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Rev. 2

Engineering Evaluation/ Conceptual Plan for the 200-UP-1 Groundwater Operable Unit Interim Remedial Measure

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Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Bechtel Hanford, Inc.
Richland, Washington

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ACRONYMS

AAMSR	Aggregate Area Management Study Report
ARAR	applicable or relevant and appropriate requirements
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
GAC	granular activated carbon
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
IRM	interim remedial measure
LERF	Liquid Effluent Retention Facility
MCL	maximum contaminant level
NCP	National Contingency Plan
NOC	Notices of Construction
NPL	National Priorities List
PUREX	Plutonium/Uranium Extraction
RCRA	*Resource Conservation and Recovery Act*
SALDS	state approved land disposal site
SDWA	*Safe Drinking Water Act*
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UV	ultraviolet
UV/OX	ultraviolet/oxidation
WAC	*Washington Administrative Code*
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

This report presents an engineering evaluation and conceptual plan for an interim remedial measure (IRM) to address a uranium and technetium-99 groundwater plume in the 200-UP-1 Groundwater Operable Unit located in the 200 West Area of the Hanford Site. This report provides information regarding the need for an IRM and its potentially achievable objectives and goals. The report also evaluates alternatives to contain elevated concentrations of uranium and technetium-99 and to obtain information necessary to develop final remedial actions for the operable unit.

2.0 SITE CHARACTERIZATION

2.1 BACKGROUND

The 200 Areas of the Hanford Site are included on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical separations and reprocessing plants. Operations in the 200 Areas involved mainly separation of special nuclear materials from irradiated nuclear fuel and related chemical and fuel processing and waste management. In general, chemical and low-level radioactive liquid wastes associated with operations were disposed to the ground via infiltration structures such as cribs, ponds, ditches, and injection wells, resulting in soil and groundwater contamination.

Process wastewater consisting primarily of dilute nitric acid containing uranium, technetium-99, and other fission products was disposed to the ground through cribs associated with the U Plant in the 200 West Area of the Hanford Site between 1951 and 1968. Mobile contaminants, such as technetium-99, reached groundwater during the years when the cribs were in use. Most of the uranium, however, was retained in the upper portion of the soil column beneath the cribs as a uranium phosphate mineral phase until the final years of crib operation when highly acidic waste solutions were discharged to the crib. The acid waste dissolved the uranium mineral deposits in the soil column and increased its solubility and mobility. The mobile uranium was transported to groundwater in the mid-1980's when large volumes of process water were discharged to a new crib located in the vicinity of the disposal cribs. The process water created a perched zone of saturation that spread laterally to the soil column containing the soluble uranium. Uranium was then carried to groundwater via unsealed well casings or through the soil column. When this contamination was identified in groundwater samples in 1985, a uranium recovery program was instituted that reduced contaminant levels to the concentrations present today. The source of nitrate contamination is the co-disposed dilute nitric acid.

Process water containing carbon tetrachloride was disposed to the ground through Z Plant operations. Widespread contamination of the 200 West Area groundwater has resulted from these discharges. Carbon tetrachloride is present in 200-UP-1 groundwater at concentrations as high as 470 μg/L.

An aggregate area management study program was implemented under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) to assess soil and groundwater contamination in the 200 Areas. Based on the findings of the studies, an overall remedial action strategy for the 200 Areas was developed for potential interim remedial actions to expedite the

cleanup process. The *200 West Groundwater Aggregate Area Management Study Report* (AAMSR) (DOE-RL 1992) summarized information about groundwater contaminants beneath the 200 West Area and provided recommendations for prioritizing, investigating, and remediating various contaminants and plumes. The 200 West Groundwater AAMSR provided a detailed description of contaminant plumes in the area, including uranium, technetium-99, and nitrate in the 200-UP-1 Operable Unit. The 200 West Groundwater AAMSR (DOE-RL 1992) recommended that three contaminants/plumes containing the highest concentrations of uranium, technetium-99, and nitrate be addressed under an IRM. This engineering evaluation report evaluates alternatives for taking interim remedial actions to address the uranium and technetium-99 in 200-UP-1 groundwater. A description of this groundwater contamination is summarized in Appendix A.

A field investigation program (DOE-RL 1994b) in 1994 focused on the uranium, technetium-99, and nitrate plumes. The program consisted of installing four characterization wells screened at various depths, soil sampling, geophysical logging, aquifer testing, and groundwater monitoring. The investigation was used to refine the conceptual model regarding the nature and extent of contamination. Results from these activities are summarized in the *Borehole Summary Report for 200-UP-1 Operable Unit, 200 West Area* (Kelty et al. 1994) and the *200-UP-1 Vertical Profiling Activity Summary Report* (Ford 1995).

A pilot-scale pump-and-treat system was started in 1994 and is currently operating at 200-UP-1 as a treatability test under authority of the Tri-Party Agreement (change control form M-13-93-03). The scope and purpose of this treatability test were set forth in the treatability test plan (DOE-RL 1994a), which is available in the administrative record. This test is evaluating treatment of uranium and technetium-99 contaminated groundwater in the 200 West Area using ion-exchange resins. Carbon tetrachloride is being removed using granular activated carbon (GAC). During 1995 the pilot-scale program was enhanced to increase the water available for treatment. This enhancement included the construction of two new production wells (one extraction and one injection) and three new monitoring wells. The new production wells have resulted in an increased flow rate through the treatment system to 190 L/min (50 gal/min) and increased capability to monitor the effect of the increased pumping rate.

2.2 EXTENT OF CONTAMINATION

The plumes of nitrate, uranium (Figure 1), and technetium-99 (Figure 2) contamination have migrated eastward to their present location. The uranium and technetium-99 plumes cover approximately 0.7 km^2 (0.24 mi^2). The maximum concentration of nitrate is approximately 1,700,000 μg/L. The maximum concentration of uranium present in groundwater is approximately 3,900 μg/L. Technetium-99 is measurable in concentrations up to 34,300 pCi/L. A recent evaluation of the vertical distribution of contamination indicates that groundwater containing contamination in concentrations exceeding the proposed *Safe Drinking Water Act* (SDWA) standards for uranium and existing SDWA standards for technetium-99 (derived based on the 4-mrem/yr annual average dose limit for beta emitters) is present in the upper 15 to 18 m (50 to 60 ft) of the water table (Ford 1995). Technetium-99 is entirely dissolved in groundwater and mobile. Uranium is slightly less mobile, and a portion of the contaminant is likely adsorbed on the soil. Carbon tetrachloride is present in 200-UP-1 groundwater from Z Plant operations. The predominant use of carbon tetrachloride from these operations was in extraction processes. This substance was also used, to a much lesser degree, in Z Plant degreasing operations.

Figure 1. Concentration Isopleths for Uranium (in $\mu g/L$).

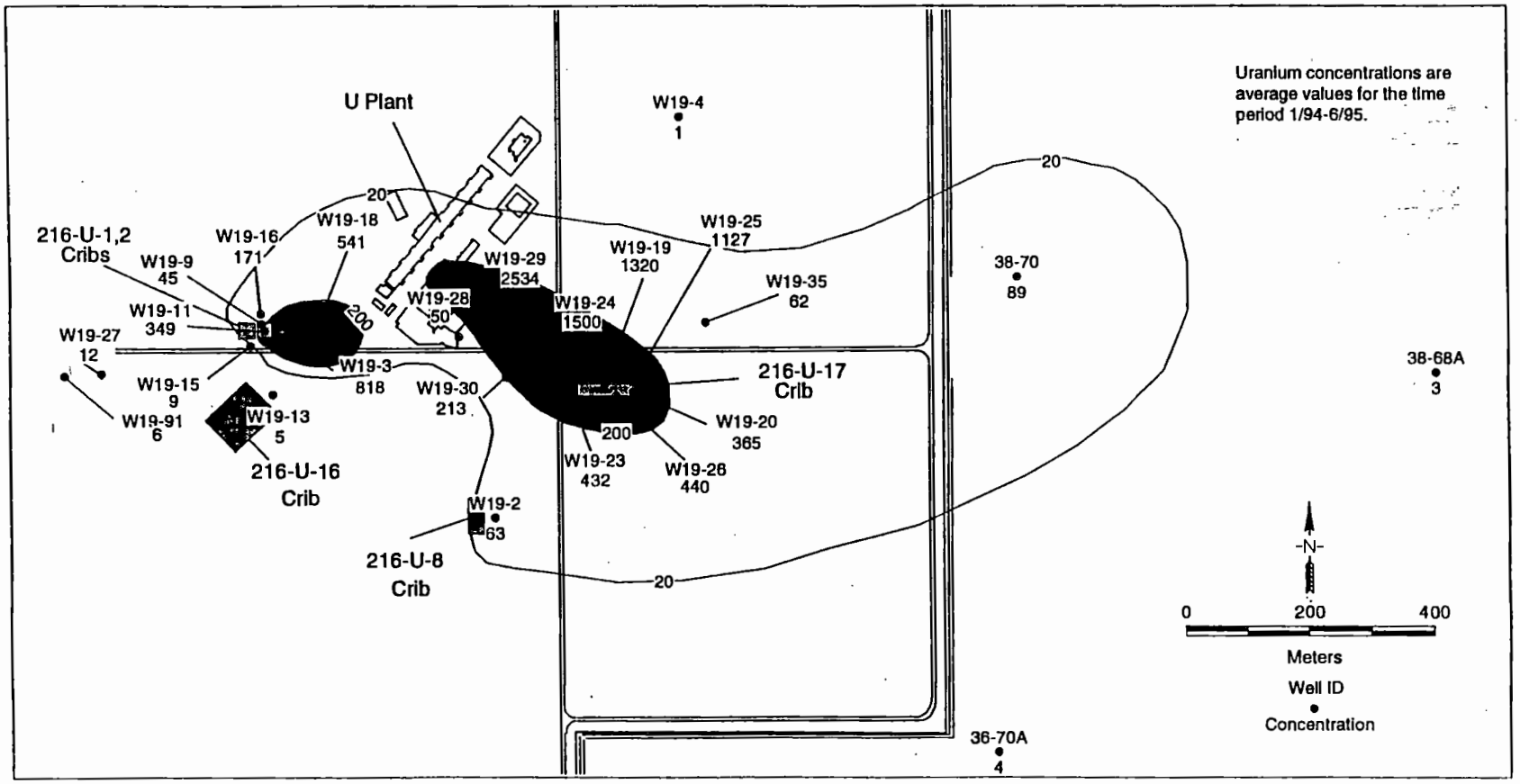
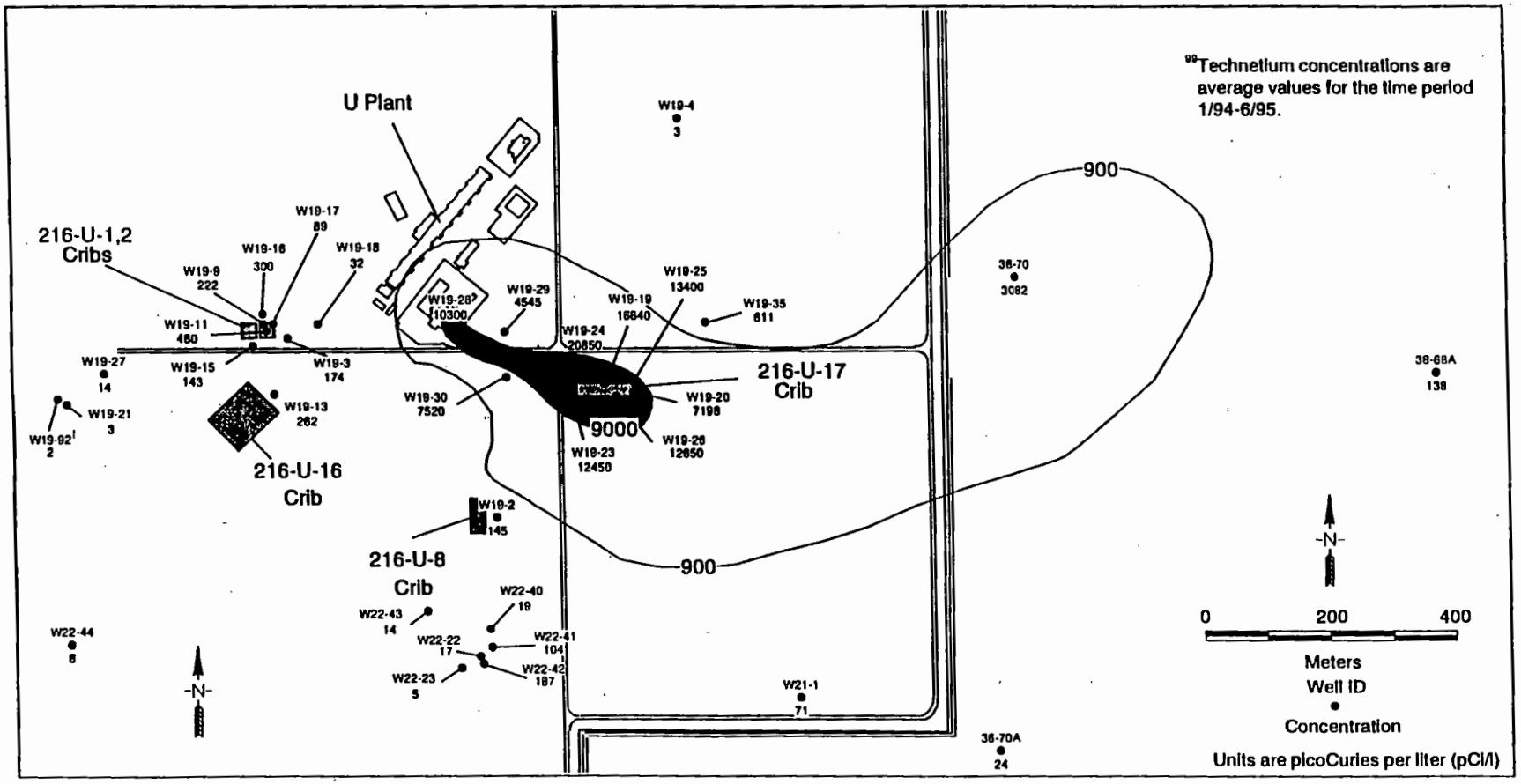


Figure 2. Concentration Isopleths for Technetium-99 (in pCi/L).



2.3 RISK ANALYSIS

A preliminary analysis of risk was performed to assess the impacts of the uranium, technetium-99, and nitrate contamination at a hypothetical exposure point near the boundary of the 200 Area Plateau. This analysis indicates that under the no-action alternative, if unrestricted use of the groundwater is permitted, an estimated incremental lifetime cancer risk (ILCR) would be 3×10^{-5} and the estimated hazard quotient (HQ) for noncarcinogens (uranium and nitrate) would be much greater than one. An HQ of one represents no additional risk. An HQ greater than or equal to one poses a potential human health risk. A discussion of the preliminary risk analysis is provided in Appendix B.

The likely effects of partial remediation of the 200-UP-1 uranium and technetium-99 plume through an IRM are shown in Table 1. Risk is generally reduced to less than or equal to 10^{-5}, and concentrations would be less than the applicable maximum contaminant level (MCL) at the hypothetical point of exposure. The HQ would be reduced by removal of uranium, but would remain greater than one due to nitrate. Treatment of the water to remove nitrate would have no discernable impact on the HQ at the hypothetical exposure point due to the expanse of the nitrate plume. Land use and associated target risks are key factors in the determination of compliance and the degree of cleanup needed at the source and will be addressed during development of a final remedy.

Table 1. Predicted Effects of Partial Remediation of the 200-UP-1 Uranium and Technetium Plume.

Contaminant	Current conditions within 200-UP-1	Future conditions at hypothetical point of exposure	
		No remediation	With remediation[a]
Maximum contaminant concentrations			
Technetium-99 (pCi/L)	23,900	1,100	409
Uranium (μg/L)	1,690	52	18
Maximum ILCR			
Technetium-99	2.62×10^{-4} [b]	3.1×10^{-5}	1.2×10^{-5}
Uranium		1.5×10^{-5}	5.1×10^{-6}

[a]Assumes removal of technetium-99 and uranium concentrations greater than 9,000 pCi/L and 600 μg/L, respectively.

[b]Combined technetium-99 and uranium.

3.0 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES

The EPA guidance *Interim Final Guidance on Preparing Superfund Decision Documents* (EPA 1989) states that appropriate objectives for interim actions include site stabilization, prevention of further degradation, and significant rapid risk reduction. For 200-UP-1, the proposed site-specific interim remedial objectives are to minimize the migration of contaminated groundwater beyond the high-concentration areas of the plume; to remove uranium, technetium-99, and carbon tetrachloride; and to

obtain additional information that is necessary for developing a final remedy. It is estimated that 57% of the uranium and 21% of the technetium-99, dissolved in the groundwater, from the U Cribs, is located in the area of the proposed IRM. Minimizing migration of this highly contaminated groundwater will help stabilize the plumes, prevent further degradation of groundwater quality outside of the source area, and mitigate future risks to human health and the environment. Specific interim remedial objectives include the following:

1. Preventing further movement of uranium and technetium-99 from the area of highest concentration

2. Extracting contaminants from the area of highest concentrations

3. Providing information that will be necessary for development of a final remedy that will be protective of human health and the environment.

These proposed remedial objectives are consistent with the overall strategy for groundwater remediation at the Hanford Site and with the recommendations of the *200 West Groundwater Aggregate Area Management Study Report* (DOE-RL 1992).

4.0 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

The 200 West Groundwater AAMSR (DOE-RL 1992) provided an initial feasibility study that screened technologies for groundwater remediation in the 200 West Area and developed preliminary action alternatives. Alternative interim actions to address the combined uranium and technetium-99 plumes include no action, institutional control, treatment at the point of use or discharge, physical containment, and pump-and-treat.

4.1 NO ACTION

The no-action alternative is retained for further evaluation as required by the National Contingency Plan (NCP) (Title 40, *Code of Federal Regulations* [CFR], Part 300.430).

4.2 PHYSICAL CONTAINMENT

The alternative of physical containment is not retained for further evaluation because it is not considered implementable in the 200 West Area due to the great depth to groundwater [67 to 73 m (220 to 240 ft) below ground surface]. In addition, this alternative is removed from further consideration because it would not meet the remedial action objective of removing contamination from the aquifer and would be difficult to maintain.

4.3 INSTITUTIONAL CONTROL

The alternative of institutional control is not retained for further evaluation because it would not provide any removal of contamination from the aquifer and would not meet the remedial action objectives. Institutional control is essentially the same as the no-action alternative, but with controls on the current and future use of groundwater.

4.4 TREATMENT AT POINT OF USE

The alternative of treatment at the point of use is not retained for further evaluation because it does not meet the remedial action objectives. Future land uses, including water consumption parameters, have not been defined and thus do not permit further evaluation of this alternative.

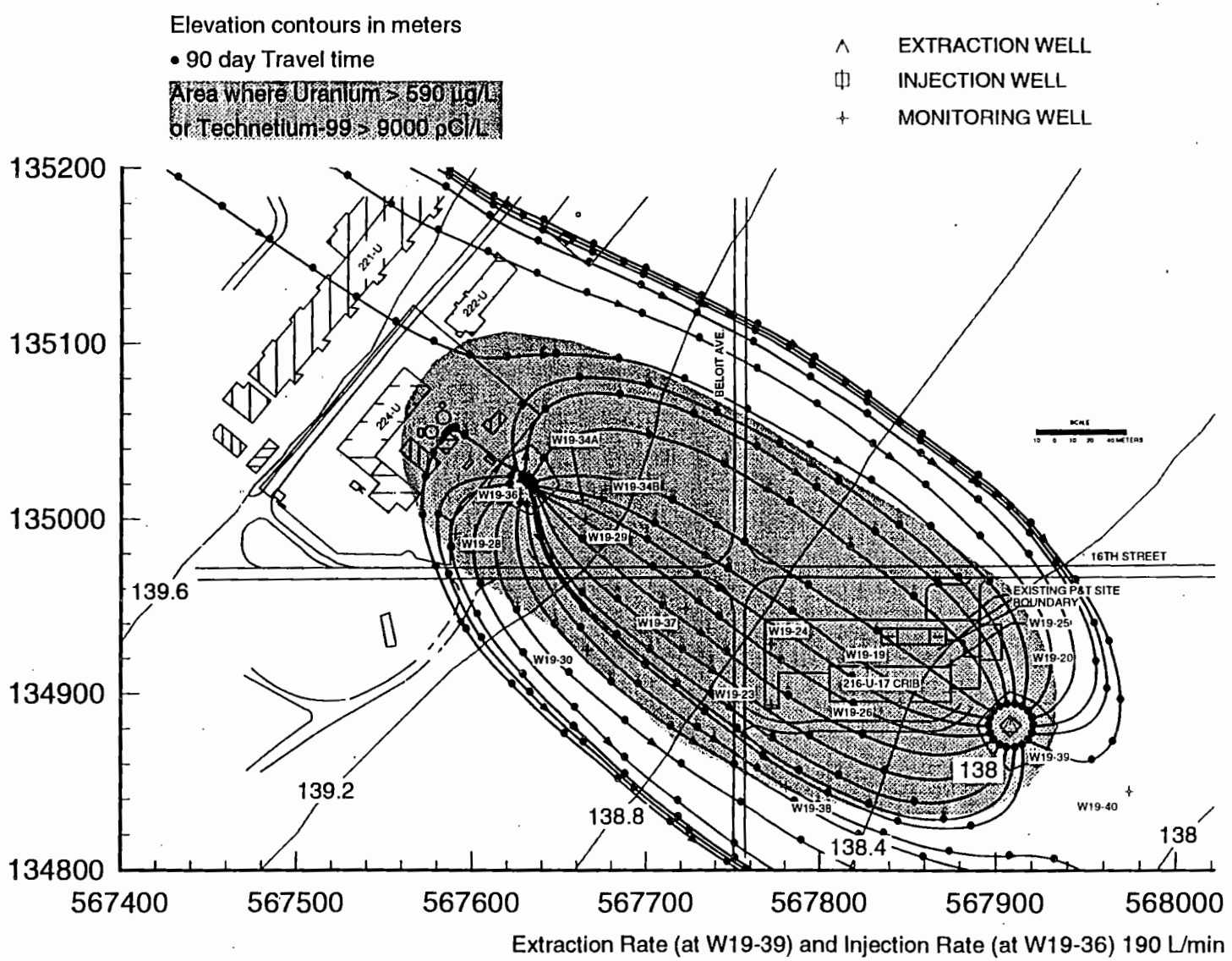
4.5 PUMP AND TREAT

The alternative of pump and treat is retained for further evaluation because it is considered to be readily implementable and may be able to achieve the interim remedial objectives of containing the concentrated portion of the plume, extracting contaminants from the area of highest concentration, and providing information necessary for final remedy development. Pump-and-treat technologies are considered the primary proven technology available to contain, remove, and treat contaminants in groundwater. Two phases are proposed: the first phase consists of continued use of the pilot-scale treatment system, as it exists, with a capacity of about 190 L/min (50 gal/min). The second phase would implement the IRM based on a record of decision. Two treatment options for Phase II are described in Sections 4.5.2 and 4.5.3.

Interim remediation would proceed at least until information sufficient to determine a final remedy has been obtained. Such information would define the effectiveness and permanence of the removal action. These data will be used to set final cleanup standards and to define key site conditions and mechanisms that could limit restoration potential. It is expected that with reinjection, approximately four years are required to remove one pore volume and to obtain the necessary data for final remediation.

This approach would create a hydraulic containment zone in the area of highest nitrate, uranium, and technetium-99 contamination (greater than the 450,000 μg/L, 590 μg/L, and 9,000 pCi/L isopleths, respectively). This target plume is an elliptically shaped area (0.05 km^2) downgradient of the uranium and technetium-99 contamination sources (the 216-U-1 and 216-U-2 Cribs) (Figure 3). These isopleths represent 590 μg/L and 9,000 pCi/L contours for uranium and technetium-99 and coincidentally represent an ILCR of approximately 10^{-4}. This area is targeted because it contains the highest concentrations of dissolved contamination in the aquifer, is limited in areal extent, and therefore provides the best opportunity to control local plume migration and reduce contaminant mass. Specifically, the target plume contains about 57% and 21% of the total inventory of dissolved uranium and technetium-99, respectively, but covers only 7% of the total plume area [these values are revised values from the IRM Proposed Plan (DOE-RL 1995b)]. This proposal addresses uranium, technetium-99, and carbon tetrachloride contamination. Other contaminants are known to be present (i.e., nitrate) and would be treated with one of the two Phase II treatment options.

Figure 3. Capture Zone Analysis for Existing Phase I Pumping.



Earlier analyses in the IRM Proposed Plan (DOE-RL 1995b) indicated that as much as 450 L/min (120 gal/min) would be required to contain the target plume. Reanalysis of the capture system, using aquifer parameters derived from the site-specific aquifer test and an up-to-date configuration of the water table, indicates that 190 L/min (50 gal/min) will contain and capture the target plume and attain the IRM objectives. Based on numerical modeling of the contaminant plume, it is estimated that containment and remediation of the major high-concentration portion of the target plume to MCLs would require multiple exchanges or flushes of water through the area of the target plume. These exchanges should reduce the currently dissolved uranium in the concentrated portion of the plume. Technetium-99, because of its greater mobility, should be reduced more quickly.

4.5.1 Phase I Treatment

As part of the current treatability study, which began March 31, 1994, groundwater is being extracted, treated, and reinjected using the pilot-scale treatment system. The pilot-scale treatment system was upgraded from a 57-L/min (15-gal/min) to a 190-L/min (50-gal/min) flow rate in September 1995 and would continue as the Phase I system under the record of decision. The Phase I treatability operation will continue until the start of Phase II operations.

The 200-UP-1 treatability system uses existing wells to provide contaminated water for ion exchange and GAC treatment. Ion exchange is used to remove technetium-99 and uranium; GAC is used to remove carbon tetrachloride. Reinjection of the treated water provides a measurable front of "clean" water to assess the movement of contaminants within the aquifer system.

Continued operations will provide additional engineering data for further optimization of the treatment system. During this period, plume monitoring will continue and may include the installation of additional monitoring and backup production wells. Information to be gained during this initial phase includes further optimization of groundwater withdrawal and return rates; optimizing pumping, injection, and monitoring well placement; and refining the knowledge of contaminant distribution within the aquifer. The existing system does not include nitrate treatment capability; thus, nitrate will not be addressed. However, the treatment of carbon tetrachloride is being addressed in this phase.

4.5.2 Phase II Treatment Option A: 200 Area Effluent Treatment Facility

Extracted water from the 200-UP-1 Operable Unit could be pumped to the Liquid Effluent Retention Facility (LERF) and subsequently treated at the existing Effluent Treatment Facility (ETF). Both of these facilities are located in the northeast corner of the 200 East Area. The ETF, originally designed to treat process condensate from the 242-A Evaporator and two Plutonium/Uranium Extraction (PUREX) facility waste streams, is potentially capable of treating contaminated groundwater. The feasibility a cost effectiveness of treating groundwater at the ETF under CERCLA authority needs to be verified by treatability studies.

The ETF process consists of a main treatment train, which discharges treated water, and a secondary treatment train, which results in dry powder drums of concentrated contaminants. Treated effluent is discharged from verification tanks to the state-approved land disposal site (SALDS) north of the 200 West Area. The SALDS was chosen for its slow local groundwater migration rate, which will allow tritium in the effluent to decay before reaching the Columbia River. Technology for large-scale tritium treatment does not presently exist.

The ETF main treatment train can be reconfigured as needed to process a wide variety of dilute low-level radioactive and nonradioactive wastewater streams. Pilot plant testing (WHC 1993) demonstrated the capabilities of ETF's individual treatment systems on a series of nonradioactive surrogate feeds. The ETF has been treating radioactive 242-A Evaporator process condensate since facility startup in December 1995.

The pilot plant testing showed that dissolved nitrates competitively absorb ultraviolet (UV) light, thus high nitrate concentrations limit the effectiveness of the ultraviolet/oxidation (UV/OX) system for destruction of some organic compounds. Further studies of carbon tetrachloride destruction in the presence of various nitrate levels (WHC 1995) verify that the carbon tetrachloride destruction rate is inversely proportional to the nitrate level. The pilot plant tests indicated that an extended UV/OX residence time is required to meet the MCL for carbon tetrachloride at 200-UP-1 concentration levels. Carbon tetrachloride concentration levels up to 470 μg/L have been observed in 200-UP-1 groundwater. Carbon tetrachloride is known to be difficult to oxidize. The required residence time exceeds that of ETF's existing UV/OX system. The required residence time may be reduced if nitrate concentrations can be reduced prior to entering the UV/OX system. Carbon tetrachloride destruction rates would be verified during the recommended treatability test.

To support the treatment of 200-UP-1 groundwater, the main treatment trains would be reordered from their present configuration so that a significant portion of the nitrates is removed by reverse osmosis prior to carbon tetrachloride destruction in the UV/OX system. The proposed system order is as follows:

- Rough filter - remove coarse suspended solids from effluent
- pH adjustment tank - adjust pH for reverse osmosis and carbonate removal
- Fine filter - remove fine particulates
- Degas column - remove dissolved carbon dioxide
- Reverse osmosis - remove dissolved solids, including nitrates
- Surge tank - collect reverse osmosis output and receive condensed overheads from evaporator and thin film dryer in secondary treatment train
- UV/OX - destroy organics, principally carbon tetrachloride
- Peroxide decomposer - remove residual peroxide from UV/OX
- Effluent pH adjustment tank - adjust effluent pH for discharge
- Verification tanks - retain effluent until quality is confirmed, supply purified water to ETF systems, discharge treated effluent to SALDS.

Because ETF pilot plant testing employed nonradioactive feed simulants, uranium and technetium-99 removal were not tested. However, data for similar chemical species indicate that uranium and technetium may be removed with at least 95% efficiency on a single pass through reverse osmosis. The ion-exchange polishers may drive overall removal to greater than 99%. ETF removal efficiencies

will need to be demonstrated through comprehensive testing of the ETF treatment processes using actual 200-UP-1 groundwater.

Under the ETF treatment option, water from the 200-UP-1 extraction wells would be pumped via an existing underground pipeline to the LERF, where it would be accumulated for treatment in the ETF. The functional capacity of treating 200-UP-1 groundwater is 300 L/min (80 gal/min). Additional piping would need to be installed to complete the connection. The transfer line must meet the substantive design requirements of the *Resource Conservation and Recovery Act* (e.g., dual-containment pipeline with leak detection) unless the Washington State Department of Ecology (Ecology)/EPA determines otherwise under appropriate regulatory authorities.

Secondary waste (dry powder) resulting from 200-UP-1 groundwater treatment may be disposed of in low-level mixed waste trenches, or at the Environmental Restoration Disposal Facility (ERDF) if the waste can be cost-effectively segregated from secondary waste generated by other ETF feed streams and if it meets ERDF waste acceptance criteria.

4.5.2.1 With Reinjection of Water Within the Plume. Under this scenario, water from an outside source would be reinjected within the plume. The hydrologic effects of such injection are described in Section 6.2. Two sources of water have been identified: untreated Columbia River water from the 200 West Area raw water system and treated Columbia River water from the 200 West Area potable water system. Geochemical differences between groundwater and Columbia River water are present in both options. Columbia River water is low in dissolved solids (1994 average 78 mg/L [PNL 1995]) and high in dissolved oxygen (1994 average 12.0 mg/L [PNL 1995]). Average groundwater dissolved solids are approximately 320 mg/L in the vicinity of the 200-UP-1 system. Dissolved oxygen was monitored during the treatability study and found to be 4 to 6 mg/L.

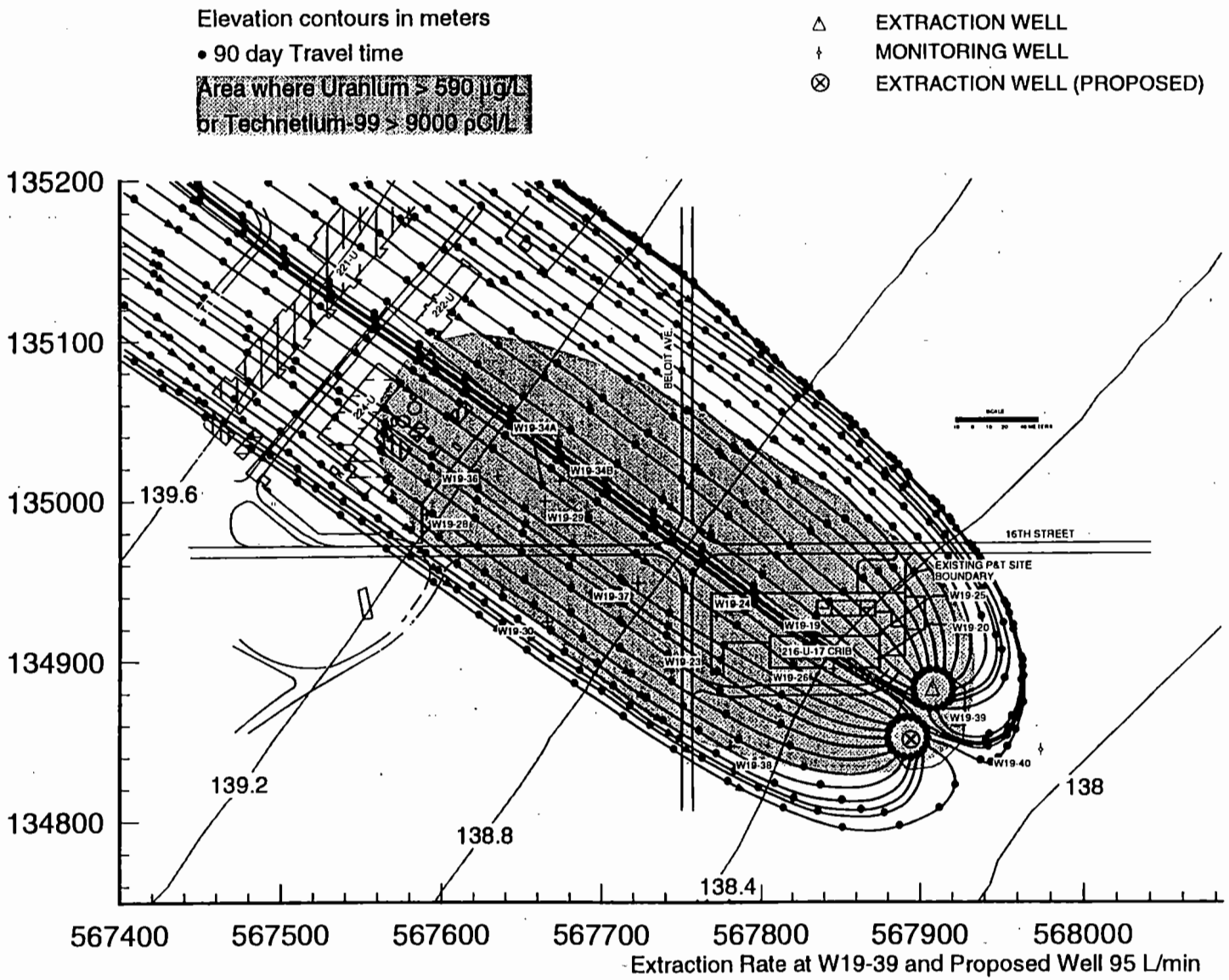
Reinjection using raw Columbia River water is an alternative. However, without treatment, micro-organisms will be introduced to the aquifer that are likely to cause plugging of the well screen/filter pack and near well sediments. A problem with iron-reducing bacteria occurred in the operable unit during treatability testing, and well remediation was required to control it. Reinjection of treated Columbia River water is possible from a bacteriological standpoint. For either case, water lines to the injection well(s) would have to be constructed.

4.5.2.2 Without Reinjection of Water Within the Plume. Under this scenario, water would not be reinjected within the plume. Numerical analysis of this scenario is shown in Figure 4. Extraction without reinjection may require additional time to meet IRM objectives.

4.5.3 Phase II Treatment Option B: 200-UP-1 Onsite Treatment Facility

Under this option, the existing pilot-scale system would be upgraded to provide for double containment and automated operation. The treatment system would be placed in a permanent building to provide protection from the weather and containment of fluids in the unlikely event that a tank should rupture. External piping runs would be double contained with leak detection and buried to provide frost protection.

Figure 4. Pump and Treat Without Reinjection.



The treatment system consists of one main treatment train. The extracted groundwater passes through the treatment train in the following order:

- Influent storage tank: Accumulates extracted groundwater for treatment
- Pretreat filter: Removal of suspended solids from groundwater
- Ion-exchange treatment: Removes uranium and technetium-99
- GAC treatment: Removes carbon tetrachloride
- Effluent storage tank: Accumulates treated water for reinjection
- Post-treat filter: Removes suspended solids from treated water prior to reinjection.

Under this option, the treated water would be reinjected on the upgradient end of the plume. Disposal using a trench in the same area as the existing injection well(s) has been eliminated based on spatial requirements. Spent ion-exchange resins will be removed from the columns, drained, and appropriately packaged for disposal at the low-level mixed waste trench or ERDF, which is currently under construction. Spent carbon will either be regenerated or disposed of at an approved facility.

The current treatment system has been proven to have greater than 99% removal efficiency for uranium, technetium-99, and carbon tetrachloride as documented in the treatability test report for the 200-UP-1 Operable Unit (DOE-RL 1995a).

A bench-scale treatability test evaluating the effectiveness of biodenitrification was performed by Brown (1995). This test showed that biodenitrification would be a successful method for removing nitrate from 200-UP-1 groundwater. The process was eliminated from consideration due to its initial capital cost and the minor impact treatment would have on the overall nitrate plume.

5.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

CERCLA requires that remedial alternatives be evaluated against nine criteria: (1) overall protection of human health and the environment; (2) compliance with federal and state regulations; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume through treatment; (5) short-term effectiveness; (6) implementability; (7) cost; (8) state acceptance; and (9) community acceptance. Based on the preliminary screening of alternatives in Section 4.0, only the no-action and the pump-and-treat alternatives are retained for detailed evaluation. This is consistent with the CERCLA statute, as EPA guidance (EPA 1989) recognizes that such a limited number of alternatives may be acceptable when considered for purposes of taking interim actions.

5.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This criterion evaluates whether the alternative achieves adequate overall elimination, reduction, or control of risks to human health and the environment posed by the likely exposure pathways. It is a summary check that takes into account the other criteria and includes an evaluation of short-term and cross-media impacts.

The no-action alternative provides no additional protection of human health and the environment, except by attenuation of the contaminant plumes over an extended period of time. The plumes will migrate and result in additional groundwater being contaminated.

The pump-and-treat alternative would provide overall protection of human health and the environment in accordance with the cleanup goals identified for the IRM. Implementing the pump-and-treat alternative would minimize the potential for further migration of the high-concentration portion of the plume and remove contaminant mass from the groundwater, thereby reducing the potential risks associated with this plume. Although either Phase II treatment option provides adequate protection, the ETF treatment option would treat for a greater range of contaminants than the proposed 200-UP-1 upgrade system (e.g., nitrate). The onsite treatment system could be modified to treat other contaminants. The ETF treatment option may pose a greater risk of releases due to the transport of contaminated water over a distance of several miles to the treatment location. This risk can be mitigated by using a double-contained pipeline or other technology-based measures (such as a single-contained pipeline with inventory monitoring and pressure testing). Neither the 200-UP-1 upgrade system nor the ETF treatment system will have a significant adverse impact on human health or the environment.

5.2 COMPLIANCE WITH FEDERAL AND STATE REGULATIONS

This section provides a general discussion of applicable or relevant and appropriate requirements (ARARs) pertinent to the proposed IRM activities. ARARs are standards, requirements, criteria, or limitations promulgated under federal or state law that must be met or waived for remedial actions conducted under CERCLA authority (Sec. 121(d)). The substantive provisions of requirements that are ARARs must be met (or waived) for remedial actions conducted entirely onsite (Sec. 121(d)(2)), however, such onsite actions are exempted from obtaining federal, state, and local permits (Sec. 121(e)(1)). In accordance with 40 CFR 300.430(f)(1)(ii)(C), there are six conditions under which an ARAR may be waived. One of these is the interim action waiver, which is for a temporary action that does not attain all ARARs, but which will be followed by measures that will complete the cleanup and attain all ARARs. Waivers apply only when an action is conducted onsite.

A list of potential ARARs for remedial actions in the 200 West Area of the Hanford Site was previously identified in the AAMSR (DOE-RL 1992). The major requirements pertinent to an interim action at the 200-UP-1 Operable Unit are the dangerous waste management standards, the Model Toxics Control Act (MTCA) cleanup standards (including references to safe drinking water standards), state underground injection standards, state waste discharge standards, and air emission standards. These are described further in the sections below.

CERCLA Section 104(d)(4) states where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the President may, at his discretion, treat these related facilities as one for purposes of this section. The preamble to the NCP clarifies EPA's stated interpretation that when noncontiguous facilities are reasonably close to one another and waste at these sites are compatible for a selected treatment or disposal approach, CERCLA Section 104(d)(4) allows the lead agency to treat these related facilities as one site for response purposes and, therefore, allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit.

The ETF, originally designed to treat process condensate from the 242-A Evaporator in support of tank farm operations and two PUREX waste streams, has the capability to treat contaminated groundwater from adjacent 200 Area groundwater plumes. Furthermore, the comprehensive design of the ETF and LERF will allow treatment of extracted water from contaminant plumes in the 100, 200, and 300 Areas.

Similarly, the potential discharge point for the treated groundwater, the SALDS, is capable of receiving a range of treated groundwater streams. Although the discharge point is not located within a groundwater plume, it is located at the most suitable site in close proximity to the plumes, given the need to avoid mobilizing existing soil contamination. Therefore, the ETF, LERF, SALDS, and the groundwater plumes in the 100, 200, and 300 Area NPL sites are considered to be a single site for response purposes.

5.2.1 No-Action Alternative

The no-action alternative invokes no ARARs that need to be satisfied. Under the no-action alternative, uranium and technetium-99 would continue to migrate, causing the contaminant plume to expand. Current monitoring would continue.

5.2.2 Pump-and-Treat Alternative

A 200-UP-1 treatment system would comply with most chemical-, action-, and location-specific ARARs. A waiver is requested for relief from certain design standards as described in Section 5.2.2.1. A waiver is requested in Section 5.2.2.2 with respect to underground injection standards.

5.2.2.1 Dangerous Waste Management Standards. The provisions of *Washington Administrative Code* (WAC), Chapter 173-303, "Dangerous Waste Regulations," would be applicable to management and treatment of the groundwater at 200-UP-1 because of the presence of carbon tetrachloride in the groundwater. The carbon tetrachloride was associated primarily with Z Plant separation and reprocessing activities. Because a small fraction of the carbon tetrachloride was used for degreasing, the dangerous waste regulations require the groundwater contaminated by the carbon tetrachloride to be managed as a listed dangerous waste. There are no de minimis values for listed wastes, so wastes and environmental media contaminated by the carbon tetrachloride must be managed as dangerous wastes, regardless of the concentration of carbon tetrachloride. Therefore, the extracted groundwater and any secondary wastes resulting from treatment would be designated as listed wastes until an appropriate regulatory determination is made that the media no longer contain listed waste. The basis for approval generally requires a demonstration that contaminants do not exceed health-based levels.

The Phase I treatment system does not meet the dangerous waste standard for secondary containment for tank and piping systems. However, because Phase I is a continuation of the treatability test and operation is of short duration, an interim action waiver is requested to allow continued operation of the existing Phase I system until a Phase II treatment system has been selected, designed, and implemented. The Phase II system will be designed to meet the requirements for secondary containment.

The Phase II 200-UP-1 onsite treatment system will provide double containment for all tanks and ancillary equipment (e.g., pumps, piping, valves) and otherwise meet all substantive requirements of the dangerous waste regulations. Secondary wastes derived from both the Phase I and Phase II 200-UP-1 onsite treatment system, including spent ion-exchange resins and GAC, would be managed as dangerous waste. If any secondary wastes meet the waste acceptance criteria for disposal at the ERDF, they may be disposed of there. Otherwise, they will be transported to a permitted facility for appropriate treatment and final disposal.

The ETF treatment alternative would comply with the substantive requirements of the dangerous waste regulations. These regulations would typically require that contaminated groundwater be transported

from the 200 West Area to the ETF via either a double-contained pipeline or by tanker truck. However, a technology-based variance from the requirement for secondary containment may be granted by EPA if it is demonstrated that an alternative transport system (such as the existing single-walled pipeline combined with inventory monitoring and pressure testing) is as reliable as secondary containment. Secondary wastes derived from ETF operations, including spent ion-exchange resins, are planned to be managed as dangerous waste. Secondary waste resulting from processing the 200-UP-1 groundwater may be disposed of in the ERDF, if it can be segregated in a cost-efficient manner and meets ERDF waste acceptance criteria. Otherwise, it will be transported to a permitted facility for appropriate treatment and final disposal.

The dangerous waste regulations would not be ARARs for disposal of treated groundwater from ETF to the SALDS. A federal delisting petition was approved by EPA for wastewater treated at the ETF (DOE-RL 1993). The petition reflects the ETF treatment technologies designed to eliminate dangerous characteristics of the waste and to delist the effluent in accordance with the requirements found in 40 CFR 260.20 and 260.22. The petition demonstrated that treatment at the ETF would reduce contaminant concentrations to below health-based standards for both the originally expected ETF waste streams and for a range of other potential waste streams, including category F001 spent solvents (such as carbon tetrachloride). The delisting petition is presumed to meet the substantive requirements for state delisting, as a prerequisite to receiving the State Waste Discharge Permit issued by Ecology for the ETF. Treatment of the 200-UP-1 contaminated groundwater would meet the substantive provisions of the delisting petition and, therefore, the groundwater would no longer be regulated as a dangerous waste following treatment.

5.2.2.2 MTCA Cleanup Standards. MTCA is a chemical-specific ARAR that establishes goals for remediation of groundwater (WAC 173-340). Under MTCA, the final remediation goals for groundwater are generally MCLs and non-zero MCL goals established under the SWDA, where such values are available. These goals may not be met during the IRM, although the final remedy for the 200-UP-1 Operable Unit will address these goals at the time of final remedy implementation. In the preamble to the NCP, EPA acknowledges the situation where "chemical-specific ARARs used as remediation goals, such as MCLs as ARARs for groundwater remediation, cannot be attained during implementation [of the interim action]." (55 Federal Register [FR] 8755). In such cases, EPA "recognizes that ARARs that are used to determine final remediation levels apply only at the completion of the action." Inasmuch as this action is an ongoing remediation effort, cleanup standards such as MCLs are considered ARARs to be met at completion of the final remedy.

5.2.2.3 Underground Injection Standards/Waste Discharge Standards. The land disposal restrictions of WAC 173-303 (which incorporates by reference 40 CFR 268) and the provisions of WAC 173-218, "Underground Injection Program," are applicable to reinjection of groundwater treated both in Phase I and in the Phase II 200-UP-1 upgrade alternative. The treated effluent at the 200-UP-1 site will not meet the state standards for reinjection. The federal injection program regulations incorporate provisions to allow reinjection where it would facilitate CERCLA cleanups, but the state injection program regulations do not incorporate those provisions. Therefore, an interim action waiver of the state discharge standards will be required to allow reinjection of water treated in Phase I and under the 200-UP-1 upgrade system in Phase II. These treatment systems will achieve substantial reduction in the hazardous constituents; reinjection will not cause further expansion of the plume; there is no current use of the groundwater so there is no loss of protection of human health or the environment; and the final remedy will address all ARARs.

One option is available for disposal of treated effluent from the ETF, the SALDS. This facility involves discharge of treated wastewater to the ground via infiltration. It is permitted under

WAC 173-216. Discharge of the treated 200-UP-1 groundwater at this facility has been determined to be "onsite" for response purposes. Therefore, only the substantive requirements for discharge of the treated groundwater at the facility apply. Discharge of 200-UP-1 groundwater following treatment at the ETF would comply with all substantive requirements of the SALDS permit, including volume and constituent concentration limits. As discussed in the previous section, the discharge of treated 200-UP-1 water would meet the substantive delisting requirements and therefore would meet the state discharge standards. Therefore, the ETF treatment alternative would comply with all ARARs for waste discharge.

5.2.2.4 Air Emission Standards. Provisions of 40 CFR 61, Subpart H, and WAC 246-247 are ARARs for emissions of radionuclides from the various treatment systems. These regulations specify that radionuclide airborne emissions from all combined operations at the Hanford Site may not exceed 10 mrem/yr effective dose equivalent to the hypothetical offsite maximally exposed individual. WAC 173-460 is an ARAR for emissions of hazardous constituents and establishes acceptable source impact levels for more than 500 carcinogenic and acutely toxic air pollutants.

The radionuclide and hazardous constituent emission requirements would apply to all fugitive, diffuse, and point source air emissions generated by any of the treatment alternatives. If the alternative generated an increase of toxic air pollutants to the atmosphere above the small quantity emission rates, implementation of Best Available Control Technology for Toxics would be required. The Phase I system and Phase II 200-UP-1 onsite system would be closed to the atmosphere, and it is anticipated that air emissions will not exceed the small quantity threshold.

The ETF will operate under Notices of Construction (NOC) approved under WAC 246-247 and WAC 173-460. Treatment of 200-UP-1 groundwater at ETF has been determined to be "onsite" for purposes of this IRM. Therefore, only the substantive air emission requirements apply. Treatment of the 200-UP-1 groundwater would comply with all substantive requirements of the NOCs and therefore would comply with all ARARs for air emissions.

5.2.2.5 Other ARARs. Other ARARs pertinent to treatment of the groundwater at the 200-UP-1 system include the requirements related to earth-disturbing activities and the siting, construction, and operation of new facilities. These would include requirements of the *Endangered Species Act of 1973*, as amended, and the protective requirements for significant cultural resources as identified in statutes such as the *National Historic Preservation Act*, *Archaeological Resources Protection Act*, *American Indian Religious Freedom Act*, and the *Native American Graves Protection and Repatriation Act*. Biological and cultural resource surveys have been performed within the 200-UP-1 Operable Unit. Based on these surveys, it has been determined that a treatment system located within that area would not adversely affect any significant natural or cultural resources at the operable unit. A survey would be performed for any new intrusive activity (e.g., installation of double containment for the pipeline to ETF), surveys would be performed not covered under existing surveys, to ensure that there continue to be no significant adverse effects to biological or cultural resources. Therefore, the pump-and-treat alternative would be in compliance with other ARARs.

Because the ETF is an existing facility, location-specific requirements for siting and operating new facilities (e.g., the *Archaeological Resources Protection Act*) are not ARARs. However, if groundwater is extracted and treated at ETF, raw or treated water might be reinjected at the 200-UP-1 Operable Unit in order to maintain a balanced hydrogeologic regime. If water is injected, other ARARs would include the injection regulations of WAC 173-216.

5.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

The long-term effectiveness and permanence criterion assesses whether the alternatives leave an unacceptable risk after the conclusion of remedial activities. The no-action alternative would effectively reduce risk in the very long term through natural attenuation; however, the time necessary to achieve this risk reduction is many hundreds of years. Until natural attenuation is achieved, the potential risk to human health and the environment would likely increase as the plume migrates. The pump-and-treat alternative would not, by itself, achieve long-term effectiveness and permanence for the entire plume. Containment of the high-concentration area of the plume will reduce risk resulting from plume migration. In addition, removal of contaminants would provide a measure of long-term and permanent reduction in risk by removing a significant portion of the total mass that contributes to those risks. Pump and treat is consistent with potential final remedies and could improve the likelihood for those final remedies to achieve long-term effectiveness and permanence.

5.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

This criterion, reducing the toxicity, mobility, or volume via a treatment alternative, assesses whether the alternative permanently and significantly reduces the hazard posed. This is accomplished by destroying the contaminants, reducing the quantity of contaminants, or irreversibly reducing the mobility of the contaminants.

The no-action alternative provides no immediate reduction of toxicity, mobility, or volume through treatment. The plume volume is expected to increase in size as groundwater movement displaces it. Toxicity would be reduced as the plume disperses, but this will require hundreds of years to reach the MCLs.

The pump-and-treat alternative with reinjection would restrict the movement of the plume and would provide immediate reduction of the contaminant mass in the aquifer. Extracted groundwater would be treated to remove contaminants, thereby reducing the toxicity of the groundwater in the high-concentration area of the plume. Contaminants removed during treatment would be concentrated (e.g., in spent resin) in a stable waste form. Carbon tetrachloride will be destroyed via UV/OX or captured in GAC, which may then be disposed of or regenerated (i.e., carbon tetrachloride would be destroyed).

The pump-and-treat alternative without reinjection, as discussed in Chapter 4.0, would partially restrict the movement of the plume and would provide immediate reduction of the contaminant mass in the aquifer. As above, the extracted groundwater would be treated to remove contaminants. Contaminants removed during treatment at ETF would be concentrated and subsequently stabilized in a dry waste form. Carbon tetrachloride, passing the concentration stage, would be destroyed via UV/OX.

5.5 SHORT-TERM EFFECTIVENESS

The short-term effectiveness criterion assesses whether the alternatives provide adequate protection to human health and the environment during the remedial action and how long it will take for the action to achieve the established objectives. Because the groundwater in the 200 West Area is not currently used as a source of drinking water, there is no immediate risk to human health. However, under the no-action alternative, the plume will continue to migrate, increasing the affected area and creating a

potential threat to human health and the environment. The time for the no-action alternative to achieve restoration of the aquifer to acceptable levels is extremely long.

The greatest hazard associated with normal operation of either treatment system is to workers. Potential exposure would occur when spent ion-exchange resin or other secondary concentrated waste streams are being handled. The ETF option introduces additional potential chemical hazards because chemicals are required by the proposed treatment processes. The risk to the worker is mitigated by using personnel protective equipment and following radiation work procedures and site safety plans. The pump-and-treat alternative does not present a significant risk to human health and the environment because it would be implemented in a manner that is protective of workers and the environment.

The ETF treatment option poses short-term risk to the environment due to the transport of contaminated water over a significant distance (approximately 10 km). This risk can be mitigated by using a double-contained pipeline or other technology-based measures.

5.6 IMPLEMENTABILITY

The implementability criterion assesses whether the alternatives are technically and administratively feasible. The no-action alternative is implementable. The Phase I pump-and-treat system is in place and is therefore implementable. The Phase II pump-and-treat system could be implemented without administrative difficulty using available technology and a low level of construction activity regardless of the treatment option.

The ETF treatment option could be implemented with additional construction of several miles of double-contained pipeline. An existing single-walled pipeline may be used if a technology-based variance from secondary containment requirements is granted by Ecology. A treatability test will be necessary to provide assurance that the ETF is capable of fully treating the 200-UP-1 waste stream. Because of the uncertainties for issuance of an interim record of decision, the continuation of the existing Phase I pump-and-treat system, and the time required to design, procure, and construct ETF pipeline extensions, implementation of the ETF option may not be completed prior to accomplishing a significant portion of the IRM remedial objectives.

It is not completely certain that the remedial objective of containment could be achieved by the pump-and-treat alternative; however, remediation simulations using computer models indicate that it is feasible. The primary contaminants of concern are highly soluble and are conservatively expected to be flushed from the high-concentration portion of the aquifer using reinjection pump and treat within a reasonable time.

5.7 COST

The cost criterion evaluates the cost effectiveness of the alternatives and associated treatment options. The no-action alternative invokes no additional costs. Cost estimates for the treatment options were prepared based on historic costs for operating the 200-UP-1 Phase I treatment system. Treatment costs associated with operation of the ETF were estimates provided by Westinghouse Hanford Company (WHC). The cost estimates provided by WHC for the ETF options assume that a variance to secondary containment requirements is granted by Ecology. Specifically, the ETF costs assume that an existing single-walled pipeline can be used to transfer the contaminated groundwater from the 200-UP-1 site to ETF. The new portions of pipeline required are also assumed to be single-walled. If

a technical equivalency variance is not obtained, a double-walled pipeline would need to be installed at an additional estimated cost of $1.6 million. The ETF costs also assume that the 200-UP-1 water can be treated in a single pass.

Each treatment option assumes secondary waste disposal at the low-level mixed waste trenches in the 200 West Area. Significant waste disposal cost savings may be realized if the ERDF is used.

The estimated costs for each option are provided in Tables 2 through 4.

5.8 STATE ACCEPTANCE

The state acceptance criterion evaluates whether the technical and administrative concerns of the state have been addressed. The no-action alternative does not meet the concern expressed by the state regarding the continued migration of contaminants in groundwater at the Hanford Site. The pump-and-treat alternative has generally been accepted by the State of Washington.

5.9 COMMUNITY ACCEPTANCE

The community acceptance criterion evaluates how the alternatives address the concerns of the local community. The local community has expressed concern regarding the continued migration of contaminants in groundwater at the Hanford Site. The no-action alternative does not address these expressed concerns. The pump-and-treat alternative was first proposed as part of the Fourth Amendment to the Tri-Party Agreement and received favorable public comments. Additional community acceptance of the alternative was evaluated during the prior public comment period on the 200-UP-1 IRM Proposed Plan. With only a few exceptions, the community was in favor of the proposed interim remedial measure for the operable unit. Community acceptance discussions focused primarily on the treatment systems, not on the need to take action. As a result of that public meeting, this plan has been revised to include treatment of water at the ETF. If the ETF treatment option is determined to be the preferred option, the IRM Proposed Plan will be revised accordingly and additional public comment will be requested.

6.0 PREFERRED INTERIM REMEDIAL ALTERNATIVE

The preferred interim alternative is pump-and-treat with reinjection. Selection of a Phase II treatment option will depend on public comment, state agency evaluation, pipeline requirements for transporting 200-UP-1 groundwater to ETF, and performance testing of the ETF using 200-UP-1 groundwater. The primary objectives of the pump-and-treat alternative are to contain the contaminant plumes, extract contaminants from the area of highest concentrations, and to provide information that will be necessary for development of a final remedy that will be protective of human health and the environment. In addition to the pump-and-treat operation, site investigation and other field activities (discussed below) would be conducted during the IRM to assess and optimize the remedial action.

Table 2. Pump-and-Treat Costs Using the Effluent Treatment Facility with Reinjection.

($ x 1000)	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000
Operations and Maintenance[a,b]		1,400	1,400	1,400	233
Consumables (Chemicals, Ion-Exchange Resin)[c]		35	35	35	6
Waste Disposal[d]		600	600	600	100
Process Monitoring/Sampling[e]		130	130	130	22
Utilities[f]		200	200	200	50
Modify Effluent Treatment Facility Process[g]	250				
Connect 200-UP-1 to Transfer Line[h,i]	334				
Connect Transfer Line to Liquid Effluent Retention Facility[h,j]	278				
Pump Groundwater[k,l]	95.9	575.6	575.6	575.6	
Connect Injection Well to Sanitary Water[m]	6.6				
Phase I Onsite Treatment[n]	1,132.4				
Performance Monitoring/Sampling[o]	502.7	502.7	502.7	502.7	
Well Installation[p]	600				
Data Management/Reporting[q]	76.3	76.3	76.3	76.3	
Escalation (2.3%/yr)		81	163.8	248.5	39
Total	3,275.9	3,600.6	3,683.4	3,768.1	450

[a]Groundwater is pumped continuously at 50 gal/min; groundwater to be processed by the ETF at an average of 80 gal/min.
[b]Operations and Maintenance costs are based on fiscal year (FY) 1996 costs. Operations costs include process operations at $115K/mo, engineering support at $22K/mo, radiological control support at $20K/mo, plus G&A at 13%, minus a 15% productivity challenge imposed at the program level. Maintenance costs include corrective maintenance at $35K/mo, material control at $3K/mo, plus G&A at 13%, minus a 15% productivity challenge imposed at the program level.
[c]Includes $25K/yr for sulfuric acid, sodium hydroxide, and hydrogen peroxide; and $10K/yr for ion-exchange resin.
[d]Groundwater at 50 gal/min and 1,000 ppm TDS average produces 3,510 ft^3/yr solid waste; disposal in Westinghouse Hanford Company Low-Level Mixed Waste trench costs $158.95/$ft^3$; drums cost $80/drum and hold 6.62 ft^3/drum when filled to 90% capacity.
[e]Groundwater at 50 gal/min fills 43.3 verification tanks at 600,000 gal/verification tank; sampling for environmental compliance costs $3,000/verification tank.
[f]Electrical cost is energy and demand charges of $30K/mo when ETF is operating, minus energy and demand charges of $10K/mo if ETF is not operating. Assessment to maintain site electrical system is not included as this would be paid by the site regardless of whether groundwater is treated in the ETF.
[g]Includes design/engineering, piping changes, control system reprogramming, procedure updates, and training.
[h]Assumes flow monitoring with leak detection are acceptable alternatives to double-containment.
[i]Includes $89K for construction, $70K for general conditions, $44K for design, $15K for engineering/inspection, $10K for construction management, $4K for quality support, $22K for project management, $3K for general support, and $77K for contingency.
[j]Includes $74K for construction, $58K for general conditions, $36K for design, $13K for engineering/inspection, $8K for construction management, $4K for quality support, $18K for project management, $3K for general support, and $64K for contingency.
[k]Same as Utilities cost for environmental restoration pilot-scale system plus costs for injecting sanitary water (@ 2¢/gal) at 50 gal/min.
[l]FY 1996 cost prorated based on start date of August 1, 1996.
[m]Assumes 300 ft buried pipe from raw water source to injection well, assume water provided at no cost (estimate by ERC).
[n]Phase I operational costs are based on FY 1996 Cost Account prorated for 10 months of operation (October 1995 through July 1996) including operations and maintenance, consumables, waste disposal, process monitoring/sampling, and utilities.
[o]Performance monitoring includes monthly sampling of 12 monitoring wells to assess interim remedial measure (IRM) performance.
[p]Well installation costs include design, procurement, installation, and surveying costs for one extraction, one injection, and one monitoring well.
[q]Data interpretation/reporting includes preparation of quarterly IRM performance reports summarizing process and groundwater data.

Table 3. Pump-and-Treat Costs Using the Effluent Treatment Facility without Reinjection.

($ x 1000)	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
Operations and Maintenance[a,b]		1,400	1,400	1,400	1,400	1,400	233
Consumables (Chemicals, Ion-Exchange Resin)[c]		35	35	35	35	35	6
Waste Disposal[d]		600	600	600	600	600	100
Process Monitoring/Sampling[e]		130	130	130	130	130	22
Utilities[f]		200	200	200	200	200	50
Modify ETF Process[g]	250						
Connect 200-UP-1 to Transfer Line[h,i]	334						
Connect Transfer Line to Liquid Effluent Retention Facility[h,j]	278						
Pump Groundwater[k,l]	8.3	50	50	50	50	50	
Phase I Onsite Treatment[m]	1,132.4						
Performance Monitoring/ Sampling[n]	502.7	502.7	502.7	502.7	502.7	502.7	
Well Installation[o]	400						
Data Management/Reporting[p]	76.3	76.3	76.3	76.3	76.3	76.3	
Escalation (2.3%/yr)		68.9	139.3	211.4	285.1	360.5	60.1
Total	2,981.7	3,062.9	3,133.3	3,205.4	3,279.1	3,354.5	471.1

[a]Groundwater is pumped continuously at 50 gal/min; groundwater to be processed by the ETF at an average of 80 gal/min.
[b]Operations and Maintenance costs are based on fiscal year (FY) 1996 costs. Operations costs include process operations at $115K/mo, engineering support at $22K/mo, radiological control support at $20K/mo, plus G&A at 13%, minus a 15% productivity challenge imposed at the program level. Maintenance costs include corrective maintenance at $35K/mo, material control at $3K/mo, plus G&A at 13%, minus a 15% productivity challenge imposed at the program level.
[c]Includes $25K/yr for sulfuric acid, sodium hydroxide, and hydrogen peroxide; and $10K/yr for ion-exchange resin.
[d]Groundwater at 50 gal/min and 1,000 ppm TDS average produces 3,510 ft^3/yr solid waste; disposal in Westinghouse Hanford Company Low-Level Mixed Waste trench costs $158.95/$ft^3$; drums cost $80/drum and hold 6.62 ft^3/drum when filled to 90% capacity.
[e]Groundwater at 50 gal/min fills 43.3 verification tanks at 600,000 gal/verification tank; sampling for environmental compliance costs $3,000/verification tank.
[f]Electrical cost is energy and demand charges of $30K/mo when ETF is operating, minus energy and demand charges of $10K/mo if ETF is not operating. Assessment to maintain site electrical system is not included as this would be paid by the site regardless of whether groundwater is treated in the ETF.
[g]Includes design/engineering, piping changes, control system reprogramming, procedure updates, and training.
[h]Assumes flow monitoring with leak detection are acceptable alternatives to double-containment.
[i]Includes $89K for construction, $70K for general conditions, $44K for design, $15K for engineering/inspection, $10K for construction management, $4K for quality support, $22K for project management, $3K for general support, and $77K for contingency.
[j]Includes $74K for construction, $58K for general conditions, $36K for design, $13K for engineering/inspection, $8K for construction management, $4K for quality support, $18K for project management, $3K for general support, and $64K for contingency.
[k]Same as Utilities cost for environmental restoration pilot-scale system.
[l]FY 1996 cost prorated based on start date of August 1, 1996.
[m]Phase I operational costs are based on FY 1996 Cost Account prorated for 10 months of operation (October 1995 through July 1996) including operations and maintenance, consumables, waste disposal, process monitoring/sampling, and utilities.
[n]Performance monitoring includes monthly sampling of 12 monitoring wells to assess interim remedial measure (IRM) performance.
[o]Well installation costs include design, procurement, installation, and surveying costs for one extraction and one monitoring well.
[p]Data interpretation/reporting includes preparation of quarterly IRM performance reports summarizing process and groundwater data.

Table 4. Pump-and-Treat Costs Using the Onsite 200-UP-1 Facility.

($ x 1000)	FY1996[a]	FY1997[b]	FY1998[c]	FY1999[c]	FY2000[d]
Operations and Maintenance[e]	559.8	466.5	559.8	560	93.3
Consumables[f]	150	125	150	150	25
Waste Disposal[g]	174.9	145.8	174.9	175	29.2
Process Monitoring/Sampling[h]	424.2	353.5	424.2	424	70.7
Utilities	50	41.6	50	50	8.3
Performance Monitoring[i]	502.7	502.7	502.7	503	83.8
Phase II Process Upgrades[j]	836.2	163.8			
Well Installation[k]	600				
Data Management/Reporting[l]	76.3	76.3	76.3	76	12.7
Escalation (2.3%/yr)		43.1	90.2	136.8	30.8
Total Cost to Treat	3374.1	1918.3	2028.1	2075	353.8

[a]Fiscal year (FY) 1996 activities include 12 months of operating existing system at 50 gal/min (Phase I) and design, and procurement of Phase II system upgrades (e.g., building, double-walled pipeline with leak detection).
[b]FY 1997 activities include 2 months for completion of Phase II system upgrades and 10 months of Phase II operations at 50 gal/min.
[c]FY 1998 and FY 1999 activities include 12 months of Phase II operations.
[d]FY 2000 activities include 2 months of Phase II operations.
[e]Operations and Maintenance costs are based on actual FY 1996 cost accounts and include process operations labor, engineering support, field support, radiological control, site safety, quality assurance oversite, and associated overheads (G&A).
[f]Consumables include ion-exchange resin, granular activated carbon (GAC), process filters and miscellaneous materials for maintenance.
[g]Waste disposal costs include materials (drums, labels, etc.), waste designation and disposal. Disposal costs assume 1,065 ft^3/yr of ion-exchange resin disposed of at the Low-Level Mixed Waste Trenches @ \$160/ft^3 and 75 ft^3/yr of GAC @ \$60/ft^3.
[h]Process monitoring/sampling includes two influent and two effluent samples per 500,000 gal of groundwater treated (analyzed onsite), 2 monthly treatment system efficiency/confirmatory samples analyzed by an independent laboratory (offsite), five samples per month for waste designation (analyzed offsite) and supporting quality assurance/quality control samples. Process monitoring costs also include sample disposal costs.
[i]Performance monitoring includes monthly sampling of 12 monitoring wells to assess interim remedial measure (IRM) performance.
[j]Phase II upgrades include design, procurement, and capital costs associated with secondary containment upgrades including dual contained piping systems, a process building with concrete basin and sump, resin/GAC slurry changeout system, and associated leak detection equipment in FY 1996 (includes 262.5K for design, 529.7K for procurement/capital costs, 157.8K for construction, and 50K to revise operating procedures) (Capital costs for final tie-in activities are accrued in FY 1997).
[k]Well installation costs include design, procurement, installation, and surveying costs for one extraction, one injection, and one monitoring well.
[l]Data interpretation/reporting includes preparation of quarterly IRM performance reports summarizing process and groundwater data.

The following sections present the technical basis for the preferred alternative, conceptualization of the well field, evaluation of the capture zone, criteria for technical evaluation of performance of the pump-and-treat system, and additional proposed activities.

6.1 TECHNICAL BASIS AND SCOPE OF THE PREFERRED ALTERNATIVE

The preferred alternative would create a hydraulic containment zone within the area of highest nitrate, uranium, and technetium-99 contamination (greater than the 450,000 μg/L, 590 μg/L, and 9,000 pCi/L isopleths, respectively) for approximately 4 years with reinjection (Figure 5). This contaminant zone is an elliptical area (0.05 km^2) downgradient of the contaminant source (the 216-U-1 and 216-U-2 Cribs) (Figure 1). These isopleths represent ILCR of approximately 10^{-4}. This area is proposed because it contains the highest concentrations of dissolved contamination in the aquifer, is limited in areal extent, and therefore provides the best opportunity to control local plume migration and reduce contaminant mass.

Containment and mass reduction of the entire nitrate, uranium, and technetium-99 plume are impracticable with current or next-generation technology. The high-concentration portion of the plume, where concentrations are 10 to 30 times the current MCL, contains about 57% and 21% of the total inventory of dissolved uranium and technetium-99, respectively, but covers only 7% of the total plume area (as defined by the uranium and/or technetium-99 concentration greater than MCL).

A small change in the retardation factor or contaminant distribution can significantly affect the time for remediation. Additionally, these estimations of cleanup time do not consider continuing source(s) of contamination (uranium), which could extend or nullify remediation efforts. Remediation times would change in a linear fashion if the input parameters for the calculation are varied. For example, doubling the porosity and the thickness of the contaminated interval quadruples the remediation time. This illustration points to the need for additional, accurate aquifer and contaminant migration data in order to make more reliable estimates of remediation times.

6.2 WELL FIELD CONCEPTUALIZATION/CAPTURE ZONE ANALYSIS

Preliminary design efforts have evaluated actions necessary to create a well field that would meet the remedial action objectives of containing the concentrated portion of the plume in a cost-effective manner and obtaining data necessary to develop a final remedy. The capture of groundwater within this area of high concentration for technetium-99 and uranium would be constrained by the following considerations:

- Minimize the number of wells and pumping rates while maximizing the areal extent of the groundwater capture zone (this optimizes well field efficiency and minimizes associated costs)
- Recirculate as much water as possible within the envelope of the groundwater capture zone to direct the movement of contaminants toward the extraction well(s)
- Limit the time to capture each pore volume of the high-concentration portion of the plume, thereby rapidly reducing the highest concentrations of contaminants to the target levels.

The proposed extraction and injection well screens are assumed to extend through the entire depth [approximately 10 m (30 ft)] of high contaminant concentration.

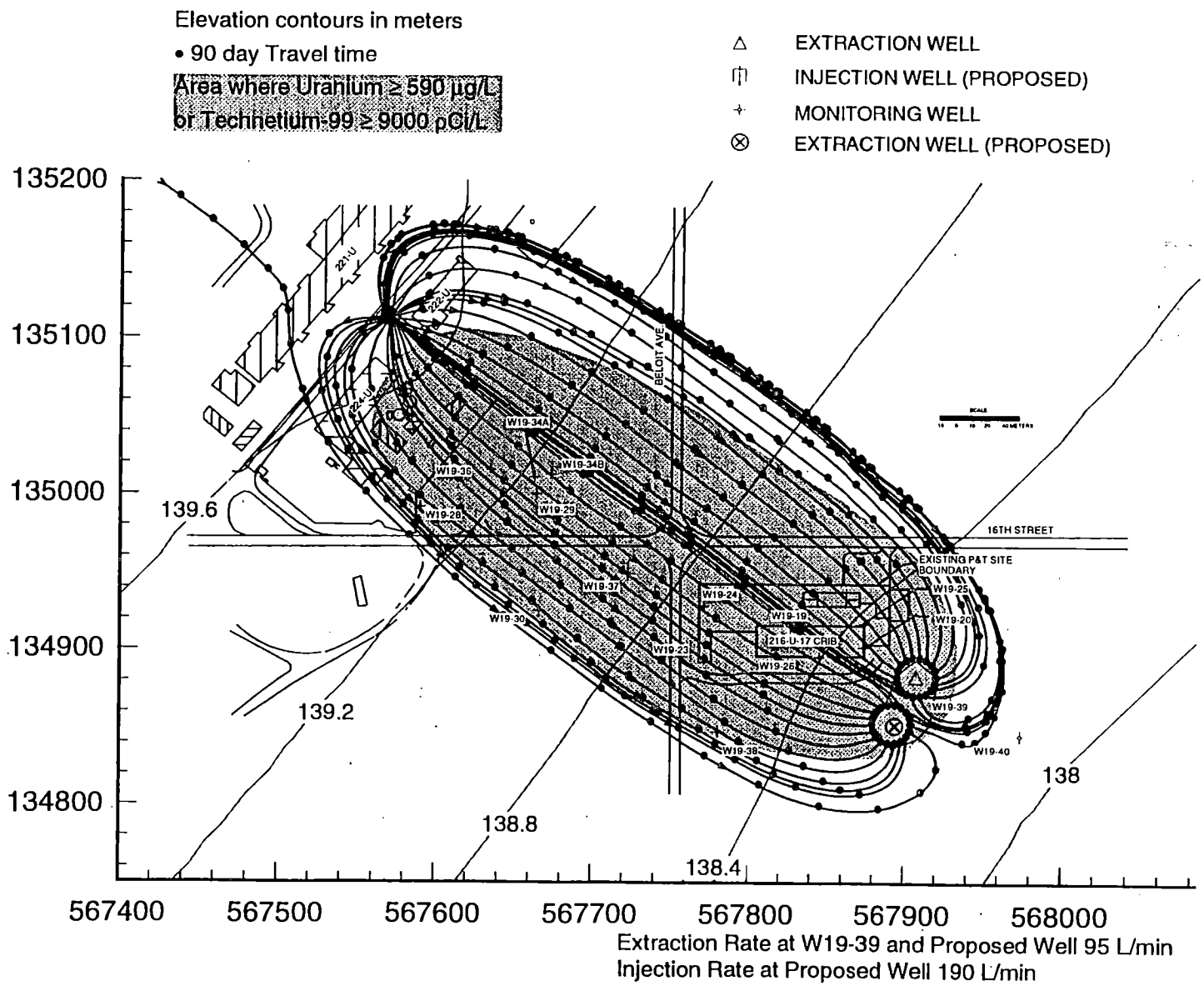


Figure 5. Capture Zone of Preferred Alternative.

One of the primary factors influencing groundwater flow and transport in the area of the 200-UP-1 Operable Unit is the spatial variability in hydraulic conductivity due to lenticular zones of sand, silty sand, silt, and gravelly sands within the aquifer system. The extent and continuity of these lenticular zones has not been extensively characterized to enable prediction of the extent and continuity of the corresponding high and low hydraulic conductivity zones (Kelty et al. 1995). Therefore, for numerical modeling purposes, the aquifer was assigned uniform hydraulic properties. These properties were determined based on a long-term aquifer test of production wells drilled in 1995.

The groundwater capture within the composite target plume of uranium and technetium-99 was characterized using an EPA-accepted, screening-level, three-dimensional groundwater capture zone analysis. The MODFLOW (McDonald and Harbaugh 1988) computer code was used for all simulations of groundwater flow. To determine the areal extent of groundwater capture zones, particle tracking was performed using MODPATH (Pollock 1989). MODPATH uses the output from MODFLOW to track an inert "particle" through the aquifer flow field. Particle tracking assumes no chemical interaction with the aquifer matrix or groundwater and, therefore, no retardation or molecular diffusion of the contaminants in the groundwater flow field. Particle tracking also neglects the spreading of contaminants due to tortuous paths through the aquifer matrix (i.e., mechanical dispersion).

Hydraulic conductivity, boundary conditions, and other input parameters were derived from site-specific aquifer tests and previous studies by Kelty et al. (1994, 1995); Connelly (1994); Thorne et al. (1994); DOE-RL (1993b); Kasza et al. (1993a, 1993b); and Serkowski et al. (1994). The model was configured with three layers and assumed that the extraction and injection wells fully penetrated layer 1 (uppermost layer). Input parameters and conditions for the screening-level numerical model are listed below.

Input Parameters

- Hydraulic conductivity -- 15 m/day (50 ft/day)
- Vertical hydraulic conductivity -- 1.5 m/day (5 ft/day)
- Porosity -- 15%
- Pumping rate -- 190 L/min/well (50 gal/min/well)
- Layer thickness -- 30 m (100 ft) (L2, L3); 10 m (30 ft) (L1)
- Elevation, bottom layer 1 -- 130 m (425 ft) amsl

Model Conditions

- Constant head boundaries
- Steady-state hydraulic field
- Water levels = top of layer 1 (for all layers).

The well field configuration shown in Figure 5 was found to be an efficient scenario for groundwater capture encompassing the target plume for uranium and technetium-99. The model result also shows that one pore volume of groundwater will pass through the high-concentration area of the plume in about 3 years at a 190-L/min extraction rate. Additional scenarios will be modeled to support the IRM.

6.3 PERFORMANCE EVALUATION

Performance evaluation for the IRM pump-and-treat will be based on parameters that are directly measurable during remediation using the proposed extraction and injection scenario. These parameters will be used to assess the effectiveness of the action and judge whether the remedial objectives are being fulfilled.

Performance goals include the following:

- Maintain hydraulic control and contain the high-concentration area of the plume by establishing a hydraulic capture zone in the area of the extraction wells (i.e., capturing the uranium and technetium-99 target plume)

- Prevent uranium and technetium-99 concentrations from increasing downgradient from the containment zone

- Reduce uranium, technetium-99, and carbon tetrachloride to the MCLs prior to reinjection or disposal of treated groundwater

- Obtain data to support development of a final remedy.

A technically successful interim remedy would (1) hydraulically contain the highly contaminated portion of the plume, (2) reduce contaminant concentrations, (3) remove significant contaminant mass, and (4) provide data necessary to develop a final remedy. Therefore, to evaluate the technical success of the preferred alternative during operation and prior to each stage of expansion or alteration, a periodic performance evaluation using the observational approach will be conducted. Several specific technical criteria will be addressed in the evaluation.

- Criterion 1

  Is the well field hydraulically containing and/or intercepting the combined uranium and technetium-99 plume? This evaluation will require estimating the extent of the three-dimensional capture zone. Field measurements to support this evaluation will consist of monitoring water levels in the extraction and monitoring wells. If this criterion is met, the action will have achieved the overall interim goal of containment.

- Criterion 2

  Have contaminant concentrations within or downgradient of the containment zone been stabilized or reduced? Field activities will consist of collecting and analyzing groundwater samples at monitoring wells and extraction wells. Analytical results will be used to plot contaminant concentrations versus time and to evaluate the pump-and-treat system effectiveness.

- Criterion 3

  Is mass removal occurring at a rate that will remove the dissolved contamination in a reasonable period of time and at a reasonable cost? Field and laboratory measurements will include flow rates and contaminant concentration changes over time in the extraction and monitoring wells and evaluation of treatment system effectiveness/efficiency.

- Criterion 4

  Have data been obtained on aquifer and contaminant response to remediation measures sufficient to support a determination of the need for and feasibility of final remedial measures for the Site? The information from the IRM pump-and-treat activity will be developed in an iterative manner, as precise system performance goals justifying continued operations are difficult to predict. However, it is likely that hydrologic factors, contaminant capture factors, or reaching an acceptable level of remediation will determine whether or not the IRM should be continued, terminated, or redirected. The temporal and areal distribution of contaminant concentrations will be used to refine the contaminant transport parameters, to set final cleanup standards, and to establish the technical feasibility of meeting those standards.

- Criterion 5

  Is the treatment system performance meeting the treatment goals? Process monitoring will consist of post-treatment water sampling and analysis. These results will be monitored to ensure the treatment goals are met. In the event the chosen treatment option cannot fully meet MCL requirements, the agencies will be informed and alternate treatment levels or an alternative treatment method proposed.

In conclusion, the remedial objectives and goals will be achieved if the high-concentration plume is hydraulically contained; contaminant mass is removed in a reasonable time frame and at a reasonable cost; contaminant concentrations are reduced, thus stabilizing or shrinking the plume in this area; and the remedial activities and related actions provide valuable information for the final remedy selection.

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APPENDIX A

URANIUM, TECHNETIUM-99, AND NITRATE CONTAMINATION IN THE 200-UP-1 OPERABLE UNIT

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APPENDIX A

URANIUM, TECHNETIUM-99 AND NITRATE CONTAMINATION IN THE 200-UP-1 OPERABLE UNIT

A1.0 SOURCE CHARACTERISTICS

The UO_3 Plant discharged considerable volumes of liquid containing uranium and technetium-99 into five cribs (216-U-1, 216-U-2, 216-U-8, 216-U-12, and 26-U-16) located in the vicinity of the facility (Figure A-1). Although each crib had the potential to impact groundwater, only the 216-U-1, 216-U-2, and 216-U-12 Cribs have been clearly identified as sources of groundwater contamination. The 216-U-1 and 216-U-2 Cribs are the primary sources of the uranium, technetium-99, and nitrate plumes in the 200-UP-1 Operable Unit; the disposal history for these cribs is discussed below. The summary information presented in this section has been distilled from a number of sources, including Delegard et al. (1986), Rockwell (1986), WHC (1986), and DOE-RL (1993).

A1.1 DISPOSAL HISTORY

Process wastewater from the UO_3 Plant, consisting primarily of dilute nitric acid containing uranium, technetium-99, and other fission products, was discharged to the soil column via two cribs (216-U-1 and 216-U-2) between 1951 and 1967. More than 70 pore column volumes of wastewater were discharged, thus easily transporting mobile constituents, particularly technetium-99, to the water table. However, most of the 4,000 kg (8,800 lb) of uranium discharged to the 216-U-1 and 216-U-2 Cribs was retained in the upper 20 m (66 ft) of the soil column as autunite ($Ca(UO_2)_2(PO_4)_2 \cdot 10\text{-}12H_20$), a relatively insoluble phosphate mineral phase. Phosphate was added from uranium recovery operations during the 1950's. Under these conditions the principal uranium species in solution would be a phosphate complex ($UO_2(HPO_4)_2^{2-}$) (Drever 1982), and reaction with calcium (Ca^{2+} or $CaCO_3$) to form autunite would serve as a major retardation mechanism for the transport of uranium through the vadose zone.

During the final years of crib operation (ca. 1966-67), smaller volumes of highly acidic decontamination wastes were disposed. The acid would have served to shift the equilibrium in favor of the solution species and resulted in the dissolution of part of the previously deposited autunite. The volume of process wastes disposed to the cribs was only sufficient to transport a small fraction of the mobile anionic uranium phosphate complex to groundwater, and only low concentrations of uranium were seen in the groundwater monitoring wells near the 216-U-1 and 216-U-2 Cribs during this period. The majority of the dissolved uranium was distributed throughout the soil column beneath the crib with the largest concentration deposited above a caliche layer at about a 50-m depth.

The mobile uranium fraction in the 216-U-1 and 216-U-2 Cribs was later transported (broke through) to groundwater after large volumes of cooling water were discharged to the adjacent 216-U-16 Crib, located less than 60 m (200 ft) away, in 1984. Water from the 216-U-16 Crib spread laterally as a perched water layer. This subsurface water source reached the 216-U-1 and 216-U-2 Cribs and carried the mobilized uranium down to groundwater via preferential pathways (e.g., outside of unsealed well casings adjacent to the 216-U-1 and 216-U-2 Cribs) and/or migrated downward through the soil column. Upon reaching groundwater, the higher ambient pH resulted in the conversion of the uranyl phosphate complex into a uranyl carbonate complex ($UO_2[CO_3]_3^{4-}$), which is the form transported in the existing groundwater plume.

A1.2 REMEDIAL ACTIONS IN 1985

In February 1985, uranium concentrations in the groundwater abruptly increased from 166 to about 72,000 pCi/L. Three actions were instituted to address uranium discharge to groundwater: (1) a pump-and-treat action was initiated through an ion-exchange column to remove uranium, (2) portions of existing wells that may have provided preferential pathways were grouted to prevent further vertical communication, and (3) new monitoring wells were installed to aid in the characterization of the uranium plume and the cleanup activities. Eight-million gallons of groundwater were pumped and treated during a 6-month period from June 13, 1985 to November 26, 1985. An estimated 687 kg of uranium was removed during this operation, and concentrations in 199-W19-3 were reduced from 72,000 pCi/L to about 1,700 pCi/L. After treatment was terminated groundwater concentrations rebounded significantly in early 1986 (to 20,400 pCi/L) but declined as drainage of most of the contaminated wastewater from the soil column beneath the cribs continued for approximately 5 years and subsequently diminished.

A2.0 CURRENT CONTAMINANT DISTRIBUTION

Plume distributions for uranium and technetium-99 are illustrated in Figures A-2 and A-3. The leading edge of contamination for all three plumes has migrated beyond the 200 West Area boundary. The combined uranium and technetium-99 contaminant plume that is above regulatory standards covers an area of 5.0×10^5 m^2 (.2 mi^2). The nitrate plume is much larger and coalesces with other nitrate contaminant plumes from 200 West Area facilities. The Drinking Water Standards maximum contaminant levels (MCLs) or proposed standards for uranium, technetium-99, and nitrate are 20 ppb, 900 pCi/L, and 45,000 ppb, respectively. The highest concentrations for each of the contaminants are essentially collocated near the treatability test site. Maximum concentrations (June 1995) were approximately 2,300 ppb (uranium), 23,700 pCi/L (technetium-99), and 1,700,000 ppb (nitrate). Uranium and technetium-99 maximum concentrations exceed the applicable MCLs by a factor of about 115 and 25, respectively. Nitrate's maximum concentration is nearly 40 times the MCL. The uranium plume distribution pattern suggests the possibility of a continuing source of uranium at or near the 216-U-1 and 216-U-2 Cribs. This may be due to continuing slow drainage of remobilized uranium from the vadose zone, as noted above.

Carbon tetrachloride is also present beneath 200-UP-1 in concentrations as high as 320 ppb at the treatability test site. The source for the carbon tetrachloride is believed to be to the west and north, outside the 200-UP-1 Operable Unit from disposal sites associated with Z Plant. The MCL for carbon tetrachloride is 5 ppb; therefore, the maximum concentration is about 65 times the regulatory standard.

A2.1 UNSATURATED ZONE DISTRIBUTION

The current distribution of contamination in the unsaturated zone beneath the 216-U-1/216-U-2 Crib site was investigated in late 1993/early 1994; a summary of the results is reported in the *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area* (Kelty et al. 1995). Borehole 299-W19-96 was drilled through the 216-U-1 Crib to characterize the vertical extent of uranium contamination beneath the 216-U-1/216-U-2 Crib site. The borehole was placed in the northwest corner of the 216-U-1 Crib. During drilling, radiological contamination was reported at 1.2 m (4 ft)

and extended at elevated levels from 5 to 18 m (15 to 60 ft). Activity levels dropped to below detection limits for field screening instruments by 18 m (60 ft), with sporadic contamination occurring to 21 m (70 ft). Low-level radiological contamination was reported again in a thin caliche layer from 51.5 to 51.8 m (169 to 170 ft). Subsequent radiologic soil analyses and geophysical logging of the borehole confirms a zone of uranium contamination from about 6 to 17 m (20 to 57 ft) (highest levels exceeding 20,000 pCi/g) and a second zone at the top of the caliche layer at 50.3 to 51.5 (165 to 169 ft) (highest concentration < 100 pCi/g). The zones of uranium contamination in 299-W19-96 are comparable to those reported for well 299-W19-11, which was drilled and sampled in 1983 and logged in 1985 (Delegard 1986). Detailed physical and chemical characterization of 299-W19-11 sediment in 1985 established that a sample taken at 10.8 m (35.5 ft) contained autunite in a low pH environment.

A2.2 SATURATED ZONE DISTRIBUTION

The areal extent of contamination of uranium, technetium-99, nitrate, and carbon tetrachloride in the saturated zone was presented in Section A1.2. Two phases of vertical characterization work have been conducted in support of the 200-UP-1 Operable Unit investigation and reported in Ford (1995). The first phase, conducted from August 1993 through December 1993, used existing boreholes that had been completed and perforated or screened over intervals spanning the water table to greater than 9 m (30 ft) into the saturated zone. Phase II sampling was conducted as a drill and test evaluation at a new three-well cluster site from June 1994 to September 1994 (Kelty et al. 1994). A well location map is presented in Figure A-4. Factors that are believed to control the vertical distribution of contaminants include reduction/oxidation conditions, hydrostratigraphic conditions that restrict vertical movement, and vertical cross-cutting preferential pathways such as unsealed wells. Based on interpreted redox conditions in the unconfined aquifer, a potential exists for mobile uranium and technetium-99 to be present at depths of up to 30 to 40 m (100 to 130 ft) below the water table. Hydrostratigraphic controls appear to limit the vertical migration of these contaminants. Uranium and technetium-99 at concentrations greater than drinking water standards in the main body of the contaminant plumes are interpreted to be present up to 18 m (60 ft) into the aquifer.

A3.0 RATE OF MOVEMENT

The apparent rate of movement of the technetium-99 plume, since initial discharge of process waste to the cribs, is approximately 1,400 m/10 yr = 140 m/yr (460 ft/yr). An apparent migration rate for the uranium plume is 945 m/10 yr = 94 m/yr (310 ft/yr).

The apparent plume migration rate of the technetium-99 is in order-of-magnitude agreement with predicted groundwater flow rates based on present (gradient has changed) hydraulic properties of the aquifer in the vicinity of the plumes (ca 80 m/yr) (260 ft/yr) (Appendix D). This suggests there is little if any reduction in the migration rate of this contaminant due to interaction with the aquifer matrix. Uranium, on the other hand, appears to have migrated more slowly, which may be related to retardation due to interaction of the uranyl ion with the aquifer matrix.

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Figure A-1. 200-UP-1 Facility Location Map.

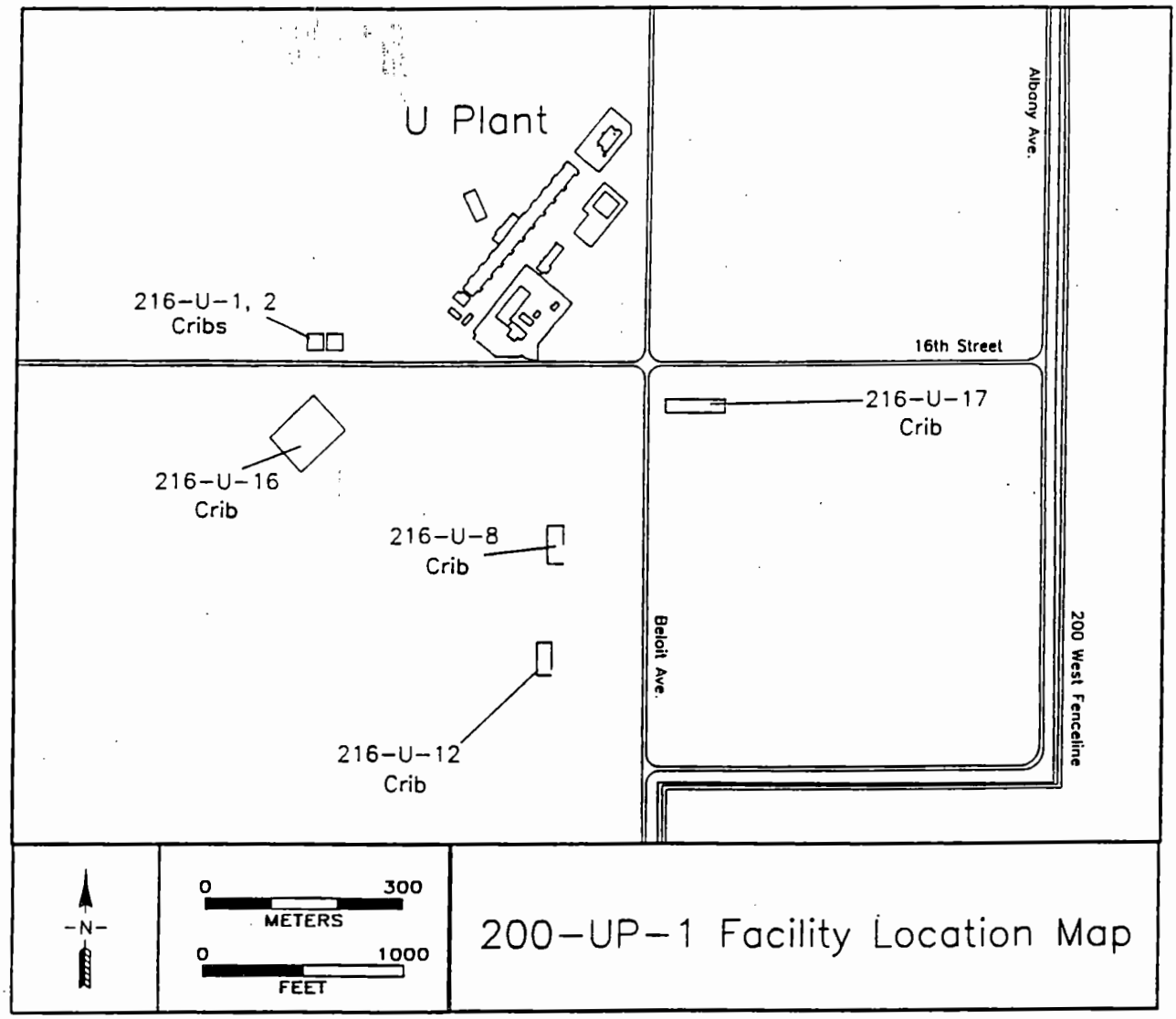


Figure A-2. Concentration Isopleths for Uranium (in ppb).

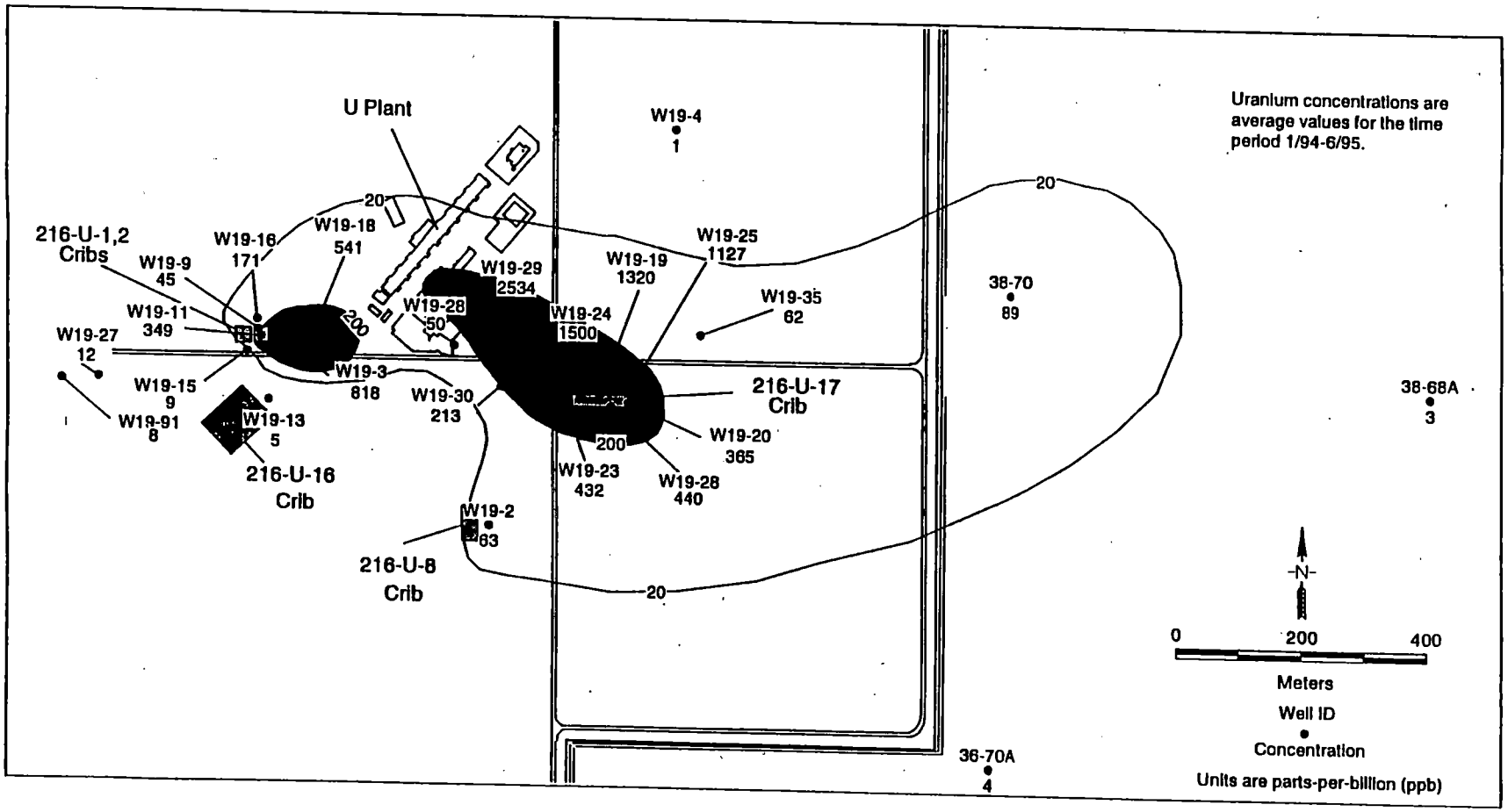


Figure A-3. Concentration Isopleths for Technetium-99 (in pCi/L).

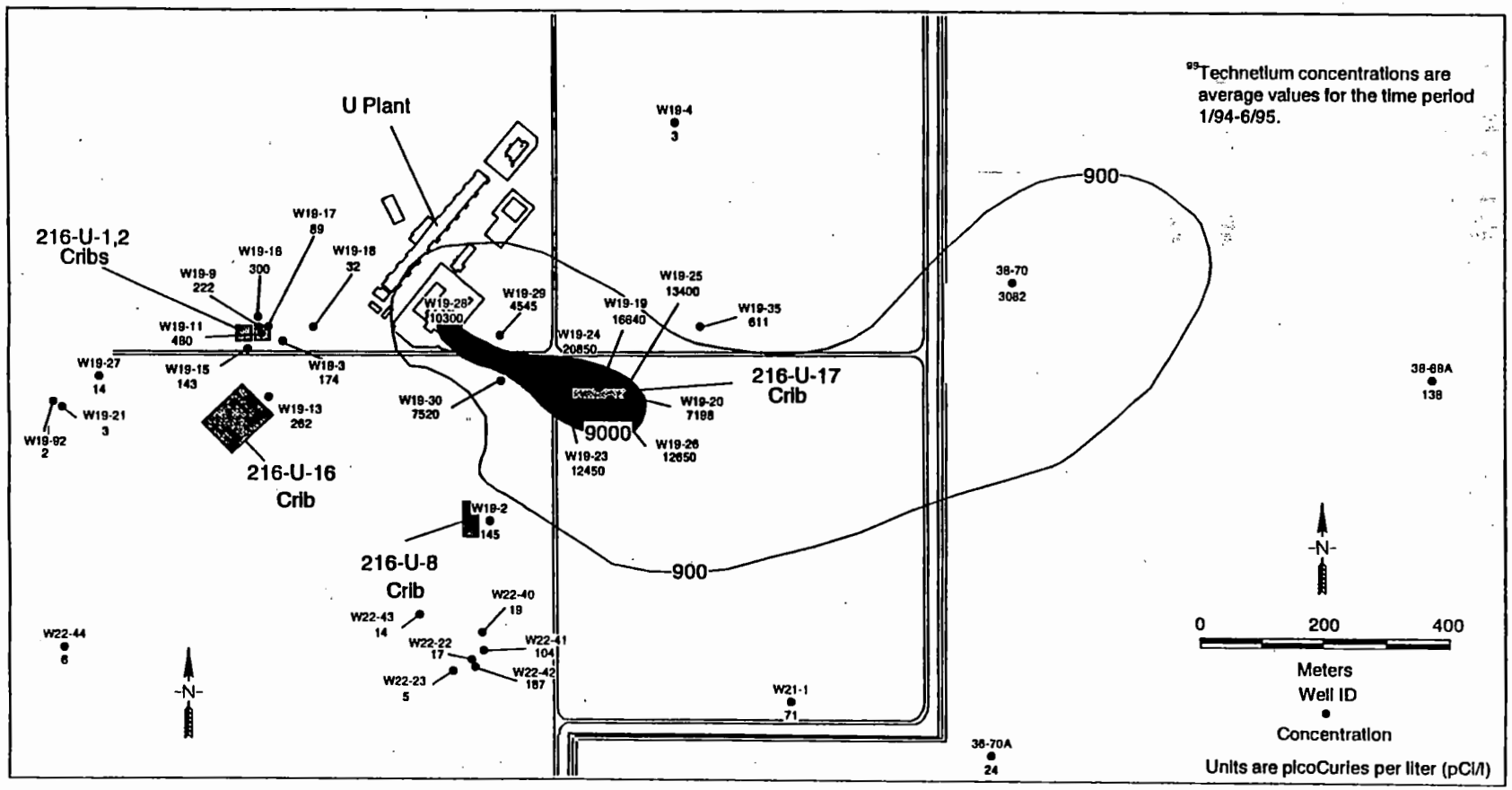
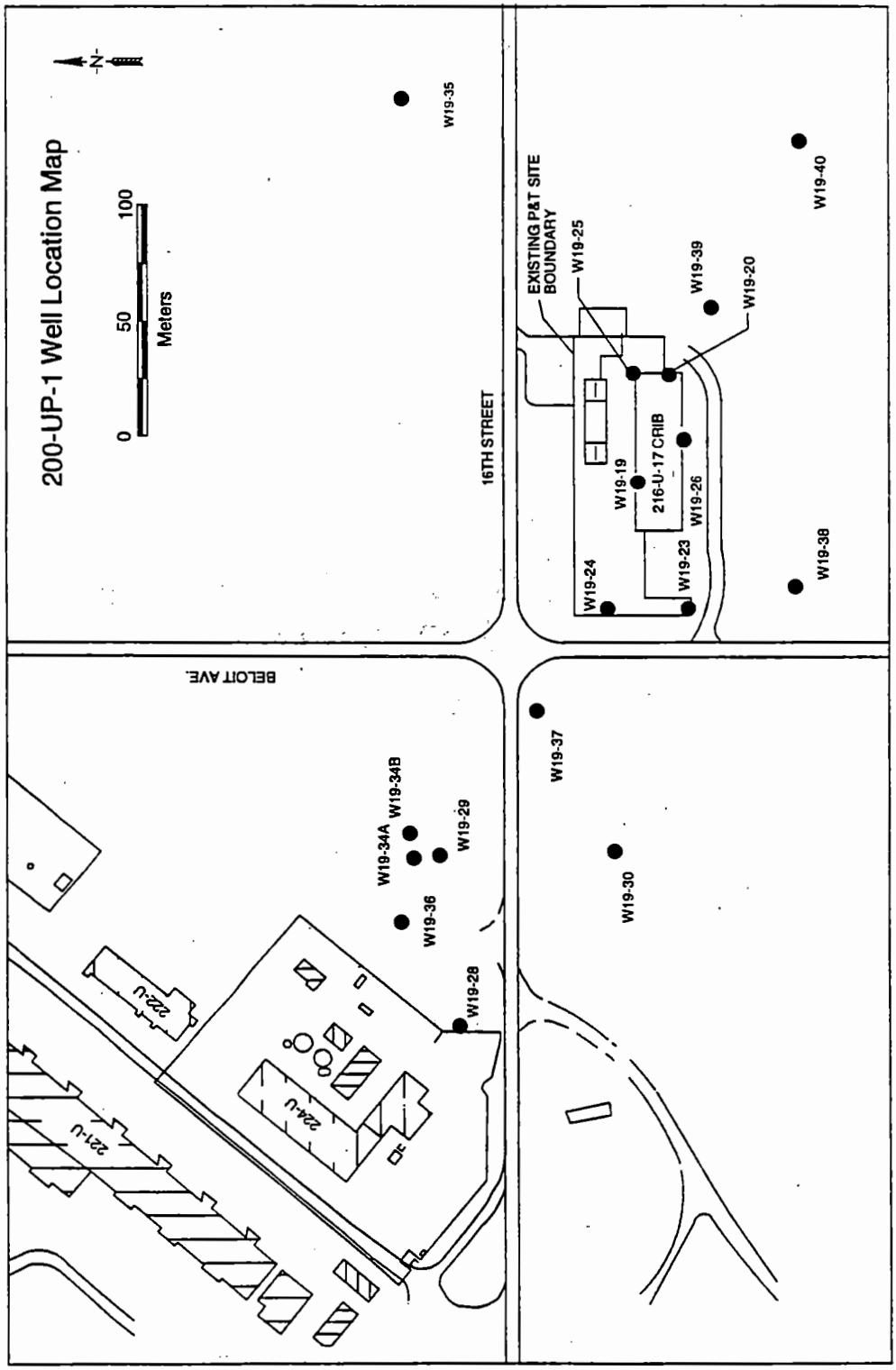


Figure A-4. Well Location Map.



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APPENDIX B

RISK-BASED DECISION ANALYSIS OF THE 200-UP-1 OPERABLE UNIT

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February 23, 1995

Jerry Chiaramonte
IT-Hanford, Inc.
2440 Stevens Drive
Richland, Washington 99352

Risk-Based Decisional Analysis For
The 200-UP-1 Groundwater Operable Unit

Dear Jerry:

A quantitative analysis of the 200-UP-1 Groundwater Operable Unit (OU) was prepared based on the document entitled Risk-Based Decision Analysis for Groundwater Operable Units (BHI-00161). The analysis includes:

- Sample-specific risk characterization of radioactive and chemical contamination in groundwater at 200-UP-1 expressed as risk contours using an industrial exposure scenario to establish risk levels for local workers ingesting groundwater.

- Estimation of retardation and dispersion of the 200-UP-1 contamination during natural, downgradient migration to the hypothetical exposure point, assuming no remediation at 200-UP-1.

- Contaminant-specific risk characterization for protection of public health at the hypothetical exposure point, using the same industrial scenario for direct comparison of attenuation and a conservative, residential exposure scenario to gauge remediation.

Risk Characterization of 200-UP-1 Groundwater

Incremental lifetime cancer risks (ILCR) and noncancer hazard quotient (HQ) were estimated from sample-specific analytical data obtained during the period March 1993 to October 1994. The cancer and noncancer risks were calculated assuming an industrial groundwater ingestion scenario and the definition of a reasonable maximum exposure (RME). Typically, the RME is based on the 95 percent upper confidence limit (UCL) of the mean contaminant levels in the groundwater samples. However, only one sample event per well was obtained during the sampling period such that the sample-specific data for 200-UP-1 plumes were based on single values. The RME also assumes upper 90th to 95th percentile values, or best professional judgement, for exposure parameters such as contact rate, exposure frequency, and duration. The estimated RMEs were consistent with the equations and parametric values recommended in the Hanford Site Baseline Risk Assessment Methodology (HSBRAM 1993).

Risk contours for ILCRs and HQs are shown in Figures 1 and 2, respectively. Remedial actions are generally not required for contamination where the composite ILCRs are less than 1×10^{-4} and the composite HQs are less than 1. The areas inside these contours, as shown in Figures 1 and 2, establish the plan view basis for estimating target cleanup volumes.

Contaminants of potential concern (COPC) in groundwater at the 200-UP-1 OU include ^{99}Tc, uranium, and nitrate. The radioisotopes of uranium and ^{99}Tc are known to be human carcinogens (cancer-

causing substances). Figure 9 shows the combined ^{99}Tc and total uranium concentrations that will yield an ILCR of 1 X 10^{-4} for industrial exposure to these radionuclides in the existing groundwater plume beneath the 200 West Area. This figure indicates that the combination of ^{99}Tc and total uranium concentrations in groundwater corresponding to an ILCR of 1 x 10^{-4} vary depending on the ratio of the radionuclide concentrations. For example, if ^{99}Tc and uranium contribute 60 and 40 percent, respectively, to the total radiological ILCR, then the ^{99}Tc and total uranium concentrations that correspond to an ILCR of 1 X 10^{-4} are approximately 10,000 pCi/L and 500 ug/L, respectively. This 60/40 ^{99}Tc ratio is approximately the ratio observed in the 200-UP-1 plume where the total radiological ILCR exceeds 1 X 10^{-4}. The ILCRs assume that uranium is present in the following naturally-occurring isotopic quantities:

^{238}U = 99.2743%
^{235}U = 0.7200%
^{234}U = 0.0057%.

Nitrate and the chemical form of uranium do not cause cancer but can produce other health effects in humans. Nitrate is the dominant factor in the estimate of noncancer-causing health effects in the 200-UP-1 groundwater. The HQ = 1 contour approximately corresponds to the 45,000 ppb drinking water standard for Washington State. Nitrate has been classified as a contaminant with potential of producing methemoglobinemia (blue baby) when infants are exposed to high concentrations in groundwater.

Natural Attenuation of the 200-UP-1 Plume

If no remediation is implemented, the plume of contamination will continue to move downgradient until it eventually reaches the boundary of the Central Plateau. The flow path from the 200-UP-1 plume location to the hypothetical exposure point was estimated to be 31,250 ft. This path length, used in the flow and contaminant transport modeling, was estimated from previous groundwater modeling, which showed that the plume will move to the east and then turn north. It would take approximately 130 years for this to happen with unretarded COPCs. However, uranium is retarded during migration causing the uranium plume to separate from the ^{99}Tc and nitrate plumes with ^{99}Tc and nitrate arriving at the hypothetical exposure point several hundred years ahead of the uranium.

A two-dimensional analytical flow and transport equation was used to estimate receptor concentrations (or activities) at the boundary of the Central Plateau. The analytical equation describes contaminant migration in a uniform one-directional flow from a slug source. The analytical model is called CONMIG and is documented in the book entitled Analytical Groundwater Modeling, Flow and Contaminant Migration by William Walton (1989). Hydrogeologic parameters used for the analytical calculations were:

Effective porosity = 0.15
Aquifer thickness = 33 ft
Hydraulic conductivity = 50 ft/day
Hydraulic gradient = 0.0019
Longitudinal dispersivity = 200 ft
Transverse dispersivity = 20 ft
Seepage velocity = 0.63 ft/day
Aquifer bulk density = 1.65 gm/cm^3
Distribution coefficients = 0 (^{99}Tc and nitrate)
= 1 (uranium).

Risk Characterization

If it is assumed that the land use is unrestricted (residential bounding condition) and humans drink the groundwater, the estimated maximum ILCR is 3 X 10^{-5} (over a person's lifetime) and the estimated maximum HQ is 4 for the noncancer-causing constituents. Figures 2 through 8 show risk contours at the hypothetical exposure point for both the future residential and future industrial scenarios and contaminants ^{99}Tc, uranium, and nitrate. The land use and associated target risks are key factors in the determination of compliance and the degree of cleanup at the source (200-UP-1). Thus, the target risks must be established in order to estimate risk reduction factors or target cleanup goals at the source.

The calculations have been documented in calculation briefs per IT quality assurance procedures. If you have any questions or need additional information, please contact me or Bob Sobocinski.

Respectfully yours,

IT CORPORATION

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Manager, Risk Assessment Section

Enclosure: Calculation Briefs

c: Dave Myers
Bob Sobocinski
Curt Wittreich

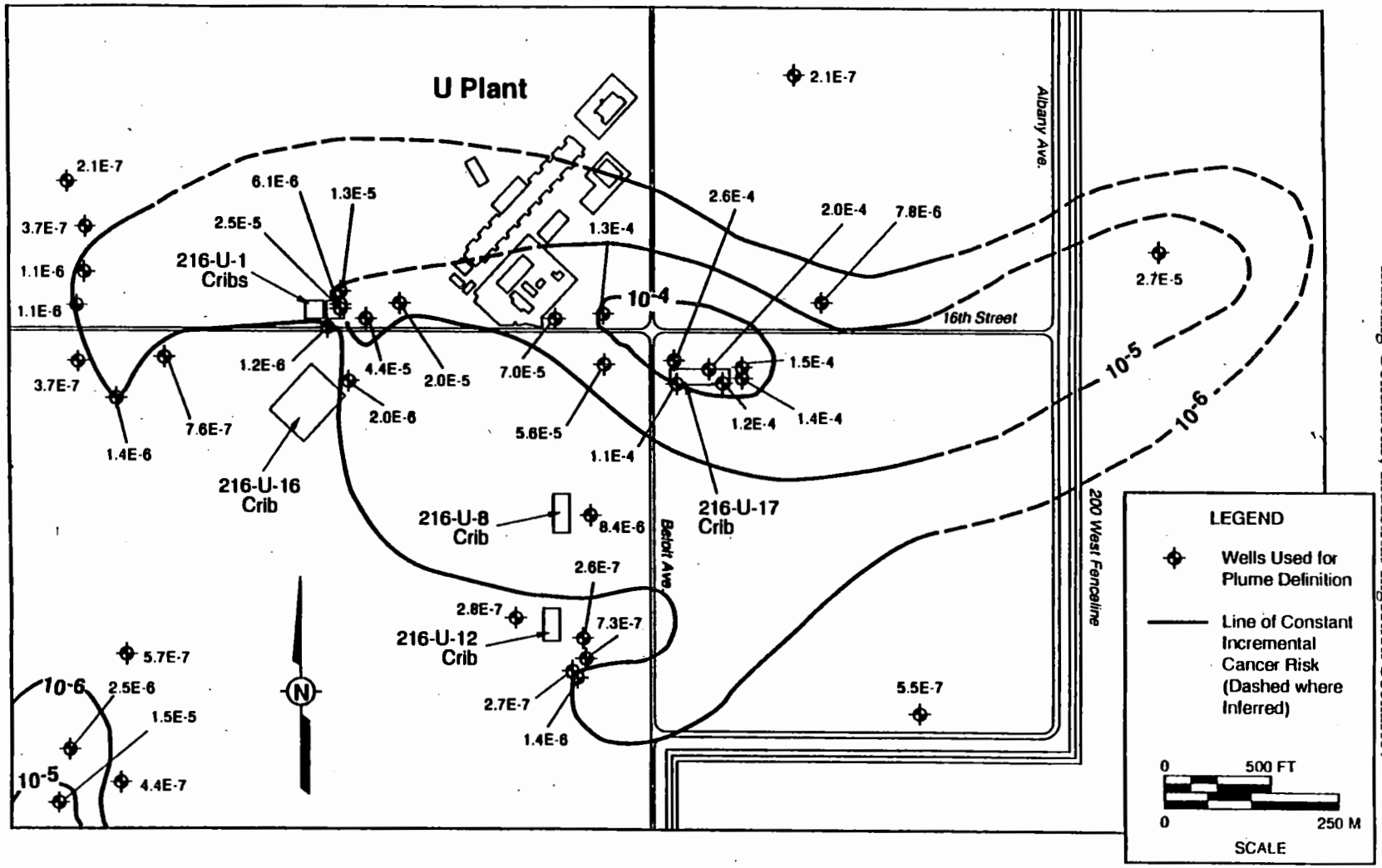

Figure 1. Lifetime Incremental Cancer Risk for Reasonable Maximum Exposure to Uranium-234, -235, -238, and Technetium-99 in Groundwater, Existing Conditions, Industrial Ingestion Scenario.

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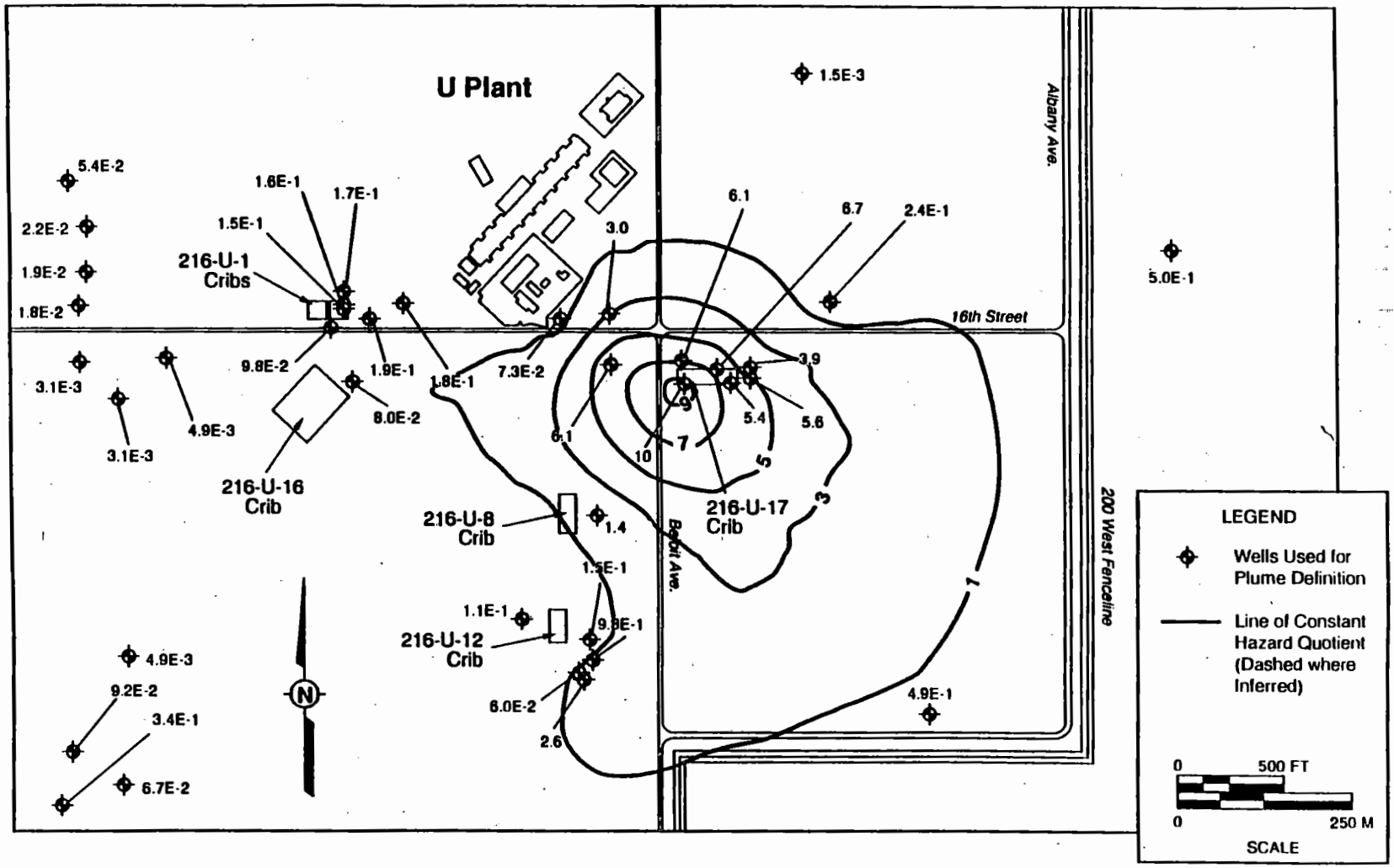


Figure 2. Hazard Quotient for Reasonable Maximum Exposure to Nitrate in Groundwater, Existing Conditions, Industrial Ingestion Scenario.

Figure 3. Lifetime Incremental Cancer Risk for Reasonable Maximum Exposure to Technetium-99 in Groundwater, Future Conditions at Hypothetical Exposure Point, Industrial Ingestion Scenario.

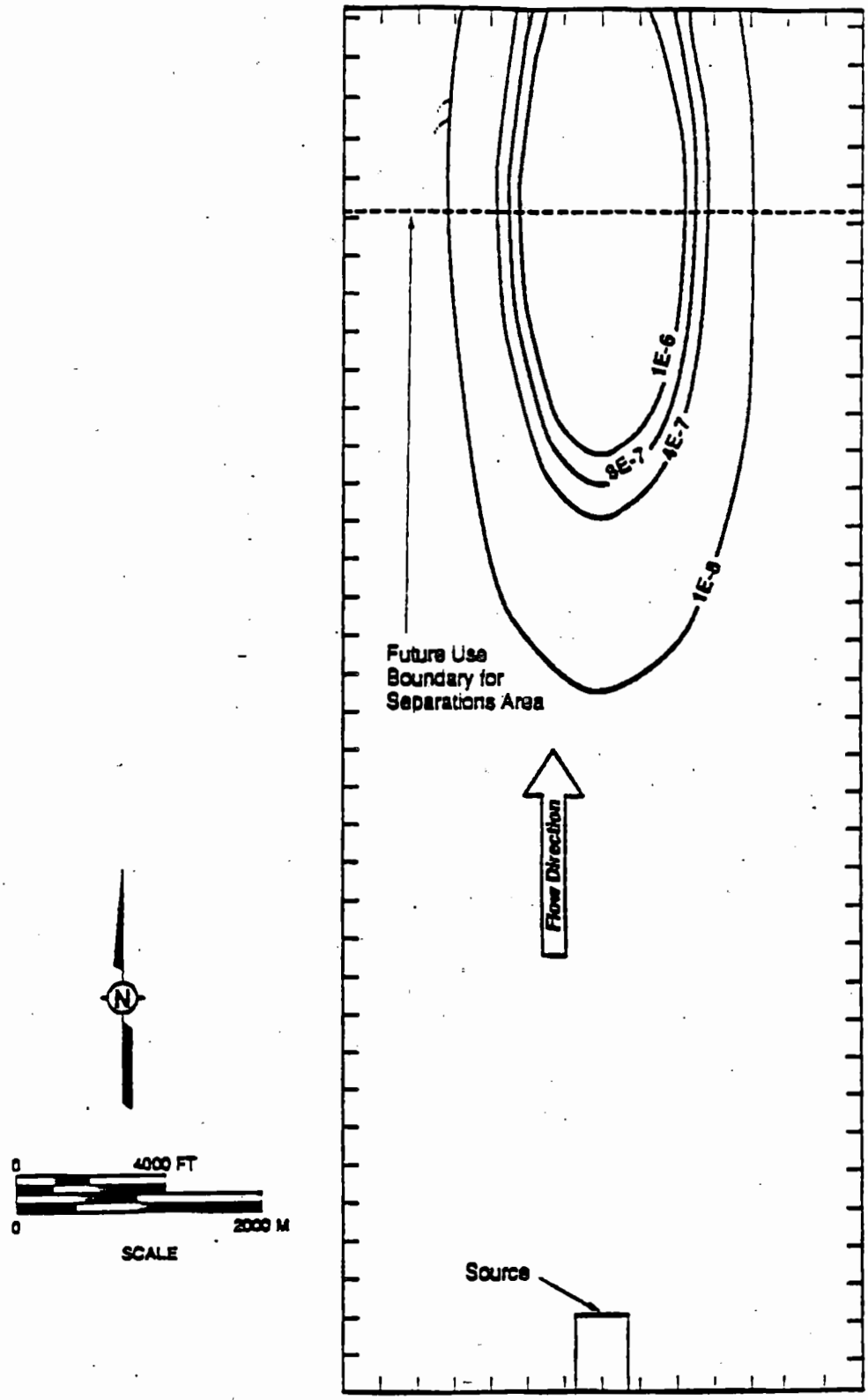


Figure 4. Lifetime Incremental Cancer Risk for Reasonable Maximum Exposure to Uranium-234, -235, and -238 in Groundwater, Future Conditions at Hypothetical Exposure Point, Industrial Ingestion Scenario.

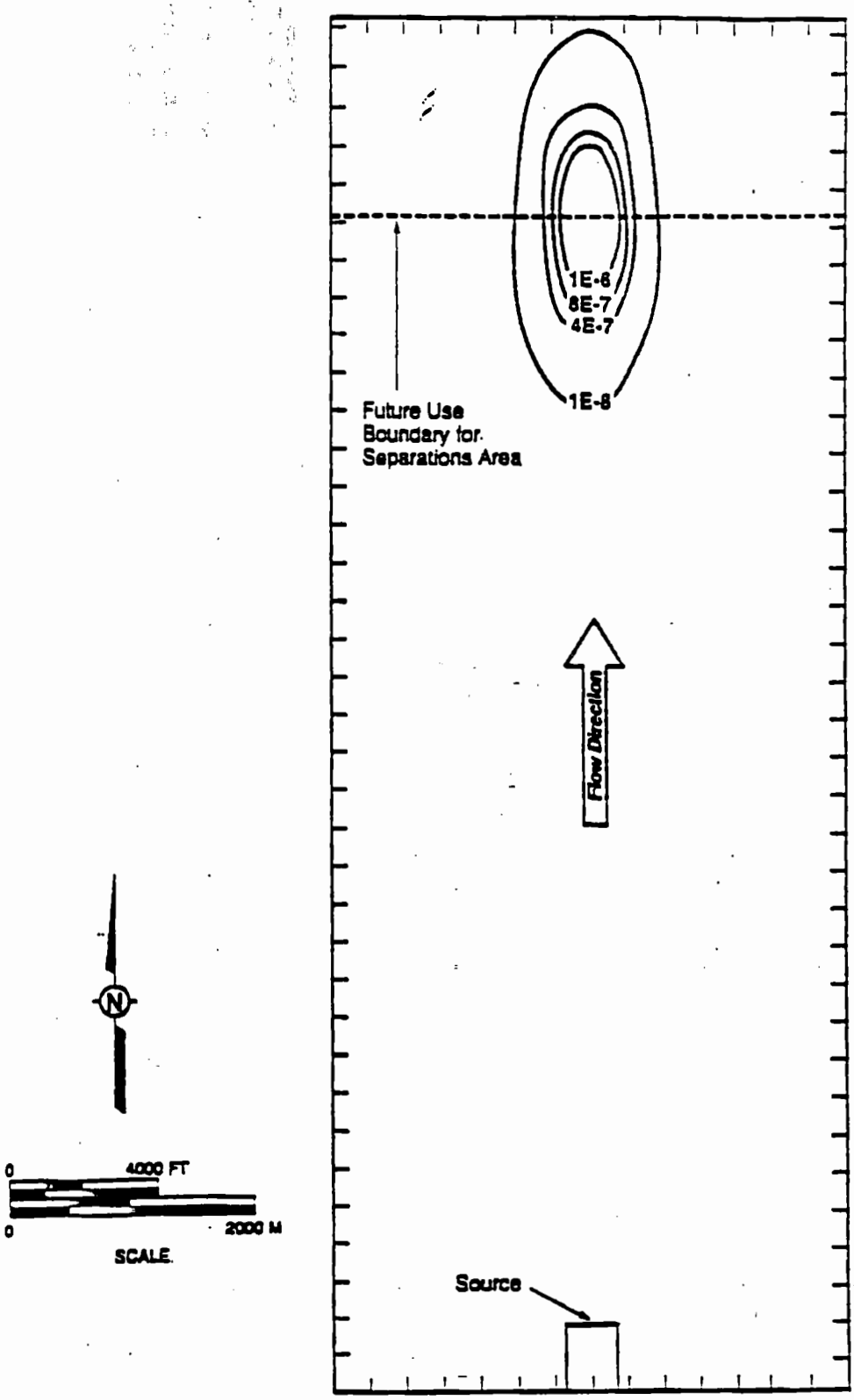


Figure 5. Lifetime Incremental Cancer Risk for Reasonable Maximum Exposure to Technetium-99 in Groundwater, Future Conditions at Hypothetical Exposure Point, Residential Ingestion Scenario.

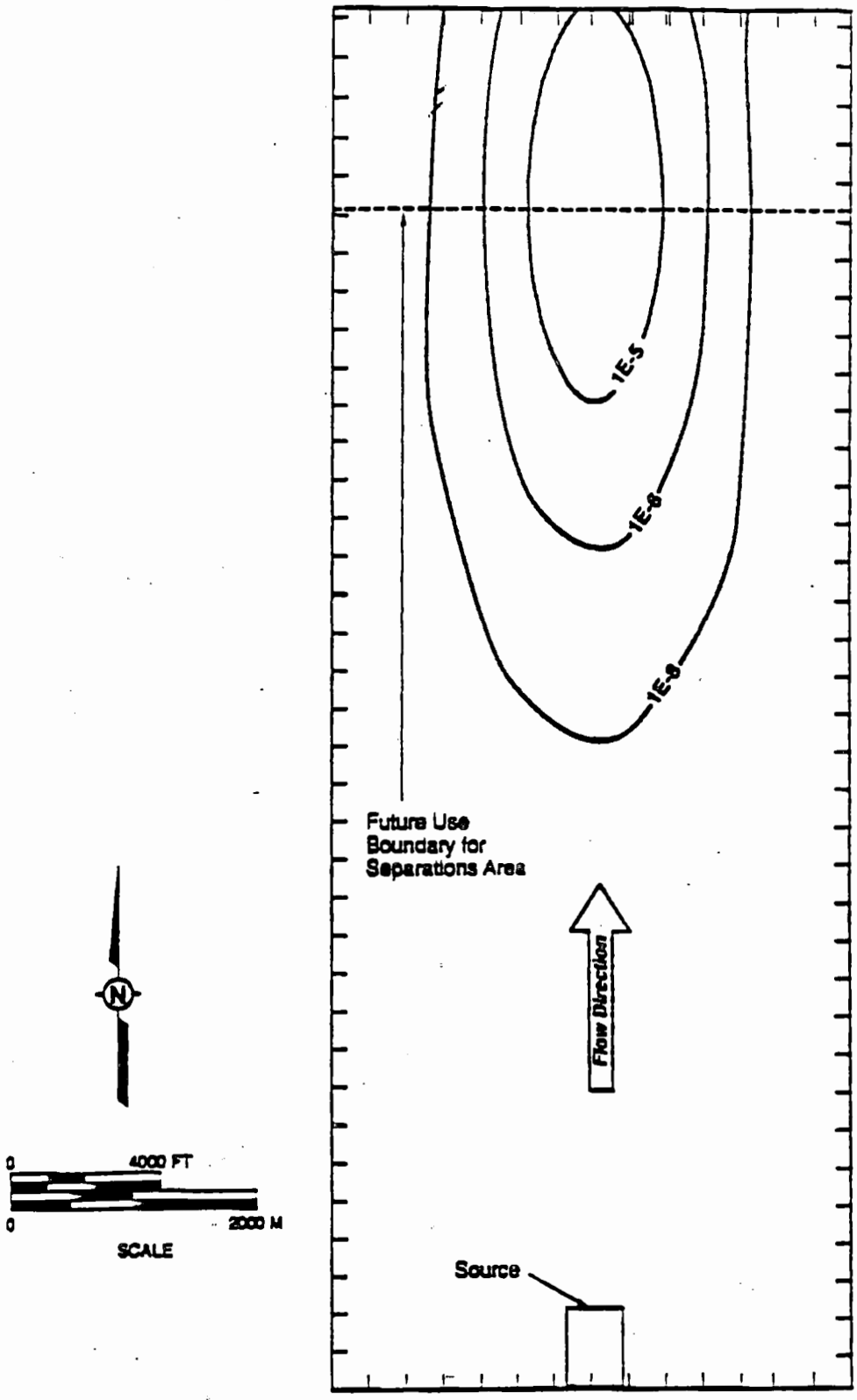


Figure 6. Lifetime Incremental Cancer Risk for Reasonable Maximum Exposure to Uranium-234, -235, and -238 in Groundwaer, Future Conditions at Hypothetical Exposure Point, Residential Ingestion Scenario.

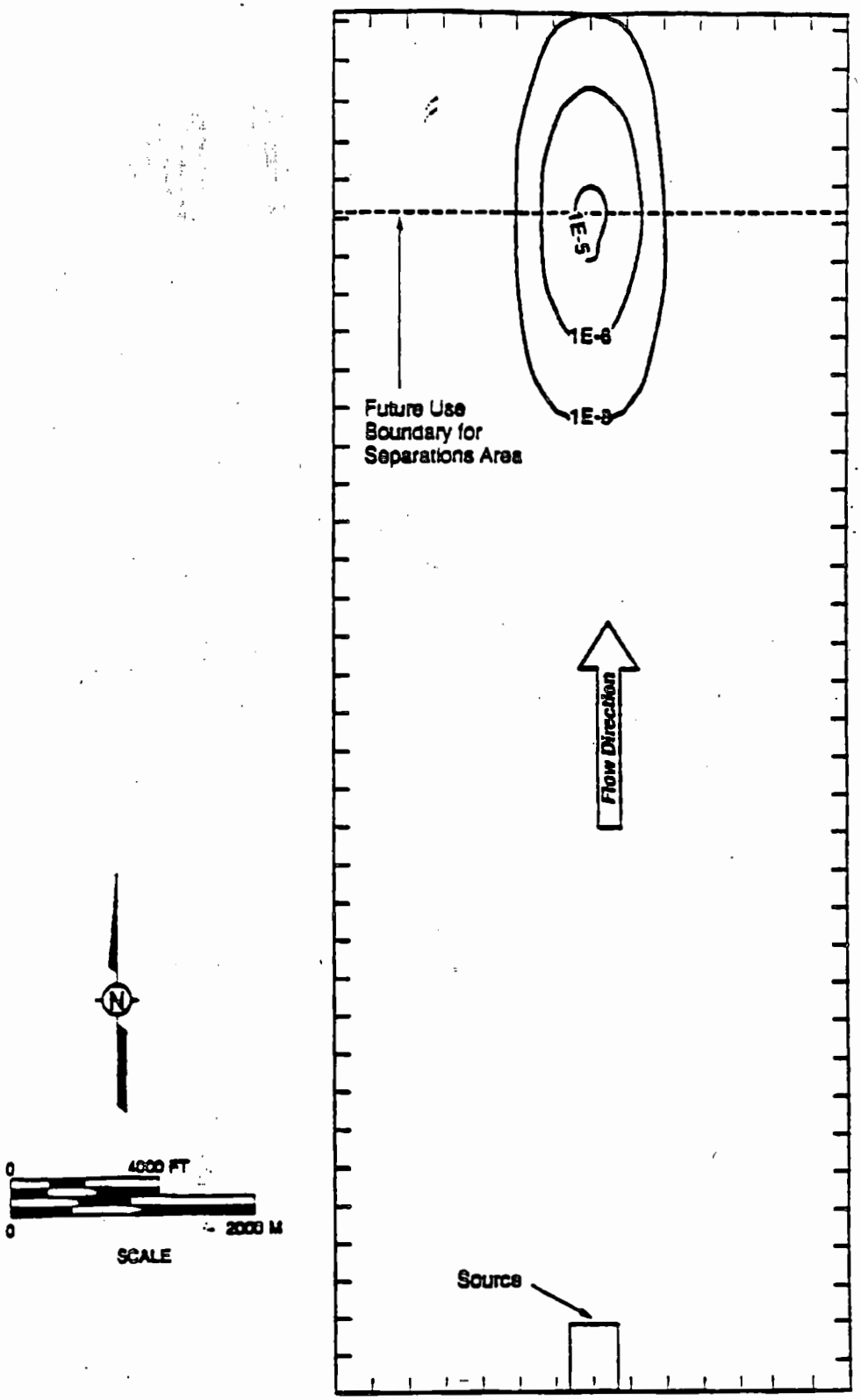


Figure 7. Hazard Quotient for Reasonable Maximum Exposure to Nitrate in Groundwater, Future Conditions at Hypothetical Exposure Point, Industrial Ingestion Scenario.

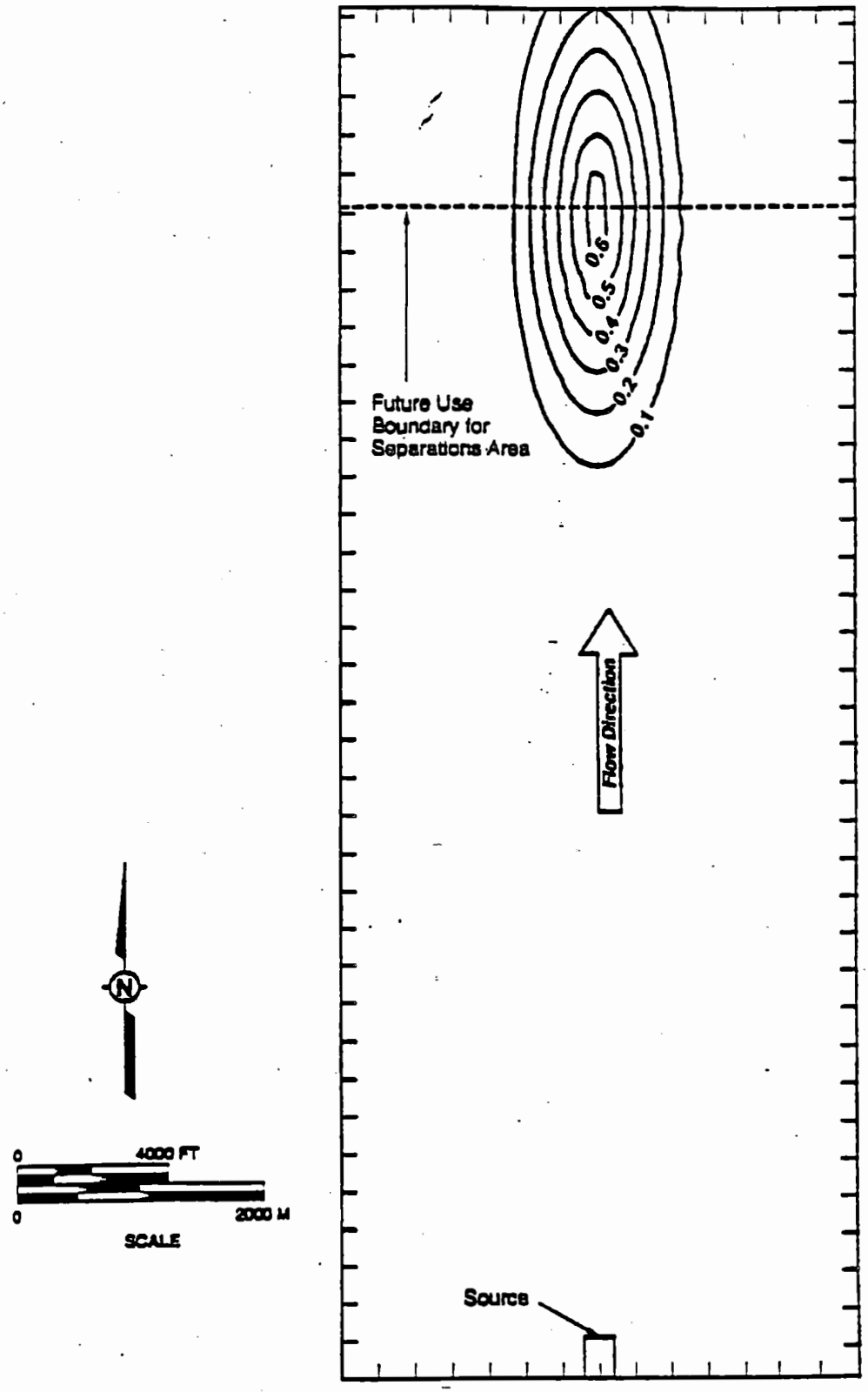


Figure 8. Hazard Quotient for Reasonable Maximum Exposure to Nitrate in Groundwater, Future Conditions at Hypothetical Exposure Point, Residential Ingestion Scenario.

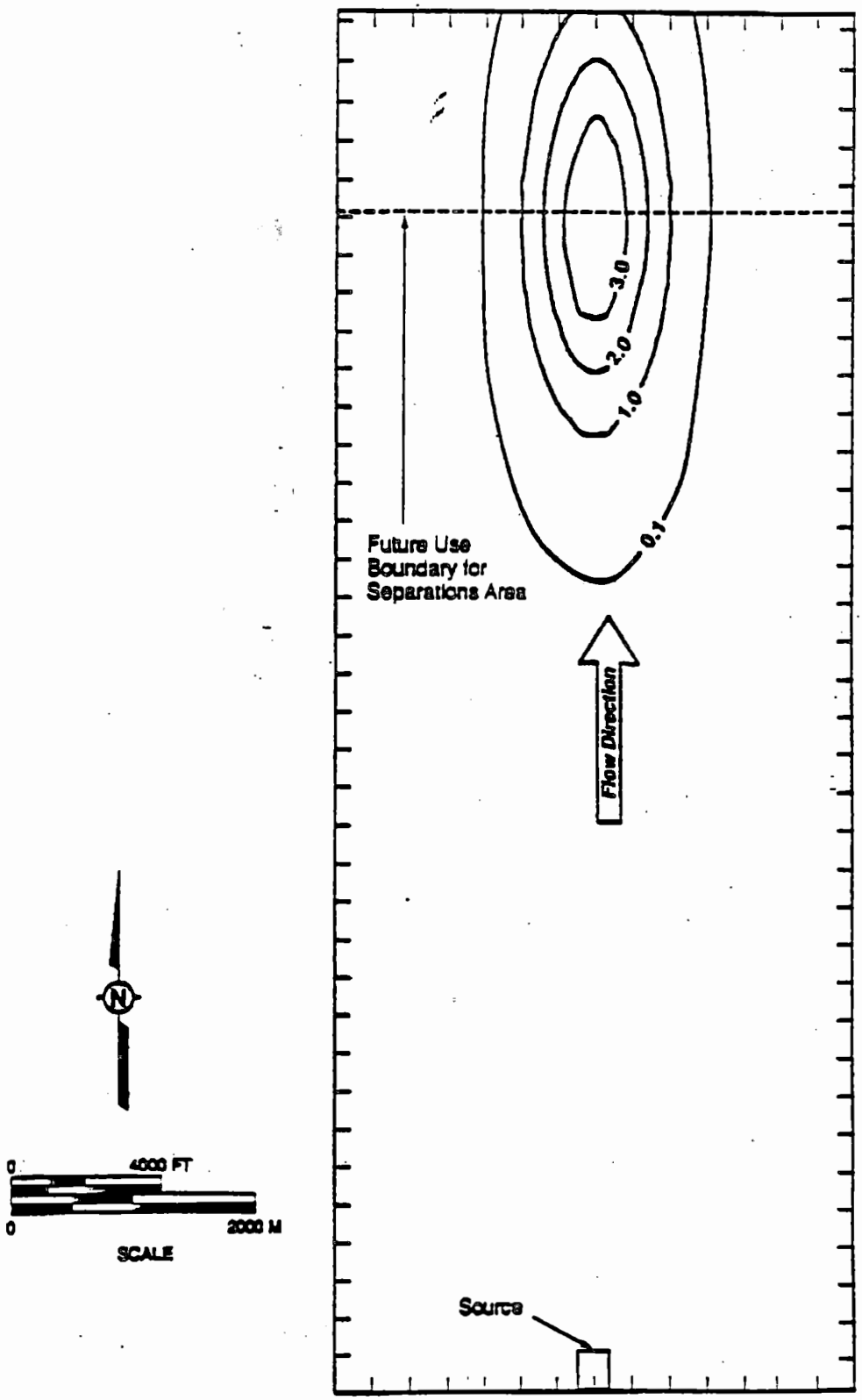
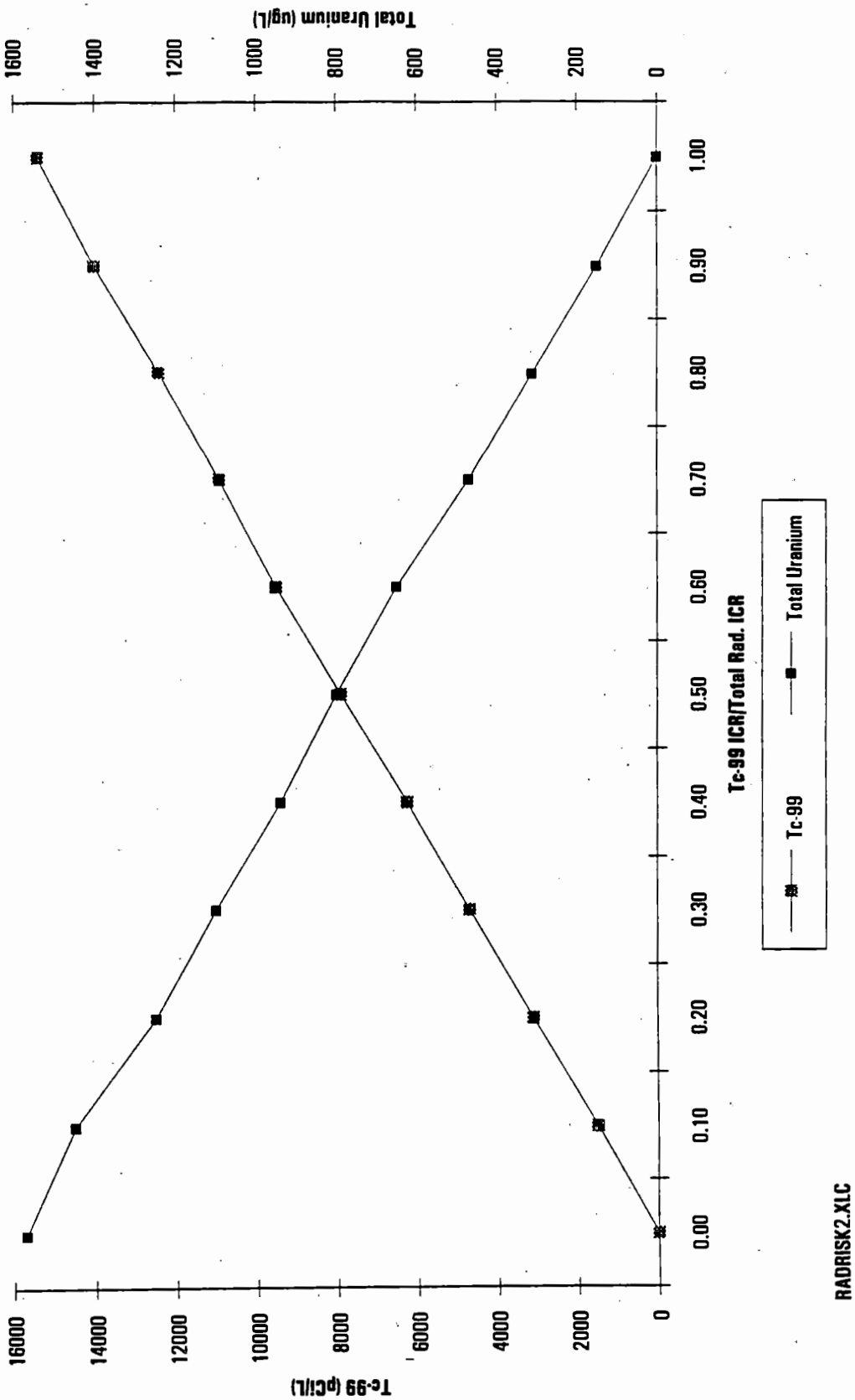


Figure 9. Technetium-99 and Total Uranium Concentrations That Meet 1E-4 Incremental Cancer Risk.



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