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HANFORD SITE RIVER PROTECTION PROJECT HIGH-LEVEL WASTE SAFE STORAGE

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ABSTRACT

The CH2M HILL Hanford Group (CHG) conducts business to achieve the goals of the U.S. Department of Energy's (DOE) Office of River Protection at the Hanford Site. The CHG is organized to manage and perform work to safely store, retrieve, dispose of or store immobilized Hanford Site tank waste, and to dispose of the strontium and cesium capsules presently stored at the Waste Encapsulation Storage Facility. Safety and environmental awareness is integrated into all activities, and work is accomplished in a manner that achieves high levels of quality while protecting the environment and the safety and health of workers and the public.

The high-level waste is stored underground in 149 single-shell tanks (SST) and 28 double-shell tanks (DST). The older SSTs are well beyond their design life and pose risks to the public, the environment, and Site workers from potential leakage over both the near and long term. The Defense Nuclear Facilities Safety Board (DNFSB) has issued several recommendations associated with potential tank waste hazards and characterization efforts. Failure to meet regulatory interim stabilization milestones led the state of Washington to announce its intent to sue the DOE. Periodic releases of significant concentrations of hydrogen gas from Tank 241-SY-101 had been mitigated by a mixer pump installation; however, the tank has begun to exhibit new behavior that challenges our understanding of the waste system.

Despite the complex programmatic, regulatory and technical nature of the River Protection Project (RPP), accomplishments over the past three years have demonstrated that personnel, hardware and management are in place to maintain the tank farm system in a known, safe, and controlled configuration. Emerging safety issues can be understood and actions taken to protect the environment, the public, and the workers, and major infrastructure upgrades can be planned, constructed, and implemented to support the retrieval and disposal mission.

INTRODUCTION

The Hanford Site tank farms, until recently called the Tank Waste Remediation System, comprise the largest cleanup activity at the Hanford Site, located in southeastern Washington. The tank farms store approximately 200 ML (53 Mgal) of mixed radioactive waste in 177 underground tanks. The tanks contain liquid, sludge, and salt cake waste as well as discarded equipment such as manual tapes and broken lights. The waste resulted from processing fuel elements to extract plutonium for America's nuclear weapons. The waste tanks range in capacity from 208 kL (55 Kgal) to 4.9 ML (1.3 Mgal). The 149 older SSTs were built between 1943 and 1964, with a single shell of carbon steel inside a concrete encasement. The 28 newer DSTs were built between 1968 and 1978, with a double shell of carbon steel inside a concrete encasement. The tanks are located in two areas (200 East and 200 West) located approximately 10 km (6 mi) apart and near the center of the 1,460 km^2 (564-mi^2) Hanford Site (Fig. 1). The tanks are grouped into 18 tank farms with associated utilities to support safe storage activities. The Columbia River, sometimes referred to as the lifeblood of the Pacific Northwest, is located just 11 km (7 mi) from the nearest tank.

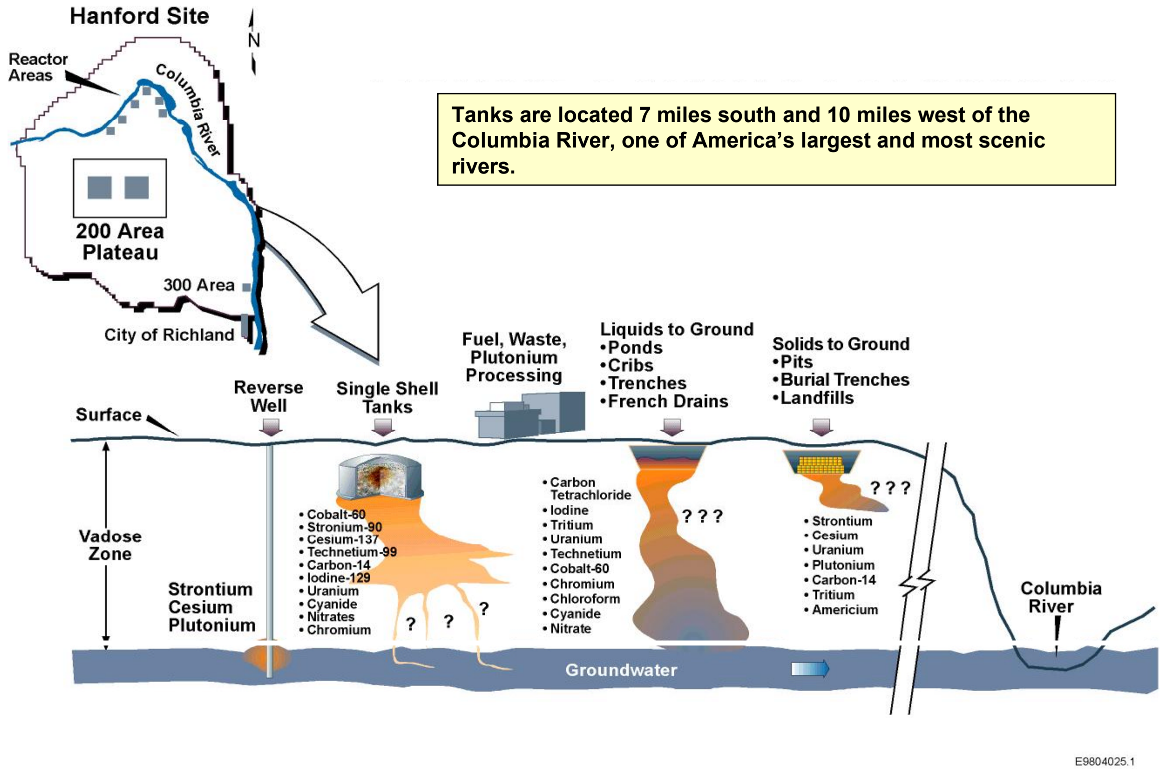

Fig. 1. Legacy of 50 Years of Production.

CHARACTERIZATION

Timely characterization of tank waste has been a key to ensuring that wastes can be stored safely and operations can be conducted safely and that the information needs of future disposal programs can be met. A concerted and systematic effort to revolutionize the characterization efforts at Hanford has occurred since the DNFSB issued recommendation 93-5 on July 19, 1993 (1). The site has comprehensively re-examined and restructured the characterization effort to focus on strong technical management, reliable sampling equipment for a variety of waste configurations, and trained and competent staff. This refocusing has resulted in a durable characterization project, which can and does provide samples and analytical results to meet the needs of a variety of data users. The Site now has sufficient characterization data to ensure that the tank wastes can be safely stored and managed and that the disposal program information needs are being met. Importantly, the program has the integrity to respond to changing needs as evidenced by the rapid response to the unresolved safety question involving the crust growth in Tank 241-SY-101 (Fig. 2).

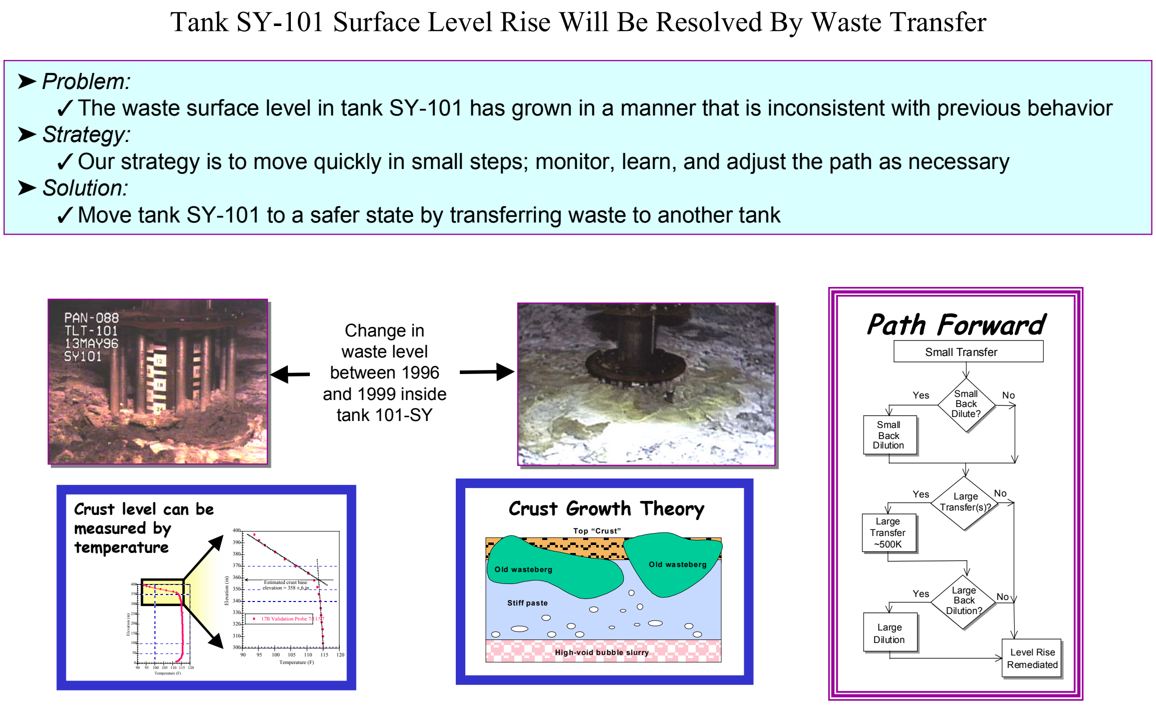

Fig. 2. Ability to Manage the Unexpected.

INTEGRATED SAFETY MANAGEMENT

To effectively protect workers, the public, and the environment, the project has adopted the Integrated Environmental, Safety, and Health Management System (ISMS) that integrates these elements into work planning and execution processes. The DOE ISMS verification team noted a very positive attitude by senior managers and union leadership toward ISMS implementation. This positive attitude was demonstrated in interviews, meetings, and at job sites. Additionally, as members of the team observed activities for work planning, the Facility Excellence Program, and the President's/Area Zero Accident Council, worker involvement was very visible and important to the success of the overall safety program. It was evident that personnel are aware of their roles and responsibilities and that line management has accepted responsibility for safety.

SAFETY ISSUE RESOLUTION

A robust, systematic approach to the resolution of safety issues has developed at the Hanford Site. Historical process records have been located, researched and collated into a comprehensive compendium (2). These records make it possible to evaluate the extent of the hazardous constituents across the tank farms (e.g., it was shown that ferrocyanide was transferred to limited number of tanks). Criteria for safe storage conditions are developed, and theoretical and simulant studies are used to verify the criteria. Models are developed and tested with both simulants and real waste samples. Finally, bounding waste tanks (those with the highest potential hazard) are characterized.

<u>Ferrocyanide Safety Issue</u>: Ferrocyanide was used to scavenge cesium from Hanford Site tank waste liquids in the 1950's. In the presence of oxidizing materials such as sodium nitrate, ferrocyanide can react exothermically if heated to sufficiently high temperatures. Because the scavenging process precipitated ferrocyanide from solutions containing nitrate, there has been a concern that intimate mixtures of ferrocyanide and nitrates might have been established in some regions of the tanks. However, studies with simulants and examination of the open literature indicated that ferrocyanide would slowly decompose to inert materials when exposed to tank waste conditions (high pH, high temperatures, and radiation). Sampling and analysis of selected tanks between 1993 and 1997 showed that the ferrocyanide had decomposed to trivial concentrations and the safety issued was closed in 1997.

<u>Organic Complexant Safety Issue</u>: Processes used at the Hanford Site for plutonium production introduced organic complexants and solvents into the tank farm system. The materials are commingled with inert materials, diluents (e.g., water, excess sodium nitrate/nitrite, sodium carbonate, sodium sulfate, and hydroxy salts of aluminum, iron, and silicon) and oxidizers (sodium nitrate/nitrite). The complexant salts can react exothermically by heating to high temperatures or by application of a robust ignition source. Early assessments showed that a bulk runaway reaction similar to the 1957 Kyshtm accident could not occur because tank temperatures were well below those required to initiate such an event. Subsequently, it was suggested that an external ignition source may cause a propogating combustion reaction to occur. The approach to resolving this issue was similar to that used for resolution of the ferrocyanide safety issue. The conditions that could support such a reaction were determined, historical records were reviewed, waste samples were characterized, simulant combustion properties were studied, and the combustion properties of actual waste samples were examined. The open literature and experiments with waste simulants and waste samples indicated that high complexant concentrations were required to sustain combustion. Sampling and analysis of the tanks from 1993 through 1998 (141 of the total 177 tanks were sampled) demonstrated that the waste had insufficient complexant concentrations to sustain combustion. All the tanks with potentially the highest complexant concentrations were sampled as part of this campaign. The organic complexant safety issue was closed in December 1998 (3).

<u>Organic Solvent Safety Issue</u>: Various separation processes involving organic solvents (primarily normal paraffin hydrocarbons and tributyl phosphate) were used at the Hanford Site. Some of these solvents were sent to the storage tanks. These solvents can burn, given a sufficient ignition source. The open literature and experiments show that sparks, impacts, shocks, and friction cannot ignite an organic solvent fire, and the only credible ignition sources have been narrowed to robust and/or sustained energy sources such as lightning strikes. Analyses showed that in the highly unlikely event that a solvent fire could be ignited, radiological and toxicological consequences would be low (below risk evaluation guidelines). Lockheed Martin Hanford Corporation submitted documentation to close the organic solvent safety issue in October 1999. Closure of the safety issue by ORP is pending.

<u>Criticality Safety Issue</u>: In September 1999, the DOE resolved the Hanford tank farms nuclear criticality safety issue relating to the storage of high-level wastes in the Hanford underground waste storage tanks. Nuclear criticality safety was determined to be a safety issue in 1992 because of the uncertainty of the quantity and distribution of fissile material in the Hanford high-

level waste storage tanks. To address the issue, there was a detailed review of historical process records and tank waste composition data, and a comprehensive technical evaluation was performed. The conclusions were that the neutralized waste streams transferred to the tank farms contained subcritical concentrations of fissile material and that the fissile material was mixed with sufficient amounts of neutron-absorbing hydroxide solids. Therefore, under current fissile material inventories and operating conditions, a nuclear criticality accident in the Hanford waste tanks is incredible. Effective administration controls are in place to ensure that the waste form remains subcritical under storage conditions as well as during future tank farm operations. A nuclear criticality safety program has been established to ensure that controls are effectively implemented and issues are adequately addressed.

High-Heat Safety Issue: The high-heat safety issue was defined in 1991 specific to single-shell Tank 241-C-106 because this tank required periodic water additions to remove heat from the waste. It was identified for its potential to release high-level waste as a result of uncontrolled increases in the temperature, which could damage the tank structure. A sufficient amount of waste was recently sluiced from Tank 241-C-106 to resolve this issue. The evaluation of post-sluicing waste dryout for this tank has shown that water additions for evaporative cooling are no longer required as a result of the removal of waste from the tank. Tank 241-C-106 is in the process of being taken off the Watch List.

Flammable Gas Safety Issue: Radioactive waste generates flammable gas (mainly hydrogen, nitrous oxide, ammonia, nitrogen, and traces of methane and other hydrocarbons) by complex chemical reactions resulting from thermal and radiological decomposition of organic compounds, radiolysis of water, and corrosion of the carbon steel walls of the storage tanks. The generation rate is low enough that ventilation can keep flammable gas levels far below the concentration necessary for ignition. Thus, flammable gas generation in itself is not a safety issue in any tank in which the flammable gas is continuously released to the tank dome space. However, many tanks have enough gas stored in the waste to cause worker injury or damage to equipment if a significant fraction of the retained gas were released suddenly into the dome space and ignited. Gas releases may be spontaneous or induced by external forces (e.g., earthquakes, salt well pumping, barometric pressure changes) or by waste intrusive activities (e.g., core sampling, equipment installation). The potential for such releases and their undesirable consequences constitutes the flammable gas safety issue. An unreviewed safety question (USQ) was declared for 25 Watch List tanks in 1990 and expanded in 1996 to include all TWRS facilities that contain waste. The USQ for single-shell and double-shell tanks was closed in September 1998.

The approach for safety issue resolution centers on the following items:

- Develop an understanding of gas generation, retention, and release.

- Collect data to develop an understanding of the behavior of the various waste tanks.

- Assess the potential hazards posed by the presence of flammable gas and potential ignition sources.

- Develop and implement appropriate means to monitor the tanks and mitigate, if required, the accumulation and release of unacceptable quantities of flammable gas and potential ignition sources.

Extensive studies have been conducted to understand gas generation, retention, and release. Waste characterization, via core sampling, retained gas sampling, in situ measurements of gas void and waste properties, dome-space sampling and specialized laboratory tests have been conducted on wastes from both single- and double-shell tanks. Hazards have been assessed and controls are in place with an approved authorization basis. Monitoring is in place for all flammable gas Watch List tanks and only one tank, 241-SY-101, required mitigation.

A safety analysis and authorization basis amendment are being developed for submittal in fiscal year 2000. Resolution of this safety issue is slated for September 2001.

SINGLE-SHELL TANK STABILIZATION

Of Hanford's 149 SSTs, 67 previously have leaked more than 3.8 ML (1 Mgal) of radioactive waste. Of the 29 SSTs that still contain liquids, the DOE believes that none are currently leaking. To reduce risk to human health and the environment the state of Washington, DOE, and the U.S. Department of Justice developed a pumping schedule that first will pump the tanks that pose the greatest risk to human health and the environment, thereby protecting the Columbia River and the public. The agreement, to be included in a court-ordered consent decree, will replace language in the Tri-Party Agreement pertaining to tank stabilization. Of the remaining liquid waste, 98 percent is expected to be pumped by September 30, 2003, and the final 2 percent will be removed by September 30, 2004. The pumping activities are ahead of schedule.

INFRASTRUCTURE UPGRADES

Major infrastructure upgrade projects have been completed and brought into operational readiness. A new ventilation system has been installed for the AY and AZ Tank Farms, which are essential for staging high-heat wastes for the future tank waste vitrification mission. The upgrade enhanced safety and reduced environmental and worker risks and air emissions.

A new 10 km (6.3 mi) long double-walled cross-site transfer system, which complies with modern regulatory requirements, has been constructed and put into operation. The first transfer was so successful that transfers will be scheduled as a routine activity.

Completion of construction and operation of equipment for removing waste sludges out of single-shell Tank 241-C-106 (Fig. 3) has demonstrated retrieval technology under current safety and environmental requirements. The work has provided important lessons learned for the planning and execution of future waste retrieval operations from the other 148 single-shell tanks. Sluicing operations have transferred over 95 percent of the sludge containing high levels of strontium 90 to a safer DST allowing the cessation of cooling water additions to C-106.

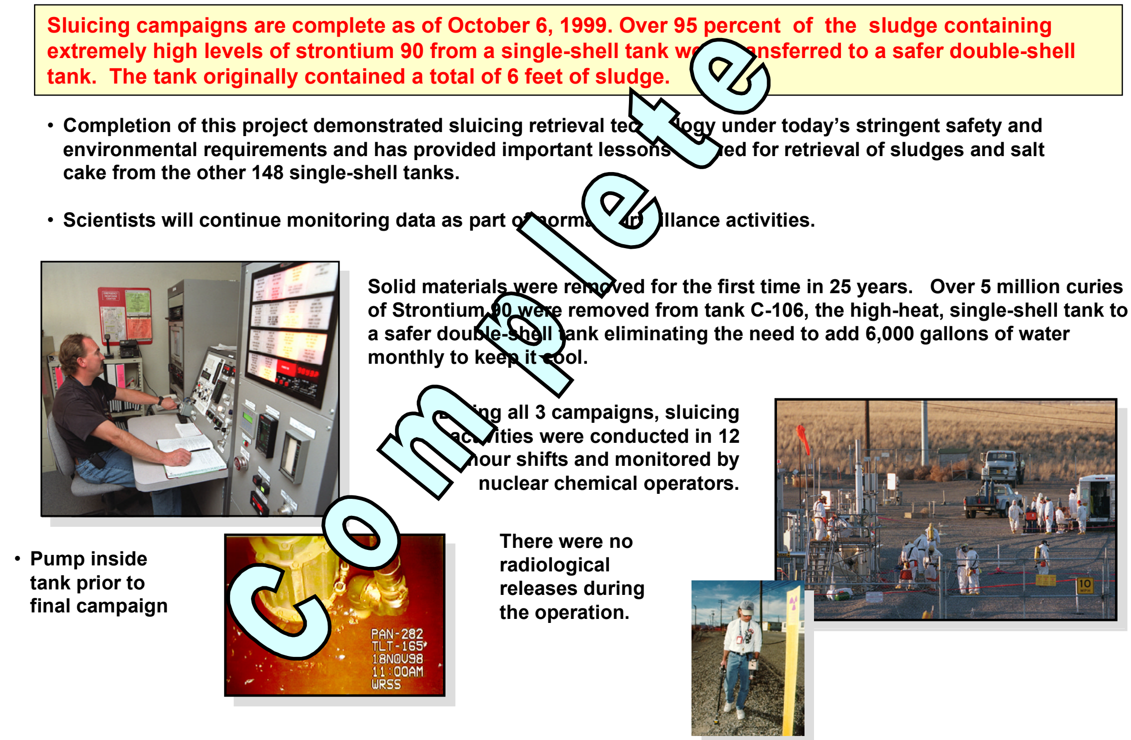

Fig. 3. Major Safety Risk Removed from Hanford, C-106.

LICENSING

As recently as three years ago, the tank farms were operated under a compendium of safety licensing requirements. These documents, numbering in the hundreds, were inconsistent, duplicative, outdated and sometimes incomplete. Since then, a master safety document called the Basis for Interim Operation (BIO) has been developed and implemented (4). The BIO documents a comprehensive understanding of the tank farm operations, equipment and hazards to ensure that a suitable set of controls is in place and implemented. The safety licensing has been recently taken to a new level with the issuance and implementation of the final safety analysis report (FSAR) (5).

The FSAR became the authorization basis for the tank farms on October 18, 1999. This was the culmination of a multi-year effort that began in late 1995; it represents a significant milestone for RPP, because DOE orders require the development of safety analysis reports for non-reactor nuclear facilities such as the tank farms. The DOE completed a detailed 18-mo review ultimately concluding that the final document complied with the relevant orders. With the FSAR in place for tank farm operations, the licensing focus now shifts to optimization and improvement of control with an emphasis on facilitating the forthcoming retrieval and disposal missions.

EMPLOYEE OWNERSHIP

Ongoing programs have also improved tank farm conditions. An extensive drawing and labeling program was initiated in 1997, and the backlog of corrective maintenance activities has been reduced. The Facility Excellence Program (Fig. 4), an employee program of weekly inspections, has resulted in the correction of more than 9,000 deficiencies identified in the areas of environment, safety and health; conduct of operations; maintenance; and housekeeping. Pride in doing a job right and a commitment to safety has been demonstrated in the achievement of 1 million work hours without a recorded job-related illness or injury resulting in an employee missed work day for the second time in three years.

Fig. 4. Facility Excellence Program.

CONCLUSION

The RPP has made excellent progress in carrying out the mission to safely store the highly radioactive tank waste, enhance the infrastructure necessary to support the retrieval and disposal mission, and respond to emerging issues. This progress has been accomplished in the context of the complex programmatic, regulatory, and technical nature of the project. The accomplishments of the past few years have demonstrated that personnel, hardware, and management are in place to maintain the tank farm system in a known, safe, and controlled configuration. Emerging safety issues can be understood and actions taken to protect the environment, the public, and the workers and that major infrastructure upgrades can be planned, constructed, and implemented to support the retrieval and disposal mission.

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