DRILLING AND SAMPLING HIGHLY RADIOACTIVE CONTAMINATED SOIL AT THE 200-BP-1 OPERABLE UNIT HANFORD SITE RICHLAND, WASHINGTON

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ABSTRACT

The Hanford Site, Richland, Washington, contains over 1,500 identified waste sites and four groundwater plumes that will be characterized and remediated over the next 30 years. In support of the Hanford Federal Facility Agreement and Consent Order, the U.S. Department of Energy has initiated a remedial investigation/feasibility study at the 200-BP-1 Operable Unit. The 200-BP-1 remedial investigation is the first Comprehensive Environmental Response, Compensation, and Liability Act of 1980 investigation on the Hanford Site that involves drilling into highly radioactive and chemically contaminated soils. The initial phase of the site characterization is oriented toward determining the nature and extent of any contamination present in the vicinity of the 200-BP-1 Operable Unit. The major focus of the Phase I remedial investigation is the drilling and sampling of 10 inactive waste disposal units that received low level radioactive liquid waste.

INTRODUCTION

The Hanford Site, approximately 1,450 km^2 of semiarid land located in south-central Washington state (Fig. 1), is owned by the U.S. Department of Energy (DOE). Since 1943, the Hanford Site has been used for reactor operations, reprocessing of spent fuel, and management of radioactive waste. In recent years, the mission has switched from production of special nuclear materials to waste management and environmental restoration.

Hanford Site facilities are generally centralized into four numerically designated areas (100, 200, 300, and 1100 Areas) which the U.S. Environmental Protection Agency (EPA) has placed on the National Priority List under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Within the 200 Area, the site is divided into eight waste area groups largely corresponding to the major processing plants. The waste area groups include liquid waste disposal sites (i.e., cribs, ponds, and ditches), solid waste burial grounds, underground storage tanks, and unplanned releases. The contamination is in the form of nonhazardous, hazardous, radioactive, and mixed wastes. Each waste area group is further divided into operable units on the basis of waste disposal practices, geology, hydrogeology, and pertinent site characteristics. To date, a total of 38 operable units have been identified within the 200 Areas.

Site characterization and remediation activities at each operable unit are being addressed through the "Hanford Federal Facility Agreement and Consent Order" (1), which was negotiated and approved in May 1989 by the DOE, the EPA, and the State of Washington Department of Ecology (Ecology).

200-BP-1 OPERABLE UNIT DESCRIPTION

The 200-BP-1 Operable Unit is located in the north-central portion of the 200 East Area. The operable unit includes 13 waste management units (10 inactive cribs and 3 unplanned releases) and encompasses approximately 10 ha with the majority of the waste management units concentrated in a 1.6 ha region at the eastern end of 200-BP-1 (Fig. 2). The 200-BP-1 waste disposal activities were associated with the management of waste from the U Plant uranium reclamation operations and waste storage condensate from the adjacent 241-BY Tank Farm.

U Plant uranium reclamation operations employed the tributyl phosphate (TBP) process at the 221-U Building. The process was used to recover uranium metal from waste generated by the bismuth phosphate process in B Plant. Before implementing the TBP process, the waste had been stored in the 241-BY Tank Farm.

From 1952 to 1958, stored waste in the 241-BY Tank Farm was transferred to the U Plant from uranium recovery. The stored waste sludge was dissolved in nitric acid, and the uranium was extracted using TBP in a normal paraffin diluent. The TBP process wastes contained fission products, sulfate, and phosphate ions in an aqueous nitric acid solution. The acid solution was made alkaline for transfer to and storage in the 241-BY Tank Farm. The stored TBP wastes were then treated with potassium ferrocyanide as a cesium scavenger. The supernatant was discharged to a crib after the activity of cesium-137 dropped below 0.1 μCi/mL.

During the period in which TBP supernatant was discharged to the cribs, the concept of specific-retention disposal was employed. This practice limited discharge to the specific-retention volumes of the soils, based on their moisture retention capacity. It is apparent that this concept was not fully

Fig. 1. The Hanford Site, Washington.

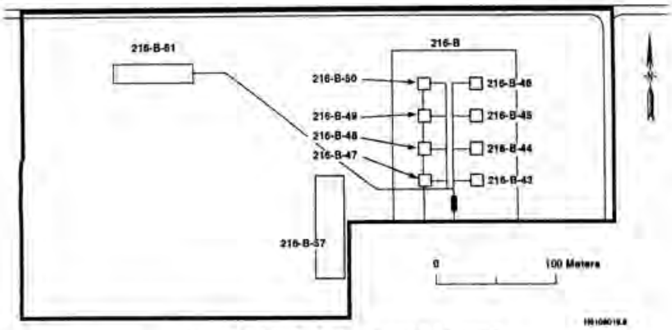

Fig. 2. 200-BP-1 operable unit.

implemented as the calculated specific-retention volumes of the soil columns were exceeded.

From 1965 to 1974, 241-BY Tank Farm waste storage tank condensate was also discharged to a crib in the 200-BP-1 Operable Unit. The condensate was a result of an in-tank solidification (ITS) process which was accomplished by in-tank heating. Evaporates were collected, condensed and subsequently discharged to the cribs.

The exact concentration and quantity of radionuclides and contaminants of concern remaining within 200-BP-1 is uncertain. Historical records indicate that seven cribs received an estimated 33,840,000 L of TBP supernatant waste, two cribs received an estimated 139,200,000 L of ITS condensate, and one crib was constructed but has no documented history of past disposal operations. The primary known contaminants are radionuclides (hydrogen-3, technetium-99, strontium-90, cesium-137, cobalt-60, plutonium-238/239/240, total uranium, and ruthenium-106) and nonmetallic ions (nitrate, phosphate, total cyanide, ferrocyanide, and free cyanide).

200-BP-1 REMEDIAL INVESTIGATION

In March 1990, EPA approved the work plan for remedial investigation/ feasibility study (RI/FS) for the 200-BP-1 Operable Unit (2). The 200-BP-1 RI is the first CERCLA investigation on the Hanford Site that involves drilling into highly radioactive and chemically contaminated soils. The purpose of this document is to guide DOE and Westinghouse Hanford Company in the implementation of all RI/FS activities conducted at this operable unit. The initial phase of the RI is oriented toward determining the nature and extent of any contamination present in the vicinity of the 200-BP-1 Operable Unit. Primary objectives of the RI/FS are to collect onsite data and waste characteristics, contamination pathways, transport mechanisms, and to conduct treatability testing as necessary to support the evaluation of proposed remedies.

Nonintrusive characterization activities were initiated in the summer of 1989. Activities included topographic mapping, ground-penetrating radar (GPR), and biota and surface scintillation surveys. A topographic map was prepared at a 0.5-m contour interval extending approximately 100 m beyond the operable unit boundary. The map included all surface features and anomalies found during the scintillation and GPR surveys. The GPR survey identified one unidentified underground pipeline within the operable unit. The biota survey consisted of a site inspection which resulted in no visible signs of endangered plant or animal species. Approximately 4 ha were hand surveyed for dose rates and contamination levels using alpha and beta/gamma radiation detection equipment. The survey results found widespread surface contamination with general contamination of 400 counts per minute and localized spots up to 10 mRem/hr. The contamination is thought to be windblown contamination from the cribs and/or adjacent tank farm areas.

As a result of the migrating radioactive contamination, surface stabilization activities were initiated in the spring of 1991. Approximately 0.1 to 0.3 m of surface soil was removed from the eastern half of the operable unit and consolidated on the crib areas. The contaminated soil was then stabilized with approximately 0.5 m of clean topsoil. Revegetation with natural grasses was completed in the fall of 1991.

A recently identified groundwater cyanide plume to the north of the 200 East Area is believed to be attributed to past crib operations at the 200-BP-1 Operable Unit. After reviewing existing groundwater data, work plan actions determined that additional hydrogeologic characterization was required. To determine the nature and extent of the contamination, sampling of a groundwater well monitoring network was initiated in January 1991. The network consists of 35 existing and 9 new wells constructed to support 200-BP-1 characterization. Figure 3 illustrates a preliminary cyanide plume map based on the first two quarters of 1991 groundwater sampling and analysis. The total list of contaminants of concern being evaluated in the groundwater were discussed previously.

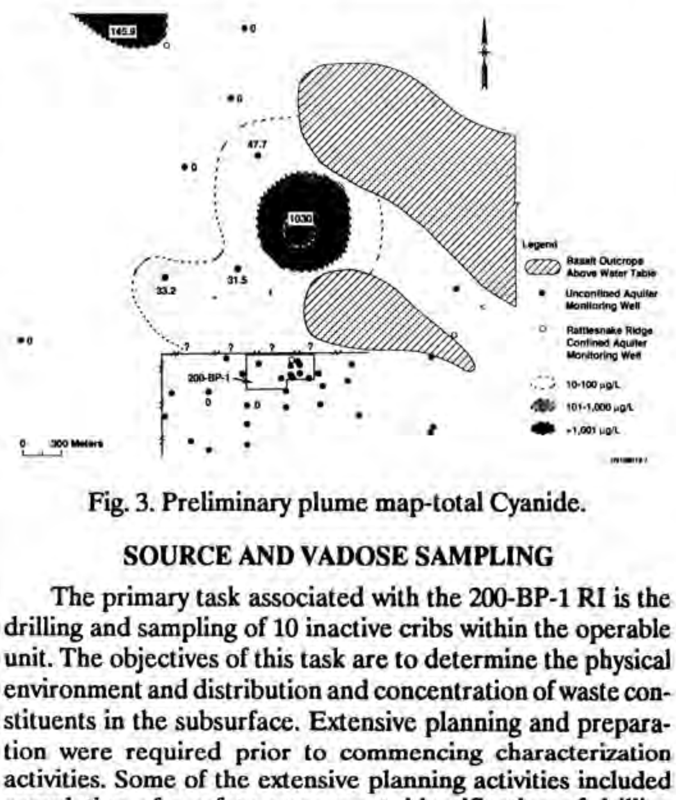

Fig. 3. Preliminary plume map-total Cyanide.

SOURCE AND VADOSE SAMPLING

The primary task associated with the 200-BP-1 RI is the drilling and sampling of 10 inactive cribs within the operable unit. The objectives of this task are to determine the physical environment and distribution and concentration of waste constituents in the subsurface. Extensive planning and preparation were required prior to commencing characterization activities. Some of the extensive planning activities included completion of a safety assessment, identification of drilling and sampling methodologies, and procurement of an interim storage facility to accommodate mixed waste.

Safety Assessment

A safety classification (3) was completed to evaluate potential exposures and/or releases of contaminants in the soil beneath the cribs. Some of the hazards considered in this safety assessment included estimates of radio-logical soil concentration, calculated dose rates, potential for an explosive reaction of ferrocyanide within the crib soils, and criticality.

The estimate of radioactively contaminated soil concentrations assumed that the activity discharged to the cribs was uniformly distributed over some volume of soil under each crib. The volume of soil was varied to provide a range of possible contamination levels. Dose rates were then calculated from these estimates for three simple geometries (split-tube sampler, 250-mL sample bottle, and 208-L drum). A time-and-motion study for split-tube sampling operations was also completed to determine approximate exposure rates to the worker.

The elements required to obtain an ignition or explosive reaction of ferrocyanide within the crib soils were reviewed. The elements reviewed included ignition temperature of the ferrocyanide, potential ignition sources, concentration of ferrocyanide and concentration of nitrate within the cribs. Laboratory tests and analyses conducted to date indicate a potential for deflagration/detonation if large quantities of ferrocyanide compounds were to reach temperatures in excess of 200°C. These temperatures cannot be reached with the cable-tool drilling method. Laboratory tests to date also conclude that impact, sparks, or friction are not capable of igniting ferrocyanide.

The examination of existing data and flow sheets indicated that relatively small amounts of nickel ferrocyanide solids were diverted to the cribs. Furthermore, the ferrocyanide and nitrate salts discharged to the cribs have been diluted by the soil to a significant extent. This information, when examined in context of the range of reactive compositions of ferrocyanide and general soil characteristics, indicated that no credible hazard exists for generating an ignition or explosive reaction of ferrocyanide as a result of cable-tool drilling operations.

Potential criticality events were evaluated and found not to be a hazard due to the insufficient inventory of fissionable material in the cribs.

Drilling and Sampling Methodology

An evaluation of drilling and sampling methodologies was completed to assure data quality objectives were accomplished. A detailed guidance document was prepared to assist field personnel and to identify acceptable drilling and sampling methodologies for each borehole.

Drilling and sampling is conducted in two phases. The initial vadose zone phase includes the drilling of three deep (approximately 70 m) boreholes through separate cribs. The boreholes will be continuously sampled for physical properties and sampled at selected intervals for radiological and chemical analyses. The second phase is to drill three boreholes through each crib to a depth of approximately 10 m. Chemical samples are collected at designated intervals in these boreholes. The data quality objectives of these boreholes are the following.

- Identify all waste constituents remaining in cribs.
- Obtain detailed geologic stratigraphic information to assess possibility of infiltrating effluent waste becoming perched and migrating laterally.
- Obtain concentration profiles of waste constituents to evaluate vertical migration and assess the future impact to groundwater.
- Obtain representative vadose zone samples for physical laboratory testing including column leach tests, physical properties, and potential bench-scale treatment tests.

The drilling technique used on all boreholes is the cable-tool method. This technique was chosen primarily for radiological contamination control. Temporary casings are telescoped through intervals of contamination to limit the driving of contaminants deeper into the vadose zone.

Soil samples are extracted from each borehole via a split-tube sampler. Radiological sample handling procedures have been developed to be consistent with the as low as reasonably achievable policy. The procedures were initially implemented during a nonradioactive hands on training session. The session allowed field personnel the opportunity to become acclimated to handling highly radioactive samples and to illuminate any potential problems prior to drilling through the radiologically contaminated cribs. When handling radioactive soils, lead blankets and shielded waste drums are used whenever possible to reduce radiation exposures to the worker. A glovebox is also employed to reduce radiation exposure and is located within a sample preparation trailer. The glovebox is used to transfer material from the split-tube sampler to sample bottles for shipment to an appropriate physical or analytical laboratory.

Storage Facility

An interim storage facility for mixed waste compliant with EPA and Ecology policies and regulations was required prior to initiating drilling activities. The interim storage building has capacity of 27, 208-L containers. The building interior has a chemical resistant coating, a grated floor covering, and a chemical-resistant containment sump. Waste drums are initially segregated according to suspected radioactive or mixed, nonradioactive, or unknown waste. When field instruments indicate the potential of a mixed waste, the drill cuttings are placed in a lined drum and transferred to the interim storage facility. The drums are held pending evaluation of analytical results.

PRELIMINARY ANALYTICAL RESULTS

The nature and extent of contamination within the vadose zone is described below. Only preliminary radiological data and field instrument readings were available as of the writing of this paper.

The 216-B-61 Crib was constructed to receive ITS waste from the 241-BY Tank Farm, but there is no documentation that it was used or received wastes. One 10-m borehole was drilled and sampled at the head end of the crib to verify that it was never used. Initial laboratory data and field instrument readings have confirmed that the crib never received wastes.

The 216-B-57 Crib received very large volumes of ITS waste (84,400,000 L). One 70-m and two 15-m boreholes were drilled and sampled near the head end, center, and end of the crib. Contamination levels were lower and encountered deeper than anticipated. General contamination was encountered at a depth of 5-7 m below the crib infiltration gravels with no contamination encountered in the borehole drilled at the end of the crib. The highest activity was 62.9 nCi/g of cesium-137 located at a depth of 4.6 m near the head end of the crib. No detectable radioactivity was encountered between 7 and 70 m in any of the boreholes.

The 216-B-49 Crib received 6,700,000 L of supernatant waste containing approximately 3,000 Ci of radioactivity. One

70-m and two 10-m boreholes were drilled between the distribution pipelines within the crib. The majority of the contamination was encountered directly under the crib infiltration *gravels (0.3 m)*. Contamination levels dropped off very rapidly and were less than detectable at a depth of 10 m. Contamination levels *varied within* the crib ranging from 2.1 μCi/g to 0.49 nCi/g total activity. The highest activity encountered was 1.9 μCi/g cesium-137 and 0.2 μCi/g strontium-90 directly under the crib. This activity level resulted in dose rates of 8,000 mrad/hr beta and 1,000 mRem/hr gamma.

Drilling is underway at the 216-B-50, 216-B-46, and 216-B-43 cribs. Initial field data indicate similar contamination levels and distribution that was encountered in the 216-B-49 crib.

CONCLUSION

The Hanford Site presents unique challenges for site characterization activities. Drilling and sampling the inactive cribs at the 200-BP-1 Operable Unit has produced many uncertainties. Contamination levels have been an order of magnitude higher than anticipated in the safety assessment. However, due to the extensive planning and preparation, drilling and sampling efforts have continued with only minor delays.

The successful development and implementation of many new drilling and sampling strategies at the 200-BP-1 inactive cribs, in addition to the development of field structures for weather protection, will benefit subsequent site characterization activities and lead the way to the ultimate cleanup of the Hanford Site.

REFERENCES

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