

CHEMICALS AND EXCESS MATERIALS DISPOSITION DURING FACILITY DEACTIVATION AS A MEANS OF POLLUTION PREVENTION

Gregory J. LeBaron
B&W Hanford Company, S4-49
Richland, Washington 99352

Steven D. Godfrey
B&W Hanford Company, S4-49
Richland, Washington 99353

ABSTRACT

This paper presents several innovative and common sense approaches to pollution prevention that have been employed during facility deactivation at the Hanford site in South Central Washington. It also presents several pollution prevention principles applicable to other projects.

Innovative pollution prevention ideas employed at the Hanford site during facility deactivation included:

- 1) Recycling more than 185,000 gallons of radioactively contaminated nitric acid by sending it to an operating nuclear fuels reprocessing facility in England.
- 2) Recycling millions of pounds of chemicals and excess materials to other industries for reuse.
- 3) Evaporating flush water at a low rate and discharging it into the facility exhaust air stream to avoid discharging thousands of gallons of liquid to the soil column.
- 4) Decontaminating and disposing of thousands of gallons of radioactively contaminated organic solvent waste to a RCRA licensed, power-producing, commercial incinerator.

Common sense pollution prevention ideas that were employed include recycling office furniture, recycling paper from office files, and redeploying tools and miscellaneous process equipment. Additional pollution prevention occurred as the facility liquid and gaseous discharge streams were deactivated.

From the facilities deactivation experiences at Hanford and the ensuing efforts to disposition excess chemicals and materials, several key pollution prevention principles should be considered at other projects and facilities, especially during the operational periods of the facility's mission. These principles include:

- Institute pollution prevention as a fundamental requirement early in the planning stage of a project or during the operational phase of a facility's mission.
- Promote recognition and implementation of pollution prevention initiatives
- Instill pollution prevention as a value in all participants in the project or facility work scope
- Minimize the amount of chemical products and materials on hand during facility operations, in anticipation of a shutdown or abrupt end to the operating phase of the mission
- Plan the final facility operating periods to minimize residual chemical products and in-process materials left at the end of the mission.

KEYWORDS

Deactivation - Activities associated with removing facility systems and/or areas from operational service with the intent of being ready for facility transition, to either convert the facility for another use or move to permanent shutdown. These activities could include fuel removal, draining and/or de-energizing systems, removal of accessible radioactive and hazardous materials, and other actions to place the facility in a safe and stable condition so a surveillance and maintenance (S&M) program can cost effectively prevent unacceptable risk to the public or the environment until ultimate disposition of the facility. (Note: These activities are usually conducted during the facility transition phase.)

Decommissioning - The sequential phases for a facility once a shutdown decision is made, beginning with facility transition, through S&M, and final facility disposition.

Disposition - Final period in the life of a facility. This phase occurs when no future use is identified and priority is given to proceed with disposition. This phase primarily involves processes to achieve a final end state for the facility (e.g., entombment, and/or dismantlement and site restoration), including closure of any treatment, storage and disposal (TSD) units.

Surveillance and maintenance - Period in the life of a facility following completion of deactivation until such time as the facility is dispositioned for other uses, or facility disposition has commenced. The S&M phase ensures that facilities are maintained in a safe and environmentally sound manner until a final disposition occurs. In addition, the S&M level of effort will be established to minimize the costs of final disposition whether the facility is planned to be released for alternate use or for dismantlement and site restoration, and/or entombment under the facility disposition phase.

Transition - A period of time during which activities necessary to place the facility in a safe, stable, and environmentally sound condition, suitable for an extended period of S&M pending final disposition, are completed. Facility transition starts with termination of operations, includes the establishment of an S&M program, and ends with the achievement of facility-specific end point criteria.

INTRODUCTION

Many facilities at the Hanford Site previously used in nuclear materials production and waste management operations have been declared surplus with no identified future mission. Optimally, the facilities would be decommissioned and the land returned to its natural state. However, decommissioning these large radioactively contaminated facilities is extremely expensive, and removal of the radioactive materials from one place only means that they will be taken to another location. Therefore, the Department of Energy (DOE) has directed the facilities to be deactivated, and placed in a safe, environmentally secure, low-cost surveillance and maintenance condition, pending final disposition of the facility structures and remaining waste.

The main activities involved in achieving a safe, environmentally secure condition include:

- Remove/stabilize facility hazards; particularly fuel, special nuclear materials, chemical solutions, and wastes.
- Place the facility in a stable condition; remove or stabilize radionuclides.

- Shut down utilities; consolidate and shut down heating, ventilation and air conditioning (HVAC) systems, eliminate liquid effluents and deactivate the systems, and perform housekeeping
- Disposition property, and collect and archive records.

Inherent in these activities are many opportunities for pollution prevention. Some of these ideas and methods have application to other projects.

BACKGROUND

In December 1941, the same month Pearl Harbor was attacked and the United States entered the Second World War, the federal Office of Scientific Research and Development sponsored an intensive research project on plutonium. This resulted in a two-track war effort, the military track and the scientific track to produce plutonium. Reactors were constructed to irradiate uranium, converting a small portion of it to plutonium. Large chemical reprocessing plants, around 1,000 feet long, 100 feet high and 80 feet wide (referred to as canyons), were erected along with a number (more than 50) of smaller support buildings and structures to separate and purify the plutonium.

The original separations processes used at the Hanford Engineering Works were bismuth-phosphate processes. B Plant was constructed in 1943-1945, and separated plutonium from irradiated fuel from 1945 until 1952. The plant was refurbished in 1961-1967 and operated through 1984 to separate cesium and strontium from the tank waste. The Waste Encapsulation and Storage Facility (WESF) was added onto B Plant to encapsulate and store the cesium and strontium.

Just as the Korean War entered its second year in June 1951, it was decided to examine Program X, the development of a new irradiated fuel separations facility, later called the Plutonium Uranium Extraction (PUREX) facility. Hot startup of the facility occurred in January 1956, just less than three years from the time construction was started in April 1953. PUREX reprocessed fuel from 1956 until shut down in September 1972. The facility was restarted in November 1983, and reprocessed N-Reactor fuel intermittently until March 1990, at which time the facility was shut down in a configuration that anticipated restart within a short period of time. Process solutions were left in various vessels and significant volumes of essential chemicals were left in storage. The deactivation of PUREX was completed in May 1997, after receiving orders to deactivate in December 1992.

INNOVATIVE POLLUTION PREVENTION IDEAS

Shutdown and deactivation of the PUREX facility at Hanford represents one of the largest, most complex, DOE deactivation projects to date. This highly successful project was completed 15 months ahead of schedule and \$77 million under budget, largely through schedule acceleration and innovative approaches to complex problems. Deactivating B Plant, another large canyon facility at Hanford, was completed in September 1998, four years ahead of schedule and \$100 million under budget. Five of these innovative approaches, applicable to pollution prevention, are described below to provide an example for other projects/project managers to follow. More importantly, the following pollution prevention ideas highlight the type of thinking that is required to continue the growing trend of pollution prevention initiatives that are sweeping the

world and are saving companies millions of dollars, while at the same time protecting the public and the environment. Already at Hanford, the lessons learned from PUREX and B Plant deactivations are being effectively applied to other projects across the DOE complex.

Since PUREX and B Plant are such large and complex facilities, there was a relatively large inventory of chemicals and other materials that had to be removed. There was also a large volume of liquid and gaseous effluents that had to be consolidated or eliminated from the facilities which provided extensive opportunities for pollution prevention. However, since some of the chemicals and materials were radiologically contaminated, such as, radioactively contaminated nitric acid, flush water, and process organic solvent; innovative ideas had to be implemented for preventing pollution when dealing with these materials.

Recycling Chemicals and Excess Materials to Other Industries

To enhance pollution prevention and achieve other benefits, if possible, facility deactivation should be determined prior to final facility operations so that product materials can be processed completely, systems can be flushed, and wastes can be disposed of as part of the final operation.

The chemicals and materials remaining at PUREX and B Plant when the DOE directed the facilities to be deactivated included those identified in Table I.

Table I. Remaining Chemicals

Chemical	Volume of Material	
	B Plant	PUREX
Process solution (gallons)	8,000	6,000
11M radioactive nitric acid (gallons)	N/A	186,000
Radioactive water/dilute nitric acid (gallons)	9,700	200,000
Radioactive TBP/NPH organic (gallons)	4,700	21,000
Other essential materials (pounds)	200,000	2,270,000

If it had been possible to identify that the facilities were going to be deactivated before the final operation, many of the essential materials (chemicals) could have been used. The process solutions could have been run through and made into product, and the vessels could have been flushed as part of the final production run. Running the process solutions through to become product and using the essential materials in the process minimizes the potential for the materials to become waste, and thus, prevents pollution. While the concept sounds easy and logical, it does require additional up-front planning.

Radioactively contaminated essential materials must be dispositioned in a manner to ensure that contamination is adequately contained and properly handled. Methods used for their disposition will be discussed in following sections.

Essential materials left from an operation can be transferred to other facilities. This sometimes requires extra effort and planning, but can result in cost savings and pollution prevention.

When it is not possible to use essential materials during the final production run, those materials that are not radioactively contaminated can be returned to the vendor or transferred to other facilities for beneficial use. Again, while this sounds easy and logical, within the framework of governmental regulations, it can require extra effort and planning. A problem arises in that the General Services Administration procurement processes do not have a procedure to sell the essential materials back to the original vendors. At Hanford, a decision was made to sell these materials as excess on the open market by placing notices in the *Commerce Business Daily*. Chemical brokers and distributors, local fertilizer companies and another DOE site purchased or accepted most of the essential materials. These materials sold for about 20 percent of their original cost, but this avoided disposal fees and potential additional expenses if the landfill that accepted the materials ever leaked.

Nearly 331,000 pounds of a special mixture of chemicals, ordered specifically for the PUREX process, had to be disposed of as waste. Over the course of three years during deactivation, the other essential materials, except for about 8,000 pounds, were successfully transferred to other facilities. Approximately \$80,000 was recovered from the sale of essential materials and an estimated \$300,000 to \$400,000 in disposal fees were avoided by not disposing of these materials as waste. Other benefits included, avoiding pollution and realizing beneficial uses from these essential materials at other facilities.

Even if the essential materials are given away and/or transportation is paid for by the seller, it is still less expensive than having to dispose of them as waste. Therefore, plans should be made to go to the effort of transferring chemicals in order to reduce disposal costs and prevent pollution.

Recycling Radioactively Contaminated Nitric Acid

Include people working at the facility in pollution prevention and encourage innovative ideas.

The traditional method for disposing of radioactive liquid waste from the Hanford chemical reprocessing facilities is to adjust the pH of the waste solution to greater than 12, add sodium nitrite to minimize corrosion to the transfer lines and underground waste storage tanks, and transfer it to underground waste storage tanks. However, this process would have turned the ~186,000 gallons of 11M radioactive nitric acid remaining in the PUREX process into ~270,000 gallons of waste containing over 5.4 million moles of sodium. Since sodium limits the ability to minimize the resulting waste and the intent is to vitrify that waste for future handling and storage, it was not desirable to add sodium.

The idea was presented to chemically denitrate the nitric acid waste using sugar (Figure 1). This was a permitted treatment conducted as part of the waste treatment during PUREX operations. Sugar denitration of the nitric acid would result in less than 178,000 gallons of waste with less than 0.9 million moles of sodium that would have to be sent to the underground waste storage

tanks. However, about 240 metric tons of nitric oxide gasses (NO_x) would be discharged to the atmosphere from the stack. Facility and regulatory personnel wanted to avoid this discharge, if possible.

Finally, an idea was proposed to send the nitric acid to another chemical reprocessing facility (Figure 1). After some research, it was determined that the nitric acid could be sent to the Sellafield, England, fuel reprocessing facility where it could be used as a product instead of disposed as a waste. Eighteen shipping containers were constructed to international shipping standards, and two at a time were filled with the

radioactively contaminated nitric acid, trucked to the East Coast, and transferred to ships headed for England. The nitric acid was then loaded into storage containers to be used at the fuel reprocessing facility at Sellafield. Reusing the acid, rather than handling it as a waste, allowed the deactivation project schedule end date to be moved forward, saved considerable money, avoided future cost or liability in having to deal with the waste, and minimized waste by reusing the contaminated nitric acid at another facility.

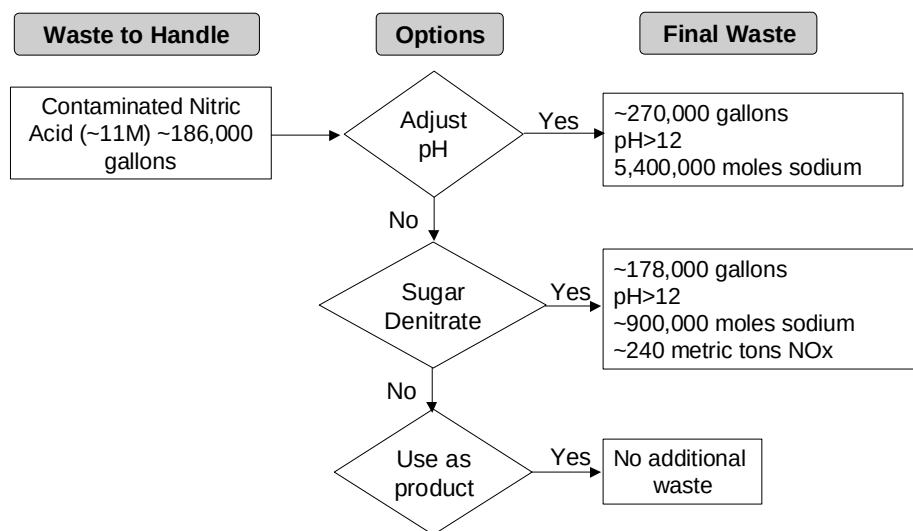


Figure 1. Radioactive Nitric Acid Handling

Cascading Vessel Flushing

Evaluate process to reutilize materials and minimize wastes

Vessels in the PUREX process had to be flushed during deactivation to remove residual chemicals and to meet regulatory criteria. Originally, the desire was to flush and sample each vessel separately. However, it was possible to place vessels into groups so they were connected such that a flush solution could be moved from one vessel to the next and then sampled in the final vessel (Figure 2) to determine if the flush criteria had been met. Seventy-eight vessels were organized into 16 loops with up to 9

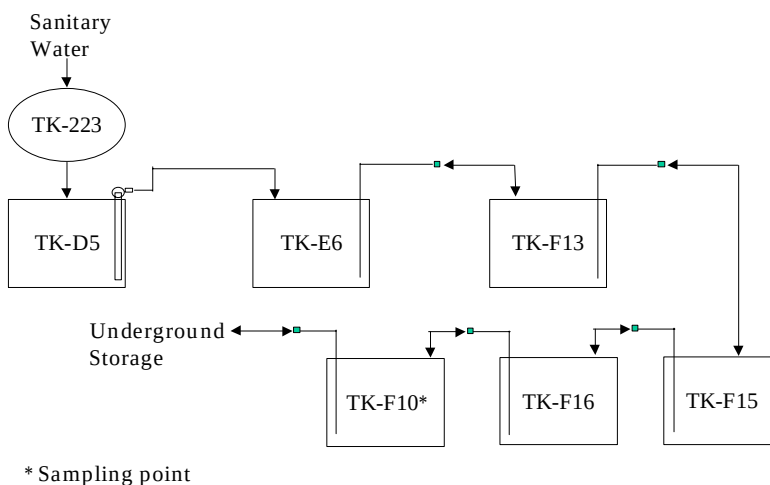


Figure 2. Vessel Flush Loop

vessels per loop. In some cases, only one flush was required, in other cases, it was necessary to flush the group up to six times before the flush criteria could be met.

Overall, flushing the vessels in loops avoided the generation of more than 230,000 gallons of solution. This volume would have grown even larger as it was treated, and transferred to underground storage tanks until final disposal. Therefore, the objective of flushing the vessels was achieved while significantly minimizing the waste generated and preventing pollution.

Evaporating Contaminated Flush Water

Evaluate various process options to determine the best option to be efficient and achieve the greatest pollution prevention.

Radioactively contaminated process water and dilute process solutions in the facility needed to be disposed of during deactivation. These solutions could have been treated to meet waste disposal specifications and transferred to underground waste storage tanks. However, a more innovative method to prevent pollution was implemented by evaporating the water at a slow rate (2-3 gallons per minute) and bleeding the water vapor into the building ventilation air system to exhaust from the stack (Figure 3). The water vapor discharged from the stack did not increase the radionuclide emissions and was bled into the air steam so that the air was maintained below the saturation point to avoid problems in the air off-gas train.

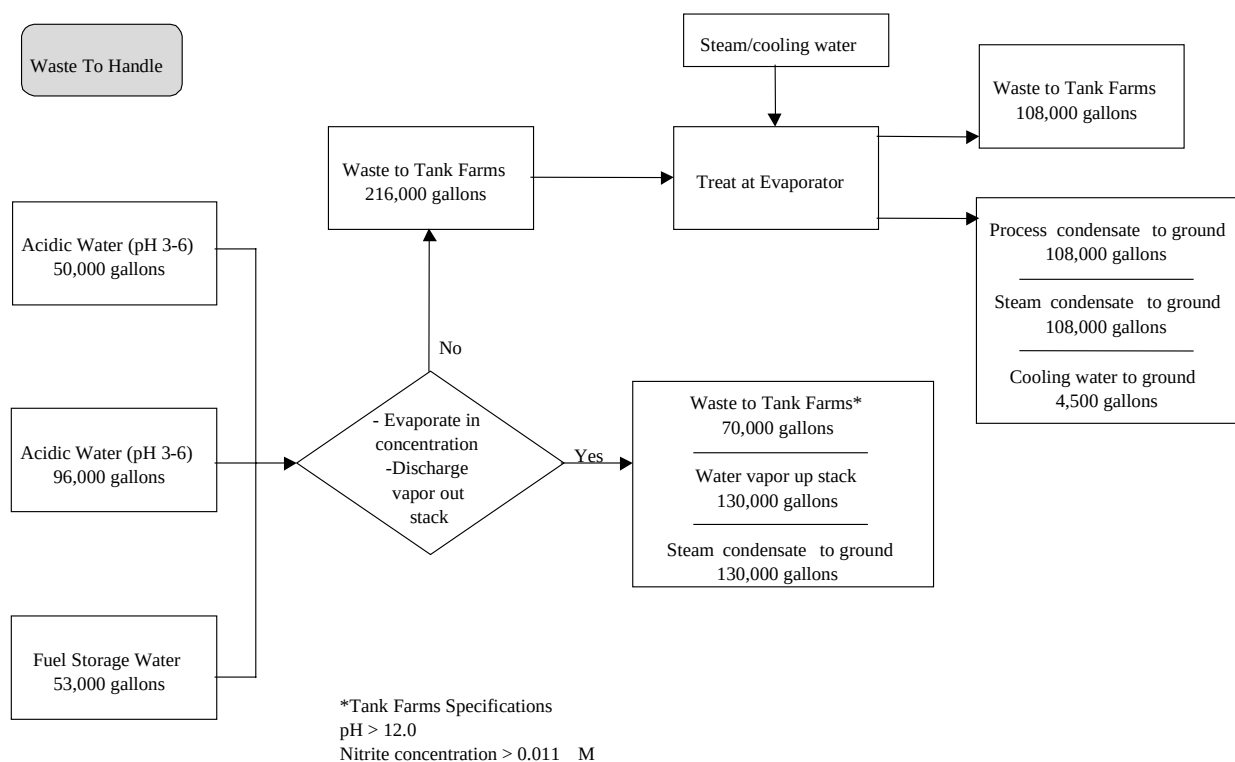


Figure 3. Pollution Prevention Using Plant Contaminated Water Evaporation

In looking at the waste generated, one might compare the 216,000 gallons of waste sent to underground waste storage tanks to the 330,000 gallons of waste generated by sending the water to the concentrator (Figure 3). However, it was necessary to look at the full process cycle and consider that the dilute waste sent to underground waste storage tanks would be reduced at the evaporator. Since the waste was treated to meet waste disposal specifications, it was not possible to get the concentration efficiency at the evaporator as in the concentrator before the waste was treated. Also, since the evaporated water is condensed at the evaporator used to concentrate tank farm waste, a large volume of cooling water goes to the ground.

Figure 3, demonstrates how using this process resulted in an overall reduction of waste going to the underground waste storage tanks by 38,000 gallons, a volume that would increase as the waste is further treated (vitrification is currently the preferred treatment method). In addition, the process resulted in reducing the volume of water going to the ground by more than 4,500,000 gallons by saturating the air with 130,000 gallons of water and discharging it from the stack with no increase in contamination. Various process options should be evaluated to determine the best option to be efficient and achieve the greatest pollution prevention. Also, options need to be evaluated by taking the waste to its final state before determining which path provides optimum pollution prevention.

Disposing of Contaminated Organic Solvent

Determine ways to derive benefit even from waste

There was more than 25,000 gallons of radioactively contaminated organic (a mixture of about 20% tri-butyl phosphate in normal paraffin hydrocarbon) in the B Plant and PUREX process systems when it was determined that the facilities should be deactivated. It was not possible to find another facility that could use the material as a product; therefore, it had to be declared a waste.

Options for disposal of the contaminated organic were developed, with incineration being the most favorable option. Investigation into incineration facilities revealed a RCRA permitted waste disposal facility in Tennessee, which also generated electricity using the heat evolved from burning the organic waste. The specifications for incinerating the contaminated organic were reviewed and it was determined that the organic would have to be decontaminated to remove radionuclides before being shipped offsite for disposal.

Extensive decontamination was performed at both B Plant and PUREX to remove radionuclides from the organic. At PUREX, the installed organic recycling and recovery system was utilized to effectively decontaminate the PUREX organic. At B Plant, the solvent decontamination systems had long since been deactivated, so a modified approach was needed. The B Plant organic was washed in batch tanks with a series of chemical washes, based on laboratory studies of organic decontamination agents. The washes were effective at removing the dissolved contaminants; however, the organic solution also contained a large amount of entrained solids that were highly radioactive. A filtration system was designed, fabricated, and installed in the B Plant canyon to remove the entrained solids. The organic was pumped through a series of filters, down to a level of 0.5 micron, removing the vast majority of solids and decontaminating the organic to meet the disposal facility specifications.

Extensive effort was required to decontaminate and dispose of these legacy organic solvents, with the intention of eliminating any long-term storage and handling costs. Even though this waste could not be recycled or reused as a product, a way was found to gain benefit by converting the heat evolved in the thermal destruction of the waste to electricity.

COMMON SENSE POLLUTION PREVENTION IDEAS

Several common sense pollution prevention ideas have been effectively employed at Hanford, both during facility deactivation and during facility operations. The cost savings associated with any one of these simple pollution prevention methods are small in comparison with the more innovative approaches described above. However, when combined into an overall pollution prevention program, applied over the life of the facility mission, the accumulation of savings and pollution prevention value are significant.

During deactivation, recycling office furniture to other operating facilities and recycling excess paper to commercial recycling companies avoided significant generation of waste. In addition, re-useable tools and equipment were redeployed to other operating facilities. More than 65 semi loads with 40-foot long trailers and 10 smaller truck loads of reusable equipment; materials and tools have been excessed.

These deactivation experiences at Hanford highlight the need to implement common sense pollution prevention ideas on an ongoing basis. This will minimize the effort to disposition materials and equipment at the end of the facility mission.

LIQUID AND GASEOUS DISCHARGES

Reducing effluent discharges to the environment continues to be a major focus for environmental cleanup at Hanford and other DOE sites. Three significant effluent reduction efforts have been completed during recent deactivation projects, which represent common industry practices for minimizing effluent discharges to the environment. These efforts highlight another important aspect of pollution prevention. Reducing effluent discharges will create significant environmental value and public good will, but will require an up-front investment with a relatively small return over the long term. These examples of effluent reductions have application to other projects and industries.

Consolidated Ventilation Systems

Following deactivation, facilities are maintained in a safe, stable low-cost S&M condition. The main operational system associated with radiologically contaminated facilities is the ventilation systems required to contain radioactive contamination within the facility structure. These ventilation systems may or may not be suitable for the S&M phase and may need to be reconfigured or replaced.

At B Plant for example, the ventilation system used for the past 54 years of operation contains filters that are highly contaminated with radioactive materials. In addition, the flow rate of the ventilation system was about twice the flow required for the S&M phase. Therefore, a replacement ventilation system was installed to operate at a reduced flow, isolate the existing contaminated filters, and utilize contact handled, changeable filters. The resulting new ventilation system saves energy, reduces gaseous emissions, and reduces the risk of radioactive releases associated with the retired filters.

The PUREX ventilation systems were more complicated, being that four facility ventilation systems were required for radioactive contamination control. Utilizing the primary ventilation system fans and changeable filter units, the four ventilation systems were consolidated into a single system capable of maintaining contamination control throughout the facility by cascading air from one area to another. This reconfiguration resulted in reduced gaseous emissions and energy savings.

Closed Loop Cooling Systems

Reducing liquid effluents from B Plant and PUREX involved shutting down utilities such as water and air systems, as described below. At B Plant, it also involved “decoupling” B Plant from the adjacent WESF to allow WESF to continue its ongoing cesium and strontium capsule storage mission. Since the liquid effluent systems between the two facilities were coupled, and those systems associated with B Plant were being deactivated, decoupling the liquid effluent systems was required.

One of the key WESF decoupling projects was the installation of a closed loop cooling system (Figure 4) to maintain the temperature of the WESF pool cells where ~2000 cesium/strontium capsules are stored under water. Prior to installation of the closed loop cooling system, raw water at ~1,000 gallons per minute (gpm) was used in a “once-through” cooling system to keep the capsule storage pools at the required temperature. The resulting cooling water was discharged to a pond via a retention basin common to both B Plant and WESF liquid effluent discharges. The B Plant sources to the basin and pond were discontinued through deactivation efforts. However, the WESF sources were required for the ongoing life of the facility mission. Both the basin and the pond were designated for deactivation and closure, making the closed loop cooling system necessary for WESF operations.

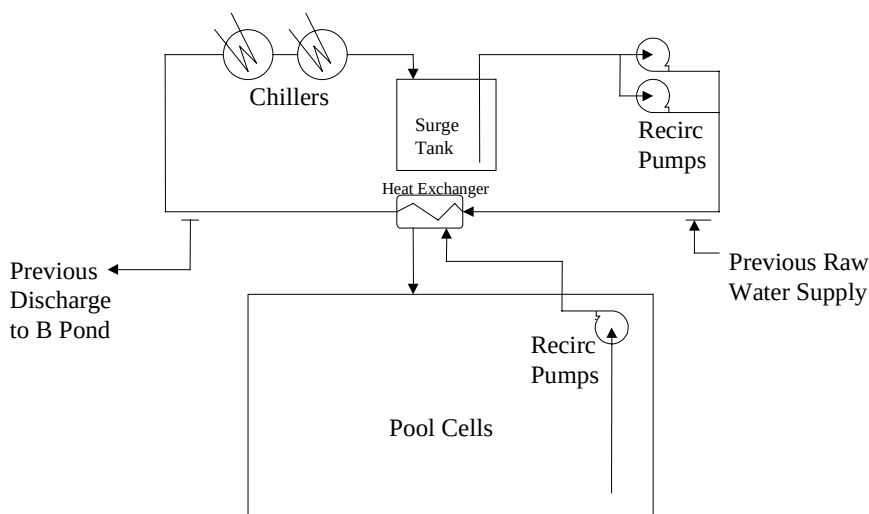


Figure 4. Closed Loop Cooling System

A closed loop cooling system was designed, tested, and installed to eliminate the ~1,000 gpm discharge to the environment. The capsules are now maintained at their required storage temperatures using a refrigerant cycle, which is more energy efficient than once-through cooling systems. This new system eliminates the discharges of potentially contaminated effluents to the ground (via previously contaminated piping) and to a contaminated pond where additional flows cause the gradual migration of contaminants to the water table below.

CONCLUSIONS

Pollution prevention in a project can result in cost savings and can enhance the schedule. Cost reduction and schedule enhancements are best achieved by incorporating pollution prevention at

the very beginning of the project, demonstrating strong management support and encouragement, and involving project people at all levels and encouraging them to be innovative. Project management must be receptive to new ideas, willing to implement them as they meet project goals and recognize individuals for their contributions. Management involvement and enthusiasm is key to having a strong pollution prevention program.

As the result of these successful projects, the DOE has directed the development of a team of individuals who were involved in the planning and management of the deactivation projects to help others jumpstart their projects. The team, Facility Stabilization and Environmental Restoration (FASTER) Services, has assisted at more than 20 other facilities across the DOE complex by sharing experiences and tools, helping to prepare plans, and working with facility personnel to develop cost efficient approaches to meet project goals, including pollution prevention.