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Status of Remedial Investigation Activities in the Hanford Site 300 Area Groundwater Operable Unit

L. C. Hulstrom
B. E. Innis
M. A. Frank

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Westinghouse Hanford Company P.O. Box 1970
Richland, Washington 99352

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STATUS OF REMEDIAL INVESTIGATION ACTIVITIES IN THE HANFORD SITE 300 AREA GROUNDWATER OPERABLE UNIT

L. C. Hulstrom, B. E. Innis, M. A. Frank
Westinghouse Hanford Company

ABSTRACT

The Phase I remedial investigation (RI) and Phase I and II feasibility studies (FS) for the 300-FF-5 groundwater operable unit underlying the 300 Area on the Hanford Site have been completed. Analysis and evaluation of soil, sediment, and surface water, and biotic sampling data, groundwater chemistry, and radiological data gathered over the past 3 years has been completed. Risk assessment calculations have been performed. Use of the data gathered, coupled with information from an automated water level data collection system, has enabled engineers to track three plumes that represent the most significant contamination of the groundwater.

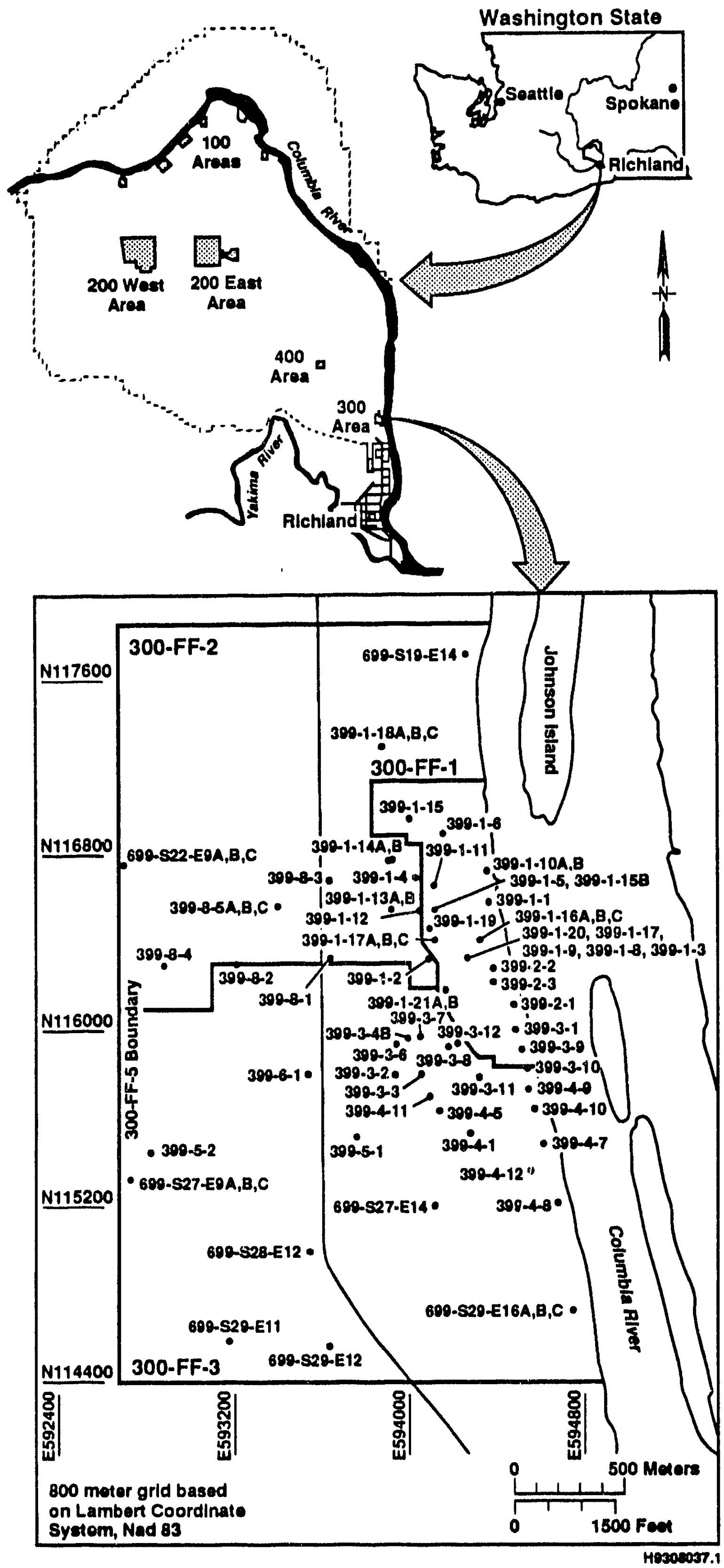
INTRODUCTION

The 300 Area was placed on the National Priorities List (NPL) in November 1989 by the U.S. Environmental Protection Agency (EPA) (Fig. 1). The 300 Area NPL site was divided into six operable units, with 300-FF-5 designated as the groundwater operable unit beneath three primary source operable units. Activities in the 300 Area have historically been related primarily to the fabrication of nuclear fuel elements. In addition, technical and service support, and research and development activities related to fuels fabrication have been carried out in the recent past. Fuels fabrication operations generated both liquid and solid waste. Most of the liquid waste was disposed of in the waste management units assigned to the 300-FF-1 source operable unit. Solid waste was disposed of in burial grounds, some of which are contained in the 300-FF-1, 300-FF-2, or 300-IU-1 operable units. The burial grounds contain mixed waste of mostly unknown composition, but are known to contain various fission products and isotopes of uranium and plutonium. The 300-FF-5 operable unit was designated to address the groundwater/surface water pathway within the 300 Area and to aid in identifying groundwater contamination from other areas that commingle in the groundwater of the operable unit area before discharging into the Columbia River. RI work was conducted under a work plan that was approved by the EPA in June 1990 (1). The Phase I RI report (2) and the Phase I and II FS report (3) for the 300-FF-5 operable unit were provided to the regulatory agencies for review in July, 1993. Discussions and negotiations for future work scope are ongoing.

REMEDIAL INVESTIGATION ACTIVITIES

RI work conducted during the first phase in the operable unit includes geophysical surveys of the stratigraphy in the 300 Area to delineate subsurface features; soil sampling during well construction; installation of two boreholes for aquifer pump tests; archaeological and radiological surveys of new groundwater well locations; remediation of existing groundwater wells; installation of automated water level measurement systems and one river monitoring station; riparian zone plant and small mammal sampling and aquatic biota sampling; sampling of groundwater discharges via riverbank springs and characterization of near-shore river water and sediments; and preparation of computer models for risk assessment activities.

Figure 1. Hanford Site and 300 Area Map.



Surface water and sediment investigation activities identified 14 active riverbank springs and near-shore submerged springs along the shoreline of the Columbia River, which represents the eastern boundary of the operable unit. Samples from five of the major active springs were collected in September, 1992, along with samples of near-shore river water. Field measurements were made at the sample sites to determine the seep-water temperature, pH, and conductivity. Sampling was conducted during a 24-hour time period when the river flow was artificially lowered to maximize the potential for the seeps to be actively flowing and to maximize the impact of the contaminated groundwater entering the river.

Geophysical surveys were conducted to delineate subsurface features via an evaluation of the reflective properties of major sedimentary units, the water table and the top of the underlying basalt units. Specifically, the effort was focused to determine the existence of a proposed paleochannel located near the eastern boundary of the operable unit near and parallel to the present-day Columbia River, and to define the lateral extent of one of the lower confining mud units. Survey methods included shallow, high-resolution seismic reflection, seismic refraction, ground-penetrating radar, electromagnetic induction, and gross gamma and spectral gamma surveys of boreholes.

Other geological investigation activities included the installation of 19 additional groundwater monitoring wells. These wells, plus pre-existing wells, were sampled and instrumented to determine groundwater flow directions and to determine if waste disposal sites that are considered actual or potential sources of contamination are contributing to groundwater contamination. Five rounds of groundwater sampling from as many as 63 wells in the vicinity of the 300 Area have been completed and results have been compiled. Analyte classes of interest included volatile and semivolatile organics, pesticide/PCB, wet chemistry, filtered and unfiltered metals, and radionuclides. As results became available and data evaluations were performed, it was possible to reduce the number of analytes and wells being sampled.

Because of the dynamic interactions between the Columbia River and the groundwater of this operable unit, it was determined that monitoring was required. After well construction activities were completed 34 wells and one river monitoring station were instrumented with pressure transducers and dataloggers to measure groundwater elevations simultaneously and hourly for a period of over 1 year. The monitoring network collected and stored the data for automatic retrieval by radio telemetry into a computer for storage and processing. The water level data were used to prepare an animated time-sequence video, which graphically portrays the groundwater and surface water interactions in the operable unit.

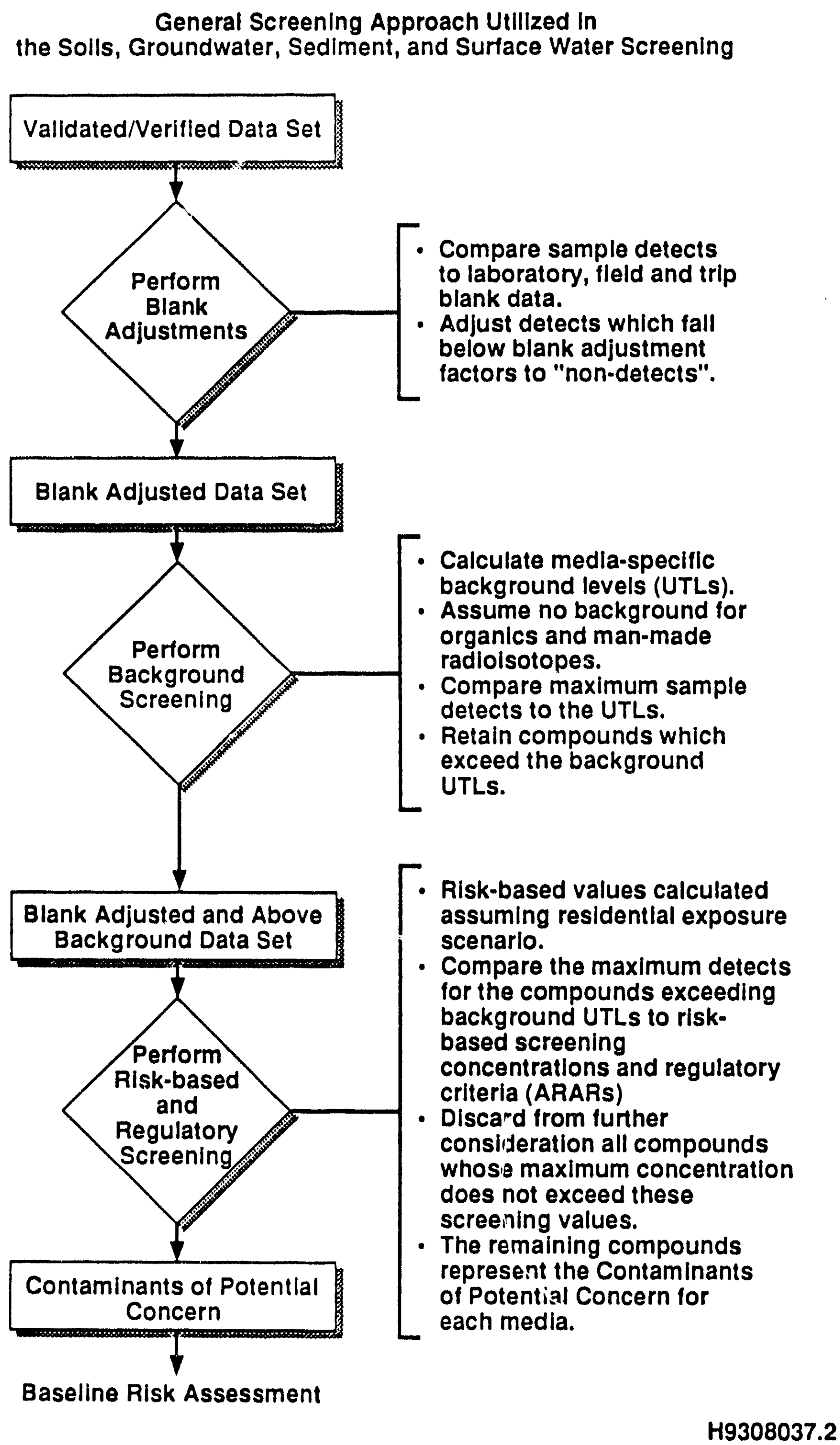
In parallel with groundwater sampling activities, two additional boreholes were constructed and used as temporary pumping wells for aquifer testing. Aquifer tests consisted of step drawdown, constant discharge, slug, slug interference, constant head, and laboratory tests to determine hydraulic properties of the subsurface units. An attempt was also made to install a geologic characterization boring, which was intended to help identify hydrofacies that were relatively thin (< 1.5 m) and to evaluate the heterogeneity of one of the major sedimentary units. Drilling was eventually terminated after several unsuccessful attempts to recover core and because of excessive loss of drilling fluid to the formation.

Ecological investigation activities consisted of data collection activities related to the characterization of potential receptor wildlife organisms in the vicinity of the operable unit. Operable unit-specific surveys pertaining to the occurrence of birds, mammals, and vegetation in the operable unit was conducted along with a specific survey to identify endangered and threatened species, or habitats critical to their existence. Surveys were confined within the riparian zone defined by the crest of the river bank and the margin of the Columbia River.

DATA EVALUATION

Chemical and radiological compounds that potentially pose risk to human health and the environment were defined from historical records and process knowledge during development of the work plan for this operable unit. These contaminants of concern were chosen for each media considered (soil, groundwater, sediment and surface water, and biota) that represent a potential contaminant exposure route. After data collection activities had been completed, a step-wise screening process was used to evaluate the data gathered for these compounds (Fig. 2). This screening process considered data validation and verification, laboratory and field blank data, background concentrations, appropriate regulatory criteria, and media-specific risk-based screening concentrations. The approach used in this evaluation is based on guidelines for defining risk presented by EPA (4), Bleyler (5,6) and the *Hanford Site Baseline Risk Assessment Methodology* (7), which narrows the list of detected contaminants to those that represent actual contamination, pose potential risk, and/or exceed regulatory criteria. This process is described in more detail in the following paragraphs.

Figure 2. Screening Approach.



Data validation and verification activities result in a database of analytical results that have been checked and confirmed, and that can then be used in the contaminant screening steps that follow. Blank adjustments remove detect bias which results from laboratory, field or equipment contamination. Background screening eliminates those compounds present below established background values for the various relevant media. Background values are obtained from a combination of literature sources and operable unit-specific data. Compounds that remain after the background screening constitute actual contamination. The final step in the screening process is the risk-based and regulatory screening. This identifies, of the compounds that exceed background, those which pose a potential risk to human health and/or exceed the most stringent regulatory criteria. The resulting list of contaminants is termed the contaminants of potential concern (CsOPC). These compounds are retained for further consideration in their fate and transport and in the human risk assessment. An example of this screening process is provided in the following paragraphs for groundwater.

Three scenarios of background screening were performed for groundwater as shown in Fig. 3: (1) screening groundwater data from all wells sampled against site-specific background values; (2) screening data from the single onsite industrial process well; and (3) screening data from three wells representative of a tritium plume migrating into the operable unit from the north. For each of these scenarios, screening was performed separately for the unconfined and confined aquifers, as appropriate. The first scenario provided a comprehensive list of compounds above background throughout the 300-FF-5 operable unit, regardless of contaminant source or location. The second scenario was aimed at determining CsOPC in the industrial process well, which represented a current groundwater exposure pathway to industrial workers at the 300-FF-5 operable unit. The third scenario was performed to separately assess contamination associated with the tritium plume, which was derived from sources in the 200 Areas.

In addition to the tritium plume, another non-300 Area-derived contaminant plume is associated with the 300-FF-5 operable unit (Fig. 4). Nitrate, trichloroethene (TCE) and technetium-99 are migrating in groundwater from the vicinity of the Horn Rapids Landfill, located approximately 1.6 km to the west of the southern portion of the 300-FF-5 operable unit (8,9). A separate screening scenario was not performed for this plume, however, because risks posed by the contaminated groundwater were evaluated in the 1100-EM-1 RI/FS process. The incremental increase in 300-FF-5 operable unit risk posed by the 1100-EM-1 groundwater plume is evaluated and presented elsewhere (8,9); however, it has been included in this evaluation for completeness.

The results of the background screening for the three groundwater screening scenarios were summarized. The compounds detected at levels above the background upper tolerance limits (UTL) and all detected organics and fission product radionuclides were carried forward into the risk-based and regulatory screening portion of the process. This focuses the list of contaminants exceeding background to those with the greatest likelihood of dominating the overall risk at the 300-FF-5 operable unit. The risk-based screening process is conducted as described by DOE (7). The procedure involves the calculation of risk-based benchmark screening concentrations against which the maximum detected concentration of a contaminant is compared. Risk-based benchmark concentrations are media-specific (sediment, groundwater or surface water) concentrations that correspond to a specific hazard quotient (HQ) or lifetime incremental cancer risk (LICR) using defined exposure assumptions, as discussed below. As recommended by DOE (7), risk-based benchmark concentrations are calculated for media concentrations that would be equivalent to exposures at an HQ of 0.1 for contaminants with noncarcinogenic effects. A concentration equivalent to an LICR of 1E-07 is used for contaminants with carcinogenic effects. If the maximum concentration detected for a contaminant does not exceed any of the risk-based benchmark concentrations for that contaminant, it may be eliminated from further consideration in the risk assessment. The screening process provides a high degree of confidence that the eliminated contaminants pose only an insignificant risk to human health or the environment.

Exceedance of a conservative risk-based benchmark concentration does not necessarily establish the existence of a significant risk. At this point in the overall analysis, it simply indicates the need to retain the contaminant for further evaluation in the risk assessment. As a supplement to the risk-based screening, potential contaminant-specific cleanup regulations are also compared to the maximum detected concentrations. Any contaminants exceeding potential regulatory cleanup guidelines are also retained for further evaluation in the risk assessment. For screening purposes, the maximum contaminant levels (MCL) are reduced by a factor of 10 to account for the possible additive effects from the presence of multiple contaminants and multiple sources.

Figure 3. Screening Approach.

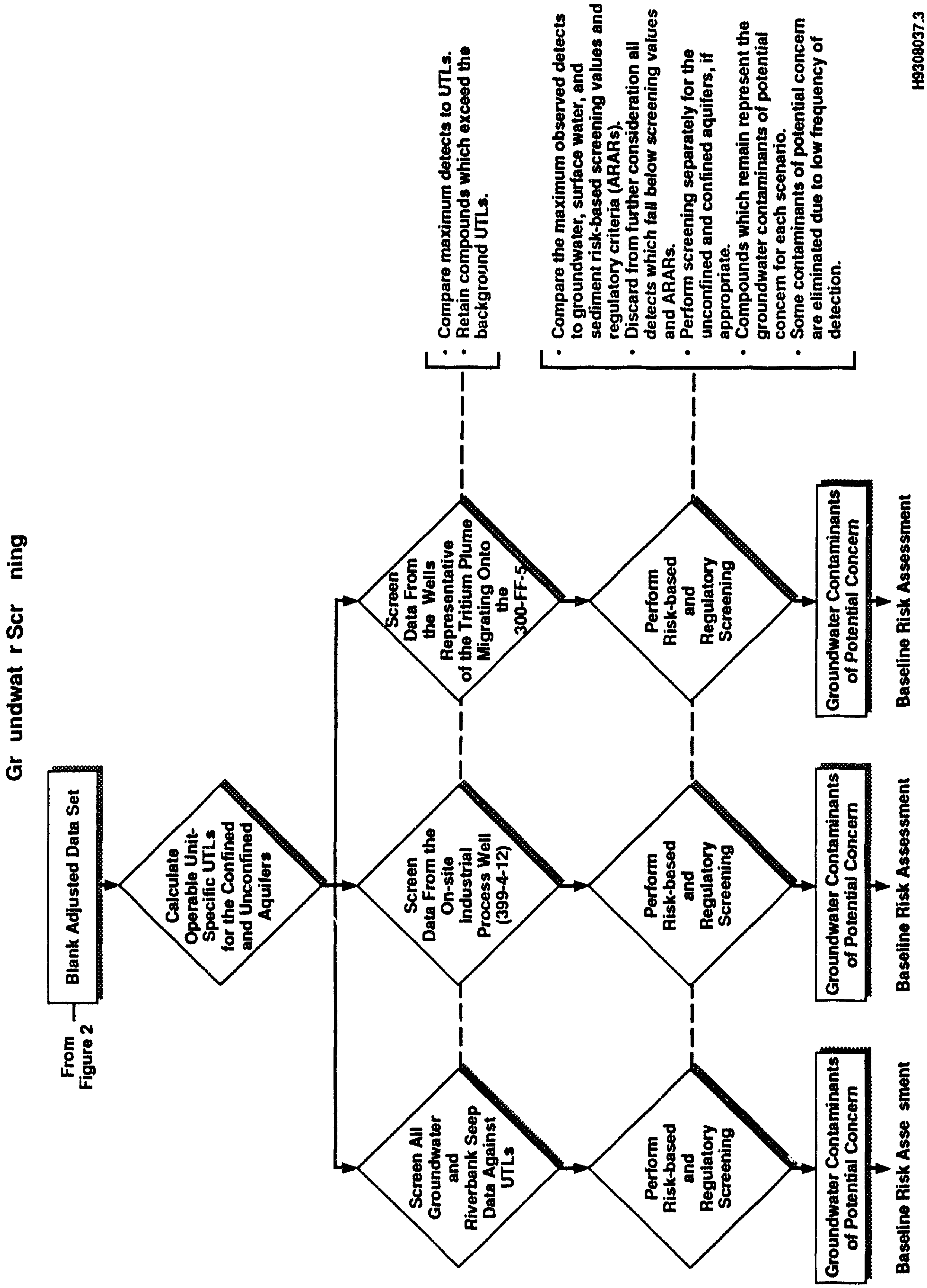
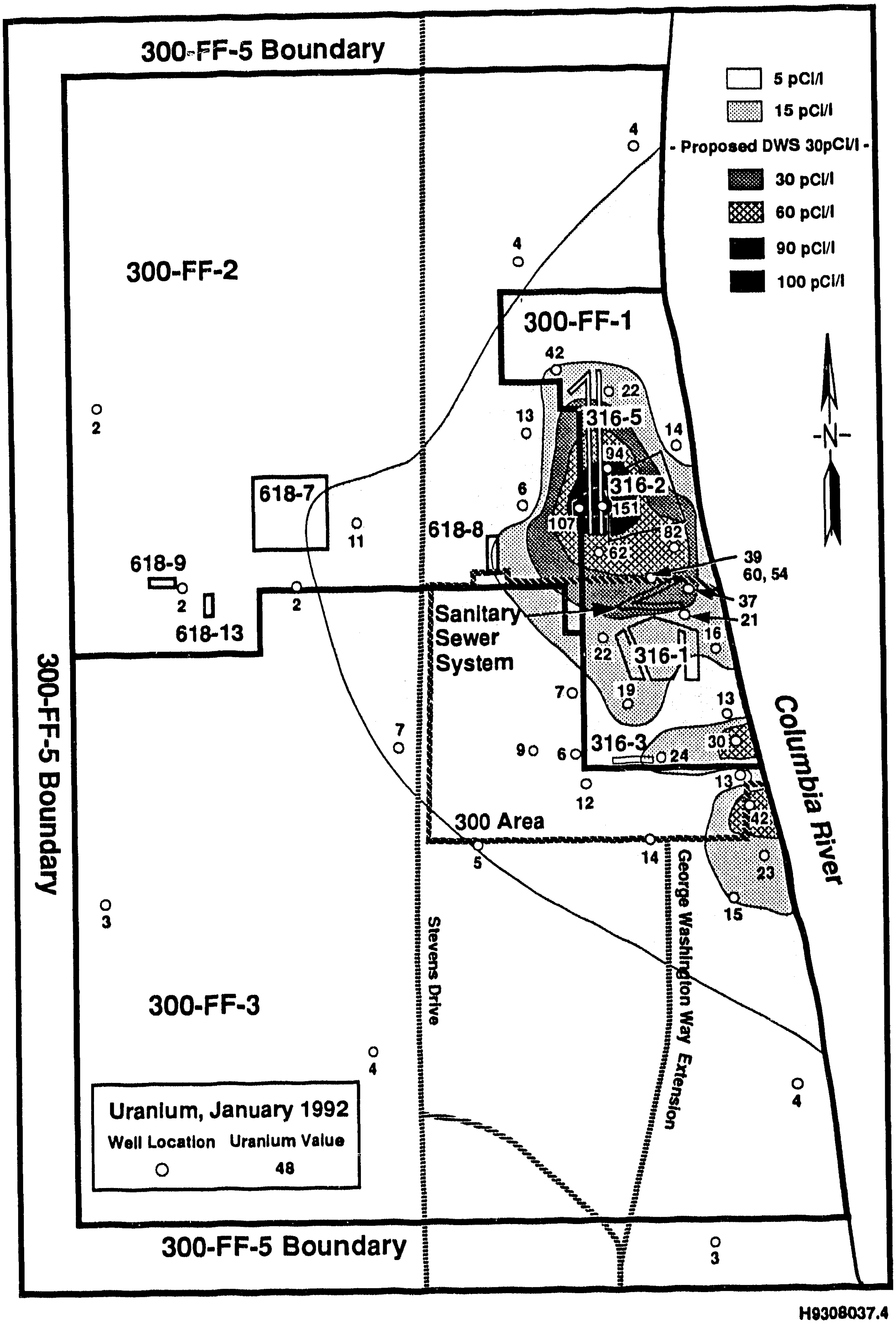


Figure 4. General Plume Map.



For those CsOPC identified to this point, a final qualitative evaluation was performed to address contaminant frequency, distribution, and chemical activity. This final step helps to eliminate, where appropriate, a few remaining constituents, and to further focus the list of CsOPC. A similar process was conducted for each remaining media of interest (sediment, surface water, and biota). The lists of CsOPC for each of the remaining media were processed through environmental fate and transport analyses to determine the human and ecological receptor exposure scenarios and pathways. Additionally, the transport analyses provided reasonably conservative estimates of future contaminant concentrations at points of potential receptor exposure. Both numerical and analytical modeling methods were used. Following this stage, the remaining contaminants of potential concern were used for input for the baseline risk assessment.

Three scenarios were considered for groundwater: (1) "all data"; (2) involving well 399-4-12 only; and (3) wells considered representative of the tritium plume migrating into the 300 Area from the north.

For the "all data" scenario, the CsOPC retained for use in the risk assessment were total coliform, 1,2-DCE (total and trans), TCE, chloroform, nitrate, strontium-90, technetium-99, tritium, total uranium, uranium-234,235,238, nickel, and copper. These contaminants are associated only with the unconfined aquifer. All CsOPC identified for the confined aquifer were eliminated due to low frequency of detection, inconsistent detection, and/or suspected problems with poor well construction. For the screening scenario involving well 399-4-12 only, the CsOPC retained for use in the risk assessment were chloroform, TCE, tritium, uranium-234,235,238, and total uranium. For the screening scenario involving the wells considered representative of the tritium plume migrating into the 300 Area from the north, tritium was the only CsOPC retained for use in the risk assessment.

The baseline risk assessment provided an assessment of the threats posed to human health and the environment under current and future scenarios. In accordance with DOE (7) and an agreement with the regulatory agencies overseeing this operable unit, four exposure scenarios (industrial, residential, recreational, and agricultural) were evaluated. These scenarios were evaluated at three locations (within the 300 Area, on the Hanford Site outside of the 300 Area, and off the Hanford Site).

The largest estimated HQ associated with noncarcinogenic effects is 0.2 (associated with 1,2-dichloroethene (total) in future groundwater. Since this value is nearly an order of magnitude <1, no systemic toxic effects are expected to occur as a result of exposure to contaminants at the operable unit. The only current scenario that exceeds a 10^{-6} ICR is the industrial scenario with receptors on the 300 Area (2E-5). However, this risk is primarily due to chloroform in groundwater, which is attributable to water chlorination. By considering only those contaminants associated with 300 Area past practices, the groundwater risk drops to 1E-6 (due to TCE). The current risk to receptors off the Hanford Site is negligible ($<10^{-6}$). Based on the use of predicted average river contaminant concentrations, the only future scenario $>10^{-6}$ risk is the industrial scenario with receptors on the 300 Area (7E-6). Approximately half of this risk is associated with the tritium plume from the 200 Area that is discharging to the Columbia River. By considering only those contaminants associated with 300 Area past practices, the future groundwater risk is 4E-6 (attributable to TCE and uranium). The TCE risk is based on the conservative assumption that current TCE groundwater concentrations will remain constant in the foreseeable future. If the source of TCE is depleted in the near future, the remaining industrial scenario risk (on the 300 Area) becomes 1E-6 (associated with isotopes of uranium). Based on the use of predicted average river concentrations, the risk to future receptors on and off the Hanford Site is negligible.

A major current downstream user of Columbia River water is the city of Richland, which supplies the municipality with drinking water from the Columbia River. This water supply is routinely analyzed. Based on available data, ICR from the water supply system for all uses is currently $<10^{-6}$. The future risk to the city of Richland river water supply from 300-FF-5 contaminants should be less than estimated for today, since the risk to the river is expected to decrease with time.

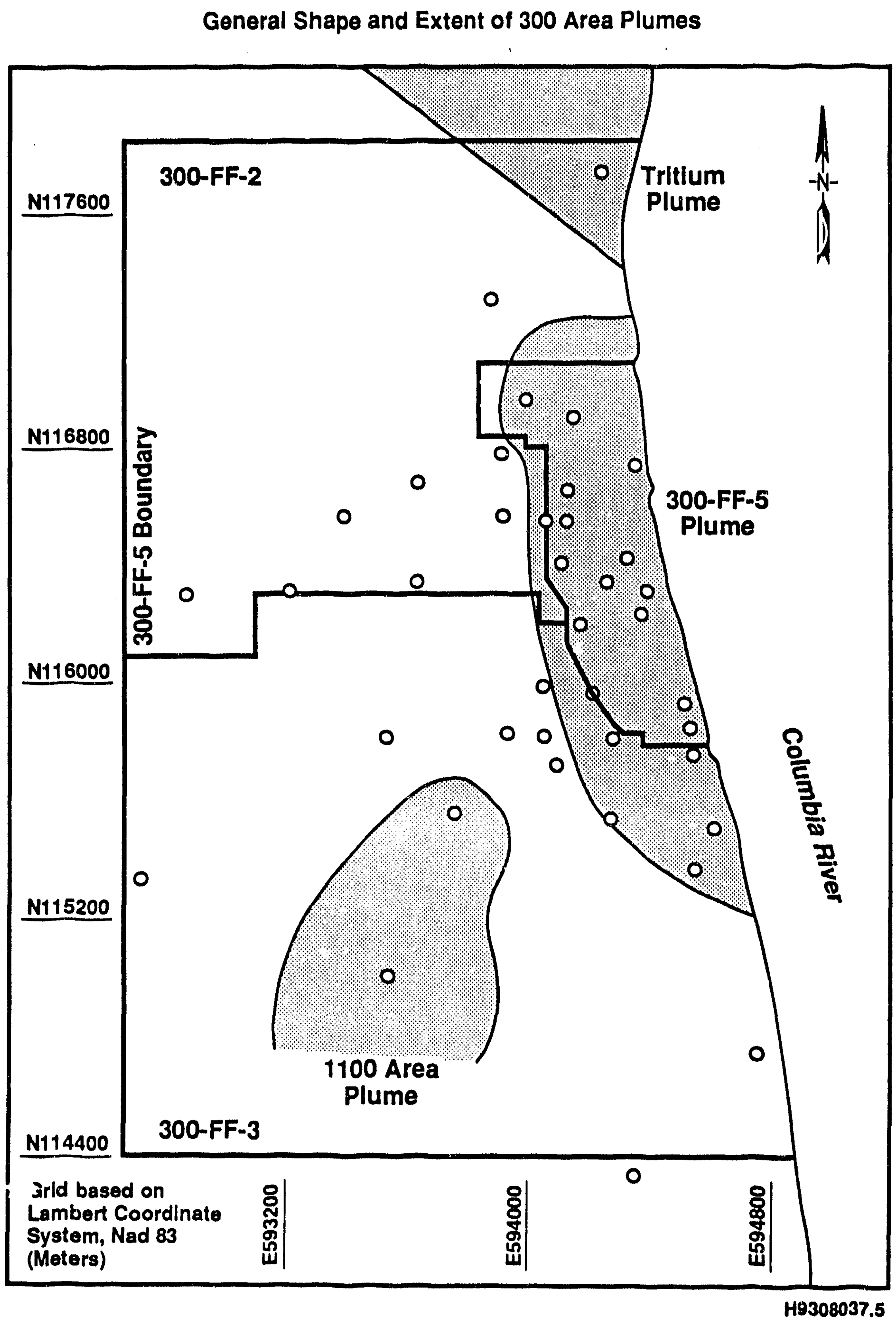
RESULTS AND DISCUSSION

Groundwater contamination at the 300-FF-5 operable unit generally consists of three main plumes (Fig. 4), all of which are associated with the unconfined aquifer. The primary plume, and the only one of the three that is derived from 300 Area operations, is associated with the 300-FF-1 source operable unit (Fig. 5). Compounds associated with this plume are the organic compounds (DCE and TCE), nickel, copper, strontium-90, and uranium-234,-235,-238). Uranium concentrations are highest in the north central portion of the operable unit (approximately 270 μg/L for total uranium) and decline to the south. A second plume, consisting of tritium contamination entering the 300-FF-5 operable unit from the north, is present throughout the north and eastern portions of the 300-FF-5 operable unit. This plume is derived from operations in the 200 Area, approximately 26 km northwest of the 300 Area. This tritium plume is very extensive, covering approximately 100 km^2 on the Hanford Site. Tritium concentrations are highest in the northern portions of the operable unit (approximately 12,000 pCi/L) and decline to the south. The third plume is composed of technetium-99 and nitrate contamination that is migrating from the vicinity of the Horn Rapids Landfill, a waste management unit in the 1100-EM-1 operable unit, located approximately 1.6 km to the west of the southern portion of the 300-FF-5 operable unit.

Baseline risk assessment calculations indicate minimal risk at this time and out to the year 2018. The year 2018 represents the earliest time at which institutional controls might be removed and additional uses of the aquifers could occur. The ecological risk assessment indicates some potential risk to aquatic organisms. However, there is uncertainty in the source term, rate of contaminant uptake by organisms, size and weight of receptor organisms, frequency of the site use, etc.

Expedited response actions are not justified based on the data available at this time. Recommended remedial action objectives for the FS include limiting future impacts to groundwater by implementation of source control measures in the remaining source operable units, and institutional controls to limit the exposure to contaminated groundwater. Additional characterization activities proposed to the EPA include additional sampling of the Columbia River adjacent to the 300 Area to refine the estimates of the average concentrations of CsOPC, continued monitoring of the uranium and organics plume, and some additional laboratory testing to better understand the fate and transport of uranium in the unconfined aquifer at the 300-FF-5 operable unit. Discussions and negotiations regarding this potential future work scope are presently ongoing.

Figure 5. Uranium Plume Map.



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