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Data Quality Objectives Summary Report – Designing a Groundwater Monitoring Network for the 200-BP-5 and 200-PO-1 Operable Units

E. C. Thornton
J. W. Lindberg

September 2002

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Richland, Washington 99352

Summary

This document presents the results of a series of interviews held with technical, management, and regulatory staff to determine the groundwater data quality objectives (DQOs) for monitoring activities associated with the 200-BP-5 and 200-PO-1 operable units located in the Hanford Site 200 East Area. This assessment is needed to address changing contaminant plume conditions (e.g., plume migration) and to ensure that monitoring activities meet the requirements for performance monitoring as prescribed by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Resource Conservation and Recovery Act of 1976 (RCRA) past practice, and Atomic Energy Act of 1954 (AEA) regulatory requirements and orders.

The general objectives and decisions associated with the DQO process were the following:

- Identify contaminants of concern (COCs) for the 200 East Area.

- Define the approach for assessing the adequacy of the current monitoring networks with respect to:
  - Detection and monitoring of COC groundwater plumes
  - Water table elevation and flow direction
  - Optimum sampling frequency

- Define the methodology for redesigning networks.

- Actual network design activities will be undertaken in separate meetings related to preparation of sampling and analysis plans for the 200-BP-5 and 200-PO-1 Operable Units.

The COCs identified for the 200-BP-5 Operable Unit were Tc-99, Co-60, cyanide, uranium, nitrate, Cs-137, Sr-90, I-129, tritium, and Pu-239/240. COCs specified for the 200-PO-1 Operable Unit were tritium, I-129, nitrate, Tc-99, cyanide, chromium, Sr-90, arsenic, manganese, and vanadium.

The following decision statements were developed in the interviews as guidance for redesigning the monitoring networks:

- Determine if the current monitoring well networks for the 200-BP-5 and 200-PO-1 Operable Units delineate plume extent and, therefore, require no action; if the networks need to be redesigned using existing wells; or if new monitoring wells should be installed.

- Determine if the current monitoring well networks for the 200-BP-5 and 200-PO-1 Operable Units define groundwater elevation contours and flow direction.

- Determine if the current sampling frequencies for the monitoring well networks for the 200-BP-5 and 200-PO-1 Operable Units are capable of tracking plume movement and, therefore, require no action; or do sampling frequencies need to be changed for some or all wells.

A methodology for data collection and sampling design is presented in this document to meet the above objectives. The approach to be used will primarily involve review of current and past contaminant plume and water-table maps and associated monitoring data to design groundwater monitoring networks for the 200-BP-5 and 200-PO-1 Operable Units that will satisfy these objectives. It is assumed a non-statistical approach will be implemented that is based primarily on expert judgment. However, geostatistical modeling may be used to optimize the new monitoring well networks, especially if a major change arises in the new network designs relative to the current networks.

The monitoring network designs that are developed will be defined in sampling and analysis plans. These plans will also define the sampling frequency for the wells of these networks. Any proposed new groundwater monitoring wells will be prioritized so that they can be installed on the basis of budget availability. The sampling and analysis plans for 200-BP-5 and 200-PO-1 Operable Units will be updated on an annual basis after reviewing the current adequacy of the monitoring well network design based on the past year's data.

Several areas were identified with regard to potential additional well needs for these operable units. It was suggested that a sufficient number of wells may not be present in the area north of the Gable Mountain Gap to the Columbia River to adequately define the northern extent of contamination in the 200-BP-5 Operable Unit. It was also recognized that upgradient and downgradient wells may be needed to more adequately monitor the BC cribs in the 200-PO-1 Operable Unit. These needs will be assessed in the development of the sampling and analysis plans for the two operable units.

Acknowledgments

This document benefited from the contributions and reviews of a number of individuals. In particular, the authors acknowledge the input provided by Craig Cameron, Evan Dresel, John Fruchter, Marv Furman, Dib Goswami, Mary Hartman, Stuart Luttrell, Chris Murray, Susan Narbutovskih, and Bruce Williams during the Data Quality Objectives development process. Mark Byrnes provided guidance in the initial stages of the process and information related to presentation of the results.

Acronyms

AEA	Atomic Energy Act of 1954
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DQO	data quality objective
DR	decision rule
DS	decision statement
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
OU	operable unit
PSQ	principal study question
RCRA	Resource Conservation and Recovery Act of 1976
RSD	relative standard deviation
SAP	sampling and analysis plan
TSD	treatment, storage, or disposal

Metric Conversion Chart

Into Metric Units			Out of Metric Units		
If You Know	Multiply By	To Get	If You Know	Multiply By	To Get
Length			**Length**		
Inches	25.4	Millimeters	Millimeters	0.039	inches
Inches	2.54	Centimeters	Centimeters	0.394	inches
Feet	0.305	Meters	Meters	3.281	feet
Yards	0.914	Meters	Meters	1.094	yards
Miles	1.609	Kilometers	Kilometers	0.621	miles
Area			**Area**		
Sq. inches	6.452	Sq. centimeters	Sq. centimeters	0.155	sq. inches
Sq. feet	0.093	Sq. meters	Sq. meters	10.76	sq. feet
Sq. yards	0.836	Sq. meters	Sq. meters	1.196	sq. yards
Sq. miles	2.6	Sq. kilometers	Sq. kilometers	0.4	sq. miles
Acres	0.405	Hectares	Hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
Ounces	28.35	Grams	Grams	0.035	ounces
Pounds	0.454	Kilograms	Kilograms	2.205	pounds
Ton	0.907	Metric ton	Metric ton	1.102	ton
Volume			**Volume**		
Teaspoons	5	Milliliters	Milliliters	0.033	fluid ounces
Tablespoons	15	Milliliters	Liters	2.1	pints
Fluid ounces	30	Milliliters	Liters	1.057	quarts
Cups	0.24	Liters	Liters	0.264	gallons
Pints	0.47	Liters	Cubic meters	35.315	cubic feet
Quarts	0.95	Liters	Cubic meters	1.308	cubic yards
Gallons	3.8	Liters			
Cubic feet	0.028	Cubic meters			
Cubic yards	0.765	Cubic meters			
Temperature			**Temperature**		
Fahrenheit	Subtract 32, then multiply by 5/9	Celsius	Celsius	Multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
Picocuries	37	Millibecquerel	Millibecquerels	0.027	picocuries

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1.0 Step 1 - State the Problem

The purpose of this document is to present the data quality objectives (DQOs) that will be used to assess the current groundwater monitoring approach and redesign the well-field network for the 200-BP-5 and 200-PO-1 Operable Units (OUs). This assessment is needed to address changing contaminant plume conditions (e.g., plume migration) and to ensure that monitoring activities meet the requirements for remediation performance monitoring (i.e., Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA] monitoring), Resource Conservation and Recovery Act of 1976 (RCRA) Past Practice monitoring, and site-wide surveillance monitoring (Atomic Energy Act of 1954 [AEA]) activities as directed in U.S. Department of Energy [DOE] orders. This DQO summary report was prepared in response to the U.S. Environmental Protection Agency (EPA) 5-year review of groundwater remedial actions of the Hanford Site and supports Action Items 200-7 and 200-8 (EPA 2001).

The objective of DQO Step 1 is to use the information gathered from the DQO scoping process, as well as other relevant information to clearly and concisely state the problem to be resolved. The tables provided in this section document the personnel involved in the DQO process, identify the contaminants of concern, and summarize the key information needed to support the writing of the problem statement.

1.1 Project Objectives

Because of the changing configuration of the groundwater contaminant plume contours over time and the identification of new specific monitoring needs, the 200-BP-5 and 200-PO-1 OU groundwater monitoring networks require periodic re-evaluation. Groundwater remediation is not currently being performed in the 200 East Area. This is because some of the contaminants associated with the plumes are not considered to pose a risk to the public at current concentrations and areal distributions while other contaminants are at too low a level to be effectively remediated using currently known technologies. However, monitoring groundwater contamination in the area is necessary to determine if contaminant levels are attenuating with time and to assure that no new or previously unidentified groundwater contamination goes undetected.

The general objectives of the CERCLA, RCRA past practice, and site-wide surveillance monitoring programs are to determine baseline conditions of groundwater quality, characterize hydrogeologic and chemical trends in the groundwater system, and to assess existing and emerging groundwater quality problems. Data on which decisions can be made concerning land disposal practices and the management and protection of groundwater resources are also important.

Specific primary objectives and decisions associated with this DQO process were the following:

- Identify contaminants of concern (COCs) for the 200 East Area.

- Define the approach for assessing the adequacy of the current monitoring networks with respect to:
  - Detection and monitoring of COC groundwater plumes
  - Water table elevation and flow direction
  - Optimum sampling frequency

- Define the methodology for redesigning networks.

- Actual network design activities will be undertaken in separate meetings related to preparation of sampling and analysis plans for the 200-BP-5 and 200-PO-1 Operable Units.

The DQO process identified the contaminants of concern (COCs) for the 200-BP-5 and 200-PO-1 Operable Units in the 200 East Area (see below) and identified the approach for redesigning the monitoring networks for these operable units. Tasks involved in redesigning the networks include determining the optimum number and placement of groundwater wells needed to monitor groundwater contaminant plumes and determining if any new wells need to be installed. Other concerns include determining sampling frequency, the chemical species that will be monitored, detection limit requirements, and other analytical performance requirements (e.g., precision and accuracy). It is also necessary to design the well field networks to obtain information related to water-table elevations and flow rates and direction. The general approach and objectives related to redesigning these networks is described in this document. The implementation and details related to redesigning networks will be undertaken separately during the preparation of sampling and analysis plans for the operable units.

1.2 Project Assumptions

The following project assumptions were taken into consideration during the preparation of this DQO summary report:

- This DQO process shall be used to address CERCLA and RCRA past practice and surveillance monitoring (AEA) requirements in the 200 East Area; RCRA treatment, storage, and disposal (TSD) unit monitoring requirements will be considered separately.

- RCRA TSD groundwater monitoring data will be used to support CERCLA/RCRA past practice goals and sampling will be coordinated. A list of RCRA TSD wells that can supplement the CERCLA and RCRA past practice monitoring wells will be included in the sampling and analysis plans (SAPs) for the operable units.

- Because of the benefit to CERCLA monitoring, investigation derived waste associated with other groundwater investigations may be handled as CERCLA waste.

- Monitoring well network design will be presented in sampling and analysis plans, which will be reviewed annually and updated, if needed (the monitoring network for the prior year is also presented in the groundwater monitoring annual report [e.g., PNNL-13788]).

- Data gaps will be considered in the DQO, but specific well replacements will be identified during preparation of the sampling and analysis plans.

- The intent of this DQO process is to maximize the use of existing monitoring wells.

- EPA is the lead regulatory agency for the 200-BP-5 OU.

- The Washington State Department of Ecology (Ecology) is the lead regulatory agency for the 200-PO-1 OU.

- It is assumed that the long-term goal in the 200-BP-5 and 200-PO-1 operable units is to monitor the attenuation of COCs by natural processes. This assumption is subject to revision, based on future CERCLA or RCRA past practice agreements (e.g., Records of Decision).

1.3 Project Issues

The following section presents issues that needed to be agreed upon between the decision makers.

1.3.1 Global Issues

The global issues that were identified during the decision-making interviews are as follows:

1. How will monitoring of groundwater plumes be performed for COCs that cross the operable unit boundaries?

Many of the contaminant plumes in the 200-BP-5 operable unit are fairly localized or have migrated towards the northern portion of the operable unit and hence have not crossed into the 200-PO-1 OU. However, the major nitrate, tritium, and I-129 plumes that largely originated in the vicinity of the PUREX facility in the 200-PO-1 OU have crossed the boundary into 200-BP-5. The monitoring network for the 200-BP-5 OU will thus need to have wells designated for collection of monitoring data related to the distribution of these COCs within this operable unit to complement the network developed for the 200-PO-1 Operable Unit.

2. Any major data gaps need to be identified.

Monitoring networks will be designed with the objective of defining the extent and movement of known groundwater plumes. Any new releases of contamination or unknown releases should be revealed by ongoing CERCLA and RCRA monitoring activities designed to track known contaminant plumes. It is recognized, however, that flexibility should be maintained to respond quickly when it is clear that new or previously unidentified contamination is discovered.

1.3.2 Task-Specific Technical Issues and Resolutions

No task-specific issues were identified in the DQO interviews. It was agreed that issues of this nature will be identified and addressed during the network redesign activities associated with preparation of the sampling and analysis plans for the 200-BP-5 and 200-PO-1 Operable Units.

1.4 Existing References

Table 1.1 presents a list of all of the references that were reviewed as part of the scoping process, as well as a summary of the pertinent information contained within each reference. These references are the primary source for the background information presented in Section 1.5.

Table 1.1. Existing References

Reference	Summary
EPA First Five Year Review (EPA 2001)	Identifies Action Items 200-7 and 200-8 and provides summary of 200 East Area contaminant sources and distribution of groundwater plumes.
RCRA Facility Investigation Report for the 200-PO-1 Operable Unit (DOE/RL-95-100)	Reports data in support of the RFI (RCRA Facilities Investigation) corrective measures study process. Prepared in lieu of an RFI/CMS work plan since it is agreed that sufficient data is currently available and that further data-gathering activities are not warranted at this time.
RCRA Corrective Measure Study for the 299-PO-1 Operable Unit (DOE-RL-96-66)	Examines the need for interim actions and evaluates potential corrective measures that could be used if interim actions are necessary.
200-BP-5 Operable Unit Treatability Test Report (DOE/RL-95-59)	Summarizes the performance of pilot-scale treatability tests conducted to assess the ability of an aboveground pump-and-treat system to extract and treat groundwater from the B-5 reverse well and BY cribs plumes.
Hanford Site Groundwater Monitoring for Fiscal Year 2001 (PNNL-13788)	Presents groundwater contours and the perimeter of contaminant plumes within the 200-BP-5 and 200-PO-1 OUs based on FY 2001 monitoring data.
FY 2002 Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project (PNNL-13698)	This document is an integrated monitoring plan for the groundwater project. It documents well and constituent lists for monitoring required by the *Atomic Energy Act of 1954* and its implementing orders; includes other, established monitoring plans by reference; and appends a master well/constituent/ frequency matrix for the entire site.
Water-Level Monitoring Plan for the Hanford Groundwater Monitoring Project (PNNL-13021)	Presents requirements of water-level monitoring activities conducted at the Hanford Site primarily to determine groundwater flow rates and directions.

Table 1.1. (contd)

Reference	Summary
Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington (PNNL-1226)	The primary objective of this document was to refine the conceptual groundwater flow model for the 200 East Area. Recommendations are provided for revision and expansion of the groundwater monitoring network to provide a more accurate groundwater contaminant tracking capability.
"Rethinking Groundwater Monitoring at the Hanford Site" (Michael et al. 2000)	Summarizes a DQO study conducted in 1998 for the 200-PO-1 OU and associated geostatistical modeling activities used to optimize the tritium monitoring network in the 600 Area.
Hanford Well Information System database	This database provides well completion forms needed to identify the well screen intervals, depth to water, etc., in each of the sampled wells.
Hanford Environmental Information System (HEIS) database	This database provides chemical analytical results for samples collected from Hanford Site wells.
Groundwater monitoring plans for RCRA sites in the 200 East Area	RCRA monitoring plans include those for PUREX cribs (PNNL-11523), B Pond (PNNL-11604), and Waste Management Areas A-AX (PNNL-13023), B-BX-BY (PNNL-13022), C (PNNL-13024), and Low Level Burial Grounds WMA 1 and 2.
CMS = Corrective measure study. DQO = Data quality objective. PUREX = Plutonium-Uranium Extraction Plant. RFI = RCRA facility investigation.	

1.5 Site Background Information

The following section provides a summary of historical groundwater monitoring and remediation activities in the 200-BP-5 and 200-PO-1 operable units.

1.5.1 200-BP-5 Operable Unit

Groundwater contamination in the 200-BP-5 OU is primarily related to waste disposal associated with B Plant past operations. B Plant was used to recover plutonium from irradiated fuel using the bismuth phosphate process from 1945 to 1956 (PNNL-13788; PNNL-13080; DOE-RL-92-05). From 1968 to 1985, the plant was used to recover cesium and strontium from tank farm waste (DOE/RL-95-100). Waste from these operations was disposed to the soil at a variety of locations and included effluent from process streams, chemicals, cooling water, and condensate.

In 1954 and 1955, scavenged uranium recovery waste supernatant from U Plant operations was discharged to the BY cribs (PNNL-13080). This waste contained large amounts of ferrocyanide and other chemical and radiological components. Disposal of this waste was discontinued because high levels of Co-60 were detected in the groundwater.

There are instances where contaminant sources can be ascribed to specific waste facilities within the 200-BP-5 Operable Unit, such as the BY cribs and the B-5 reverse well. The larger groundwater plumes that are broadly distributed throughout the Central Plateau, however, are the result of disposal to multiple waste units within the B Plant area and adjacent PUREX complexes and are difficult to assign to specific waste facilities owing to similarity in waste chemistry.

The major CERCLA sites associated with 200-BP-5 are the B-5 reverse well, the BY cribs, and Gable Mountain Pond. Examples of other potential contaminant sources include the B-BX-BY and C tank farms (monitored under RCRA), the B-7A, B-7B, and B-8 cribs, the B-37 trench, B-62 crib, 216-B-63 ditch (RCRA), B Plant, the Liquid Effluent Retention Facility (RCRA), and the low-level burial grounds Waste Management Areas 1 and 2 (RCRA). Of the RCRA facilities associated with B Plant, only the Waste Management Area B-BX-BY tank farm is monitored under a groundwater quality assessment plan because it is believed to have contaminated groundwater with hazardous constituents. Other RCRA TSD facilities are also monitored, however there is no evidence to date to suggest that groundwater has been contaminated by these sites.

The surveillance monitoring program in the 200-BP-5 has been designed to meet several objectives and to complement the RCRA TSD monitoring networks. The first objective is to monitor the extent of plumes emanating from 200 East Area waste sites and facilities in the operable unit identified above. Operations have ceased at most of these sites, but monitoring is needed to track the rate and dissipation of these plumes. A band of guard wells is located in the gap between Gable Mountain and Gable Butte and serves to detect contaminant movement to the north (PNNL-13698).

Remediation activities conducted at the 200-BP-5 OU include pump-and-treat tests at the B-5 reverse well and north of BY cribs. These tests were undertaken from August 1994 through May 1995 (DOE/RL-95-59). No remediation activities are currently being performed or are planned for the 200-BP-5 OU in the near future.

1.5.2 200-PO-1 Operable Unit

Groundwater contamination in the 200-PO-1 OU is primarily related to waste disposal associated with PUREX operations. The PUREX process used tributyl phosphate in normal paraffin hydrocarbon solvent to recover uranium and plutonium from irradiated fuel rods dissolved in nitric acid solutions (DOE/RL-95-100). The plant operated from 1955 to 1972 and again from 1983 to 1992 when it was officially closed. Low-level PUREX waste was disposed to liquid waste disposal units, such as cribs, trenches, and french drains, whereas high-level waste was contained in the tank farms. In particular, numerous cribs to the south and east of the PUREX building have affected groundwater quality over a large area (PNNL-13788). The most extensive and significant contaminants are iodine-129, nitrate, and tritium.

Three cribs (the 216-A-10, 216-A-36B, and 216-A-37-1 PUREX Cribs) are at least partially responsible for significant contamination and are monitored in accordance with RCRA. Other facilities located generally northeast and east of the PUREX Plant have affected groundwater and are being addressed under the RCRA past practice process. The A-45 crib, located south of PUREX, is presently monitored under the surveillance program. Facilities in the 200-PO-1 operable unit monitored in accordance with RCRA include the B Ponds (216-B-3), the 216-A-29 ditch, 200 Areas Treated Effluent Disposal Facility, and high-level waste tanks in Waste Management Areas A-AX. However, to date there is little evidence to suggest that groundwater at these sites has been contaminated with RCRA-regulated waste. The BC cribs are potential sources of contamination (based on Tc-99 disposal inventories), though limited monitoring activities to date have not indicated significant groundwater contamination in the area.

Several bands of guard wells are also used to monitor the extent of plumes emanating from waste sites in the 200-PO-1 operable unit. One band is located to the southeast of the 200 East Area and detects contamination moving into the southern and eastern parts of the Hanford Site (PNNL-13698). A second band is positioned along the Columbia River at the eastern edge of the Hanford Site to provide assurance that offsite effects are identified.

No groundwater remediation activities have been undertaken in this operable unit and none are planned for the near future.

1.6 Data Quality Objective Team Members and Key Decision Makers

Individual members of the DQO team were carefully selected to participate in the seven-step DQO process based on their technical background to provide expertise in all of the technical areas needed to meet the task objectives. The key decision makers included representatives from DOE, Ecology, and EPA, Region 10. The role of the key decision makers was to make final decisions related to the approach and objectives of the sampling design.

Tables 1.2 and 1.3 identify each of the individual members of the DQO team and the key decision makers. These tables also identify the organization that each DQO team member or key decision maker represents, as well as their technical area of expertise.

Table 1.2. Data Quality Objective Team Members[(a)]

Name	Role and Responsibility
Evan Dresel	Hydrogeologist
John Fruchter	Groundwater Project Manager
Mary Hartman	Hydrogeologist
Jon Lindberg	Hydrogeologist
Stuart Luttrell	Monitoring Task Manager
Chris Murray	Geostatistical Modeler
Susan Narbutovskih	Hydrogeologist
Ed Thornton	Hydrogeologist/DQO Facilitator
Bruce Williams	Hydrogeologist
(a) All team members are from Pacific Northwest National Laboratory.	

Table 1.3. Data Quality Objective Key Decision Makers

Name	Organization	Role and Responsibility
Craig Cameron	EPA	EPA, Region 10 Representative
Dib Goswami	Ecology	Ecology Representative
Marv Furman	RL	DOE/RL Representative

1.7 Milestone Dates

Table 1.4 presents the schedule for the completion of the task activities associated with the development and implementation of the sampling program, the performance of laboratory analyses, the performance of a data quality assessment, and the evaluation and reporting of investigation results.

Table 1.4. Milestone Dates

Task Activities	Milestone Date
DQO workbook development	PNNL document September 2002
Sampling and analysis plan development	DOE December 2002
EPA and Ecology review/approval	By 03/03
Field implementation	Start 10/03 (or earlier)
Laboratory analyses	Start 10/03 (or earlier)
Revise sampling and analysis plan	Revise annually by April, if required
Documentation of investigation results	FY04 PNNL Annual Groundwater Monitoring Report; operable unit project specific reports, if required

1.8 Contaminants of Concern

A list of the contaminants of concern for the 200-BP-5 and 200-PO-1 operable units was generated by initially listing all of the contaminants of potential concern (COPCs) based on historical process operations. Certain COPCs identified below are in other plans (i.e., RCRA TSD monitoring plans), but were included in the final list of COCs to prevent missing them during monitoring.

1.8.1 Total List of Contaminants of Potential Concern

Table 1.5 identifies all of the COPCs for each of the types of media to undergo monitoring. This DQO addresses monitoring of the COPCs presented in Table 1.5 for CERCLA and AEA (surveillance) requirements in 200-BP-5 OU and for RCRA Past Practice requirements in the 200-PO-1 OU. In addition, monitoring associated with RCRA TSD facilities in these operable units will be addressed separately and may address additional contaminants. Data collected under these RCRA monitoring programs will be available for use as supplemental monitoring data for the 200-BP-5 and 200-PO-1 operable units.

A number of the COPCs for the 200-BP-5 OU are associated with the BY cribs, the B-5 reverse well, and Gable Mountain Pond, as indicated in Table 1.5. Tritium, I-129, and nitrate are associated with various sites in 200-BP-5, but have also entered the operable unit from 200-PO-1. Uranium is a significant contaminant in 200-BP-5, although its source is not clear. Uranium is monitored in conjunction with the quality assessment monitoring plan for Waste Management Area B-BX-BY (PNNL-13022), but will receive at least a minimal amount of monitoring under the CERCLA program at 200-BP-5 to assure that adequate data is available to track its movement. The sampling and analysis plan prepared for the 200-BP-5 OU will define the monitoring activities conducted in support of CERCLA and will indicate supplemental data available from monitoring associated with RCRA TSD facilities located within the operable unit.

The monitoring activities associated with the 200-PO-1 OU may be divided into near field and far field regions. Far field monitoring consists of the regional tritium, I-129, and nitrate groundwater plumes. Near field monitoring is associated primarily with TSD facilities, but also includes the BC cribs, and consists of monitoring conducted near the contaminant sources. Near field constituents associated with the BC cribs that will be monitored as defined in the sampling and analysis plan for the 200-PO-1 OU include Tc-99, Co-60, cyanide, chromium, and nitrate. Near field constituents associated with RCRA TSD facilities in the 200-PO-1 OU identified in Table 1.5 include Sr-90, arsenic, chromium, manganese, and vanadium. In general, these constituents are monitored under programs associated with RCRA TSD facilities, but are included here for completeness. Most are of limited areal extent and have been identified in only a few wells at generally low concentrations. The sampling and analysis plan prepared for the 200-PO-1 OU will define the monitoring activities conducted in support of RCRA past practice and will indicate supplemental data available from monitoring associated with RCRA TSD facilities located within the operable unit.

Table 1.5. List of all Contaminants of Potential Concern (COPCs) for Each Media Type

Media	Known or Suspected Source of Contamination	Type of Contamination (general)	COPCs (specific)
200-BP-5 Operable Unit			
Groundwater	BY cribs	Radionuclide Radionuclide Anion Radionuclide/toxic metal Anion	Tc-99 Co-60 Cyanide Uranium Nitrate
	B-5 reverse well; B Plant	Radionuclide Radionuclide Radionuclide	Cs-137 Sr-90 Pu-239/240
	Gable Mountain Pond	Radionuclide	Sr-90
	Various sites associated with discharges or waste from B Plant operations; facilities associated with the PUREX Plant in the 200-PO-1 OU	Radionuclide Radionuclide Radionuclide Anion	Tritium I-129 U Nitrate
200-PO-1 Operable Unit			
Groundwater	23 cribs, 4 trenches, 15 French drains, and B Pond (all associated with the PUREX Plant; B Pond also had discharges from the B Plant)	Radionuclides	Tritium I-129
		Anion	Nitrate
		Minor near field COCs: Radionuclide Anion Cation/metal Cation/metal Cation/metal	 Sr-90 Arsenic Chromium Manganese Vanadium
	BC cribs (received discharges from U-Plant and trenches)	Radionuclide Radionuclide Anion Cation/metal Anion	Tc-99 Co-60 Cyanide Chromium Nitrate

1.8.2 Contaminants of Potential Concern Exclusions

It was decided that no COPCs would be eliminated from the final list of COCs. It is recognized that certain constituents are currently monitored at RCRA TSD facilities, but inclusion of these contaminants in the final list of COCs will assure that they are not overlooked. Sampling of these constituents will be evaluated annually and the sampling and analysis plans prepared for the operable units will define the monitoring activities conducted in support of CERCLA or RCRA past practice and will indicate supplemental data available from monitoring associated with RCRA TSD facilities located within each operable unit.

1.8.3 Final List of Contaminants of Concern

Table 1.6 presents the final list of COCs for each media to be carried through the remainder of the DQO process. No constituents were eliminated from the list of COPCs, as discussed above.

Table 1.6. Final List of Contaminants of Concern

Media	COCs
200-BP-5 Operable Unit	
Groundwater	Tc-99, Co-60, cyanide, uranium, nitrate, Cs-137, Sr-90, I-129, tritium, Pu-239/240
200-PO-1 Operable Unit	
Groundwater	Far field COCs: Tritium, I-129, nitrate. Near field COCs: Tc-99, cyanide, chromium, Sr-90, arsenic, manganese, vanadium.

1.8.4 Distribution of Contaminants of Concern

Table 1.7 identifies the best understanding of how each of the COCs arrived at the site and the fate and transport mechanisms (e.g., wind or water) that may have impacted the distribution (e.g., layering or lateral homogeneity) of each of the COCs.

1.9 Current and Potential Future Land Use

Current and future uses for the land will be industrial in the central plateau core zone of the Hanford Site. In other areas the land use will be consistent with the sitewide groundwater strategy that is under development and with relevant documents covering the various areas. This information is used in the DQO process to support the evaluation of decision error consequences.

Table 1.7. Distribution of Contaminants of Concern

Media	Contaminant	How COC Arrived at Site	Fate and Transport Mechanisms	Expected Distribution (heterogeneous/ homogeneous)
200-BP-5 Operable Unit				
Groundwater	Technetium-99	Ferrocyanide waste liquids released to BY Cribs from U Plant process operations	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Cobalt-60	Ferrocyanide waste liquids released to BY Cribs from U Plant process operations	Groundwater and soil moisture	Semi-homogeneous[(b)]
	Cyanide	Ferrocyanide waste liquids released to BY Cribs from U Plant process operations	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Uranium	Injection of waste liquids into the B-5 reverse well; monitored in wells near the WMA B-BX-BY tank farms	Groundwater and soil moisture	Semi-homogeneous[(b)]
	Nitrate	Various sites in the operable unit	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Cesium-137	Injection of waste liquids into the B-5 reverse well	Groundwater and soil moisture	Semi-homogeneous[(b)]
	Strontium-90	Injection of waste liquids into the B-5 reverse well	Groundwater and soil moisture	Semi-homogeneous[(b)]
	Iodine-129	Associated with various sites in the operable unit	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Tritium	Associated with various sites in the operable unit	Groundwater and soil moisture	Semi-homogeneous[(a)]
200-PO-1 Operable Unit				
Groundwater	Tritium	Associated with various sites in the operable unit	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Iodine-129	Associated with various sites in the operable unit	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Nitrate	Associated with various sites in the operable unit	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Tc-99	Ferrocyanide waste liquids potentially released to BC cribs from U Plan process operations	Groundwater and soil moisture	Semi-homogeneous[(a)]

Table 1.7. (contd)

Media	Contaminant	How COC Arrived at Site	Fate and Transport Mechanisms	Expected Distribution (heterogeneous/ homogeneous)
Groundwater	Co-60	Ferrocyanide waste liquids potentially released to BC cribs from U Plan process operations	Groundwater and soil moisture	Semi-homogeneous[(b)]
	Cyanide	Ferrocyanide waste liquids potentially released to BC cribs from U Plan process operations	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Chromium	Ferrocyanide waste liquids potentially released to BC cribs from U Plan process operations	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Sr-90	Minor COC associated with disposal to the PUREX Cribs	Groundwater and soil moisture	Semi-homogeneous[(b)]
	Arsenic	Minor COC associated with disposal to the PUREX Cribs	Groundwater and soil moisture	Semi-homogeneous[(a)]
	Manganese	Minor COC associated with disposal to the PUREX Cribs	Groundwater and soil moisture	Semi-homogeneous[(b)]
	Vanadium	Minor COC associated with disposal to the PUREX Cribs	Groundwater and soil moisture	Semi-homogeneous[(b)]

(a) Dissolved in groundwater.
(b) Dissolved in groundwater and sorbed on aquifer sediment.

1.10 Preliminary Action Levels

The preliminary action levels that apply to each of the COCs are presented in Table 1.8 with the basis for each action level. The action level is defined as the threshold value that provides the criterion for choosing between alternative actions. The preliminary action levels presented in Table 1.8 are based on groundwater maximum contaminant levels (MCLs). The final numerical action level will be set in DQO Step 5 and alternative actions will be identified.

1.11 Conceptual Site Model

The goal of the DQO process is to develop a sampling design that will either confirm or reject the conceptual site model. The conceptual site model is continuously refined as additional data become available. Table 1.9 presents a tabular depiction of the conceptual site model, identifying the sources, release mechanisms, migration pathways, and potential receptors for each of the COCs. This table also summarizes the potential exposure scenarios.

Table 1.8. List of Preliminary Action Levels

Media	COCs	Preliminary Action Level (MCL)	Basis[b]
Groundwater	Tc-99	900 pCi/L[a]	http://www.epa.gov/safewater/mcl.html
	Co-60	100 pCi/L[a]	http://www.epa.gov/safewater/mcl.html
	Cyanide	200 ug/L	http://www.epa.gov/safewater/mcl.html
	Uranium	30 ug/L	http://www.epa.gov/safewater/mcl.html
	Arsenic	10 ug/L	http://www.epa.gov/safewater/mcl.html
	Chromium	100 ug/L	http://www.epa.gov/safewater/mcl.html
	Manganese	50 ug/L	http://www.epa.gov/safewater/mcl.html
	Vanadium	(c)	(c)
	Cs-137	200 pCi/L[a]	http://www.epa.gov/safewater/mcl.html
	Sr-90	8 pCi/L[a]	http://www.epa.gov/safewater/mcl.html
	Pu 239/240	1.2 pCi/L[a]	http://www.epa.gov/safewater/mcl.html
	Tritium	20,000 pCi/L[a]	http://www.epa.gov/safewater/mcl.html
	I-129	1 pCi/L[a]	http://www.epa.gov/safewater/mcl.html
	Nitrate	45,000 ug/L as NO_3	http://www.epa.gov/safewater/mcl.html

(a) Concentration assumed to yield an annual dose equivalent of 4 mrem/yr.
(b) 40 CFR 141 and 40 CFR 143.
(c) No MCL has been assigned to vanadium.

Table 1.9. Tabular Depiction of the Conceptual Site Model

Media	COCs	Source	Release Mechanism	Migration Pathways	Potential Receptors
200-BP-5 and 200-PO-1 OUs					
Ground-water	Tc-99, Co-60, cyanide	200-BP-5 and 200-PO-1: Liquid process wastes from U Plant operations.	Waste liquids released to the BY cribs and BC cribs.	Percolation through the vadose zone Downgradient groundwater flow	Human (primarily workers) and ecological (primarily rodents and birds)
Exposure Scenario: Receptors may be exposed to contamination by ingesting contaminated surface soils (human and ecological receptors), ingesting contaminated groundwater (human receptors), consuming contaminated ecological receptors (birds of prey), or by inhaling or ingesting contaminated soil particles (human and ecological receptors).					
Ground-water	Sr-90, Cs-137, Pu 239/240	200-BP-5: Liquid waste injected into the B-5 reverse well from B Plant operations	Injection of liquid waste into B-5 reverse well	Downgradient groundwater flow	Human (primarily workers) and ecological (primarily rodents and birds)
Exposure Scenario: Receptors may be exposed to contamination by ingesting contaminated surface soils (human and ecological receptors), ingesting contaminated groundwater (human receptors), consuming contaminated ecological receptors (birds of prey), or by inhaling or ingesting contaminated soil particles (human and ecological receptors).					

Table 1.9. (contd)

Media	COCs	Source	Release Mechanism	Migration Pathways	Potential Receptors
Ground-water	Sr-90	200-BP-5: Water from B Plant operations	Water released to Gable Mountain Pond	Percolation through the vadose zone Downgradient groundwater flow	Human (primarily workers) and ecological (primarily rodents and birds)
Exposure Scenario: Receptors may be exposed to contamination by ingesting contaminated surface soils (human and ecological receptors), ingesting contaminated groundwater (human receptors), consuming contaminated ecological receptors (birds of prey), or by inhaling contaminated soil particles (human and ecological receptors).					
Ground-water	Tritium, nitrate, and I-129	200-PO-1 and 200-BP-5: Wastewater from PUREX and B Plant operations	Wastewater released to cribs, ponds, and trenches	Percolation through the vadose zone Downgradient groundwater flow	Human (primarily workers) and ecological (primarily rodents and birds)
Exposure Scenario: Receptors may be exposed to contamination primarily by ingesting contaminated groundwater (human receptors).					

1.12 Statement of the Problem

Somewhat different statements of the problem were developed for the two operable units. This reflected a greater use of geostatistical modeling used to develop the monitoring network for the 200-PO-1 OU, particularly for the large tritium plume that originates in the 200 East Area and extends across the eastern side of the Hanford Site.

A statement of the problem with respect to monitoring of the 200-BP-5 Operable Unit was formulated as follows:

> The shape and concentration of the COC plumes within the 200-BP-5 OU has changed over time as a result of natural groundwater flow, source term variability, and natural attenuation. Therefore, the network of wells used to monitor known COCs in groundwater and the associated sampling frequency and analytical methods need to be reassessed to determine if the requirements of the CERCLA and AEA monitoring programs are being met. The current design of the 200-BP-5 OU network is based primarily on expert judgment and to a limited extent on geostatistical modeling results. Groundwater flow direction is also difficult to assess in the 200 East Area because of a low hydraulic gradient and, thus, an accurate definition of the water table elevation is needed. In addition, a number of wells are anticipated to go dry as water levels drop locally and their replacements, if possible, need to be planned.

Following is a statement of the problem for monitoring of the 200-PO-1 Operable Unit:

> The shape and concentration of the COC plumes within the 200-PO-1 OU has changed over time as a result of natural groundwater flow, source term variability, and natural attenuation. Therefore, the network of wells used to monitor known COCs in groundwater and the associated sampling frequency and analytical methods need to be reassessed to determine if the requirements of the RCRA Past Practice and AEA monitoring programs are being met. Design of the network is currently based on a combination of expert judgment and geostatistical modeling. Groundwater flow direction is also difficult to assess in the 200 East Area because of a low hydraulic gradient and, thus, an accurate definition of the water table elevation is needed. However, the general flow directions (E and SE) can be assumed by the extent of the contaminant groundwater plumes emanating from the PUREX waste discharge facilities. In addition, a number of wells are anticipated to go dry as water levels drop locally and their replacements, if possible, need to be planned.

2.0 Step 2 – Identify the Decision

The purpose of DQO Step 2 is to define the principal study questions (PSQs) that need to be answered to address the problem identified in DQO Step 1 and the alternative actions (AAs) that would result from the resolution of these questions. The PSQs and AAs are then combined into decision statements (DSs) that express a choice among alternative actions. Table 2.1 presents the task-specific PSQs, AAs, and resulting DSs. This table also provides a qualitative assessment of the severity of the consequences of taking an AA if it is incorrect. This assessment takes into consideration human health and the environment (flora/fauna) and political, economic, and legal ramifications. The severity of the consequences is expressed as low, moderate, or severe.

Table 2.1. Summary of Data Quality Objective Step 2 Information

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
PSQ #1 – Do the current monitoring well networks at the 200-BP-5 and 200-PO-1 Operable Units delineate the COC plumes and do contaminant isopleth maps show the concentration contours associated with the MCLs?			
1-1	No action (use existing networks)	The COC contours may not be clearly defined (plume extent not well known)	Moderate/Severe
1-2	Select a new monitoring well network from existing wells to better define plume extent.	Unnecessary cost of developing new monitoring well network and preparing supporting documents.	Moderate
1-3	Drill and install new monitoring wells to supplement existing or new monitoring well network.	Unnecessary cost of drilling new monitoring wells.	Moderate/Severe
DS #1 – Determine if the current monitoring well networks for the 200-BP-5 and 200-PO-1 Operable Units delineate plume extent and, therefore, require no action; if the networks need to be redesigned using existing wells; or if new monitoring wells should be installed. (Criteria to determine an adequate well spacing will be defined after the DQO process is completed and before the sampling and analysis plans are prepared. Meetings will be held with regulators during the preparation of the SAPS and in the course of redesigning the monitoring networks.) Note – The two OUs operate under different regulatory criteria.			
PSQ #2 – Does the current set of monitoring wells provide sufficient water level information to permit construction of acceptable groundwater table contour maps and definition of flow direction?			
2-1	No action (use existing networks)	The hydraulic gradient and groundwater flow direction may not be well known.	Moderate

Table 2.2. (contd)

PSQ-AA #	Alternative Action	Description of Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
2-2	Select a new monitoring well network from existing wells to better define water table elevations.	Unnecessary cost of developing new monitoring well network and preparing supporting documents.	Moderate
2-3	Drill and install new monitoring wells to supplement existing or new monitoring well network.	Unnecessary cost of drilling new monitoring wells.	Moderate/Severe
2-4	Use other methods to define flow directions.	Unnecessary cost of conducting field investigations to determine flow directions.	Moderate
DS #2 – Determine if the current monitoring well networks at the 200-BP-5 and 200-PO-1 Operable Units define groundwater elevation contours and flow direction. Note – In some areas (e.g., 200 East Area) the water table is too low to determine flow direction and rate from water table maps. The total uncertainty in terms of the extremely small gradient and measurement error are as large at some locations as the differences in hydraulic head across the site. Therefore, although the current well networks in the 200 East Area are possibly inadequate for determining flow direction and rate, it may not be possible to redesign the networks to provide this information.			
PSQ #3 – Can current sampling frequencies track plume movement?			
3-1	No action (maintain current sampling frequencies)	The COC contours may not be clearly defined (plume extent not well known)	Moderate
3-2	Revise sample frequencies in some or all wells to better define plume movement.	Unnecessary cost of developing new well sampling schedules and preparing supporting documents.	Moderate
DS #3 – Determine if the current sampling frequencies for the 200-BP-5 and 200-PO-1 monitoring well networks are capable of tracking plume movement and, therefore, require no action; or do sampling frequencies need to be changed for some or all wells. Note – Consider designing and implementing a test to determine if the current sampling frequency is adequate. This could involve statistical modeling. Sampling design for other contaminant plumes (such as cyanide) may rely primarily on expert judgment, however, since only a limited number of wells are available in the vicinity of the plume. These decisions will be made and implemented during the preparation of the sampling and analysis plans since the approach employed will vary somewhat depending on the COC and groundwater plume being considered.			

3.0 Step 3 – Identify Inputs to the Decision

The purpose of DQO Step 3 is to identify the type of data needed to resolve each of the decision statements identified in DQO Step 2. The data may already exist or may be derived from computational or surveying/sampling and analysis methods. Analytical performance requirements (e.g., detection limit requirements, precision, and accuracy) are also provided in this step for any new data that need to be collected.

3.1 Information Required to Resolve Decision Statements

Table 3.1 specifies the information (data) required to resolve each of the decision statements identified in Table 2.1 and identifies whether the data already exist. For the existing data, the source references for the data have been provided with a qualitative assessment as to whether or not the data are of sufficient quality to resolve the corresponding decision statement.

3.2 Basis for Setting the Action Level

The action level is the threshold value that provides the criterion for choosing between alternative actions. Table 3.2 identifies the basis (i.e., regulatory threshold or risk-based) for establishing the action level for each of the COCs. The numerical value for the action level is defined in DQO Step 5.

3.3 Computational and Survey/Analytical Methods

Existing well data will be used to resolve the decision statements. The monitoring network for tritium was developed in 1998 through expert judgment and the number of wells subsequently reduced by 25%

Table 3.1. Required Information and Reference Sources

DS #	Variable	Required Data	Do Data Exist? (Y/N)	Source Reference	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
200-BP-5 and 200-PO-1 Operable Units						
1	COCs	Map showing all potentially useable groundwater wells within the 200-BP-5 and 200-PO-1 OUs, wells that are part of the current monitoring network, and current understanding of COC contours. Other data required includes well screen intervals and well completion information, trend plots of COC concentrations versus time, and map showing aquifer boundaries and flow directions.	Y	HEIS database. *Hanford Site Groundwater Monitoring for Fiscal Year 2001* (PNNL-13788)	Y	N

Table 3.1. (contd)

DS #	Variable	Required Data	Do Data Exist? (Y/N)	Source Reference	Sufficient Quality? (Y/N)	Additional Information Required? (Y/N)
2	Water level	Map showing all potentially useable groundwater wells within the 200-BP-5 and 200-PO-1 OUs, wells that are part of the current water level monitoring network, and current understanding of water-table elevations and piezometric surfaces. Other data required includes well screen intervals and well completion information, and map showing aquifer boundaries and recharge areas.	Y	Hanford Well Information System database. *Hanford Site Groundwater Monitoring for Fiscal Year 2001* (PNNL-13788)	Y	N
3	Sampling frequency	Map showing all potentially useable groundwater wells within the 200-BP-5 and 200-PO-1 OUs, wells that are part of the current monitoring network, and current understanding of water-table elevations, and sampling dates for COCs from wells located in these OUs. Other information required includes trend plots of COC concentrations versus time.	Y	Hanford Well Information System database *Hanford Site Groundwater Monitoring for Fiscal Year 2001* (PNNL-13788) *FY 2002 Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project* (PNNL-13698)	Y	N

based on a geostatistical model. It is anticipated that re-evaluation of the monitoring networks for the 200-BP-5 and 200-PO-1 OUs will be undertaken on the basis of expert judgment. If a major redesign of the network results from this effort, the geostatistical model can be rerun to determine if the number of wells should be changed or the proposed design modified.

3.4 Analytical Performance Requirements

While it was determined that additional data is not needed to resolve the DSs identified in Table 2.1, Table 3.3 was prepared to indicate the analytical performance criteria for future groundwater sampling activities resulting from the implementation of the final sampling design to be developed as specified in Section 7.0. The groundwater analytical methods and precision/accuracy requirements presented in Table 3.3 are summarized from PNNL Quality Assurance Plan[(a)] (ETD-012) and PNNL-13080 (2000).

(a) ETD-012, Rev. 2. 2000. *The Hanford Ground-Water Monitoring Project Quality Assurance Project Plan.* Pacific Northwest National Laboratory, Richland, Washington.

Table 3.2. Basis for Setting Action Level

DS #	Monitoring Variable	COCs	Basis for Setting Action Level[(a)]
200-BP-5 and 200-PO-1 Operable Units			
1	Concentration in groundwater	Tc-99	http://www.epa.gov/safewater/mcl.html
		Co-60	http://www.epa.gov/safewater/mcl.html
		Cyanide	http://www.epa.gov/safewater/mcl.html
		Cs-137	http://www.epa.gov/safewater/mcl.html
		Sr-90	http://www.epa.gov/safewater/mcl.html
		Pu 239/240	http://www.epa.gov/safewater/mcl.html
		Uranium	http://www.epa.gov/safewater/mcl.html
		Arsenic	http://www.epa.gov/safewater/mcl.html
		Chromium	http://www.epa.gov/safewater/mcl.html
		Manganese	http://www.epa.gov/safewater/mcl.html
		Vanadium	(b)
		Tritium	http://www.epa.gov/safewater/mcl.html
		I-129	http://www.epa.gov/safewater/mcl.html
		Nitrate	http://www.epa.gov/safewater/mcl.html
2	Water-table elevation	N/A	General requirements provided in PNNL-13021.
3	Sampling frequency	Same as DS #1	Same as DS #1

N/A = Not applicable.
DS = Decision statement.
(a) 40 CFR 141 and 40 CFR 143.
(b) No MCL value has been assigned to vanadium.

Table 3.3. Analytical Performance Requirements

Type of COC	COCs	Survey/ Analytical Method	Action Level (MCL)	Contract Required Detection Limit	Precision (%RSD)[a]	Recommended Recovery (%)
200-BP-5 and 200-PO-1 Operable Units						
Radionuclide	Tc-99	Chemical separation and liquid scintillation beta counting (PNNL-13080)	900 pCi/L	15 pCi/L	+20%	70-130%
	Co-60	Gamma spectrometry; Method 901.1 (EPA-600/4-80-032)	100 pCi/L	25 pCi/L	+20%	70-130%
	Cs-137	Gamma spectrometry; Method 901.1 (EPA-600/4-80-032)	200 pCi/L	15 pCi/L	+20%	70-130%
	Sr-90	Gas proportional counting; Method 905.0 (EPA-600/4-80-032)	8 pCi/L	2 pCi/L	+20%	70-130%
	Pu 239/240	Chemical separation/alpha spectrometry (PNNL-13080)	1.2 pCi/L	1 pCi/L	+20%	70-130%
	Uranium	Fluorometry or laser kinetic phosphorimetry (PNNL-13080)	30 ug/L	0.1 ug/L	+20%	70-130%
	Tritium	Liquid scintillation; Method 906.0 (EPA-600/4-80-032)	20,000 pCi/L	400 pCi/L	+20%	70-130%
	I-129	Chemical separation and low-energy photon scintillation (PNNL-13080)	1 pCi/L	1 pCi/L	+20%	70-130%
Metal	Arsenic	Graphite furnace atomic absorption; Method 7060 (SW-846)	10 ug/L	10 ug/L	+25%	80-120%
	Chromium	Inductively coupled plasma emission spectrometry; Method 6010 (SW-846)	100 ug/L	10 ug/L	+20%	80-120%
	Manganese	Inductively coupled plasma emission spectrometry; Method 6010 (SW-846)	50 ug/L	15 ug/L	+20%	80-120%
	Vanadium	Inductively coupled plasma emission spectrometry; Method 6010 (SW-846)	MCL not defined	50 ug/L	+20%	80-120%
Anion	Nitrate	EPA Method 300.0 (EPA-600/R-93-100)	45,000 ug/L as NO_3	250 ug/L as NO_3	+25%	75-125%
	Cyanide	Method 9010/9012 (SW-846)	200 ug/L	5 ug/L	+25%	75-125%

(a) Relative standard deviation is calculated from a set of replicate sample values as follows:

$$RSD = \frac{\text{standard deviation}}{\text{Mean}} \times 100.$$

4.0 Step 4 – Define the Boundaries of the Study

The primary objective of DQO Step 4 is to identify the population of interest, define the spatial and temporal boundaries that apply to each decision statement, define the scale of decision making, and identify any practical constraints that must be taken into consideration in the sampling design. Implementing this step assures that the sampling design will result in the collection of data that accurately reflect the true condition of the site under investigation.

4.1 Population of Interest

Prior to defining the spatial and temporal boundaries of the site under investigation, it is first necessary to clearly define the populations of interest that apply for each decision statement (Table 4.1). The intent of Table 4.1 is to clearly define the attributes that make up each population of interest by stating them in a way that makes the focus of the study unambiguous.

Table 4.1. Characteristics that Define the Population of Interest

Population of Interest	Unit Measurement Size	Total Number of Potential Measurement Units Within the Population
200-BP-5 and 200-PO-1 Operable Units		
Tc-99, Co-60, cyanide, uranium, Cs-137, Sr-90, Pu-239/240, tritium, I-129, and nitrate in groundwater	~1 liter	Many
Water-level data	Meters or feet	Unlimited
Sampling frequency	Samples/year	Many

4.2 Geographic Boundaries

Figure 4.1 and Table 4.2 identify the geographic boundaries that apply to each decision statement associated with groundwater monitoring in the 200-BP-5 and 200-PO-1 operable units. Limiting the geographic boundaries of the study area ensures that the investigation does not expand beyond the original scope of the task.

4.3 Vertical Boundaries

Vertical boundaries that exist within the Hanford Site aquifers in the 200 East Area are the unconfined aquifer, the confined Ringold aquifer, and the confined upper basalt aquifer (PNNL-13080). It is important to distinguish these aquifers or incorrect interpretations can be made regarding contaminant distributions or water-table gradients and flow directions.

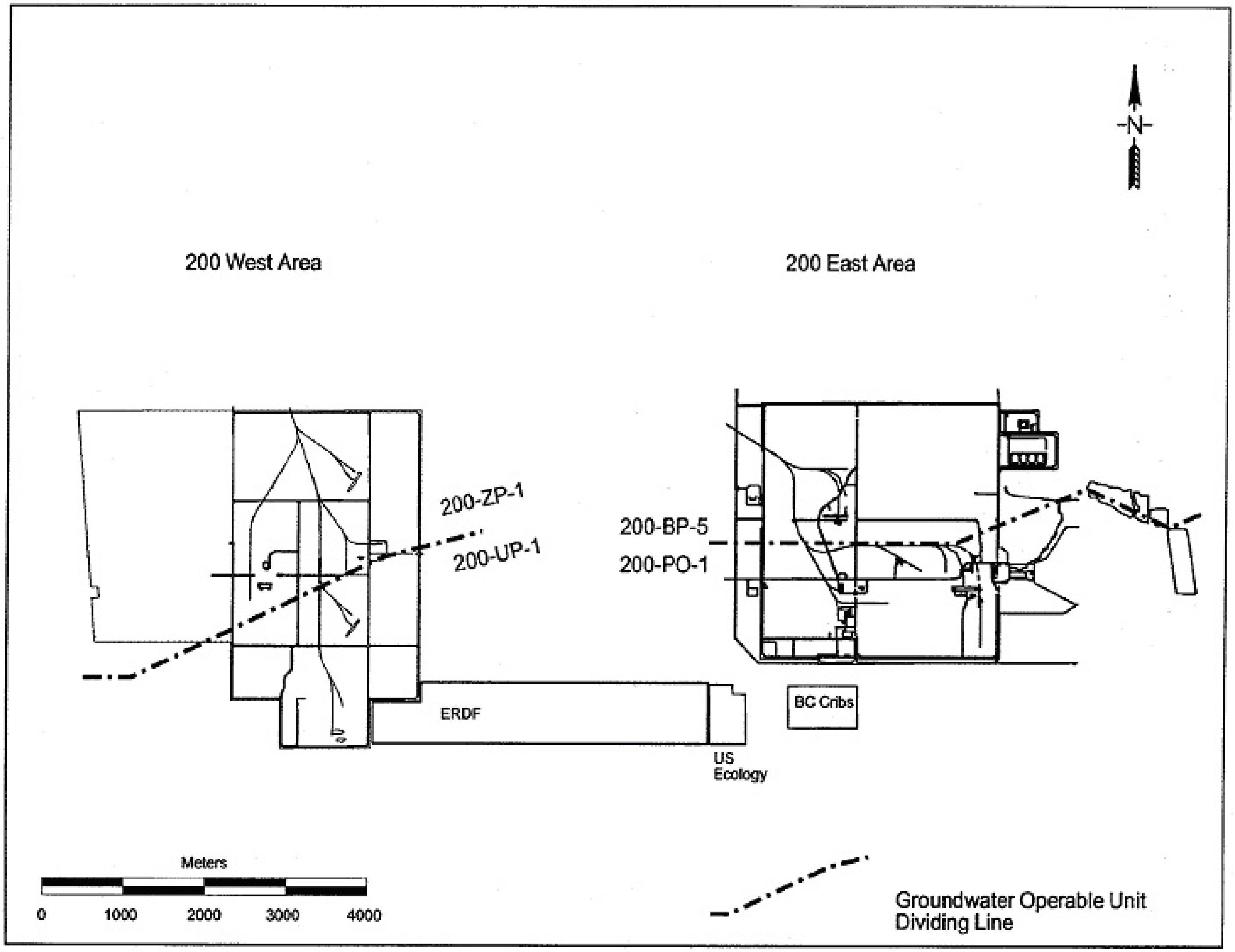

Figure 4.1. 200 Area Groundwater Operable Units

Table 4.2. Geographic Boundaries of the Investigation

DS #	Geographic Boundaries of the Investigation
200-BP-5 Operable Unit	
1 and 2	Perimeter of operable unit is defined as follows: The southern boundary is the boundary with the 200-PO-1 OU (Figure 4.1). Tritium contamination extends north through the gap between Gable Mountain and Gable Butte (Figure 4.2) and serves to provide a northern limit of the study area for the 200-BP-5 OU.
200-PO-1 Operable Unit	
1 and 2	Perimeter of the operable unit is defined as follows: The northern boundary is the boundary with the 200-BP-5 OU (Figure 4.1). The western, southern, and eastern boundaries are the 2,000 pCi/L isopleth line for the tritium plume except where it passes into the Columbia River (Figure 4.2). At that point, the Columbia River is the eastern boundary.

4.4 Zones with Homogeneous Characteristics

Table 4.3 defines the zones within the site under investigation that have relatively homogeneous characteristics. Dividing the site into separate zones having relatively homogeneous characteristics reduces the overall complexity of the problem by breaking the site into more manageable pieces. For the 200-BP-5 and 200-PO-1 operable units; however, the aquifer is a relatively homogeneous aqueous phase (e.g., no dense non-aqueous phase liquid plumes are present) and therefore cannot be broken into subunits.

4.5 Temporal Boundaries

Table 4.4 identifies temporal boundaries that may apply to each decision statement. The temporal boundary refers to both the timeframe over which the final monitoring well network defined in DQO Step 7 will apply and when is the optimum time to collect the samples or water level measurements. After 1 year, the monitoring well network should be reevaluated because sampling needs will change as the shape of the contaminant plume changes.

4.6 Scale of Decision Making

In Table 4.5, the scale of decision making has been defined for each decision statement. The scale of decision making is defined by joining the population of interest and the geographic and temporal boundaries of the area under investigation.

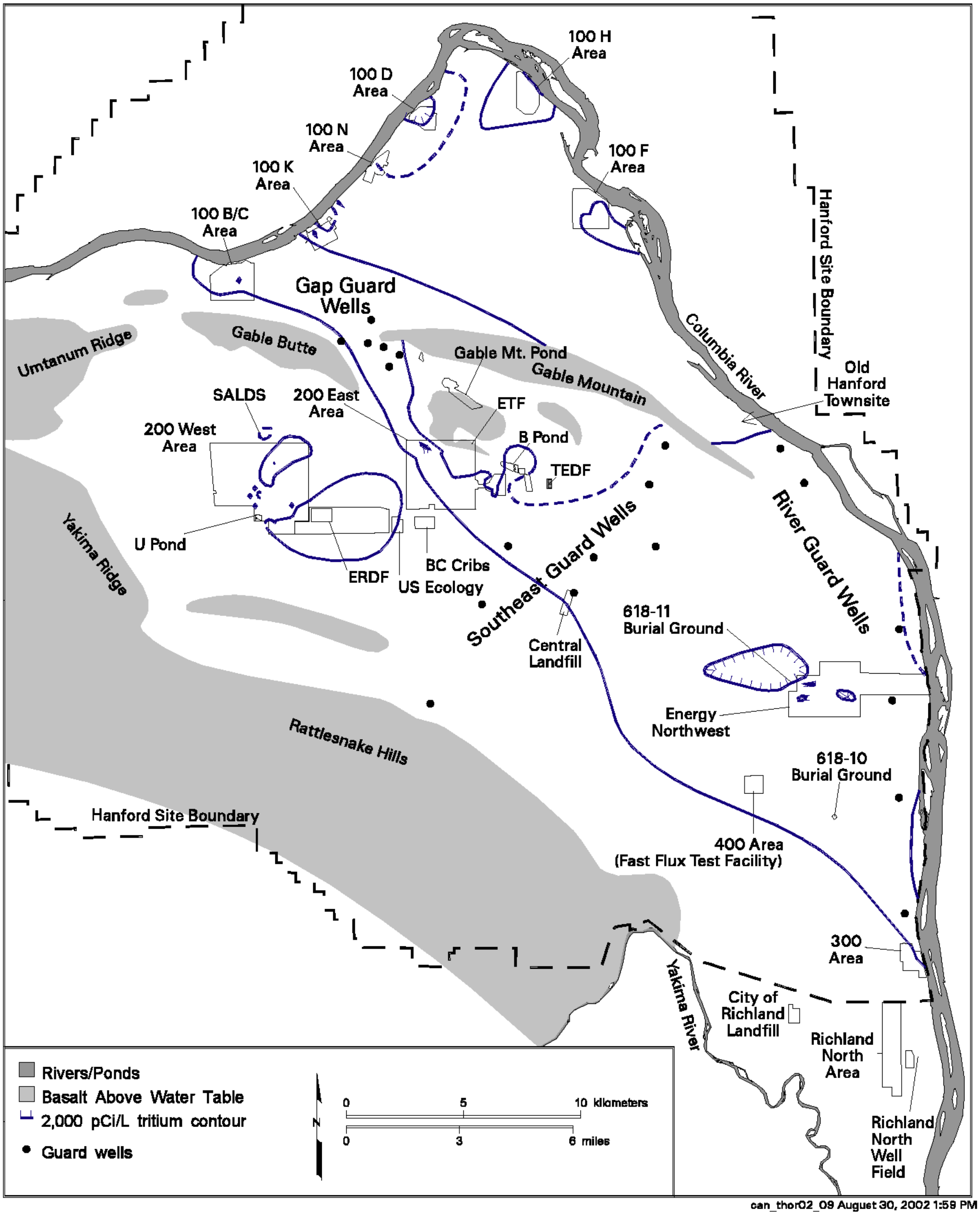

Figure 4.2. 2,000 pCi/L Tritium Contour

Table 4.3. Vertical Boundaries of the Investigation

DS #	Population of Interest	Zone
200-BP-5 and 200-PO-1 Operable Units		
1 and 3	Tc-99, Co-60, cyanide, uranium, Cs-137, Sr-90, Pu 239/240, uranium, tritium, I-129, and nitrate in groundwater	Unconfined aquifer, and confined upper
		Confined Ringold
		Confined basalt aquifer (if contaminated)
2	Water-table elevations	Unconfined aquifer, and
		Confined Ringold
		Confined upper basalt aquifer (if contaminated)

Table 4.4. Temporal Boundaries of the Investigation

DS #	Timeframe	When to Collect Data
200-BP-5 and 200-PO-1 Operable Units		
1, 2, and 3	- Groundwater samples collected annually for selected wells - Samples collected at minimum at a frequency sufficient to meet the needs of the 5-year review (i.e., at least two times before the 5-year review); however, collection of more or less samples will be based on the specific needs of individual well locations.	No constraints in general regarding time of sampling. Water level measurements should be taken at nearly the same time to minimize time effects and to coincide with site-wide measurements, and should be taken if possible during a season when the barometric pressure and/or storm effects are at a minimum (typically June through August.

4.7 Potential Constraints

Potential constraints that could interfere with the implementation of the groundwater monitoring program outlined in Section 7.0 are as follows:

- Because of dropping water levels, some of the monitoring wells identified for sampling could go dry some time in the future. (Note: The water level is dropping below the base of the unconfined aquifer in some areas, so dry wells at these locations cannot be replaced.)

- Well maintenance or pump problems could impede collection of some samples.

Table 4.5. Scale of Decision Making

DS #	Population of Interest	Geographic Boundary	Temporal Boundary		Scale of Decision
			Timeframe	When to Collect Data	
200-BP-5 Operable Unit					
1 and 3	Tc-99, Co-60, cyanide, uranium, Cs-137, Sr-90, Pu 239/240, tritium, I-129, and nitrate in groundwater	Perimeter of 200-BP-5 compliance boundary	Annually and 5-year review	No constraints in general regarding time of sampling.	Concentration of COC within the perimeter of the 200-BP-5 compliance boundary over the next year.
2	Water level	Perimeter of 200-BP-5 compliance boundary	Annually	Water-level measurements should be taken at nearly the same time to minimize time effects and to coincide with site-wide measurements, and should be taken if possible during a season when the barometric pressure and/or storm effects are at a minimum (typically June through August..	Water-table level within the perimeter of the 200-BP-5 compliance boundary over the next year.
200-PO-1 Operable Unit					
1 and 3	Tritium, I-129, nitrate, Tc-99, Sr-90, arsenic, chromium, manganese, and vanadium in groundwater	Perimeter of 200-PO-1 compliance boundary	Annually and 5-year review	No constraints in general regarding time of sampling.	Concentration of COC and water table level within the perimeter of the 200-PO-1 compliance boundary over the next year.
2	Water level	Perimeter of 200-PO-1 compliance boundary	Annually	Water-level measurements should be taken at nearly the same time to minimize time effects and to coincide with site-wide measurements, and should be taken if possible during a season when the barometric pressure and/or storm effects are at a minimum (typically June through August).	Water-table level within the perimeter of the 200-PO-1 compliance boundary over the next year.

5.0 Step 5 – Develop a Decision Rule

The purpose of DQO Step 5 is to develop a decision rule (DR) for each decision statement in the form of an “IF…THEN…” statement that incorporates the parameter of interest, the scale of decision making, the action level, and the alternative action(s) that would result from resolution of the decision. Note that the scale of decision making and alternative actions were identified earlier in DQO Steps 4 and 2, respectively.

5.1 Inputs Needed to Develop Decision Rules

Tables 5.1 and 5.2 present all of the information needed to formulate the decision rules identified in Section 5.2. This information includes the decision statements and alternative actions identified earlier in DQO Step 2, the scale of decision making identified in DQO Step 4, the statistical parameter of interest, and the final action levels for each of the COCs.

In general, the MCL for each COC has been designated as the final action level. An MCL has not been defined for vanadium; however, vanadium has been detected in a well downgradient of the 216-A-37-2 crib, a RCRA TSD unit, at levels between the Washington State Model Toxics Control Act (MTCA) B and C (112 ug/L and 245 ug/L, respectively; DOE/RL-96-66). It has been retained in the list of COCs for the 200-PO-1 Operable Unit on this basis.

5.2 Decision Rules

Table 5.3 presents decision rules that correspond to each of the decision statements identified in Table 5.1.

Table 5.1. Decision Statements

DS #	Decision Statement
200-BP-5 and 200-PO-1 Operable Units	
1	Determine if the current 200-BP-5 and 200-PO-1 monitoring well networks delineate extent of COC plumes and, therefore, require no action; if the networks need to be redesigned using existing wells; or if new monitoring wells should be installed. (Criteria to determine an adequate well spacing will be defined after the DQO process is completed and before the SAPs are prepared. Meetings will be held with regulators during the preparation of the SAPS and in the course of redesigning the monitoring networks.)
2	Determine if the current 200-BP-5 and 200-PO-1 monitoring well networks define groundwater elevation contours and flow direction.
3	Determine if the current sampling frequencies for the 200-BP-5 and 200-PO-1 monitoring well networks are capable of tracking plume movement and, therefore, require no action; or if sampling frequencies need to be changed for some or all wells.

Table 5.2. Inputs Needed to Develop Decision Rules

DS #	COCs	Statistical Parameter of Interest	Scale of Decision Making	Final Action Level (MCL)	Alternative Actions
200-BP-5 and 200-PO-1 Operable Units					
1	Tc-99[(a), (b)]	pCi/L	Concentration of COC in groundwater within the perimeter of the 200-BP-5 and 200-PO-1 compliance boundary over the next year.	900 pCi/L	1) No action. 2) Select a new monitoring well network from existing wells to better define plume extent. 3) Drill and install new monitoring wells to supplement existing or new monitoring well network.
	Co-60[(a), (b)]	pCi/L		100 pCi/L	
	Cs-137[(a)]	pCi/L		200 pCi/L	
	Cyanide[(a), (b)]	µg/L		200 µg/L	
	Sr-90[(a), (b)]	pCi/L		8 pCi/L	
	Pu 239/240[(a)]	pCi/L		1.2 pCi/L	
	Uranium[(a)]	µg/L		30 µg/L	
	Arsenic[(b)]	µg/L		10 µg/L	
	Chromium[(b)]	µg/L		100 µg/L	
	Manganese[(b)]	µg/L		50 µg/L	
	Vanadium[(b)]	[(c)]		[(c)]	
	Tritium[(a), (b)]	pCi/L		20,000 pCi/L	
	I-129[(a), (b)]	pCi/L		1 pCi/L	
	Nitrate[(a), (b)]	µg/L		45,000 µg/L as NO_3	
2	Water level	m or ft	Groundwater level within the perimeter of the 200-BP-5 and 200-PO-1 compliance boundary over the next year.	No prescribed action level	1) No action. 2) Select a new monitoring well network from existing wells to better define water table elevations. 3) Drill and install new monitoring wells to supplement existing or new monitoring well network. 4) Use other methods to define flow directions.
3	Sampling frequency	Samples/year	Number of groundwater samples for wells within the perimeter of the 200-BP-5 and 200-PO-1 compliance boundary over the next year.	No prescribed action level	1) No action (maintain current sampling frequencies) 2) Revise sample frequencies in some or all wells to better define plume movement.

(a) COC for 200-BP-5 OU.
(b) COC for 200-PO-1 OU.
(c) No MCL value has been established for vanadium.

Table 5.3. Decision Rules

DS #	DR #	Decision Rule
200-BP-5 and 200-PO-1 Operable Units		
1	1	IF the results from the evaluation of the current monitoring networks indicate that they adequately define the extent of the COC groundwater plumes THEN no action is required; otherwise, select new monitoring well networks from existing wells based on expert judgment and/or drill and install new monitoring wells to supplement the existing or new monitoring well networks.
2	2	IF the results from the evaluation of the current monitoring networks indicate that they define water table elevations and groundwater flow direction THEN no action is required; otherwise, select a new monitoring well network from existing wells and/or drill and install new monitoring wells to supplement the existing or new monitoring well network, and/or apply another method to define groundwater flow direction.
3	3	IF the current frequencies permit tracking of plume movement, THEN no action is required; otherwise, select a new frequency that will permit tracking of plume.

6.0 Step 6 – Specify Tolerable Limits on Decision Errors

Because sample analytical data and field measurements can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). For this reason, the primary objective of DQO Step 6 is to determine which decision statements (if any) require a statistically based sample design.

6.1 Statistical Versus Non-Statistical Sampling Design

Table 6.1 provides a summary of the information used to support the selection between a statistical versus a non-statistical sampling design for each decision statement. The factors that were taken into consideration in making this selection included the timeframe over which each of the decision statements applies, the qualitative consequences of an inadequate sampling design, and the accessibility of the site if resampling is required. Because a new groundwater monitoring well costs approximately $250,000 to drill and install prior to sampling, traditional statistical sampling designs are not feasible for groundwater investigations. Furthermore, traditional statistics do not apply to the spatial aspects of designing a groundwater monitoring network. Thus, tables defining the null hypothesis, alpha and beta error, and width of the gray region have been excluded from this DQO process. It is concluded that non-statistical (expert judgment) methods will be used primarily as the basis for sampling design; however, geostatistical modeling will be employed where appropriate. Geostatistical modeling potentially could be used to reduce the number of wells sampled, for example, if a major change in the monitor network design results from the application of expert judgment. Section 7.0 provides details regarding the non-statistical methodologies implemented to develop the proposed groundwater monitoring network.

Table 6.1. Statistical Versus Non-Statistical Sampling Design

DS #	Timeframe (years)	Qualitative Consequences of Inadequate Sampling Design (low/moderate/severe)	Resampling Access (accessible/inaccessible)	Proposed Sampling Design (statistical/ non-statistical)
200-BP-5 and 200-PO-1 Operable Units				
1, 2, and 3	1 and 5*	Moderate	Accessible	Non-statistical (expert judgment) ± geostatistical
* At least two samples must be collected from each well in a 5-year period to support the 5-year review.				

7.0 Step 7 – Optimize the Design

The objective of DQO Step 7 is to present alternative data collection designs that meet the minimum data quality requirements specified in DQO Steps 1 through 6. A selection process is then used to identify the most resource-effective data collection design that satisfies all of the data quality requirements. This DQO step assumes a non-statistical design approach will be implemented for the reasons discussed in Section 6.0. However, geostatistical modeling may also be employed if appropriate. Geostatistical methods have been used previously, for example, to reduce the number of wells resulting from a non-statistical (expert judgment) approach, resulting in significant cost savings.

7.1 Non-Statistical Design Methodology

A well list will be developed for the 200-BP-5 and 200-PO-1 operable units based on hydrogeologic expertise and by considering the goals of the CERCLA, RCRA past practice, and AEA site-wide surveillance monitoring programs of the 200 East Area. The method to be used in the sampling design process primarily will involve review of current and past COC contaminant plume maps, trend plots of COC concentration versus time for individual wells, and water-table maps. Wells that are not currently being sampled but could be used also will be identified.

Development of the monitoring well networks for defining COC distributions will involve a review of the annual or latest quarter plume map for each COC. These plume maps will identify the locations of the monitoring wells used and the COC value associated with each well. COC maps from previous years (e.g., 5 and 10 years ago) and trend plots also will be examined to define recent plume movement and develop a conceptual model of potential movement over the next several years. The primary objective of this activity is to define the location of the contour associated with the action level of each COC (i.e., the MCL contour plus selected contours within this boundary) and determine if this location is adequately known from the current well network design. If not, the network will be redesigned using existing wells and/or new wells will be added. Consideration of well quality will be undertaken, because some wells will go dry in the near future and should, if possible, be replaced with existing or new wells. Decisions will also be made regarding the appropriate sampling frequency for each monitoring well and associated COCs.

Groundwater elevation maps of the 200 East Area will be examined and an assessment made of the adequacy of the current water-table elevation monitoring networks and the methods used to acquire, resolve, and interpret data. A primary objective of this activity is to determine if the current networks in the 200-BP-5 and 200-PO-1 Operable Units will be adequate to construct water table elevation maps over the next several years that are of sufficient accuracy to define water-table elevations and flow directions in an acceptable manner. Another objective is to evaluate, reduce, and/or correct to the extent possible all potential sources of uncertainty associated with water-level measurements. If needed, the network will be redesigned using existing wells and/or new wells will be added. Consideration of well quality will be undertaken, since some wells will go dry in the near future and should, if possible, be replaced with existing or new wells. Alternative approaches may be evaluated to measure water levels and flow direction if it is determined that the above approaches cannot be utilized to design acceptable water-table elevation monitoring networks.

7.2 Implementation Strategy

The results of the DQO process indicate that a non-statistical approach is merited for evaluation of the current monitoring well networks in the 200-BP-5 and 200-PO-1 operable units. Based on expert judgment and the methodology indicated above, the networks either will not be changed or will be redesigned using existing and/or new wells if possible. If a major change occurs in the monitoring well networks relative to the existing ones, geostatistical modeling may be used to determine if the size of the new monitoring well networks can be reduced without loss of information.

The monitoring network designs that are developed will be defined in sampling and analysis plans. These plans also will define the sampling frequency for the wells of these networks. Any proposed new groundwater monitoring wells will be prioritized so that they can be installed on the basis of budget availability. The sampling and analysis plans for 200-BP-5 and 200-PO-1 operable units will be updated, if needed, on an annual basis after reviewing the current adequacy of the monitoring well network design based on the past year's data.

Several potential needs were recognized during the DQO process regarding new wells that should be considered. It was suggested that a sufficient number of wells may not be present in the area north of the Gable Mountain Gap to the Columbia River to adequately define the northern extent of contamination in the 200-BP-5 Operable Unit. It was also recognized that upgradient and downgradient wells may be needed to more adequately monitor the BC cribs in the 200-PO-1 Operable Unit. These potential new well needs will be considered during the development of the sampling and analysis plans for the two operable units.

8.0 References

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