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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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ABSTRACT

This paper describes dramatic improvements in the safety record of the Soil and Groundwater Remediation Project (SGRP) at the Hanford Site in southeast Washington state over the past four years. During a period of enormous growth in project work and scope, contractor Fluor Hanford reduced injuries, accidents, and other safety-related incidents and enhanced a safety culture that earned the SGRP Star Status in the Department of Energy's (DOE's) Voluntary Protection Program (VPP) in 2007.

This paper outlines the complex and multi-faceted work of Fluor Hanford's SGRP and details the steps taken by the project's Field Operations and Safety organizations to improve safety. Holding field safety meetings and walkdowns, broadening safety inspections, organizing employee safety councils, intensively flowing down safety requirements to subcontractors, and adopting other methods to achieve remarkable improvement in safety are discussed. The roles of management, labor and subcontractors are detailed. Finally, SGRP's safety improvements are discussed within the context of overall safety enhancements made by Fluor Hanford in the company's 11 years of managing nuclear waste cleanup at the Hanford Site.

INTRODUCTION

In 2002, Fluor Hanford, a prime cleanup contractor to the DOE at the Hanford Site in southeast Washington state, began managing the complex and multi-faceted Groundwater Remediation Project. While the scope of the project was already formidable in 2002, it grew further in the ensuing years. When the work scope for remediating the large waste sites and areas of contaminated soil was added in late 2006, the effort became known as the Soil and Groundwater Remediation Project (SGRP).

In 2002, safety statistics as measured by accepted industrial standards were well below DOE expectations. When attitudes about safety were evaluated by a VPP self-assessment in 2004, they were found to be poor. Fluor Hanford took specific, targeted measures to change the mindset and improve safety performance -- and succeeded emphatically. The Field Operations and Safety organizations within Fluor Hanford's SGRP took steps that can be useful and instructive to other projects wishing to improve safety.

Cleanup Responsibilities Huge for Hanford Groundwater and Soil

The risk profile at the Hanford Site, resulting from 40 years of manufacturing plutonium for nuclear weapons, is complicated. The Columbia River – lifeblood of the Pacific Northwest region - flows through and by the Site for more than 50 miles. About 80 square miles of groundwater under the Site contain radionuclides and hazardous chemicals above allowable standards, and the groundwater flows inexorably toward the river. The SGRP at Hanford has four major tasks: clean up the groundwater to the extent possible, prevent the flow of contaminants already in the groundwater into the river, prevent recharge or further contamination of groundwater from soil sites, and monitor groundwater and soil sites to assess and record conditions and progress.

In 2002, four years after groundwater work at the 586-square mile Hanford Site was first organized into a project, Fluor Hanford began managing it. Groundwater contamination was already a "crazy quilt" of multiple radionuclides and chemicals running in plumes among and throughout confined and unconfined aquifers. In the 100 Areas of the Site along the Columbia in north Hanford, and in the 300 Area 20-30 miles further south along the river, the water table is only 30-80 feet below the land surface. In the 200 Areas in the center of the Site, it begins 250-300 feet down. The unconsolidated soils – ash, sand and gravel – exist in roughly two uneven layers. The more transmissive Hanford formation lies above the tighter Ringold formation.

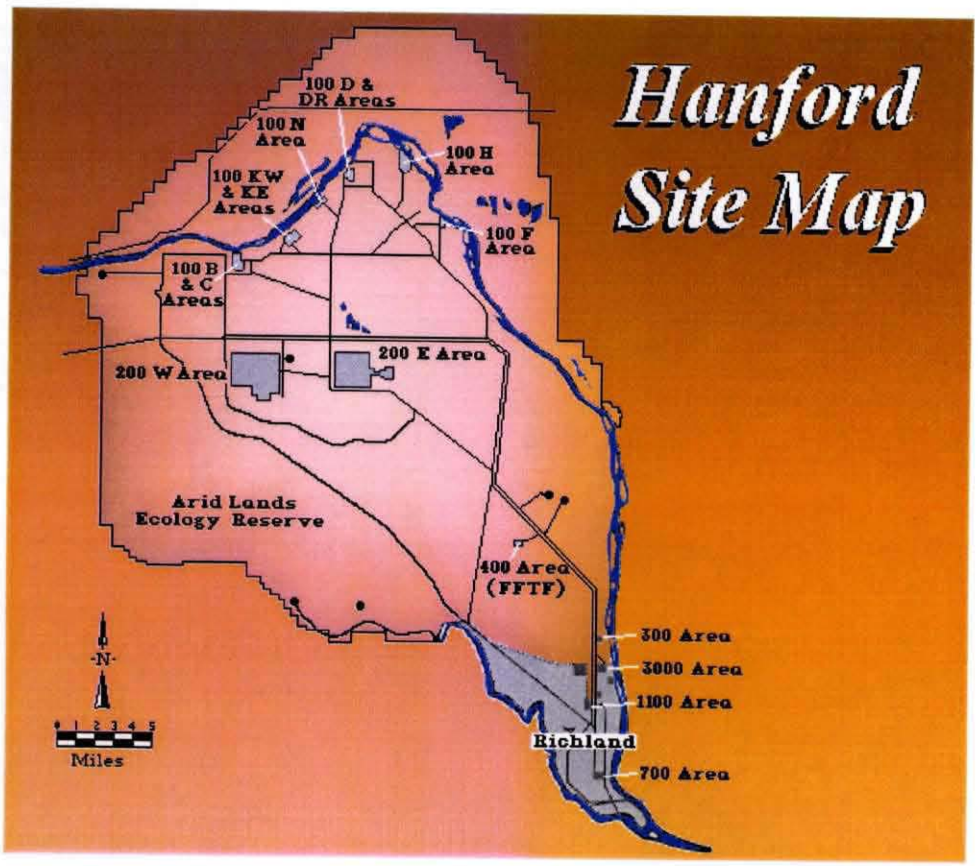

Fig. 1. Hanford is a complex Site, with significant amounts of groundwater contamination in various areas.

Further complicating matters is the fact that during the production years massive untreated discharges of liquid (estimated at 440 billion gallons) created mounds in the groundwater table. The mounds sometimes rose up 75 feet, and they shifted the hydraulic gradients underground so that groundwater flowed in unnatural patterns – sometimes up-gradient and through narrow channels and barriers – mixing contaminant plumes in unexpected ways. Contaminants mingled with each other, sometimes speeding up as new compounds were formed. Early science, based on laboratory soil experiments, had not predicted the situations that now exist in Hanford's groundwater.

The variety of radionuclides and chemicals in the groundwater is also complex. Uranium-fuel manufacturing, along with radiochemical experimentation, in the 300 Area sent uranium and other heavy-metal dust combined with acids, trichloroethylene, dichloroethylene, perchloroethylene, acetone, kerosene, and other hazardous substances percolating through shallow soil into the groundwater. Reactor operations in the 100 Areas soaked the ground with water contaminated with sodium dichromate and strontium 90 (Sr-90).

Chemical-processing operations in the 200 Areas released bismuth phosphate, as well as potassium permanganate, lanthanum fluoride, nitrates and sodium hydroxide complexed with plutonium and fission products into engineered trenches and drains. As Hanford's chemistry changed to reprocess irradiated fuel more efficiently, tributyl phosphate, methyl isobytyl ketone, aluminum nitrate nonahydrate, carbon tetrachloride, and dissolved radioactive elements were disposed to Hanford's soil.

In addition, some liquids with higher radioactivity levels escaped unintentionally from tanks storing waste. In 1997, the DOE verified that tank wastes had reached the groundwater in the 200 Areas adjacent to the tank "farms." (At Hanford, 18 groups of underground tanks in fenced areas are known as tank farms.)

Working to understand, contain and remediate these groundwater contaminants posed unique and daunting challenges. Adding Hanford's soil waste sites work into the consolidated SGRP made it one of the largest, most visible and most debated projects at the Site. Central Hanford alone has more than 43 miles of solid waste burial grounds; more than 100 miles of buried contaminated pipelines and appurtenances; hundreds of liquid waste disposal "cribs," drains, and tiles fields, as well as seven major disposal "ponds" totaling nearly 150 acres.

Much of SGRP Work is Heavy and Industrial

While some SGRP tasks consist of studying data, researching technologies and writing reports, much of the project's work employs manual labor working in outdoor conditions and using drill rigs and other heavy machinery. The project drilled 100 new wells this past year – a new record and a number that has increased every year since 2002. It also decommissioned 90 old and unsealed wells, using mechanical-perforation methods and sometimes explosives. Decommissioning a well with a double or even triple casing, the most challenging scenario, requires placing and detonating explosive devices down inside the well to perforate all the casings. A technique called "jet shot" perforation is used in multiple-cased Hanford wells – 70 such jet-shot perforations were performed in 2006 alone.

Fig. 2. A Fluor Hanford crew drills a well in the 200 Area of central Hanford, 2005.

In addition, the SGRP drills several deep boreholes each year into highly contaminated soil zones – including a unique slanted borehole under a plutonium site in 2006. It also installs dozens of aquifer tubes in steep banks along the Columbia River. Seven large pump-and-treat operations across the Hanford Site pump contaminated groundwater up and through treatment tanks and columns, and back to the soil.

At least four new technologies have been developed and tested in the past four years to replace or augment pump-and-treat operations. During 2006-07, SGRP installed a 300-foot, underground chemical barrier to capture strontium-90 along the Columbia River and injected it twice with thousands of gallons of solution. It also installed and tested two unique, experimental treatment systems. One uses electrocoagulation to reduce toxic hexavalent chromium to non-toxic trivalent chromium and the other utilizes new ion-exchange resins to remove other radionuclides from groundwater. The project also constructed and tested a calcium polyphosphate injection system to reduce hexavalent chromium to trivalent chromium.

As part of its "routine" work, SGRP samples thousands of wells, soil sites and environmental media each year. In 2007, the project's field sampling program collected nearly 70,000 samples bottles from Site wells, totaling about 13,000 gallons of water. About 2,400 samples were collected from wells on a routine basis, to support groundwater characterization, reporting and research requirements, and each one generated purgewater waste that had to be managed according to tight regulations. The project also collected more than 150 "multi-media" samples -- wide variety of non-routine or specialty samples that are collected on an as-needed basis, including samples of diesel and transformer oils, paint chips, asbestos, non-standard drums or barrels, and other materials found or spilled in the course of Site work. The number and volume of samples collected in 2007 all represent approximately a ten percent increase over the previous year, and the 2008 numbers are growing by yet another ten percent. In addition, hundreds of soil and waste site samples are collected each year.

Fig. 3. Fluor Hanford workers collect and carefully handle a soil sample containing plutonium, 2006.

The SGRP also conducts geophysical logging, electrical-resistivity surveys, and many other types of data-gathering activities - all performed in an environment contaminated with radioactivity and hazardous chemicals.

As concern about potentially contaminating the Columbia River grows throughout the Pacific Northwest, the DOE has directed additional funds at SGRP and the project's work has expanded exponentially. In 2007, special appropriations to expand work and try multiple new technologies came from DOE offices other than the main project office of Environmental Management. Signatories of Hanford's Tri-Party Agreement – the pact among the DOE, the U.S. Environmental Protection Agency, and Washington state that governs cleanup – are currently discussing still more expansions in the SGRP.

Field Operations Group Coordinates, Facilitates Multiple Physical Tasks

Within Fluor Hanford's SGRP, a large and growing field operations organization is responsible for making sure that the fieldwork, most of it outdoors, occurs safely, efficiently, and in a coordinated manner that doesn't waste resources. In 2002, this organization had about 30 people and was simply called the "field team." By 2004, it had about 75 people; then 100 people by 2006, and now it numbers nearly 150 people.

Its job is to coordinate, plan, monitor, and assure the safety of SGRP work, including the work of subcontractors. It provides radiological-control expertise and support, safety inspections, industrial hygiene, work control, waste management and logistical support and, in many cases, personnel. It supplies the trucks and drivers to remove purgewater and other wastes generated in sampling and drilling and also coordinates the movements into and out of work sites.

Safety in SGRP Needed and Received Attention

In 2002, when Fluor Hanford began managing groundwater work at Hanford, the project worked only just under 55,000 person-hours, but had a recordable accident rate of 3.65 per 200,000 hours worked. The following year, project growth pushed the number of person-hours to just under 145,000, with a recordable accident rate of 2.78 per 200,000 hours worked. While these rates were still below the national averages for such work, Fluor Hanford was not satisfied. Fluor's corporate target recordable accident rate was .75, and it decided to take aggressive steps to lower accident rates in the crucial groundwater program.

To begin, Fluor Hanford brought in a new field-operations director and a safety manager, both of whom located their offices in the field and had direct access to the groundwater project's vice president. They conducted a self-assessment in the project through DOE's VPP program, a strict and comprehensive safety program modeled after that of the Occupational Safety and Health Administration. The average score was an abysmal 3.84 out of 10, and the new leaders stopped the self-assessment after just two days.

They began a series of meetings with employees to understand the issues. They found compartmentalized groups of workers who did not trust one another and did not share information. They found that many workers believed that managers emphasized meeting schedule commitments before caring about safety. Workers gave examples of safety issues both large and small that had been pointed out but not corrected. The workers said they had decided to become silent about safety concerns, because no one listened. There was even a sense that some work groups might even sabotage the ability of others to be productive by not telling them about broken equipment in the field, well-heads choked with vegetation, or conflicting schedules of support services that could hamper or halt work.

Among the first corrective actions taken by Fluor's field director and safety manager were to invigorate the safety councils and keep an active record of the concerns raised at them. At Hanford, project safety councils are called Employee Zero Accident Councils (EZACs). They are led by workers, with management participation. There is also a company-wide Presidents' Zero Accident Council (PZAC) that meets monthly in a large open forum and reviews every accident. With workers, labor leaders, and senior management present, any and all topics that can improve safety are placed on the table.

The groundwater EZAC had become a symposium for grumbling, but the new leaders attended every one. The safety manager even became the EZAC co-chair, and challenged the complainers to offer solutions, and kept a record of every safety concern raised. At subsequent meetings, the new leaders demonstrated their good faith by listing the problems they had investigated and corrected since the previous meeting.

Fig. 4. Regular, open meetings between SGRP management and labor helped to improve communications about safety and reach solutions.

The SGRP field management team also held Monday-morning "tailgate" meetings with field workers and monthly meetings with union stewards, visited job sites every day, and kept a visible record of the safety issues and grievances listed and the solutions that followed. They immediately realized they would need more personnel, and persuaded the vice president to hire more people whose full time job was to improve safety. Fortunately, Fluor Hanford, which was already in the midst of dramatically lowering injury, accident and injury rates across the company, held the belief that "you can't afford not to invest in safety." (In the 11 years that Fluor Hanford has managed major cleanup projects at the Hanford Site, the recordable injury rate across those projects has dropped by 80 percent.) Fluor Hanford immediately authorized a larger safety staff for groundwater work, and that staff now numbers eight full-time, SGRP safety officers.

Fortunately, the existing field management staff members in the groundwater program quickly became enthusiastic when they saw that safety was becoming a very high priority. Safety improvements and successes "bred success" and energized the whole team – new and existing – became involved in making further improvements.

Because groundwater work depends on heavy equipment – especially vehicles – they strengthened the equipment inspection program by developing, with worker input, specific safety-inspection checklists for each type of equipment. Pumps, hoses, sampling trucks, drill rigs, forklifts, and even the barbecues used by workers to prepare lunches in fair weather were given their own particular list of items to be checked for safety and operability before use. Likewise, the field management team checked signs, road obstructions, holes, and other obstacles around wells, and made sure the safe accessibility was maintained. They coordinated with the Hanford Fire Department to cut brush and maintain clear work areas around well-heads.

Lock-and-tag and electrical safety issues had been an issue in the project. The new leadership adopted a clear policy tolerating no shortcuts or lackadaisical adherence to Fluor Hanford lock-and tag procedures. Every single worker at Fluor Hanford has "stop work" authority if he or she believes a job condition is or will be unsafe. Attitudes and morale improved in the groundwater project as workers saw that safe work rules were being taken seriously and enforced with management backing.

Hanford, because of its large size and unique hazards, has a very formal system of controlling work to ensure that safe practices are followed. An Automated Job Hazards Assessment (AJHA) is needed before most jobs can begin. The AJHA is a sophisticated yet user-friendly, computerized tool in which the potential risks of every job are evaluated and mitigations built in. Part of Fluor Hanford's Integrated Safety Management System, the AJHA uses a graded approach, so that undue bureaucracy is not inserted into simple or routine jobs, yet more complex jobs receive the step-wise scrutiny they need.

In the SGRP, hazards identification – part of the AJHA - can be doubly difficult when the work is going to penetrate far below the surface. Depending on the information generated in the AHJA, many requirements can emerge before any job can begin at Fluor Hanford. In 2004, the groundwater field management team made it clear they would follow the mandates of the AJHA, and bring together the resources required. If a job called for a certain level of radiological control support, that support was provided. Qualified teamsters were scheduled to drive the purgewater trucks. Data loggers who needed support to maintain proper documented "chain of custody" of well samples got the equipment they needed.

Industrial hygiene personnel were brought in to develop monitoring plans for the various types of wells, and were sent with field crews to sample vapors as wells were vented during jobs. Workers were given access to all the data collected by the industrial hygiene personnel, and participated in decisions about protective masks and other equipment that might be needed.

Subcontractors, whether used for drilling, sampling, geophysical logging, or other work, were also made to understand that following safety rules and procedures, learning safety practices, performing inspections, airing grievances, and keeping safety logbooks are requirements of working on the Hanford Site. The groundwater field management team made sure that AJHA and other safety requirements "flowed down" to subcontractors. For example, if it was mandatory that Fluor Hanford workers wear hard hats and steel-toed boots for a given job, it was also mandatory that subcontractors to wear them.

Extremely important considerations at Hanford are the Site's size and the number and variety of crafts and other workers involved in jobs. If a sampling crew travels to a distant well site and finds that maintenance personnel have not cleared well screens or that a nearby nuclear facility is holding a drill with a security perimeter extending beyond the well that day, then a costly trip has been wasted. The new safety leaders in the groundwater project in 2004 saw that coordination was not only important, but it was also a safety issue. Needless travel across the Site, expenses incurred with no gain, and frustration engendered by simple obstacles to work bred resentment and low morale. In addition, not synchronizing the movement of equipment and people in and out of job sites, so as not to interfere with the work of others, constituted a direct safety hazard.

Members of the groundwater field management team in 2004 made it their business to coordinate work so that all contractors and subcontractors in the cross-cutting project could be successful. They melded schedules, notified all involved about the work of others, and involved all groups of workers in planning jobs. They insisted that jobs be "walked down" before being planned, and then that work packages have input from all types of crafts, support services, professionals and others who would be involved in performing them. They also developed a "back-up" set of packages for routine jobs, so that if a crew could not perform a planned task they could at least perform another useful job in the field that day. Morale improved along with productivity, and as one manager said the "gotcha" attitude in the project was gradually replaced by cooperative partnerships.

The Payoff: Safety Improvements 2004-2008

In 2004, Hanford's groundwater project worked nearly 300,000 person-hours – then a record for the project. Fluor's new field director and safety manager, just getting started, reduced the recordable accident rate to 2.01, and they cut the lost or restricted workday case rate by more than half – from 1.39 in 2003 to 0.67 in 2004. In 2005, the statistics looked even better. That year, the project worked nearly 340,000 person-hours and had a recordable accident rate of only 0.59, and a lost or restricted workday case rate of zero!

In addition, a change in attitude became evident in the project. EZACs were well-attended and grew from "gripe sessions" to forums where real solutions were hammered out. Multi-disciplinary teams performing job walk-downs and work packaged talked with each other, cooperating and sharing ideas. Meetings between management and union stewards lost much of their tension, and people even began to campaign for starting a VPP submittal to obtain Star Status.

In 2006, the SGRP worked over 520,000 person-hours, yet remarkably both the recordable accident rate and the lost or restricted workday case rate stood at zero! The VPP self-assessment conducted that year returned an average score of 8.1. Likewise, lock-and-tag violations stood at zero in 2006, vehicle accidents declined significantly, and other safety indicators all trended in a positive direction. In mid-2007, the project reached two million hours without a day lost to an injury. At nearly the same time, the SGRP was awarded Star Status in the VPP system. Only seven first aid cases occurred during that entire year. As 2008 dawned, the projects' safe record continued, surpassing 2.2-million hours without a day lost to an injury.

Fig. 5. SGRP workers, along with high-level DOE officials, stand near two drill rigs and celebrate as they receive their VPP Star flag in May 2007.

Conclusion

Real and specific steps were taken by Fluor Hanford to substantially improve safety in the large Soil and Groundwater Remediation Project at the Hanford Site. Despite project growth, accident rates and all other safety indicators trended in an extremely positive direction. The steps to improve safety can be shared, to help improve safety at other Department of Energy and industrial projects.