Hanford Groundwater Remediation

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ABSTRACT

By 1990 nearly 50 years of producing plutonium put approximately 1.70E + 12 liters (450 billion gallons) of liquid wastes into the soil of the 1,518-square kilometer (586-square mile) Hanford Site in southeast Washington State. The liquid releases consisted of chemicals used in laboratory experiments, manufacturing and rinsing uranium fuel, dissolving that fuel after irradiation in Hanford’s nuclear reactors, and in liquefying plutonium scraps needed to feed other plutonium-processing operations. Chemicals were also added to the water used to cool Hanford’s reactors to prevent corrosion in the reactor tubes. In addition, water and acid rinses were used to clean plutonium deposits from piping in Hanford’s large radiochemical facilities. All of these chemicals became contaminated with radionuclides.

As Hanford raced to help win World War II, and then raced to produce materials for the Cold War, these radioactive liquid wastes were released to the Site’s sandy soils. Early scientific experiments seemed to show that the most highly radioactive components of these liquids would bind to the soil just below the surface of the land, thus posing no threat to groundwater. Other experiments predicted that the water containing most radionuclides would take hundreds of years to seep into groundwater, decaying (or losing) most of its radioactivity before reaching the groundwater or subsequently flowing into the Columbia River, although it was known that some contaminants like tritium would move quickly.

Evidence today, however, shows that many contaminants have reached the Site’s groundwater and the Columbia River, with more on its way. Over 259 square kilometers (100 square miles) of groundwater at Hanford have contaminant levels above drinking-water standards.

Also key to successfully cleaning up the Site is providing information resources and public-involvement opportunities to Hanford’s stakeholders. This large, passionate, diverse, and geographically dispersed community is united in its desire to protect the Columbia River and have a voice in Hanford’s future.

This paper presents the challenges, and then discusses the progress and efforts underway to reduce the risk posed by contaminated groundwater at Hanford. While Hanford groundwater is not a source of drinking water on or off the Site, there are possible near-shore impacts where it

flows into the Columbia River. Therefore, this remediation is critical to the overall efforts to clean up the Site, as well as protect a natural resource.

INTRODUCTION

The Groundwater Remediation Project (GRP), managed by Fluor Hanford (Fluor), is a cross-cutting project that works with scientists from the Pacific Northwest National Laboratory (PNNL) and other Site contractors and subcontractors to understand and remediate plumes of contamination that could affect the Columbia River.

The GRP has four major tasks: shrink the footprint of contaminated areas; reduce "recharge" (or re-supply) of clean or contaminated water that may drive soil contaminants deeper into the subsurface; implement final groundwater remedies; and integrate groundwater monitoring needs. To accomplish these tasks, the GRP operates seven major pump-and-treat systems at key points on the Hanford Site where concentrated plumes of contamination can be intercepted and brought to the surface to be cleaned. The Project also operates three test systems in production-reactor areas (the 100 D, 100 N and 100 K Areas) that apply new approaches to chemically alter the contaminants in groundwater (Figure 1).

In addition, the GRP decommissions old wells that act as preferential pathways for contaminants to move into groundwater more quickly, and it drills new monitoring, extraction and injection wells every year. Extensive monitoring programs, underground mapping, records searches, and investigations of new technologies to provide better remedies for groundwater contamination are also vital parts of Hanford's GRP.

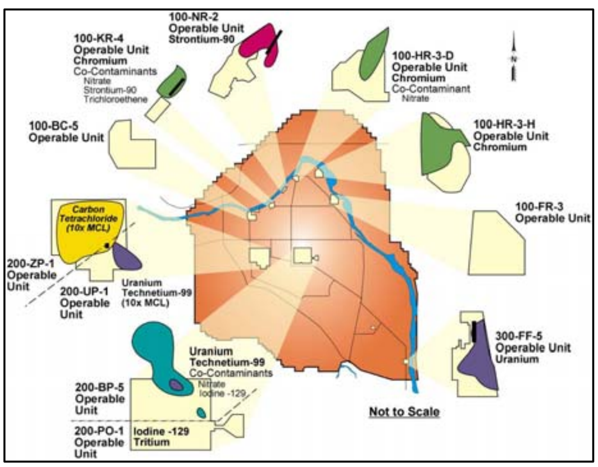

Figure 1. Groundwater contamination is attacked across the Hanford Site through multiple strategies.

TEN YEARS OF ACCOMPLISHMENTS

The last decade has yielded multiple successes in cleaning up groundwater. Chief among them is treating 10 billion liters (2.6 billion gallons) of contaminated groundwater, and eliminating or reducing multiple drivers of groundwater contaminants. In 1995, the Hanford Site met a crucial milestone in its regulatory agreement among the DOE, the U.S. Environmental Protection Agency (EPA) and Washington State. Known as the Tri-Party Agreement, this pact has governed Site cleanup since 1989.[1] The Site stopped unpermitted discharges of liquid waste to the soil by starting up major new systems for collecting and treating liquid effluent in its chemical-processing and fuel-fabrication areas, as well as its nuclear laboratories.

Site workers also pumped all of the retrievable liquid from 149 single-shell waste tanks to prevent leaks to the groundwater, installed berms around the tank farms to prevent localized flooding, and decommissioned water lines that were no longer needed in or near the tank farms. Using a technique called mortar-lining, workers refurbished four miles of aging water lines to help prevent leaks that could drive contaminants already in the soil (vadose zone) deeper to groundwater. They also removed six million tons of contaminated soil from waste sites along the Columbia River Corridor that have/could contribute to large plumes of contamination. Removing this soil, as well as the 2,300 tons of spent nuclear fuel from the K Basins, and demolishing buildings in the River Corridor, removed about 65 million curies (Ci) of radioactive material from along the Columbia River shoreline.

Groundwater-protection programs also used a vapor-extraction technique to remove about 173,000 pounds (78,600 kilograms [kg]) of carbon tetrachloride from soil near the Plutonium Finishing Plant. An additional 20,000 pounds (9,120 kg) of carbon tetrachloride was removed from the groundwater with a pump-and-treat system. Another pump-and-treat system in the same area was installed to remove uranium (U) and technetium 99 (Tc-99) from groundwater.

In the Site’s reactor-production areas, workers have installed four pump-and-treat systems since 1995 to treat and remove hexavalent chromium (Cr+6) and strontium 90 (Sr-90). Two of these pump-and-treat systems are close to meeting remedial action objectives (RAOs) defined in Records of Decision for Interim Actions under the 1980 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). [2] The heart of the U/Tc-99 plume near U Plant in one of the chemical-processing areas has been removed. Pumping has stopped; the area is being monitored for rebound. This system removed 212 kg (467 pounds) of U, two Ci (119 grams) of Tc-99, and 27,344 kg (60,000 pounds) of nitrate. In addition, the pump-and-treat system at the 100-H Reactor Area is approaching its RAO; pumping may be suspended in a few months. Subsequent monitoring will be done for rebound.

To replace or augment pump-and-treat systems, Hanford’s groundwater strategies have deployed innovative technologies. Workers installed a chemical barrier that works by *in situ* (in the groundwater) reduction-oxidation manipulation to help decrease the amount of chromium (Cr+6) in groundwater that is moving toward the river in the 100 D Area. The barrier converts hexavalent chromium, which is toxic to fish, into trivalent chromium (Cr+3). Fluor’s GRP is now testing calcium polysulfide treatment systems for treating Cr+6 *in situ*, and it is testing sequestration technologies to bind mobile contaminants *in situ*.

Groundwater protection programs have also installed a cumulative total of 45 monitoring wells in the past three years, and are currently six months ahead of the Tri-Party Agreement schedule for installing wells. They have also decommissioned about 500 wells since 1995, including 250 high-risk wells that could potentially be a path for contaminants to move to groundwater.

HUGE ACCOMPLISHMENTS IN PAST YEAR

In just the past year – calendar 2005 – Fluor’s GRP actions have produced a plethora of achievements. These successes include meeting the RAOs for the U/Tc-99 pump-and-treat system in the U Plant region of the chemical processing areas, approaching the RAOs for Cr+6 at the 100-H Reactor Area, upgrading all of the chromium pump-and-treat systems along the Columbia River, evaluating the innovative calcium polysulfide treatment technology for Cr+6, and increasing the throughput of the carbon tetrachloride pump-and-treat system near the Plutonium Finishing Plant from 719 liters per minute (190 gallons per minute [gpm]) to 1,041 liters per minute (275 gpm).

In addition, 30 new wells supporting monitoring and remediation have been installed; at least 116 wells that were potential pathways for aquifer contamination have been decommissioned; and 792 meters (2,600 feet) of old, leaking pressurized fresh-water lines have been lined. Field activities are underway to evaluate a sequestration alternative for a large plume of Sr-90 at the 100 N Reactor Area, as well as options to address the plume of U in the fuel-fabrication area.

100-H REACTOR AREA PROGRESS

In mid-2005, the Cr+6 contamination levels in groundwater in the 100-H Reactor Area were reduced to below (within) the drinking-water standard for the first time in nearly 50 years. A truly hallmark event! Eleven years of pump-and-treat operations in this area reduced the Cr+6 contamination levels to less than 100 micrograms per liter(µg/L) in all parts of 100 H Area, and to below 50 µg/L in all but a small area between the 100 H reactor and the Columbia River. (A microgram is a measure of parts per billion.) The pump-and-treat program in 100 H Area removed over 34 kg (75 pounds) of Cr+6.

Chromium+6 contaminated the groundwater in Hanford’s 100 Areas during operation of the defense production reactors. Sodium dichromate was added to filtered river water before it was pumped through the reactors to cool them during the irradiation process. The sodium dichromate was used to prevent the aluminum process tubes in the reactors from corroding.

Sodium dichromate arrived at the Hanford Site as a solid, and was dissolved in influent water being prepared in the process pump houses at each reactor area. Each early Hanford reactor used about 136,078 kg (300,000 pounds) of the chemical per year. That amount rose dramatically as reactor power levels were increased throughout the 1950s and early 1960s.

Due to the rush of construction, underground piping between the early reactors and their process pump houses was susceptible to breaking. In addition, effluent water piping and holding basins cracked and leaked over time. Thus, a great deal of sodium dichromate reached groundwater.

Today, with the acceptable standard reached for drinking water, the GRP is continuing to pump and treat the remaining contamination to drive the level even lower. Fluor plans to continue pumping in the 100 H Area into mid-2006, striving toward the aquatic water safety standard (10 parts per billion [ppb] or 22 µg/L) – an even more restrictive level than the human drinking water standard of 100 ppb for Cr+6 established by the U.S. EPA.

Hanford's 100 H Area, located near the northernmost portion of the main Hanford Site borders some of the most important and prolific salmon spawning areas in the United States. The Hanford Reach of the Columbia River – the 51-mile stretch of river flowing through the Hanford Site – has been documented as an important habitat for salmon, steelhead and other fish species. Fish biologists at PNNL have confirmed that within the Hanford Reach, salmon preferentially spawn near the 100 H Area, making water cleanup there even more important.

Six extraction wells in the 100-H Area remove contaminated groundwater from the 100 H Area, and send it to a treatment facility in the nearby 100 D Area where sodium dithionate is added to the water to sorb the Cr+6, effectively changing it to Cr+3. Chromium+3 is not harmful to living organisms because it is not soluble and doesn't bind to their systems. Chromium+6 is soluble and is a carcinogen.

The water is then returned to the ground under the 100 H Area, where it is monitored by four compliance wells, 18 monitoring wells, and seven aquifer tubes. (Aquifer tubes are shallow groundwater sampling tubes installed in adjacent holes at regularly spaced intervals and are used to monitor the concentration of contaminant in near-surface depths along the banks of the River.)

Today, one monitoring well in the 100 H Area shows secondary contaminant levels of tritium, U, and nitrates above drinking-water standards; a few wells show Sr-90 concentrations above the EPA standard. Seven major chromium liquid waste sites have already been remediated. All are planned to be cleaned up by 2010, as is the remediation and re-vegetation of solid waste sites in the 100 H Area. Further, a major solid waste site between the100 H and 100 D Areas, where sodium dichromate drums were crushed and abandoned, has been removed and closed.

100 DR-5 GROUNDWATER TREATMENT SYSTEM EXPANDS

At the 100-D Reactor Area, hugging the River's shoreline upstream of the 100 H Area, Fluor's GRP has expanded pump-and-treat systems to remediate plumes of contaminated water under the DR-5 sector – the center portion – of the area. This sector, just upstream from the "cocooned" D and DR Reactors, has plumes with the highest concentrations of Cr+6 anywhere on the Site.

Pump-and-treat systems have operated in the 100 D Area for over eight years, processing nearly 1.3 billion liters (350 million gallons) of groundwater and removing nearly 272 kg (600 pounds) of Cr+6. In addition, a passive, underground chemical-barrier system has been treating groundwater contaminated with Cr+6 in the 100 D Area since 1999. Groundwater remediation systems serving the 100 H Area have been so successful that next year they may meet the RAO of 20 ppb agreed to by the signatories of Hanford's Tri-Party Agreement.

However in 2004, new and more concentrated groundwater plumes – measuring up to 3,000 ppb of Cr+6 – were detected northwest of the D and DR Reactors (an area known as the 100-DR-5 region). Almost immediately, pumping was ramped up in the 100-D Area. With the addition in 2005 of another pump-and-treat system that uses more efficient resins to treat the Cr+6, the GRP is better able to capture the highly concentrated plume before it reaches the Columbia River.

The new resins can be regenerated or cleaned on Site – significantly lowering operating costs. Also, treatment capacity was increased from about 114 liters per minute (30 gpm) to nearly 189 liters per minute (50gpm) to maintain progress against any movement by this plume.

A major challenge is finding the source of the new, highly concentrated plume in the 100 D Area. Spills of highly concentrated “stocks” of sodium dichromate, and leakage of coolant water, left a messy trail of contaminated groundwater, especially in Hanford’s middle reactor areas (K, D and H Areas). Now GRP scientists are trying to pinpoint the underground pathways that cause the Cr+6 plumes to flow in certain directions and concentrate in specific areas.

GROUNDWATER TREATABILITY TEST IN 100-K AREA – EARLY SUCCESS

At the 100 K Reactor Area, about three miles west of 100 D Area, an innovative system is being tested to treat and clean groundwater. The 100-KR-4 treatability test, begun in June 2005, has already cut levels of Cr+6 in the groundwater by more than 75 percent at the test site.(Figure 2.)

The 100-KR-4 test system consists of an extraction well (199-K-126) approximately 30.4 meters (100 feet) deep, surrounded by four injection wells each located about 30.4 meters (100 feet) away. All five wells have wire-wrapped screen that provide tiny holes in the bottom areas where they interact with the groundwater. In the treatment process, groundwater is pumped out through well 199-K-126, then mixed with calcium polysulfide in an above-ground tank, and re-introduced into the aquifer through the injection wells.(Figure 2.) The calcium polysulfide chemically reacts with the Cr+6, reducing it to Cr+3, some of which precipitates in the mixing tank. The treated water is then filtered and re-introduced into the aquifer through the injection wells.

The new calcium polysulfide system seems to be working extremely well. Data collected in the first four months of the test have reduced Cr+6 concentrations from about 70 ppb in groundwater at the bottom of the extraction well, to less than 10 ppb in groundwater at the test site.

The 100-KR-4 test was conceived after an expert advisory panel recommended that Fluor develop innovative ways to remediate 100 Area’s groundwater. Several members of the GRP team worked together, developing and implementing the test plan. The concept was developed, approved by DOE and the EPA, the wells drilled, and the test underway all within eight months.

Some scientific and physical obstacles have yet to be overcome. The more heterogeneous the sub-strata, the more time it will take to treat all of the Cr+6. In other words, if the underground mobility of the water is high, it will take longer to clean up the area. Therefore, the calcium polysulfide technique may not be adaptable to all other Hanford environments.

In addition, some of the water re-injected into the ground has shown lower concentrations of oxygen than desirable for fish. The hypo-oxygenation issue may not be a problem because, in the current test, the injection wells are several hundred feet from the Columbia River. Natural groundwater flow should cause the water to be re-oxygenated by the time it reaches the River. However, the hypo-oxygenation issues will be carefully considered in subsequent applications.

A report due out this month will document the strengths and drawbacks of the calcium polysulfide system, and will help guide a decision on whether or not the method will be deployed in other parts of Hanford’s 100 Areas.

Figure 2. Treatability test equipment, including an above-ground Mixing tank, has been installed in the 100 K Area.

NEW IDEAS, TECHNIQUES TRIED IN 100-N AREA

Located between the 100 D and 100 K Reactor areas in north Hanford lays 100 N Area, home to the largest production reactor ever built at the Site. The New Production Reactor (or N Reactor), built in response to the launch of Sputnik by the former Soviet Union in 1957, took nearly six years to build. It operated longer than any of Hanford’s other production reactors (23 years), and its fuel assemblies were over eight times the size of the fuel used in other Hanford reactors.

N Reactor also produced electric power, and for most of the 1970s, it irradiated its fuel loads for weeks to months longer than fuel is normally irradiated for weapons production. All of these factors combined to produce a large plume of Sr-90 in the soil and groundwater in 100 N Area. Sr-90 is harmful to living organisms because it is a bone-seeker, replacing calcium in bones and weakening or sickening the animals (including humans) it enters. In 100 N Area, strontium is present in groundwater at levels more than one thousand times those allowed in drinking water, and is found in river plants and clams.

The battle to prevent Sr-90 from reaching the River began in 1995. However, pump-and-treat systems there have removed far less Sr-90 than is naturally removed by radioactive decay. By 2003, the DOE deemed 100 N pump-and-treat system ineffective. A sheet-metal barrier system was also tried but the 9.1-meter (30-foot) sheet pilings hit buried boulders in the soil and bent.

Now, GRP scientists and engineers are implementing a new approach to cleaning up the strontium: pump a form of calcium phosphate compound into the soil to bind the strontium. The calcium compound – which forms an apatite barrier – is similar to that found in tooth enamel. Hopefully, a chemical reaction between the Sr-90 and the apatite will bind the strontium in place for decades, keeping it from the river while it radioactively decays. Vetted with stakeholders at a workshop this past Fall, the apatite test is underway. Results will be evaluated later this year.

PLUTONIUM FINISHING PLANT AREA GROUNDWATER TREATMENT SYSTEM

In the chemical-processing sector of Hanford referred to as the 200 West Area, on a plateau known as central Hanford, the GRP has also expanded a groundwater extraction and treatment system removing carbon tetrachloride from groundwater near the Plutonium Finishing Plant (PFP). Four new extraction wells have been added to a set of five wells that have operated for the past nine years to extract groundwater contaminated with carbon tetrachloride (CCl_4), increasing the pumping capacity from approximately 757 liters per minute (200 gpm) to approximately 1,325 liters per minute (350 gpm).

The four new wells are needed to capture the north end of a plume of CCl_4 (2,000 micrograms per liter [ug/L]) believed to have originated from trenches and cribs surrounding PFP. Concentrations of CCl_4 in groundwater in the plume today sometimes exceed 4,000 ug/L.

The CCl_4 contamination stems mainly from historical operations at Recuplex and the Plutonium Reclamation Facility (PRF) where plutonium-bearing scraps were dissolved in corrosive chemicals (tributyl phosphate diluted with CCl_4) to recover the plutonium. Liquid wastes containing CCl_4 were discharged to the trenches and cribs from 1955 to 1973.

An interim Record of Decision currently in place, agreed to by the signatories of the Tri-Party Agreement, calls for groundwater concentrations to be reduced to less than 2,000 ug/L. A final agreement may set a different standard. The permissible concentration level for CCl_4 in drinking water is 5 ug/L.

The CCl_4 extraction and treatment program in the PFP area of Hanford is particularly challenging due to the size of the plume and the fact that the highest concentrations are sometimes found deeper within the aquifer.

A full remedial-action feasibility study, a required process under CERCLA, will begin in FY 2007 and will evaluate multiple technologies and approaches to mitigating the plume of carbon tetrachloride. It will also determine the final end state, through public participation.

For now, expanding the pump-and-treat system for this groundwater plume this past year was a prudent interim measure, while awaiting the final CERCLA decision.

The contaminated water pumped from the five existing wells and the four new wells in the PFP area travels through pipelines to a small treatment building located nearby. There, an air-stripper tower outside the building removes CCl_4 from the water. Contaminated air from the tower is then routed inside the building and through a heater/chiller that removes moisture, and then through a granulated activated carbon (GAC) filter that captures the CCl_4 from the air. Clean air is then released to the environment. When the filter becomes saturated, it is sent off site to be regenerated by a commercial company.

Treated, or clean, groundwater is re-injected into the aquifer at points up the hydraulic gradient from the CCl_4 plume. In other words, the clean water is put into the groundwater at points where it will flow toward the contaminated plume – helping to dilute the plume and drive it to the extraction wells.

The GRP expects to pump from the nine extraction wells in the PFP area at least through 2008. Meanwhile, new technologies such as air sparging and enhanced *in-situ* reductive dechlorination will be evaluated to remove CCl_4 from Hanford's groundwater.

DECOMMISSIONING OLD WELLS AT HANFORD

A crucial task for Hanford's GRP, and one important to stakeholders, is identifying and decommissioning old wells that have been drilled to monitor water levels or groundwater contamination, or to inject liquid waste. Many of the old wells can be pathways that allow contamination to reach groundwater.

Decommissioning a well essentially means sealing it, usually with special cement called grout, so it can no longer act as a conduit for contaminants. Where possible, the well casings are filled with grout as they are withdrawn from the ground. If the casings cannot be withdrawn, they must be perforated so that grout can be injected under pressure through the perforations and can fill void spaces in the soil that have developed along the outside of the casings.

The first task in decommissioning a well involves sorting through various databases and identifying which wells actually existed and were doing real damage. Over decades, slightly more than 7,000 wells were drilled on the Site, most of them to monitor contaminants. However they were catalogued in at least seven different databases, lending confusion to current efforts.

Fluor led an effort to assess the current database for information needed, and then initiated field inspections as appropriate. Fluor teams found many wells had already been decommissioned but the required paperwork had not been filed. In addition, they determined which entries were for sample tracking purposes, not related to conventionally drilled wells.

Once the number of actual Site wells (an ongoing process) was winnowed down, well "owners" were sought out. Some wells were clearly in use, others were dormant but owned by projects still planning to use them, and still others could not be decommissioned because they are located on Hanford land leased by other specially permitted entities not performing DOE missions.

According to the Washington State Administrative Code "any well which is unusable, abandoned, or whose use has been permanently discontinued, or which is in such disrepair that its continued use is impractical or is an environmental, safety or public health hazard shall be decommissioned." In addition, the code states, "cased water wells that were not constructed in accordance with these regulations, or wells which are decommissioned to allow the placement of potential sources of contamination within one hundred feet of the well, or for which a drilling report required under WAC 173-160-141 is missing, shall be decommissioned…."[3]

Today, only about 2,000 Hanford wells in the well-decommissioning program are potential candidates for decommissioning. Of those, about 1,100 wells may need physical decommissioning; the remainder can be administratively decommissioned (paperwork process).

For the GRP, the question then became one of how to set priorities for which Hanford wells would be decommissioned first or quickly. Using a decision process developed in conjunction with the DOE and Washington State, the GRP decided to set priorities based on both risk and programmatic criteria. The wells with the highest risk are those closest to waste sites that penetrate through the vadose zone and into the groundwater. Such wells can act as direct conduits for mobile contaminants. The highest priority, however, must be given to wells that are impacted by Site cleanup project schedules. Fortunately, many of the highest risk wells are located within expedited cleanup sites already being worked by other cleanup projects.

Such a case recently occurred when wells near U Plant in the 200 West Area were decommissioned as part of a larger program to decommission U Plant and its associated liquid-waste disposal areas. Wells that will be under the footprints of water infiltration covers planned for contaminated soil sites must be decommissioned before the covers can be constructed.

Managing the multiple interfaces and intricate coordination requirements of this program is almost more difficult than decommissioning the wells. Detailed coordination is needed so as to not interfere with any other projects, respect facility boundaries, and keep all personnel safe. The GRP also looks at relative costs and manages the work to achieve contracting efficiencies, as some wells are more difficult to decommission than others. For each well selected, the GRP writes a "Decommissioning Profile" and negotiates its approval by Washington State.

Decommissioning wells with double or even triple casing provides the most challenging cases, because explosive devices must be used down inside the wells to perforate all the casings. A technique called "jet-shot" perforation is used in multiple-cased Hanford wells, and requires extensive analysis and assistance from a variety of Site workers – safety professionals, industrial hygienists, radiation control personnel, facility managers, security personnel, and others. Notice of the planned detonation must be given to everyone within 305 meters (1,000 feet) of the well, and to some facilities further away that might be affected. The Laser Interferometer Gravitational Observatory (LIGO) – a University of California experimental facility a few miles south of central Hanford – must be notified about every shot, because its instrumentation is very sensitive to shocks. Seventy wells were decommissioned using jet shot techniques in 2005.

Many, but not all, multiple-cased wells at Hanford are so-called "Webster wells," named for an engineer in the 1980s. Tasked with sealing several wells, he perforated the single casing, and then ran a smaller-diameter casing down the well and injected grout into the annulus between the two casings. His technique relied on hydrostatic pressure to move the grout through the holes to fill the entire borehole and the void spaces on the outside of the wells. However, significant void spaces were not filled, and the wells are now considered a high priority for decommissioning.(Figure 3.)

Fluor’s GRP also made good progress toward decommissioning 45 single-cased wells last year using mechanical perforation methods.(Figure 3.) Along with 146 wells successfully decommissioned in 2003 and 2004, the program decommissioned over 260 wells by the end of 2005. In addition, almost 1,200 previously plugged wells were administratively decommissioned since January 2003, with the concurrence of Washington State.

It is clear that Hanford well decommissioning work will be a long-term endeavor, possibly lasting for more than 10 years. It is one of the ironies of Hanford history that so many holes/wells installed for monitoring groundwater contamination in the past now may be actually contributing to the contamination of groundwater.

Fig. 3. A mechanical perforator is ready for use in an older Hanford single-cased well.

PREVENTING RECHARGE OF CONTAMINANTS

Along with decommissioning old wells, the GRP strives to reduce water recharge into contaminated soil areas by re-lining leaky water lines using a process called mortar-lining. Re-lining water lines eliminates leaks that drive contaminants downward to the water table.

While the mortar-lining technique has been used before, and has even won awards at Hanford, crews this past summer successfully deployed a different method of scraping out the old piping before re-lining. In each case, they opened a port into a pipe and inserted a hard rubber device shaped like a rounded torpedo or an extra-large bullet – called a “pig.” They then sealed the port in the pipe, and forced the pig through the pipe with pressurized water. As it traveled through the pipe, the pig scraped out encrusted material on the inner surface and then flew out the far end of the pipe. Pipe “pigging” prompted jests among workers about "when pigs fly at Hanford."

ADDITIONAL GRP INVESTIGATIVE WORK

Additional investigations and in-field tests underway at Hanford include drilling and sampling four characterization boreholes in the fuel-fabrication area. Just three miles from Richland, the fuel-fabrication area has soil and groundwater saturated with uranium powders and plumes.

In some of the waste-tank areas of central Hanford, the GRP has been conducting in-ground sampling for over a year to understand the seepage of contaminants out of leaky tanks. Under "T" tank farm (a cluster or "field" of tanks) in the 200 West Area, the oldest radioactive tank farm in the world, the migration of Tc-99 is being mapped. Under "A" tank farm in 200 East Area, the original farm to receive wastes from the Plutonium-Uranium Extraction Plant, investigations are tracking a contamination plumes. Under the "B/C" cribs, just south of the 200 East Area, an experimental discharge site from the 1950s, the GRP is also sampling and formulating potential remediation plans.

WELL DRILLING AT HANFORD

None of the groundwater protection methods implemented by the GRP at Hanford could be successful without a first-class well drilling program. The well-drilling program is the active implementation arm of the monitoring programs across the Site. Fluor has drilled 45 wells in the last three years, some as deep as122 meters (400 feet). Planning, procurement and drilling are already in progress on most of the 15 wells required by the Tri-Party Agreement in CY 2006.

Fluor well-drilling work is cross-cutting, involving work all over the Site, and support to different contractors and different facilities. Contamination control and flow down of Fluor safety programs to the multiple subcontractors involved in drilling work is key to success.

The GRP also drills extraction wells to remove groundwater for treatment.(Figure 4.) The average well depth can vary between 100 and 300 feet, and subsurface conditions also vary widely.

Fig. 4. Wells are drilled on the central Hanford Plateau to extract contaminated water.

SAFETY AND SUBCONTRACTOR MANAGEMENT IN THE GRP

In addition to the data gathering, pollution prevention, and plume remediation, perhaps the GRP’s most satisfying achievement has been the dramatic improvement in safety. The project recently received a special award at Fluor’s President’s Zero Accident Council for achieving a million safe work hours (hours without a lost time injury). The million hours represents almost three years of work in the project, with 21 percent of that work done by subcontractors last year. At least 17 subcontractors performed in-field work for the GRP at the Site last year, with Fluor requiring each of them to implement a strict safety program prescribed and flowed down by Fluor. Because work at Hanford is inherently more risky and contains more potential surprises than other sites where the subcontractors are used to working, the company insisted that they must all adhere to one meticulous safety system. The results have been amazing. The recordable injury rate for the GRP was 0.55 this past year, lower than Fluor’s Corporate goal of 0.75 and lower than the national average for well-drilling and environmental work of nearly 5.9. Last month, the GRP submitted its application for recognition in DOE’s Voluntary Protection Program – safety program modeled on that of the Occupational Safety and Health Administration.

SUMMARY

In conclusion, the Hanford Groundwater Remediation Project is making major strides in finding and treating contaminated groundwater, and protecting the Columbia River and its fish. Radionuclides and chemicals of long-term concern are being tracked, intercepted and treated at their most concentrated points and at the places where they most threaten crucial natural resources. Innovative chemical barriers and treatments, and well as more standard pump-and-treat methods are being used as the DOE and Fluor strive to protect the Hanford region.

REFERENCES

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2. *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
3. *Minimum Standards for Construction and Maintenance of Wells*, Washington Administrative Code (WAC), as amended WAC-173-160 (Olympia: Washington State Department of Ecology).

APPEDICES:

1. Additional Reading List: Hanford's Groundwater Remediation Program
2. Table I: Environmental Protection Agency Aquatic and Drinking Water Standards for Contaminants of Interest at Hanford Site

Appendix I: Additional Reading List: Hanford's Groundwater Remediation Program

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Appendix II

Table I. EPA Aquatic and Drinking Water Standards for Contaminants of Interest

Constituent	Abbreviation	*DWS- ug/L	*DWS – pCi/L	*Aquatic Std-ug/L
Carbon tetrachloride	CCl4	5		
Trichloroethene	TCE	5		
Chloroform	TCM	100		
Uranium	U	30		
Technetium 99	Tc-99		900	
Strontium 90	Sr-90		8	
Iodine 129	I-129		1	
Tritium	H3		20,000	
Chromium	100			
Nitrate	NO3	45,000		

*Drinking Water Standard – ug/L (micrograms per liter)
*Drinking Water Standard – pCi/L (picocuries per liter)
*Aquatic Standard – ug/L (micrograms per liter)