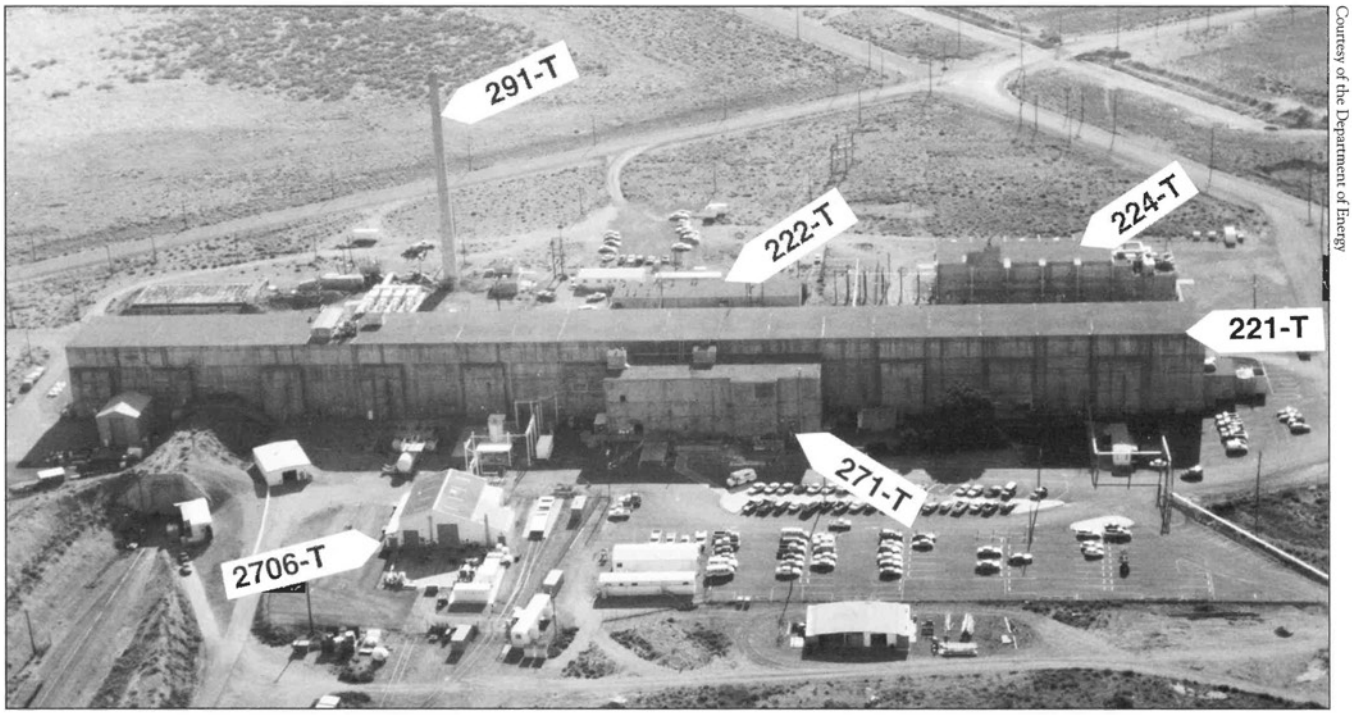
By Michele S. Gerber

Hanford's PAC-MEN

Five Plutonium Separations Plants Await Decommissioning



Courtesy of the Department of Energy

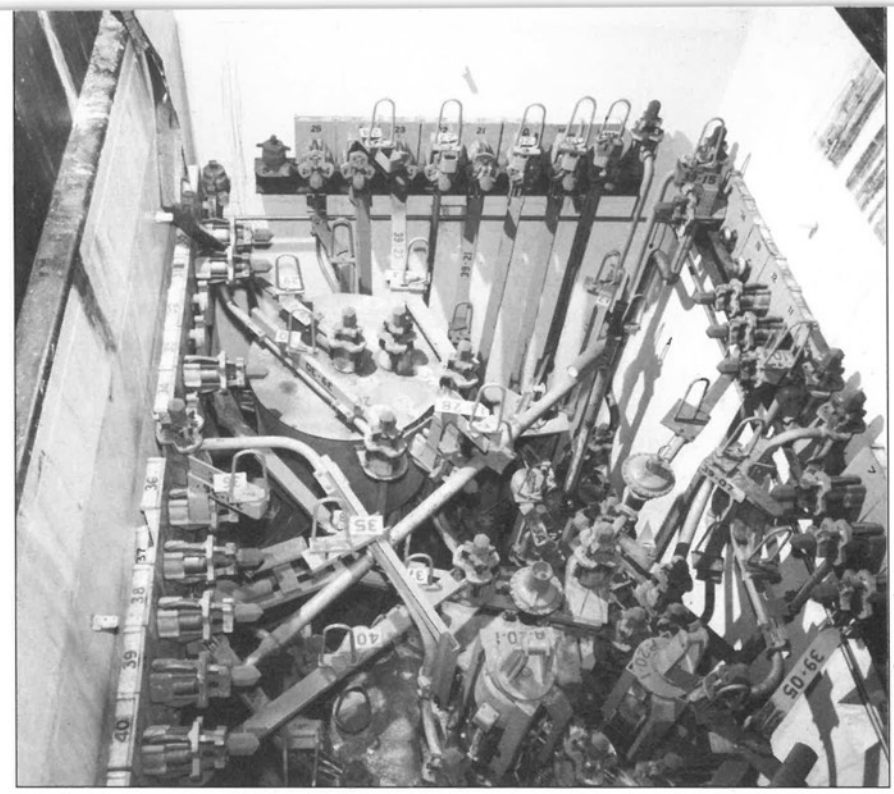
AT THE PRESENT TIME five giant chemical processing buildings, used at the Hanford Site to separate plutonium and uranium from irradiated uranium fuel elements during the World War II and Cold War eras, await the final phase of their life cycles: decontamination and decommissioning (D&D). These cavernous structures were originally called "Queen Marys" or "canyons" by Hanford workers because of their enormous size, and more recently they were dubbed "Pac-Men" by former DOE Assistant Secretary Thomas Grumbly because their costs "could eat the Department of Energy."

Two of the buildings are presently unoccupied, two are undergoing cleanout and deactivation, and one is preparing for at least a ten-year role as a waste processing and decontamination facility in the site's cleanup mission. Standing as stark and gray reminders of past defense imperatives, these structures now must undergo scrutiny as decisions about their ultimate disposition are negotiated.

The oldest of the canyon buildings, T-Plant, B-Plant and U-Plant, date from the 1943-44 construction frenzy of the Manhattan Project, the wartime effort to produce the world's first atomic weapons. Originally designed as 810-foot-long identical triplets, each contained 40 concrete cells with thick walls

OPPOSITE PAGE:
The T-Plant complex in 1993: 291-T is the exhaust stack; 271-T is the office area; 224-T was part of the old World War II processing but now stores wastes contaminated with transuranic elements; 222-T (now idle) was a World War II process control laboratory; 221-T is T-Plant itself; 2706-T is the low-level decontamination annex.

RIGHT: Radiochemical processing equipment inside a shielded cell, U-Plant, 1960s.



Courtesy of the Department of Energy

and huge cover blocks. In these cells, uranium fuel elements that had passed through the inferno of Hanford's reactors first were to be dissolved and then pumped through various steps that added and mixed chemicals to unlock the desired plutonium from its waste by-products. Early in the construction phase, however, a special 65-foot addition was placed on the head end (northeast end, in this case) of T-Plant. This annex, fitted with miniaturized versions of the actual processing equipment, served as a radiochemistry laboratory to research and develop improvements in the separations process.

Original Separations Method

THE WORLD WAR II Hanford Site used the bismuth-phosphate separations method, a batch precipitation process that achieved separation by repeatedly centrifuging and redissolving various plutonium-bearing solutions. Based on the principle that bismuth phosphate (sodium bismuthate combined with phosphoric acid) is similar in crystal structure to plutonium phosphate, the process manipulated the valent state of plutonium so that it alternately was carried along with, or left behind, bismuth phosphate solutions. As the various solution transfers took place, a more and more purified and concentrated batch of plutonium-bearing solution emerged. This solution was purified further in additional, smaller Hanford structures until a plutonium nitrate paste, similar in consistency to unset gelatin, emerged as the site's final product. (Terminal processing steps that fashioned the paste into metallic weapons shapes took place at the Los Alamos Site in New Mexico.)

T-Plant began operations using the bismuth phosphate process on December 26, 1944, and became the headquarters of Hanford's chemical processing operations. The process itself, initially extremely slow and wasteful (processing one ton of irradiated uranium per day), managed to reduce its chemical consumption dramatically and bring the time cycle for processing one batch down to four hours by 1956. In April 1945 B-Plant became operational.

Due to the efficiencies implemented at T- and B-Plants, U-Plant, although completed shortly thereafter, was not needed. Rather than subject it to radioactive contamination, Hanford operators decided to hold U-Plant in reserve. It served as a "cold" training facility (one that used unirradiated materials) for the next five years.

T- and B-Plants, together with Hanford's original three reactors, produced the plutonium used in the world's first, third, fourth and fifth atomic explosions: the Trinity bomb test of July 16, 1945; the weapon dropped over Nagasaki, Japan on August 9, 1945; and the Able and Baker test shots detonated in Operation Crossroads at Bikini Atoll in the South Pacific in July 1946. (These same facilities also produced the plutonium used in the 1948 Operation Sandstone and 1951 Operation Greenhouse nuclear tests conducted at the Pacific Proving Grounds, as well as the 1951 Operation Ranger and Operation Buster trials at the Nevada Test Site.)

T- AND B-PLANTS, TOGETHER WITH HANFORD'S ORIGINAL THREE REACTORS, PRODUCED THE PLUTONIUM USED IN THE WORLD'S FIRST, THIRD, FOURTH AND FIFTH ATOMIC EXPLOSIONS.

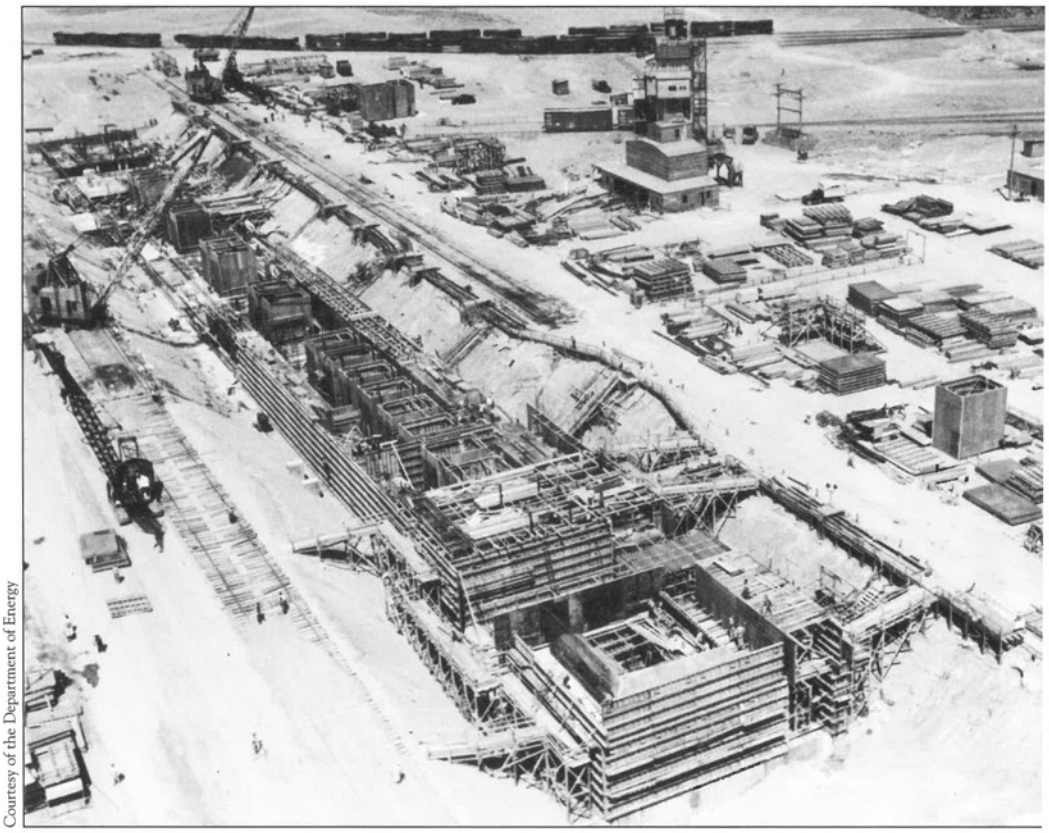
Cold War Fosters New Process

THE EMERGING TENSIONS of the Cold War prompted a series of seminal decisions to increase America's atomic weapons supply in the spring of 1947. The new Atomic Energy Commission (AEC, successor agency to the Manhattan Project) turned to the Hanford Site for quick re-

sults. It ordered the immediate construction of two new, standard-issue, graphite moderated reactors and the development of a prototypical solvent extraction chemical processing plant.

Solvent extraction, a continuous process that would separate and save not just the plutonium but the unconverted (unfissioned) uranium in the irradiated fuel elements, had been the process of choice since the earliest days of the Manhattan Project. However, the exigencies and short deadlines of wartime had prevented its development. Now the AEC was adamant. Supplies of fresh uranium were limited, and the builders of the new atomic frontier believed that they could afford to waste none of it.

The new process developed at Hanford was called REDOX (reduction oxidation). It utilized a methyl isobutyl ketone ("hexone") chemistry, and produced both a liquid plutonium product stream and uranyl nitrate hexahydrate (UNH), a uranium product stream complexed in acid. UNH then could be sent to another facility for calcination into uranium trioxide powder and used as part of the feed material in other nuclear processes.



Courtesy of the Department of Energy

B-Plant under construction, 1944.

Construction was begun on the REDOX production facility itself in 1949, and the plant opened to "hot" operations (those using irradiated materials) in January 1952. Although it was only 467 feet long, the REDOX canyon was much taller than T-, B- and U-Plants, due to significant differences in its processing configuration. It also was vastly more efficient. The Hanford Site produced 44 percent more plutonium in 1952 than it had in 1951, and the overall output was more than five times as much as that of 1947. Just a few months after REDOX proved itself, B-Plant was retired from service. Production rates continued to climb, with the total plutonium output of the Hanford Site nearly doubling during the period 1953-55, and the REDOX plant processing almost 85 percent of that amount.

THE HANFORD SITE PRODUCED 44 PERCENT MORE PLUTONIUM IN 1952 THAN IT HAD IN 1951, AND THE OVERALL OUTPUT WAS MORE THAN FIVE TIMES AS MUCH AS THAT OF 1947.

Uranium Recovery Mission

URANIUM WAS IN very short supply in the early 1950s when the Manhattan Project's cache from the "Belgian Congo" (now Zaire) had been consumed and large deposits in the Colorado Plateau and western Canada had not yet been discovered. The desire not to waste uranium prompted another key development at Hanford. U-Plant, nearly idle since its 1945 completion, was modified to conduct the "metal (uranium) recovery" mission. A solvent extraction process utilizing tri-butyl phosphate (TBP) diluted with natural paraffin hydrocarbon (NPH, a saturated kerosene) as the extractant was developed and fitted into U-Plant. Underground tanks holding uranium-laden, high level wastes from the bismuth phosphate process were sluice-mined to deliver their contents to specially constructed vaults. There, the wastes were liquefied with acids and sent through the U-Plant cells to recover the precious metal. The U-Plant mission was carried out from 1952 through late 1957, when most of the bismuth phosphate wastes had been processed.

Meanwhile, the Cold War surged ahead, fueled by the unfolding of famous spy cases, the Korean Conflict, and the nearly simultaneous American and Soviet development of thermonuclear (hydrogen) weapons in 1952 and 1953. President Dwight Eisenhower campaigned in 1952 on the pledge that he would cut the burgeoning defense budget with a "new look" in armaments. Coupled with the policy of

"massive retaliation," the Eisenhower presidency meant one thing for the Hanford Site: more dramatic expansion. "Program X," discussed in the AEC's inner circles throughout 1952, came to fruition at Hanford under Eisenhower's direction. Two new reactors, massive by the standards of the day, along with vastly augmented plutonium separations capacity in the form of a huge new processing plant, were constructed during 1953-55. The PUREX (plutonium-uranium extraction) facility, Hanford's largest at just over 1,000 feet long, was designed to separate 200 tons of irradiated uranium per month. It began hot processing in January 1956.

PUREX Satisfies Demand

DURING THE PUREX construction period, the U.S. demand for plutonium was so great that the Hanford Site embarked on the "4X Program." It was so named because it planned to operate all four of the site's chemical processing buildings (aside from U-Plant) for plutonium separations. Renovations for the restart of B-Plant took place throughout 1955, and were completed just as the PUREX facility came on line. However, the first year of PUREX operations demonstrated such an overwhelming production capacity, along with economic efficiency as compared with the other separations plants, that the 4X Program was abandoned. In 1956 alone, the PUREX facility processed 56 percent of the total plutonium output of the Hanford Site, and the total 1956 production was 59 percent above that of 1955. T-Plant was shut down as a processing facility in mid 1956, and plans to restart B-Plant were terminated.

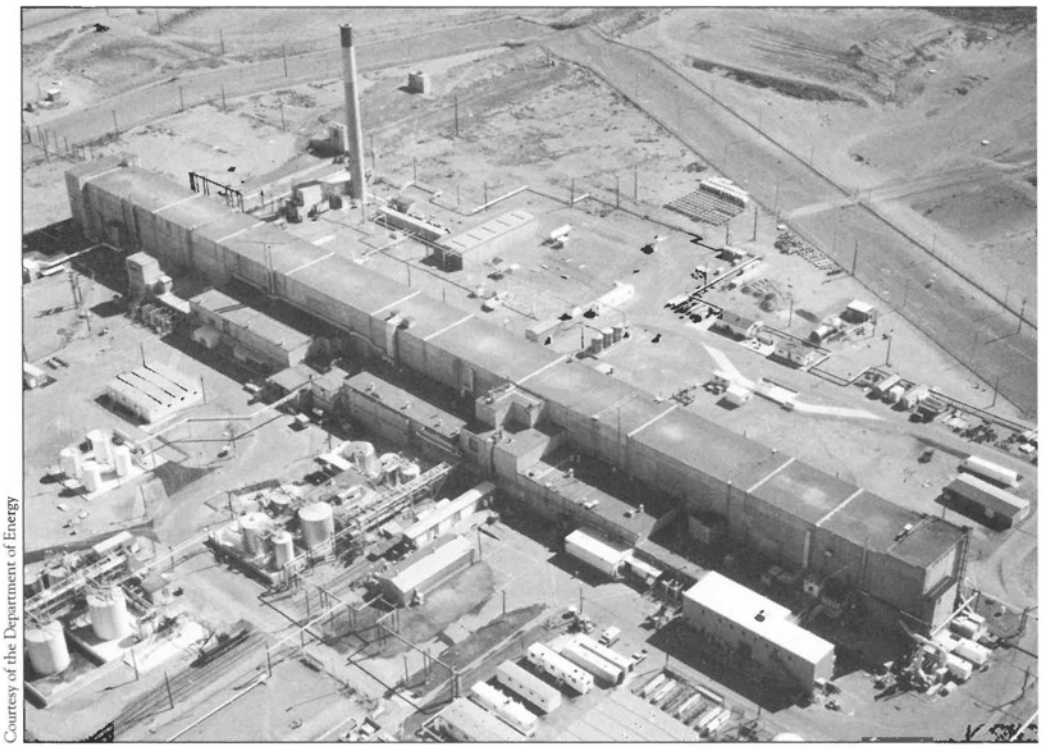
The design of the PUREX plant incorporated several new features that accounted for its vast efficiency. Like the U-Plant, it utilized a TBP/NPH chemistry, albeit in different proportions from those used in the metal recovery mission. Not only were these chemicals more efficient in plutonium extraction than the hexone used at REDOX, but they had a higher flash point, which meant that no components of the PUREX plant had to be built to explosion-proof standards. Also, another key chemical used at REDOX, aluminum nitrate, could not be recycled and reused, while the nitric acid used at PUREX could be partially decontaminated and reworked. Additionally, the PUREX facility moved its solutions through electrically pulsed columns rather than through the packed columns that had necessitated making the REDOX plant so tall. Unique in-line monitoring instruments also were especially designed for continuous operation in the PUREX facility, and equipment innovations acted to prolong equipment life.

Over the years of operation many other equipment changes at PUREX acted to improve efficiency and boost production still further. In 1958 the plant began the recovery of neptunium 237 from its normal product stream. Immediately, the facility became the AEC's prime supplier of this isotope, much desired for its space power applications. In October 1960 PUREX reached the point of having processed 22,000 tons of irradiated uranium, thus surpassing the combined totals of T- and B-Plants and the REDOX facility during all of their years of operation. By that time PUREX was processing 80-85 percent of the irradiated uranium at Hanford, with the REDOX plant handling only the small portion of "E-metal" (enriched uranium) used in special reactor loadings. By 1965 the PUREX facility was operating routinely at four times its initial design capacity of 200 tons per month. Two years later the REDOX plant completely ceased operations, and PUREX became the sole provider of separations processing at the Hanford Site.

Sole Provider Ordered to Close

THE PUREX FACILITY operated until 1972, when it was placed on standby for eleven years. Many modifications were made during that period, especially in terms of waste minimization and waste management, in response to changing federal and site policies. In 1983 it resumed operations as part of the nuclear arms buildup mandated by President Ronald Reagan. Beginning in the mid 1980s the plant closed and restarted a number of times in response to safety and environmental

PUREX plant in 1990.



Courtesy of the Department of Energy

incidents. The Department of Energy (DOE, a federal heir to the AEC) placed the PUREX facility on "standby" status in October 1990 and issued a final closure order in December 1992.

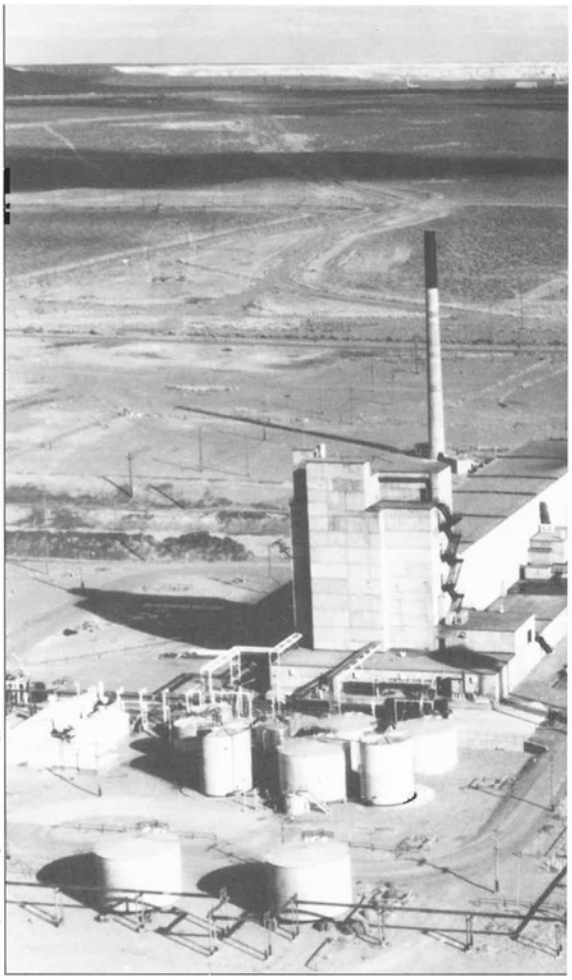
Today the PUREX plant is entering the fourth and last year of a model deactivation plan. Deactivation is the facility transition phase between operations and D&D. During deactivation hazardous chemicals and bulk nuclear materials are removed from the plant, and contamination resting on interior surfaces or within pieces of equipment are fixed with special sealants or isolated so that it cannot migrate into the environment. These steps are necessary to decrease the frequency of expensive monitoring and maintenance activities. Lastly, utilities will be disconnected, and no workers will inhabit the building except to perform periodic surveillances. However, neither equipment nor the building itself will be removed.

Supported by more than 100 complex schedules of activities, "loaded" with manpower and other resource needs, the PUREX deactivation project will cost approximately $160 million over a four-year period. Thereafter, it is projected to save the $35-40 million per year that was spent in the early 1990s to monitor potentially mobile contaminants within the huge facility. Public involvement has been sought concerning the methods and strategies used in the deactivation project and will be sought as to the final disposition of the building and its ancillary and associated structures.

B-Plant Engaged in Deactivation

LIKE PUREX, B-PLANT today is engaged in the business of deactivation, having received its DOE order for terminal clean-out in 1995. After its 1952 shut down, B-Plant stood idle, except for miscellaneous storage activities, until 1961 when renovation began for the Fission Product Recovery Mission. Officially designated a waste management activity, this project operated from 1968 to 1984 to recover cesium 137 and strontium 90 out of Hanford's high level waste. The isotopes attracted various off-site customers interested in medical, space power and other applications. In 1974 a companion facility called the Waste Encapsulation and Storage Facility (WESF) was completed on the west end of B-Plant to enclose, cool, store and monitor the capsules that held these high-heat-generating isotopes. WESF and B-Plant were tied by common utilities and power sources, but because an ongoing storage mission exists for WESF, the facilities will be split or "de-coupled" during the deactivation process.

In 1985 B-Plant undertook a demonstration project in the pretreatment of neutralized current acid waste, one form of high level mixed waste from Hanford's underground storage tanks that will need to be solidified or otherwise stabilized as part of the site's overall cleanup. In 1991, however, DOE decided that the old facility could not meet modern standards required of pretreatment plants. Since that time major clean-outs of specific B-Plant areas have taken place, and the push to achieve "minimum operations" (staffing by only a few people) is expected to be completed about the year 1999. The task facing B-Plant is difficult in that the fission product separations mission produced levels of residual contamination far in excess of those existing in other Hanford canyon buildings. Meanwhile, public input is being sought concerning both the B-Plant deactivation project and the future of WESF.



Courtesy of the Department of Energy

REDOX facility, early 1950s.

SUPPORTED BY MORE THAN 100 COMPLEX SCHEDULES OF ACTIVITIES, THE PUREX DEACTIVATION PROJECT WILL COST APPROXIMATELY $160 MILLION OVER A FOUR-YEAR PERIOD.

T-Plant Support for Cleanup

IN CONTRAST TO B-Plant, T-Plant now bustles with major upgrade activities required to obtain its permit to perform waste processing and decontamination operations throughout at least 10 years of the Hanford Site waste cleanup. Almost immediately after its 1956 shutdown as a chemical processing facility, T-Plant began its conversion to the site's equipment decontamination center. In 1958 an annex known as 2706-T was constructed just west of the plant to perform decontamination on equipment contaminated with only low levels of radioactivity. Using sand or steam blasting, chemical rinses, high-pressure water sprays and other abrasive methods, T-Plant and 2706-T operated for over three decades to reduce contamination levels on equipment sent from various other Hanford facilities. Significant equipment replacement and disposal costs were thus saved.

However, the unglamorous decon-

tamination business made T-Plant an "orphan facility" over the years. In other words, it was used by many organizations within the Hanford contractor companies, but no one took singular responsibility for maintaining the facility itself. As a result, 1990 found the old plant and its annex in a degraded state, and a "limited operations" order issued in January 1991 forged a Task Team to evaluate the plants' viability for future operations. When the team concluded that central, on-site decontamination facilities were economic and logistical necessities for Hanford's cleanup, T-Plant and the 2706-T annex began the long road back with a series of transforming modifications.

In early 1994, 2706-T passed its full-scale operational readiness review and now performs regular low-level decontamination and waste repackaging operations. More extensive upgrades are needed at T-Plant itself, and the permitting process will take longer. As soon as it can meet modern requirements the old facility will take its place, albeit still not an exalted one, as a workhorse in the Hanford Site cleanup. No future date for its ultimate D&D has been scheduled.

U-Plant and REDOX Stand Idle

NEITHER U-PLANT NOR the REDOX facility took on new missions after their initial ones were completed. Because it did not process irradiated reactor fuel, U-Plant did not acquire the high levels of contamination that accrued to the other Hanford canyon facilities. Therefore, not much clean-out or deactivation was done after the 1957 shutdown. U-Plant served as a storage facility for contaminated equipment from around the Hanford Site for many years, with some intermittent but fairly insignificant decontamination work performed on machinery. Today the facility receives periodic surveillance and is scheduled for final D&D to begin in 2023.

The REDOX facility underwent deactivation procedures that were state-of-the-art for the 1967 time frame in which they occurred. Work began with a complete flushing of the process equipment and lines with a 57 percent nitric acid solution. The product solution then was mixed with dissolved fuel solutions in the PUREX plant and processed for residual plutonium recovery. Intermetallic compounds and vessel sludges then were dissolved with other acids and flushed from the REDOX facility. This procedure was followed by caustic flushes and then steam blasting. Much of the process piping, maintenance and waste lines, and some of the utilities were blanked off, and bulk fresh chemicals and pyrophoric materials were removed. The waste pond was blanketed with fresh raw water, but the waste cribs, diversion boxes and tanks were kept in operation for use by other Hanford facilities.

For two years the REDOX plant existed on standby status while negotiations for its potential use as a commercial reactor fuel reprocessing plant took place. When the commercial mission was ruled out, the facility received its final "layaway" order in August 1969. The few more "deactivation extension" activities that were carried out became the last initiatives, aside from routine surveillance checks, to occur at the plant since that time. REDOX's final D&D is scheduled to begin in 2016.

Today at the Hanford Site all waste cleanup work is being reevaluated in light of a goal set in May 1996 by incoming DOE Assistant Secretary for Environmental Management (EM) Al Alm. In a letter to DOE's EM employees, Alm stated that he intended to "reduce most of the risks and most of the mortgages over a ten-year period." Toward achieving this goal, he listed reduction of the "large costs that are being devoted to sustaining the current" facilities as a primary step. In other words, like Grumbly, Alm sees aging canyon facilities such as the five Hanford relics as costly burdens on the entire DOE system, and he is looking for ways to streamline their deactivation, their follow-on surveillance and maintenance, and their ultimate D&D.

Will he entertain the idea, already advanced by some at the Hanford Site, of turning the canyon buildings into "tombs" for layer upon cemented layer of low and mixed level wastes, covered by a specially permitted "cap" of earth and engineered barriers? If the entombment idea prevails, the canyons would not be torn down but would become "permanent" (as far as can be foreseen) waste disposal units. If this were to happen, would historians and archaeologists of future ages be able to read our history in these landmarks as surely as those of today read the lifeways of Indian cultures in burial and ceremonial mounds or interpret the traditions and values of ancient Egyptians in the Sphinx and pyramids near the Nile River? If so, what would building entombment, as opposed to removal, say about the constant effort put forth at Hanford to subdue and control nature?

Michele S. Gerber is principal historian for the Westinghouse Hanford Company and author of On the Home Front: The Cold War Legacy of the Hanford Nuclear site *(1992). She has worked for historical agencies, served as a history consultant, taught American history, and served as National Academy of Sciences committee member.*

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FRONT COVER: Woman's dress, Plains (Blackfeet) or Plateau, collected by Peter John De Smet, S.J., 1859. This dress was one of several presents sent by De Smet to Belgian relatives and patrons following the meeting in 1859 between General Harney and Plateau chiefs at Fort Vancouver. The cut of the yoke, the pony-bead circles at the shoulders, and the uneven hem line all suggest Blackfeet manufacture. See related story beginning on page 24. BACK COVER: *Sheet music issued by the Northern Pacific Railway Dining Car Department, c. 1910. The song consisted of three verses and this chorus line: "For your breakfast dinner or lunch, on the N.P.R.R. in the Dining Car, Get a Great Big Baked POTATO." See related story beginning on page 20. (Special Collections, Washington State Historical Society)*