Groundwater Pump and Treat Remediation System Overview, Hanford 200-West Area – 11508

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ABSTRACT

The Hanford Site 200-West Area Pump and Treat Facility (Treatment Facility) will be designed, installed, and operated to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride, total chromium, nitrate, trichloroethylene, uranium, and technetium-99. The Treatment Facility will treat groundwater from as many as 20 new extraction wells with a total average operating flow of 2,000 gal/min (2,500 gpm maximum flow). The treated water will be injected to the aquifer. The Treatment Facility will consist of an ion exchange system, anoxic/anaerobic bioreactor(s), aeration/membrane tanks, and air stripper systems.

INTRODUCTION

The Hanford Site 200 Area is referred to as the Central Plateau, encompassing approximately 194 km^2 (75 mi^2) near the center of the Site. The Central Plateau contains multiple waste sites, contaminated facilities, and groundwater contamination plumes. During the Manhattan Project and the Cold War period, liquids contaminated with chemicals and radioactive elements were discharged from plutonium production facilities to several soil disposal sites, resulting in an 8 km^2 (5 mi^2) area of groundwater contaminated above drinking water levels. Leaks from large underground storage tanks containing high-level radioactive waste have also contributed to soil and groundwater contamination.

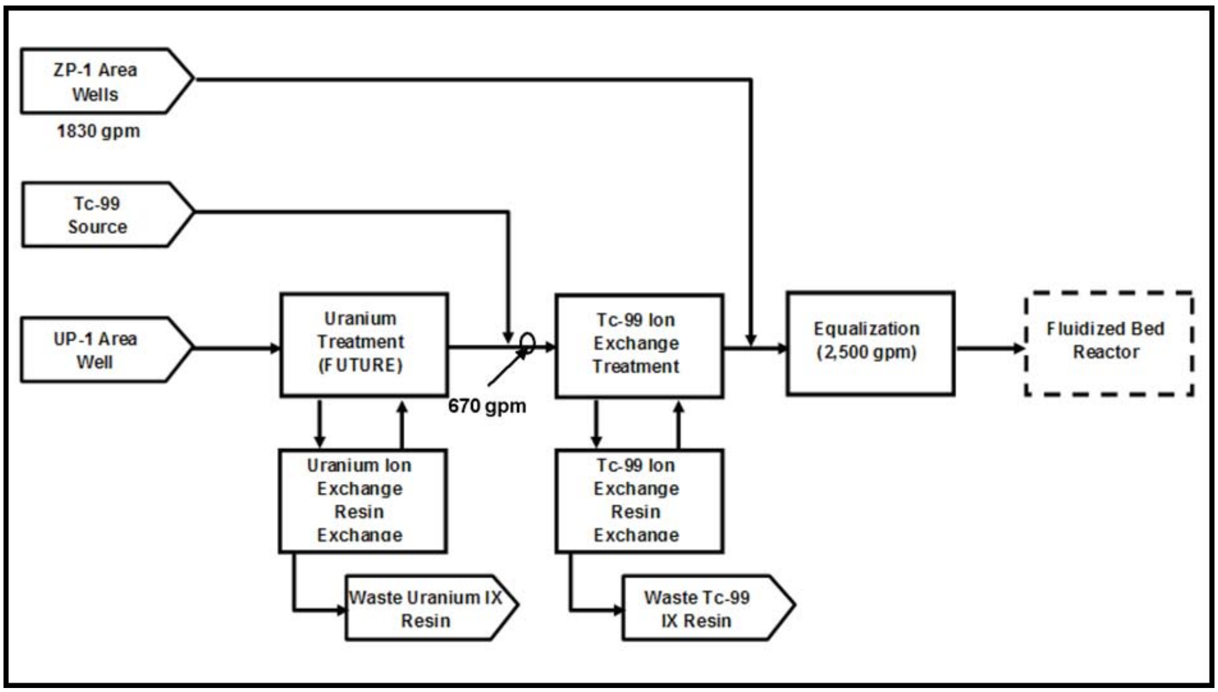
The *Record of Decision Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* [1], was signed by the U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DOE), and Washington State Department of Ecology (Ecology) on September 30, 2008. The selected remedy for the 200–ZP-1 Operable Unit (OU) was a combination of pump and treat, monitored natural attenuation (MNA), flow-path control, and institutional controls. The overarching requirement is to meet the groundwater cleanup levels identified in the Record of Decision (ROD) [1] within 125 years. The 200-ZP-1 OU ROD requires that a groundwater pump and treat system be designed, installed, and operated in accordance with an approved remedial design/remedial action (RD/RA) work plan [2].

200-WEST AREA PUMP AND TREAT REMEDIATION SYSTEM

The 200-West Area Pump and Treat Facility (Treatment Facility) has been designed and is being installed on the Hanford Site and will be operated to capture and treat contaminated groundwater to remove several chemical and radioactive contaminants of concern (COC)– including carbon tetrachloride, total chromium (Cr(III) and Cr(VI)), nitrate, trichloroethylene, uranium, and technetium-99 throughout the 200-West

Area OU [1]. The Treatment Facility will treat groundwater from as many as 20 new extraction wells with a total maximum operating flow of 2,500 gal/min. The treated water will be injected to the aquifer to facilitate movement of contaminants to the extraction wells, reduce plume size and prevent further migration of contaminants.

The Treatment Facility will consist of an ion exchange system, which pretreats approximately 25 percent of the total extracted groundwater to remove radionuclides. After pre-treatment, this water is combined with the remaining 75 percent of the total extracted groundwater prior to treatment in the Centralized Treatment System. The Centralized Treatment System is a biological treatment system consisting of anoxic/anaerobic bioreactor(s), aeration/membrane tanks, and air stripper systems, respectively, which treat 100 percent of the groundwater to remove all remaining COCs before it is injected into the aquifer. Fig. 1-A and Fig. 1-B depict the process block flow diagrams of the pump and treat system.



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ig. 1-A. Block Flow Diagram of the Ion Exchange System

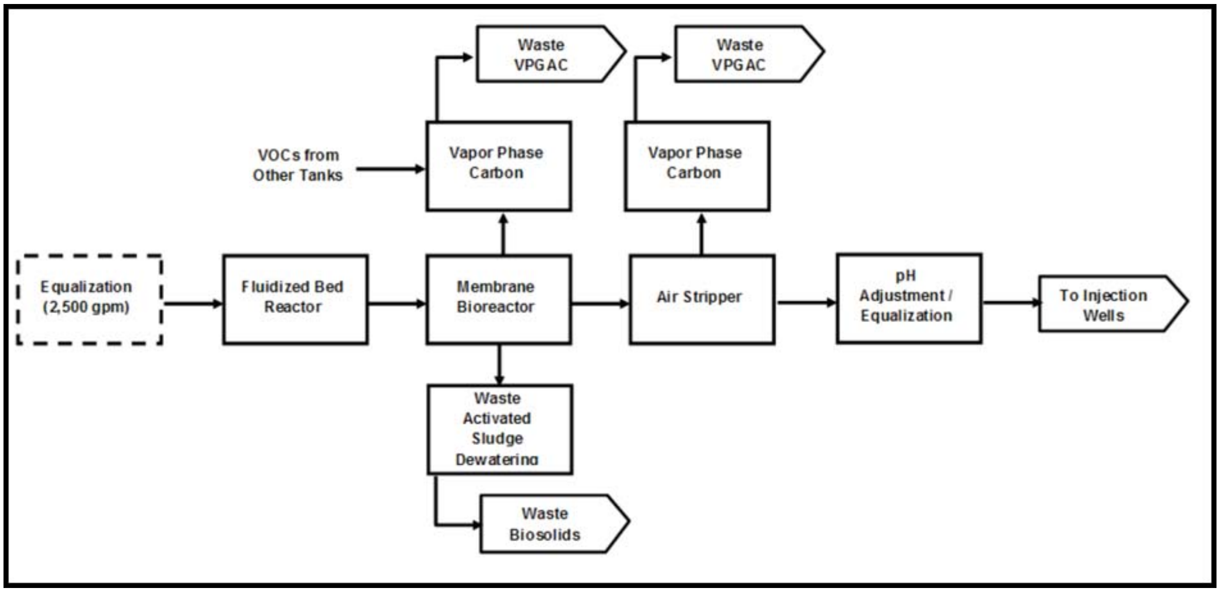

Fig. 1-B. Block Flow Diagram of the Centralized Treatment System

The major system treatment components are described in the following sections.

URANIUM ION EXCHANGE SYSTEM

Groundwater pumped from three wells at approximately 100 gal/min each (300 gal/min total) will first be pretreated separately with anion ion exchange resin columns to reduce uranium concentrations. Incoming groundwater will be sent through bag filters to remove fine particulate matter. The filtered water flows to anion ion exchange vessels (three in series) containing a resin, which has demonstrated reliable and predictable reduction of uranium. The effluent will flow through bag filters serving as resin traps, to the technetium-99 ion exchange system for further treatment.

TECHNETIUM-99 ION EXCHANGE SYSTEM

Groundwater pumped from seven wells at approximately 370 gal/min total, which contain concentrations of technetium-99 greater than 900 pCi/L, will be combined with the water pretreated for uranium and treated with ion exchange resins to reduce the concentrations of radionuclides. Incoming groundwater will be sent through bag filters to remove fine particulate matter. The water flows to ion exchange vessels (three in series) containing a resin that has demonstrated reliable and predictable reduction of technetium-99 [3]. The effluent will flow through bag filters serving as resin traps to the Centralized Treatment System for further treatment (Fig. 2).

When the ion exchange resins reach their radionuclide loading limits, the spent resins will be removed from the vessel by sluicing it with finished water (fully treated) into a carbon tetrachloride stripping tank (Strip Tank) (Fig. 3). It is anticipated that carbon tetrachloride will be weakly adsorbed onto the spent ion exchange resin and must be removed prior to disposal. In the Strip Tank, the resin will be fully submerged with finished water and heated to 93.3 °C (200 °F) to strip off any carbon tetrachloride. The vapor emissions will be treated with vapor-phase granular activated carbon (VPGAC). After treatment (6 to 24 hours), the stripping water will be pumped downstream to the Centralized Treatment System.

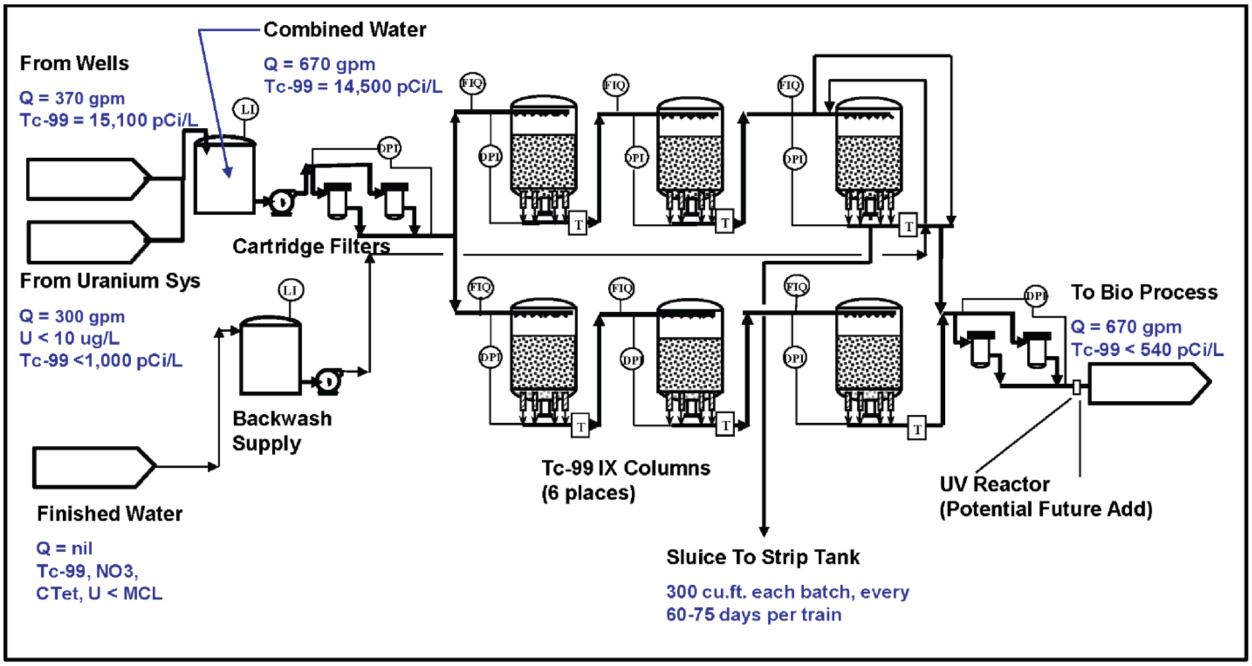

Fig. 2. Technetium-99 IX Process Schematic

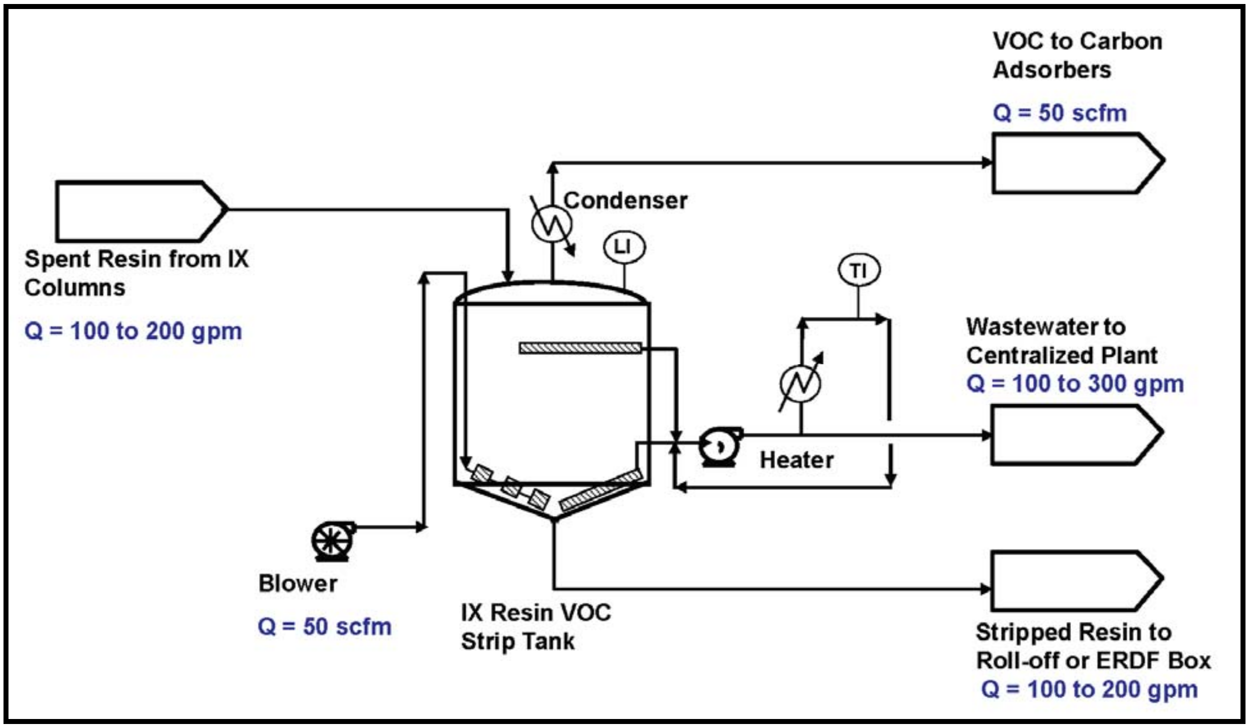

Fig. 3. IX Resin Strip Tank Schematic

The resin will be sluiced to a roll-off container and dewatered. The dewatered resin will be transported to the Environmental Restoration Disposal Facility (ERDF) on the Hanford Site.

BIOLOGICAL TREATMENT SYSTEM

Water from the Technetium-99 IX System will flow to the Centralized Treatment System equalization tank where it will be blended with the extracted groundwater from the remainder of the well field. The Centralized Treatment System process will have two treatment trains initially to accommodate maximum flow ranges up to 2,500 gal/min (1,250 gal/min each). Space within the facility will be reserved for a third parallel train that can be added in the future to accommodate a higher flow rate of 3,750 gal/min.

FLUIDIZED BED REACTOR

The blended groundwater will be pumped from the equalization tank to a fluidized bed reactor (FBR), which is for nitrate removal and carbon tetrachloride dechlorination. The FBR will be operated under anoxic condition (no dissolved oxygen) to reduce the nitrate-nitrogen to nitrogen gas by the heterotrophic facultative bacteria. Nitrate-nitrogen acts as an electron acceptor in the absence of dissolved oxygen. Organic carbon is an electron donor and energy source for bacteria.

The FBR vessel contains an integral fluidization and effluent collection system designed to enhance uniform flow distribution for anoxic and anaerobic microbial growth. The water is pumped into the bottom of the FBR creating upflow to suspend the granular activated carbon (GAC) media. The FBR will initially be seeded with microbes that are suited for nitrate-nitrogen removal (denitrification) and carbon tetrachloride degradation. An organic carbon substrate (MicroCg™)[1] and phosphorus will be added into the FBR to serve as the electron donor and nutrient to promote microbial growth. As the microbes grow on the GAC, the fluidized bed height will expand. Some excess biomass will be removed by shear of the normal flow through the FBR. Additional excess biomass will be removed with a biomass separator and will flow out with the effluent. Biomass removal rates will be a function of process flow rate, FBR fluidization pumping rate, FBR biomass concentration, biomass film thickness on GAC particles, and other variables. The carbon separator will recycle some biomass with the GAC but most of the biomass will not settle and will be removed with the FBR effluent (Fig. 4).

[1] MicroCg™ is a trademarked product of Environmental Operating Solutions, Inc., Bourne, MA.

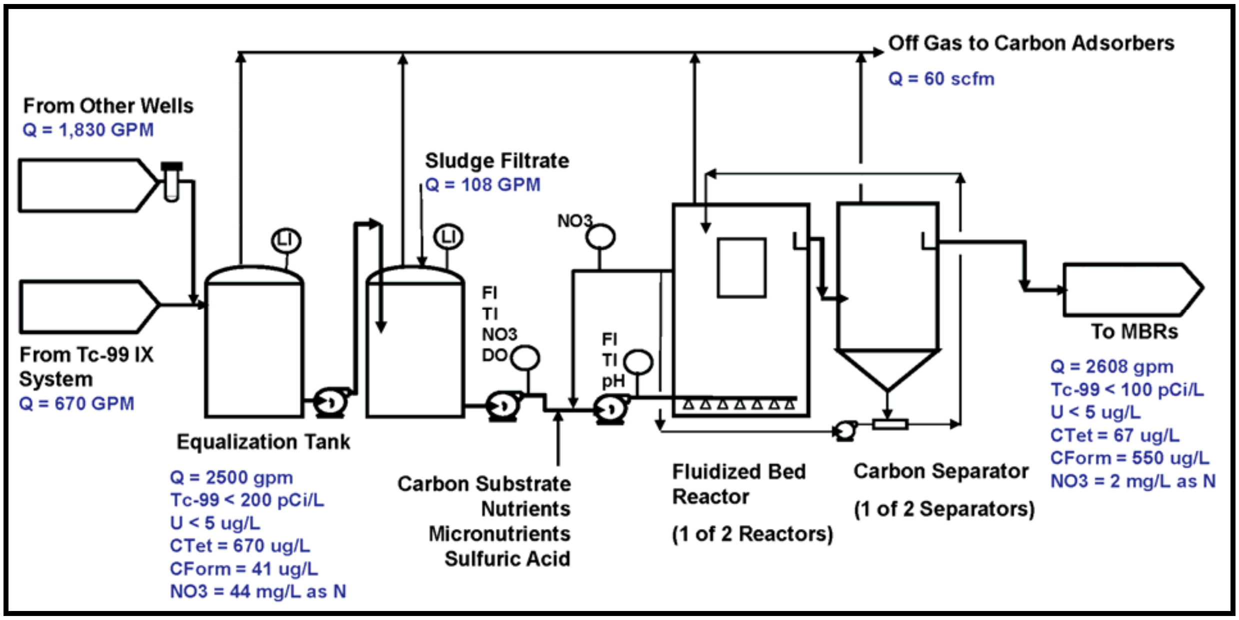

Fig. 4. Biological Process – Anoxic Fluidized Bed Reactor Schematic

MEMBRANE BIOLOGICAL REACTORS

The effluent from the FBR will flow by gravity to a covered aeration tank for removal of the residual carbon substrate through aerobic biodegradation. The aeration tank effluent flows by gravity and is split in a splitter structure into multiple submerged membrane tanks called Membrane Biological Reactors (MBR) for additional removal of the residual carbon substrate and removal of the total suspended solids including biomass from the FBR. The aeration tank and the membrane tanks will have a combined aeration capacity to ensure sufficient oxygen is available to maintain the aerobic biological process to reduce the residual carbon substrate. The membrane tanks will have an aeration zone followed by a zone with submerged membranes for filtration. The aeration zone will have a blower that diffuses air into the tank that continues the aerobic biodegradation of carbon substrate. There will also be a blower for the membrane zone for air scouring to remove accumulated organic debris from the membrane surface to maintain permeability. It is anticipated that the aeration and air scouring processes will strip off carbon tetrachloride. Vapor emissions will be collected for treatment with VPGAC.

In the membrane zone, there will be modules of vertically or horizontally strung membrane fibers. Water will be filtered by applying a slight vacuum to the end of each fiber, which draws the water through the tiny pores into the fibers. These filters will remove solids to less than 0.1 Nephelometric Turbidity Unit (NTU) with the biosolids and particles remaining in the tank concentrate. A portion of the concentrate will be recycled to the aeration tank to maintain the biomass concentration. To prevent fouling of the membranes, maintenance cleanings will be required (Fig. 5).

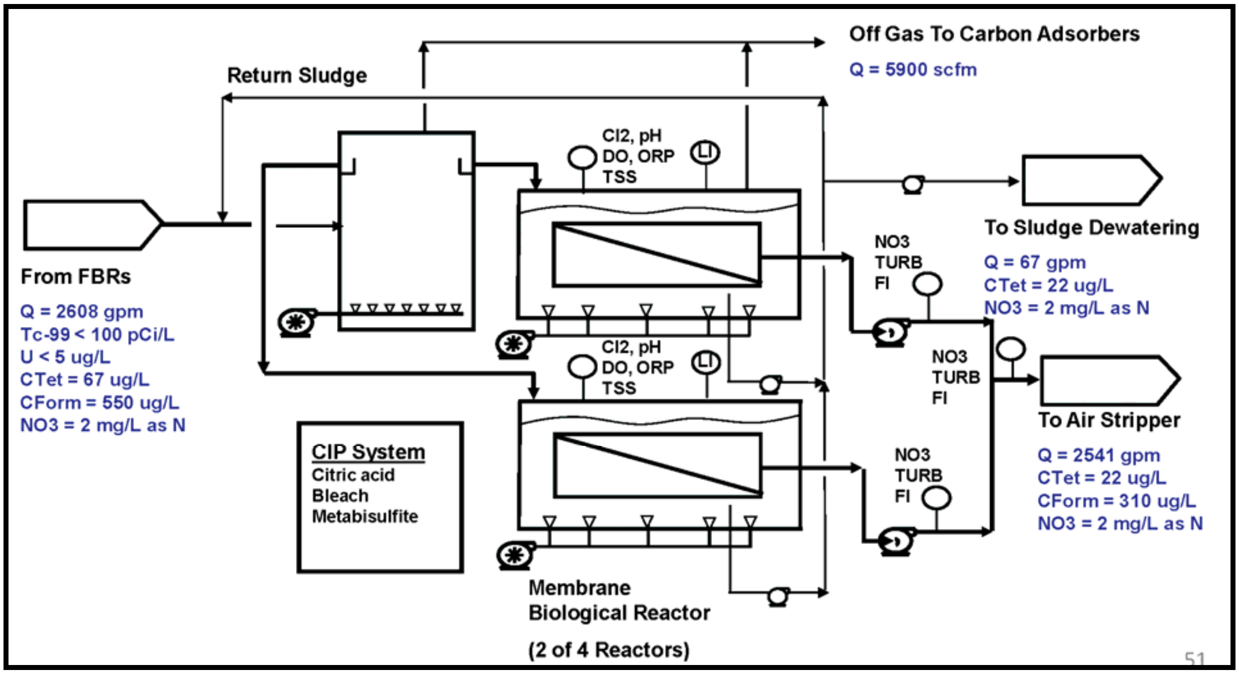

Fig. 5. Biological Process – Aerobic Membrane Biological Reactors Schematic

AIR STRIPPING

The treated water from the membrane bioreactors will be pumped to packed-bed tower air strippers for removal of the remaining carbon tetrachloride and other volatile organic compounds. Off-gas from the stripper, influent equalization tank, FBR(s), MBR(s), sludge-holding tank(s), rotary drum thickeners, and centrifuges will be combined and treated by VPGAC. The sludge-holding tank(s), rotary drum thickeners, and centrifuges are discussed subsequently. Each of two air strippers will treat 1,250-gal/min water flow with an associated off-gas air flow estimated to be 6,100 standard cubic feet per minute (scfm) (12,200 scfm total). To avoid unwanted buildup of radionuclides in the VPGAC, all air streams to the VPGAC system are pretreated by a demister to minimize any liquid water mist carryover. The air stripper-treated effluent will be pumped to the Centralized Treatment System effluent tank. The pH of the air stripper effluent will be lowered slightly using sulfuric acid mixed through an inline static mixer, prior to reinjection of the effluent into the aquifer through 16 new injection wells operating at rates up to 240-gal/min per well (Fig. 6).

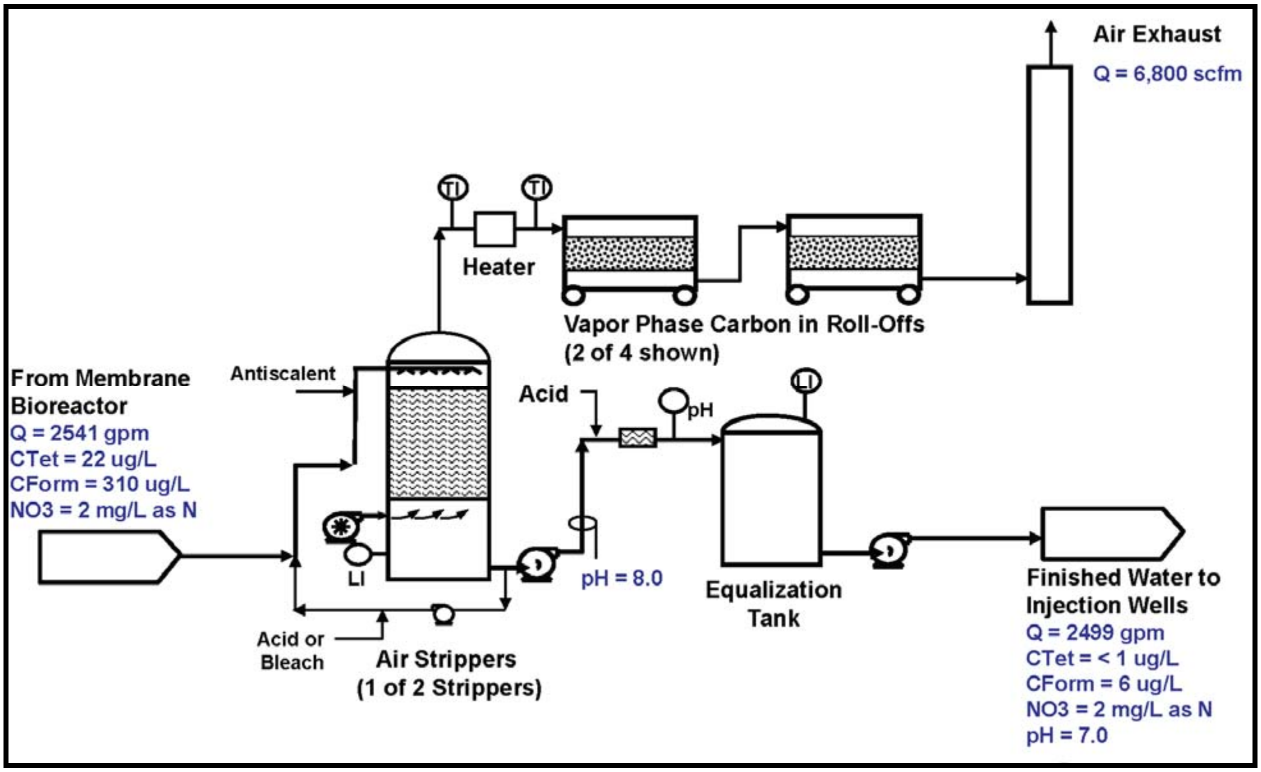

Fig. 6. Air Stripper System Diagram Schematic

SLUDGE SYSTEM

Solids from the membrane bioreactors will be pumped to the sludge-holding tanks. The sludge-holding tanks will be aerated for aerobic digestion of the solids and to keep the solids from going anaerobic. The sludge will be pumped to rotary drum thickeners for sludge thickening and recirculated back to the sludge-holding tanks to maintain solids levels in the tanks between 2 and 3 percent. Polymer will be added upstream of the rotary drum thickeners, if necessary, to thicken the solids. The thickened solids will be pumped from the sludge-holding tanks to centrifuges for dewatering on a periodic basis. Polymer will be added upstream of the centrifuges to aid in solids dewatering. Screw conveyors will be used to move the dewatered sludge from the centrifuges to the lime stabilization system. The supernatant from the rotary drum thickeners and centrifuges will be sent to the recycle tank located upstream of the FBR (Fig. 7).

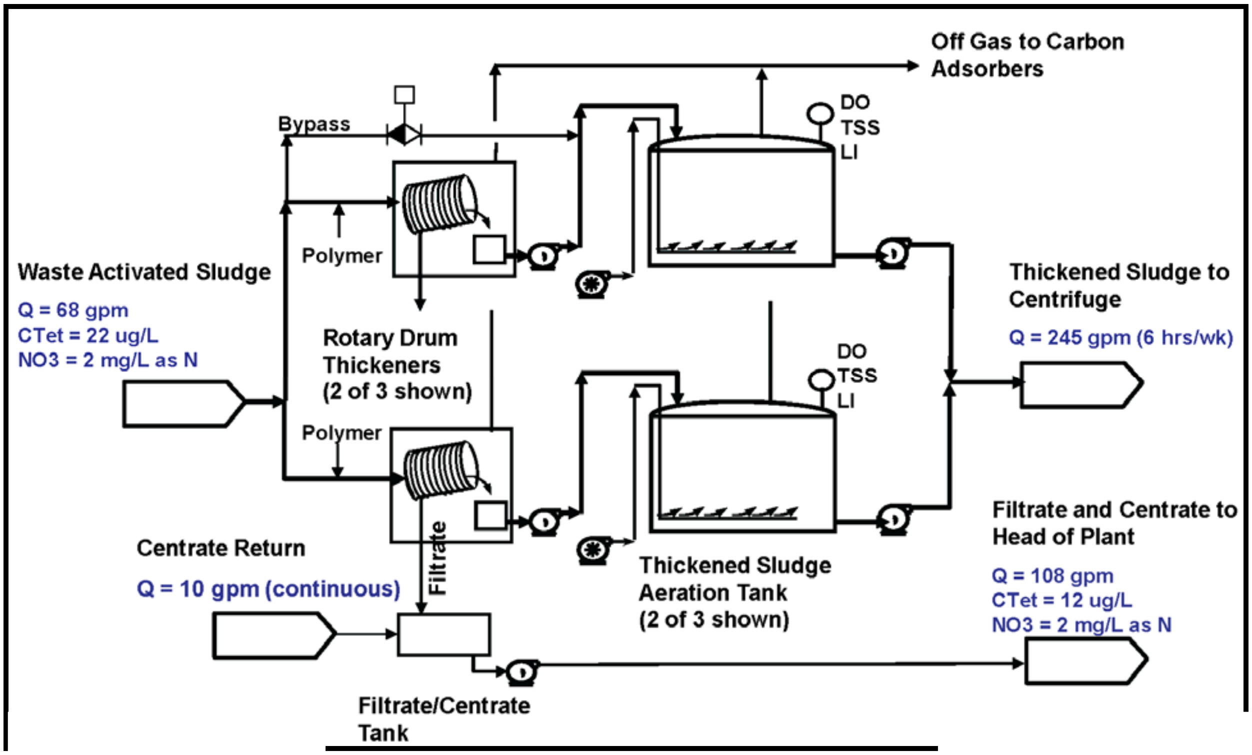

Fig. 7. Solids Handling System -- Thickeners and Aerated Centrifugal Feed Tanks

LIME STABILIZATION SYSTEM

Dewatered sludge from the centrifuges will be stabilized with lime to control free water and to prevent further decomposition and generation of objectionable gasses and odors. Dewatered sludge screw conveyors will transfer dewatered sludge from the centrifuges to pug mill mechanical mixers where lime will be added and mixed with the sludge. Stabilized sludge screw conveyors will transport the stabilized sludge to ERDF containers for disposal. The system also includes two 50-ton capacity lime silos and lime transfer screw conveyors (Fig. 8).

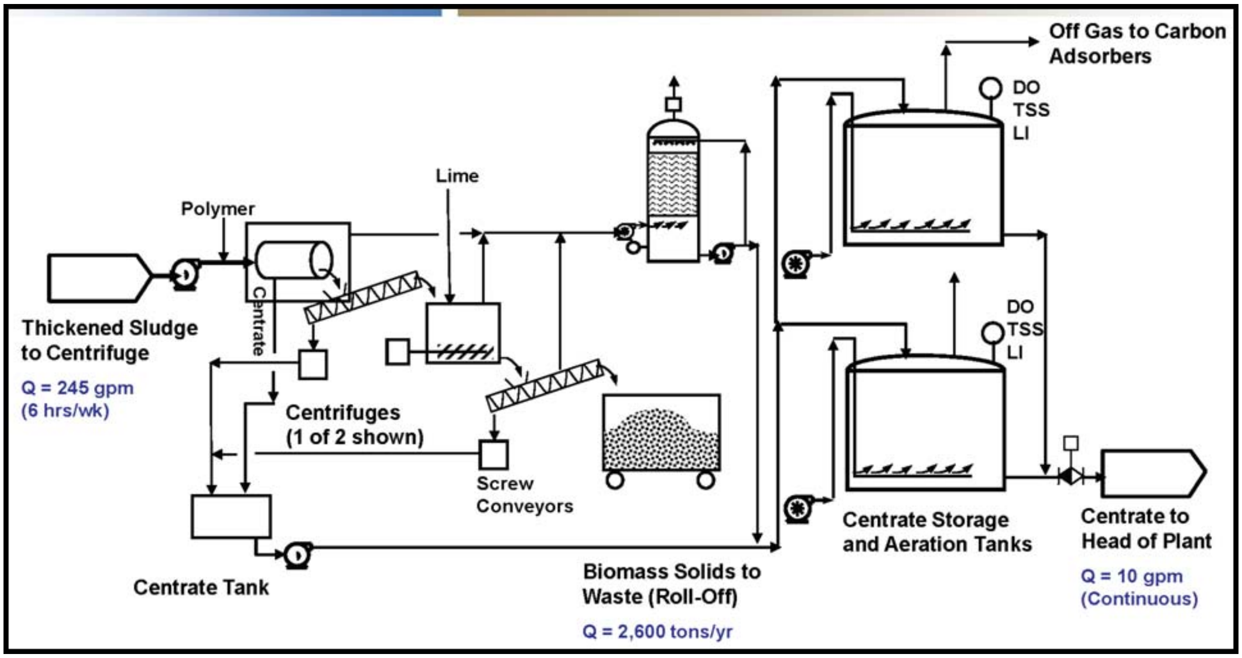

Fig. 8. Solids-Handling System – Centrifuge Dewatering and Lime Treatment

CONCLUSION

The 200-West Pump and Treat Remediation system incorporates innovative biological technologies to treat over 5 mi^2 of contaminated groundwater to drinking water standards. By far, the majority of the contaminants of concern, including nitrate and volatile organic compounds, will be converted to nitrogen, carbon dioxide, and water. The radionuclides will be removed and stored in a disposal facility on the Hanford Site. Over the course of its planned 25-year operation, the 200-West Pump and Treat Remediation System will treat and reinject over 20 billion gallons of water, creating a hydraulic barrier to protect the nearby Columbia River and its ecological population in addition to restoring the aquifer.

The 200-West Pump and Treat Remediation system is currently under construction with an anticipated start-up date of December 2011.

REFERENCES

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

2. DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*, U.S. Department of Energy, Richland Operations Office, Richland, Washington (2009).

3. DOE/RL-2008-25, Rev. 0., *Treatability Test to Remove Technetium-99 from the 200-ZP-1 Groundwater Unit, Hanford Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington (2008).