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Limited Field Investigation Report for the 100-BC-5 Operable Unit

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EXECUTIVE SUMMARY

This limited field investigation (LFI) was conducted to assess the applicability of interim remedial measures (IRM) for reducing human health and environmental risks within the 100-BC-5 Groundwater Operable Unit. The 100-BC-5 Operable Unit is one of three operable units associated with the 100 B/C Area. Operable units 1 and 2 address contaminant sources while 100-BC-5 addresses contamination present in the underlying groundwater.

The primary method of investigation used during this LFI was the installation of monitoring wells. Samples were collected from the groundwater and soils and submitted for laboratory analysis. Boreholes were surveyed for radiological contamination using downhole geophysical techniques to further delineate the locations and levels of contaminants. All samples were screened to ascertain the presence of volatile organic compounds and radionuclides. Analytical data were subjected to validation; all first round and 10% of the subsequent rounds of data associated with the LFI were validated.

A screening method was used to identify contaminants of potential concern (COPC). This screening method eliminated from further consideration constituents that were below background. Constituents considered nontoxic to humans were eliminated from the human health evaluation. Inconsistency and blank contamination were also evaluated in the screening process. These COPC were evaluated further in the qualitative risk assessment (QRA).

A QRA was performed using conservative (highest reported contaminant levels from the LFI) analyses. The risk assessment evaluated frequent-use and occasional-use scenarios. The QRA analysis indicates that there is a low risk for both the frequent- and occasional-use scenarios. Neither of these land use scenarios currently occur at the site. No constituents identified in the Columbia River water were determined to have acute or chronic toxicity to aquatic biota. Although undiluted spring and groundwater constituents may have either acute or chronic toxicity.

No contaminants of concern were identified at 100-BC-5. Based on the low risks and concentrations below applicable or relevant and appropriate requirements, an IRM is not recommended and the operable unit should be removed from the IRM pathway. After sources have been remediated, groundwater contamination should be reevaluated to determine the effects of the remediation and the associated remaining risk. This reevaluation should be coordinated with ongoing remedial investigation/feasibility study and decommissioning and decontamination activities.

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ACRONYMS

ARAR	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COPC	contaminants of potential concern
DOE	U.S. Department of Energy
Ecology	Washington Department of Ecology
EII	environmental investigation instruction
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
FR	Federal Register
HEIS	Hanford Environmental Information System
HQ	hazard quotient
HPPS	Hanford Past-Practice Strategy
ICR	incremental cancer risk
IRM	interim remedial measure
LFI	limited field investigation
LOEL	lowest observable effect level
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MTCA	Model Toxics Control Act
QRA	qualitative risk assessment
RI/FS	remedial investigation/feasibility study
RLS	radiation logging system
TAL	target analyte list
TBC	to-be-considered
TCL	target compound list
WHC	Westinghouse Hanford Company
VOC	volatile organic compounds

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1.0 INTRODUCTION

This limited field investigation (LFI) report is a secondary document summarizing the data collection and analysis activities conducted during the 100-BC-5 Groundwater Operable Unit LFI and the associated qualitative risk assessment (QRA).

1.1 SITE LOCATION

The 100-BC-5 Operable Unit is located in the north-central portion of the Hanford Site along the southern shoreline of the Columbia River (Figure 1-1). The site is approximately 45 km (28 mi) northwest of the city of Richland and encompasses approximately 3.0 km^2 (1.1 mi^2). It lies predominantly within Section 11, the southern portion of Section 2, and the western portion of Section 12 of Township 13N, Range 25E. The 100 B/C Area lies approximately between the north/south Washington State coordinates N143700 and N145500 and east/west coordinates E564200 and E566800.

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The 100-BC-5 Operable Unit is one of three operable units associated with the 100 B/C Area at the Hanford Site (Figure 1-2). Two of the 100 B/C Area operable units are source operable units and one is a groundwater operable unit. The 100-BC-1 Operable Unit includes the liquid and sludge disposal sites generally associated with operation of the B Reactor. The 100-BC-2 Operable Unit includes C Reactor and its associated facilities, the burial grounds south of the C Reactor, and the solid waste facilities northeast of B Reactor. The 100-BC-5 Groundwater Operable Unit includes the groundwater below the source operable units plus the adjacent groundwater, surface water, sediments, and aquatic biota impacted by the 100 B/C Area operations.

1.2 SITE HISTORY

The 100 B/C Area was the site of two water-cooled, graphite moderated, plutonium production reactors. The B Reactor was constructed in 1943 and operated from 1944 until 1968. The C Reactor was constructed in 1951 and operated from 1952 until 1969. The operation of these reactors and their ancillary facilities resulted in the disposal of large quantities of waste. Of primary concern for this LFI is the liquid waste, because it is believed to have the biggest influence on the groundwater. The major liquid waste disposal sites (Figure 1-2) are:

- The retention basin area which includes the 116-B-11 and 116-C-5 retention basins; the 116-B-1 and 116-C-1 overflow trenches; 116-B-7, 132-B-6, and 132-C-2 outfall structures; effluent discharge pipelines; and the 116-B-13 and 116-B-14 sludge disposal trenches. These sites were contaminated with cooling water which contained low concentrations of radionuclides and potentially hazardous species including chromium. Cooling water with elevated concentrations of radionuclides (as a result of

fuel cladding failures) was generally diverted to overflow trenches associated with the basins.

- The group of liquid waste disposal sites east of the B Reactor. The 116-B-2 fuel storage basin trench was used for the disposal of contaminated water from the B Reactor fuel storage basin. The 116-B-3 pluto crib received contaminated cooling water resulting from fuel cladding failures. The 116-B-4 dummy decontamination french drain received contaminated chromic and nitric acid solutions from the dummy decontamination wash pad at the B Reactor building. The 116-B-6A crib received waste from decontamination activities at the 111-B decontamination station. The 116-B-6B crib received radioactive liquid waste from fuel element decontamination activities at the 111-B decontamination station. The 116-B-12 crib received drainage from the confinement system seal pits in the 132-B-4 air filtration ventilation building.

- The 116-B-5 crib, which received liquid waste, much of it contaminated with tritium (Stenner et al. 1988).

- The 116-C-2 pluto crib system which is located east of the C Reactor and was used as the primary liquid waste disposal site for the C Reactor operations.

These facilities are discussed in more detail below and in the 100-BC-1, 100-BC-2, and 100-BC-5 remedial investigation/feasibility study (RI/FS) work plans (DOE-RL 1992a, 1993a, and 1992b).

1.3 LIMITED FIELD INVESTIGATION STRATEGY

To expedite the cleanup and reduce the cost of cleaning up contaminated sites at Hanford, the U.S. Department of Energy (DOE), the Washington Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) developed the *Hanford Past-Practice Strategy* (HPPS) (DOE-RL 1991). This strategy stresses use of existing data to make decisions and is biased-for-action. If a site poses a risk to human health or the environment, the bias is to take action to clean it up. Figure 1-3 outlines the four decision paths of the HPPS. These paths are:

- Expedited response action (ERA) is performed when a rapid response is necessary to mitigate an unacceptable health or environmental risk from a site.

- Interim remedial measure (IRM) is performed at a site that is known to pose an unacceptable, non-time-critical health or environmental risk.

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- LFI is performed to gather any additional information necessary to determine whether or not an ERA or an IRM is necessary.

- RI/FS is the baseline method of addressing potentially contaminated sites.

The LFI is an integral part of the RI/FS process and functions as a focused RI for selection of IRMs. A QRA is performed as part of the LFI, and is focused on the principal risk drivers in the operable unit. The results of this assessment may be used to help determine the need for IRMs, to select the IRMs, and to determine risk-based cleanup levels for the IRMs. If an IRM is not justified, the site is still subject to further investigation and/or remediation. A further discussion of the LFI/IRM process is provided in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988).

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The LFI at the 100-BC-5 Area was conducted to determine the nature and extent of hazardous/radioactive materials present in the groundwater. This was done by collecting data from existing wells and 10 new wells drilled for the RI/FS. The new wells were installed to define the groundwater quality in areas of potential public or environmental exposure (e.g., near seeps and springs along the Columbia River shoreline that are downgradient of contaminant sources) and to define the groundwater quality immediately downgradient of priority and potential sources of groundwater contamination. Samples were collected for chemical and radioactive analyses and physical property determination. Aquifer tests were also performed and hydraulic heads were measured.

The LFI for the 100-BC-5 Operable Unit included the following tasks:

- geological investigation

- vadose zone investigation

- groundwater investigation

- data evaluation

- risk assessment

- verification of applicable or relevant and appropriate requirements (ARAR)

- LFI reporting.

Several data compilation reports were prepared as part of early characterization activities for the 100 Areas. Lindsey (1992) summarizes the geologic data available and the geologic setting of the 100 Areas. Peterson (1992) provides an inventory of wells, chemical data, and water level data for the northern part of the Hanford Site. Hartman and Peterson (1992) summarize hydrologic conditions for the 100 Areas, including water

table maps, waste indicator constituents, and aquifer hydraulic properties. They include an analysis of existing wells relative to their potential for future use. Lewis and Pearson (1992) present a catalog of historical borehole geophysical data for the 100 Areas. Ledgerwood (1991) summarizes well construction and condition information for existing 100 Area wells.

A limited number of LFI tasks were conducted under a separate 100 Area site-wide effort. These tasks include:

- surface water and sediments investigation
- air investigation
- ecological investigation.

Data compilations and summaries that pertain to these areas include Dirkes (1992), which provides an extensive annotated bibliography for river-related investigations. Peterson and Johnson (1992) summarize historical riverbank seepage, sediment and nearshore monitoring well data, and relate it to results obtained during September 1991 (DOE-RL 1992c). Campbell et al. (1993) describe the extensive data acquisition capability that exists to gather data for the Hanford Site aquifer/Columbia River interaction investigations (Tri-Party Agreement Milestone M-30). Weiss and Mitchell (1992) present a synthesis of ecological information for the 100 Areas. The potential ARARs are discussed in the 100 Area FS (DOE-RL 1993b).

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1.4 DATA VALIDATION

Data validation was performed by a qualified independent contractor. The validation responsibilities are defined in associated statements of work. All validation was performed in compliance with Westinghouse Hanford Company (WHC) *Sample Management Administration Manual* (WHC 1990), Section 2.1 for inorganic analyses, Section 2.2 for organics analyses, and Sections 2.3 and 2.4 for radionuclide analyses. All data packages were verified. The first round and 10% of the subsequent rounds of data were validated. The data validation process is presented in:

- *Data Validation Report for the 100-BC-5 Operable Unit Groundwater Samples, Round One* (WHC 1992a).

- *Data Validation Report for the 100-BC-5 Operable Unit Second Quarter Groundwater Sampling* (WHC 1993a).

- *Data Validation Report for the 100-BC-5 Operable Unit First Quarter 1993 Groundwater Sampling* (WHC 1993b).

Figure 1-1 Location of the 100 B/C Area

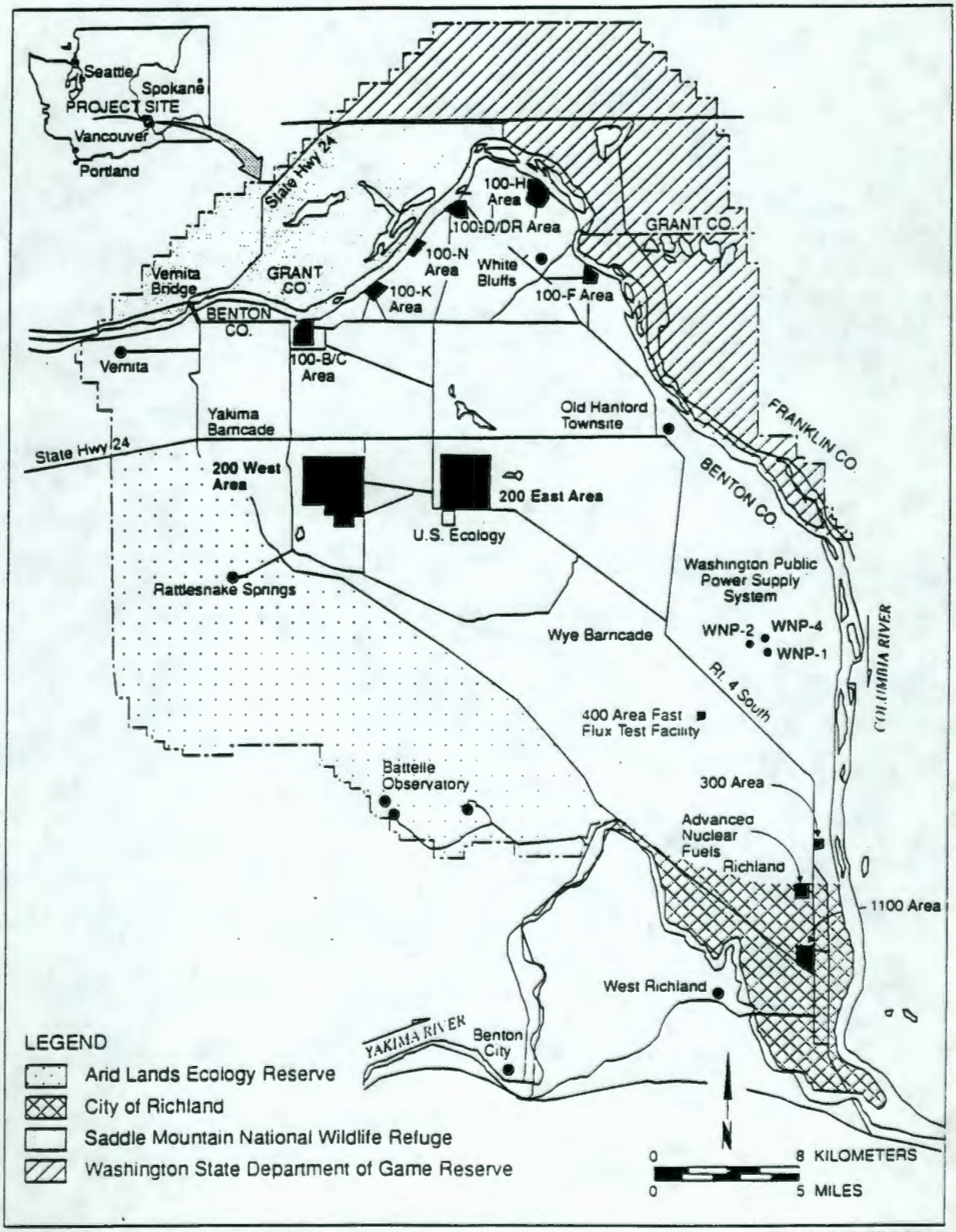

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Figure 1-2 Map of the 100 B/C Area Showing Source and Groundwater Operable Units

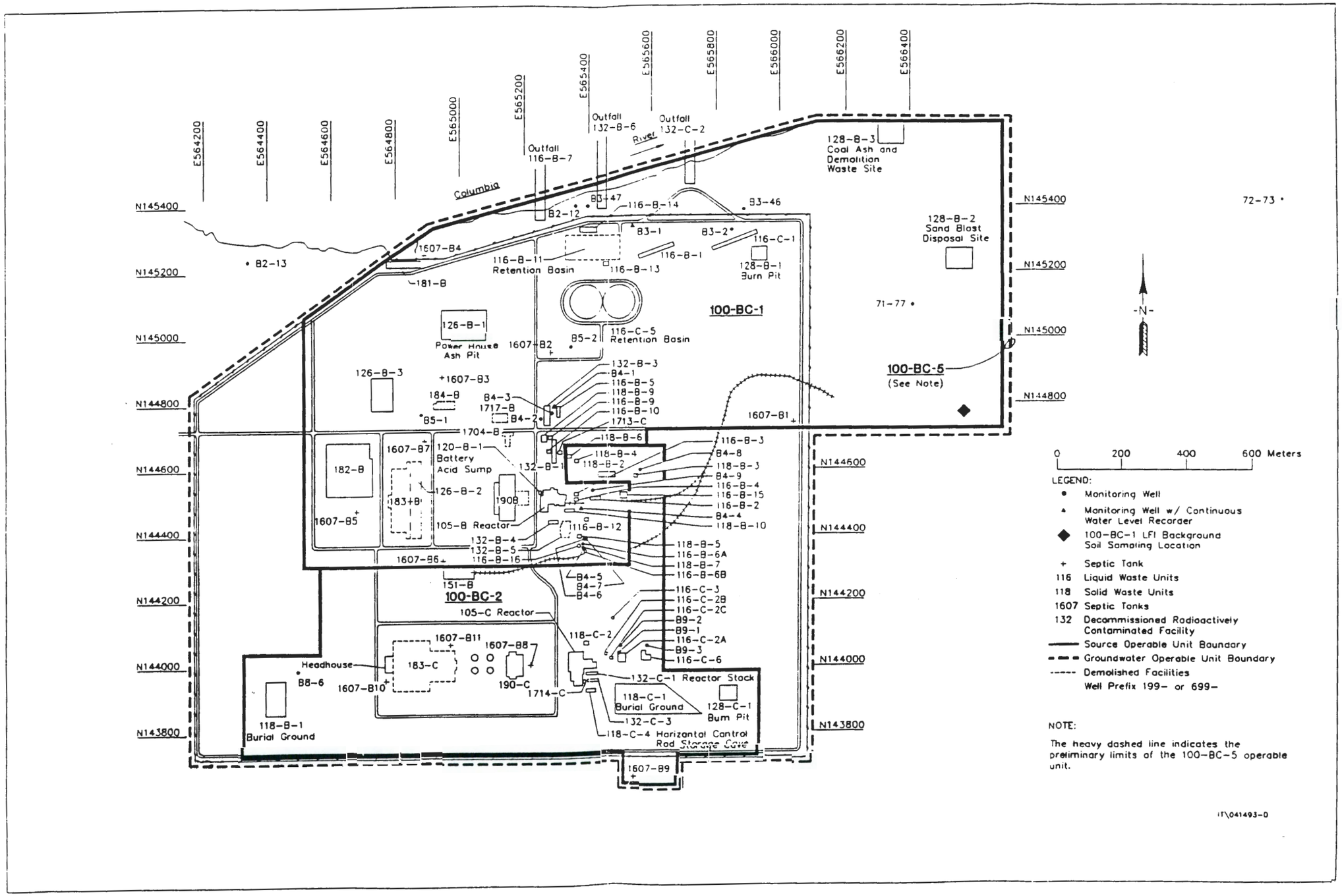
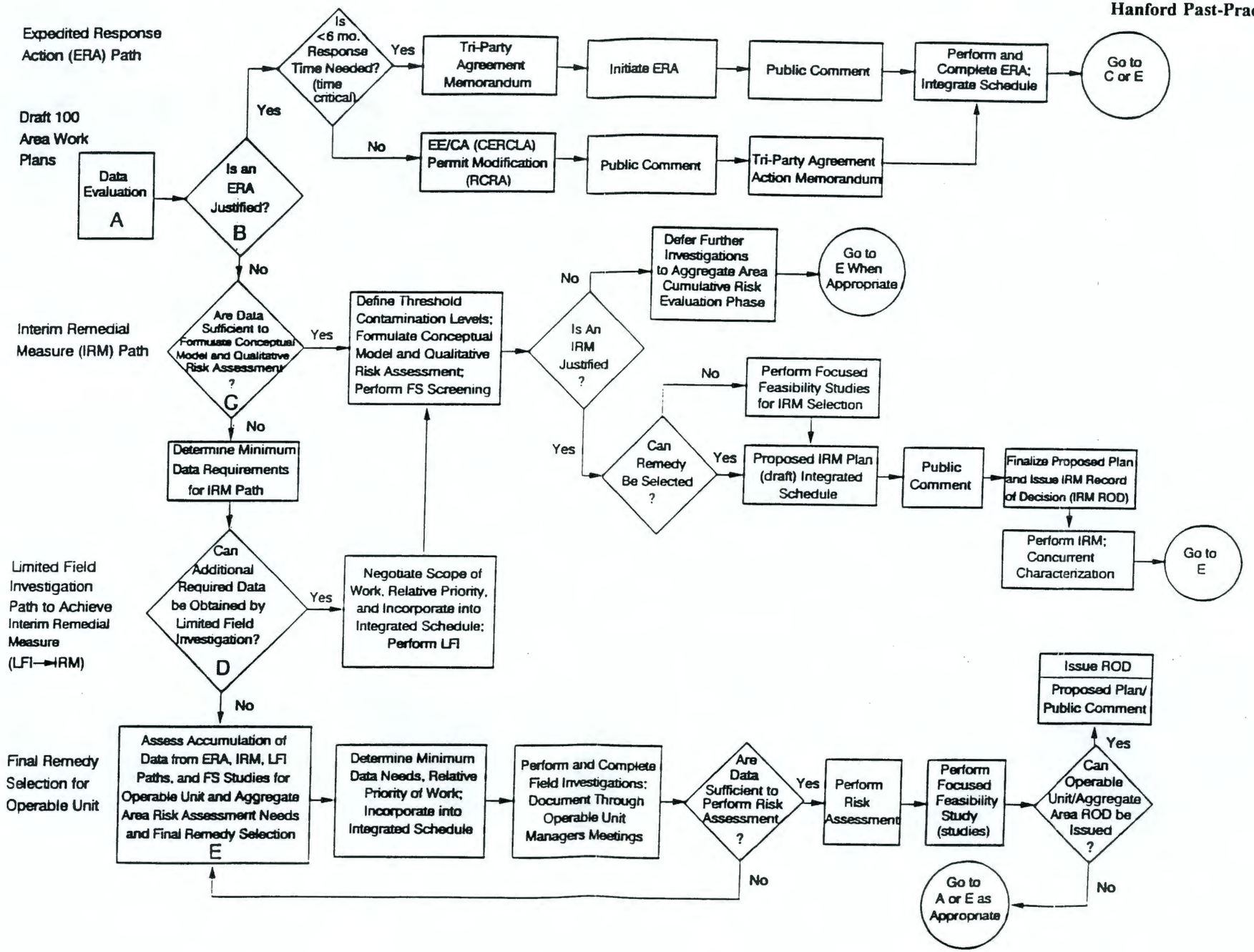


Figure 1-3

Hanford Past-Practice Strategy Decision Paths



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2.0 INVESTIGATION ACTIVITIES AND RESULTS

This chapter provides a summary of the activities performed and the data collected during the 100-BC-5 LFI.

2.1 GEOLOGY

During the LFI, one deep well (199-B2-12) and nine shallow wells (199-B2-13, 199-B3-46, 199-B3-47, 199-B4-8, 199-B4-9, 199-B5-2, 199-B8-6, 199-B9-2, and 199-B9-3) were installed (Figures 1-2 and 2-1) to define the groundwater quality in areas of potential public or environmental exposure and to define the groundwater quality immediately downgradient of priority and potential sources of groundwater contamination. The justification for each well location is discussed in the 100-BC-5 work plan (DOE-RL 1992b). Boreholes were advanced and sampled using cable-tool drilling methods and split-spoon or core barrel samplers. Cable-tool drilling was used because of the gravels, cobbles, and boulders common to the operable unit, and because the quantity of drilling residuals is minimal and can be easily controlled compared to other drilling methods. Detailed procedures for borehole drilling are described in the *Environmental Investigations and Site Characterization Manual*, Section 6.0 - Drilling (WHC 1988). A summary of the well construction is provided in Table 2-1; these data are also available in the Hanford Environmental Information System (HEIS) database.

Geologic samples were collected at 1.5-m (5-ft) intervals and at major lithologic changes. The shallow wells were drilled approximately 4.5 m (15 ft) below the water table. The deep well was completed in the upper 3 m (10 ft) of the upper confined/semi confined aquifer.

The following discussions are based on all of the data available for the 100 B/C Area. The geologic discussions are primarily from Lindberg (1993), which presents a detailed description of the 100 B/C Area geology and includes data from the new wells.

2.1.1 Topography

Surface topography in the 100 B/C Area is the product of cataclysmic flood deposition and erosion, post-flood eolian activity, and post-flood erosion and deposition associated with the Columbia River. Much of this topography has been modified by site activities. The 100 B/C Area lies on an essentially flat semi-arid bench south of the Columbia River. The elevation of the area ranges from approximately 149 m (490 ft) above mean sea level (amsl) along the southern border to 131 m (430 ft) amsl near the river. Erosion has created a steep bank that drops approximately 9 m (30 ft) to an elevation of 122 m (400 ft) amsl along the Columbia River.

2.1.2 Structure

Structurally, the Hanford Site lies in the eastern Yakima Fold Belt. This belt consists of a series of segmented, narrow, asymmetric, and generally east-west trending anticlines. Between these anticlines lie broad, shallow synclines. The Hanford Site is situated in the Pasco Basin, a structural basin. Within the Pasco Basin, the Gable Mountain anticline separates the Wahluke and Cold Creek synclines; the 100-BC-5 Operable Unit is on the north limb of the Wahluke syncline. South of the 100-BC-5 Area, basalt flows and the older units of the Ringold Formation dip steeply to the north. Beneath and to the north of the area, those same strata dip at shallow angles (about 5°) to the south (Lindberg 1993).

2.1.3 Stratigraphy

The 100 B/C Area is underlain (from oldest to youngest) by flows of Columbia River Basalt with intercalated Ellensburg Formation, six units of the Ringold Formation, the Hanford formation, and scattered Holocene surficial deposits (Figure 2-2).

2.1.3.1. Columbia River Basalt Group and Ellensburg Formation. The Columbia River Basalt Group is an assemblage of tholeiitic, continental flood basalts of Miocene age (DOE 1988; Reidel and Hooper 1989). Isotopic age determinations indicate that basalt flows were erupted between approximately 17 to 6 millon years ago (Reidel et al. 1989).

The Ellensburg Formation consists of a mix of volcaniclastic and siliciclastic deposits that occur between the basalt flows of the Columbia River Basalt Group (DOE 1988; Smith 1988).

2.1.3.2. Ringold Formation. The Ringold Formation beneath the 100 B/C Area contains most of the Ringold units commonly encountered elsewhere at the Hanford Site (Figure 2-2) (Lindsey 1992, Lindberg 1993). The sediments consist of semi-indurated clay, silt, fine to coarse-grained sand, and pebble to cobble-sized gravel. Four facies of the Ringold Formation are:

1. Fluvial gravel - This facies consists of pebble to cobble-sized gravel with a fine- to medium-grained sand matrix. Grain size distributions are often bimodal; coarse-grained sand is rare. The gravels exhibit a wide range of cementation and compaction. Low angle, lenticular bedding is common. Wide, shallow, shifting channels characterize the depositional environment.

2. Fluvial sand - This facies consists of stratified fine- to coarse-grained, quartzo-feldspathic sands. Wide, shallow channels incised into muddy floodplains characterize the depositional environment.

3. Overbank-Paleosol - This facies consists of laminated to massive silty sand, silt, clay and paleosols. Floodplain conditions characterize the depositional environment.

4. Lacustrine - This facies consists of well stratified clay with interbedded silt and silty sand. A lake with deltaic conditions characterizes the depositional environment.

In borehole 199-B3-2 (the deepest borehole within the 100 B/C Area) the total thickness of the Ringold Formation is approximately 200 m (650 ft) and consists of (from oldest to youngest):

- approximately 18 m (60 ft) of sandy gravel, sand, and sandy silt
- the lower mud unit, which is approximately 44 m (143 ft) thick and consists predominantly of blue to blue-grey lacustrine muds that grade upward into brown fluvial overbank deposits typical of Ringold Formation muds
- two beds of silty to gravelly sands intercalated with paleosols and fluvial overbank deposits (muds). The two sandy beds are 2.4 and 1.8 m (8 and 6 ft) thick
- a 15-m (50-ft) thick sequence of paleosols and fluvial overbank deposits
- a series of fluvial channel deposits, predominantly a coarse-grained series of silty sand to sandy gravel about 34 m (113 ft) thick
- Paleosols and overbank deposits typical of Ringold Formation muddy deposits, approximately 34 m (110 ft) thick
- a coarse-grained fluvial deposit that is 30 m (100 ft) thick.

2.1.3.3. Hanford Formation. The Hanford formation was deposited during Pleistocene cataclysmic flooding on an erosional surface of the Ringold Formation. The Hanford formation ranges in thickness from over 30 m (100 ft) in the southern and southeastern portions of the 100 B/C Area to <15 m (50 ft) near the Columbia River to the north and northwest (Lindberg 1993).

There are two facies of the Hanford formation, a gravel-dominated facies and a sand-dominated facies. The gravel-dominated facies predominates in the Hanford formation throughout the 100 B/C Area. The sand-dominated facies occurs locally in a few intervals, but is not thick or extensive enough to correlate from borehole to borehole. Boulder gravel is often found in the upper 6 to 15 m (20 to 50 ft) of the Hanford formation causing difficult drilling conditions (Lindberg 1993).

2.1.3.4. Holocene Deposits. Holocene deposits in the study area are dominated by Columbia River deposits and eolian deposits. The river deposits consist of gravels and coarse-grained sands deposited in channels and silts and fine sands deposited in overbank areas. A large deposit of river sediments is located in the northwestern portion of the study area and extends to the northwest along the Columbia River for over 3 km (2 mi). Eolian deposits consist predominantly of thin (<1 m [3 ft]) silty fine-

grained sands that blanket much of the area except in locations where it was removed for construction purposes (Lindberg 1993).

2.1.4 Physical Properties

The 100 Area operable units were combined into one aggregate unit for the purpose of collecting samples for physical property testing. The sampling program consisted of 54 samples from 18 wells in the 100 Areas. The plan was to collect two or three samples in the vadose zone and one sample in the saturated zone. In the 100 B/C Area, samples were collected for physical property analyses from four depths in wells 199-B3-47, 199-B4-9, and 199-B9-2, for a total of 12 samples. The physical property samples were analyzed for the following parameters using American Society for Testing and Materials (ASTM) methods:

- bulk density
- particle size distribution (ASTM D422-63)
- moisture content (ASTM D2216)
- moisture retention (ASTM D2325-68, D3152-72)
- saturated hydraulic conductivity (ASTM D2434-68)
- unsaturated hydraulic conductivity at 10% moisture content after full saturation.

Cable-tool sampling is more successful at collecting fine-grained sediments than coarse-grained sediments therefore the results presented below are biased toward finer-grained sediments. Consequently, the resulting values may not represent actual conditions and should not be used for design purposes. Unless otherwise noted, the results discussed below are for the combined 100 Area samples.

The Hanford formation is coarser grained, more dense (1.98 versus 1.88 g/cm^3) and has a higher specific gravity (2.72 versus 2.66) than the Ringold Formation. The sediments described as fines have a bulk density range of 1.36 to 1.57 g/cm^3 and a specific gravity of 2.44 to 2.64. The sand has a bulk density range of 1.67 to 2.13 g/cm^3 and a specific gravity of 2.65 to 2.80. The gravel has a bulk density range of 1.83 to 2.28 g/cm^3 and a specific gravity of 2.63 to 2.85.

Moisture contents (by weight) of the unsaturated sediments vary from 0.07% to 3.73% with an average of 2.26%. Sand had a moisture content of 1.15% to 3.73% with an average of 2.06%. Gravel had a moisture content of 0.07% to 3.73% with an average of 2.46%.

Laboratory vertical saturated hydraulic conductivity was measured and laboratory hydraulic conductivity varies considerably. In the 100 Areas, as in other areas of the Hanford Site, the Hanford formation has a higher vertical hydraulic conductivity than the Ringold Formation. The respective average values for the 100 Areas are 4×10^{-3} cm/s (11.2 ft/day) and 8×10^{-4} cm/s (2.2 ft/day). In the 100 B/C Area, samples were collected for vertical hydraulic conductivity measurement from wells 199-B2-12, 199-B4-9, and 199-B9-2. The results indicate that the vertical hydraulic conductivity in the 100 B/C Area ranges from 1×10^{-4} to 4×10^{-4} cm/s (0.4 to 1.2 ft/day) in the Hanford formation and 2×10^{-4} to 6×10^{-4} cm/s (0.7 to 1.7 ft/day) in the Ringold Formation.

2.2 HYDROGEOLOGY

The vadose zone beneath the 100 B/C Area includes minor backfill, Holocene surficial deposits, the Hanford formation, and in places, the uppermost portion of the Ringold Formation (Figure 2-2). The vadose zone ranges in thickness from about 15 m (50 ft) at borehole 199-B2-12 to over 30 m (100 ft) near borehole 699-63-89. The majority of the vadose zone lies within the gravel-dominated facies of the Hanford formation (Lindberg 1993).

The uppermost aquifer is found within the Ringold Formation and occasionally within the lowermost part of the Hanford formation. This aquifer is unconfined and consists of coarse-grained fluvial sediments which are about 30 m (100 ft) thick. This aquifer is bounded on the bottom by paleosols and overbank deposits which are approximately 34 m (110 ft) thick at well 199-B3-2.

Below the uppermost aquifer, the Ringold Formation consists of series of aquitards and water-producing zones. These units are confined to semi confined and lie within alternating layers of coarse and fine Ringold Formation sediments. The conductivity of these water-producing zones tends to be lower than that of the unconfined aquifer. The Ringold Formation is underlain by alternating aquitards and confined aquifers which lie within alternating basalt flow interiors and higher transmissive zones associated with flow tops, rubbly and scoriaceous zones, or sedimentary interbeds.

Groundwater in the uppermost aquifer flows toward the Columbia River (Figures 2-3 and 2-4) (Kasza et al. 1992). Groundwater flow directions and the gradients are highly dependent on river-level elevations within several hundred meters of the shoreline. In general, groundwater flows from the reactor area toward the Columbia River with some discharge occurring at seeps and springs along the shoreline. Figure 2-3 is a water table map at high river stage. The groundwater table during this period is relatively flat with a gradient of about 0.0008 across the site. During this period, the water-level elevation in well 199-B3-1 is lower than the elevation of the river, this is probably the result of differences in measurement times or survey inaccuracies. Figure 2-4 is at a low river stage. The water table is again relatively flat in the area of the reactors, but a steep gradient (about 0.03) has developed adjacent to the river. These

changes in gradient result in higher groundwater flow rates near the river during periods of low river-level elevation.

A river gauge is located at the outfall structure in the 100 B/C Area and continuous water level recorders are installed in wells 199-B3-1, 199-B4-1 and 199-B4-4 (Campbell et al. 1993). A comparison of river elevation to well elevations confirms that well 199-B3-1 is affected by changes in the river stage while the water-level elevations in wells 199-B4-1 and 199-B4-4 do not appear to be affected by the fluctuations in river elevation.

Well 199-B2-12 was installed to help characterize the groundwater in the uppermost confined aquifer. This well is screened within a water-bearing zone located in the upper paleosols and overbank deposits shown on Figure 2-2. Water-level elevation data collected during the LFI indicate that the hydraulic potential is generally upward (comparing water-level elevations in well 199-B2-12 and adjacent shallow well 199-B3-47). Although at times of low river level (August and September 1992) there was a slight downward potential. The water-level elevation in well 199-B2-12 ranged from 0.02 m (0.07 ft) lower to 0.77 m (2.5 ft) higher than in well 199-B3-47.

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Slug tests were performed in each of the wells per Environmental Investigation Instruction (EII) 10.1, Aquifer Testing (WHC 1988). The slug test method was selected to minimize the withdrawal of potentially contaminated water. From these tests and development data the hydraulic conductivity was determined for three of the wells (199-B2-12, 199-B2-13 and 199-B3-46). The other well data were not interpreted for two primary reasons: the development time was too short for the effects of delayed yield to dissipate; or the hydraulic conductivity was too high to accurately determine using a slug test. All of the slug test data and calculations are available in the project file and the results are summarized in Table 2-1.

The hydraulic conductivity values were calculated with the Bouwer and Rice method (Bouwer and Rice 1976; Bouwer 1989). The estimated conductivity values were 7×10^{-4} to 2×10^{-3} cm/s (2 to 6 ft/d) for well 199-B2-12 (the deep well in the confined Ringold Formation), 2×10^{-2} cm/s (50 ft/d) for well 199-B2-13 (in the unconfined Ringold/Hanford), and 5×10^{-3} cm/s (15 ft/d) for well 199-B3-46 (in the unconfined Ringold/Hanford). It is likely that the conductivity at the other wells is greater than these calculated values, as it was too high to calculate with the Bouwer and Rice method. The hydraulic conductivity for the unconfined Hanford/Ringold in the 100 Areas ranges from 4.9×10^{-5} to 2.1 cm/s (0.14 to 5,940 ft/d) (Hartman and Peterson 1992). The data from other aquifer tests performed in the 100 Areas are provided by Hartman and Peterson (1992). Vertical hydraulic conductivity values are discussed in Section 2.1.4.

2.3 DOWNHOLE GEOPHYSICS

Gross gamma geophysical logging was performed in 15 boreholes in the 100 B/C Area per EII 11.1, Geophysical Logging (WHC 1988). The high resolution, passive

spectral gamma-ray radiation logging system (RLS) was used in wells where contamination was indicated by the gross gamma logging or field screening. The RLS borehole surveys identify the presence of man-made gamma-ray-emitting radionuclides, their concentration, and position in the borehole. The system provided graphs of radionuclide concentration in picocuries per gram versus depth for each man-made radionuclide. Concentrations and positions of naturally occurring gamma-ray emitting isotopes of potassium, uranium, and thorium are also recorded during the RLS surveys.

The results of the geophysical surveys are summarized in Table 2-2 for wells where gamma emitting radionuclides were detected. The gross gamma logging identified contamination at up to 380 counts per second (cps) and the RLS identified up to 530 cps (both from well 199-B9-1 which is located in the 116-C-2A crib). All other readings were 135 cps or less and many of the wells had no indication of gamma emitting radionuclides. These results are similar to those from the soil sampling. The data from other geophysics performed in the 100 Areas are provided in Lewis and Pearson (1992).

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2.4 SOIL CONTAMINATION

Samples of vadose zone soils were collected during the installation of groundwater monitoring wells. These samples were analyzed to determine if the soil retained contaminants from exposure to contaminated groundwater or process effluent. All samples and cuttings were field screened for evidence of volatile organic compounds (VOC) and radionuclides (DOE-RL 1992b, WHC 1992b). The field geologist screened for VOCs using an organic vapor monitor that was used, maintained, and calibrated consistent with EII 3.2, Health and Safety Monitoring Instruments, and EII 3.4, Field Screening (WHC 1988). Radionuclides were also screened per EII 3.4. Radionuclide screening was performed by the field geologist and screening results were recorded in the borehole log per EII 9.1, Geologic Logging (WHC 1988). The health and safety screening action level for radionuclides was twice background while the action level for organics was 5 ppm above background.

Soil samples were collected in shallow wells at 3 m (10 ft) above the expected groundwater level, 1.5 m (5 ft) above the groundwater level, and 1.5 m (5 ft) below the groundwater level per EII 5.2, Soil and Sediment Sampling (WHC 1988). In addition, soil samples were collected at 1.5-m (5-ft) intervals if contaminant screening values exceeded action levels until either two consecutive screening values fell below the action limits or until 1.5 m (5 ft) below the groundwater (WHC 1992b). Samples collected for chemical analysis were analyzed for the full suite of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Contract Laboratory Program (CLP) target compound list (TCL) and target analyte list (TAL) constituents, specific anions, and for radionuclides. Chemical analysis was conducted using CLP protocols. Analytical methods, routine analytical detection and quantitation limits, and precision and accuracy specified for the methods are listed in Table QAPjP-1 of the Quality Assurance Project Plan in the 100-BC-5 Operable Unit work plan (DOE-RL 1992b).

Most of the soil analyses show that the soil is contaminated with low levels of radionuclides and some metals. Volatile and semivolatile organics were reported but are probably the result of laboratory- or sampling-induced contamination. Samples collected during this LFI confirm data collected during source LFI in the 100 B/C Area, indicating that soil contamination is restricted to the immediate vicinity of major liquid disposal facilities. These areas are addressed in the source investigations.

2.5 GROUNDWATER CONTAMINATION

All new wells and several pre-1991 wells (199-B3-1, 199-B4-1, 199-B4-4, 199-B4-5, 199-B4-7, 199-B5-1, and 199-B9-1) were sampled as part of the 100-BC-5 LFI, per EII 5.8, Groundwater Sampling (WHC 1988). The groundwater samples were analyzed for the full suite of CERCLA CLP TCL and TAL constituents, specific anions, and radionuclides. Chemical analysis was conducted using CLP protocols. Analytical methods, routine analytical detection and quantitation limits, and precision and accuracy specified for the methods are listed in Table QAPjP-1 of the Quality Assurance Project Plan in the 100-BC-5 Operable Unit work plan (DOE-RL 1992b). Three rounds of LFI groundwater sampling data are available (July and October 1992 and January 1993). In addition, some of the wells were sampled previously.

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2.5.1 Validation/Verification of Historical Data

Data regarding the chemical and radiological content of groundwater in the 100-BC-5 Operable Unit have been collected for a number of years (Peterson 1992; Hartman and Peterson 1992). These data were collected under the site-wide environmental monitoring program. These data provide a significant resource against which to judge trends and the adequacy of historical information.

The majority of contaminants at the Hanford Site are radiological. The Hanford site-wide monitoring program has developed and maintained a record of these constituents for over 20 years. The routine radioanalytes included gross beta, tritium, strontium, and uranium. Non radioactive constituents were commonly limited to nitrate and chromium. These historical data have been used, where possible, to confirm the results of sampling conducted during the LFI and to evaluate data trends. If historical and LFI data follow the same trends then the historical data are probably "valid," in the sense of being usable for this LFI. Insufficient historical data were available for the contaminants of potential concern (COPC) to perform a statistical analysis of the data.

2.5.2 Determination of Contaminants of Potential Concern

The LFI data were analyzed following the flow chart illustrated in Figure 2-5. This process was used to determine which analytes may be of concern to human health

or environmental quality. The following is a brief discussion of that process:

- Determine the maximum concentration for each analyte in the groundwater in the 100-BC-5 Area.

- Is the analyte an EPA Region 10 (1991) excluded element (aluminum, calcium, iron, potassium, magnesium, and sodium)? These elements have been determined to be nontoxic for human health and are categorically excluded from the list of COPC, although they are retained for the ecological risk assessment.

- Are the LFI selected maxima internally and externally consistent? Are the maximum analyte concentrations consistent with duplicate values (internal consistency #1)? Are the concentrations consistent between sampling rounds (internal consistency #2)? Is the contaminant expected based on site operations or data from the closest nearby wells (external consistency)? (Note that nearby wells were evaluated even if they were far away to help determine if a contaminant was "expected.") If a maximum analyte concentration fails <u>all</u> of these tests then the value is determined to be inconsistent and the next highest concentration value is selected and evaluated.

  An example of inconsistency is di-N-butylphthalate which was detected in well 199-B4-5 in the third round at 2 μg/L (estimated), but was not detected in the duplicate or split (internal consistency #1), it was not detected in the 1st and 2nd rounds (internal consistency #2), and it was not expected based on site operations (external consistency). Therefore, the value was determined to be inconsistent. Appendix A includes a list of constituents which were eliminated due to inconsistencies and the reasons why they were eliminated.

- Are the analytes found in sample blanks associated with the sample exhibiting the maximum concentration? If the analyte is found in the associated blank, the EPA 5x-10x rule is applied (EPA 1989). For analytes commonly used in the laboratory, the value is eliminated if it is less than ten times the blank concentration. For other analytes, the value is eliminated if it is less than five times the blank concentration. If a maximum concentration value is eliminated, a new maximum concentration is identified and evaluated. This lower concentration may be able to survive this test if it is from another sampling round or batch of samples not associated with the contaminated blank.

- Does the maximum concentration exceed Hanford background? Analytes present at or below background concentrations are excluded from additional consideration. Analytes at or below background are excluded because if calculated cleanup levels are below background then "the cleanup level shall be established at a concentration equal to the natural

background concentrations" (WAC 173-340-700(4)(d)). Background values are from Hanford site-wide characterization of the groundwater (DOE-RL 1992d). The characterization of background involved the determination of the types and concentrations of selected analytes that exist naturally in the groundwater at the Hanford Site. Provisional threshold levels (based on a tolerance interval approach - WAC 173-340-708) for inorganic analytes, gross alpha, gross beta, total radium, total strontium, total uranium, and selected anions were developed from the characterization effort to represent site-wide background conditions (DOE-RL 1992d).

This screening method is similar to the method used for the source operable unit LFIs. The major difference is that for the source LFIs, only one round of data were available, therefore it was not possible to do a consistency check. Also, the source operable unit blanks were evaluated based on the data validation report since there is no 5x-10x rule for soils.

Tables 2-3 through 2-10 show the results of the above screening and the constituents identified as COPC. The screening process was performed for all of the wells for use in the human health evaluation and for near river wells (199-B2-13, 199-B3-1, 199-B3-46, and 199-B3-47) for the ecological evaluation. In addition, for inorganics, unfiltered data were screened for the ecological evaluation and filtered inorganic data were screened for the human health evaluation. Contaminants of concern (COC) will be identified if the constituents are found to have a medium or high risk and/or exceed ARARs.

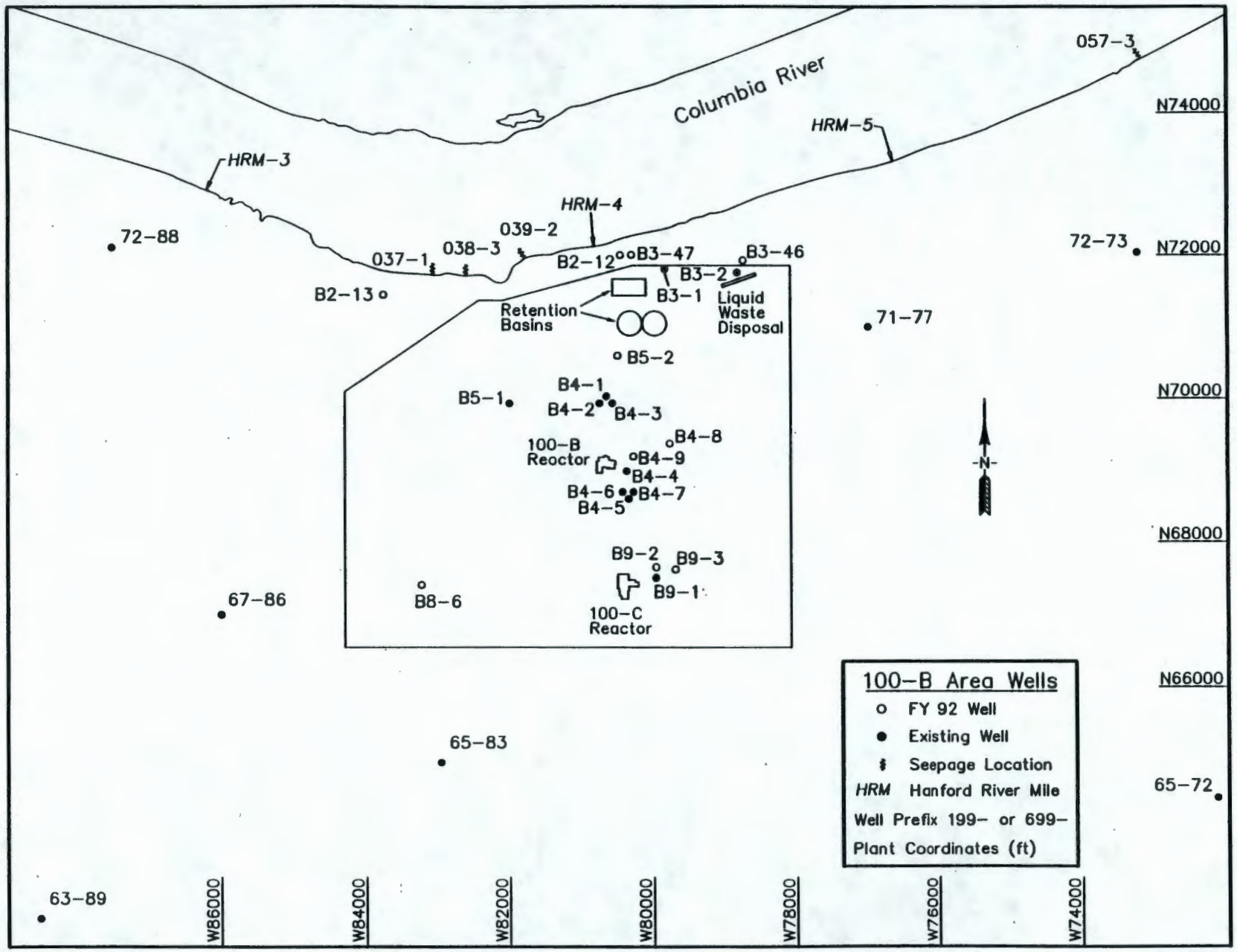

Figure 2-1 Monitoring Wells in the Vicinity of the 100 B/C Area

Figure 2-2 Generalized Hydrostratigraphic Units at the 100 B/C Area (from Lindberg 1993)

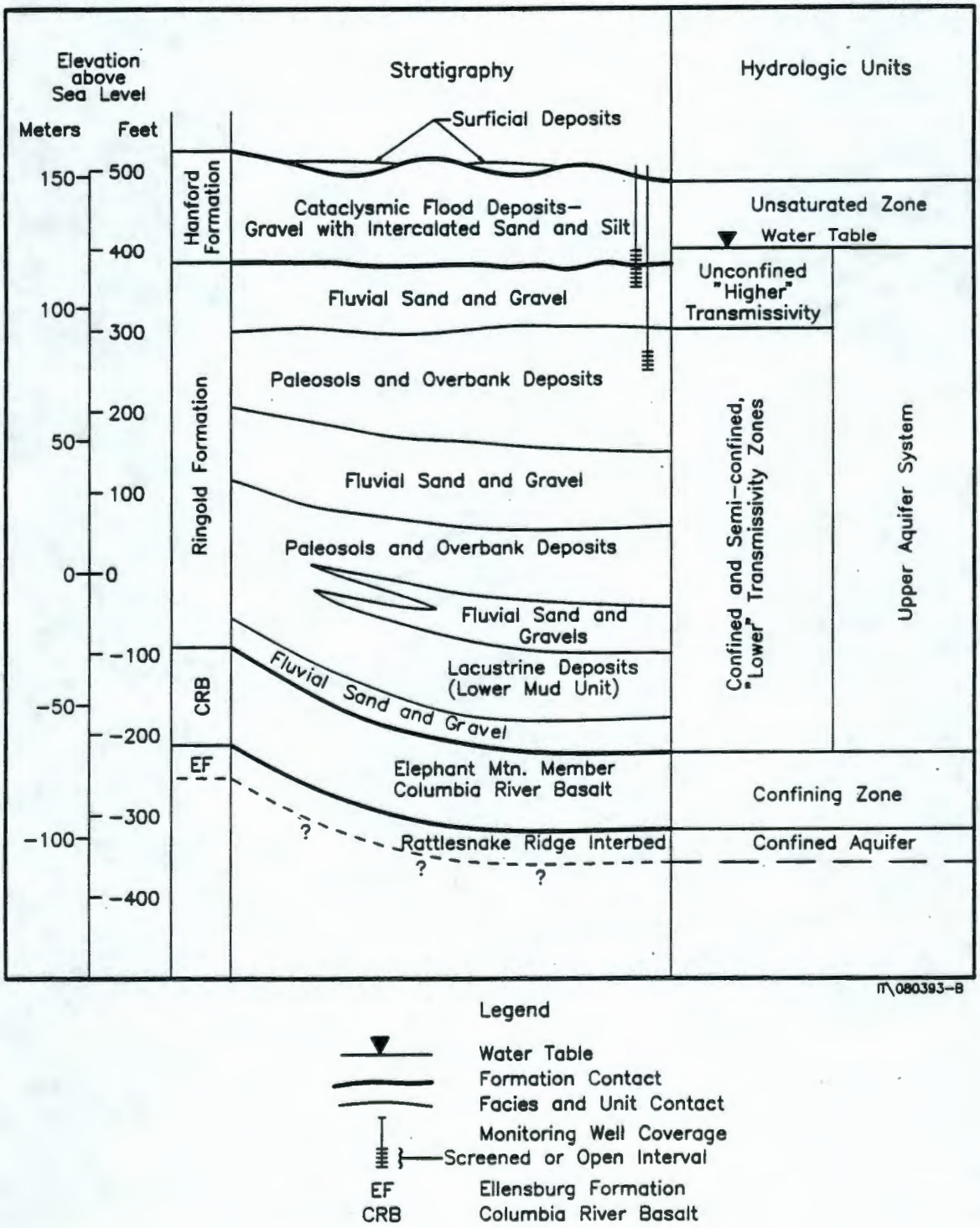

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Figure 2-3 Water-Level Elevations in the 100 B/C Area in July 1992

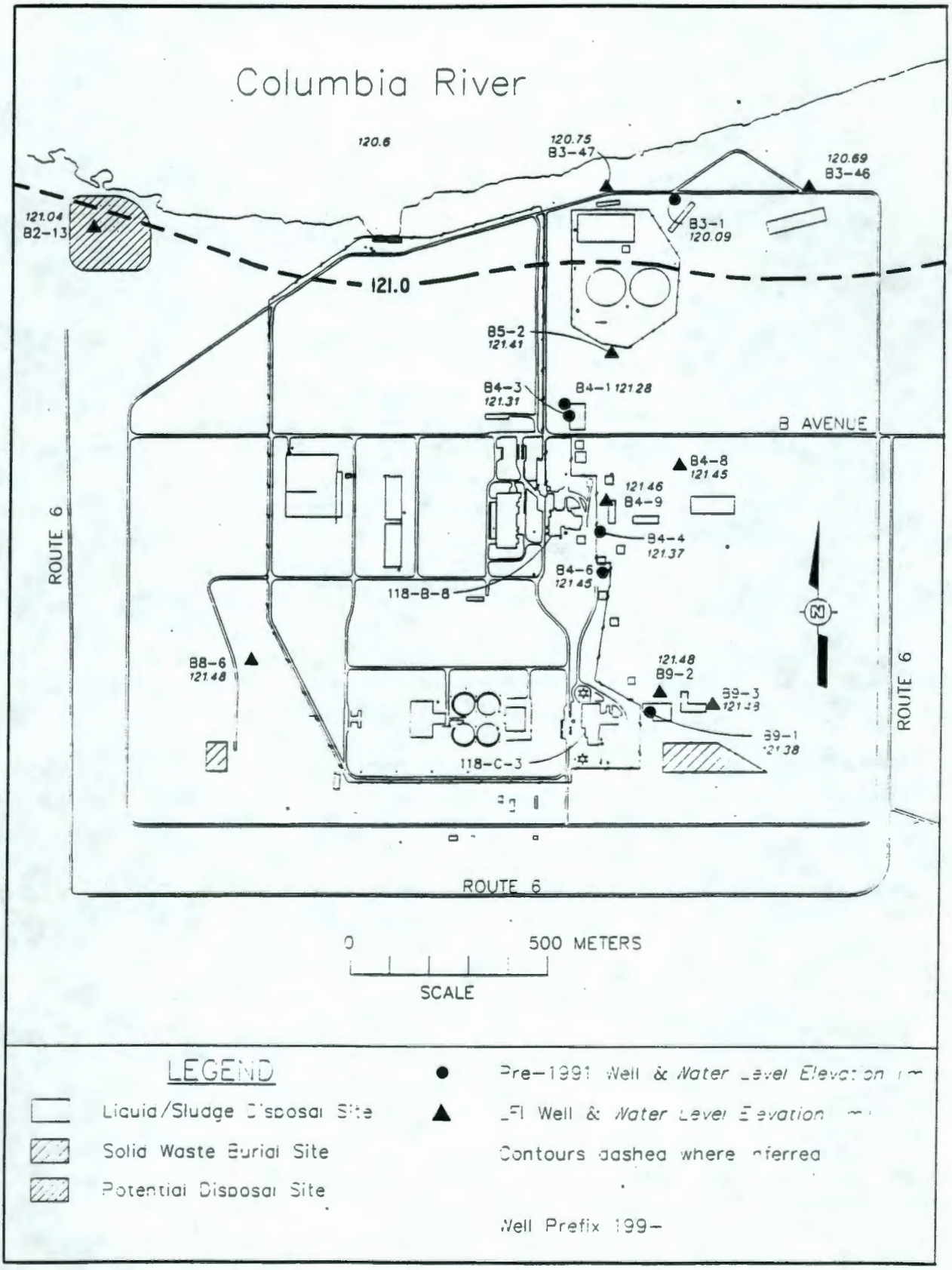

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Figure 2-4 Water-Level Elevations in the 100 B/C Area in September 1992

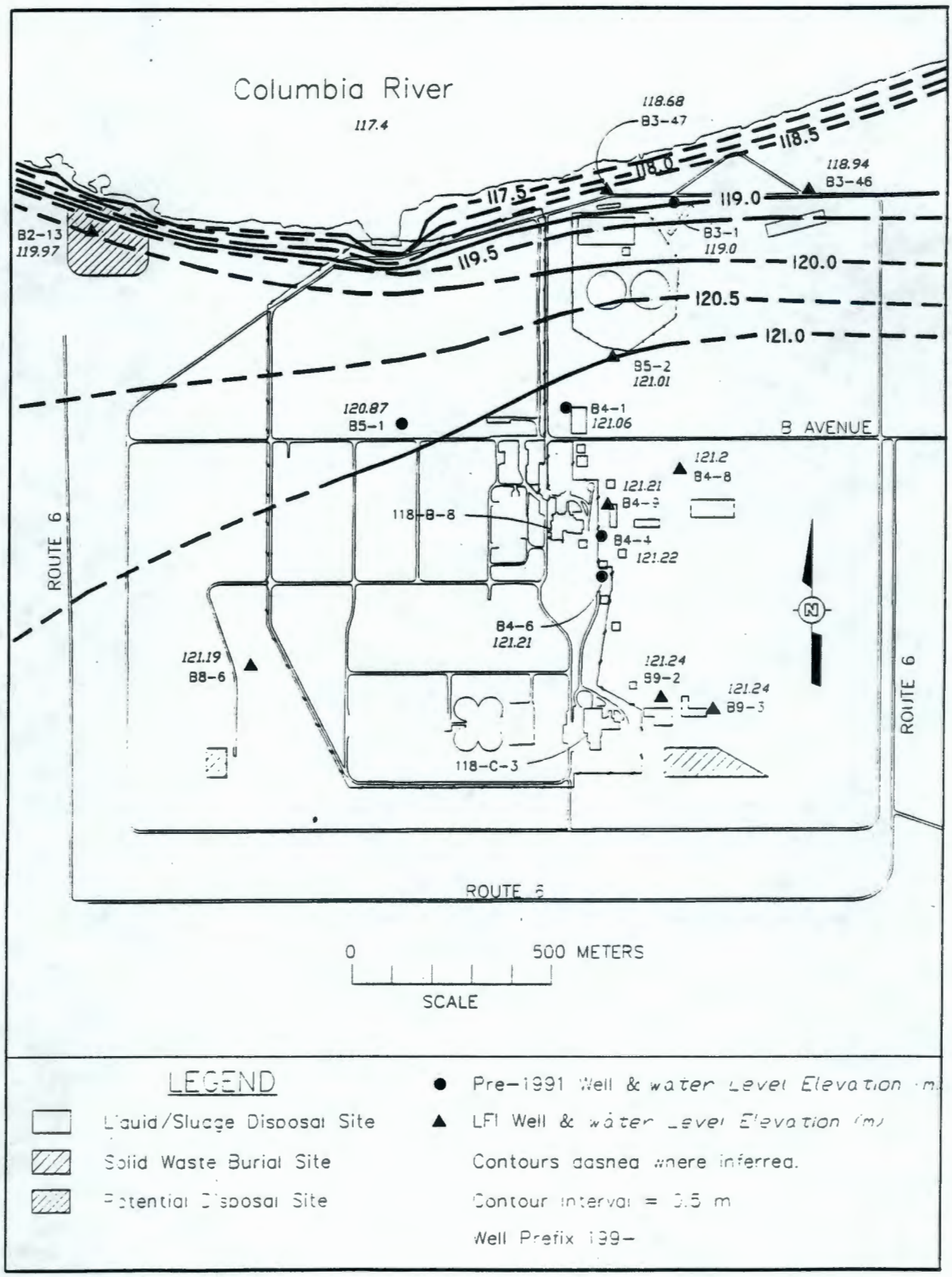

Figure 2-5 Flow Chart used to Determine Contaminants of Potential Concern

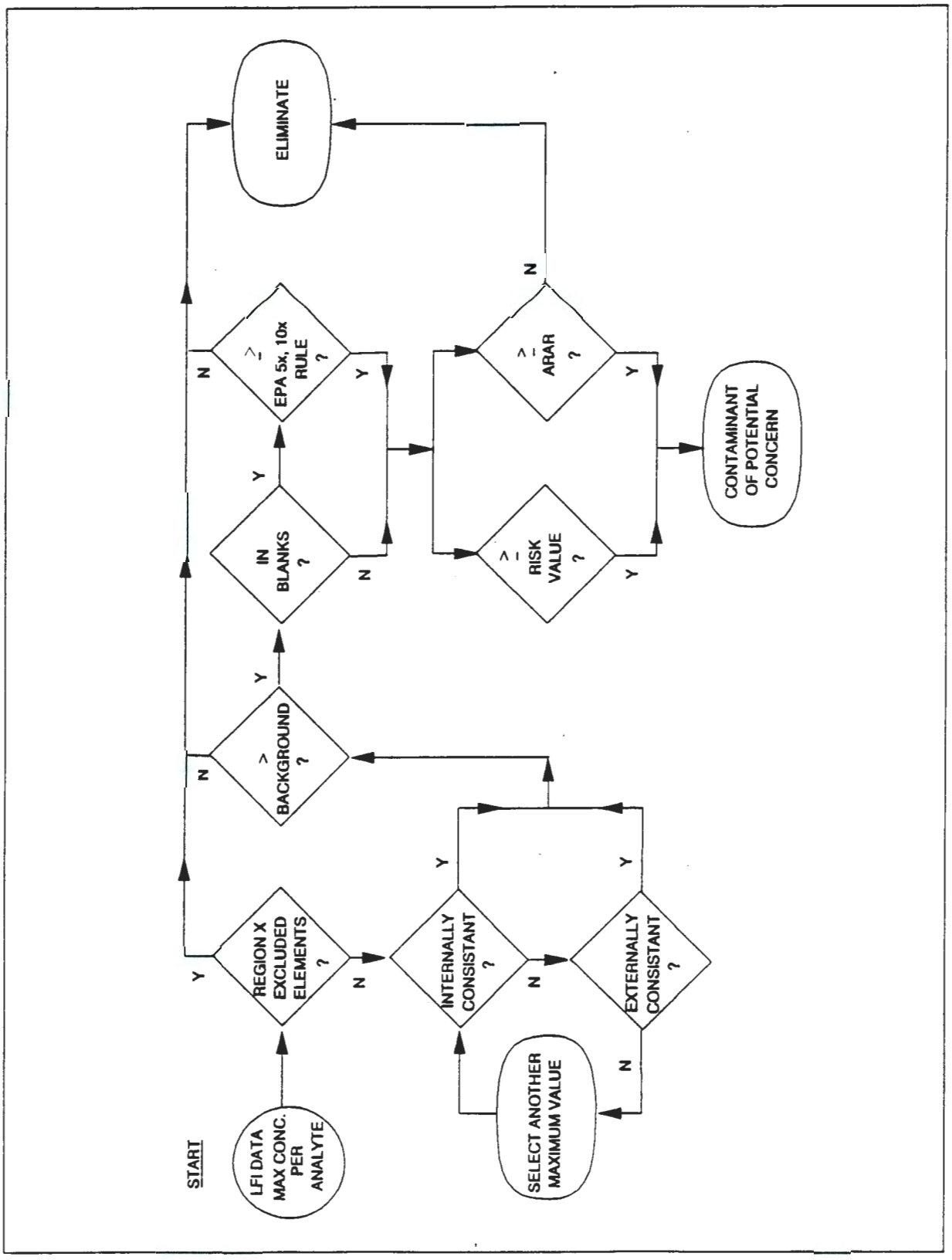

Table 2-1 Well Construction Details for 100 B/C Area Wells (page 1 of 2)

WELL NUMBER	DEPTH ft.+	COMPLETION DIA. in.	COMPLETION	SCREEN INTERVAL ft.+	SAMPLE METHOD	AQUIFER TEST AND METHOD	FORMATION
199-B2-12	178.8	4	SCREEN	165-175	PUMP	K = 2 FT/DAY/ SLUG TEST	H/R <50
199-B2-13	40	4	SCREEN	14.4-35.5	PUMP	K = 50 FT/DAY/ SLUG TEST	H/R <40 FT
199-B3-1	63	8	PERFORATED	20-60	PUMP	NONE	H/R @ 50 FT
199-B3-2	768	8	PERFORATED	635-645	PUMP	NONE	COLUMBIA RIVER BASALT GROUP
199-B3-46	66.77	4	SCREEN	40-65	PUMP	K = 15 FT/DAY/ SLUG TEST	H/R @ ~60 FT
199-B3-47	61.1	4	SCREEN	38.1-59.2	PUMP	*	H/R <50 FT
199-B4-1	83	8	PERFORATED	50-83	PUMP	NONE	H/R @ 69 FT
199-B4-2	86	6	PERFORATED	62-86	BAILER	NONE	HR @ ~70 FT
199-B4-3	86	8	PERFORATED	60-86	BAILER	NONE	H/R @ 69 FT
199-B4-4	96	8	PERFORATED	49-96	PUMP	NONE	H/R @ ~85 FT
199-B4-5	97	4	PERFORATED	76-97	PUMP	NONE	H/R @ ~90 FT
199-B4-6	97	4	PERFORATED	76-77	PUMP	NONE	H/R @ ~90 FT
199-B4-7	97	4	PERFORATED	76-97	PUMP	NONE	H/R @ ~90 FT
199-B4-8	90.4	4	SCREEN	64.7-85.8	PUMP	*	H/R @ ~80 FT
199-B4-9	92.8	4	SCREEN	60-80	PUMP	*	H/R @ ~80 FT
199-B5-1	100	8	PERFORATED	40-100	PUMP	NONE	H/R @ 65 FT
199-B5-2	75	4	SCREEN	54-74	PUMP	*	H/R @ 65 FT
199-B8-6	89	4	SCREEN	68.7-88.7	PUMP	*	H/R @ 78 FT
199-B9-1	117	8	PERFORATED	80-110	PUMP	NONE	H/R @ ~88 FT

Table 2-1 Well Construction Details for 100 B/C Area Wells (page 2 of 2)

WELL NUMBER	DEPTH ft.+	COMPLETION DIA. in.	COMPLETION	SCREEN INTERVAL ft.+	SAMPLE METHOD	AQUIFER TEST AND METHOD	FORMATION
199-B9-2	118	4	SCREEN	90.4-110.4	PUMP	*	H/R @ 88 FT
199-B9-3	109	4	SCREEN	85-105	PUMP	NONE	H/R @ ~88
199-63-89	220	6	NONE	OPEN	PUMP	NONE	H/R @ 110 FT BASALT
199-72-73	135	8	PERFORATED	60-135	PUMP	NONE	H/R @ 79 FT
199-66-64	119	6	SCREEN	96-116	PUMP	NONE	NA
199-71-77	125	8	PERFORATED	60-125	PUMP	NONE	H/R @ 94 FT
199-72-88	52	8	PERFORATED	33-48	PUMP	NONE	NA
199-67-86	80	8	PERFORATED	60-80	PUMP	NONE	H/R @ ~79 FT
199-65-83	117	6	PERFORATED	60-117	PUMP	NONE	H/R @ 97 FT
199-65-72	172	12	PERFORATED	137-157	PUMP	NONE	NA

* Test data for well was not interpretable, i.e., hydraulic conductivity was too high.
NA = Not available
H/R = Hanford-Ringold contact
\+ = precision varies based on purpose and age of well
Data derived from: DOE-RL 1992b, Peterson 1992, and McGhan et al. 1985

Table 2-2 100-BC-5 Geophysical Log Survey Summary

Borehole	Casing Size/Depth	PNL LOG SURVEY Date	Interpretation[1]	RLS BOREHOLE SURVEY Date	Depths (ft)	Results[2]
199-B2-13	10" to 22'	3/02/92	Possible Contamination 5-9' (95 cps) 9-22' (50 cps)	3/09/92	0 - 34	Natural (60-90 cps) 5-9' K>10 pCi/g
	8" to 38'	3/05/92	Below 22' (35-55 cps)			
199-B3-1	8" to 63'	7/17/92	Natural (45-75 cps) 32-46' (55-100 cps)	6/30/92	0 - 52	Cs-137 27-51' <1 pCi/g Eu-152 32-45' <3 pCi/g Total-gamma(70-135 cps)
199-B3-46	10" to 19'	2/21/92	Possible Contamination 4-12' (55 cps) 12-20' (70 cps)			
	8" to 67'	3/05/92	Natural (35-75 cps)			
199-B3-47	10" to 19'	2/20/92	Contamination 5-6' (60 cps) 6-9' (100 cps) 9-18' (60 cps)	3/05/92	0 - 56	Cs-137 29-43' <1 pCi/g Total-gamma(60-100 cps)
	8" to 59'	2/26/92	Below 19' (35-70 cps)			
199-B4-9	10" to 30' 8" to 87'		No Survey Performed	4/22/92	0 - 78	Cs-137 13-78' (60 pCi/g @ 19') Co-60 13-26' (13 pCi/g @ 19') Eu-152 14-26' (65 pCi/g @ 19') Eu-154 15-27' (<7 pCi/g)
199-B9-1	8" to 117'	7/21/92	Contamination 3-18' (50 cps) 18-25' (380 cps) 25-95' (50 cps) 95-115' (35 cps)	7/7/92	0 -112	Co-60 18-23' (<5 pCi/g) Eu-152 18-23' (12 pCi/g @ 21') Eu-154 21-23' (<2 pCi/g Total-gamma (530 cps @ 21.5')

[1]Gross-Gamma Log Survey can not distinguish natural radiation from man-made radionuclides. Interpretation is subjective.

[2]RLS Spectral-Gamma Survey can identify and quantify each radionuclide, whether natural or man-made.

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Table 2-3 LFI Volatile and Semivolatile Organic Data Summary (Page 1 of 3)

Analyte	Max. Conc.	Non-toxic?	Well	>Bkg.?	Elim.	COPC
1,1,1-Trichloroethane	ND	NO	NA	NA	X	
1,1,2,2-Tetrachloroethane	ND	NO	NA	NA	X	
1,1,2-Trichloroethane	ND	NO	NA	NA	X	
1,1-Dichloroethane	ND	NO	NA	NA	X	
1,1-Dichloroethene	ND	NO	NA	NA	X	
1,2-Dichloroethane	ND	NO	NA	NA	X	
1,2-Dichloroethene	ND	NO	NA	NA	X	
1,2-Dichloropropane	ND	NO	NA	NA	X	
2-Butanone	ND	NO	NA	NA	X	
2-Hexanone	ND	NO	NA	NA	X	
4-Methyl-2-Pentanone	ND	NO	NA	NA	X	
Acetone	26 ug/L	NO	B3-47	Na		X
Benzene	ND	NO	NA	NA	X	
Bromodichloromethane	ND	NO	NA	NA	X	
Bromoform	ND	NO	NA	NA	X	
Bromomethane	ND	NO	NA	NA	X	
Carbon Disulfide	ND	NO	NA	NA	X	
Carbon Tetrachloride	ND	NO	NA	NA	X	
Chlorobenzene	ND	NO	NA	NA	X	
Chloroethane	ND	NO	NA	NA	X	
Chloroform	ND	NO	NA	NA	X	
Chloromethane	ND	NO	NA	NA	X	
Dibromochloromethane	ND	NO	NA	NA	X	
Ethlybenzene	ND	NO	NA	NA	X	
Methylene chloride	ND	NO	NA	NA	X	
Styrene	ND	NO	NA	NA	X	
Tetrachloroethene	ND	NO	NA	NA	X	
Toluene	ND	NO	NA	NA	X	
Trichloroethene	3 ug/L (J)	NO	B4-4 *	Na		X
Vinyl Chloride	ND	NO	NA	NA	X	
Xylenes (total)	ND	NO	NA	NA	X	
cis-1,3-Dichloropropene	ND	NO	NA	NA	X	
trans-1,3-Dichloropropene	ND	NO	NA	NA	X	

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Table 2-3 LFI Volatile and Semivolatile Organic Data Summary (Page 2 of 3)

Analyte	Max. Conc.	Well	Non-toxic?	>Bkg.?	Elim.	COPC
1,2,4-Trichlorobenzene	ND	NA	NO	NA	X	
1,2-Dichlorobenzene	ND	NA	NO	NA	X	
1,3-Dichlorobenzene	ND	NA	NO	NA	X	
1,4-Dichlorobenzene	ND	NA	NO	NA	X	
2,4,5-Trichlorophenol	ND	NA	NO	NA	X	
2,4,6-Trichlorophenol	ND	NA	NO	NA	X	
2,4-Dichlorophenol	ND	NA	NO	NA	X	
2,4-Dimethylphenol	ND	NA	NO	NA	X	
2,4-Dinitrophenol	ND	NA	NO	NA	X	
2,4-Dinitrotoluene	ND	NA	NO	NA	X	
2,6-Dinitrotoluene	ND	NA	NO	NA	X	
2,Chlorophenol	ND	NA	NO	NA	X	
2-Chloronaphthalene	ND	NA	NO	NA	X	
2-Methylnaphthalene	ND	NA	NO	NA	X	
2-Methylphenol	ND	NA	NO	NA	X	
2-Nitroaniline	ND	NA	NO	NA	X	
2-Nitrophenol	ND	NA	NO	NA	X	
3,3'-Dichlorobenzidine	ND	NA	NO	NA	X	
3-Nitroaniline	ND	NA	NO	NA	X	
4,6-Dinitro-2-methylphenol	ND	NA	NO	NA	X	
4-Bromophenyl-phenyl ether	ND	NA	NO	NA	X	
4-Chloro-3-methylphenol	ND	NA	NO	NA	X	
4-Chloroaniline	ND	NA	NO	NA	X	
4-Chlorophenyl-phenyl ether	ND	NA	NO	NA	X	
4-Methylphenol	ND	NA	NO	NA	X	
4-Nitroaniline	ND	NA	NO	NA	X	
4-Nitrophenol	ND	NA	NO	NA	X	
9H-Carbazole	ND	NA	NO	NA	X	
Acenaphthene	ND	NA	NO	NA	X	
Acenaphthylene	ND	NA	NO	NA	X	
Anthracene	ND	NA	NO	NA	X	
Benzo(a)anthracene	ND	NA	NO	NA	X	
Benzo(a)pyrene	ND	NA	NO	NA	X	
Benzo(b)fluoranthene	ND	NA	NO	NA	X	
Benzo(ghi)perylene	ND	NA	NO	NA	X	
Benzo(k)fluoranthene	ND	NA	NO	NA	X	
Bis(2-chloroethoxy)methane	ND	NA	NO	NA	X	
Bis(2-chloroethyl)ether	ND	NA	NO	NA	X	
Bis(2-chloroisopropyl)ether	ND	NA	NO	NA	X	
Bis(2-ethylhexyl)phthalate	11 ug/L	B4-1	NO	Na		X
Butylbenzylphthalate	ND	NA	NO	NA	X	
Chrysene	ND	NA	NO	NA	X	
Di-n-butylphthalate	ND	NA	NO	NA	X	
Di-n-octylphthalate	ND	NA	NO	NA	X	
Dibenz[a,h]anthracene	ND	NA	NO	NA	X	
Dibenzofuran	ND	NA	NO	NA	X	
Diethyl phthalate	ND	NA	NO	NA	X	

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Table 2-3 LFI Volatile and Semivolatile Organic Data Summary (Page 3 of 3)

Analyte	Max. Conc.	Well	Non-toxic?	>Bkg.?	Elim.	COPC
Dimethyphthalate	ND	NA	NO	NA	X	
Fluoranthene	ND	NA	NO	NA	X	
Fluorene	ND	NA	NO	NA	X	
Hexachlorobenzene	ND	NA	NO	NA	X	
Hexachlorobutadiene	ND	NA	NO	NA	X	
Hexachlorocyclopentadiene	ND	NA	NO	NA	X	
Hexachloroethane	ND	NA	NO	NA	X	
Indeno(1,2,3-cd)pyrene	ND	NA	NO	NA	X	
Isophorone	ND	NA	NO	NA	X	
N-nitroso-di-n-dipropylamine	ND	NA	NO	NA	X	
N-Nitrosodiphenylamine	ND	NA	NO	NA	X	
Naphthalene	ND	NA	NO	NA	X	
Nitrobenzene	ND	NA	NO	NA	X	
Pentachlorophenol	ND	NA	NO	NA	X	
Phenanthrene	ND	NA	NO	NA	X	
Phenol	ND	NA	NO	NA	X	
Pyrene	ND	NA	NO	NA	X	

Shading indicates reason for elimination or identification as contaminant of potential concern

* Maximum concentration found in several wells

J = value is less than contract detection limit and is estimated

NA = not applicable, ND = not detected, Na = not available

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Table 2-4 LFI Filtered Inorganic Data Summary

Analyte	Max. Conc.	Well #	Non-Toxic	>Bkg.?	Elim.	COPC
Aluminum	291 ug/L	B4-9	YES	YES	X	
Antimony	ND	NA	NA	NA	X	
Arsenic	ND	NA	NA	NA	X	
Barium	43.1 ug/L (B)	B4-9	NO	NO	X	
Beryllium	ND	NA	NA	NA	X	
Cadmium	ND	NA	NA	NA	X	
Calcium	68,600 ug/L (*)	B4-8	YES	Yes	X	
Chromium	26.8 ug/L	B5-1	NO	NO	X	
Cobalt	ND	NA	NA	NA	X	
Copper	ND	NA	NA	NA	X	
Iron	174 ug/L	B4-7	YES	YES	X	
Lead	ND	NA	NA	NA	X	
Magnesium	11,200 ug/L	B9-3	YES	NO	X	
Manganese	18.8 ug/L	B9-2	NO	NO	X	
Mercury	ND	NA	NA	NA	X	
Nickel	7 ug/L (B)	B4-7	NO	NO	X	
Potassium	7,770 ug/L	B4-8	YES	NO	X	
Selenium	ND	NA	NA	NA	X	
Silver	ND	NA	NA	NA	X	
Sodium	16,100 ug/L	B4-8	YES	NO	X	
Thallium	ND	NA	NA	NA	X	
Vanadium	17.8 ug/L (B)	B4-5	NO	YES		X
Zinc	13.1 ug/L (N*)	B4-8	NO	NO	X	

Shading indicates reason for elimination or identification as contaminant of potential concern.

B = estimated value, less than contract detection limit

* = duplicate analysis not within control limits

N = spiked sample recovery not within control limits

NA = not applicable; ND = not detected

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Table 2-5 LFI Radionuclide Data Summary

Analyte	Max. Conc.	Well	Non-toxic?	>Bkg.?	Elim.	COPC
Americium 241	.021 pCi/L (J)	B9-2	NO	Na		X
Carbon 14	110 pCi/L	B2-13	NO	Na		X
Cesium 134	ND	NA	NO	NA	X	
Cesium 137	ND	NA	NO	NA	X	
Chromium 51	ND	NA	NO	NA	X	
Cobalt 60	ND	NA	NO	NA	X	
Europium 152	ND	NA	NO	NA	X	
Europium 154	ND	NA	NO	NA	X	
Gross Alpha	ND (R)	B3-47	NO	NA	X	
Gross Beta	290 pCi/L (J)	B3-46	NO	YES		X
Iron 59	ND	NA	NO	NA	X	
Plutonium 238	ND	NA	NO	NA	X	
Plutonium 239/240	ND	NA	NO	NA	X	
Potassium 40	ND	NA	NO	NA	X	
Radium 226	ND	NA	NO	NA	X	
Ruthenium 106	ND	NA	NO	NA	X	
Strontium 90	130 pCi/L (J)	B3-46	NO	Na		X
Technetium 99	130 pCi/L	B3-46	NO	Na		X
Thorium 228	ND	NA	NO	NA	X	
Thorium 232	ND	NA	NO	NA	X	
Tritium	24000 pCi/L	B3-47	NO	Na		X
Uranium 233/234	1.2 pCi/L	B3-47*	NO	NO	X	
Uranium 235	ND	NA	NO	NA	X	
Uranium 238	1.1 pCi/L	B3-1	NO	NO	X	
Zinc 65	ND	NA	NO	NA	X	

Shading indicates reason for elimination or identification as a contaminant of potential concern

* Maximum concentration found in several wells

Qualifiers: J = value is less than the contract detection limit and is estimated

R = all gross alpha data were rejected due to quality control deficencies

NA = not applicable, ND = not detected, Na = not available

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Table 2-6 LFI Other Constituent Data Summary

Analyte	Max. Conc.	Well #	Non-toxic?	>Bkg.?	Elim.	COPC
Alkalinity	112 mg/L	B9-3 *	NO	NO	X	
Ammonia	0.4 mg/L	B3-46	NO	Na		X
COD	30 mg/L	B5-2	NO	Na		X
Chloride	13.8 mg/L	B9-3	NO	YES		X
Cyanide	ND	NA	NO	NA	X	
Electric Cond.	407 umhos/cm	B4-9	NO	NO	X	
Fluoride	0.5 mg/L (J)	B5-2	NO	NO	X	
Hydrazine	ND (R)	NA	NO	NA	X	
Nitrate/Nitrite	6.9 mg/L	B4-4	NO	NO	X	
pH	7.5 - 8.3	B5-1 - B4-5	NO	YES		X
Phosphate	0.4 mg/L	B5-2	NO	NO	X	
Sulfate	57.1 mg/L	B9-2	NO	NO	X	
Sulfide	1.0 mg/L	B5-2	NO	Na		X
TDS	283 mg/L	B4-8	NO	Na		X
TOC	10 mg/L	B4-5	NO	NO	X	
TOX	136 ug/L	B5-2	NO	Na		X

Shading indicates reason for elimination or identification as a contaminant of potential concern

* Maximum concentration found in several wells

Qualifiers: J = value is estimated; R = all values were rejected due to quality control deficencies

NA = not applicable, ND = not detected, Na = not available

COD = chemical oxygen demand, TDS = total dissolved solids

TOC = total organic carbon, TOX = total organic halides

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Table 2-7 LFI Volatile and Semivolatile Organic Data Summary for Near River Wells (Page 1 of 3)

Analyte	Max. Conc.	Well	>Bkg.?	Elim.	COPC
1,1,1-Trichloroethane	ND	NA	NA	X	
1,1,2,2-Tetrachloroethane	ND	NA	NA	X	
1,1,2-Trichloroethane	ND	NA	NA	X	
1,1-Dichloroethane	ND	NA	NA	X	
1,1-Dichloroethene	ND	NA	NA	X	
1,2-Dichloroethane	ND	NA	NA	X	
1,2-Dichloroethene	ND	NA	NA	X	
1,2-Dichloropropane	ND	NA	NA	X	
2-Butanone	ND	NA	NA	X	
2-Hexanone	ND	NA	NA	X	
4-Methyl-2-Pentanone	ND	NA	NA	X	
Acetone	26 ug/L	B3-47	Na		X
Benzene	ND	NA	NA	X	
Bromodichloromethane	ND	NA	NA	X	
Bromoform	ND	NA	NA	X	
Bromomethane	ND	NA	NA	X	
Carbon Disulfide	ND	NA	NA	X	
Carbon Tetrachloride	ND	NA	NA	X	
Chlorobenzene	ND	NA	NA	X	
Chloroethane	ND	NA	NA	X	
Chloroform	ND	NA	NA	X	
Chloromethane	ND	NA	NA	X	
Dibromochloromethane	ND	NA	NA	X	
Ethlybenzene	ND	NA	NA	X	
Methylene chloride	ND	NA	NA	X	
Styrene	ND	NA	NA	X	
Tetrachloroethene	ND	NA	NA	X	
Toluene	ND	NA	NA	X	
Trichloroethene	2 ug/L (J)	B3-46*	Na		X
Vinyl Chloride	ND	NA	NA	X	
Xylenes (total)	ND	NA	NA	X	
cis-1,3-Dichloropropene	ND	NA	NA	X	
trans-1,3-Dichloropropene	ND	NA	NA	X	

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Table 2-7 LFI Volatile and Semivolatile Organic Data Summary for Near River Wells (Page 2 of 3)

Analyte	Max. Conc.	Well	>Bkg.?	Elim.	COPC
1,2,4-Trichlorobenzene	ND	NA	NA	X	
1,2-Dichlorobenzene	ND	NA	NA	X	
1,3-Dichlorobenzene	ND	NA	NA	X	
1,4-Dichlorobenzene	ND	NA	NA	X	
2,4,5-Trichlorophenol	ND	NA	NA	X	
2,4,6-Trichlorophenol	ND	NA	NA	X	
2,4-Dichlorophenol	ND	NA	NA	X	
2,4-Dimethylphenol	ND	NA	NA	X	
2,4-Dinitrophenol	ND	NA	NA	X	
2,4-Dinitrotoluene	ND	NA	NA	X	
2,6-Dinitrotoluene	ND	NA	NA	X	
2,Chlorophenol	ND	NA	NA	X	
2-Chloronaphthalene	ND	NA	NA	X	
2-Methylnaphthalene	ND	NA	NA	X	
2-Methylphenol	ND	NA	NA	X	
2-Nitroaniline	ND	NA	NA	X	
2-Nitrophenol	ND	NA	NA	X	
3,3'-Dichlorobenzidine	ND	NA	NA	X	
3-Nitroaniline	ND	NA	NA	X	
4,6-Dinitro-2-methylphenol	ND	NA	NA	X	
4-Bromophenyl-phenyl ether	ND	NA	NA	X	
4-Chloro-3-methylphenol	ND	NA	NA	X	
4-Chloroaniline	ND	NA	NA	X	
4-Chlorophenyl-phenyl ether	ND	NA	NA	X	
4-Methylphenol	ND	NA	NA	X	
4-Nitroaniline	ND	NA	NA	X	
4-Nitrophenol	ND	NA	NA	X	
9H-Carbazole	ND	NA	NA	X	
Acenaphthene	ND	NA	NA	X	
Acenaphthylene	ND	NA	NA	X	
Anthracene	ND	NA	NA	X	
Benzo(a)anthracene	ND	NA	NA	X	
Benzo(a)pyrene	ND	NA	NA	X	
Benzo(b)fluoranthene	ND	NA	NA	X	
Benzo(ghi)perylene	ND	NA	NA	X	
Benzo(k)fluoranthene	ND	NA	NA	X	
Bis(2-chloroethoxy)methane	ND	NA	NA	X	
Bis(2-chloroethyl)ether	ND	NA	NA	X	
Bis(2-chloroisopropyl)ether	ND	NA	NA	X	
Bis(2-ethylhexyl)phthalate	ND	NA	NA	X	
Butylbenzylphthalate	ND	NA	NA	X	
Chrysene	ND	NA	NA	X	
Di-n-butylphthalate	ND	NA	NA	X	
Di-n-octylphthalate	ND	NA	NA	X	
Dibenz[a,h]anthracene	ND	NA	NA	X	
Dibenzofuran	ND	NA	NA	X	
Diethyl phthalate	ND	NA	NA	X	

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Table 2-7 LFI Volatile and Semivolatile Organic Data Summary for Near River Wells (Page 3 of 3)

Analyte	Max. Conc.	Well	>Bkg.?	Elim.	COPC
Dimethyphthalate	ND	NA	NA	X	
Fluoranthene	ND	NA	NA	X	
Fluorene	ND	NA	NA	X	
Hexachlorobenzene	ND	NA	NA	X	
Hexachlorobutadiene	ND	NA	NA	X	
Hexachlorocyclopentadiene	ND	NA	NA	X	
Hexachloroethane	ND	NA	NA	X	
Indeno(1,2,3-cd)pyrene	ND	NA	NA	X	
Isophorone	ND	NA	NA	X	
N-nitroso-di-n-dipropylamine	ND	NA	NA	X	
N-Nitrosodiphenylamine	ND	NA	NA	X	
Naphthalene	ND	NA	NA	X	
Nitrobenzene	ND	NA	NA	X	
Pentachlorophenol	ND	NA	NA	X	
Phenanthrene	ND	NA	NA	X	
Phenol	ND	NA	NA	X	
Pyrene	ND	NA	NA	X	

Shading indicates reason for elimination or identification as contaminant of potential concern

* Maximum concentration found in several wells

J = value is less than contract detection limit and is estimated

NA = not applicable, ND = not detected, Na = not available

Table 2-8 LFI Inorganic Data Summary for Near River Wells

Analyte	Max. Conc.	Well #	>Bkg.?	Elim.	COPC
Aluminum	327 ug/L	B3-47	YES		X
Antimony	ND	NA	NA	X	
Arsenic	ND	NA	NA	X	
Barium	40.4 ug/L (B)	B3-47	NO	X	
Beryllium	ND	NA	NA	X	
Cadmium	ND	NA	NA	X	
Calcium	52,200 ug/L	B3-46	NO	X	
Chromium	36 ug/L	B2-13	YES		X
Cobalt	ND	NA	NA	X	
Copper	ND	NA	NA	X	
Iron	318 ug/L	B2-13	YES		X
Lead	ND	NA	NA	X	
Magnesium	9,990 ug/L	B2-13	NO	X	
Manganese	23.2 ug/L	B3-1	NO	X	
Mercury	ND	NA	NA	X	
Nickel	ND	NA	NA	X	
Potassium	4,450 ug/L (B)	B2-13	NO	X	
Selenium	ND	NA	NA	X	
Silver	ND	NA	NA	X	
Sodium	13,800 ug/L	B3-46	NO	X	
Thallium	ND	NA	NA	X	
Vanadium	ND	NA	NA	X	
Zinc	ND	NA	NA	X	

Shading indicates reason for elimination or identification as potential contaminant of concern.

Qualifier: B = estimated value, less than contract detection limit

NA = not applicable; ND = not detected

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Table 2-9 LFI Radionuclide Data Summary for Near River Wells

Analyte	Max. Conc.	Well	>Bkg.?	Elim.	COPC
Americium 241	ND	NA	NA	X	
Carbon 14	110 pCi/L	B2-13	Na		X
Cesium 134	ND	NA	NA	X	
Cesium 137	ND	NA	NA	X	
Chromium 51	ND	NA	NA	X	
Cobalt 60	ND	NA	NA	X	
Europium 152	ND	NA	NA	X	
Europium 154	ND	NA	NA	X	
Gross Alpha	ND (R)	B3-47	NA	X	
Gross Beta	290 pCi/L (J)	B3-46	YES		X
Iron 59	ND	NA	NA	X	
Plutonium 238	ND	NA	NA	X	
Plutonium 239/240	ND	NA	NA	X	
Potassium 40	ND	NA	NA	X	
Radium 226	ND	NA	NA	X	
Ruthenium 106	ND	NA	NA	X	
Strontium 90	130 pCi/L (J)	B3-46	Na		X
Technetium 99	130 pCi/L	B3-46	Na		X
Thorium 228	ND	NA	NA	X	
Thorium 232	ND	NA	NA	X	
Tritium	24000 pCi/L	B3-47	Na		X
Uranium 233/234	1.2 pCi/L	B3-47*	NO	X	
Uranium 235	ND	NA	NA	X	
Uranium 238	1.1 pCi/L	B3-1	NO	X	
Zinc 65	ND	NA	NA	X	

Shading indicates reason for elimination or identification as contaminant of potential concern

* Maximum concentration found in several wells

Qualifiers: J = value is less than the contract detection limit and is estimated
R = all gross alpha values were rejected due to quality control deficiencies

NA = not applicable, ND = not detected, Na = not available

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Table 2-10 LFI Other Constituent Data Summary for Near River Wells

Analyte	Max. Conc.	Well #	>Bkg.?	Elim.	COPC
Alkalinity	110 mg/L	B3-46 *	NO	X	
Ammonia	0.4 mg/L	B3-46	Na		X
COD	ND	NA	NA	X	
Chloride	9.9 mg/L	B3-47	YES		X
Cyanide	ND	NA	NA	X	
Electric Cond.	379 umhos/cm	B3-46	NO	X	
Fluoride	0.381 mg/L (J)	B2-13	NO	X	
Hydrazine	ND (R)	B2-13*	NA	X	
Nitrate/Nitrite	6.81 mg/L	B3-46	NO	X	
pH	7.8 (J) - 8.1 (R)	B2-13 - 3-46	NO	X	
Phosphate	ND	NA	NA	X	
Sulfate	53 mg/L (J)	B3-47	NO	X	
Sulfide	ND	NA	NA	X	
TDS	253 mg/L (J)	B3-46	Na		X
TOC	1.7 mg/L	B3-1	YES		X
TOX	16.8 ug/L	B2-13	NO	X	

Shading indicates reason for elimination or identification as contaminant of potential concern

* Maximum concentration found in several wells

Qualifiers : J = value is estimated; R = value was rejected due to quality control deficiencies; all hydrazine values were rejected

NA = not applicable, ND = not detected, Na = not available

COD = chemical oxygen demand, TDS = total dissolved solids

TOC = total organic carbon, TOX = total organic halides

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3.0 QUALITATIVE RISK ASSESSMENT

This section provides a summary of the QRA which was performed for the 100-BC-5 Operable Unit. Complete results of the QRA are provided in the 100-BC-5 QRA report (WHC 1993c). The QRA is intended to provide information to support the HPPS.

The QRA for the 100-BC-5 Operable Unit is an evaluation of risk for a predefined set of human and environmental exposure scenarios. The QRA is not intended to replace or be a substitute for a baseline risk assessment. This report includes qualitative assessments of threats to human health receptors and ecological receptors from groundwater associated with the 100-BC-5 Operable Unit. The QRA is prepared as agreed upon by the 100 Area Tri-Party unit managers, and as recommended in the *Hanford Site Baseline Risk Assessment Methodology* (DOE-RL 1993c).

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3.1 QRA SUMMARY OF DATA

Prior to the evaluation of risk in the QRA, the COPC (as defined in Chapter 2) were further screened against risk-based concentrations and ARARs, as recommended in the risk assessment methodology (DOE-RL 1993c). The risk-based concentrations were at an incremental cancer risk (ICR) of 1E-07 and a hazard quotient (HQ) of 0.1. The data available to conduct the QRA are LFI data from three rounds of sampling. Confidence levels are estimated for the data based on available knowledge of the operable unit. Confidence in the contaminant identification is based primarily on the quality of the data used in the QRA. The confidence in the concentrations is based on the data quality and confidence in the representativeness of that data.

A high confidence rating is given for contaminant identification at the 100-BC-5 Operable Unit since the LFI data used in the QRA were collected specifically for characterization of the 100-BC-5 Operable Unit groundwater, and the data are of known quality. The confidence in the concentrations is given a high rating because the data were from three sampling rounds.

The maximum groundwater concentrations of the wells in the upper, unconfined aquifer of the 100-BC-5 Operable Unit were used for the human health evaluation. However, since exposure of humans to groundwater is most likely to occur to site trespassers at the river edge, concentrations of contaminants in the springs and the river were compared to maximum groundwater concentrations. In most cases the surface water concentrations were either below maximum groundwater concentrations or below background levels.

The data evaluated in the human health evaluation are from filtered sample results. This is because several of the wells sampled in the LFI are newly constructed, and exhibit enhanced concentrations of particulates and colloidal which tend to exist for a period of several sampling rounds. Subsequently, the unfiltered inorganic

concentrations in these wells are higher than the filtered results in some of the early sampling rounds. These concentrations decrease and are roughly equivalent to the filtered results by the third sampling round. The variation in unfiltered sample results indicates that suspended particulate matter or well construction artifacts remain, which could affect unfiltered sample results.

In general, unfiltered groundwater samples from monitoring wells are often not representative of true groundwater concentrations extracted from a production well for a variety of reasons (e.g., chemical changes to stagnant water in the monitoring well casing, reaction with well construction materials, and poor well development). The use of unfiltered monitoring well data for evaluating human health risks may result in overestimation of risk that could hinder effective site investigation and remediation efforts. Based on this observation, the data evaluated in the human health evaluation are from filtered sample results.

The maximum groundwater concentrations of the near-river wells (199-B2-13, 199-B3-1, 199-B3-46, and 199-B3-47) in the upper, unconfined aquifer of the 100-BC-5 Operable Unit were used for the ecological evaluation. The data evaluated in the ecological evaluation are from unfiltered sample results which conservatively represent groundwater that potentially flows into the river.

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3.2 HUMAN HEALTH QUALITATIVE RISK ASSESSMENT

The QRA provides estimates of risk that might occur under frequent-use or occasional-use scenarios based on the best available knowledge of current contaminant conditions, but does not represent actual risks since neither frequent-use nor occasional-use of groundwater occurs at the 100-BC-5 Operable Unit. However, there is a potential for trespassers to use springs and seeps along the river on an occasional basis.

3.2.1 Overview of Human Health Risk Evaluation Process

Two exposure scenarios (frequent- and occasional-use) and two pathways (groundwater ingestion of radioactive and non radioactive contaminants and inhalation of volatile organics from groundwater use) for the QRA have been discussed and selected by the 100 Area Tri-Party unit managers for evaluation in the QRA. The frequent- and occasional-use scenarios were evaluated using residential and recreational exposure parameters from risk assessment methodology (DOE-RL 1993c), respectively. Currently, there is no use of groundwater in the 100-BC-5 Operable Unit. Thus, the risks presented in the QRA are not actual risks but estimates of potential risks under high-frequency use (e.g., residential) or low-frequency use (e.g., recreational).

The human health evaluation also included a focused analysis of the most probable exposure scenario (occasional-use of springs and seeps by trespassers near the river) by providing a comparison of concentrations in springs and seeps near the river, and in the river, to maximum groundwater concentrations of contaminants. The

inhalation pathway was only evaluated in the frequent-use scenario because it is assumed that exposures to VOCs would occur during water use such as would occur within the confines of a residence, which would not be expected to occur in an occasional-use (e.g., recreational) setting. Other exposure pathways are possible such as dermal absorption of contaminants during water use or exposure to radionuclides through submersion in water. However, the risks associated with these pathways would probably not be as significant as the risks associated with ingestion and inhalation, because the COPC, in general, do not have high dermal permeabilities and the duration of exposure is generally shorter. These other exposure pathways were discussed qualitatively, but actual risks were not calculated.

3.2.2 Results of the Human Health QRA

The information is summarized in Table 3-1 for the human health QRA and includes:

- qualitative risk estimation
- risk driving contaminant for the frequent- and occasional-use scenarios
- risk driving pathway for the frequent- and occasional-use scenarios.

The qualitative risk estimations presented in Table 3-1 are grouped into high (ICR >1E-02 or HQ >1), medium (ICR 1E-04 to 1E-02), low (ICR 1E-06 to 1E-04), and very low (ICR <1E-06 and HQ <1) risk categories based on the results presented in the QRA.

The following is a summary of the human health risk assessment:

- Four radioactive contaminants (tritium, carbon-14, strontium-90, and technetium-99) are the risk-drivers and together present a low risk under the frequent-use scenario.
- Bis(2-ethylhexyl)phthalate is estimated to have a low risk for the frequent-use scenario. This estimate is likely an overestimate because the concentrations evaluated may be an artifact of the analytical process. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant, there is no evidence of its use at the site, and it was not identified as a COPC in the 100-BC-1 source operable units. However, due to the qualitative nature of the assessment there was insufficient information to eliminate it from evaluation in the QRA.
- Strontium-90 presents a low risk in the occasional-use scenario. The risk was very low for noncarcinogenic nonradioactive contaminants in the occasional-use scenario.

- In general, the estimated risks for the frequent-use scenario are two orders of magnitude greater than for the occasional-use scenario.

- The hazard indices for the frequent- and occasional-use scenarios are < 1, and thus represent a very low risk.

The risk estimates, both carcinogenic and noncarcinogenic, are deterministic estimates based on multiple assumptions about exposure, toxicity, and other variables. Consequently, uncertainty exists for the evaluation of the contaminants, the exposures, the toxicities, and the risk characterization for the QRA. This uncertainty is discussed more extensively in the following sections.

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3.2.3 Summary of Key Uncertainties in the Human Health Risk Assessment

3.2.3.1 Uncertainty in Contaminants and Concentrations. Uncertainty in contaminant identification and contaminant concentrations is related to the accuracy of the data used in the QRA. The accuracy of the data is based on its quality and representativeness. The use of three sampling rounds provides confidence in the types and concentrations of contaminants present in the groundwater.

There is uncertainty associated with the identification of bis(2-ethylhexyl)phthalate as a COPC. Bis(2-ethylhexyl)phthalate is considered a common laboratory contaminant, and it is likely that the concentration reported for this compound is not representative of 100-BC-5 groundwater.

3.2.3.2 Uncertainty in the Exposure Assessment. The QRA estimates risk that might occur under frequent-use (e.g., residential) or occasional-use (e.g., recreational) based on the agreements by the 100 Area Tri-Party unit managers. These scenarios are not current land or water uses in the 100-BC-5 Operable Unit. While the risk is estimated from the best available knowledge of current contaminant conditions, it does not represent actual risks since neither frequent- nor occasional-use of groundwater currently occurs.

Uncertainty exists in the exposure assessments because they are presented as a bounding of potential exposures (i.e., between frequent- and occasional-use). The receptors evaluated for the 100-BC-5 Operable Unit are based on assumed receptors under current contaminant conditions. However, the use of maximum concentrations from different well locations to calculate risks for the QRA results is an overestimation of risk, since each receptor would be extracting groundwater from a single point. In addition, it is assumed that there is no change in current contaminant conditions. For some radionuclides, radioactive decay over time can significantly reduce the concentrations to which a receptor may be exposed. For example, concentrations of strontium-90, one of the risk-driving contaminants, would be reduced to 10% or an order of magnitude, in 100 years. Tritium has a half-life that is less than strontium-90, thus concentrations and estimated exposures would decrease by more than two orders of magnitude over 100 years. Carbon-14 and technetium-99 concentrations and exposures

would not be effectively reduced, by radionuclide decay, within 100 years due to the extremely long half-lives of these radionuclides.

3.2.3.3 Uncertainty in the Toxicity Assessment. Uncertainty is associated with the toxicity values and the toxicity information available to assess potential adverse effects. This uncertainty in the information and the lack of specific toxicity information contribute to uncertainty in the toxicity assessment. For radioactive and nonradioactive contaminants identified at the 100-BC-5 Operable Unit, there is relatively good toxicity information for evaluating potential exposures through the oral route. However, toxicity values and information to evaluate the inhalation route of exposure for the nonradioactive, volatile contaminants is more limited.

3.2.3.4 Uncertainty in the Risk Characterization. The estimated risks or HQs by themselves do not fully characterize the risk impacts associated with environmental contamination. Such an evaluation must be understood in light of the uncertainties presented above. The risk estimates are based on point estimates from LFI data assuming two different sets of exposure assumptions (i.e., frequent-use and occasional-use).

Uncertainty in the risk characterization results from summing cancer risks or HQs across contaminants and pathways, which gives equal weight to toxicity information derived from different sources or species. Exposures to multiple contaminants may result in additive effects or effects that are greater or less than additive.

3.3 ECOLOGICAL QUALITATIVE RISK ASSESSMENT

The ecological risk is characterized by assessing the dose to plants, crustaceans, fish, ducks, and several other aquatic related organisms by comparing doses to DOE Order 5400.5, Radiation Protection of the Public and the Environment. Metals and organic concentrations are compared to ambient water quality criteria (EPA 1986). The data used in the ecological risk assessment are the maximum groundwater concentrations in the near-river wells (Tables 2-7 through 2-10) and the spring and river concentrations near the 100 B/C Area from 1991 sampling (DOE-RL 1992c).

For radionuclides in the near-river wells and the springs and seeps, none of the concentrations exceeded the 1 rad/day benchmark established by DOE Order 5400.5.

For nonradiological constituents, chromium exceeded both the acute and chronic lowest observable effect levels (LOEL), and aluminum exceeded the chronic LOEL. In the seep samples, acute LOELs were exceeded for chromium and iron, and chronic LOELs were exceeded for aluminum and nickel. These constituents were not detected in the river samples. Manganese was detectable in 100 B/C Area spring and river samples at very low levels and were below background levels in the near-river wells. No aquatic standard exists for manganese. Acetone and trichloroethene were detected in the near river wells and were below known LOELs for trichloroethene. No known LOEL exists for acetone.

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There are several uncertainties in the environmental risk assessment. It is assumed that maximum well concentrations are aquatic exposure concentrations at the point of compliance. It is also assumed that the aquatic organisms are exposed to these levels irrespective of their habitat. All contaminants are assumed to be 100% biologically active and bioavailable, and uniformly distributed in the river. These are conservative assumptions based on situations that do not generally occur since many contaminants in aquatic systems are transported via suspended particulate material. It is assumed that contaminants will bioaccumulate in aquatic organisms such as a fish through direct uptake from the water column and foodchain. The risks developed in the ecological evaluation are not actual risks, but estimates of potential risk under high-frequency use by the organism. The actual use is not known, however, it can be safely assumed that exposure would be less than presented in this evaluation.

3.4 QUALITATIVE OVERVIEW OF POTENTIAL FUTURE GROUNDWATER IMPACTS

The existence of separate operable units for groundwater and sources leads to questions regarding allocation (separation) and potential overlap of investigations of groundwater and source operable units. Although the constituents in sediments or soils associated with high-priority waste units (sources) in the 100 B/C Area may migrate through the vadose zone and into the groundwater, the 100 B/C Area source operable units should evaluate future impacts to the 100-BC-5 Groundwater Operable Unit and consider future groundwater impacts in the development of source control remedial action objectives. This approach is consistent with recommendations in the 300-FF-5 and 200-BP-1 RI reports (DOE-RL 1993d, DOE-RL 1993e). For this reason, the QRA focuses on existing groundwater contamination only and assumes that 100 B/C Area source operable units will address future groundwater impacts.

3.5 CONCLUSIONS

The human health risk assessment identified bis(2-ethylhexyl)phthalate, tritium, carbon-14, strontium-90, and technetium-99 as COPC in the frequent- and occasional-use scenarios. The risks are estimated to be low to very low for these constituents.

The environmental risk assessment for aquatic toxicity for fish from nonradioactive contaminants indicated that for the near river wells, aluminum and chromium (IV) exceeded either an acute or chronic toxicity value. For the seeps, aluminum, chromium, iron, and nickel exceeded acute or chronic levels. These constituents were not detected in the river samples. No radionuclide dose exceeded the levels set forth in DOE Order 5400.5.

Table 3-1 Human Health Risk Assessment Summary for the 100-BC-5 Operable Unit[a]

Contaminant Type	Frequent-Use Scenario[b]			Occasional-Use Scenario[c]		
	Estimated Qualitative Risk	Risk-Driving Contaminant	Risk-Driving Pathway	Estimated Qualitative Risk	Risk-Driving Contaminant	Risk-Driving Pathway
Radioactive	low	strontium-90, tritium, carbon-14, technetium-99	ingestion only[d]	low	strontium-90	ingestion only[d]
Non-radioactive, Carcinogenic	low	bis(2-ethylhexyl) phthalate	ingestion	very low	None	None
Non-radioactive, Noncarcinogenic	low	None	None	low	None	None

[a] Based on maximum contaminant concentrations in groundwater.
[b] Frequent-use scenario is based on residential exposure parameters.
[c] Occasional-use scenario is based on recreational exposure parameters.
[d] The inhalation pathway is evaluated for volatile nonradioactive contaminants only.

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4.0 CONTAMINANTS OF POTENTIAL CONCERN IN THE GROUNDWATER

Groundwater chemistry data were obtained from wells drilled during this LFI and from pre-1991 wells determined to be "fit-for-use" as monitoring structures. The pre-1991 wells that were sampled during the LFI were 199-B3-1, 199-B4-1, 199-B4-4, 199-B4-5, 199-B4-7, 199-B5-1, and 199-B9-1.

As mentioned in Chapter 3, bis(2-ethylhexyl)phthalate, tritium, carbon-14, strontium-90, and technetium-99 were identified as COPC for human health. Except for bis(2-ethylhexyl)phthalate, these COPC are consistent with those expected based on operating history, past site activities, and source LFI data. No constituents were identified as ecological COPC in the Columbia River water. A few constituents in the seeps and groundwater were identified as potentially harmful although these constituents are diluted to below harmful levels by the Columbia River. No contaminants of concern (COC) (constituents with a medium or high risk) were identified in the QRA.

The following sections discuss the analytes that were detected in the LFI groundwater sampling and identified as COPC in the QRA. The data for the COPC from the three rounds of LFI sampling are shown in Table 4-1.

4.1 BIS(2-ETHYLHEXYL)PHTHALATE

Bis(2-ethylhexyl)phthalate has been found in several wells in the first three rounds of groundwater sampling (Table 4-1). It has not been found in any well consistently. Although it was only found in wells 199-B4-1 and 199-B4-5 in both the first and second round. It was only detected in one sample (from well 199-B3-1) in the third round. Historically, three 100 B/C Area wells (199-B4-5, 199-B4-6, and 199-B4-7) were sampled and analyzed for bis(2-ethylhexyl)phthalate in March 1990 and it was not detected. This compound is likely present due to laboratory contamination since it is a common plasticizer and there is no historical or process knowledge indicating use of this material in the 100 B/C Area.

4.2 CARBON-14

Carbon-14 has been identified as a COPC. The highest concentration was 410 pCi/L (estimated) in well 199-B8-6 in October 1992, however, it was not detected in this well in July 1992 or January 1993 (Table 4-1). The only well in which carbon-14 was detected in all three rounds was 199-B2-13, which had concentrations of 93 (estimated), 110, and 86 (estimated) pCi/L in July 1992, October 1992 and January 1993, respectively. This well is located in the area of a potential waste site and confirms the presence of carbon-14 contamination in this area, although only low concentrations of other radionuclides were identified in this well. Figure 4-1 shows the carbon-14 distribution in the groundwater from January 1993. This date was selected to show the current

groundwater conditions. Carbon-14 was not analyzed for in the 1991 seep sampling (DOE-RL 1992c). In addition, there are no historical data for carbon-14.

4.3 STRONTIUM-90

Strontium-90 is a COPC. In the first three rounds of sampling, the highest concentration observed was 130 pCi/L in well 199-B3-46 in January 1993 (Table 4-1). There appear to be two major areas of strontium-90 contamination: the 116-B-1 and 116-C-1 overflow trenches and the liquid waste facilities east of B Reactor (Figure 4-2). In addition, the concentrations in well 199-B3-47 indicate groundwater contamination downgradient from the 116-B-14 sludge disposal site. The concentrations are highest in the vicinity of the 116-C-1 overflow trench. Strontium-90 has been observed in the groundwater since analyses were first performed in 1982 and concentrations are about the same as from recent sampling (Figure 4-3). Strontium-90 was only found in very low concentrations (estimates of 0.96 and 6.3 pCi/L) in two of the seeps sampled in 1991 (DOE-RL 1992c). The distribution of strontium-90 is consistent with known waste disposal and operations.

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4.4 TECHNETIUM-99

Technetium-99 is found in most of the wells in the 100-BC-5 area (Figure 4-4). The highest concentration was 120 pCi/L in January 1993 in well 199-B3-46, downgradient of the 116-C-1 overflow trench. High concentrations are found downgradient of all of the liquid waste sites discussed in Chapter 1 including the 116-C-2 pluto crib. Technetium-99 is also found in high concentrations in the 600 Area wells to the east of the site. Concentrations in these wells ranged from 130 to 260 pCi/L (in wells 699-72-73 and 699-66-64, respectively) in July 1992, which are higher than any of the concentrations within the 100-BC-5 area. It is possible that some of the technetium-99 groundwater contamination is coming from outside of the 100 B/C Area where it would have been produced in the separations process. Technetium-99 is also a fission product and would be found as a result of fuel cladding failures. Technetium-99 was observed in the groundwater in the 100-BC-5 area the first year it was analyzed for, 1987. It has not been analyzed for in the seep sampling although gross beta concentrations ranged from estimates of 5 to 42 pCi/L and the technetium-99 concentrations would be expected to be lower since gross beta measures all beta emitters.

4.4 TRITIUM

Tritium was identified as a COPC because of the relatively high concentrations in the groundwater at well 199-B3-47 (Figure 4-5). The concentrations in this well were 24,000, 22,000, 17,000 pCi/L in July 1992, October 1992 and January 1993, respectively. This well is located downgradient of the retention basin area. Tritium was found in all of the other 100 B/C Area wells, but at low concentrations. Tritium was detected in all

three of the seep samples collected in the 100 B/C Area in 1991. The concentrations in seeps 037-1 and 038-3 are higher than that reported for much of the groundwater in the 100 B/C Area (DOE-RL 1992c; Peterson and Johnson 1992). The source of these high concentrations is uncertain. Tritium has been found in the 100 B/C Area since sampling first began in 1962. Figure 4-6 shows an example of how tritium concentrations in the 100 B/C Area are quite variable over time due to site operations and high groundwater travel times.

4.5 CONSTITUENTS IN THE CONFINED AQUIFER

The groundwater from well 199-B2-12 was analyzed to determine the chemistry of the upper confined aquifer only, the concentrations of manganese were elevated in this aquifer and ranged from 121 to 321 μg/L. There are no data on background values for manganese in this aquifer and it is likely that it is naturally occurring.

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4.6 POTENTIAL APPLICABLE AND RELEVANT OR APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE

Potential chemical-specific ARARs for the 100-BC-5 Operable Unit are discussed in the following sections. Potential location-specific ARARs are identified in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1993b).

Safe Drinking Water Act. The maximum contaminant levels (MCL) prescribed in EPA's National Primary Drinking Water Regulations[1] under the Safe Drinking Water Act are relevant and appropriate regulations for the 100-BC-5 Operable Unit. Title 40 Code of Federal Regulations (CFR) 141.16 limits the concentrations of photon and beta particle emitters to levels which would not exceed an annual dose equivalent to the total body or any internal organ of 4 mrem/yr. This section also prescribes a methodology for calculating the concentration of radionuclides using a daily intake of 2 L/day and the 168 hr data listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure* (NBS 1963). Primary MCLs have been established for two of the contaminants of interest: tritium at 20,000 pCi/L and strontium-90 at 8 pCi/L. Values are calculated for carbon-14 of 6,400 pCi/L and for technetium-99 of 2,400 pCi/L. No maximum contaminant level goals (MCLG) have been developed for these constituents; no MCLs or MCLGs are available for bis(2-ethylhexyl) phthalate.

Model Toxics Control Act. The Model Toxics Control Act (MTCA) (WAC 173-340) defines ground and surface water standards for both residential and industrial scenarios. The MTCA does not include standards for radionuclides. The Method B (residential) levels for bis(2-ethylhexyl) phthalate are 6.25 μg/L for groundwater and

[1]Title 40 CFR as amended at 56 FR 32113, July 15, 1991; 57 FR 1852, January 15, 1992; 57 FR 22178, May 27, 1992; 57 FR 24747, June 10, 1992; 57 FR 28788, June 29, 1992; 57 FR 31838, July 17, 1992.

3.56 μg/L for surface water based on carcinogenicity. The Method C (industrial) levels for the same chemical are 62.5 μg/L for groundwater and 89 μg/L for surface water.

In addition to these ARARs, several to-be-considered (TBC) guidelines exist for water. The DOE Order 5400.5 establishes groundwater standards based on a 100-mrem/yr dose. Converting these standards to correspond to a 4-mrem/yr dose (dividing by 25) results in the following levels:

- tritium - 80,000 pCi/L
- carbon-14 - 2,800 pCi/L
- strontium-90 - 40 pCi/L
- technetium-99 - 4,000 pCi/L.

Federal MCLs for radionuclides are proposed at 56 Federal Register (FR) 33050, Appendix B. The following proposed MCLs are pertinent to the 100-BC-5 Operable Unit:

- tritium - 60,900 pCi/L
- carbon-14 - 3,200 pCi/L
- strontium-90 - 42 pCi/L
- technetium-99 - 3,790 pCi/L.

The EPA has proposed criteria under the Clean Water Act for the protection of human health at 56 FR 50420. The criteria for bis(2-ethylhexyl) phthalate is 1.8 μg/L.

No secondary federal MCLs have been established for the COPC.

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Figure 4-1 Carbon-14 Concentrations in the Groundwater in January 1993

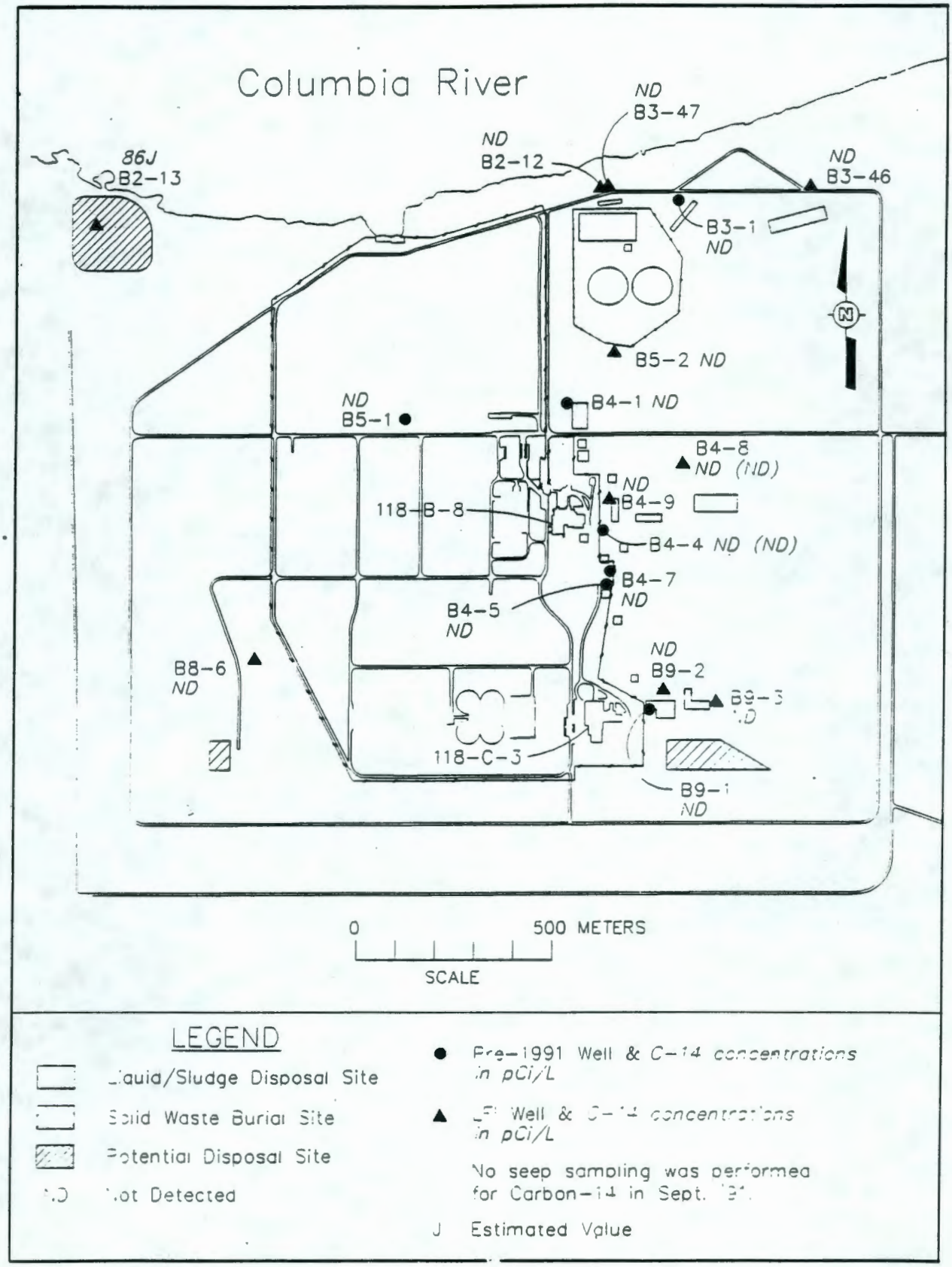

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Figure 4-2 Strontium-90 Concentrations in the Groundwater in January 1993

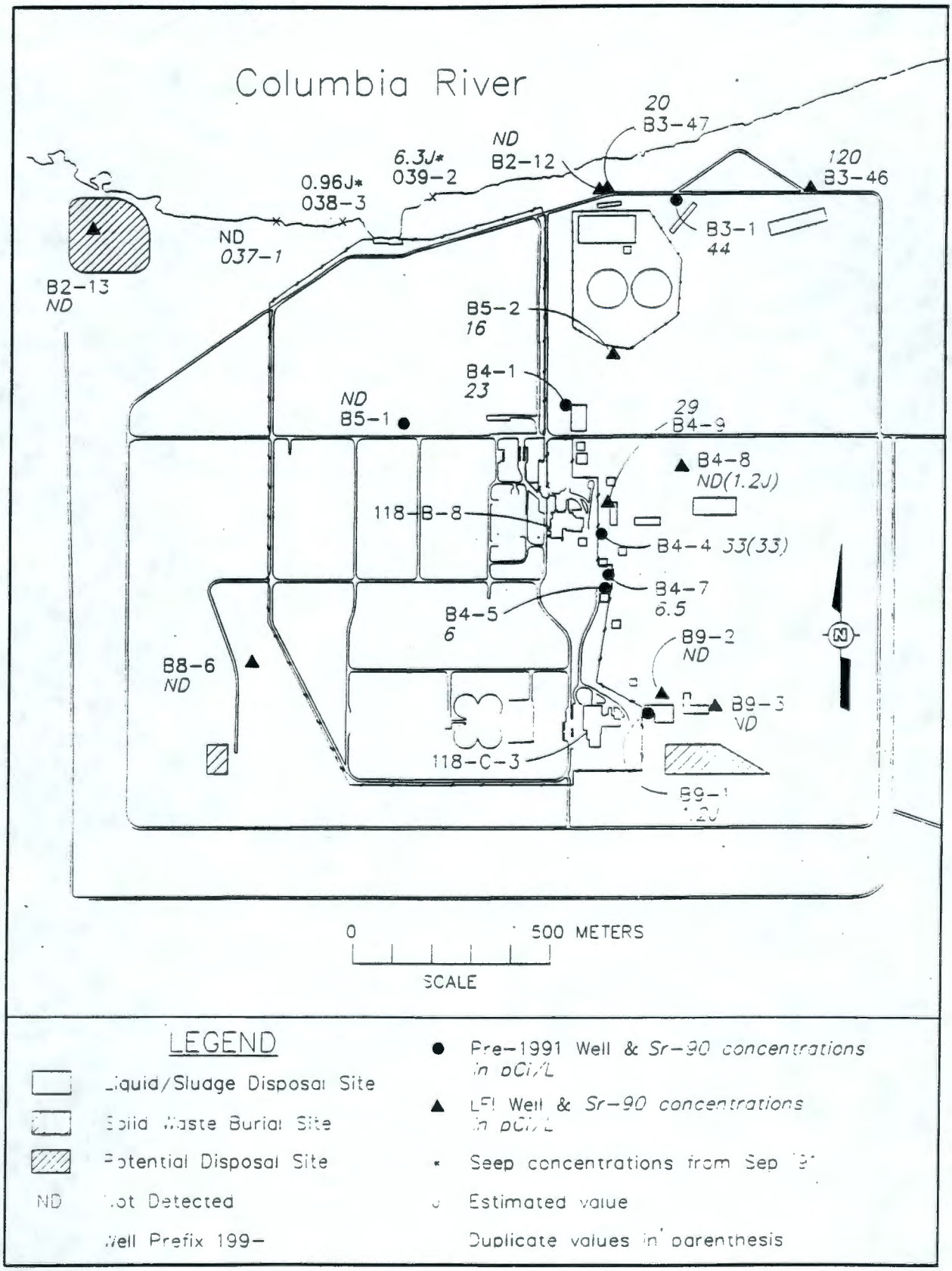

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Figure 4-3 Historical Strontium-90 Concentrations in the Groundwater in the 100 B/C Area

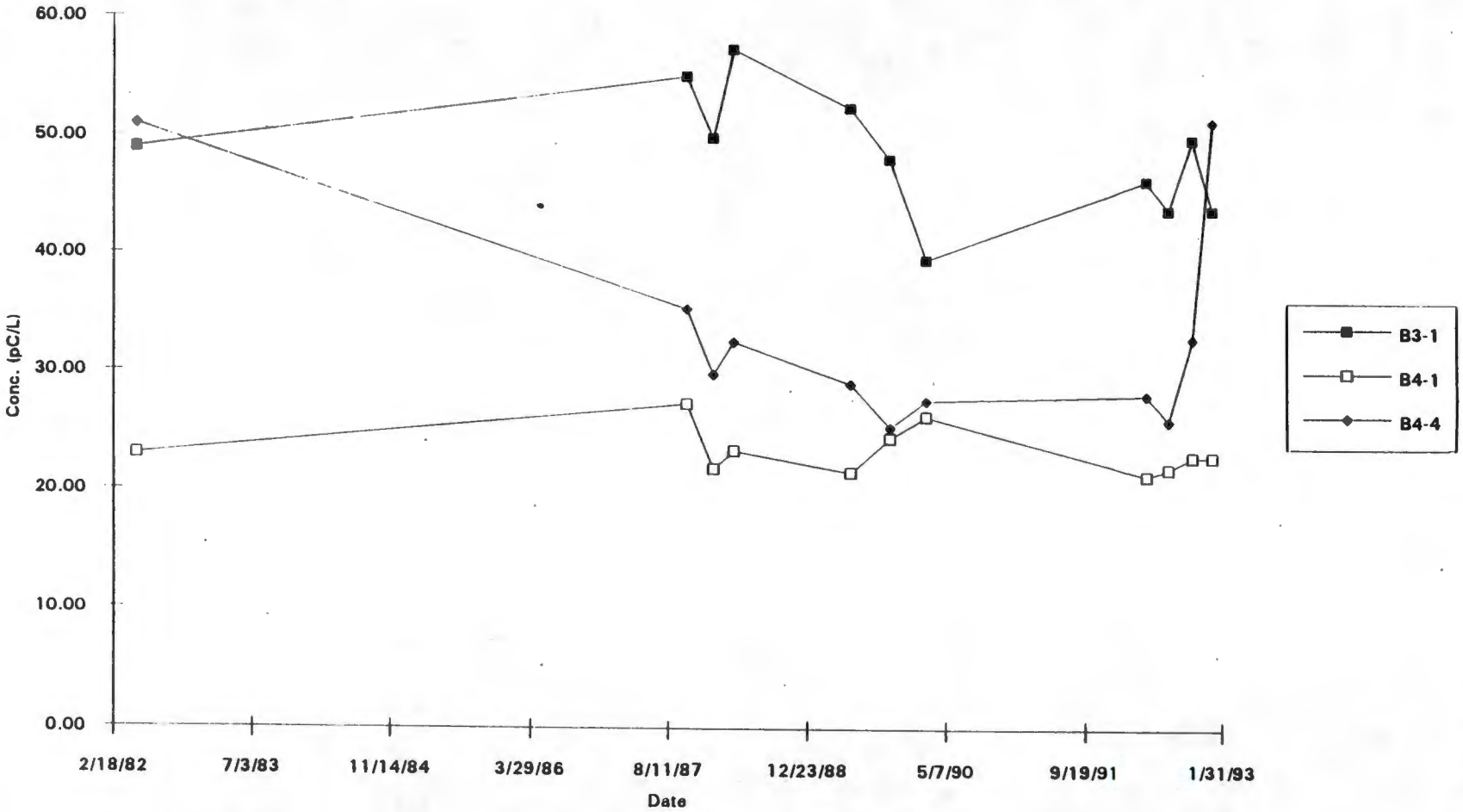

Figure 4-4 Technetium-99 Concentrations in the Groundwater in January 1993

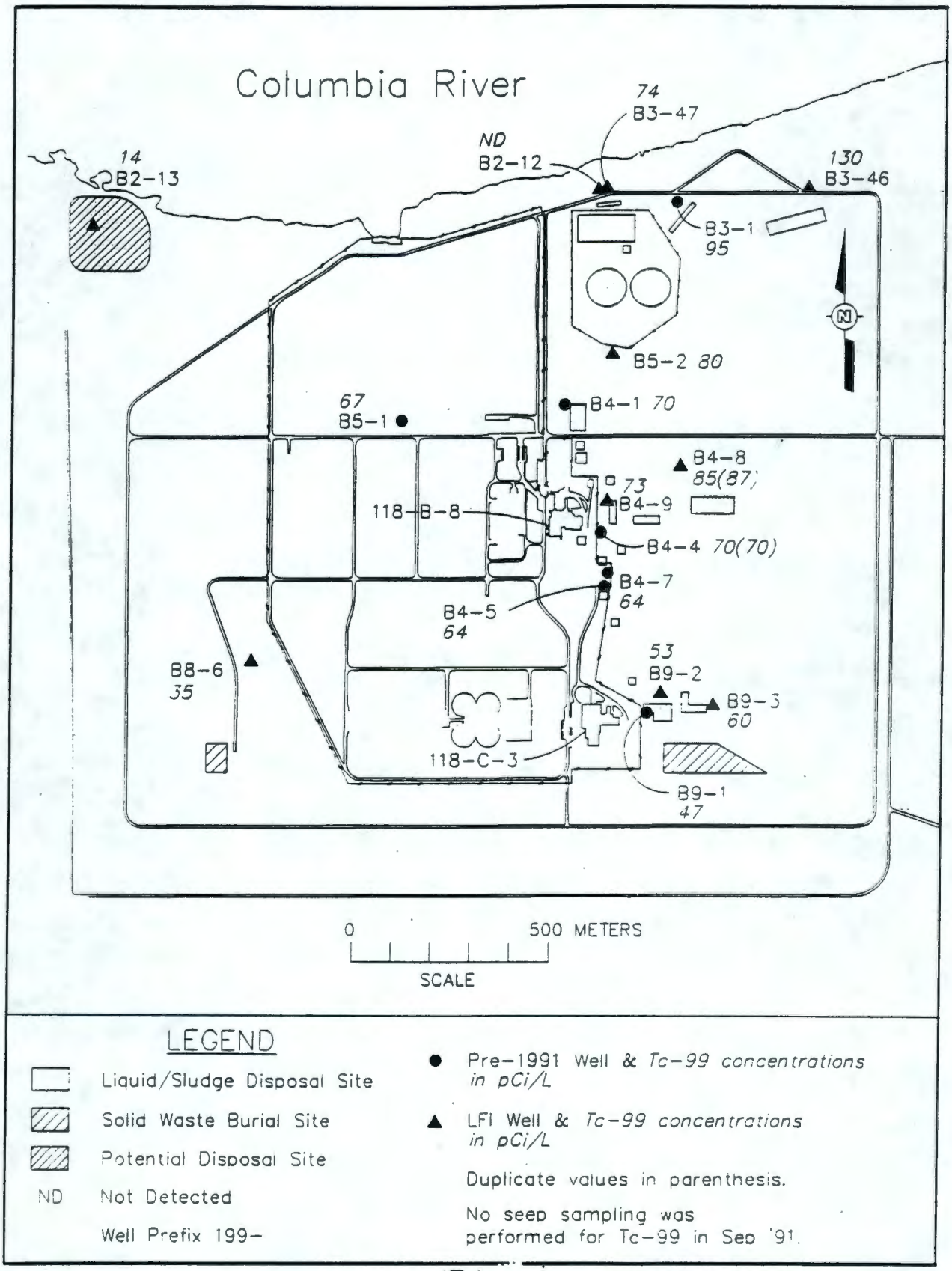

Figure 4-5 Tritium Concentrations in the Groundwater in January 1993

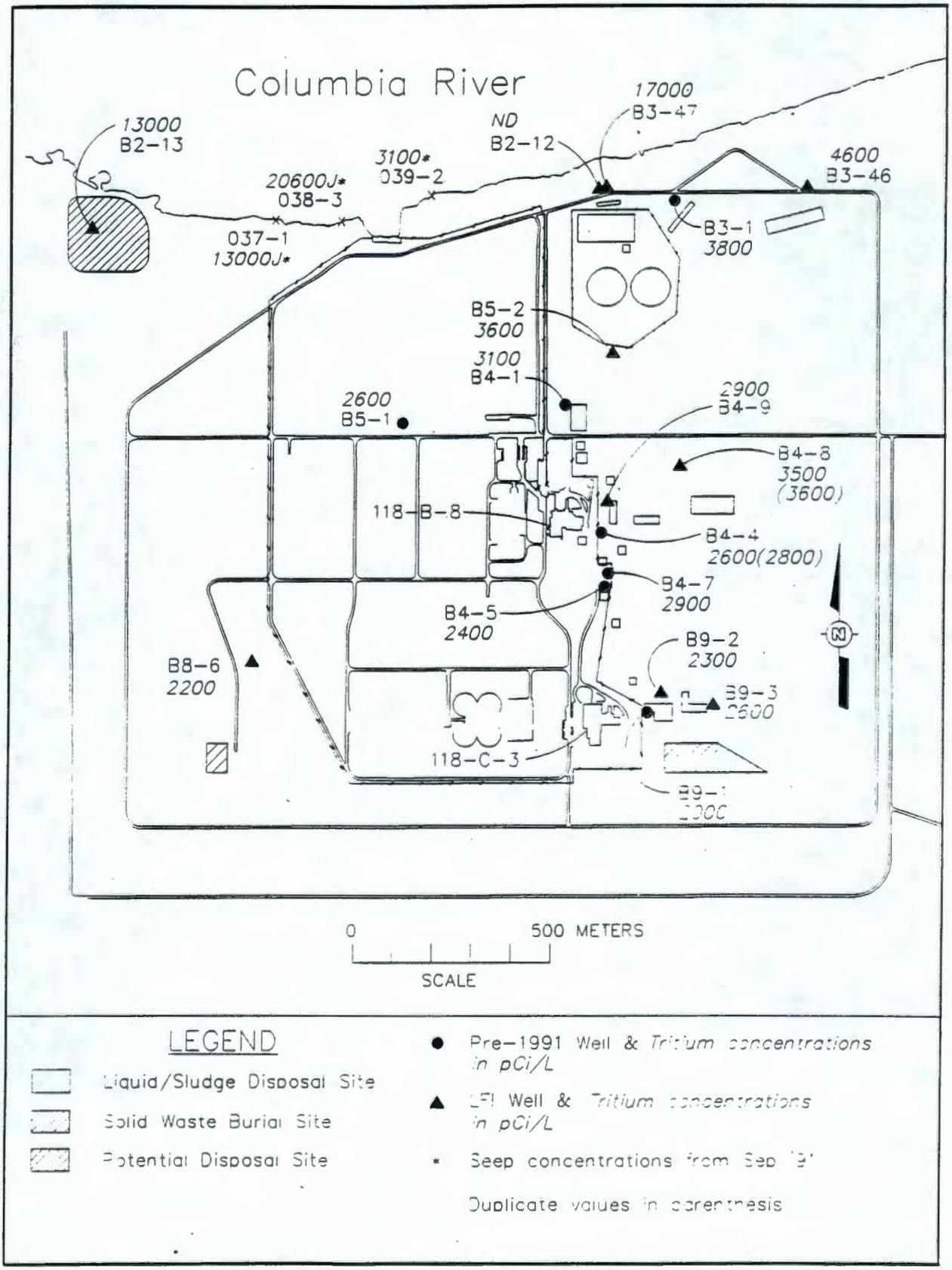

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Figure 4-6 Historical Tritium Concentrations in Well 199-B4-3

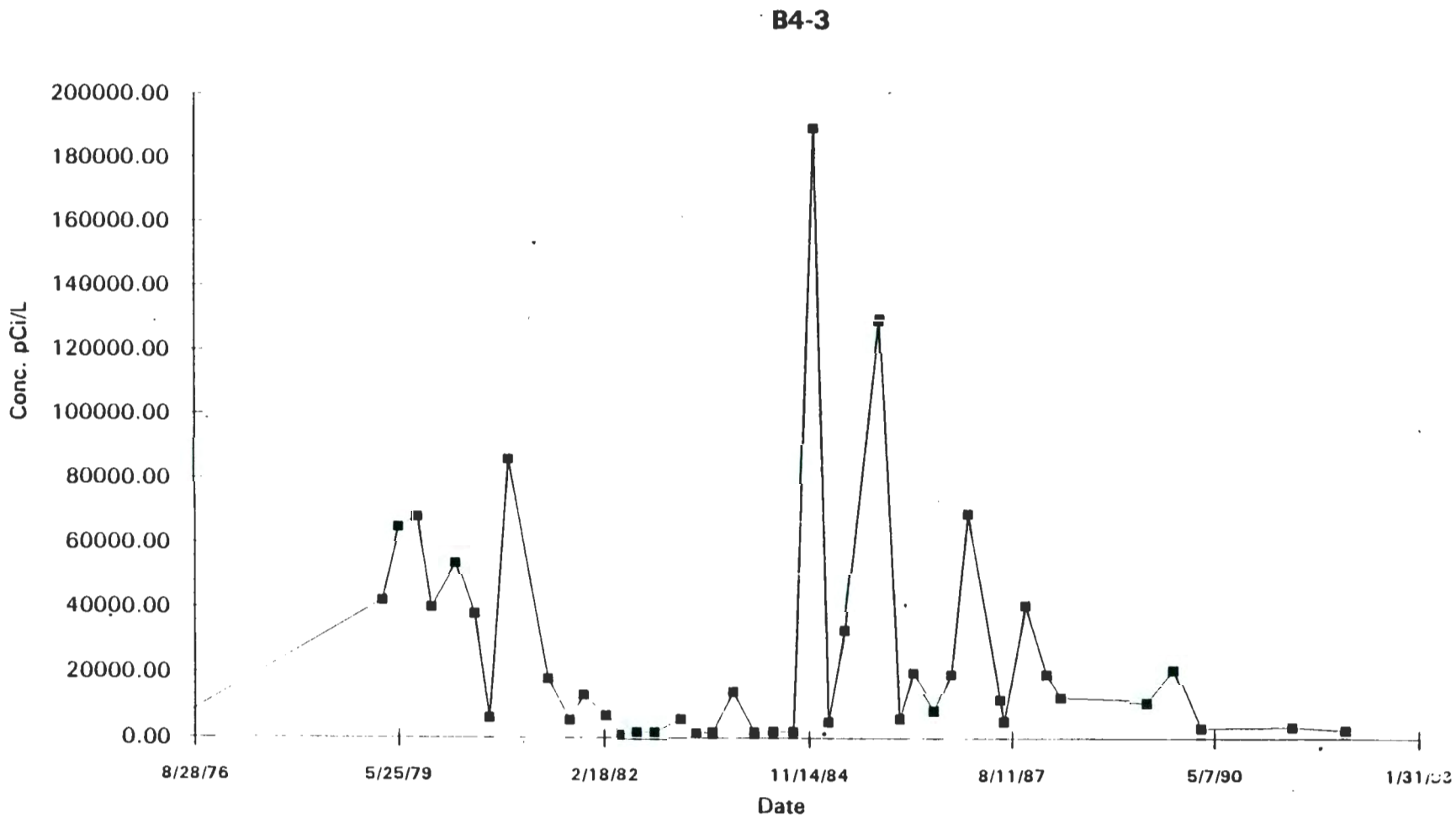

Table 4-1 Contaminant of Concern Data (Page 1 of 3)

Well Number	B2-13			B3-1			B3-46		
Round Number	1	2	3	1	2	3	1	2	3
Sample Number	B070H7	B07K61	B07ZG7	B070J2	B07K66	B07ZH2	B070J7	B07K51	B07ZH7
Bis(2-ethylhexyl) phthalate (ug/L)	ND	ND	ND	ND	ND	35	ND	ND	ND
Carbon-14 (pCi/L)	93 J	110	86 J	ND	ND	ND	ND	ND	ND
Strontium-90 (pCi/L)	0.089	ND	ND	44	50 J	44	57	130 J	130
Technetium-99 (pCi/L)	12	15 R	14	92	90	95	93	97	120
Tritium (pCi/L)	14000	15000	13000	3500	4000	3800	4800	4600	4600

Well Number	B3-47			B4-1		
Round Number	1	2	3	1	2	3
Sample Number	B070K2	B07K46	B07ZJ2	B070K7	B07K71	B07ZJ7
Bis(2-ethylhexyl) phthalate (ug/L)	ND	ND	ND	11	6 J	ND
Carbon-14 (pCi/L)	130 J	ND	ND	ND	ND	ND
Strontium-90 (pCi/L)	21	20 J	20	22	23 J	23
Technetium-99 (pCi/L)	68	55	74	68	59	70
Tritium (pCi/L)	24000	22000	17000	2700	2700	3100

Well Number	B4-4						
Round Number	1	2	2:Dup #1	2:Split #1	3	3:Dup #2	3:Split #2
Sample Number	B070L2	B07KM3	B07KJ1	B07KL1	B07ZK2	B07ZV7	B07ZW7
Bis(2-ethylhexyl) phthalate (ug/L)	ND	ND	ND	ND	ND	ND	0.9J
Carbon-14 (pCi/L)	ND	96	ND	NA	ND	ND	NA
Strontium-90 (pCi/L)	26	33 J	34 J	NA	70	33	NA
Technetium-99 (pCi/L)	65	65	63	NA	33	70	NA
Tritium (pCi/L)	3000	2600	2600	NA	2800	2600	NA

Table 4-1 Contaminant of Concern Data (Page 2 of 3)

Well Number	B4-5					B4-7		
Round Number	1	2	2:Dup #2	2:Split #2	3	1	2	3
Sample Number	B070L7	B07K86	B07KJ6	B07KL6	B07ZK7	B070M2	B07KH6	B07ZL2
Bis(2-ethylhexyl) phthalate (ug/L)	4J	8 J	1 J	3 J	ND	ND	ND	ND
Carbon-14 (pCi/L)	290 J	ND	ND	NA	ND	250	ND	ND
Strontium-90 (pCi/L)	6.2	5.9	5.6	NA	6	8.1	5.2	6.5
Technetium-99 (pCi/L)	64	57	60	NA	64	66	58	64
Tritium (pCi/L)	2800	2300	2600	NA	2400	2800	2400	2900

Well Number	B4-8					B4-9		
Round Number	1	2	3	3:Dup #1	3:Split #1	1	2	3
Sample Number	B070M7	B07K76	B07ZL7	B07ZV2	B07ZW2	B070N2	B07K81	B07ZM2
Bis(2-ethylhexyl) phthalate (ug/L)	6J	ND	ND	ND	NA	ND	ND	ND
Carbon-14 (pCi/L)	ND	ND	ND	ND	NA	ND	ND	ND
Strontium-90 (pCi/L)	1.3	1.3 J	1.2 J	0.66	NA	29	26 J	29
Technetium-99 (pCi/L)	79	75	87	85	NA	64	71	73
Tritium (pCi/L)	3000	3300	3600	3500	NA	2900	2800	2900

Well Number	B5-1			B5-2			B8-6		
Round Number	1	2	3	1	2	3	1	2	3
Sample Number	B070N7	B07K56	B07ZM7	B070P2	B07KC1	B07ZN2	B070P7	B07KB6	B07ZN7
Bis(2-ethylhexyl) phthalate (ug/L)	69	ND	ND	ND	ND	ND	ND	ND	ND
Carbon-14 (pCi/L)	ND	ND	ND	ND	ND	ND	410 J	ND	ND
Strontium-90 (pCi/L)	1	ND	ND	15	19 J	ND	0	-0.071	ND
Technetium-99 (pCi/L)	57	59	ND	72	62 R	ND	35	33	35
Tritium (pCi/L)	2700	2500	2600	4800	3300	3600	6300	2400	2200

Table 4-1 Contaminant of Concern Data (Page 3 of 3)

Well Number	B9-1			B9-2			B9-3		
Round Number	1	2	3	1	2	3	1	2	3
Sample Number	B072S4	B07K91	B07ZP2	B072S9	B07K96	B07ZP7	B072T4	B07KB1	B07ZQ2
Bis(2-ethylhexyl) phthalate (ug/L)	ND	ND	ND	52	ND	ND	ND	ND	ND
Carbon-14 (pCi/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Strontium-90 (pCi/L)	ND	1.7 J	1.2 J	0.16	ND	ND	0	ND	ND
Technetium-99 (pCi/L)	48	40 R	47	52	52	53	55	60	60
Tritium (pCi/L)	1900	1900	2000	2100	2200	2300	2100	2700	2600

NA: Not Available
J: Estimated Value
ND: Not Detected
R: Rejected Value

5.0 CONCLUSIONS

The LFI for the 100-BC-5 area was conducted to determine the nature and extent of hazardous/radioactive materials present in the groundwater. The analytical results from the groundwater sampling were compared to Hanford Site background values as well as calculated risk values and groundwater potential ARARs to determine COPC.

The human health risk assessment identified bis(2-ethylhexyl)phthalate, carbon-14, strontium-90, technetium-99, and tritium as COPC in the frequent- and occasional-use scenarios. The risks are estimated to be low to very low for these constituents. Currently there are no direct receptors able to access the groundwater as either a sole or supplemental drinking water source.

The environmental risk assessment for aquatic toxicity for fish from non-radioactive contaminants indicated that for the near river wells, aluminum and chromium (IV) exceeded either an acute or chronic toxicity value. For the seeps, aluminum, chromium, iron, and nickel exceeded acute or chronic levels. These constituents were not detected in the river samples. No radionuclide dose exceeded the levels set forth in DOE Order 5400.5.

The results of the LFI confirm that groundwater contamination has resulted from previous activities in the 100 B/C Area. No IRM is recommended because no COC were identified (i.e., low risk related to the current site usage and to frequent- and occasional-use scenarios). Therefore, the operable unit should be removed from the IRM pathway. An IRM may be recommended at a later date if conditions change. Identification and characterization of contaminants in the groundwater should continue through the RI/FS process. This effort should be coordinated with other 100 B/C Area RI/FS and decommissioning and decontamination activities. Monitoring of key groundwater contaminants should be continued until remedial actions associated with the source operable units are completed. The extent of groundwater contamination should then be reevaluated as well as the associated risk. A decision should be made at that time regarding the necessity of groundwater remediation.

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APPENDIX A

Rejected Maximum Concentration Logic

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Volatiles and Semi-volatiles (ug/L)

Analyte	Value	Well	Round	Logic behind rejection
Trichloroethane	2 J	B3-46	1	Not consistent with other rounds
1,1,2,2-Tetrachloroethane	2 J	B3-46	1	Not consistent with other rounds
2 Hexanone	4 J	B9-2	3	Not consistent with other rounds
4-Methyl-2-pentanone	3 J	B3-46	1	Not consistent with other rounds
4-Methyl-2-pentanone	2 J	B3-47	1	Not consistent with other rounds
Acetone	29	B3-46	1	Not consistent with other rounds
Benzene	5 J	B4-5	3	Not consistent with other rounds
Benzene	1 J	B4-7	3	Not consistent with other rounds
Chlorobenzene	2 J	B4-1	2	Not consistent with other rounds
Chloroform	2 J	B4-5	2	Not consistent with duplicate, split and other rounds
Chloroform	1 J	B4-5	2	Not consistent with duplicate, split and other rounds
Methylene Chloride	5 J	B4-5	2	Not consistent with duplicate, split and other rounds
Methylene Chloride	4 J	B4-5	2	Not consistent with duplicate, split and other rounds
Methylene Chloride	3 J	B3-47	2	Not consistent with other rounds
Toluene	3 J	B4-4	3	Not consistent with duplicate and other rounds
Toluene	3 J	B4-7	3	Not consistent with other rounds
Toluene	2 J	B4-5	3	Not consistent with other rounds
Toluene	2 J	B3-1	2	Not consistent with other rounds
Toluene	2 J	B4-1	2	Not consistent with other rounds
Toluene	1 J	B3-1	3	Less than 5x the equipment blank conc. of 1
Bis(2-ethylhexyl)phthalate	69	B5-1	1	Not consistent with other rounds
Bis(2-ethylhexyl)phthalate	52	B9-2	1	Not consistent with other rounds
Bis(2-ethylhexyl)phthalate	35	B3-1	3	Not consistent with other rounds
Di-n-butylphthalate	2 J	B4-5	2	Not consistent with duplicate, split and other rounds

Other constituents (ug/L)

Analyte	Value	Well	Round	Logic behind rejection
TOX	R *		2	Rejected in Validation due to quality control deficiencies

Filtered Inorganics (ug/L)

Analyte	Value	Well	Round	Logic behind rejection
Arsenic	4.7	B4-7	3	Not consistent with other rounds
Arsenic	4.4	B4-8	1	Not consistent with other rounds
Arsenic	4	B4-5	3	Not consistent with other rounds
Arsenic	3	B5-1	1	Not consistent with other rounds
Arsenic	2.7	B4-4	2	Not consistent with duplicate. split and other rounds
Beryllium	0.52	B2-13	2	Not consistent with other rounds
Beryllium	0.41	B4-9	2	Not consistent with other rounds
Beryllium	0.32	B4-8	2	Not consistent with other rounds
Cadmium	2.1	B4-7	3	Not consistent with other rounds
Cadmium	1.1	B4-5	2	Not consistent with split and other rounds
Cadmium	1.1	B4-5	2	Not consistent with split and other rounds
Cobalt	1.4	B9-3	2	Not consistent with other rounds
Copper	9.7	B4-5	2	Not consistent with duplicate. split and other rounds
Iron	862	B4-8	3	Not consistent with duplicate and other rounds
Iron	676	B4-5	2	Not consistent with duplicate. split and other rounds
Iron	644	B9-3	3	Not consistent with other rounds
Lead	3.5	B2-13	2	Not consistent with other rounds
Lead	3.4	B5-1	2	Less than 5x the equipment blank conc. of 2.1
Lead	3.3	B4-5	2	Less than 5x the equipment blank conc. of 2.1
Lead	2.7	B9-3	2	Not consistent with other rounds
Lead	2.7	B4-7	2	Less than 5x the equipment blank conc. of 2.1
Lead	2.6	B4-8	2	Not consistent with other rounds
Lead	2.3	B3-1	3	Not consistent with other rounds
Lead	2.3	B8-6	2	Not consistent with other rounds
Lead	2.3	B4-5	2	Less than 5x the equipment blank conc. of 2.1
Lead	2.2	B4-5	3	Less than 5x the equipment blank conc. of 2.7
Lead	2.1	B3-47	2	Not consistent with other rounds
Lead	2.1	B5-2	2	Not consistent with other rounds
Lead	2	B4-7	3	Less than 5x the equipment blank conc. of 2.7
Lead	1.9	B5-1	3	Less than 5x the equipment blank conc. of 2.7
Lead	1.6	B4-8	3	Less than 5x the equipment blank conc. of 2.7
Mercury	0.17	B2-13	2	Not consistent with other rounds
Mercury	0.12	B3-46	2	Not consistnat with other rounds
Mercury	0.12	B4-8	2	Not consistent with other rounds
Mercury	0.12	B4-9	2	Not consistent with other rounds
Mercury	0.12	B5-2	2	Not consistent with other rounds
Mercury	0.12	B4-7	2	Not consistent with other rounds
Nickel	47.5	B4-5	2	Not consistent with duplicate. split and other rounds
Nickel	14.1	B4-4	2	Not consistent with duplicate. split and other rounds
Selenium	21.3	B4-5	3	Not consistent with other rounds
Selenium	10.7	B2-13	1	Not consistent with other rounds
Selenium	4.9	B4-7	3	Not consistent with other rounds
Selenium	3.3	B3-47	2	Not consistent with other rounds
Selenium	R *		2	Rejected by validation due to quality control deficiencies
Silver	2.9	B4-5	2	Not consistent with duplicate. split and other rounds
Zinc	197	B4-8	3	Not consistent with duplicate and other rounds

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Radioisotopes (pCI/L)

Analyte	Value	Well	Round	Logic behind rejection
Carbon-14	410	B8-6	1	Not consistent with other rounds
Carbon-14	130	B3-47	1	Not consistent with other rounds
Cesium-137	9.2 J	B4-5	2	Not consistent with duplicate and other rounds
Plutonium-238	0.015	B4-8	1	Not consistent with other rounds
Plutonium-238	0.014	B9-3	1	Not consistent with other rounds
Plutonium-238	0.012	B5-1	1	Not consistent with other rounds
Plutonium-238	0.005	B2-13	1	Not consistent with duplicate and other rounds
Plutonium-238	0.002	B3-47	1	Not consistent with duplicate and other rounds
Plutonium-238	0.002	B5-2	1	Not consistent with other rounds
Plutonium-238	-0.002	B3-46	1	Not consistent with duplicate and other rounds
Plutonium-238	-0.003	B8-6	1	Not consistent with other rounds
Plutonium-238	-0.004	B9-2	1	Not consistent with other rounds
Plutonium-239/240	0.014	B5-1	1	Not consistent with other rounds
Plutonium-239/240	0.003	B9-3	1	Not consistent with other rounds
Plutonium-239/240	0	B4-8	1	Not consistent with other rounds
Plutonium-239/240	0	B8-6	1	Not consistent with other rounds
Plutonium-239/240	-0.002	B9-2	1	Not consistent with other rounds
Plutonium-239/240	-0.005	B5-2	1	Not consistent with other rounds
Plutonium-239/240	R *		2	Rejected in validation due to quality control deficiencies
Potassium-40	200	B4-7	3	Not consistent with other rounds
Potassium-40	110	B4-5	2	Not consistent with duplicate and other rounds
Radium-226	30	B4-5	2	Not consistent with duplicate and other rounds
Radium-226	21	B5-1	2	Not consistent with other rounds
Thorium-228	20	B8-6	1	Not consistent with other rounds
Uranium-235	0.075	B4-8	1	Not consistent with other rounds
Uranium-235	0.067	B5-2	1	Not consistent with other rounds
Uranium-235	0.053	B3-46	1	Not consistent with other rounds
Uranium-235	0.034	B3-47	1	Not consistent with other rounds
Uranium-235	0.032	B5-1	1	Not consistent with other rounds
Uranium-235	0.029	B2-13	1	Not consistent with other rounds
Uranium-235	0.018	BB9-2	1	Not consistent with other rounds
Uranium-235	0	B8-6	1	Not consistent with other rounds
Uranium-235	-0.018	B9-2	1	Not consistent with other rounds
Uranium-235	R *		2,1	Rejected in validation due to quality control deficiencies

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Volatiles and Semi-volatiles (ug/L)

Analyte	Value	Well	Round	Logic behind rejection
1,1,2,2-Tetrachloroethane	2 J	B3-46	1	Not consistent with other rounds
4-Methyl-2-pentanone	3 J	B3-46	1	Not consistent with other rounds
4-Methyl-2-pentanone	2 J	B3-47	1	Not consistent with other rounds
Acetone	29	B3-46	1	Not consistent with other rounds
Methylene Chloride	3 J	B3-47	2	Not consistent with other rounds
Toluene	2 J	B3-1	2	Not consistent with other rounds
Toluene	1 J	B3-1	3	Less than 5x the equipment blank conc. of 1
Bis(2-ethylhexyl)phthalate	35	B3-1	3	Not consistent with other rounds

Other constituents (mg/L)

Analyte	Value	Well	Round	Logic behind rejection
TOX (ug/L)	R *		2	Rejected in validation due to quality control deficiencies
Phosphate	R *		2	Rejected in validation due to quality control deficiencies
Sulfide	R *		2	Rejected in validation due to quality control deficiencies

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Unfiltered Inorganics (ug/L)

Analyte	Value	Well	Round	Logic behind rejection
Iron	3600	B3-1	2	Not consistent with other rounds
Iron	514	B3-47	2	Not consistent with other rounds
Lead	38.4	B2-13	3	Not consistent with other rounds
Lead	3.2	B3-47	2	Not consistent with other rounds
Lead	2	B3-1	3	Not consistent with other rounds
Nickel	74.8	B2-13	1	Not consistent with other rounds
Nickel	55.6	B3-47	2	Not consistent with other rounds
Nickel	3.3	B3-1	2	Not consistent with other rounds
Selenium	R *		1,2,3	Rejected in validation due to quality control deficiencies
Vanadium	6.4	B2-13	3	Not consistent with other rounds
Zinc	20.3	B3-47	2	Not consistent with other rounds
Zinc	13.9	B3-1	3	Not consistent with other rounds

Radioisotopes (pCi/L)

Analyte	Value	Well	Round	Logic behind rejection
Americium-241	0.01	B3-46	1	Not consistent with other rounds
Americium-241	-0.005	B3-47	1	Not consistent with other rounds
Americium-241	-0.012	B2-13	1	Not consistent with other rounds
Carbon-14	130	B3-47	1	Not consistent with other rounds
Plutonium-238	0.005	B2-13	1	Not consistent with other rounds
Plutonium-238	0.002	B3-47	1	Not consistent with other rounds
Plutonium-238	-0.002	B3-46	1	Not consistent with other rounds
Plutonium-239	0.007	B3-47	1	Not consistent with other rounds
Plutonium-239	0	B2-13	1	Not consistent with other rounds
Plutonium-239	-0.002	B3-46	1	Not consistent with other rounds
Uranium-235	0.053	B3-46	1	Not consistent with other rounds
Uranium-235	0.034	B3-47	1	Not consistent with other rounds
Uranium-235	R *		1	Rejected in validation due to quality control deficiencies
Uranium-235	0.029	B2-13	1	Not consistent with other rounds

*All values with a "R" qualifier for the round(s) indicated are included