuclear Regulatory Commission's permission in order that the fission products could be removed from the water spilled in the auxiliary and fuel handling buildings. And in June, the NRC, after prolonged controversy, allowed GPU to vent the krypton gas. Also, twice now engineers have made brief, cautious entries into the containment building as part of the effort to size up the job that lies ahead.

Now, eager to get on to the next stage of the cleanup, GPU is going ahead with construction of a second demineralizer system for treating the sump water in the containment building so that workers can safely enter the containment building in force. The utility has been warned by the NRC that use of this $10-million unit is still subject to its review and approval.

Meanwhile, Arnold faces some major management headaches. Some 2500 workers will be needed when the cleanup reaches its peak, with workers continuously being rotated as they reach their maximum permissible exposure to radiation. Payroll costs for the cleanup will

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run $30 to $40 million a year. Especially with the start of decontamination activities within the containment building still more than a year off, Arnold must struggle to keep the financial burden on his hard-pressed company (talk of bankruptcy has been in the air) from becoming unbearable.

The first workers to clean up inside the containment building will wash down surfaces with steam jets, water cannons, and possibly the fire control sprinkler system. Then, other workers, all wearing three layers of protective clothing and respiratory protection devices, will undertake an intensive "hands on" effort to reduce radiation levels further and clean up hot spots.

The workers will often have to shield themselves from one hot spot while they try to clean up another. For shielding material they will use lead bricks and blankets, lead sheeting, thick rubber mats, steel plates, and solid concrete blocks. An internally contaminated pipe would be wrapped in lead sheeting. An immovable piece of equipment would have a wall of concrete blocks placed in front of it to attenuate the radiation.

Extraordinary quantities of material will be used. For instance, in a report delivered to GPU in July 1979, the Bechtel Power Corporation estimated that 1 million pairs of plastic coveralls will be needed, as will a like number of pairs of plastic booties and rubber gloves. The breathing masks, oxygen tanks, and other respiratory protection devices needed may run to thousands of items. Similarly, large quantities of cleaning and shielding materials will be required: 10,000 sponge mops, a million square feet of plastic sheeting, 10,000 concrete blocks, and 12,000 square feet of lead sheeting, among other supplies.

As much as 350,000 gallons of water-based or chemical decontamination solutions will be used in the cleaning of equipment, piping, and building surfaces. These liquids will become a special problem in themselves. Ion exchange demineralizers of the kind that will remove fission products from the sump water are made ineffective by the detergents, chelates, and solvents found in such decontamination solutions. Because of this, a complex evaporator unit to cost upward of $20 million must be built to reduce these liquids to a solid material that can be transported off the island and disposed of at a burial ground.

Most of the waste from the cleanup will be material that has been contaminated in the decontamination process itself. Low and intermediate level wastes will fill thousands of drums and boxes. Waste volumes could be reduced dramatically by use of an incinerator, but radiation can build up to such high levels in an incinerator as to make further use of the unit impractical.

There will be some wastes that require special packaging in hundreds of containers with shielded "overpacks," plus bulky items of hardware and equipment that cannot be easily packaged. Finally, there will be the damaged fuel assemblies from the reactor core; a third or more of the 177 assemblies in the core may have suffered damage.

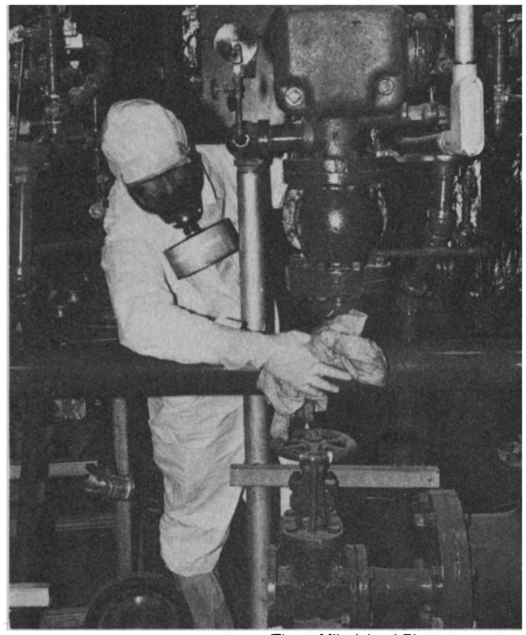
Removing the fuel from the reactor may be difficult. First, the head of the reactor vessel will have to be removed and the condition of the core assessed. Then special equipment will be needed to free fuel assemblies caught fast inside the reactor and to scoop up any uranium oxide pellets that have fallen out of their rods and assemblies to form a rubble at the bottom of the vessel.

Yet the damaged fuel, once it is recovered, may prove to be the most politically tractable of all the Three Mile Island wastes. It can be put in canisters and placed in the pool on the reactor site which is intended for routine interim storage of spent fuel assemblies; there it can remain pending the opening, some years hence, of a permanent repository, or, alternatively, of a commercial fuel reprocessing facility.

As for the other wastes from the cleanups, no one now knows what will become of them. Low level waste from the decontamination of the auxiliary and fuel handling buildings is being trucked across country to the commercial burial ground on the Hanford reservation in the state of Washington. But this means of disposal may soon be lost.

On 4 November Washington voters are expected to approve a ballot proposition to close the Hanford burial ground by next 1 July to all radioactive wastes generated out of state except those from hospitals and medical research institutions. If this happens, the equivalent of hundreds of truckloads of waste-filled boxes and drums and bulky, nonpackageable items will have no place to go.

Besides the one at Hanford, there are but two other commercial radwaste burial grounds in the United States, one at Barnwell, South Carolina, the other at Beatty, Nevada. By placing a limit on the total amount of waste which can be received monthly at Barnwell, Governor Richard Riley of South Carolina has effectively excluded the large volumes to be generated at Three Mile Island. In Nevada, Governor Robert List is supporting a decision by his Department of Human Resources to deny a license renewal to the operator of the Beatty site on grounds that improperly packaged wastes have been accepted repeatedly. If this decision is upheld by the State Board of Health, Nevada will be out of the radwaste burial business.



Three Mile Island Photo

Decontaminating Three Mile Island

Thousands of suits of protective clothing will themselves become contaminated in the cleanup process.

An especially troublesome waste disposal question has to do with the material to be generated in cleaning up the containment building's sump water. In the first stage of the ion exchange process, when most of the fission products will be removed, the radioactivity of the zeolites (or resins) used in the filters will run as high as 1500 curies per cubic foot, as opposed to a maximum of 10 curies in ordinary low level waste. Moreover, the fission products principally involved—cesium-137 and strontium-90—have a half-life of about 30 years, which means the period of hazard will extend over the next three centuries. If plutonium and other extremely long-lived transuranic elements are found in significant amounts (which is not expected), these wastes would be little different from high level waste and, in that case, eventual disposal in a deep geologic repository would be required.

Bob Arnold, GPU's man in charge, is trying hard to decouple the immediate cleanup operation from the politically volatile issues of waste disposal. His strategy is to collect the wastes in a form that permits maximum flexibility with respect to their storage, packaging, transport, and ultimate disposal. Particularly important in maintaining flexibility, he feels, is to be able to store wastes on Three Mile Island itself. "If necessary, all the wastes can be stored for a number of years on site," Arnold says.

But on-site storage could become hotly controversial because the wastes could amount to the equivalent of 600 to 1600 truck loads, which would remain on the island indefinitely. "We don't want Three Mile Island to become a waste disposal site," says Thomas M. Gerusky, Pennsylvania's top radiation protection official. "Who wants all that radioactive material to be sitting, for a considerable time, on an island in the middle of the Susquehanna?" he asks.

Bernard J. Snyder, the NRC official who is overseeing the cleanup, shares this concern. In his view, temporary storage of wastes on the island is acceptable. But, he says, referring specifically to the first-stage zeolites, "We want commitments made for their removal." Without some assurance that the hot zeolites will be removed from the island, Snyder believes that GPU's plans to operate the demineralizer unit that would generate them should not be approved. Arnold, too, wants to see commitments made, but he observes: "Progress on the cleanup should not be held hostage in the regulatory process."

If plans for disposal of all the wastes from the cleanup are to fall into place, two things appear to be needed:

- An early commitment by Pennsylvania and other northeastern states to establish a burial ground for low level waste generated within the region. Congress could encourage this by passing legislation already pending which would allow states of a particular region to establish a burial ground open only to wastes generated in those states alone.
- A speedy commitment by NRC, DOE, and Congress to a plan for disposal of the first-stage zeolites, even if this means that DOE must prepare the waste for disposal or accept custody of the waste itself.

Prospects for prompt action are dim. Last year's flap over the closing of commercial burial grounds even to medical wastes lent currency to the concept that the states of each region should establish their own disposal sites. Governor Dick Thornburgh of Pennsylvania and other members of a radwaste task force helped persuade the National Governors Association to urge the states to assume this responsibility.

Last year, Pennsylvania's Department of Environmental Resources quietly began looking for suitable areas for a burial site for medical wastes. But the state geologist, Arthur A. Socolow, says no plans are afoot to establish a burial

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African to Head International Council

Platitudes about expanding the leadership role of scientists from developing countries, heard at many an international meeting, are giving way to action, at least in one case. The International Council of Scientific Unions (ICSU) recently elected its first president from the Third World. Daniel A. Bekoe, 52, a chemist and vice-chancellor at the University of Ghana, will hold office for 4 years.

ICSU is a 60-year-old club that currently has 18 scientific unions as members and historically has a strong track record for encouraging international projects, such as the Global Atmospheric Research Program. For the past several years, ICSU has increasingly encouraged the application of science and technology to developing countries. With the ascendancy of Bekoe, this trend is expected to expand.

Case of the Missing Milk Bottles

A dearth of half-pint milk bottles has slowed the march of science, but the captains of U.S. industry are indifferent. Outlines of the problem were seen decades ago, but it is only now, with the situation in crisis proportions, that constructive moves are under way. And, as is too often the case, Yankee ingenuity has produced no answers and the worried parties are looking overseas for a solution.

In the early decades of the 20th century, geneticists hit upon an ideal subject for the study of the laws of Mendelian genetics—the lowly fruit fly, *Drosophila melanogaster*. Using the materials at hand, they housed their bugs in the ubiquitous half-pint milk bottle. The choice was ideal. The bottles were cheap, convenient, clear enough so researchers could see how the flies were doing, and strong enough to take a beating when being cleaned and handled.

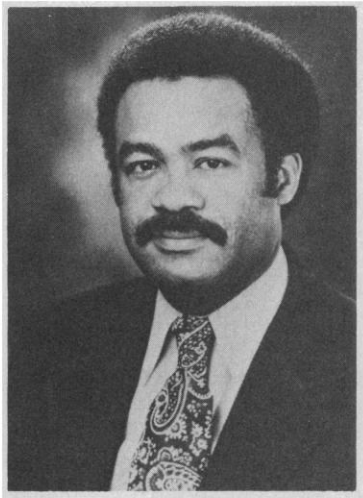
The study of fruit flies boomed, but supplies of the bottles did not. With the advent of waxed and then plasticized milk cartons, geneticists started buying up stocks of the old milk bottles, a particularly rich source proving to be abandoned dairies. Those supplies, however, are now almost exhausted, and the search is on for a new source.

"I've called ten major glass companies and with some of them I couldn't even get past the secretary," says David J. Remondini, executive secretary of the genetics study section at the National Institutes of Health. "They like to talk in terms of millions, but it's not that kind of number."

Of late Remondini has heard much from worried geneticists about the bottle crunch and has decided to do something about it. Not a milk-bottle entrepreneur, he is a middleman, trying to find a supply of the bottles and then alerting the U.S. genetics community through a newsletter he puts out, the *Drosophila Information Service*. It turns out, however, that U.S. manufacturers do not want to make the expensive molds for the old bottles, and Remondini is now looking overseas. "I estimate that we're looking for 50,000 to 100,000 of these things," he says. "I think I've unearthed a manufacturer who still makes them. But there's a possibility they're going to switch to these paper cartons, so they're rather interested in knowing the potential market for these old bottles."

Remondini is currently surveying the U.S. genetics community to gauge the extent of the demand.

Why not another type of bottle? Many of the special-order laboratory bottles are too expensive and too thin, says Remondini. Few are the right size to hold the sterilized media on which the flies feed. (The media mimics rotting apples and peaches.) The cheap plastic bottles manufactured by scientific supply houses are not clear enough so that the health of the flies can be easily determined. "We do use vials for certain types of experiments," says Remondini, "but the production of progeny per female is less than it is in the bottles. Apparently there's a certain amount of space or micro-ecology that is better in a bottle." A factor, he says, may be evolution. Some of the strains of fruit flies are 60 and 70 years old, and selection pressures during this period have killed off those flies that could not adapt to the bottles.



Slaughter confirmed at last

After nearly 3 months of delay caused by election year politics, the Senate on 23 September approved the nomination of John G. Slaughter as director of the National Science Foundation.

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ground for waste from Three Mile Island, or from any other nuclear generating plant for that matter. "Very realistically," Socolow adds, "this is a very paranoic issue in Pennsylvania, where we've seen people running away, scared half out of their pants. Our state government is very much concerned that we not add to the fears of the people."

Governor Thornburgh told *Science*: "I think this is true at the present time. But that does not mean we have written off the possibility [of a burial site for Three Mile Island wastes] for the future."

But Thornburg and his secretary of environmental resources, Clifford Jones, make it clear that it will be years before such a facility can be established in Pennsylvania or the Northeast. They have in mind a cautious, step-by-step, consensus-building approach: Pennsylvania and other northeastern states will identify potential burial sites; physicians will be asked to explain to the public that waste burial grounds are needed for the support of nuclear medicine; then the radwaste issue will continue to be patiently explained in "hearing after hearing," held to convince people that the risks are acceptable—and that the burial grounds to be established will receive no waste from Three Mile Island.

"We can't create a site for Three Mile Island waste," Jones told *Science*. "Maybe down the road we can think about that. But not now."

If disposal of the ordinary low level waste from the Three Mile Island cleanup is politically difficult, disposal of the highly radioactive first-stage zeolites may well be impossible unless DOE lends a strong helping hand. Technically, disposal of the zeolites at Hanford or another commercial burial ground might be possible given special packaging and perhaps burial at a greater depth than is required for ordinary waste. But Terry Strong, chief radiation officer for the state of Washington, observes with respect to any proposal that may be made to bury the zeolites at Hanford, "I think that, right now, doing this would be big trouble."

Some NRC officials say that much the best way to dispose of the zeolites would be to have them shipped in shielded casks to DOE's Hanford or Savannah River reservations and sluiced into one of the existing tanks for high level waste from the reprocessing plants used in the production of plutonium for nuclear weapons. "It's so simple it's ridiculous," says Homer Lowenberg, assistant director for operations and technology in NRC's waste management division.

"From a technical point of view, this is the easiest, most direct solution," he adds. "The hazards and environmental implications are far less than those of any other disposal method." The 500,000 curies of radioactivity in the zeolites would add relatively little to the some 550 to 600 million curies already in the tanks at each of the two DOE reservations.

According to Lowenberg, use of DOE's high level waste tanks was informally suggested by NRC officials but the idea went nowhere. He says that George W. Cunningham, DOE's assistant secretary for nuclear power, "told us that the military complex is off bounds." The DOE even objected, he adds, to this option being mentioned in an early version of the NRC's draft environmental impact statement on the Three Mile Island cleanup.

For his part, Cunningham says, "We have a directive from the congressional armed services committees not to commingle defense and commercial wastes." Adam Klein, staff member on the House committee, offers emphatic confirmation: "It's up to DOE and the state of Pennsylvania to find something to do with that material and keep it the hell away from Savannah River and Hanford." The committees object to commingling of commercial and military wastes because they want to run no risk of military radwaste activities being made subject to NRC licensing; in their view, licensing could interfere with weapons production and compromise secret information.

Klein suggests dryly, "Why not send the Three Mile Island waste to West Valley?" Congress has just passed a bill authorizing a $200 to $300 million project for the solidification of the 560,000 gallons of high level waste left from the commercial fuel reprocessing plant that operated at West Valley, New York, from 1966 to 1972. But any suggestion that the new solidification facility also be used for Three Mile Island waste would be rejected out of hand by New York State officials.

If DOE goes beyond small scale R & D in its support of the Three Mile Island cleanup, it may seek to adapt some of its nonmilitary facilities in Washington State, Idaho, or Tennessee for solidifying the first-stage zeolites into glass logs. These logs could, if necessary, then be sent back to Three Mile Island and kept in the spent fuel pool. The costs of modifying the DOE facilities, estimated by one official at $10 to $20 million, would be comparatively modest by Three Mile Island standards. But a proposal by DOE to take commercial waste for even temporary custody and treatment might be viewed as an undesirable precedent. Also, the fact that the regulatory commission has yet to issue criteria for the solidification of high level waste would probably be cited by those people who worry that glass may be an inferior waste form.

Three Mile Island is the first accident ever to involve major damage to the core of a large commercial reactor and to require a highly complex and costly clean up effort. If this effort arrives at an impasse because politically and technically acceptable means of disposing of the wastes are not found, the implications for the nuclear industry could be profound. Synder observes, "If DOE can't solve this little problem [of the zeolites] should NRC be licensing more nuclear plants?"

For GPU, a hang-up over waste disposal could make the cleanup a ruinously costly endeavor, as Bob Arnold is all too aware. "What is needed more than anything," he says, "is a general consensus that everyone involved must help find a solution."

In the past, the disposal of radioactive waste has been a problem that policymakers have often put off until tomorrow. But the Three Mile Island cleanup is here today, and, should there be a failure to cope with the wastes that it generates, the whole nuclear enterprise may suffer.—LUTHER J. CARTER