Startup of the New 200 West Pump-and-Treat, Hanford Site, Richland, Washington – 13214

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ABSTRACT

On June 28, 2012, CH2M HILL Plateau Remediation Company (CHPRC) completed the construction and acceptance testing for a new 2,500 gallon-per-minute (gpm) pump-and-treat (P&T) system in the 200 West Area of the Hanford Site in Washington State. This system is designed to remove Tc-99, carbon tetrachloride, trichloroethene (TCE), nitrate, and total and hexavalent chromium from groundwater using ion exchange, anoxic and aerobic bioreactors, and air stripping. The system will eventually remove uranium from groundwater using ion exchange as well. The startup of the P&T system is important because it will ensure that contaminants from the 200 West Area never reach the Columbia River.

When fully operational, the 200 West P&T will include approximately 23 extraction wells and 21 injection wells. The extraction wells are 8 inches in diameter, are completed with well screens 100 feet or more in length, and are distributed throughout the central portion of the 5-square-mile carbon tetrachloride plume. The injection wells are also 8 inches in diameter and are installed upgradient of the plumes to recharge the aquifer and downgradient of the plumes for flow-path control. Groundwater in the 200 West Area is approximately 250 feet below ground surface, and the aquifer is 200 feet or more in thickness. All of the contaminants (except nitrate) are found within the perimeter of the carbon tetrachloride plume and occur at various depths throughout the aquifer.

The 200 West P&T consists of two separate buildings to conduct groundwater treatment. The RAD building contains an ion exchange system to remove Tc-99 from groundwater at a maximum flow rate of 600 gpm. The RAD building only accepts water from those extraction wells showing elevated Tc-99 concentrations. Groundwater initially fills an influent tank, is then pumped through particulate filters (to remove suspended materials), and then passes through two parallel treatment trains containing Purolite® A530E resin[1] (which has been proven effective in removing Tc-99). The water is then transferred to the biological treatment building for further treatment. When the lead vessel in each of the two treatment trains becomes fully loaded with Tc-99, the Purolite A530E resin is transferred to a separate tank where it is heated to 160°F to remove volatile organics prior to disposal at the Environmental Restoration Disposal Facility.

The biological treatment building has a maximum flow capacity of 2,500 gpm. Groundwater from the nonradiological extraction wells and treated groundwater from the RAD building are initially pumped into an equalization tank and then into two parallel fluidized bed reactors (FBRs). The FBRs contain granulated activated carbon in suspension for microbes to populate, a carbon-based food source for the microbes to eat (e.g., MicroCg™[2], molasses, or sodium lactate), and nitrate for the microbes to breathe (represents "anoxic" conditions that contain little or no dissolved oxygen). The FBRs are maintained at a temperature between 55°F and 90°F, and at a pH between 6.5 and 6.8, to maximize microbial growth. The FBRs break down the nitrate, reduce the hexavalent chromium to trivalent chromium, and break down a good portion of the carbon tetrachloride and TCE.

From the FBRs, groundwater is pumped through a carbon separation tank, then through a splitter box that divides the water evenly between four membrane bioreactors (MBRs) that further break down the

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[1] Purolite is a registered trademark of BROTECH CORP., Bala Cynwyd, Pennsylvania.
[2] MicroCg is a trademark of Environmental Operating Solutions, Inc., Bourne, Massachusetts.

contaminants. The MBRs have aeration capacity to provide sufficient oxygen for maintaining the aerobic biological process. The MBRs use submerged membranes for filtration. Vertically strung fibers are found in the membrane zone where a vacuum draws water through tiny pores in the fibers. The liquid is then pumped to air strippers to remove any volatile organics that have passed through the bioreactors. Solids from the MBRs are pumped to rotary drum thickeners and centrifuges for dewatering prior to lime being added to kill the bacteria and control odor. The conditioned sludge is then disposed at the Environmental Restoration Disposal Facility. The final treated water is then pumped to the injection well field.

The 200 West P&T is a Leadership in Energy and Environmental Design (LEED) gold-certified facility that has an expected 70% energy cost savings over the lifetime of the plant. Fifty percent of the steel used in construction was recycled, 420 tons of recycled concrete were used, and over 75% of construction waste was diverted from landfills. The plant is only staffed one shift per day, and it uses a callout system if the plant goes down during off-shift hours. Initial sampling results have shown that the 200 West P&T is successfully reducing contaminant levels well below the cleanup levels specified in the *Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington* [1]. CHPRC and the U.S. Department of Energy are continuing to look for ways to reduce operational costs, such as testing alternative resins for removing radionuclides and finding less expensive carbon substrate sources. The benefit to others is a LEED gold-certified, 2,500 gpm P&T system that may be used as a model for other complex sites.

INTRODUCTION

On June 28, 2012, CH2M HILL Plateau Remediation Company (CHPRC) completed the construction and acceptance testing for the new 2,500 gallon-per-minute (gpm) 200 West pump-and-treat (P&T) system in the 200 West Area of the Hanford Site in Washington State. This P&T system, which is built over the top of the 200-ZP-1 Groundwater Operable Unit (OU) (Fig. 1), is designed to remove Tc-99, carbon tetrachloride, trichloroethene (TCE), nitrate, and total and hexavalent chromium from groundwater using ion exchange, anoxic and aerobic bioreactors, and air stripping. The system will eventually remove uranium from groundwater using ion exchange as well.

The 200 West P&T is a major component of the final remedial action selected in the *Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington* (hereafter referred to as the Record of Decision [1]. The following remedial action objectives (RAOs) are specified in the Record of Decision:

- RAO No. 1: Return the 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) by achieving the cleanup levels identified in Table I.
- RAO No. 2: Apply institutional controls to prevent the use of groundwater until the cleanup levels have been achieved.
- RAO No. 3: Protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU.

The final cleanup levels for 200-ZP-1 OU groundwater contaminants of concern are listed in Table I. These cleanup levels were developed using federal drinking water maximum contaminant levels (MCLs) along with a variety of Washington State regulations pertaining to drinking water (e.g., Model Toxics Control Act [MTCA], Method B). These cleanup levels need to be achieved at the completion of 25 years of P&T operations, followed by 100 years of monitored natural attenuation.

The startup of this P&T system is important since it will ensure that contaminants from the 200 West Area never reach the Columbia River.

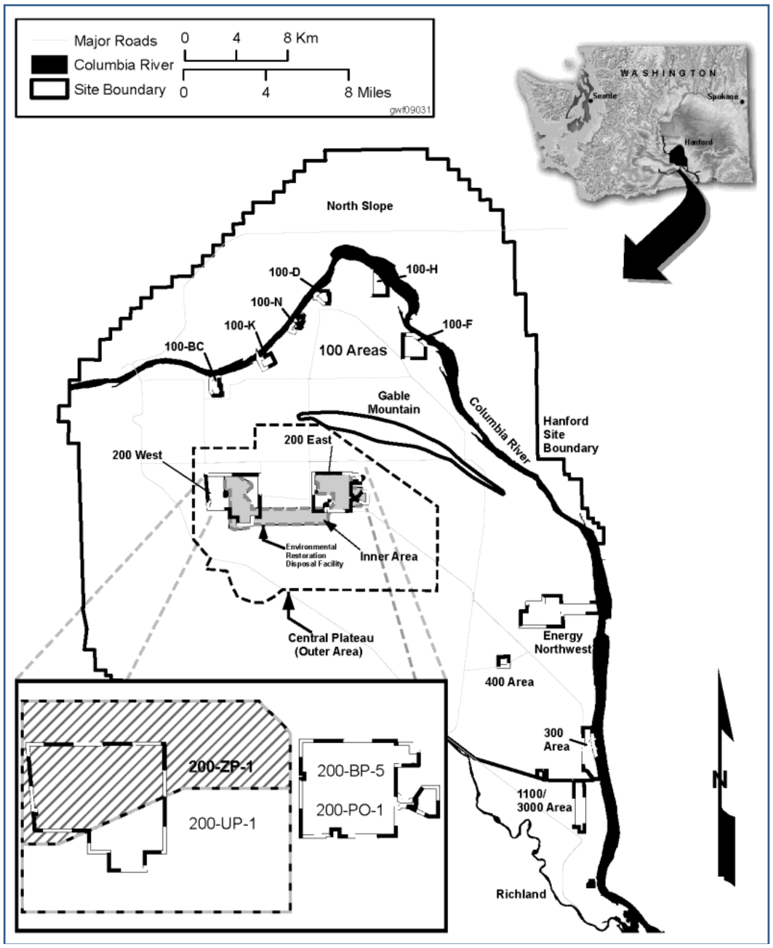

Fig. 1. Hanford Site map showing the 200-ZP-1 Groundwater OU.

TABLE I. Final Cleanup Levels for the 200-ZP-1 Groundwater OU

Contaminant of Concern	Units	Final Cleanup Level	Cleanup Level Basis
Carbon tetrachloride	µg/L	3.4	MTCA, Method B
Chromium (total)	µg/L	100	Federal/State MCL
Hexavalent chromium	µg/L	48	MTCA, Method B
Nitrate-nitrogen	µg/L	10,000	Federal/State MCL
TCE	µg/L	1	MTCA, Method B
I-129	pCi/L	1	Federal MCL
Tc-99	pCi/L	900	Federal MCL
Tritium	pCi/L	20,000	Federal MCL

DESCRIPTION

The 200 West P&T can treat up to 2,500 gpm of extracted groundwater. Fig. 2 provides the layout of the 23 extraction wells, 18 injection wells, and conveyance piping in the 200 West Area. Design of the facility included the ability to expand the system to treat a maximum flow rate of 3,750 gpm. The treatment approach that is being used to remove each of the contaminants of concern is summarized in Table II. Note that there is currently no technology to remove tritium from groundwater.

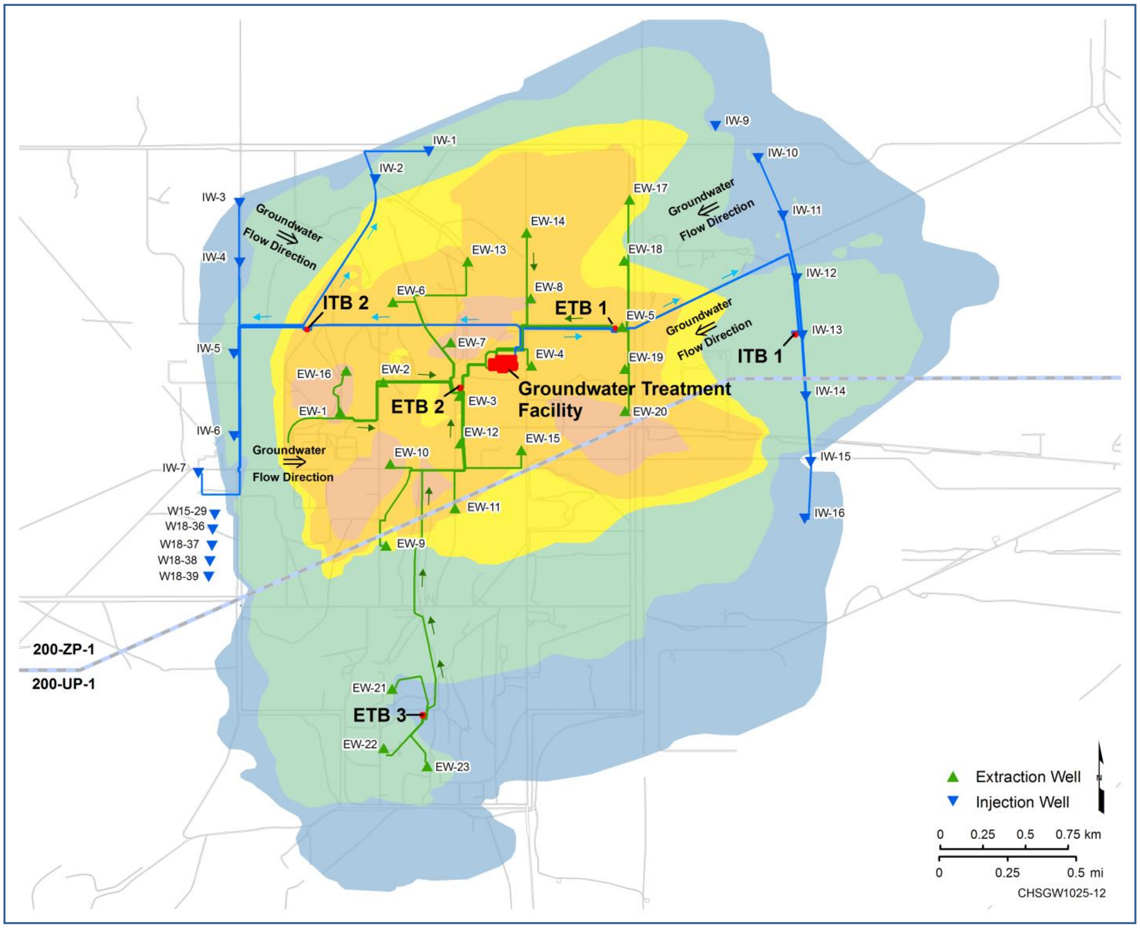

Fig. 2. Extraction/injection well locations and conveyance pipe routing for the 200 West P&T.

TABLE II. 200 West P&T Unit Process Descriptions

Unit Process	Process Benefit	Targeted Parameter
Ion exchange	Removal of Tc-99, I-129 , and uranium	Tc-99, I-129, and uranium[a]
Anoxic biodegradation (FBR)[b]	Removal of nitrate, carbon tetrachloride, and TCE, and conversion of hexavalent chromium to trivalent form	Nitrate, carbon tetrachloride, TCE, and hexavalent chromium
Aerobic biodegradation	Degradation/removal of residual organic carbon substrate	Biochemical oxygen demand
Membrane filtration	Removal of particles, biomass, and precipitated trivalent chromium	Trivalent chromium, turbidity, and biochemical oxygen demand
Air stripping	Removal of volatile organic compounds (carbon tetrachloride and TCE)	Carbon tetrachloride and TCE
Sludge thickening	Thickens biological solids for dewatering process	Solids content
Sludge dewatering	Reduces water content to allow for landfill disposal	Water content
Treated water chemistry adjustment	Provides treated water stability	pH and alkalinity

a. Uranium treatment is only required for groundwater from the 200-UP-1 OU.
b. FBR = fluidized bed reactor

The radiological portion of the 200 West P&T currently has two treatment trains in place that are filled with Purolite A530E resin,[3] which is proven very effective at removing Tc-99 contamination from groundwater. Since only a small number of extraction wells have elevated radionuclides, these two trains are capable of treating a maximum of 600 gpm. These two trains remove low concentrations of uranium and I-129 from groundwater as well. There is room within the plant to add several additional treatment trains for radionuclide removal. An evaluation of optimum resins for uranium and I-129 removal is ongoing since their concentrations will increase when groundwater extraction from certain portions of the 200-UP-1 OU begins.

The effluent from the fluidized bed reactor (FBR) flows by gravity to aerobic membrane bioreactors (MBRs) for removal of residual carbon substrate through aerobic biodegradation and removal of total suspended solids, including biomass generated in the FBR. Fig. 3 provides a schematic of the anoxic FBR. The MBRs have aeration capacity to provide sufficient oxygen for maintaining the aerobic biological process to reduce the residual carbon substrate. The membrane tanks have an aeration zone followed by a membrane zone with submerged membranes for filtration. The aeration zone is maintained by a blower that diffuses air into the tank. A second blower for the membrane zone provides air scouring to remove accumulated organic debris from the membrane surface to maintain its water permeability. The aeration and air scouring processes also strip off carbon tetrachloride. Vapor emissions are collected for treatment with granular activated carbon.

[3] *Purolite is a registered trademark of BROTECH CORP., Bala Cynwyd, Pennsylvania.*

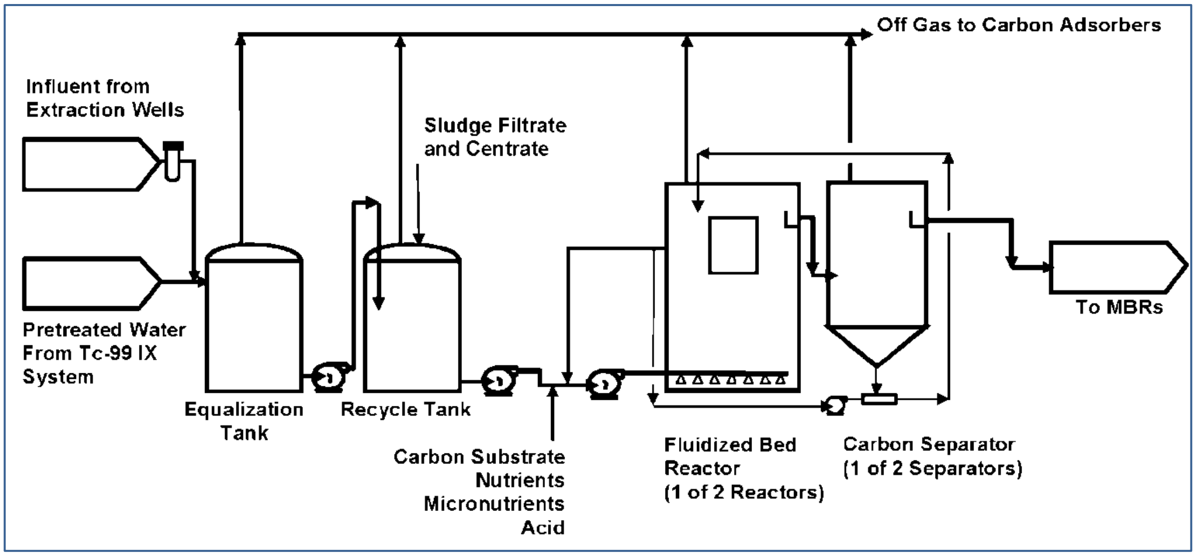

Fig. 3. Anoxic FBR schematic.

The MBRs contain multiple modules of vertically strung membrane fibers. Water is filtered by applying a slight vacuum to the end of each fiber, which draws the water through the tiny pores into the fibers. The filters remove solids, which are retained in the tank concentrate. A portion of the concentrate is recycled to the first compartment of the membrane tank to maintain the biomass concentration necessary to reduce biochemical oxygen demand.

Solids from the membrane tanks are pumped to rotary drum thickeners. Polymer is added upstream of the rotary drum thickeners, as necessary, to thicken the solids. The thickened solids are then pumped to centrifuges for dewatering. A screw conveyor is used to move the dewatered sludge from the centrifuge to a lime stabilization system where a mechanical mixer (e.g., pug mill) mixes lime with the thickened sludge. The lime sludge is then dropped into disposal containers and transported to the Environmental Restoration Disposal Facility.

Treated water from the membrane tanks is pumped to an air stripper to remove the remaining carbon tetrachloride and other volatile organic compounds. The air stripper effluent is then pumped to an effluent tank. In the process, sulfuric acid is added through an inline static mixer to adjust pH. The final treated water is then transferred to the injection wells.

CONCLUSIONS

Following completion of the construction acceptance testing and the acceptance test procedure, the 200 West P&T was turned over from construction to operations on June 28, 2012. Shortly after this transition, extraction wells with no radiological contaminants were brought online, with pumping rates ranging from 900 and 1,200 gpm. Initially, the plant operated only during dayshift hours; however, by September 2012, operations expanded to three staffed shifts supporting 24-hour operations. The plant consistently achieved pumping rates between 1,500 and 1,800 gpm. By October 2012, the plant was running unattended during off-shift hours. An automated callout system is in place to alert the plant operations manager and other key staff when a problem occurs during off-shift hours. Key staff can log into the control system from their home to determine the problem and make a decision regarding whether to send out a response team. The highest pumping rate to date has been 2,200 gpm.

During startup, in case the bacterial colonies in the bioreactors were not yet mature enough to fully reduce contaminant concentrations to below cleanup levels, the treated groundwater was only reinjected into upgradient injection wells. If there had been a problem, the reinjected water would have eventually been pulled back into the treatment plant for reprocessing. Because this problem did not occur, the downgradient injection wells were able to be brought online rather quickly.

Adjustments were needed during the first month of operation, which included increasing the amount of carbon substrate and micronutrients (molybdenum, phosphoric acid, and manganese) added to the FBRs. The initial imbalance of nutrients and micronutrients resulted in the wrong strain of bacteria (a gelatinous species) proliferating in one of the FBRs, thus requiring sterilization followed by inoculation with the preferred strain.

Another problem occurred on August 2, 2012, when a polyvinyl chloride saddle on a 6-inch utility water line inside the chemical treatment building failed during off-shift hours. The resulting leak exceeded the sump pump's capabilities, resulting in water overflowing onto the plant floor. All of the released water was contained within the walls of the plant, pumped into tanker trucks, and taken to the Hanford Site's ModuTank facility for disposal. Shortly after this event, all of the polyvinyl chloride saddles inside the plant were replaced with steel saddles.

The plant now operates 24 hour per day (except when down for repairs) and runs unattended during off-shift hours. As illustrated in Table III, the bioreactors, ion exchange columns, and air strippers are successfully reducing contaminant concentrations to well below the cleanup levels specified in the Record of Decision.

REFERENCES

1. EPA, DOE, and Ecology, 2008, *Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*, U.S. Environmental Protection Agency, U.S. Department of Energy, and Washington State Department of Ecology, Olympia, Washington.

TABLE III. October 2012 Analytical Results from 200 West P&T Operational Sampling

Contaminant	Resin Influent Tank 1	Resin Effluent Tank 1	Resin Influent Tank 2	Resin Effluent Tank 2	Bio-Building Influent	Bio-Building Effluent	Cleanup Level
Carbon tetrachloride (µg/L)	820	800	950	770	790	<1	3.4
Nitrate (mg/L)	37.5	38.9	37.1	36.3	24.3	1.98	10
Chromium (µg/L)	77	15.1	80.4	9.51	16.8	1.67	100
Hexavalent chromium (µg/L)	69.2	5.1	68.6	3	10.4	<2	48
I-129 (pCi/L)	<0.22	<0.244	0.545	<0.242	0.249	<0.157	1
Tc-99 (pCi/L)	1,071	<17	1,411	<17	51	34	900
TCE (µg/L)	<1	<1	<1	<1	<1	<1	5
Tritium (pCi/L)	22,000	20,000	18,000	18,000	9,700	7,300	20,000
Uranium (µg/L)	2.11	<0.10	2.31	<0.05	0.828	0.44	30

ACKNOWLEDGEMENTS

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