plied Research Laboratories, Sunland, Calif., 1974).
20. J. D. Chase, *J. Appl. Phys.* **42**, 4870 (1972).
21. B. Waldie, in *Conference Proceedings, International Round Table on the Study and Applications of Transport Phenomena in Thermal Plasmas* (Laboratoire des Ultra-Refractaires du C.N.R.S., Odeillo-Fontromeu, France, September 1975).
22. G. W. Dickinson and V. A. Fassel, *Anal. Chem.* **41**, 1021 (1969).
23. S. Greenfield, I. L. Jones, H. M. McGeachin, P. B. Smith, *Anal. Chim. Acta* **74**, 225 (1975).
24. R. H. Scott, V. A. Fassel, R. N. Kniseley, D. E. Nixon, *Anal. Chem.* **46**, 75 (1974).
25. J. Mermet, *Spectrochim. Acta Part B* **30**, 383 (1975).
26. G. R. Kornblum and L. de Galan, *ibid.* **32**, 71 (1977).
27. J. M. Mermet and C. Traisy, *Rev. Phys. Appl.* **12**, 1219 (1977).
28. J. Jarosz, J. M. Mermet, J. R. Robin, *Spectrochim. Acta Part B* **33**, 55 (1978).
29. P. W. J. M. Boumans and F. J. de Boer, *ibid.* **32**, 365 (1977).
30. R. Herrmann, C. T. J. Alkemade, P. T. Gilbert, *Chemical Analysis by Flame Photometry* (Interscience, New York, 1963).
31. V. A. Fassel and D. A. Becker, *Anal. Chem.* **41**, 1522 (1969).
32. G. F. Larson, V. A. Fassel, R. H. Scott, R. N. Kniseley, *ibid.* **47**, 238 (1975).
33. P. W. J. M. Boumans and F. J. de Boer, *Spectrochim. Acta Part B* **31**, 355 (1976).
34. I am indebted to R. K. Winge for making these observations.
35. I am indebted to H. Sobel and W. Sutherland for making these observations.
36. C. C. Butler, R. N. Kniseley, V. A. Fassel, *Anal. Chem.* **47**, 825 (1975).
37. J. C. Souililart and R. P. Robin, *Analysis* **1**, 427 (1972).
38. P. W. J. M. Boumans and F. J. de Boer, *Spectrochim. Acta Part B* **30**, 309 (1975).
39. I am indebted to B. Bear, M. Floyd, and W. Sutherland for making these determinations.
40. These detection limits represent the range of values reported in (9) and in J. D. Winefordner, J. J. Fitzgerald, N. Omenetto, *Appl. Spectrosc.* **29**, 369 (1975); *Techniques and Applications of AA* (AA-322G, Perkin-Elmer Corp., Norwalk, Conn., 1978).
41. S. J. Weeks. H. Haraguchi, J. D. Winefordner, *Anal. Chem.* **50**, 360 (1978).
42. R. L. Dahlquist and J. W. Knoll, *Appl. Spectrosc.* **32**, 1 (1978).
43. G. F. Larson, V. A. Fassel, R. K. Winge, R. N. Kniseley, *ibid.* **30**, 384 (1976).
44. G. F. Larson and V. A. Fassel, paper No. 23 presented at the fourth annual meeting of the Federation of Analytical Chemistry and Spectroscopy Societies, Philadelphia, 7 to 11 November 1977.
45. V. A. Fassel, J. M. Katzenberger, R. K. Winge, *Appl. Spectrosc.*, in press.
46. R. K. Skogerboe, P. J. Lamothe, G. J. Bastiaans, S. J. Freeland, G. N. Coleman, *ibid.* **30**, 495 (1976).
47. S. R. Koirtyohann, E. D. Glass, D. A. Yates, E. J. Hinterberger, F. E. Lichte, *Anal. Chem.* **49**, 1121 (1977).
48. W. J. Haas, R. K. Winge, V. A. Fassel, R. N. Kniseley, paper presented at the 29th Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, 27 February to 3 March 1978.
49. S. Greenfield, H. M. McGeachin, P. B. Smith, *Anal. Chim. Acta* **84**, 67 (1976).
50. V. A. Fassel, *Am. Soc. Test. Mater. Spec. Tech. Publ. 618* (1977).
51. _____, C. A. Peterson, F. N. Abercrombie, R. N. Kniseley, *Anal. Chem.* **40**, 516 (1976).
52. M. B. Denton, personal communication.
53. A. L. Robinson, *Science* **199**, 1324 (1978).

NEWS AND COMMENT

Uranium Mill Tailings: Congress Addresses a Long-Neglected Problem

Some 30 city blocks from Utah's state capitol building and downtown Salt Lake City is a 128-acre site containing the radioactive residues from a long-since abandoned and dismantled uranium mill. From 1951 to 1964, the Vitro Chemical Company, now defunct, processed uranium ores to produce ^{308}U, or "yellowcake," for the Atomic Energy Commission (AEC) and U.S. military programs. These operations left about 1.8 million tons of fine, sandy milling wastes or tailings right in the middle of what is now a metropolitan area of more than a half million people.

"Thousands of people work and live in close proximity to the [tailings] pile and are exposed to radioactive dust, radon gas, decay products of radon gas, and gamma radiation," Lyman J. Olsen, director of the Utah State Division of Health, told a congressional committee one day last summer. He was appealing for prompt action on legislation to clean up this site and a score of others scattered over the West, where tailings piles have been left from past uranium milling operations.

It now seems not unlikely that Congress will complete action before adjournment on legislation to deal with the mill tailings problem. Such legislation would have the Nuclear Regulatory Commission (NRC) and the Department of Energy take major new steps to clean up a mess which the old AEC and its congressional overseers were slow to recognize and do anything about.

The tailings problem is large and ever-growing. Besides the 27 million tons of tailings found at inactive sites such as the one in Salt Lake City, another 113 million tons have accumulated at sites where uranium is currently milled. Given the rapid pace at which the uranium industry is now expanding to meet its contracts with electric utilities, there could be a billion tons by the year 2000.

At an active site, tailings first leave the mill as a slurry that is discharged into a pond contained on one or more sides by dikes which may themselves have been made (often none too securely) at least in part of dry tailings. Once the water in the ponds dries up or seeps away, what remains is a dry tailings pile which, unless stabilized and covered over, may be susceptible to wind and water erosion.

Some piles are immense, with the largest in the United States being the active and still growing pile maintained by the Kerr-McGee Nuclear Corporation at its big mill near Grants, New Mexico, where 7000 tons of ore are processed daily. Containing 23 million tons of tailings, it covers 265 acres and rises to 100 feet at its highest point.

The greatest hazard from mill tailings is associated with radon-222, a short-lived daughter of radium-226 found near the end of a chain of long-lived radionuclides that begins with uranium (half-life, 4.5 billion years) and its daughter thorium-230 (half-life, 80,000 years). Unless covered deeply with clay and other material, a tailings pile may exhale radon gas at up to 500 times the natural background rate. Radon's daughter products can cause lung cancer and are responsible for the notoriously high incidence of this disease found in the past among uranium miners in Europe and the United States. The hazard is especially great in situations where radon gas can accumulate in a confined space.

Although the increases of radioactivity in the general environment attributable to tailings and radon gas are small they are never-ending, and significant health effects can be postulated, especially for people living in the regions where the piles are found. As Victor Gilinsky, a nuclear physicist and member of the NRC, has noted, unless the tailings are isolated from the atmosphere they will continue to release radon for more than 100,000 years, becoming "the dominant contribution to radiation exposure from the nuclear fuel cycle."

In fact, according to the American Physical Society's 1977 report on waste management and the nuclear fuel cycle, the ingestion hazard from tailings becomes greater than that from high-level wastes within the first 1000 years.

Whether any cancer cases have already resulted from radiation exposures associated with tailings remains to be documented. But public health authorities in states such as Utah and Colorado where the tailings piles are found are clearly apprehensive, especially with respect to those all too numerous situations where tailings have been used as a

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fill material beneath homes or other buildings. It was recently reported with no little alarm, for example, that in the sleeping quarters of Salt Lake City's Fire Station No. 1, which was built on tailings some 20 years ago, the exposure to radon daughters is seven times greater than that allowed for uranium miners.

In view of such hazards, it is not surprising that Congress is finally moving to take remedial action, both with respect to eliminating (or otherwise dealing with) piles at inactive sites such as the one in Salt Lake City and to making sure that the hazards associated with present and future uranium milling operations are kept to an acceptable minimum.

The Senate passed a bill in mid-September to reinforce the NRC's authority to regulate tailings disposal (over the past 2 years the agency has been making actual and prospective licenses under its purview adopt improved disposal practices). Also, under this bill states that have opted to license uranium mills themselves would have to follow standards at least as stringent as those of the NRC.

This latter guarantee is significant because the NRC has felt legally inhibited (unjustifiably so, the Council on Environmental Quality believes) from insisting that these states meet its substantive and procedural standards. Some states have not required even newly licensed uranium mills to adopt plans to isolate their tailings from the environment by means such as surface burial.

New Mexico, which produces nearly half of the yellowcake extracted from U.S. ores, is a case in point, although its licensing policies are now becoming more demanding. Indeed, a comparison of some of New Mexico's past licensing actions with the NRC's reveals startling and ironic disparities.

For instance, a few years ago the state allowed the United Nuclear Corporation to adopt a tailings disposal plan for its mill at Church Rock which is no great improvement on the environmentally unacceptable disposal practices of the past. Yet about the same time, the NRC, in a proceeding involving another company's license application for a mill in Wyoming (where all mills are licensed by the commission), obtained a commitment to a surface burial plan that represented a marked advance.

The House of Representatives is expected, as of this writing, to take up shortly a tailings disposal bill which its Interior and Commerce committees have

Briefing

Nitrosamines Found in NIH-Approved Animal Feed

A group of scientists at a Waltham, Massachusetts, instrument firm has developed evidence that a laboratory animal feed recommended by the National Institutes of Health (NIH) for use in testing for suspect carcinogens may be contaminated with a significant amount of nitrosamines, which are themselves carcinogens. The findings raise the obvious possibility that, in animal tests with a suspect carcinogen, a heightened incidence of cancer in the test groups may in fact be due to the NIH feed and not to the suspect material.

The scientists—four from the Thermo Electron Corporation in Waltham and one from the Massachusetts Institute of Technology—also detected nitrosamine contamination in concentrations above 1 part per billion (ppb) in seven other commonly used animal feeds they tested.

Most of the amounts were small—less than 3 ppb—but the highest contamination level of all—52 ppb—was found in the NIH open formula rat and mouse ration. Developed several years ago as the ideal diet for small rodents in carcinogen bioassays, the NIH formula has been urged on most NIH contractors by federal officials, and is considered to be widely used.

Joseph Knapka, the NIH official who developed the feed, told *Science* that he is concerned about the finding and intends to analyze other samples to determine if the problem is widespread. The scientists, who detected the contamination with a device they developed several years ago that is exquisitely sensitive to the presence of nitrosamines (*Science*, 23 January 1976), found lower but significant concentrations in other samples.

In response to a reporter's questions, officials at the National Cancer Institute (NCI) were quick to point out that the NIH feed has not been used in any of the NCI carcinogen bioassays now under way. Elizabeth Weisburger, head of the NCI Carcinogen Metabolism and Toxicology Branch, also said that presumably a control group of test animals on the same feed would also experience a heightened incidence of cancer: "As long as the test group is compared with the control group, there is no cause for concern."

Several of the Thermo Electron scientists, however, expressed concern that the nitrosamine feed contaminant could interact with the test substance to produce a synergistic effect. "The test group could have more cancers if the suspect carcinogen was only a promoter and the feed was the initiator," said Gordon Edwards, a toxicologist. He added that he and his group were not certain that the level of contamination they detected was enough to have this effect, but suggested that "feeds should be screened for nitrosamine in future bioassays, particularly when the test substance is fed to rodents in low doses."

Under NIH specifications, the feed, which contains 13 major ingredients plus vitamins and minerals to ensure a normally healthy laboratory rat and mouse population, is already screened for 14 contaminants. Edwards and his colleagues suspect that the source of the nitrosamine contamination is the 10 percent content of fish meal. Dimethyl amine, a precursor of nitrosamine, is a product of spoiled fish. "We suspect that a 15th screen will soon be added to the list," said Edwards.

DOE Appointment Prompts Environmental Heat

When Department of Energy (DOE) Secretary James Schlesinger appointed Ruth Clusen to the post of DOE assistant secretary for environment on 13 September, he immediately acquired the good will of the heretofore combative environmental constituents of that office. Clusen, 56, had just completed 4 years as president of the League of Women Voters, and considers herself "strongly identified with environmental goals."

Just as quickly, however, some of that good will evaporated when Clusen appointed her predecessor in the post, James Liverman, as her deputy, apparently at the request of higher officials in the department. Several environmental groups, including the Natural Resources Defense Council, the Environmental Policy Center, and Ralph Nader's Congress-Watch, expressed concern that Liverman was retained and now serves as Clusen's sole deputy. "Liverman didn't really

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approved. Its provisions for strengthening federal and state regulation of tailings disposal are similar to those of the Senate-passed measure.

But, in addition, this bill would have the Department of Energy clean up all of the inactive piles except perhaps for a few for which some company might be made financially responsible. The federal government would pay 90 percent of the total cost, which has been estimated, perhaps optimistically, at about $140 million; the states in which the piles are found would pay the other 10 percent.

The milling companies that created the piles will, it seems, not bear any of the cost of the cleanup. The rationale here is that the companies were operating under "cost-plus" contracts with the AEC that did not require or provide money for any better means of tailings disposal. In light of the AEC's failures in this regard, the states that have the piles argue that the federal government should foot the entire bill for the cleanup, and a tailings bill recently reported out of committee in the Senate so provides.

Most of the 20-odd inactive piles are fairly remote from cities and towns, but several are not. The exceptions include the pile in Salt Lake City and two in Colorado, at Grand Junction and Durango.

The Salt Lake City pile is expected to receive priority attention. The numerous options studied for dealing with this pile range in price from as little as $550,000 to more than $30 million. The less expensive options would all leave the pile in place, although some would provide for a covering of dirt and vegetation.

Utah health officials are insisting on removal by rail of the pile and 2 feet of radium-contaminated earth beneath it to a remote desert site 90 miles west of Salt Lake City, where all of the material would be placed in a natural depression and covered over. In their view, such removal is the only remedy because, they say, to reduce the radon emanations from the pile to near background levels would require capping the entire 128-acre site with a 22- to 30-foot layer of soil or an 8-foot layer of cement.

The task that awaits at Salt Lake City tells something about the size and difficulty of the tailings cleanup overall. Actually, the Salt Lake City pile is small compared to certain of the other inactive ones, and is but a tenth the size of Kerr-McGee's giant active pile in New Mexico. Although the Kerr-McGee site is 15 miles or so from the nearest town, this 23-million-ton pile, along with a half-doz-

Briefing

try to represent environmentalists or ascertain the environmental viewpoint," says one public-interest lobbyist.

This concern was voiced prior to Clusen's swearing-in. In response to it, Clusen obtained an understanding with DOE officials that she would have a free hand in the selection of her deputies, according to several sources. Once in the post, however, the understanding was changed to mean that she would hire James Liverman and one other deputy, whom she has yet to name.

Liverman, a biochemist, had been acting assistant secretary since October 1977, when DOE was formed from the Energy Research and Development Administration, where he had the same post. Previously, he had been the general manager for biomedical research at the Atomic Energy Commission (AEC), and it was there that he became involved in the controversy that remains the major sticking point between him and environmental groups throughout Washington. Specifically, Liverman was a principal figure in the cancellation of an AEC contract with University of Pittsburgh epidemiologist Thomas Mancuso on the effects of exposure to low-level radiation at a nuclear power plant in Hanford, Washington. The study was canceled abruptly in 1974, allegedly because it showed a significant incidence of cancer among workers at the plant exposed to levels of radiation 10 to 20 times below the federal standard. Liverman has said he acted in good faith but may have erred in judgment in ordering the cancellation.

One effect of the controversy over the cancellation, which is currently under investigation by the General Accounting Office and the AAAS, may be the removal by Congress of DOE's authority to conduct radiation research through the department that Clusen now heads.

Clusen has tried to assure outsiders that Liverman will have only administrative and not policy responsibilities in her office, which altogether is responsible for a $300 million budget and more than 300 employees (both are small by DOE standards). Clusen said she intends to more often seek the views of outsiders and to "be a strong voice to the department on environmental concerns here."

Moss Announces Retirement

Among the 31 members of the House of Representatives who have announced their retirement this year is California Democrat John E. Moss, 63, who for the last 20 years has been one of the most vigorous congressional advocates of the public's right to government information and of congressional oversight.

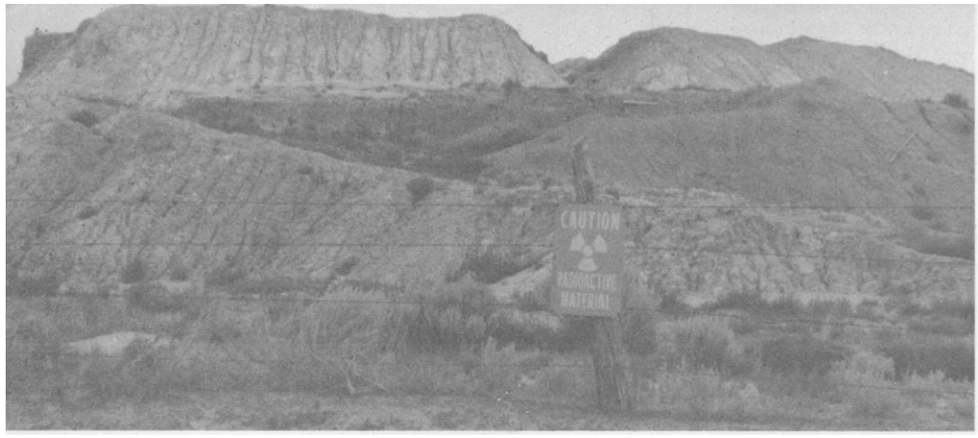
Moss was the principal author of the Freedom of Information Act, which he describes as "taking 15 years to pass" and which will undoubtedly be his greatest legacy. He also sponsored a half dozen major bills in the area of consumer protection, includng the act establishing the Consumer Product Safety Commission. But his major strength was in the area of regulatory and bureaucratic oversight from his base as chairman of an oversight and investigations subcommittee. Through hearings, he publicized dozens of issues of concern to consumers, including TRIS-treated sleepwear, Firestone 500 tires, and the incidence of unnecessary surgery.

Typically, Moss used the hearing process to excoriate bureaucratic malingerers; witnesses who appeared before him were warned that his procedure was to start early, stay late, and be extremely tough. An oft-told story about him is the occasion when he was hearing testimony in the U.S. embassy in a Latin American country on waste in the U. S. foreign aid program. In the midst of the proceedings, in a crowded room wth poor air-conditioning, the power failed and the lights went out, and everyone expected to go home. Out of the darkness, says one of Moss's staff aides, came the congressman's voice: "Mr. Ambassador, will you please bring in some candles?"

With such diligence that he has at times been described by colleagues as self-righteous, or a headline-hunter, Moss was able to kill through oversight hearings plans in the 1960's for a federal network of computers and spur federal agencies to enforce conflict-of-interest regulations for their employees. In 1976, his subcommittee produced a 400-page tome on the functioning of nine major regulatory agencies in Washington, appraising each according to its public responsiveness and recommending dozens of reforms.

Moss's decision to retire came largely as the result of declining health, due in large part to an auto accident last year.

—R. Jeffrey Smith



An abandoned tailings pile in New Mexico's uranium belt. It is from a milling operation of 15 to 20 years ago by Phillips Petroleum. [Photo by Rudi Schoenmackers]

en other active and inactive ones in the Grants uranium belt, represents a significant regional source of radon gas. Yet to move all of these tailings and bury them would be something akin to moving and burying a small mountain.

What, then, should be done? A finding in the American Physical Society report bears solemnly on this question. "For long-term waste management, the hazard associated with radium [parent of the radon emanating from tailings] is more significant than that for plutonium [found in spent fuel and high-level waste from reprocessing]. In addition, for regional population exposure, radionuclides in uranium mill tailings are potentially at least as important as the actinide elements in high-level waste; *the relative accessibility of mill tailings contrasts with the isolation proposed for other actinide-containing wastes*." [Emphasis added.]

If this means that all tailings, including the accumulations from the past, should be buried, this is going to add a significant though probably not by any means unbearable cost to the nuclear fuel cycle. For tailings generated by new mills as yet unplanned and unbuilt, the disposal problem can be made much more manageable through a careful review of alternatives when an environmental impact statement is being prepared (in several uranium-producing states outside the NRC's purview, such as New Mexico, no such statements have been prepared).

In the case of tailings piles at active mill sites which were generated in whole or in part under AEC contracts, the government could well wind up paying a good share of the cost of ultimate disposal. Indeed, two such piles in New Mexico would be covered by the pending cleanup legislation. Although it is not included in the bill, the Kerr-McGee pile dates back to 1958 and is an outstanding example of so-called "commingled" pile, containing both tailings from AEC contract operations and tailings from more recent operations under commercial contracts.

George L. Gleason, executive vice president of the American Nuclear Energy Council, was speaking for the uranium industry recently when he recommended to a congressional committee that existing mills and tailings piles in states such as New Mexico be exempted from having to meet NRC disposal criteria. "The retroactive application of [such] criteria could place an economic hardship on mill operations and disrupt production," Gleason said.

Another industry witness, Maxie L. Anderson, president of Ranchers Exploration and Development Corporation of Albuquerque (and one of the trans-Atlantic balloonists), noted that his company is able to reprocess, at a profit, tailings from a pile at Naturita, Colorado, thereby recovering uranium not captured in the relatively inefficient milling operation originally carried on at this site. But the uranium content of some if not most of the piles might not be great enough to make such processing and disposal ventures attractive to industry even if the government put up part of the money (as Anderson suggested would be appropriate in certain cases).

Since its establishment in early 1975 as a successor to the AEC, the NRC has been trying to turn over a new regulatory leaf wth respect to tailings disposal, and, given the poor record of its forebear, it has had every reason to. During its long tenure the AEC failed to respond effectively to repeated and in some cases early warnings that proper tailings disposal had to be counted as an important part of radioactive waste management.

For instance, there was the discovery in the late 1950's by investigators from the Federal Water Pollution Control Agency (FWPCA) that tailings and other wastes from the uranium mill at Durango had severely polluted the Animas River. Downstream in New Mexico, where the towns of Farmington and Aztec depended on the Animas for drinking water and farmers looked to it for irrigation water, there was such a protest that the FWPCA called an interstate pollution abatement conference.

To stop the outcry, the AEC directed its uranium mill licensees to "assure that concentrations of radioactive material in mill areas and in wastes discharged into streams are brought within permissible limits." This stopped the wholesale pollution of the Animas, but, without regulations to isolate the tailings from the forces of wind and water erosion, it was not enough. The Durango piles remained in place on a mountainside above the town, unstabilized and a clear hazard.

The fact is, the AEC still had not really acknowledged that tailings constituted a significant health hazard. Indeed, in September 1959, the agency authorized the Vitro Chemical Company to sell tailings from the Salt Lake City pile to a construction company for use as fill material. Such sales continued for a time until state health officials objected. Later, they verified that the tailings contained radium in disturbing amounts.

Yet, as H. Peter Metzger has reported in his book *The Atomic Establishment*, in the spring of 1962 (well after Utah health officials had put a stop to the sale of tailings as fill), the AEC was still avoiding the issue. An AEC official, responding to an inquiry from the milling company at Durango about use of tailings in construction work, chose not to answer the question but to reply simply that "tailings . . . are not subject to licensing requirements."

What finally forced the tailings problem to public attention was the astonishing discovery, which began unfolding in piecemeal fashion in early 1966, that hundreds of buildings in Grand Junction, Durango, and other places were contaminated with radiation from the use of tailings as fill. In 1972 the Congress was finally aroused to action and in that year it initiated a multimillion dollar project (with the state of Colorado paying a fourth) to decontaminate—by recovering the tailings fill—all buildings in the Grand Junction vicinity with radiation levels exceeding limits established by the U.S. Surgeon General. (According to a recent report of the General Accounting Office, the project has gone slowly; remedial work, on which $6.5 million has been spent, is reported to have been completed at less than half of the 700 sites needing it.)

In 1974, the same year Congress was breaking up the AEC and beginning to look with a fishy eye at its Joint Committee on Atomic Energy, a step toward a more general cleanup was taken with the authorization of an engineering survey of inactive piles. Senator Frank Moss, from Salt Lake City, was a prime mover behind this legislation.

That the NRC began taking hold of the tailings problem shortly after it was created was, as commissioner Gilinsky has acknowledged, partly due to prodding from the Natural Resources Defense Council (NRDC), an environmental law group. The NRDC filed a petition with the new agency asking that a generic environmental impact statement (GEIS) on tailings disposal be prepared and that uranium mill operators be required to post a performance bond that would cover the cost of such improved practices as might ultimately be required.

The NRC agreed to prepare the GEIS (to be issued later this year), and while it did not immediately adopt the proposal for performance bonds it eventually did so. Also, by the spring of 1977, the agency had adopted a set of performance objectives for tailings management and was insisting that companies applying for NRC licenses or license renewals observe them.

One prime objective is to have all new uranium mills sited remote from centers of population, and to have all tailings disposal sites so situated as to avoid or minimize "disruption and dispersal by natural forces." Another is to reduce, for tailings disposal sites new and old, gamma radiation to essentially background levels and radon emanations to about twice such levels. In addition, any need for continued monitoring and maintenance following tailings disposal and site reclamation would be eliminated.

An early practical test of these objectives came with a license application by the Rocky Mountain Energy Company of Denver, the mining subsidiary of the Union Pacific Corporation, to build a uranium mill in Wyoming in a joint venture with the Southern California Edison Company. This Bear Creek mill, already in operation on a company claim 70 miles northeast of Casper, is now disposing of its tailings in a carefully designed and engineered surface disposal facility but will eventually switch largely to subsurface disposal. All dry tailings will be backfilled into deep, specially prepared surface mining pits created in extracting the uranium ore; this disposal method will be similar to the United Nuclear Corporation's proposed Morton Ranch operation (near Douglas, Wyoming) which the NRC regards as a model.

The NRC is not insisting that its licensees go to the large expense of removing existing tailings piles and burying them. Instead, it is requiring that these piles be regraded to resist erosion and then covered with clay and other soil to a depth (usually of 8 to 12 feet) sufficient to meet the objective of reducing radon emanations to twice background levels. Agency staff people say that such "above-grade burial" can be adequate, especially if the pile is nestled among terrain features and is not on an exposed site.

How disposal plans of the kind described above square with the new awareness of the hazards that mill tailings pose for the long term will no doubt be fully discussed at public hearings next year on the GEIS. Tailings quite obviously cannot be disposed of in geologic repositories in the manner proposed for high level and transuranic wastes; they are far too voluminous for that even if, from the standpoint of minimizing radiation exposure over the millennia, a case could be made for it. But there clearly is a question as to how far federal and state regulatory authorities should go in making concessions to economic expediency.

However such questions may be resolved, it is clear that the NRC and Congress have now begun in earnest to address the tailings disposal problem with the seriousness it deserves.

—LUTHER J. CARTER

Fermilab in Transition: The Wilson Era Ends

Fermilab—the 2-kilometer-diameter accelerator laboratory on the plains of northern Illinois—was the unique creation of Robert R. Wilson, an extraordinary builder, technical visionary, and architect who controlled almost every detail of his organization and forcefully directed the company's largest accelerator for 11 years.

When he resigned last February in an effort—ultimately unsuccessful—to get more money for his laboratory, the circumstances were unusual. There was the hint that he might be persuaded to return if more money somehow came along, and in any event, he requested that the board of trustees keep him on in a subordinate capacity while his erstwhile deputy was promoted to be the new director. Indeed, the circumstances were unusual enough to raise questions about whether the old era of Wilson would be followed by a new era of Wilson, or whether his dominant influence on the laboratory—a controversial issue through much of his tenure—was ending.

Six months after Wilson's resignation, the delicate task of choosing new leadership has apparently come to a conclusion. As evidenced by the time required, resolution of the laboratory's quandary was not simple. Even after the board of trustees of the independent organization that directs Fermilab, University Research Associates, settled on a new director, difficulties with the funding agency, the Department of Energy (DOE), delayed final approval. The department apparently had no objection to the person chosen by the board, but bureaucratic hurdles nevertheless held up the choice from mid-August to the present. Officials at the DOE say the last hurdles have been overcome and an announcement is due in a matter of weeks.

The new director is expected to be Columbia University physicist Leon Lederman, a talented and self-effacing experimentalist who has been closely connected with the laboratory from its beginnings in 1964. Having spent his research career working on a broad range of experiments performed in many different laboratories, and much of his time at Fermilab sparring with Wilson in a friendly fashion, Lederman is expected to bring a distinctive style to the laboratory. Well known as a charming humorist, Lederman is also rated high by his colleagues for his "taste in science," energy, toughness, and understanding of the factors that can bring a loss of vitality to a laboratory. If—as seems virtually

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