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Hanford Sitewide Groundwater Remediation Strategy

United States
Department of Energy
Richland, Washington

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Hanford Sitewide Groundwater Remediation Strategy

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EXECUTIVE SUMMARY

The "Hanford Sitewide Groundwater Remediation Strategy" fulfills the requirements of the "Hanford Federal Facility Agreement and Consent Order," Milestone M-13-81,[1] *to develop a concise statement of strategy that describes "how the Hanford Site groundwater remediation will be accomplished." The strategy addresses "objectives/goals, prioritization of activities, and technical approaches" for groundwater cleanup.*

The strategy establishes that the overall goal of groundwater remediation on the Hanford Site is to restore groundwater to its beneficial uses in terms of protecting human health and the environment, and its use as a natural resource. The Hanford Future Site Uses Working Group[2] *established two categories for groundwater commensurate with various proposed land uses: (1) restricted use or access to groundwater in the Central Plateau and in a buffer zone surrounding it, and (2) unrestricted use or access to groundwater for all other areas.*

In recognition of the Hanford Future Site Uses Working Group and public values, the strategy establishes that the sitewide approach to groundwater

[1]Ecology, EPA, and DOE, 1992, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

[2]Hanford Future Site Uses Working Group, 1992, *The Final Report of the Hanford Future Site Use Group*, Richland, Washington.

cleanup is to remediate[1] the major plumes found in the reactor areas and to contain the spread and reduce[2] the mass of the major plumes found in the Central Plateau. Specifically, for the reactor areas, the following plumes are to be remediated: strontium-90 in the N Reactor area, and chromium in the K, D, and H Reactor areas. In the Central Plateau, an approach of containment and mass reduction is taken for the organic contamination associated with Plutonium Finishing Plant past operations, the combined technetium-99 and uranium plumes associated with the Uranium-Trioxide Plant, and the combined technetium-99 and cobalt-60 plumes associated with the BY Cribs.

The approach to remediate each major plume is presented. Each approach is based on the general remediation principles to (1) define the extent of contamination, (2) identify and gain control of continuing sources of contamination, and (3) implement containment/remediation of the plumes. Major information needs were revealed, including: in the 100 Areas, the geographic extent of chromium contamination at D and K Reactors, and the method to control the source of strontium-90 contamination at N Reactor; in the 200 West Area, the vertical distribution of organic, uranium, and technetium-99 contamination; and in the 200 East Area, the extent and source of technetium-99 and cobalt-60 contamination.

The reduction of operations-derived liquid effluent to the soil is deemed an integral element of the "Hanford Sitewide Groundwater Remediation

[1]Groundwater remediation refers to the reduction, elimination, or control of contaminants in the groundwater or soil matrix to restore groundwater to its intended beneficial use.

[2]Containment and mass reduction refers to controlling the movement of groundwater contamination for the purpose of treatment.

Strategy." Protecting the Columbia River, reducing the spread of contamination, maintaining a bias for action, and using available technology are all public values that are recognized in the strategy and incorporated into the approaches. Qualitative estimates of technical feasibility are incorporated into the remediation approach described for each plume.

Nitrate and tritium plumes contaminate wide areas of the aquifer under the Hanford Site. The strategy identifies the need for a detailed evaluation of practicable methods to reduce the flux of nitrate and tritium to the Columbia River.

Key regulatory issues must be resolved to accelerate remediation, e.g., criteria for discharging treated groundwater back to the soil. This treated groundwater, from which the primary contaminants have been removed, may still contain elevated levels of co-contaminants.[1] Additional treatment for co-contaminants is identified as a major factor in determining the scope and feasibility of many of the groundwater cleanup projects on the Hanford Site.

Groundwater remediation will affect portions of the existing monitoring well networks. These effects must be identified and resolved. Refinement of the existing monitoring networks and better coordination with the groundwater remediation's monitoring effort is needed to better define the extent of plumes, their movement, and the effect of cleanup on groundwater contamination.

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[1]Co-contaminant refers to those chemical species that are found in addition to the contaminants of primary concern.

The strategy identifies the following areas of technology development that may significantly improve cleanup: barriers to flow, dense nonaqueous phase liquid identification and recovery, stabilization methods, and improved ion-specific water treatment methods. Furthermore, the strategy identifies the strontium-90, cesium-137, and plutonium contamination identified with the B-5 reverse well as an area for technology demonstration.

This remediation strategy is an integral part of the "Hanford Site Groundwater Protection Management Program."[1] Coordination of groundwater remediation within the broader Hanford Site program of groundwater protection is necessary. Continuing the development and evaluation of contingency cleanup strategies is needed should the existing approaches prove infeasible.

This strategy establishes an approach to remediation that emphasizes early and aggressive field programs while simultaneously collecting and evaluating information leading to a final Record of Decision. The approaches will be refined as the remediation proceeds and a record of the cleanup results develops. The development of site- and contaminant-specific groundwater remediation goals and final remediation alternatives remains a product of risk assessment, technical feasibility, and cost considerations. The development of this information remains at the operable unit level.

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[1]DOE-RL, 1993, *Hanford Site Groundwater Protection Management Program*, DOE/RL-89-12, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Refinement of the strategy will be the responsibility of a U.S. Department of Energy, Richland Operations Office-chaired group consisting of both internal and external groups, including stakeholders who play a role in liquid effluent management and cleanup activities at the Hanford Site. The Environmental Restoration contractor, with support from the Operations and Maintenance contractor for the U.S. Department of Energy, has the primary responsibility to carry out the strategy.

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ARAR	applicable or relevant and appropriate requirement
CCl_4	carbon tetrachloride
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ETF	Effluent Treatment Facility
FS	feasibility study
gal	gallon
GPMP	*Hanford Site Groundwater Protection Management Program*
HPPS	*Hanford Past Practice Strategy*
IRM	interim response measure
km	kilometer
km^2	square kilometer
m^3	cubic meter
mi^2	square miles
OU	operable unit
pCi/L	picocuries per liter
RA	remedial action
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
RL	Richland Operations Office
ROD	Record of Decision
TEDF	Treated Effluent Disposal Facility
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and/or disposal
WAC	*Washington Administrative Code*

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HANFORD SITEWIDE GROUNDWATER REMEDIATION STRATEGY

1.0 INTRODUCTION

1.1 PURPOSE

The *Hanford Sitewide Groundwater Remediation Strategy* establishes the basis for managing remediation of contaminated groundwater at the Hanford Site. The strategy is an integral part of the refocused environmental restoration program. This document provides:

- Direction for developing sitewide cleanup objectives for groundwater remediation
- A basis for informed decision making and future planning related to groundwater remediation
- A means to prioritize cleanup actions to optimize technical, administrative, and financial resources for effective remediation of groundwater
- A means for facilitating involvement of the stakeholders.

A sitewide perspective is used in describing the strategy. Contamination problems are discussed at a broad, geographic scale and reflect the major groundwater issues facing the U.S. Department of Energy (DOE). Current stakeholder values, as well as existing *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestones (Ecology et al. 1989) are incorporated in the strategy. Future groundwater remediation milestones will be an outgrowth of this strategy. Key technical, institutional, and regulatory issues are identified.

This strategy provides direction to decisions affecting sitewide cleanup. Determination of operable unit (OU)-specific remediation goals (applicable or relevant and appropriate requirements [ARAR]) should reflect this strategy. However, interim and final remediation goals are site specific and will be developed at the OU level.

1.2 CONTEXT FOR STRATEGY DEVELOPMENT

Over 220 square kilometers (km^2) (85 square miles [mi^2]) of groundwater beneath the 1,450-km^2 (560-mi^2) Hanford Site are contaminated by hazardous and radioactive waste to levels above federal drinking water standards (DWS) (40 *Code of Federal Regulations* [CFR] 141) and the state's groundwater quality criteria (*Washington Administrative Code* [WAC] 173-200). Restoring the groundwater resource beneath the Hanford Site, reducing contaminant transport offsite via the groundwater pathway, and understanding the risks posed by contamination, are all objectives of the environmental restoration program.

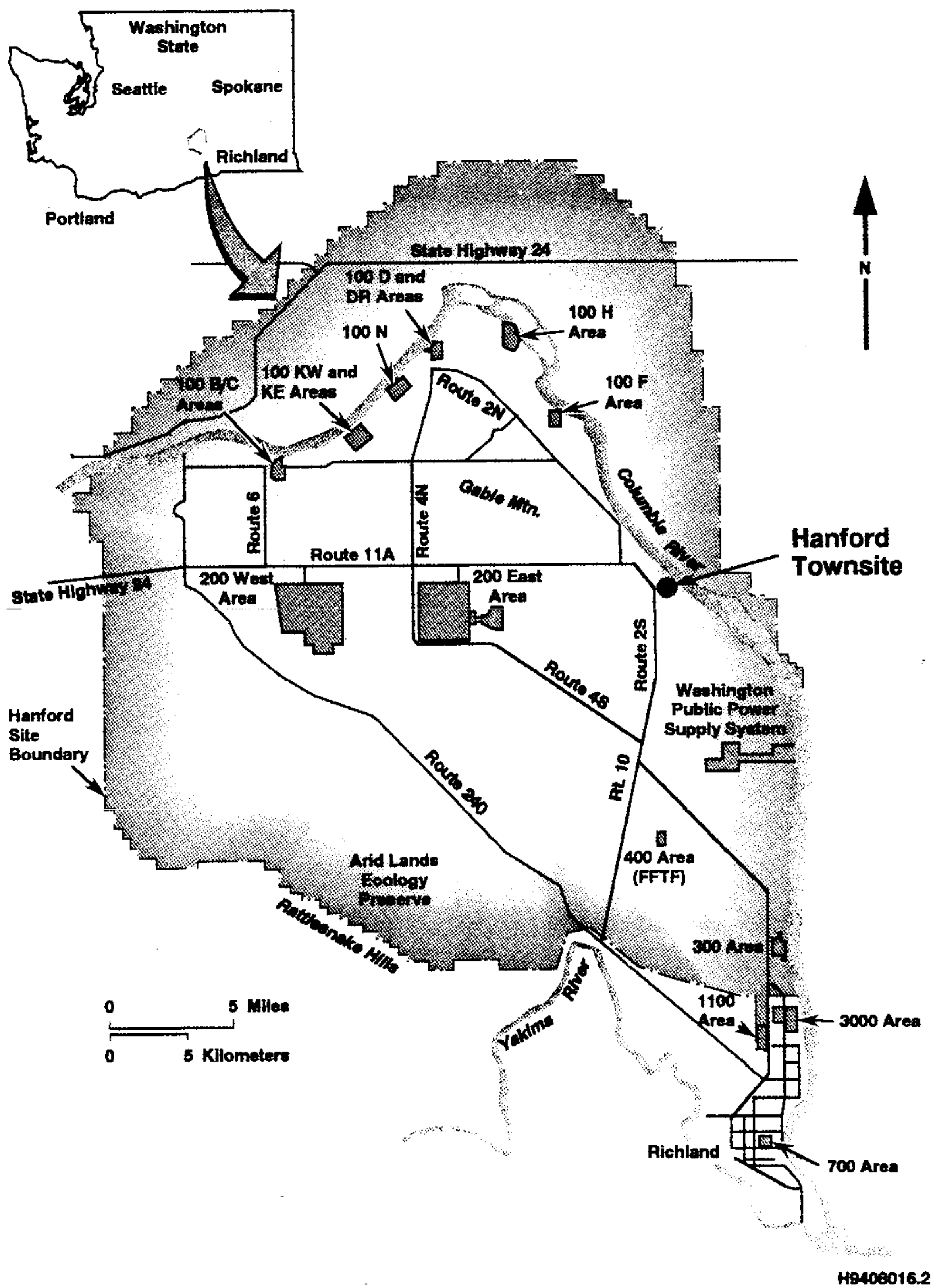
Groundwater remediation at the Hanford Site is likely to be a complex, long-term, and potentially costly endeavor.

Contamination affects a substantial volume of groundwater, which ultimately discharges to the Columbia River. The public has expressed a high degree of interest in the consequences of this discharge, and the outcome of the efforts to protect this valuable resource. Cleanup control and direction are established under the Tri-Party Agreement. This agreement between the DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) (Ecology et al. 1989) is legally binding for the DOE and is enforceable by the Ecology and the EPA.

The magnitude of the environmental restoration challenge is revealed by the number of hazardous waste sites. The Hanford Site has been subdivided into four subareas that are included on the National Priorities List (40 CFR 300, Appendix B) of hazardous waste sites. These subareas contain over 1,000 past-practices sites as defined by either the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), or the *Resource Conservation and Recovery Act of 1976* (RCRA). These sites have been grouped into over 75 "operable units" and 8 groundwater OUs associated with geographic regions and specific facilities. A location map showing the commonly cited names of operational areas is presented in Figure 1-1.

As environmental restoration progresses from the assessment phase to active cleanup, it is essential to maintain a balanced and consistent approach. The large number of individual remediation decisions and cleanup activities poses a substantial challenge to the DOE, state and federal regulators, and the contractors performing the work. Furthermore, it is evident that the outcome of remediation for a particular OU may be dependent on actions taken at other OUs within the same groundwater flow system. Thus, the need for a comprehensive, sitewide groundwater remediation strategy has been recognized and included as Tri-Party Agreement Milestone (M-13-81). The milestone requires a concise, documented strategy that describes how groundwater cleanup will be conducted at the Hanford Site. The strategy is to include objectives and goals, and the technical approaches to address each major plume.

Figure 1-1. Hanford Location Map.



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2.0 INSTITUTIONAL AND REGULATORY FRAMEWORK FOR REMEDIATING GROUNDWATER

This chapter describes the institutional and regulatory framework in which groundwater remediation is to be implemented under CERCLA. A unique process for applying CERCLA has evolved due to the complexity of administrating cleanup for the large number of individual OUs at the Hanford Site. Other important programs at the Hanford Site that have a bearing on groundwater cleanup are also summarized in this chapter.

2.1 TRI-PARTY AGREEMENT

In May 1989, the EPA, Ecology, and DOE entered into an interagency agreement, the Tri-Party Agreement (Ecology et al. 1989). The Tri-Party Agreement provides the legal and procedural basis for cleanup and regulatory compliance at the Hanford Site's numerous hazardous waste sites. It identifies timetables for waste cleanup and a series of "milestones" by which certain actions must be implemented or completed.

The Tri-Party Agreement coordinates two important regulatory programs: RCRA and CERCLA. The EPA has the lead role in administering CERCLA. Four subareas of the Hanford Site, the 100, 200, 300, and 1100 Areas, are included on the EPA's National Priorities List (40 CFR 300, Appendix B).

Ecology has the lead role in administering RCRA under provisions of the state's WAC 173-303, "Dangerous Waste Regulations." Under the Tri-Party Agreement, there are more than 50 RCRA treatment, storage, and/or disposal (TSD) units that will be closed or permitted to operate. Most of the TSDs are located within OUs.

2.2 APPLICABILITY OF SITEWIDE GROUNDWATER REMEDIATION STRATEGY

The *Hanford Sitewide Groundwater Remediation Strategy* provides a means of addressing issues of sitewide significance, and a broader perspective for planning remediation at the OU level. Future Tri-Party Agreement milestones will be developed on the basis of this strategy. Decision making at the OU level is driven by regulations, and should be compatible with the strategy. Figure 2-1 illustrates the relationship of the groundwater remediation strategy to the *Hanford Past Practice Strategy* (HPPS) (Thompson 1991).

2.3 CERCLA REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROCESS FOR THE OPERABLE UNIT

Within this document, groundwater remediation refers to those CERCLA restoration activities that return contaminated groundwaters to their beneficial uses wherever practicable. Potential beneficial uses of groundwater are in part dependent on the quality of the resource.

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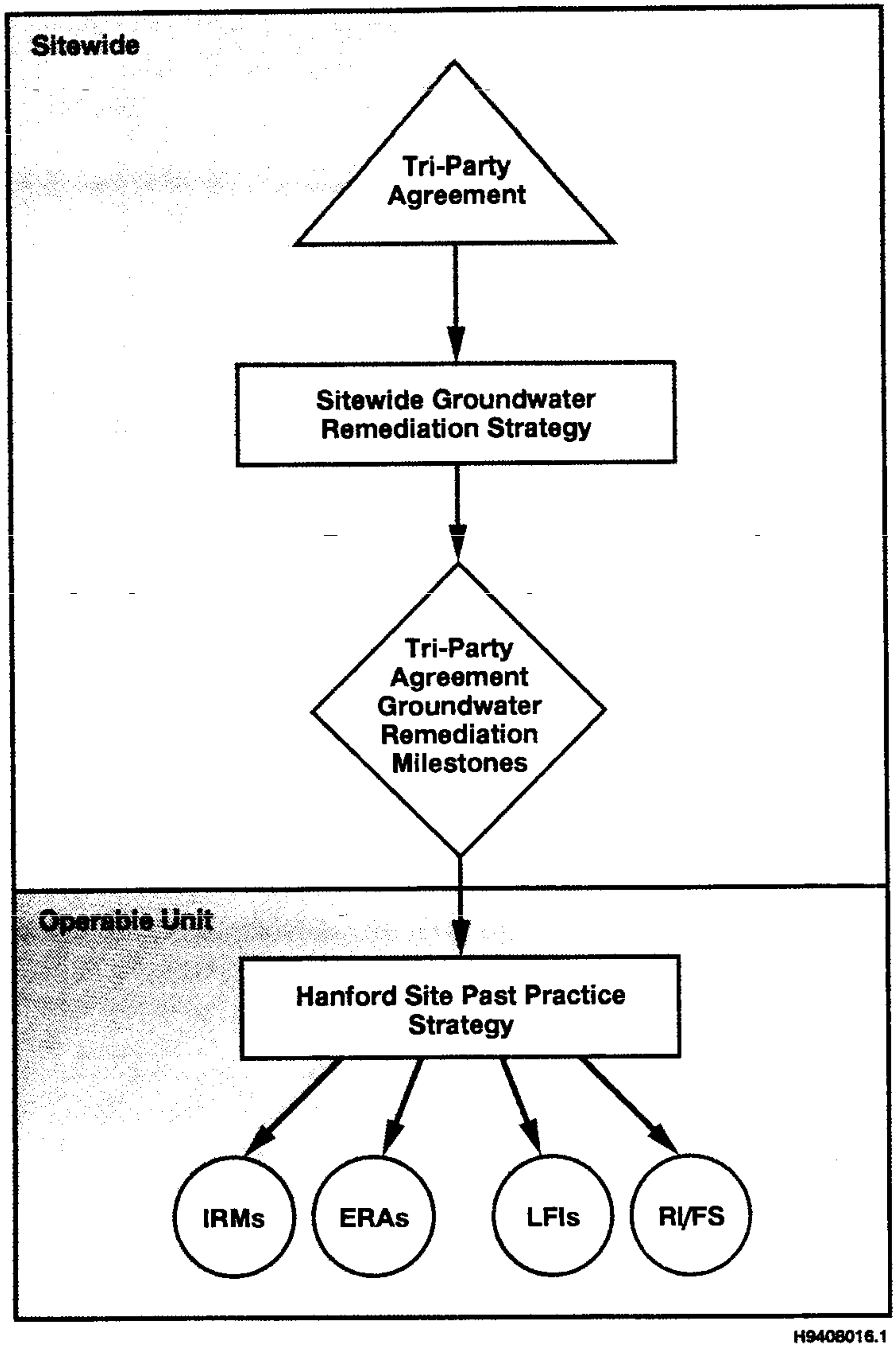
Figure 2-1. Relationship of the Sitewide Groundwater Remediation Strategy to the Hanford Past Practice Strategy.



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In general, restoration cleanup levels in the CERCLA program are established by ARARs.

The CERCLA regulatory process typically involves establishing preliminary remediation goals for individual OUs, which are modified on the basis of the remedial investigation (RI) and feasibility study (FS). Preliminary remediation goals for OUs are based on readily available information and ARARs. Goals may be modified as characterization and cleanup activities are implemented. However, final remediation goals are determined when specific remedies are selected and a Record of Decision (ROD) is reached. Preliminary and final remediation goals are generally numeric and are set at the OU level.

A significant portion of the effort in reaching a ROD leading to implementing remedial actions (RA) takes place under the RI and FS process. The RI is a process to determine the nature and extent of the problem represented by the release. The RI emphasizes data collection and site characterization and is generally performed concurrently and in an interactive fashion with the FS. The RI includes sampling and monitoring, as necessary, and the gathering of sufficient information to determine the necessity for RA, and to support the evaluation of remedial alternatives. The RI and the FS are collectively referred to as the "RI/FS."

An FS develops and evaluates options for RA. The FS emphasizes data analysis using data gathered during the RI. The RI data are used in the FS to define the objectives of the response action, to develop remedial alternatives, and to undertake an initial screening and detailed analysis of the alternatives. Each alternative (viable approach to an RA) is assessed with respect to a set of evaluation criteria. These criteria are:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

Risk assessment evaluations are also incorporated into the decision process at this time.

Once the RI/FS is completed, the EPA selects the appropriate cleanup option. This important step is documented by a ROD. Following the ROD, the remedial design is the technical analysis that follows selection of a remedy and results in detailed plans and specifications for implementation of the RA. An RA follows the remedial design and involves actual construction or implementation of a cleanup. A period of operation and maintenance may follow RA activities.

2.4 HANFORD PAST PRACTICE STRATEGY (HPPS)

The HPPS (Thompson 1991) was developed for the purpose of streamlining the past-practice corrective action process. Although investigations and studies remain important for meeting long-term goals, a significant portion of the near-term funding resources can be dedicated to that remedial work for which there is sufficient information to plan and implement interim measures. The HPPS allows for:

- Accelerating decision making by maximizing the use of existing data
- Undertaking expedited response actions (ERA) or interim response measures (IRM), as appropriate, to either remove threats to human health and welfare and the environment, or to reduce risk by reducing toxicity, mobility, or volume of contaminants.

There are three paths for decision making under the HPPS. A limited field investigation refers to the collection of limited additional site data that are sufficient to support a decision on conducting an ERA or an IRM. An ERA may be implemented for situations requiring an immediate onsite response action to abate a threat to human health or welfare or the environment. For situations in which extensive information may not be necessary to initiate some cleanup action, an IRM may be implemented before a final remediation action.

2.5 OTHER RELEVANT DOE PROGRAM ACTIVITIES

There are a number of other ongoing programs at the Hanford Site that relate to or affect groundwater and are described below. Planning and implementation of CERCLA groundwater remediation should be integrated with these other DOE program activities.

2.5.1 Groundwater Protection Management Program

In accordance with DOE Order 5400.1, *General Environmental Protection Program* (DOE 1988a), the *Hanford Site Groundwater Protection Monitoring Program* (GPMP) has been formulated (DOE-RL 1993c). The intent of this program is to protect the groundwater resources of the Hanford Site. With several DOE programs (e.g., waste management, environmental protection, and environmental restoration) engaged in activities that affect groundwater, there are circumstances where coordination of these programs is necessary to prevent duplication of effort, resolve potentially conflicting objectives, and make optimal use of resources.

In January 1994, a new Tri-Party Agreement milestone, M-13-81A, was negotiated. This milestone stipulates the revision of the existing Hanford Site GPMP document (DOE-RL 1993c) to incorporate cleanup goals, Tri-Party Agreement requirements concerning discharge to the ground, groundwater withdrawal and treatment, and the treatment of liquid effluents discharged to the soil column. The revised Hanford Site GPMP will be used to coordinate these efforts and to manage Hanford Site groundwater resources.

This will widen the purview of the document, which will serve as a vehicle for coordinating issues that cross institutional and regulatory program boundaries.

2.5.2 RCRA Waste Management Facilities

Under the direction of DOE, Richland Operations Office (RL), there also is a major effort to comply with EPA and state regulatory requirements at TSD units. The RCRA program involves application for permits to operate regulated TSD units, compliance monitoring of groundwater to detect and assess possible contamination from the TSD units, and corrective measures including development of TSD closure plans and cleanup actions. Groundwater monitoring at a TSD facility is designed to distinguish upgradient groundwater conditions from conditions downgradient of the TSD (Geosciences 1994). Groundwater remediation activities that involve pumping and reintroducing treated groundwater will affect groundwater flow and quality, and will have significant impacts on portions of the RCRA monitoring program. These impacts need to be identified and resolved.

2.5.3 Liquid Effluent Program

In December 1991, Ecology and DOE signed Consent Order No. DE 91NM-177, also known as the Liquid Effluent Consent Order. The Consent Order, together with Tri-Party Agreement Milestone M-17-00, commits the DOE to an aggressive schedule for completion of effluent disposal facility upgrades and to secure permits. Under this order, permits administered for WAC 173-216, "State Waste Discharge Permit Program" requirements are applicable to certain liquid effluent streams (Ecology and DOE 1992). The "216" Permit requires best available technology or all known and reasonable methods of prevention, control, and treatment for those waste streams. As directed by Ecology and DOE (1992) and the Tri-Party Agreement (Ecology et al. 1989), for interim compliance purposes, groundwater impact assessments were performed for a number of effluent disposal facilities (Tyler 1991). Most of these disposal facilities are also located in CERCLA OUs.

Under RL, a liquid effluent program is being conducted to bring facilities that discharge liquid effluents into compliance with environmental regulations. The focus is to reduce liquid effluent volumes generated, expand and improve treatment capacities, and to cease discharge of contaminated effluents to the ground. Efforts to reduce effluent discharges in the Central Plateau have already succeeded in reducing the rate of spread of many contaminants, most notably beneath the 200 West Area.

RL is constructing the 200 Areas Effluent Treatment Facility (ETF) to provide effluent treatment and disposal capability for the Central Plateau by June 1995. The initial mission of the 200 Areas ETF (Project C-018H) is to provide treatment of process condensate from the 242-A Evaporator. Treated effluent from the 200 Areas ETF will be disposed to a crib-type discharge facility called the State-Approved Land Disposal Site, which is being constructed north of the 200 West Area. A second liquid effluent program project, the 200 Areas Treated Effluent Disposal Facility (TEDF)

(Project W-049H), will provide a network of piping in both the 200 East and 200 West Areas. The 200 Areas TEDF will discharge the treated effluent to a new pond located in the 200 East Area.

Disposal of treated effluent from these facilities to the ground will likely result in some localized changes in groundwater flow directions. Of greater significance to groundwater remediation is the presence of potentially high concentrations (maximum 6,000,000 picocuries per liter [pCi/L]) of tritiated water in the treated effluent to be disposed to the soil column from the 200 Areas ETF. Tritium cannot be practically removed by treatment (DOE-RL 1994). This will result in the introduction of a new tritium contaminant plume to the unconfined aquifer.

2.5.4 Operational and Sitewide Monitoring

Operational groundwater monitoring and sitewide surveillance monitoring of groundwater have been conducted by the DOE for a number of years. Operational monitoring is oriented toward evaluating the effects of operational facilities (mostly related to liquid effluent disposal) on "near-field" groundwater conditions, but also examines resultant sitewide effects of operations (Johnson 1993). The sitewide program is a broad monitoring effort primarily oriented toward evaluating "far-field" sitewide conditions and offsite exposure to Hanford Site activities (Woodruff and Hanff 1993).

2.5.5 Hanford Remedial Action Environmental Impact Statement

The DOE has interpreted the *National Environmental Policy Act of 1969* requirements to be applicable to environmental restoration program activities. The Hanford Remedial Action Environmental Impact Statement is being prepared and will examine remediation alternatives and decisions germane to overall cleanup of the Hanford Site.

2.6 REGULATORY OVERLAP

Several federal and state regulations are applicable to activities affecting groundwater. Because these regulations are applied to facilities and activities often situated in the same location, there are overlapping regulatory programs with potentially conflicting requirements and conditions to be satisfied. Some of the issues raised by this overlap of regulatory programs are described below:

- Disposal of liquid effluents to the ground or surface waters that are generated by certain CERCLA pump and treat actions may be subject to WAC 173-216 requirements. For example, partially treated groundwater that must be returned to the ground may exceed state groundwater quality criteria, and thereby may be in conflict with state requirements.

- Liquid effluents disposed under a WAC 173-216 permit may affect groundwater quality or movement in a manner that is incompatible with CERCLA remediation objectives. For example, the 200 Areas ETF (Project C-018H) will dispose treated waste containing tritiated effluent to a proposed State-Approved Land Disposal Site and, as a result, there will be a new tritium plume contaminating the unconfined aquifer.

- RCRA "derived-from" and "mixture" rules for listed waste as administered by Ecology under WAC 173-303 could result in additional regulatory requirements for CERCLA cleanup actions. This would delay the start of remediation efforts if substantive requirements of RCRA are imposed.

- Movement of groundwater and reintroduction of treated groundwater for CERCLA remediations will result in changes to groundwater flow paths, water table elevation, and plume trajectories. This will compromise the effectiveness and potential regulatory compliance of portions of the RCRA groundwater monitoring network.

Effective and expedient implementation of groundwater remediation depends on clarification and resolution of potentially conflicting regulatory issues.

2.7 "CERCLA" Monitoring Network

Existing Hanford Site monitoring networks were not designed to meet the needs of the environmental restoration mission. RCRA and operational monitoring networks, and CERCLA groundwater investigations are typically designed to evaluate groundwater conditions at individual facilities or in a limited geographic area. Implementing multiple, concurrent groundwater remediation efforts will affect large areas and impact many of the localized networks, significantly reducing their effectiveness.

To support the refocused environmental restoration program, it is recommended that a CERCLA monitoring network be developed based mostly on existing wells that address: (1) the effectiveness of RAs, (2) the movement of plumes, (3) early notification of increasing contamination, and (4) compliance with selected standards in areas away from the plumes. RCRA-related and other groundwater monitoring programs would not be compromised. Coordination of groundwater data collection among the systems is required to maintain an efficient, cost-effective operation.

To better align with the regulatory framework of remediation, the CERCLA network should consist of four categories of monitoring wells:

- Treatability test monitoring wells
- RA assessment wells
- Plume periphery monitoring wells
- Compliance monitoring wells.

A remediation effort would include wells that fit each category, e.g., nesting from centers of highest contaminant concentrations (treatability test and RA wells), to lower concentration (plumes periphery wells), to areas of no contamination (compliance wells). The area of coverage for each well category, sampling, and reporting requirements would be established to meet the objectives of the well category.

The strategy recommends development of a compliance monitoring network that would surround the Central Plateau. Figure 4-3 shows an approximate location for such a network. This recommended boundary closely approximates the Hanford Future Site Uses Working Group's waste management area boundary for the Central Plateau. Sufficient wells currently exist to implement such a network.

3.0 STAKEHOLDER VALUES TO GUIDE REMEDIATION

Successful remediation of groundwater necessitates public, tribal, and regulatory acceptance of both the process and outcome. That acceptance is more likely to occur when an informed public is provided meaningful opportunities to participate in the process and help determine the outcome. This strategy was developed with recognition that stakeholder values should shape cleanup objectives and aid in prioritizing the sequence of cleanup actions. While there is a great diversity of viewpoints among the stakeholders in cleanup of the Hanford Site, there are values shared by many that may serve as themes for building consensus and providing direction to groundwater remediation. It is necessary to have a vision for what must be accomplished in the cleanup of the Hanford Site. The desired future uses for the land and resources of the Hanford Site provide the basis for determining the goals of environmental restoration. This chapter presents stakeholder values and describes proposed future uses of the Hanford Site.

3.1 VALUES

Values to guide groundwater remediation are based on comments and statements expressed by the public, Indian nations, and stakeholders in a variety of public forums. Initial information for this chapter was derived primarily from public commentary to recent revisions of Tri-Party Agreement milestones (Ecology et al. 1989), from Hanford cleanup stakeholders and tribes that participated in the Future Site Use Working Group (Hanford Future Site Uses Working Group 1992), and the Hanford Tank Waste Task Force (Tank Waste Task Force 1993). Subsequent refinement of this document will incorporate, as appropriate, public and tribal perspectives expressed during workshops for groundwater remediation and the Hanford Advisory Board perspectives.

Commonly held values to guide groundwater remediation are as follows:

- Protect human health, worker safety, and the environment
- Protect the Columbia River
- Use available technology and start remediation
- Develop new technologies to clean up contaminants less amenable to remediation with available technologies
- Reduce the mobility, toxicity, and quantity of groundwater contaminants
- Do nothing to make groundwater protection and remediation efforts less effective
- Comply with applicable federal, state, and local laws/regulations, and tribal treaty rights
- Eliminate the disposal of liquid waste to the soil column

- Clean up groundwater on a geographic basis, to the level necessary to enable the future land use option to occur
- Facilitate DOE's efforts to relinquish control of parts of the site
- Use funding wisely and effectively.

3.2 EXTENT OF CLEANUP TO ENABLE FUTURE USES

For the purpose of identifying a range of potential future uses for the Hanford Site, the Future Site Use Working Group was convened (Hanford Future Site Uses Working Group 1992). The group was composed of representatives from relevant federal, tribal, state, and local governments, as well as representatives from constituencies for labor, environmental, agricultural, economic development, and citizen interest groups, all with an interest in the cleanup and future uses of the Hanford Site. Generic proposals for how an area of the site might be used in the future, called "future use options," were developed. Types of future use options considered were:

- Agriculture
- Wildlife
- Native American uses
- Industry
- Waste management
- Research/office
- Recreational/related commercial
- Recreation.

In devising cleanup scenarios for the various future use options, the group addressed the issue of "how clean is clean" in general, nonregulatory terms. Cleanup scenarios identify distinct levels of "access" necessary to allow various future land use options, which are based on the presence of contamination to the air, surface, subsurface, and groundwater. Potential beneficial uses for groundwater are therein linked to future use options. Levels of access defined by the group are:

- Exclusive--an area where access is restricted to personnel who are trained and monitored for working with radioactive or hazardous materials
- Buffer--the part of the site that surrounds an exclusive area. It is treated like an exclusive area because of potential risks from the exclusive area, in which environmental restoration activities (but not waste management area activities) may occur
- Restricted--an area where access is limited because of contamination, with the exception that the groundwater may be restricted on an interim basis and ultimately cleaned up to unrestricted status
- Unrestricted--an area where there is no access restriction.

3.3 CLEANUP SCENARIOS AND PRIORITIES

The Future Site Use Working Group devised cleanup scenarios for six geographic study areas (Figure 3-1). The group then recommended general priorities or criteria that could be considered for focusing cleanup activities. Cleanup scenarios relevant to groundwater remediation are presented in the following sections.

3.3.1 Reactors on the River

The Reactors on the River area is an aggregation of all 100 Areas OUs and includes reactors and associated facilities within a 68.8-km^2 (26.6-mi^2) area. For all cleanup scenarios, groundwater would be remediated to an unrestricted status for the entire area. Cleaning up flows of contaminated groundwater to the Columbia River is the most immediate and highest priority. The following specific areas are identified as the most important for cleanup of groundwater:

- N Reactor area with associated springs and seeps
- K Basins
- Groundwater contamination flowing into the Columbia River.

3.3.2 Central Plateau

The Central Plateau encompasses approximately 116 km^2 (45 mi^2) at the center of the Hanford Site, and includes the 200 East and 200 West Areas and an area informally known as the 200 North Area. The cleanup scenario for the Central Plateau assumes that future use of the surface, subsurface, and groundwater in and immediately surrounding the Central Plateau would be an exclusive waste management area. Surrounding the exclusive area would be a temporary surface and subsurface buffer zone to reduce risks associated with ongoing activities in the Central Plateau. Environmental restoration, but not waste management activities, would occur in the buffer zone to clean up existing contamination. The cleanup target for the buffer zone is to remediate and restore contaminated areas (including groundwater) for ultimate availability for unrestricted use.

For the exclusive zone, the cleanup target is to reduce risk outside the zone sufficient to minimize the size of the buffer zone or restrictions posed by contaminants coming from the Central Plateau. Periodically, the size of the buffer zone would be decreased commensurate to the decrease in risks associated with waste management activities. It is important that cleanup efforts seek to prevent the spread of groundwater contaminants to other areas of the site. Localized groundwater cleanup within the Central Plateau should be quickly pursued for those actions that prevent the migration of contamination. In the foreseeable future, the waste management area would remain an exclusive zone. Depending on technical capabilities, it is desirable to ultimately achieve cleanup sufficient to allow future uses other than waste management.

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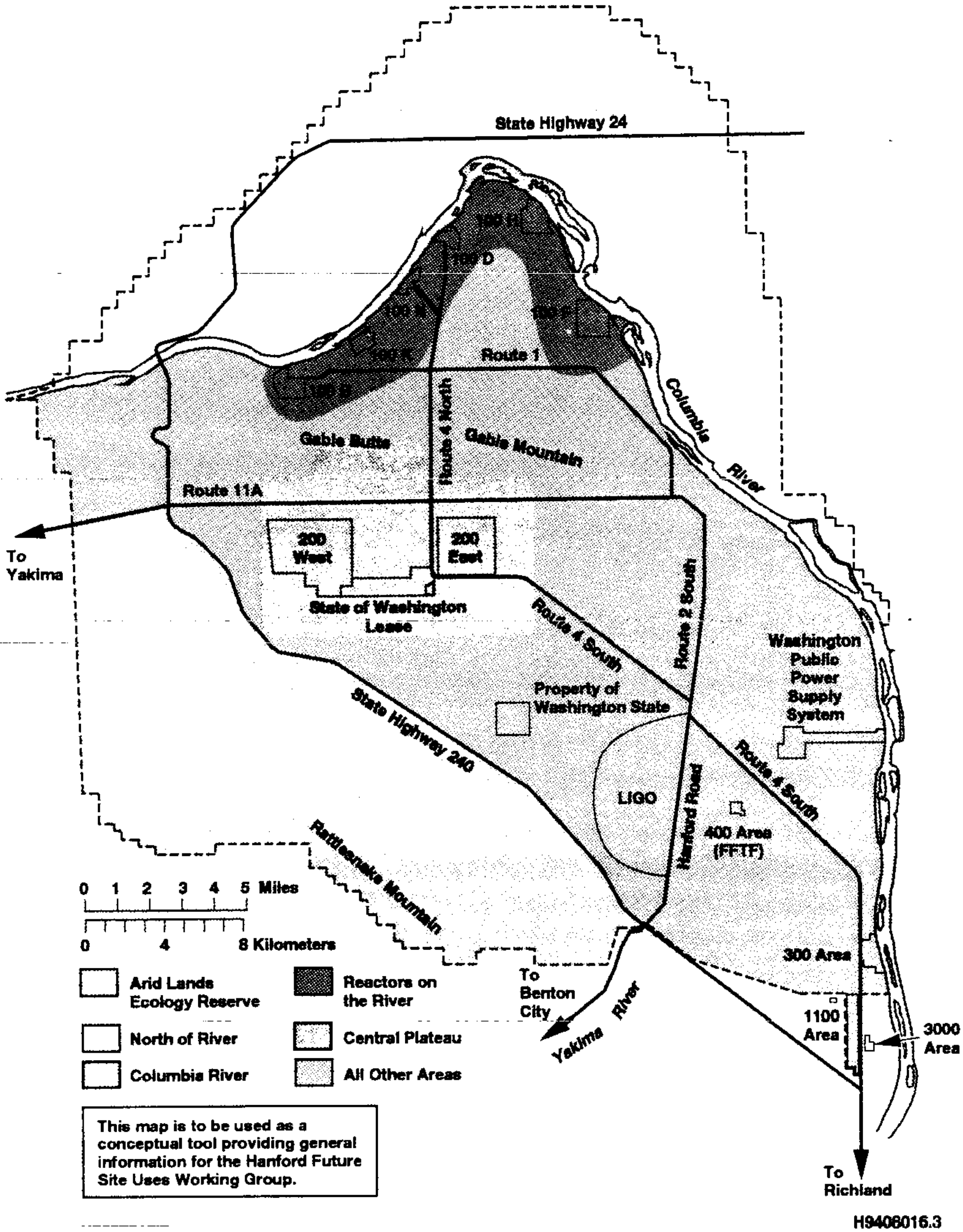
Figure 3-1. Hanford Future Site Uses Geographic Areas.



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3.3.3 Columbia River

Eighty-two kilometers (fifty-one miles) of the Columbia River flow through or border the Hanford Site. Cleanup of contaminated groundwater that discharges into the Columbia River is an immediate priority. Cleanup of sediments in the river or of contaminants in the riparian zone should be undertaken only if the cleanup can occur without causing more harm than good. There should be no dam construction or dredging in the Hanford Reach. Class A water quality should be maintained over the long term, with reasonable efforts to improve the water quality over time.

3.3.4 North of the River

The "North of the River" (Wahluke Slope) subarea refers to 363 km^2 (140 mi^2) of land north of the Columbia River that is relatively undisturbed or is returning to shrub-steppe habitat. Potential uses of the subarea North of the River would be unrestricted and would not be constrained by the presence of contamination on the surface or in the groundwater. It is assumed that cleanup can be performed relatively quickly and at a low cost using existing technology, i.e., cleanup could begin immediately. This priority for early cleanup should not detract from cleaning up areas that pose an imminent health risk. It was also assumed that cleanup costs for this area are a relatively small percentage of the overall cleanup budget. Early cleanup would allow conversion of the site to future use options and show tangible progress in cleanup.

3.3.5 Arid Lands Ecology Reserve

The Arid Lands Ecology Reserve is 311 km^2 (120 mi^2) of a relatively undisturbed habitat/wildlife reserve south of Highway 240 and west of the Yakima River. Use of groundwater would be restricted where groundwater is contaminated or where withdrawal of groundwater would spread contamination. No future use options for the Arid Lands Ecology Reserve require the use of the groundwater beneath that area. Following DOE direction, cleanup of the Arid Lands Ecology Reserve is currently underway with completion expected in the fall of 1994.

3.3.6 All Other Areas

This geographic area of 627 km^2 (242 mi^2), incorporates the 300, 400, and 1100 Areas, and all of the Hanford Site not included in the five other geographic areas described by the group. Future use options defined for "All Other Areas" assume no migration of contaminants from the Central Plateau, except existing groundwater plumes. Key cleanup priorities would be threats to drinking water supply well fields and areas where there is existing public access to the river. Where cleanup activities would threaten wildlife species and/or habitat, the benefits of groundwater remediation should be compared to the potential harm. The guiding principle is to "do no harm."

Two cleanup scenarios were proposed. For one scenario, groundwater beneath the 1100 Area would be unrestricted, because of the proximity to the city of Richland's water supply well fields and residential areas. Elsewhere, groundwater use would be restricted where it is contaminated or where withdrawal of groundwater would spread contamination.

The second scenario suggests that access to groundwater within the 300 Area should be restricted and the other areas remediated to unrestricted status. Within 100 years, after which it is assumed that there would no longer be institutional controls, the entire geographic unit should be restored to attain unrestricted status.

4.0 CONTAMINANT HYDROGEOLOGY

This chapter presents the geologic and hydrologic features that control the direction and rate of groundwater flow. The major plumes on the Hanford Site are tabulated and described relative to the quantity and extent of contaminants. Distribution patterns are also discussed.

The physical, chemical, and hydraulic characteristics of stratigraphic units determine contaminant flowpaths and migration rates. These features also influence the capability to intercept and remediate a contaminant plume. Knowing these characteristics, along with a history of wastewater disposal, the basis for selecting appropriate methods to remediate groundwater and/or restrict the spread of contamination is formed.

4.1 HYDROLOGIC CHARACTERISTICS

The Hanford Site is located in the Pasco Basin, a broad sediment-filled depression that lies within the larger Columbia Basin physiographic province. The Hanford Site is noted for its thick sedimentary fill, wide areal variability in water and contaminant movement, deep unconfined aquifer, and limited natural recharge to the aquifers.

4.1.1 Vadose Zone

The soil column above the water table is dominated by unconsolidated sandy gravels (Hanford formation) that were deposited during glacial activity during the last 10,000 to 15,000 years. These sediments are highly transmissive to water. The downward movement of moisture is slowed wherever fine-textured soils or sediments occur. In the eastern side of the Hanford Site, the water table resides in these sediments. Evapotranspiration prevents most of the precipitation from reaching groundwater.

The stratigraphy above the water table in the Central Plateau has a profound influence on the movement of liquid effluents through the soil column beneath many waste disposal sites. Layers of fine-textured sediment slow the downward movement of water, resulting in saturated water zones above and separated from the top of the unconfined aquifer ("perched" water zones). This condition expands the source area beyond the physical dimensions of disposal facility. It also significantly influences the time required for contaminants to reach the water table. Extended drainage periods may persist following termination of wastewater disposal operations. The interplay between stratigraphy and disposal operations is an important element in planning groundwater remediation.

4.1.2 Aquifers

The unconfined aquifer generally occurs in unconsolidated to semi-consolidated silts, sands, and gravels of the Ringold Formation. These sediments were deposited by the Columbia River as it meandered across the central Pasco Basin during the past several million years. The Ringold Formation is less transmissive to water than the Hanford sediments. Groundwater flow rates are highly variable due to aquifer heterogeneity, but generally range from less than 0.30 meter/day (1 foot/day) to several meters/day (feet/day) (Freshley and Graham 1988). The highest rates are in the unconsolidated gravelly sands of the Hanford sediments, and similar deposits in the middle Ringold Formation.

Underlying the Ringold Formation are the Columbia River Basalts, which are extensive layers of flood basalt. The basalts contain numerous confined aquifers, some of which are regional water sources. Vertical movement of water between aquifers may occur along fractures or faults in some areas (Early et al. 1988).

4.1.3 Aquifer Recharge

Both natural and artificial sources of water recharge the aquifers within the Pasco Basin. The most significant volume source is irrigation water from the Columbia Basin Project, although the influence is limited to the area north of the Columbia River, because the river acts as a groundwater flow divide for the unconfined aquifer.

Irrigation in the upper Cold Creek valley to the west of the Hanford Site may contribute a portion of the recharge to the unconfined aquifer beneath the Central Plateau. The volume of recharge is uncertain, because much of the irrigation water is lost to evaporation. Artificial recharge caused by Hanford Site operations historically has produced major groundwater mounds in the 200 East and 200 West Areas. The reduction or cessation of waste disposal has resulted in declines in water table elevations across much of the 200 Areas. The disappearance of mounds and changes in water table elevations have changed contaminant plume characteristics. At the southern end of the Hanford Site, the city of Richland maintains a groundwater storage "reservoir" that creates a groundwater mound, which influences groundwater flow directions in the 1100 Area.

4.1.4 River/Groundwater Interaction

The interaction between the Hanford Site aquifer and the Columbia River is an important element in assessing contaminant impacts on the river system. River water moves in and out of the banks during daily stage fluctuations, causing variable water quality characteristics in shoreline monitoring wells. Also, the interface zone between the river and the aquifer has characteristics that may retard or modify contaminants being transported by groundwater (Peterson and Johnson 1992).

4.1.5 Direction and Rate of Groundwater Movement

Contaminant plumes move in directions that are approximately perpendicular to the water table elevation contours. Plume maps that represent typical chemical and radiological waste indicators are shown in Figures 4-1 and 4-2. During the operating history, changes in the volume of liquid waste disposed to the soil column have changed the shape of the water table, resulting in alterations to migration patterns.

In the 100 Areas, flow toward the river averages several to 4.6 meters/day (15 feet/day). The rate is strongly influenced by river stage within several hundred feet of the shoreline. During extended periods of high river stage, flow is temporarily inland from the river, resulting in bank storage of river water. An upward hydraulic gradient is present from deeper, confined aquifers, which works against downward migration of contamination.

On the Central Plateau, average rates of movement in the upper unconfined aquifer are about 0.15 meter/day (0.5 foot/day) in the 200 West Area and 0.3 to 0.61 meter/day (1 to 2 feet/day) elsewhere; however, locally flow rates may reach as high as 6 meters/day (20 feet/day). Flow rates in the confined aquifers are much slower (<0.003 meter/day [<0.01 foot/day]). The potential for downward vertical movement of groundwater from the unconfined aquifer into the upper confined system in some areas beneath the Central Plateau exists, as revealed by the decrease in hydraulic head with depth (Johnson et al. 1993).

Groundwater monitoring results indicate the occurrence of mobile (iodine-129 and technetium-99) contaminants in the confined aquifers (Early et al. 1988). This occurs where natural, fracture-controlled intercommunication exists (e.g., Gable Gap area), and where preferential pathways may have been created due to unsealed wells connecting upper and lower aquifer systems (e.g., old wells drilled into the upper basalt aquifers near waste disposal sites). Where contaminants have reached the confined system, the areal extent or movement should be very limited as compared to the upper unconfined aquifer where most of the groundwater contamination occurs.

Marked variations in permeability occur within the unconfined aquifer, especially in the 200 West Area. Variable cementing of the aquifer sediments accounts for most of the differential permeability in the 200 West Area. Within the 200 East Area the major source of variability is whether the top of the water table is located within the Ringold Formation or the more permeable Hanford formation. The interaction of natural and artificial recharge sources with the variation in aquifer permeability across the Central Plateau controls the direction and rate of movement of contaminant plumes that originate from past-practice disposal sites within the 200 West and 200 East waste management areas. The rate of movement is also influenced by the chemical reactivity of the contaminant in the environment.

Two general flow directions are expected for the major contaminant plumes originating in the Central Plateau: (1) to the southeast with discharge to the river between the old Hanford townsite and the 300 Area, and (2) through Gable Gap with discharge to the river between the 100B and 100D Reactor areas (Figure 4-3). Based on current water table elevations and known aquifer transmissivities, mobile contaminants from the 200 West Area are expected to

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Figure 4-1 Areal Distribution of Chemical Contaminants in Relation to Current Water Table Contours.

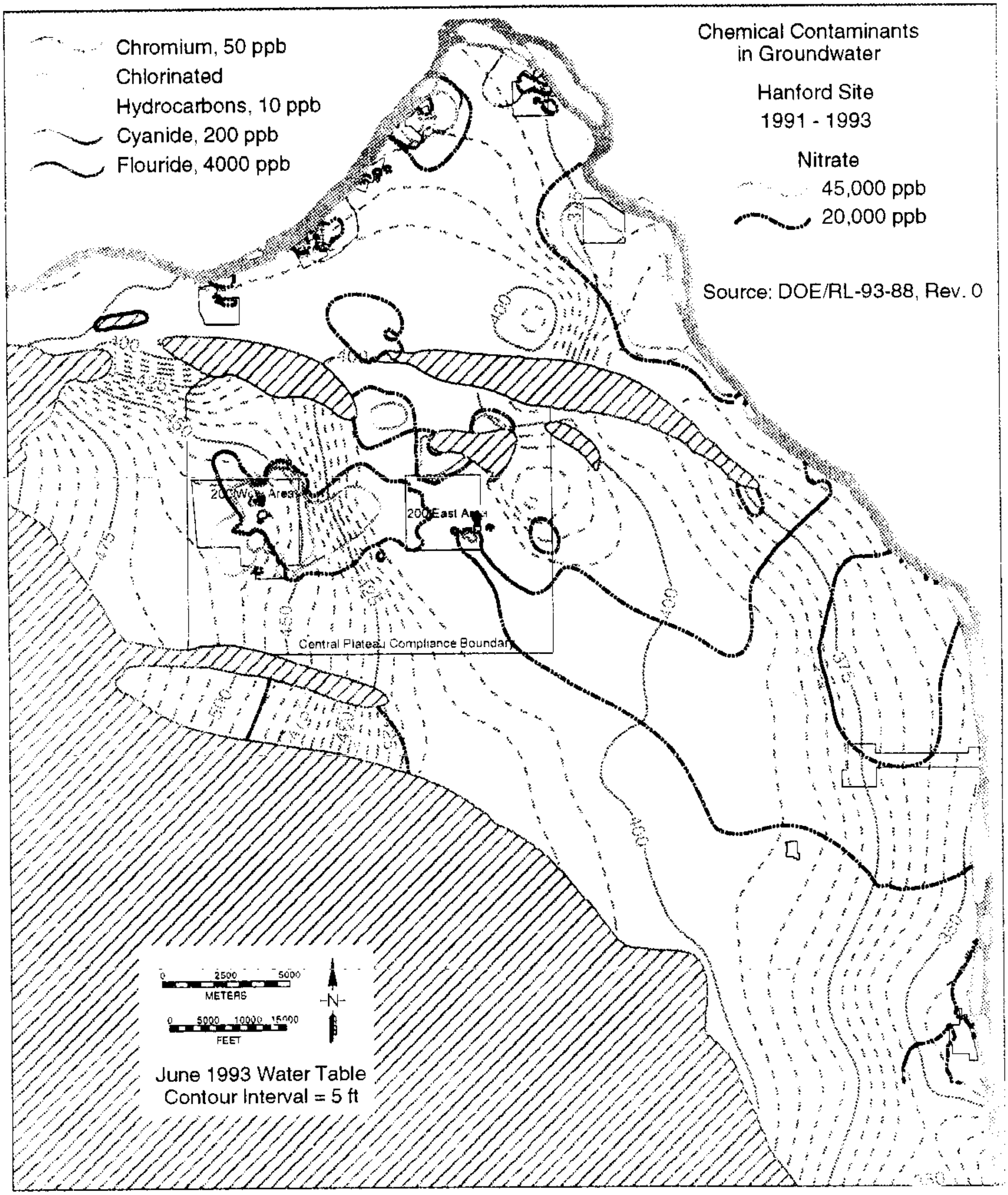

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Figure 4-2 Areal Distribution of Radioactive Contaminants in Relation to Current Water Table Contours.

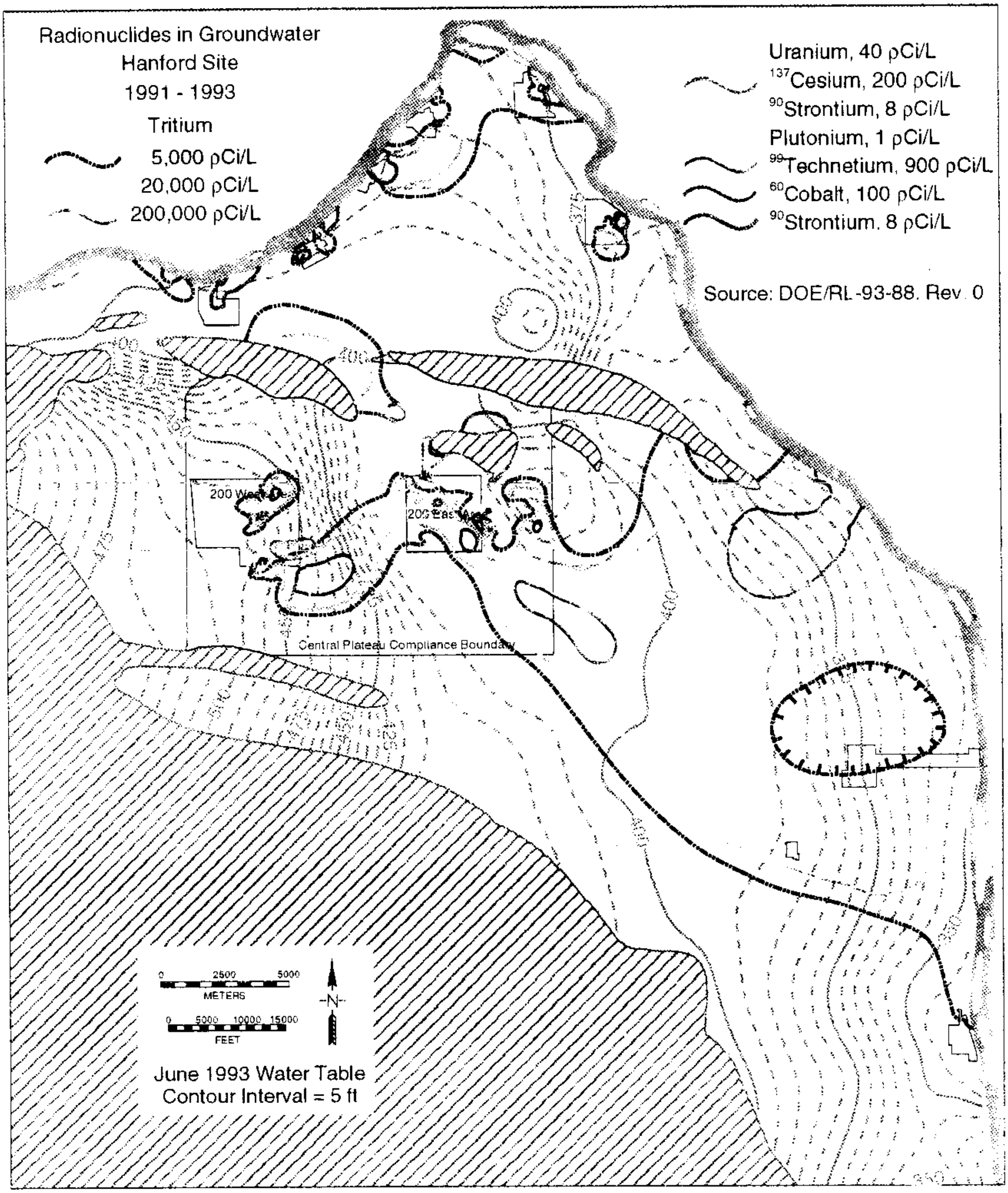

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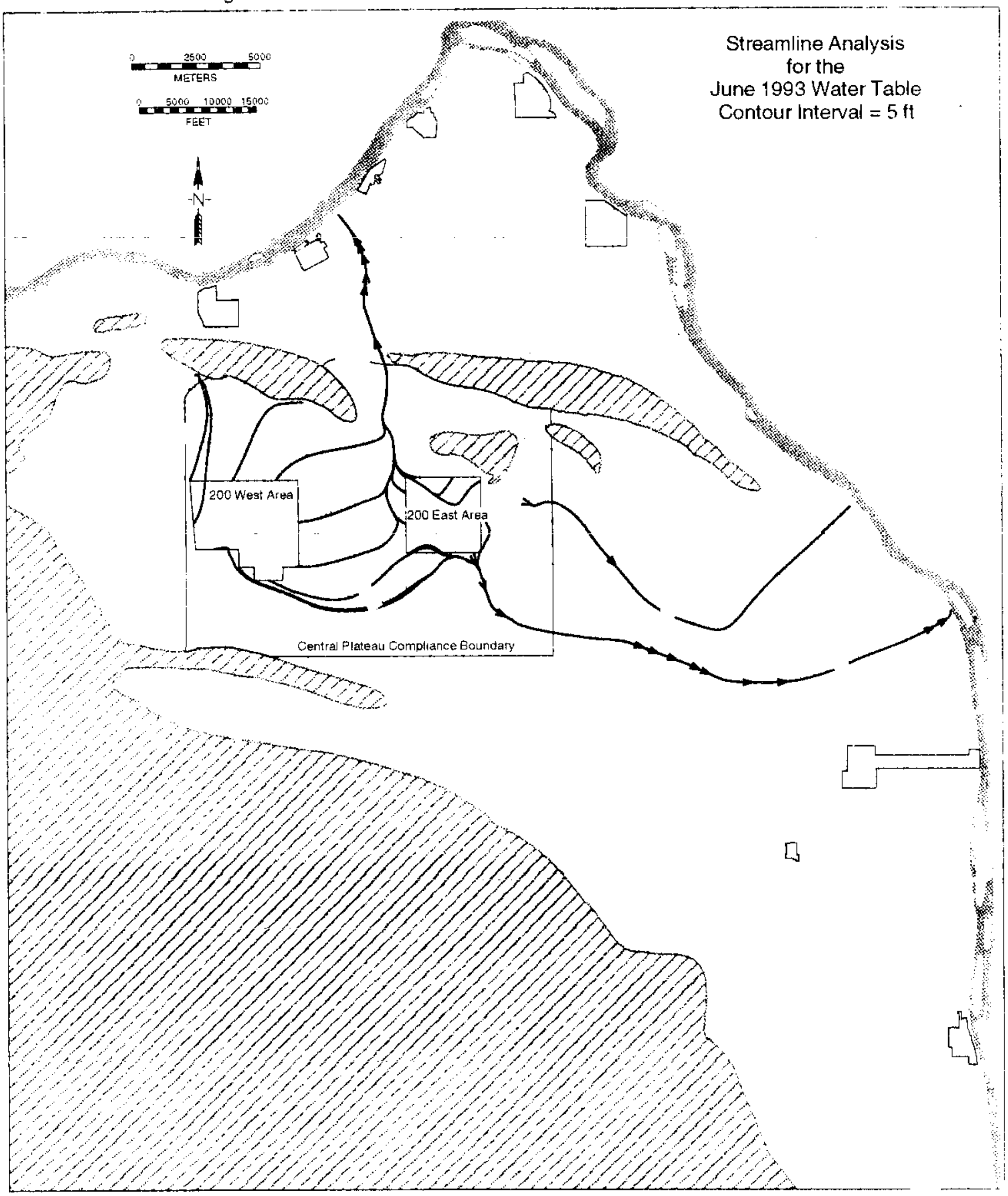
Figure 4-3 Groundwater Streamlines for the Central Plateau.



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take about 100 years to reach the Gable Gap area, followed by a much shorter travel time from Gable Gap to the river. Travel times from the 200 East Area are expected to be on the order of 10 to 20 years because of the very high aquifer transmissivities downgradient from this waste management area. The observed rates of movement of the tritium and carbon tetrachloride (CCl_4) plumes are consistent with these estimates. As water table gradients decrease as a result of significantly reduced wastewater discharges, the travel times will become longer than the estimates noted above. Flow paths may also be altered to some extent, especially as discharges to B Pond subside.

4.2 CONTAMINANT PLUME DISTRIBUTION PATTERNS AND VOLUMES

The major contaminant plume boundaries in the unconfined aquifer, as defined by exceedance of DWSs or equivalent concentrations, are shown in Figures 4-1 and 4-2. The directions and distribution patterns reflect the interaction of hydrogeologic conditions, disposal chronologies, and contaminant chemistry. For descriptive purposes, most of these plumes have been grouped into the Central Plateau and 100 Areas reactor sites geographic regions. Three contaminants (nitrate, tritium, and iodine-129) are discussed as sitewide plumes.

Several contaminant plumes overlap because of either merging of separate plumes from different sources, or because they were released as co-contaminants. The lateral extent of plume movement is influenced by the chemical reactivity or tendency of the contaminant to adhere to aquifer sediments, especially fine-grained material. Constituents such as tritium, nitrate, and technetium-99 do not interact with aquifer solids and are therefore the most widely distributed. Chlorinated hydrocarbons are only slightly adsorbed and are thus expected to be minimally influenced by aquifer solids. Strontium-90, cesium-137, and plutonium are highly reactive and/or form insoluble solid phases in groundwater, and are thus very limited in areal extent.

4.2.1 100 and 200 Areas Plumes

Table 4-1 provides estimates for individual contaminant masses and volumes within the plume boundaries shown in Figures 4-1 and 4-2. The volume estimates assume that the sampling depths of the monitoring wells upon which the plume contours are based represent the average concentration over an assumed maximum depth of 10 meters. In some cases, significant concentrations have been observed to a depth of 30 meters. Depth distribution is clearly an important factor that can significantly impact remediation strategy and the likelihood of success. The lack of definition of vertical contaminant distribution in the unconfined aquifer is a major issue that must be resolved.

The quantities or masses associated with aquifer solids listed in Table 4-1 (columns 5 and 6) were calculated using the pore fluid quantities (columns 3 and 4) and published distribution coefficients for Hanford Site soils (Ames and Serne 1991). The amount associated with aquifer solids can be much greater than the amount that occurs in pore fluid (e.g., strontium-90,

Table 4-1. Contaminant Plume Dimensions and Volumes (2 sheets).

Project	Target contaminants	Quantity				Extent of contamination		
		In pore fluid		On aquifer solids		Area		Pore fluid volume
		(Ci)	(g)	(Ci)	(g)	(m^2)	(mi^2)	(L)
200 West Area								
200-UP-1[a]	Uranium	9.1E-2	1.3E+5	0.2	2.4E+5	4.6E+5	1.7E-1	4.6E+8
	Technetium-99	2.8	1.6E+2	0	0	7.5E+5	2.8E-1	7.5E+8
200-ZP-1[a]	Carbon tetrachloride	N/A	5.8E+6	N/A	-[d]	1.1E+7	4.2	1.1E+10
	Chloroform	N/A	1.1E+5	N/A	-[d]	3.4E+6	1.3	3.4E+9
	Trichloro-ethylene	N/A	9.8E+3	N/A	-[d]	8.5E+5	3.3E-1	8.5E+8
200 East Area								
B-5 Reverse Well[a]	Plutonium-239	1.0E-1	1.5	2.4E+2	4.3E+3	3.1E+2	1.2E-4	7.8E+5
	Cesium-137	3.1E-4	9.3E-6	2.4E-1	9.3E-6	3.1E+2	1.2E-4	7.8E+5
	Strontium-90	4.1E-2	2.9E-4	6.2	4.4E-2	6.6E+4	2.5E-2	1.7E+8
50-53A[a]	Cyanide	N/A	4.3E+4	N/A	0	7.8E+4	3.0E-2	2.0E+8
	Technetium-99	5.0	[illegible]	0	0	7.5E+5	2.9E-1	1.9E+9
	Cobalt-60	3.7E-2	[illegible]	0	0	9.3E+4	3.6E-2	2.3E+8
[illegible]								
100K Area[b]	Chromium	[illegible]	[illegible]	N/A	0	5.6E+5	2.2E-1	7.1E+8
	Strontium-90	[illegible]	[illegible]	2.5	1.8E-2	2.6E+5	1.0E-1	6.5E+8
100D Area[b]	Chromium	N/A	1.4E+5	N/A	0	7.4E+5	2.8E-1	9.3E+8
	Strontium-90	1.3E-3	3.5E-6	1.9E-1	1.3E-3	2.3E+4	8.5E-3	5.5E+7
100H Area[b]	Chromium	N/A	3.6E+5	N/A	0	9.1E+5	3.5E-1	1.1E+9
	Strontium-90	6.5E-3	4.6E-5	1.0	7.0E-3	1.4E+5	5.5E-2	3.5E+8
100F Area[b]	Chromium	N/A	0	N/A	0	0	0	0
	Strontium-90	[illegible]	[illegible]	[illegible]	2.7E-2	1.3E+5	5.0E-2	3.2E+8
100N Area[b]	Chromium	N/A	0	N/A	0	0	0	0
	Strontium-90	[illegible]	[illegible]	[illegible]	5.0E-1	4.3E+5	1.7E-1	1.1E+9

Table 4-1. Contaminant Plume Dimensions and Volumes (2 sheets).

Project	Target contaminants	Quantity				Extent of contamination		
		In pore fluid		On aquifer solids		Area		Pore fluid volume
		(Ci)	(g)	(Ci)	(g)	(m^2)	(mi^2)	(L)
100B/C Area[b]	Chromium	N/A	0	N/A	0	0	0	0
	Strontium-90	1.0E-1	6.5E-4	1.4E+1	1.0E-1	5.5E+5	2.2E-1	1.4E+9
Sitewide								
Sitewide[c]	Tritium	2.1E+5	2.2E+1	0	0	1.8E+8	6.9E+1	8.9E+11
	Iodine-129	1.7E+0	1.0E+4	0	0	8.5E+7	3.3E+1	1.7E+12
	Nitrate	N/A	2.5E+10	N/A	0	4.1E+7	1.6E+1	1.4E+11

[a]Assumes that plumes have an average thickness of 10 m.
[b]Assumes that plumes have an average thickness of 5 m.
[c]Assumes plume thickness as described in Section 4.2.2.1.2.
[d]No estimates available.

cesium-137, and plutonium). Additionally, the total amount associated with pore fluid and aquifer solids relative to the total released is an important factor in assessing the fate of contaminants discharged to the soil column. For example, the total quantity of strontium-90, shown in Table 4-1, is less than 10% of the reported amount discharged. This suggests a large fraction is still contained in the vadose zone.

4.2.2 Sitewide Contamination

Three plumes in the Central Plateau extend well beyond existing CERCLA OU boundaries. These plumes have concentrations that fall both above and below accepted groundwater standards. The waste constituents are tritium, iodine-129, and nitrate. The plumes have the following elements in common:

- Widespread, covering tens of square miles
- Limited areas of high concentrations.

4.2.2.1 Tritium. This waste constituent has been introduced to groundwater at a number of locations as a result of irradiated fuel processing. Tritium was produced primarily as a fission product during reactor operations. Processing records indicate that the quantity of tritium discharged on the Hanford Site is approximately 220,000 Ci (decay corrected to December 31, 1992). Estimates for tritium based on groundwater sampling information yields a roughly comparable estimate of 210,000 Ci. The distribution of tritium on the Hanford Site is shown in Figure 4-4.

Tritium (^3H) is an isotope of hydrogen. It replaces or exchanges with nonradioactive hydrogen in water molecules and thus becomes part of the water molecule. In the environment it is indistinguishable from nontritiated water and moves with the same characteristics. The only attenuation mechanism for tritium, other than dilution, is radioactive decay with a half-life of 12.3 years.

4.2.2.1.1 Tritium Discharge to the Columbia River. Data from the Pacific Northwest Laboratory environmental reports from 1984 through 1992 have been used to estimate the Hanford Site discharge of tritium into the Columbia River. Before 1984 reported differences between upstream and downstream measurements were not statistically significant. Tritium migration into the Columbia River ranged from 3,800 to 8,400 Ci/yr during this period. The highest value occurred in 1991, with a drop to 4,600 Ci/yr in 1992. The peak in 1991 may correspond to the entry of the higher concentration portions of the Hanford townsite plume into the river. Data indicate the first arrival of significant quantities of tritium at the Columbia River near the Hanford townsite in either 1975 or 1976.

4.2.2.1.2 Tritium Plume Volume. An approximation to the quantity of tritium in Hanford Site groundwater, based on limited data concerning the deep occurrences of tritium, assumes that the tritium plume concentration in the Central Plateau extends to depths of 60 meters (197 feet) in the 200 West Area and 20 meters (66 feet) in the 200 East Area, and to depths of 20 meters (66 feet) in the 600 Area, east and southeast of the 200 East Area, and in the Gable Gap. This approximation yields a total tritium groundwater inventory of 210,000 Ci. This value is approximately 5% less than the estimated quantity discharged; however, when added to the 45,000 Ci (decay corrected) estimated for river discharge, there is an indication that there is a discrepancy of approximately 15%. The estimate is in reasonable agreement with the discharge estimates, particularly in consideration of the uncertainties in both the quantity of tritium produced and the estimates of the deep distribution of tritium.

4.2.2.2 Iodine-129. Iodine-129 is a groundwater contaminant concern because of its relatively long half-life (15 million years) and low regulatory standard (DWS = 1 pCi/L). Three extensive plumes of iodine-129 contamination originated from Central Plateau liquid waste disposal facilities that received process wastewater (Figure 4-5).

4.2.2.2.1 Iodine-129 Plume Migration. Iodine-129 occurs in wastewater and groundwater as mobile anionic species (I^- or IO^-) and travels at the same velocity as groundwater. Its distribution and centers of highest concentration roughly coincide with the tritium contaminant plumes that underlie the Central Plateau. There is no analytical data indicating that iodine-129 in concentrations exceeding the DWS have entered the Columbia River. The edge of the plume appears to be 2.5 to 3 kilometers (km) (1.6 to 1.9 miles) from the Columbia River in the vicinity of the Hanford townsite.

Figure 4-4 Hanford Site Showing Areal Extent of Major Tritium Plumes

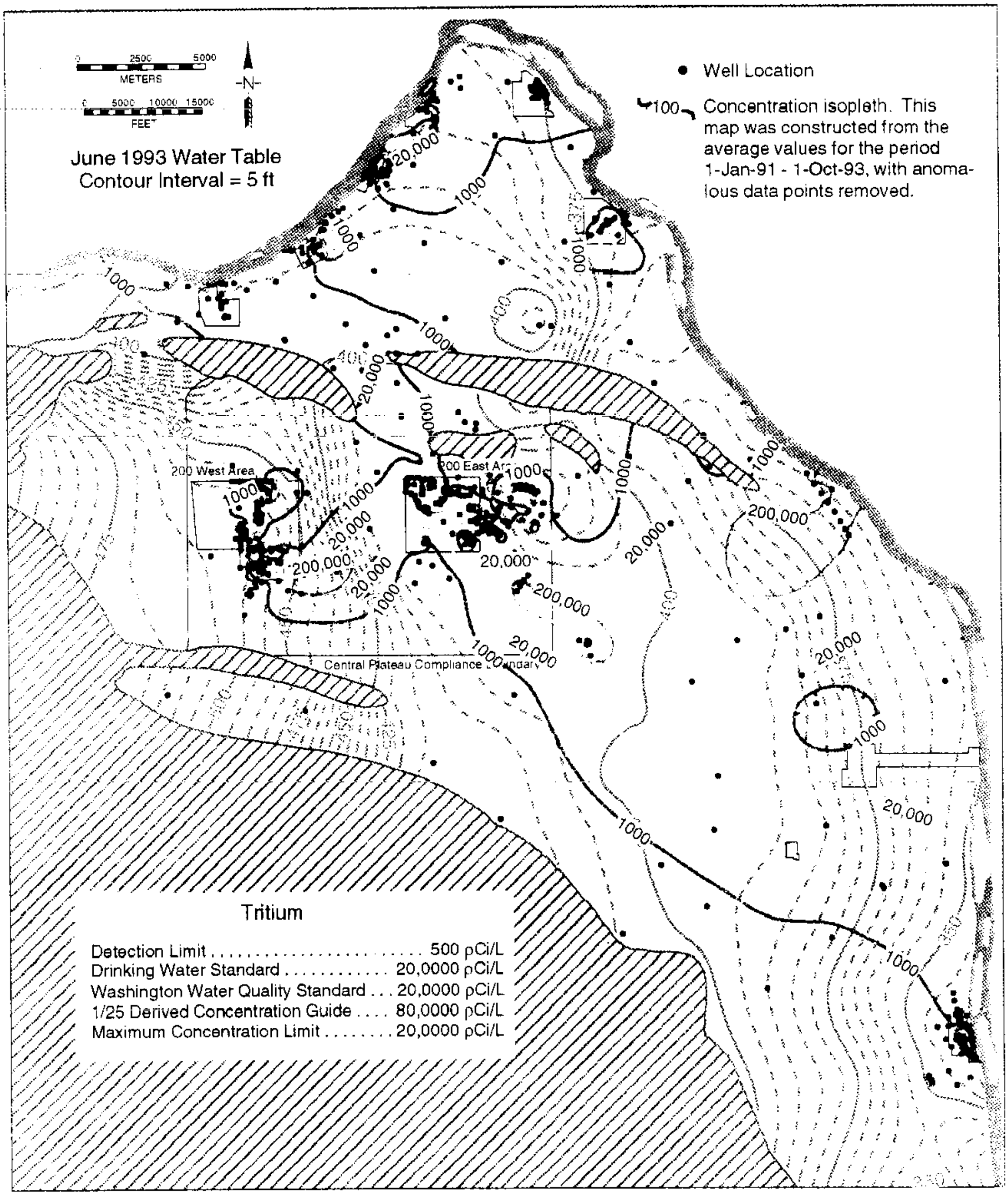

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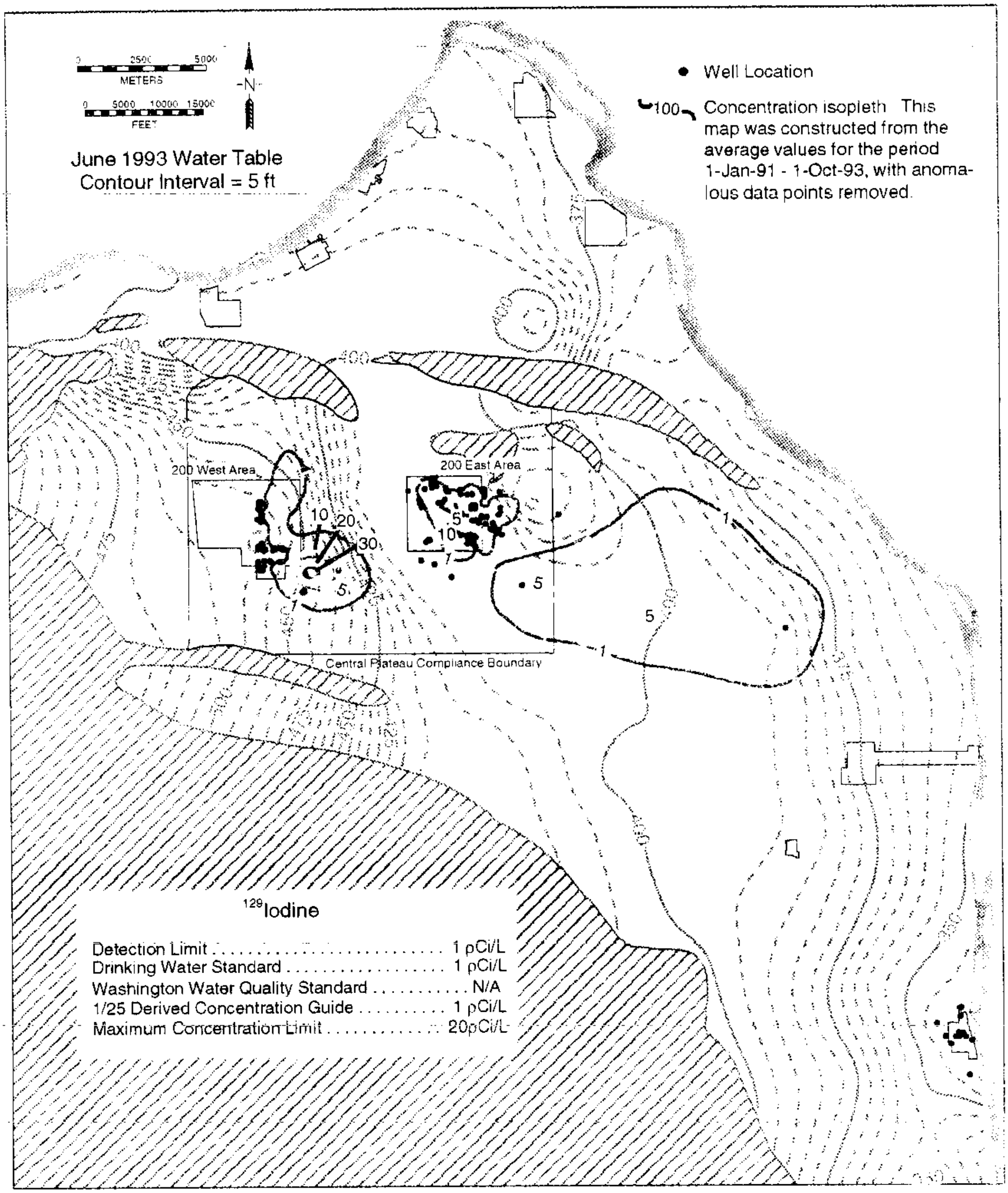
Figure 4-5 Hanford Site Showing Areal Distribution of ^{129} Iodine Plumes



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4.2.2.2.2 Iodine-129 Plume Volume. Iodine-129 contamination is present in the unconfined aquifer, over 84.5 x 10^6 m^2 (33 mi^2) of the central portion of the Hanford Site. Because iodine-129 is a co-contaminant with tritium in the Central Plateau and has the same mobility as tritium, its distribution at depth in the aquifer should be similar. Iodine-129 may be present to depths of 60 meters (197 feet) beneath the 200 West Area and 20 meters (66 feet) beneath the 200 East Area and the 600 Area east and southeast of the Central Plateau. A total volume of 1.7 x 10^9 m^3 (4.5 x 10^{11} gal) of groundwater is estimated to be contaminated with iodine-129 in excess of the DWS.

4.2.2.3 Nitrate. Nitrate contamination is present in all operational areas, as well as in significant portions of the 600 Area. Nitric acid was used in numerous site processes related to decontamination and fuel reprocessing activities. Acid waste solutions are the primary contributor to nitrate plumes currently observed in groundwater. The distribution of nitrate is shown in Figure 4-6.

Nitrate is an extremely mobile anion that moves at the same velocity as the groundwater. The anion is not retarded by sorption. The only attenuation mechanisms for nitrate are denitrification or biological assimilation are thought to be of minimal importance in Hanford Site aquifers.

4.2.2.3.1 Nitrate Discharge to the Columbia River. Nitrate is currently being discharged at concentrations exceeding the DWS to at least four stretches of shoreline along the 100 Areas of the Columbia River.
A significant stretch of shoreline adjacent to the Hanford townsite is the locus of nitrate discharge from 200 East Area sources at concentrations slightly below the DWS. It appears that the arrival of the nitrate plume at the Hanford townsite was coincidental with the tritium plume. Both tritium and nitrate show marked increases in well 699-40-1 beginning in 1975 to 1976. Nitrate concentrations exceeded the DWSs beginning in 1984 and remained elevated for 2.5 to 3 years. Concentrations in the well have remained slightly below the DWS from 1988 to the present.

4.2.2.3.2 Nitrate Plume Volume. The net area of nitrate contamination that exceeds the DWS for the Hanford Site as a whole is 40.7 x 10^6 m^2 (15.7 mi^2). As nitrate appears to have moved as a co-contaminant with tritium, it seems reasonable that a similar depth distribution profile is probable for plumes emanating from the Central Plateau as described in the tritium plume volume discussion (Section 4.2.2.1.2). With the assumption that nitrate contamination extends to depths of 60 meters (197 feet) in the 200 West Area, to depths of 20 meters (66 feet) in the 200 East Area and in the 600 Area east and southeast of the 200 East Area and in Gable Gap, and to 10 meters (33 feet) elsewhere on the site, the total volume of nitrate-contaminated groundwater beneath the Hanford Site is estimated to be 1.4 x 10^8 m^3 (3.7 x 10^{10} gal).

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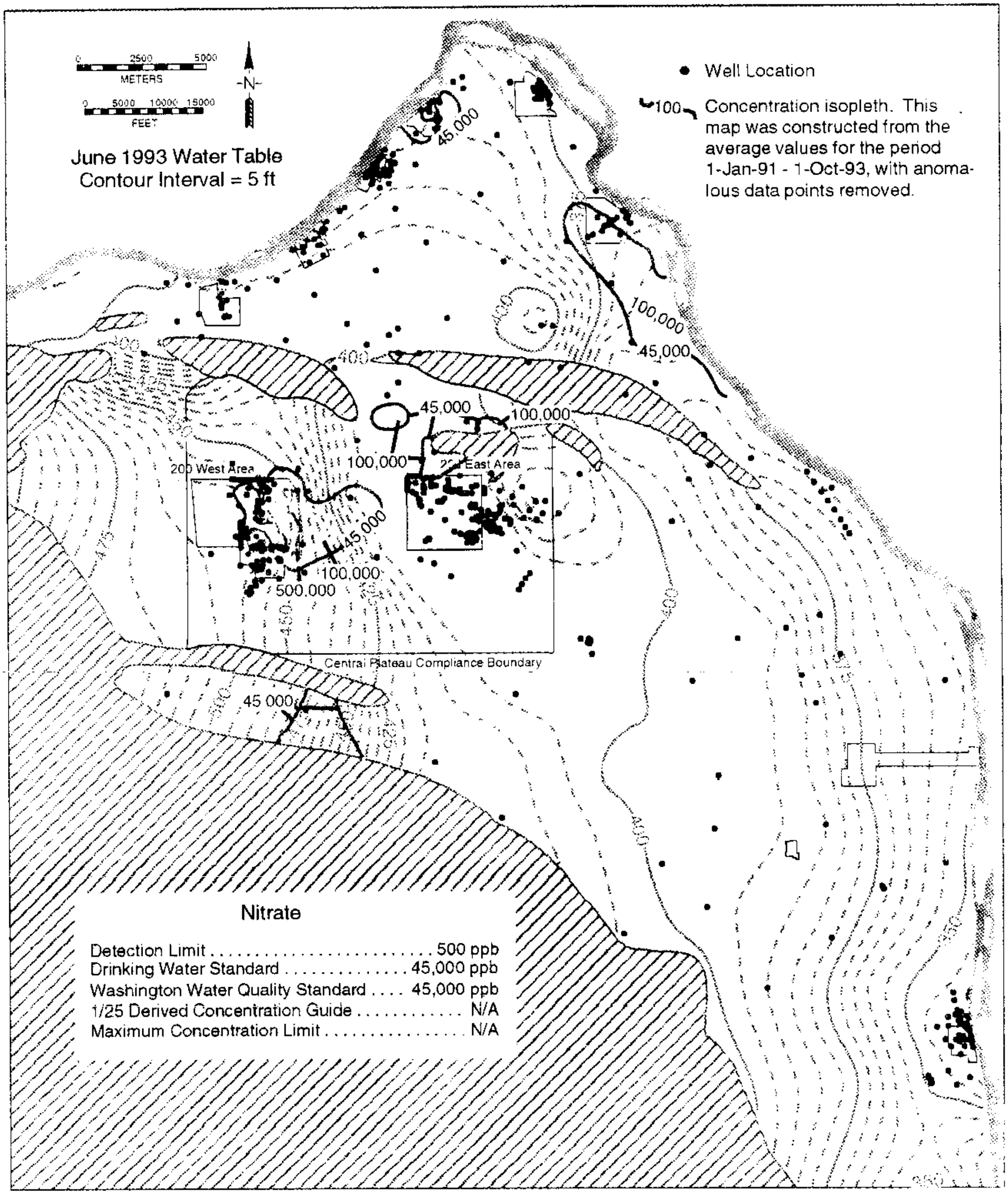
Figure 4-6 Hanford Site Showing Areal Distribution of Nitrate Plumes



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5.0 SITEWIDE GROUNDWATER REMEDIATION STRATEGY

The goal of groundwater remediation is to restore groundwater to its intended beneficial uses in terms of protecting human health and the environment. This strategy provides a common, sitewide perspective to guide the development of remediation activities for individual OUs. Guiding principles for a comprehensive groundwater remediation approach are summarized below. These principles are developed within the context of existing groundwater conditions, the institutional and regulatory framework for remediation, and stakeholder values described in previous sections of the document. Details of specific strategy elements are addressed in the following sections.

5.1 GUIDANCE

This strategy is a geographic and plume-specific approach to groundwater remediation. It is oriented to reflect public and tribal values and priorities. Key elements of this strategy are:

- Place a high priority on actions that protect the Columbia River and near-shore environment from degradation caused by the inflow of contaminated groundwater
- Reduce the contamination entering the groundwater from existing sources
- Control the migration of plumes that threaten or continue to further degrade groundwater quality beyond the boundaries of the Central Plateau.

5.1.1 Initial Remediation Efforts

Groundwater remediation efforts are already underway on the Hanford Site. These initial efforts will:

- Maintain a bias toward field remediation activities by employing the HPPS (Thompson 1991) to accelerate interim RAs
- Continue implementation of accelerated groundwater remediation projects to control plume expansion, reduce contaminant mass, and better characterize aquifer response to RAs
- Identify and control sources of contaminants in the vadose zone that impede efforts to remediate groundwater.

5.1.2 Final Remediation Efforts

Succeeding phases of RAs are oriented toward implementing the final ROD, which in turn will satisfy broader cleanup objectives, for example:

- Achieve ARARs with respect to the value of current and potential future beneficial uses for the groundwater resource
- Develop alternative containment and remediation strategies if currently available groundwater restoration technologies prove inadequate or impracticable
- Restore groundwater adjacent to the Columbia River for unrestricted beneficial use
- Prevent further degradation of groundwater quality beyond the boundaries of the Central Plateau, and ultimately restore unrestricted beneficial use of groundwater beyond that boundary.

5.1.3 Resource Optimization

An important element in the groundwater remediation strategy is optimizing the use of available resources. Key considerations are to:

- Balance the sequencing and scale of RAs to achieve efficient use of technical and monetary resources
- Incorporate existing and/or proposed treatment and disposal infrastructure
- Implement currently available technology and foster demonstrations of developing technology, where appropriate, for meeting remediation objectives
- Improve the integration of the existing groundwater monitoring networks and sampling schedules, to better characterize the contamination problem and to measure the effectiveness of remediation efforts.

5.1.4 Stewardship

The stewardship responsibility for remediating and protecting groundwater resources beneath the Hanford Site will be met by:

- Maintaining consistency with the Hanford Site GPMP
- Coordinating RAs, whenever feasible, at CERCLA OUs with adjacent OUs, with RCRA facilities undergoing closure, and with state-permitted waste discharge facilities

- Coordinating RAs that require disposal of treated groundwater with ongoing waste management and liquid effluent programs.

5.2 GEOGRAPHIC AND PLUME-SPECIFIC APPROACH

Previous studies of Hanford Site groundwater have screened and "targeted" the major groundwater contamination plumes by geographic area. Contaminant species that are widespread and/or present serious environmental concerns are addressed below. By implementing Section 5.1 and stakeholder values (see Chapter 3.0), a cleanup approach of containment and mass reduction is assigned to the major contaminant plumes identified in the Central Plateau. Similarly, contaminant plumes found in the reactor areas are assigned a cleanup approach of remediation. Table 5-1 lists the major contaminant plumes and their cleanup approach.

Table 5-1. Major Contaminant Plumes and Cleanup Approach.

Plume	Facility	Location	Cleanup approach
Uranium and technetium-99	UO_3 Plant	Central Plateau (200 West Area)	Containment and mass reduction
Organic (carbon tetrachloride, trichloroethylene, and chromium chloride)	PFP	Central Plateau (200 West Area)	Containment and mass reduction
Combined plutonium, cesium-137, and strontium-90	B Plant (B-5 reverse well)	Central Plateau (200 East Area)	Technology development
Technetium-99 and cobalt-60	BY Cribs	Central Plateau (200 East Area)	Containment and mass reduction
Strontium-90	N Reactor	Reactor areas (100N)	Remediation
Chromium	D Reactor H Reactor K Reactor	Reactor areas (100D, 100H, and 100K)	Remediation

PFP = Plutonium Finishing Plant.
UO_3 = Uranium Trioxide (Plant).

The cleanup approaches reflect the public values of protecting the river, controlling the spread of contamination, and eliminating re-contamination of cleaned areas of groundwater. The assigned approach is intended to guide the initial approach to cleanup and is not intended to limit additional cleanup, should it prove feasible.

Contamination associated with past discharges to the B-5 reverse well has an approach called "technology development." Remediation of this contamination currently requires technology development activities and may not be completely amenable to pump and treat methods. As described in later sections, this contamination is virtually immobile within the aquifer. The groundwater remediation strategy designates the B-5 reverse well-combined plumes to serve as a testing center for the purpose of technology development, leading to the reduction of the contaminant mass or its further stabilization within the aquifer.

The groundwater remediation strategy also selects one plume in the reactor areas and the Central Plateau as having higher priority over others in their respective areas. The strontium-90 plume, located at N Reactor, is selected in the reactor areas and the CCl_4 plume is selected in the Central Plateau. Both contaminants are found at levels well over state DWSs. Strontium-90 is discharging directly to the Columbia River and is the highest source of waterborne radioactivity accessible to the public. Carbon tetrachloride is a suspected carcinogen and is the largest of the targeted plumes; it has the potential to contaminate still larger areas.

For each area and plume, an overview of hydrochemical conditions is provided, followed by a brief description of an approach to cleanup. Major data and information gaps are identified along with areas where technology development would potentially accelerate groundwater cleanup.

Three widespread contaminant plumes and their remediation potential are also discussed. These plumes are: radioactive iodine-129, tritium, and nitrate. Each covers large areas, is often found above groundwater standards, and poses significant challenges to remediation. These plumes have not been "targeted" for immediate action.

Contaminants such as fluoride and arsenic that are detected as small, localized plumes or "hot spots" are best addressed on the more detailed level of the OU. Section 5.11 discusses important issues surrounding the disposal of treated and partially treated groundwater.

5.3 CENTRAL PLATEAU--200 WEST AREA--URANIUM AND TECHNETIUM-99 CONTAMINATION

5.3.1 Hydrochemical Conceptualization

Uranium and technetium-99 plumes associated with the 216-U-1/2 Cribs are expected to continue moving eastward from the 200 West Area and to eventually turn northward through Gable Gap. The rate of contaminant movement will decrease as the water table declines in the 200 West Area and the hydraulic gradient is subsequently reduced. Remediation is complicated by the textural variability and permeability of the geologic formation containing the plume, by the interaction of dissolved uranium with aquifer sediments, and the presence of co-contaminants.

5.3.2 Remediation Approach

Remediation of the uranium and technetium-99 plumes requires a combination of source identification and possible control, plume containment, and treatability testing. Although the transport of contamination can be substantially reduced by hydraulic controls, the final level of cleanup is likely to be above current ARARs using existing technologies. Technetium-99 is expected to be more amenable to pump and treat than uranium.

A multiple-phase approach is recommended that addresses data needed for design, containment, and/or remediation. Phase I should include:

- Determining the vertical extent of contamination
- Identifying continuing sources of contamination that would affect the permanence of cleanup efforts
- Treatability testing to evaluate alternatives for removing and treating groundwater
- Conducting studies to better define the direction of movement.

Based on the results of Phase I, Phase II would implement the selected alternative. Containing the spread of the contamination is the initial goal while information is collected and analyzed before the implementation of a larger remediation system. Existing site treatment infrastructure (e.g., the 200 Areas ETF) will be considered during the selection of treatment alternatives.

5.3.3 Technology Development

Technology development directed at restricting the movement of uranium in the unsaturated and saturated zones is of particular interest. These would include improved grouts and other flow-restricting additives, chemical agents directed at altering the mobility of the contaminants, and improved application methods. Improved and cost-effective physical-chemical groundwater treatment technologies for uranium and technetium-99 are also needed.

5.4 CENTRAL PLATEAU--200 WEST AREA-- ORGANIC CONTAMINATION

5.4.1 Hydrochemical Conceptualization

A CCl_4 plume in the 200 West Area is moving eastward from the vicinity of cribs associated with the Plutonium Finishing Plant. The rate of plume migration will diminish as a result of declining hydraulic gradient in the 200 West Area; however, movement to the east and eventually northward through Gable Gap will likely continue.

The fate of approximately two-thirds of the CCl_4 is unknown (Last and Rohay 1993). If present in sufficient quantities, CCl_4 can sink vertically and maintain a separate liquid phase within the vadose zone or within the aquifer. The separate liquid phase can act as a continuing source of groundwater contamination.

5.4.2 Remediation Approach

A phased approach is needed to address the major data gaps while actively preparing for containment and mass reduction of the more contaminated and the known source areas. Phase I concentrates on defining the existence of and the ability to remediate the potential source areas and pilot-scale treatability tests. Examination of the extent of contamination in the upper confined aquifer in selected locations is also recommended along with remediation of unsealed wells in the area. Based on the results of Phase I, implementation of a pump and treat system will be considered for the purpose of containment and mass reduction in the unconfined and upper confined aquifer.

5.4.3 Technology Development

Concurrent with the Phases I and II efforts, additional research is needed on improved treatment systems, containment of large plumes, in situ treatment, and immobilization methods (e.g., bio-remediation, reduction by metallic iron, enhanced natural degradation).

5.5 CENTRAL PLATEAU--200 EAST AREA--TECHNETIUM-99, COBALT-60, CYANIDE, AND NITRATE CONTAMINATION

5.5.1 Hydrochemical Conceptualization

Estimated quantities of the primary contaminants in the liquid effluent disposed to the BY Cribs include 0.45 Ci of cobalt-60, 18,900 kg (41,670 lb) of ferrocyanide, 5,700,000 kg (12,600,000 lb) of nitrate, and an unknown quantity of technetium-99 (DOE-RL 1993a, 1993b). These liquid effluents were dense brines and may have sunk into the aquifer, providing a source of continuing contamination (Kasza 1993). Plumes of technetium-99, cobalt-60, cyanide, and nitrate occur north of the 200 East Area and are believed to be associated with the BY Cribs. The plumes are moving northward through Gable Gap and the highest concentrations occur in the vicinity of well 699-50-53A. Technetium-99 and cobalt-60 are the primary contaminants of concern at this location.

5.5.2 Remediation Approach

A phased approach consisting of the following major elements will be implemented:

- Treatability testing using a pilot treatment system to remove technetium-99 and cobalt-60 from groundwater
- Areal and vertical definition of the plume
- Confirmation of the source of contamination and what potential control measures may be needed, if any
- Implementation of hydraulic controls to contain the plume, reduce the mass of contaminants, and slow its spread.

The key elements of the first phase include treatability testing and the collection of improved geohydrologic information. Based on the results of Phase I, source control and containment of the plumes would be conducted in subsequent phases.

5.5.3 Technology Development

Existing pump and treat technology appears to be adequate to successfully remediate the BY Cribs plume. However, improvements in the ability to remotely determine the elevation of the bottom of the aquifer by geophysical means could prove beneficial for locating any remnants of the dense contaminant mass and for defining any preferential groundwater flow paths.

5.6 CENTRAL PLATEAU--200 EAST AREA--PLUTONIUM, STRONTIUM-90, AND CESIUM-137

5.6.1 Hydrochemical Conceptualization

Significant quantities of plutonium, strontium-90, and cesium-137 are present in the vadose zone and aquifer material around the 216-B-5 reverse well (injection well) in the 200 East Area (Brown and Rupert 1950; Smith 1980). Because of high sorption coefficients and inclusion in relatively insoluble solid phases, the contaminants do not represent a threat to groundwater outside of the 200 East Area. However, because of their high concentrations and long half-lives, the radionuclides, particularly plutonium, represent the potential for long-term contamination of groundwater within the 200 East Area.

5.6.2 Remediation Approach

Geochemical considerations make implementation of a pump and treat system at this location appear to have little chance to succeed. It is recommended that currently planned treatability testing be directed at determining the geochemical nature of the dissolved and particulate fraction and in examining the time-dependent response of the contamination in the aquifer to treatability testing.

The groundwater remediation strategy establishes the area contaminated with the relatively immobile plutonium, strontium-90, and cesium-137 as a technology development test site for the purpose of permanently controlling contamination.

5.6.3 Technology Development

Potential technology development opportunities include the following information needed to remediate contamination found at the 216-B-5 reverse well: (1) determination of what geochemical phases are controlling distribution and transport of plutonium and strontium-90, (2) bench-scale tests with samples of contaminated sediments, (3) development of methods for physical removal of the contaminated sediments, and (4) development of barrier technology to contain the contamination.

5.7 REACTOR AREAS (100 AREAS)

5.7.1 Hydrochemical Conceptualization

Groundwater contaminants in the 100 Areas are important because of their proximity to the Columbia River. Groundwater flow is generally northward into the river. Principal contaminants forming plumes in the 100 Areas are strontium-90, tritium, nitrate, and chromium. The most significant of these are strontium-90, particularly in the 100N Area, and chromium, which is toxic to aquatic organisms.

5.7.2 Remediation Approach

The contaminants considered in the following discussion are limited to those having significant areal extent and are found at levels well above DWSs, i.e., problem areas where major efforts will be extended for remediation and that should be viewed in a sitewide context. Contaminants meeting the above general criteria for the 100 Areas include the radionuclide strontium-90, found in the 100N Area; and the chemical contaminant chromium, found in the 100D, 100H, and 100K Areas, respectively (Hartman and Peterson 1992). Strontium-90 is found at levels over 100 times the DWS of 8 pCi/L; chromium is found at levels tens of times over the freshwater fish chronic toxicity criteria of 11 ppb. Both plume types are found in groundwater discharging to the Columbia River (Peterson and Johnson 1992). Strontium-90, in sufficient concentrations, represents a potential human health hazard, and chromium is of concern due to its aquatic toxicity.

Recent commitments made under the Tri-Party Agreement for N-Springs (Milestone M-16-01) include the construction of a barrier to flow of approximately 3,800 feet in length between the source of contamination and the river. Additionally, a small-scale treatability test will be conducted to evaluate the ability of a pump and treat system to remove dissolved strontium-90 from the groundwater. The purpose of the barrier is to reduce the flux of dissolved strontium-90 to the river by increasing the travel time of the strontium to allow radioactive decay to mitigate the problem. More aggressive measures, such as chemical fixation or mobilization, are possible. However, it is recommended that aggressive approaches be phased and await the results of the initial remediation efforts and decisions on remediation of the contamination held in the soil column below the source (i.e., the 1301-N Crib) of the strontium-90 groundwater plume.

The commitments made under the Tri-Party Agreement for D and H Reactor areas (HR-3 OU) include the testing of an approximately 189-L/min (50-gal/min) pump and treat system to remove chromium. This treatability testing is being conducted in the 100D Area near a known source of chromium. Should groundwater remediation of chromium be needed, hydraulic containment with pump and treat systems and/or barriers to flow offers potential remediation alternatives. The high mobility of chromium and its ability to be selectively removed from groundwater make its remediation potentially possible using a pump and treat system. Better definition of the extent of the contamination at the D Reactor and of potential sources of continuing contamination is needed.

For each of the three chromium plumes located in the 100D, 100H, and 100K Reactor areas, the remediation strategy establishes the goal of remediation for the aquifer. The proposed cleanup approach is either pump and treat alone or in combination with cutoff wells. Sources of continuing contamination must be identified and remediated in each area.

Certain activities will be needed in each area. These activities include a detailed description of aquifer hydraulic properties and flow paths in the vicinity of the plume or waste site, treatability testing of contaminant removal systems, and constructability testing of barriers. Additional wells will be drilled for extracting contaminated water and re-injecting treated water. Numerical modeling of groundwater flow should be conducted to help the design of pump and treat systems and flow barriers.

For most of the 100 Areas, it is recommended to continue characterization of groundwater contamination under the HPPS. This includes monitoring during remediation of surface sources, e.g., cribs, underground tanks, and burial grounds. The need for groundwater remediation at the OU level should be re-evaluated if undesirable changes occurred during source remedial activities, or if previously undetected contaminant problems are revealed by continued characterization efforts.

5.7.3 Technology Development

The following processes offer areas where technology improvements can greatly accelerate the cleanup of groundwater: geochemical fixation of chromium in source areas, passive removal technologies (such as funnel and gate), improved barrier construction technologies, improved leaching/fixative methods for strontium removal/fixation, and improved physical-chemical treatment.

5.8 300 AREA

The CERCLA 300-FF-5 groundwater OU in the 300 Area has completed the Phase I RI and Phases I and II FSs. A combined Phase II RI/Phase III FS report is currently being prepared for submittal to the regulatory agencies in January 1995. A ROD for the OU is expected by late summer 1995.

Based on the findings of the RI and the remedial alternatives that will be undergoing a detailed analysis during 1994 as part of the Phase III FS, it is anticipated that active remediation could be either selective hydraulic containment or selective slurry wall containment with minimal extraction. However, based on the current contaminant levels identified in groundwater, it is probable that only institutional controls with no active remediation will be required.

5.9 1100 AREA

The 1100 Area is located north of the city of Richland in the southernmost portion of the Hanford Site. Investigations leading to a ROD indicated that no significant contamination of the aquifer currently exists. Groundwater plumes of trichloroethylene and nitrate plumes, located in the vicinity of the Horn Rapids Landfill, have had groundwater concentrations above standards.

The ROD requires continued institutional controls and monitoring of the groundwater to ensure that contaminant levels decrease as predicted. If monitoring does not confirm the predicted decrease of contaminant levels, the need for more intrusive remediation will be considered by the Tri-Party Agreement agencies.

5.10 OTHER CONTAMINATION--TRITIUM, IODINE-129, AND NITRATE

Three waste constituent plumes are characterized as sitewide contamination issues: tritium, iodine-129, and nitrate (Section 4.2.2). Currently no active remediation of these plumes is proposed. The basis for not proposing active remediation is discussed below.

The total volume of groundwater containing greater than 20,000 pCi/L of tritium is approximately 8.9×10^{11} L (2.4×10^{11} gal), spread over approximately 180 km^2 (69 mi^2). The mass of tritium contained in that volume is relatively small, amounting to approximately 22 grams (0.78 ounces). Separation of tritium from groundwater is not practical with current technology. Remediation possibilities are limited to increasing the residence time of tritium to allow for decay and/or intercepting tritium near the area of discharge to the river (or other intermediate location). It is recommended that additional evaluation of alternatives be conducted.

The volume and areal extent of water contaminated with iodine-129 places severe constraints on the ability of current technology to effectively remediate this groundwater problem. Current calculations indicate that a treatment system would have to operate continuously for 3,000 years at 3,785 L/min (1,000 gal/min) to effect a 90% reduction in observed concentrations. Iodine removal will be limited due to competing ion effects from anions in groundwater. The development and testing of innovative iodine removal technology is recommended.

Nitrate occurs as a co-contaminant that is marginally over standards with nearly every other plume of concern on the Hanford Site. The only areas in which this is not the case is the relatively large plume found in the 100F Area. The strategy recommends that alternatives for nitrate remediation be combined into the analysis of remediation alternatives for tritium previously discussed.

In summary, each of these large plumes needs to be examined in detail before an approach can be specified. However, individual segments of each plume offer some opportunity for aggressive action. It is recommended that the decision to remediate portions of these plumes be based on the following two criteria, in addition to regulatory and legal requirements:

(1) The contaminant can be shown to (a) pose a demonstratable real or potential adverse impact to Columbia River water quality or the ecosystem, or (b) compromise a current or potential beneficial use of the river

(2) The remediation effort, if conducted immediately, should reduce or eliminate the spread of contamination to uncontaminated parts of the groundwater system.

Finally, opportunities should not be overlooked for cotreatment of sitewide contaminants as part of systems that address the priority contaminant plumes. Treatment for the sitewide contaminants may be technically and economically "added on" to other systems, without significantly altering the ability of the original system to meet its intended purposes.

5.11 TREATMENT AND DISPOSAL OF TREATED GROUNDWATER

Aboveground treatment of contaminated groundwater must dispose of the treated water. Three alternatives exist: (1) re-introduction to the ground, (2) discharge to a stream or river, or (3) evaporation. Evaporation is discounted because of the projected high volumes of water coupled with the expected high energy use and its costs. Ideally, all contaminants can be reduced to levels below regulatory concern. However, in many cases, effective treatment is only feasible for the primary contaminants. The treatment of the remaining co-contaminants is often not possible or would significantly affect the feasibility of conducting the remediation.

It is recommended that treatment of groundwater have the objective of reducing both targeted and co-contaminants to levels below regulatory concern. However, should complete removal be judged unnecessary or prove infeasible, the following criteria are recommended to determine a disposal location. The selected location should:

- Not spread contamination into uncontaminated areas or impede the current and future cleanup effort
- Facilitate the containment and removal of contaminants, if possible
- Make use of existing liquid treatment and disposal facilities, as feasible
- Facilitate secondary usage of the treated effluent.

Establishing the location for the disposal of partially treated groundwater is key to the implementation of effective, large-scale containment and remediation systems and should be the focus of attention in the near future.

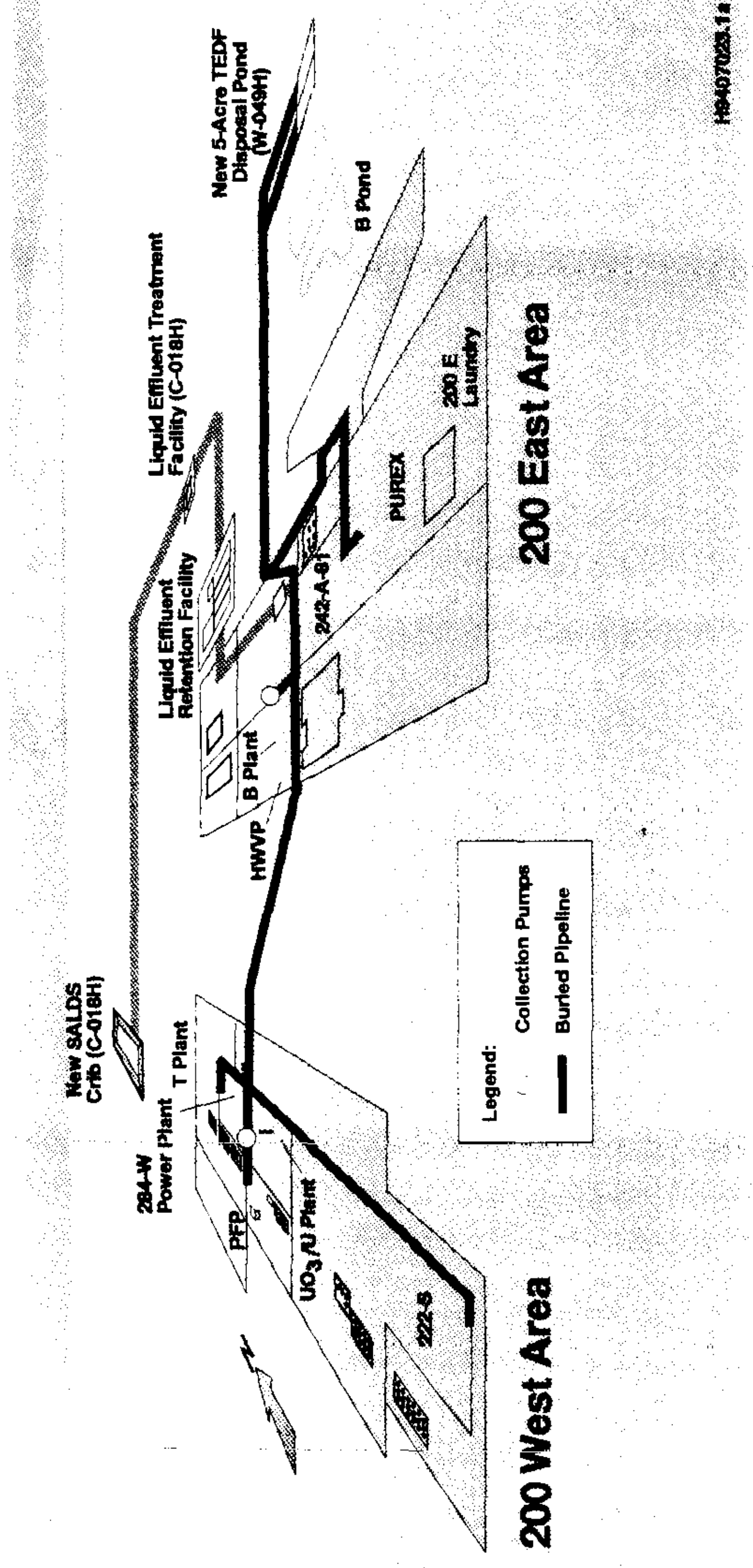
There are opportunities to optimize resources for treatment and disposal of effluents generated by CERCLA groundwater remediation activities and liquid effluent projects. The 200 Areas ETF and the TEDF are operational infrastructures that will be considered for future effluent treatment and/or disposal needs (Figure 5-1). The 200 Areas ETF is a 568-L/min (150-gal/min) mixed waste (low-level radioactive and RCRA waste) treatment facility and will be available to treat other Hanford Site dilute aqueous waste in support of the Hanford Site environmental restoration mission. To enhance the potential for the future treatment of groundwater or other restoration activity waste, a second pipeline was installed along with the 200 Areas TEDF pipeline from the 200 West Area to the 200 East Area. This pipeline could be connected to the 200 Areas ETF for transportation of the effluents across the Central Plateau for treatment. Engineering and geohydrologic studies are necessary to evaluate these opportunities.

5.12 IMPLEMENTATION OF A GROUNDWATER REMEDIATION STRATEGY

The groundwater remediation strategy provides direction for cleanup. It purposefully builds on past achievements, commitments, programs, and plans. The strategy direction can be phased in at the OU level at a pace consistent with facilitating remediation, while minimizing disruption of scheduled activities.

The value of this strategy to the implementing program is that it provides an opportunity to assess past achievements and efforts, while refining and proposing a new course of action. To the organizations outside the implementing program, the strategy presents a summary of the remediation program and its direction and thus allows for improved coordination.
A management-level coordinating group should be designated to facilitate the interaction between the remediation program and other program elements involved with liquid and solid waste disposal.

Figure 5-1 200 Areas Effluent Treatment Facility, Collection and Disposal Network.



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As remediation proceeds, reporting the effectiveness of the groundwater remediation effort, changes in approach, and understanding of successes and failures becomes increasingly important. The following three recommendations are made: (1) nonregulatory, interim goals be established to allow evaluation of progress, (2) preparation of an annual report summarizing and evaluating program progress, and (3) that prioritization of remediation efforts be coordinated by a group consisting of internal and external organizations and stakeholders impacting and being impacted by liquid effluent management and cleanup activities at the Hanford Site.

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