0049130

DOE/RL-97-96
Rev. 0

100-HR-3 and 100-KR-4 Operable Units Interim Action Performance Evaluation Report

4
MAY 1998
RECEIVED
EDMC

United States
Department of Energy
Richland, Washington

TRADEMARK DISCLAIMER
Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.
Available in paper copy and microfiche.

Available to the U.S. Department of Energy
and its contractors from
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831
(615) 576-8401

Available to the public from the U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

Printed in the United States of America

DISCLM-5.CHP (8-91)

DOE/RL-97-96
Rev. 0

100-HR-3 and 100-KR-4 Operable Units Interim Action Performance Evaluation Report

Date Published
April 1998

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

THIS PAGE INTENTIONALLY
LEFT BLANK

EXECUTIVE SUMMARY

Groundwater interim remedial actions are being executed to remediate groundwater at the 100-HR-3 and 100-KR-4 Operable Units (OUs) as stipulated in *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units* (ROD) (EPA 1996). Human health risks are minimized by maintaining institutional controls that prevent access to contaminated groundwater. However, a qualitative ecological risk assessment concluded that chromium in groundwater could cause chromium concentrations in the river substrate to exceed the U. S. Environmental Protection Agency's (EPA) Ambient Water Quality Criterion (AWQC) of 11 μg/L for protection of freshwater aquatic species. Therefore, this interim remedial action is focused on the protection of ecological receptors where groundwater from these OUs discharges along the Hanford Reach of the Columbia River. Prior to the startup of the interim action, groundwater in these OUs exceeded the AWQC by one to two orders of magnitude (EPA 1996). The ROD requires that hexavalent chromium contaminant levels in the aquifer be reduced through an interim remedial action such that the hexavalent chromium concentrations are below 22 μg/L at the compliance wells. Based on the anticipated dilution occurring between the compliance wells and the point of discharge into the Columbia River, attainment of this concentration at the compliance wells would ensure that chromium levels in the river substrate do not exceed 11 μg/L.

The selected alternative for this interim remedial action was the installation of pump-and-treat systems at the 100-HR-3 and 100-KR-4 OUs that will extract groundwater from selected wells, treat the water to remove chromium, then inject the treated water back into the aquifer (EPA 1996). The initial phase of the 100-HR-3 and 100-KR-4

interim action has been focused on target areas that were identified using past water quality data obtained from monitoring well groundwater and river substrate pore water samples (DOE-RL 1996).

This performance evaluation report is the first of several reports required by the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (RDR/RAWP) (DOE-RL 1996), to evaluate the performance of the treatment systems at the 100-HR-3 and 100-KR-4 OUs. Specifically, this performance evaluation report includes a summary and evaluation of the treatment process data, water level data, and hydrochemical data collected from the July 1, 1997 through January 1998, and from October 1, 1997 through January 1998, for the 100-HR-3 and 100-KR-4 pump-and-treat systems, respectively. At the startup of operations, the unconfined aquifer characteristics were unusual due to extreme flood conditions (50-year flood event) of the Columbia River. The data collected over these time periods reflect the unusual conditions and are not indicative of normal conditions. This report provides follow on recommendations that could improve the system performance, such as modifications to the target areas, alternate pumping strategies, treatment system modifications, or alternate sampling parameters and frequencies. This report satisfies the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990) milestone M-16-06C. This milestone requires the U. S. Department of Energy, Richland Operations Office to submit a performance evaluation report for each of the OUs to the EPA and the Washington State Department of Ecology by April 30, 1998. To meet this objective and as a cost saving measure, the evaluation of the 100-HR-3 and 100-KR-4 treatment systems have been combined into a single report.

Conclusions drawn from this evaluation, as discussed in the following sections, demonstrate how well the three remedial action objectives (RAOs) are being met since the initiation of the interim remedial actions at each of the OUs.

100-HR-3 INTERIM REMEDIAL ACTION PUMP-AND-TREAT SYSTEM

RA0 #1: Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River

- The 100-HR-3 pump-and-treat system is effective at removing chromium (hexavalent) from the groundwater using Dowex™ resin as the ion exchange (IX) media. The performance monitoring data indicate that the treatment system is greater than 95% efficient in removing chromium from the influent stream. The existing system operation has been treating the groundwater such that hexavalent chromium concentrations are less than 5 μg/L at an average treatment rate of approximately 600 L/min and at an average influent concentration of 100 μg/L.

- In both 100-HR-3 reactor areas, groundwater flux to the river in the targeted plume areas has been reduced due to hydraulic containment resulting from the operation of the extraction well field. In the 100-D Area, capture analysis coupled with water level data indicate that the combined overlapping width of the capture zone created by the two extractions wells is approximately 400 m, resulting in a hydraulic containment of approximately 400 m along the targeted shoreline. In the 100-H Area, capture analysis coupled with water level data essentially show that continuous hydraulic

™ Dowex is a registered trademark of Dow Chemical Company, Midland, Michigan.

capture (and containment along the targeted shoreline) occurs between the general vicinity of well 199-H4-15A and 199-H4-12A (a combined width of approximately 250 m). Only localized capture and containment occurs in the vicinity of extraction well 199-H4-11. Therefore, a portion of the groundwater within the targeted plume may continue discharging into the Columbia River.

- The Columbia River was at a very high flood stage (50-year) at the start of the interim remedial action pump-and-treat operation. Since the unconfined aquifer is hydraulically connected to the river, the high-river levels have skewed the sampling results such that at the startup of full-time operations, chromium levels were typically below the remedial action goal of 22 μg/L at the compliance wells. Since that time, the concentrations have risen well above the goal (e.g., as high as 230 μg/L in the 100-D Area and 125 μg/L in the 100-H Area) as the unconfined aquifer returns to more normal conditions. Because of this abnormal river condition, and the short duration of the evaluation period, it is difficult to ascertain the overall hydrochemical impact of the pump-and-treat interim remedial action on the aquifer system.

- The pump-and-treat system is reducing the toxicity, mobility, and volume of contaminants moving to the river by reducing the mass of hexavalent chromium contamination in the groundwater. Process monitoring data indicate that approximately 14,189 g of chromium have been removed in the first 7 months (estimated annual removal rate of 24,320 g). Based on current trends, the removal rate will increase in the short term in response to a return to normal aquifer conditions, and then will decrease in the long term in response to the interim remedial action.

RAO #2: Protection of human health by preventing exposure to contaminants in the groundwater

- Human health risks are minimized by maintaining institutional controls that prevent access to contaminated groundwater.

RAO #3: Provide the information that will lead to the final remedy

- Relevant information is being collected and analyzed in preparation for the upcoming final 100-Area Remedial Investigations/Feasibility Studies (RI/FS) activities. The information is accessible to the regulators via the Hanford Environmental Information System (HEIS) database, project-specific database, and monthly, quarterly, and annual performance evaluation reports.

- The treatment system has reduced concentrations of chromium in the effluent stream to the maximum extent practicable (e.g., less than 5 μg/L), which is well below the 50 μg/L chromium concentration performance criterion.

- Over the 7-month operating period, the system availability was approximately 88.9%. The downtime was attributed to system refinements, unexpected weather conditions, and fine tuning resin changeout procedures.

- Based on the initial operations, the cost per liter and cost per gram of treated groundwater, assuming an annual treatment rate of 282 million L and 24,320 g of chromium removed, is approximately 0.9 ¢/L or $109/g (present worth), respectively.

100-KR-4 INTERIM REMEDIAL ACTION PUMP-AND-TREAT SYSTEM

RAO #1: Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River

- The 100-KR-4 pump-and-treat system is effective at removing chromium (hexavalent) from the groundwater using Dowex™ resin as the IX media. The performance monitoring data indicate that the treatment system is greater than 92% efficient in removing chromium from the influent stream. The existing system operation has been treating the groundwater such that hexavalent chromium concentrations are less than 10 μg/L at an average treatment rate of approximately 450 L/min and at an average influent concentration of 125 μg/L.

- Groundwater flux to the river along the targeted shoreline has been reduced due to hydraulic containment from the extraction well field. However, capture analysis coupled with water level data indicate that some of the targeted chromium plume in the vicinity of well 199-K-118A and between wells 199-K-119A and 194-K-120A was not contained by the network because well 199-K-118A was not put into services due to continued clogging of the extraction well filters.

- Since operating the pump-and-treat system four months, the chromium levels measured by the end of January at the compliance wells are above the remedial action goal of 22 μg/L (e.g., ranged from 50 to 155 μg/L). In general, during this period, chromium concentrations have risen due to the return of the aquifer to more normal conditions as the Columbia River recedes from flood conditions.

- The pump-and-treat system is reducing the toxicity, mobility, and volume of contaminants moving to the river by reducing the mass of hexavalent chromium contamination in the groundwater. Process monitoring data indicate that approximately 9,445 g of chromium have been removed in the first 4 months (an estimated initial annual removal rate of 28,340 g). Based on current trends, the removal rate will increase in the short term in response to a return to normal aquifer conditions, and then will decrease in the long term in response to the interim remedial action.

RAO #2: Protection of human health by preventing exposure to contaminants in the groundwater

- Human health risks are minimized by maintaining institutional controls that prevent access to contaminated groundwater.

RAO #3: Provide the information that will lead to the final remedy

- Relevant information is being collected and analyzed in preparation for the upcoming final 100-Area RI/FS activities. The information is accessible to the regulators via the HEIS database, project-specific database, and monthly, quarterly and annual performance evaluation reports.

- The treatment system has reduced concentrations of chromium in the effluent stream to the maximum extent practicable (e.g., less than 10 μg/L), which is well below the 50 μg/L chromium concentration performance criterion.

- Over the 4-month operating period, the system availability was approximately 93.0%. The downtime was attributed to system refinements, unexpected weather conditions, and fine tuning resin changeout procedures.

- The cost per liter and cost per gram of treated groundwater, assuming an annual treatment rate of 228 million L and 28,340 g of chromium removed, is approximately 0.9 ¢/L or $72/g (present worth), respectively.

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

Performance monitoring data show that significant portions of the targeted areas are being captured and the mass of chromium is being reduced. However, since these systems have only been operational for a short period of time, the overall effectiveness of the pump-and-treat systems at achieving protective levels at compliance wells cannot be assessed without more performance monitoring data. As outlined in the RDR/RAWP (DOE-RL 1996), the systems will operate until one of the following criteria for termination of the interim remedial action has been met: (1) successful completion of the interim action is demonstrated, (2) the interim action is no longer effective, or (3) a final remedy is selected.

Recommended modifications to the treatment systems and performance monitoring activities are listed below:

- Continue to operate to the initial injection/extraction well field configuration for both OUs as defined in the RDR/RAWP.

- In the 100-KR-4 OU, replace extraction well 199-K-118A with another extraction well at the same location to meet the original design objectives defined in the RDR/RAWP.

- Operate at the following nominal flow rates (±20 L/m) for the 100-HR-3 extraction wells in order to provide optimal hydraulic control and containment:

99-D8-53: 151 L/min	199-H4-11: 133 L/min[1]
199-D8-54A: 151 L/min	199-H4-7: 76 L/min
199-H3-2A: 151 L/min	199-H4-12A: 76 L/min.
199-H4-15A: 76 L/min	

- Operate at the following nominal flow rates (±20 L/m) for the 100-KR-4 extraction wells in order to provide optimal hydraulic control and containment:

199-K-113A: 95 L/min	199-K-118A (replacement well): 95 L/min
199-K-115A: 95 L/min	199-K-119A: 95 L/min
199-K-116A: 190 L/min[1]	199-K-120A: 95 L/min.

- In the 100-KR-4 OU, install an additional groundwater monitoring well downstream from compliance well 199-K-112A to better define the lateral boundary of the chromium plume.

[1] Prior to implementing design modifications for well 199-H4-11 and 199-K-116A, testing should be conducted to determine sustainable yield at recommended higher rates.

- Conduct a full evaluation of chromium, co-contaminant and resin IX processes/kinetics to determine the optimum operating and monitoring procedures and/or parameters for the 100-HR-3 pump-and-treat system.

- Install an additional monitoring well in the 100-D Area, downstream from monitoring well 199-D8-70. In this area, the northeasterly extent of the chromium plume is poorly defined.

- Conduct groundwater sampling over a short period of time at the extraction and compliance wells at both 100-HR-3 and 100-KR-4 OUs. This data will be used to separate the influences caused by either the interim action or the daily and seasonal fluctuations of the Columbia River.

- Continue to monitor aquifer-sampling tubes to routinely monitor chromium concentrations in the river substrate in the targeted plume areas at both OUs. This information, along with the performance monitoring data, will help in understanding the relationship between near river and pore water contaminant concentrations.

CONTENTS

1.0 INTRODUCTION 1-1
1.1 Purpose and Objectives 1-1
1.2 Location 1-2
1.3 Interim Action Project Background 1-2
1.3.1 100-HR-3 Operable Unit 1-2
1.3.2 100-KR-4 Operable Unit 1-3
1.4 Data Collection And Evaluation 1-4
1.5 Report Organization 1-5

2.0 REMEDIAL ACTION OBJECTIVES AND PERFORMANCE CRITERIA 2-1

3.0 100-HR-3 GROUNDWATER INTERIM ACTION 3-1
3.1 Pump-and-Treat Operations 3-1
3.1.1 Facility and Well Design 3-1
3.1.2 Process Sampling and Analysis 3-3
3.1.3 System Operations 3-5
3.1.4 System Availability and Performance 3-6
3.1.5 Discussions 3-9
3.2 Aquifer Responses at 100-HR-3 3-10
3.2.1 Hydraulic Responses 3-12
3.2.2 Hydrochemical Responses 3-15
3.2.3 Discussions 3-24
3.2.4 Summary of Pump-and-Treat Impacts on the Aquifer 3-26

4.0 100-KR-4 GROUNDWATER INTERIM ACTION 4-1
4.1 Pump-and-Treat Operations 4-1
4.1.1 Facility and Well Design 4-1
4.1.2 Process Sampling and Analysis 4-3
4.1.3 System Operations 4-4
4.1.4 System Availability and Performance 4-5
4.1.5 Discussions 4-7
4.2 Aquifer Responses at 100-KR-4 4-8
4.2.1 Hydraulic Responses 4-9
4.2.2 Hydrochemical Responses 4-11
4.2.3 Discussions 4-15
4.2.4 Summary of Pump-and-Treat Impacts on the Aquifer. 4-16

5.0 PUMP-AND-TREAT SYSTEM COST DATA 5-1
5.1 100-HR-3 Pump-and-Treat System Costs 5-2
5.2 100-KR-4 Pump-and-Treat System Costs 5-3

CONTENTS (continued)

6.0 CONCLUSIONS **6-1**
6.1 100-HR-3 Interim Remedial Action Pump-and-Treat System 6-1
6.2 100-KR-4 Interim Remedial Action Pump and Treat System 6-4

7.0 RECOMMENDATIONS **7-5**

8.0 REFERENCES **8-5**

APPENDICES

A. AQUIFER RESPONSE DATA **A-1**
B. DEVELOPMENT OF FINITE ELEMENT MESH FOR WATER TABLE CONTOUR MAPS AND VELOCITY FIELDS **B-1**

FIGURES

i

1-1. 100-HR-3 OU (DOE-RL 1996). 1-6
1-2. 100-D Target Area (DOE-RL 1996). 1-7
1-3. 100-H Target Area (DOE-RL 1996). 1-8
1-4. 100-KR-4 OU (DOE-RL 1996). 1-9
1-5. 100-K Target Area (DOE-RL 1996). 1-10
3-1. 100-HR-3 Pump-and-Treat System Plot Plan 3-29
3-2. Pump-and-Treat System Schematic. 3-31
3-3. Typical Extraction and Injection Well. 3-33
3-4. 100-HR-3 Treatment System Operation. 3-35
3-5. 100-HR-3 Treatment System Operation, Cumulative Volume Processed and Mass Removed vs. Time. 3-37
3-6. Ion Exchange Breakthrough Curves for H-IX-A. 3-38
3-7. Ion Exchange Breakthrough Curves for H-IX-B. 3-39
3-8. 100-HR-3 Pump-and-Treat System Influent and Effluent. 3-40
3-9. 100-HR-3 OU 100-D Area Layout of Wells 3-41
3-10. 100-HR-3 OU 100-H Area Layout of Wells 3-42
3-11. 100-HR-3 OU 100-D Area Composite Hydrographs of Extraction Wells. 3-43
3-12. 100-HR-3 OU 100-H Area Composite Hydrographs of Injection Wells. 3-44
3-13. 100-HR-3 OU 100-H Area Composite of Hydrographs of Injection Wells. 3-46
3-14. River Stage Correlation and Drawdown Measured in 100-HR-3 OU 100-D Area Extraction Wells 3-47

CONTENTS (continued)

3-15. River Stage Correlation and Drawdown Measured in 100-HR-3 OU 100-H Area Near River Extraction Wells. 3-48
3-16. Drawdown Measured in 100-HR-3 OU 100-H Area Inland Extraction Wells. 3-49
3-17. Buildup Measured in 100-HR-3 OU 100-H Injection Wells. 3-50
3-18. River Stage Correlation and Downdraw Measured in 100-HR-3 OU 100-D Area Compliance and Monitoring Wells. 3-51
3-19. River Stage Correlation and Drawdown Measured in 100-HR-3 OU 100-H Area Near River Compliance and Monitoring Wells. 3-53
3-20. Drawdown and Buildup Measured in 100-HR-3 OU 100-H Area Inland Monitoring Wells. 3-54
3-21. Hydraulic Capture Zone Developed by 100-HR-3 OU 100-D Area Extraction Wells and Comparison to Modeled Flow Lines from DOE-RL 1996. 3-55
3-22. Hydraulic Containment Developed by 100-HR-3 OU 100-D Area Extraction Wells. 3-57
3-23. Hydraulic Capture Zone Developed by 100-HR-3 OU 100-H Area Extraction Wells and Comparison to Modeled Flow Lines from DOE-RL 1996. 3-59
3-24. Hydraulic Containment Developed by 100-HR-3 OU 100-H Area Extraction Wells without Well 199-H4-7 Operating. 3-61
3-25 Baseline Chromium Distribution For The 100-D Area Taken from the RDR/RAWP. 3-62
3-26. Baseline Chromium Distribution For The 100-H Area Taken from the RDR/RAWP. 3-63
3-27. Location Map Showing the Extraction Wells, Injection Wells, Compliance Monitoring Wells and Performance Monitoring Wells for the 100-HR-3 OU. 3-64
3-28. Trend Plots for Chromium Measured at the Injection Wells 199-D8-53, 199-D8-54A, 199-H3-2A, and 199-H4-7. 3-65
3-29. Trend Plots For Chromium Measured at the Injection Wells 199-H-11, 199-H-12A, and 199-H4-15A. 3-66
3-30. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance Monitoring Wells 199-D8-68, 199-D8-69, and 199-D8-70. 3-67
3-31. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance MonitoringWells 199-H4-4, 199-H4-5, 199-H4-63 and 199-H4-64. 3-68
3-32. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Performance Monitoring Wells 199-D8-3, 199-D8-54B, and 199-D8-71. 3-69

CONTENTS (continued)

3-33. Trend Plots for Chromium and Specific Conductance Measured at the Performance Monitoring Wells 199-H4-3 and 199-H4-6. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Performance Monitoring Wells 199-H4-8 and 199-H4-10. 3-70
3-34. Trend Plots For Chromium, Specific Conductance and Average Weekly Water Elevation at Performance Monitoring Wells 199-H4-12B and 199-H4-12C. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-H4-13 And 199-H4-14. 3-71
3-35. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation at Performance Monitoring Wells 199-H4-15B and 199-H4-15CS. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-H4-16 and 199-H4-17. 3-72
3-36. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-H4-18, 199-H4-45, 199-H4-46 and 199-H4-48. 3-73
3-37. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Performance Monitoring Wells 199-H4-49 and 199-H5-1A. 3-74
3-38. 100-D Area Chromium Plume Distribution for the Last Quarter of 1997. 3-75
3-39. 100-H Area Chromium Plume Distribution for the Last Quarter of 1997.. 3-76
4-1. 100-KR-4 Pump-and-Treat System Schematic. 4-18
4-2. 100-KR-4 Treatment System Operation. 4-19
4-3. 100-KR-4 Treatment System Operation, Cumulative Volume Processed and Mass Removed vs. Time. 4-21
4-4. Ion Exchange Breakthrough Curves for K-IX-A. 4-22
4-5. Ion Exchange Breakthrough Curves for K-IX-B. 4-23
4-6. 100-KR-4 Pump-and-Treat System Influent and Effluent. 4-24
4-7. 100-KR-4 Area Layout of Wells. 4-25
4-8. 100-KR-4 Area Composite Hydrographs of Extraction Wells. 4-26
4-9. 100-KR-4 Area Composite Hydrographs of Injection Wells. 4-28
4-10. River Stage Correlation and Drawdown Measured in 100-KR-4 Area Extraction Wells. 4-30
4-11. Buildup Measured in 100-KR-4 Injection Wells. 4-32
4-12. River Stage Correlation and Drawdown Measured in 100-KR-4 Area Compliance and Monitoring Wells. 4-34
4-13. Hydraulic Capture Zone Developed by 100-KR-4 Area Extraction Wells and Comparison to Modeled Flow Lines from DOE-RL 1996. 4-35
4-14. Hydraulic Containment Developed by 100-KR-4 Area Extraction Wells. 4-37
4-15. Baseline Chromium Distribution for the 100-K Area Taken From the RDR/RAWP. 4-38

CONTENTS (continued)

4-16. Location Map Showing the Extraction Wells, Injection Wells, Compliance Monitoring Wells and Performance Monitoring Wells for the 100-KR-4 OU 4-39
4-17. Trend Plots for Chromium Measured at the Injection Wells 199-K-113A, 199-K-115A, 199-K-116A, And 199-K-118A. 4-40
4-18. Trend Plots for Chromium Measured at the Injection Wells 199-K-119A and 199-K-120A. 4-41
4-19. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance Monitoring Wells 199-K-18, 199-K-20, 199-K-112A and 199-K-114A. 4-42
4-20. Trend Plot for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance Monitoring Well 199-K-117A. 4-43
4-21. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-K-19 and 199-K-37. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation At Performance Monitoring Wells 199-K-21 and 199-K-22 4-44
4-22. 100-K Area Chromium Plume Distribution for the Last Quarter of 1997. 4-45
5-1. 100-HR-3 Capital and Construction Costs. 5-5
5-2. 100-HR-3 Projected Operating Costs 5-5
5-3. Capital and Construction Costs. 5-6
5-4. 100-KR-4 Projected Operating Costs. 5-6

TABLES

2-1. Interim Action Design and Performance Criteria Required by the Interim Action Record of Decision. 2-2
3-1. Extraction/Injection Well Identification and Rates. 3-77
3-2. Extraction/Injection Well Operations. 3-78
3-3. IX Vessel Operational Data. 3-79
3-4. Waste Designation Results for Used IX Resin. 3-80
3-5. 100-HR-3 Pump-and-Treat System Interim Action Design and Operational Performance Against Criteria. 3-81
3-6. Drawdown and Buildup Data and December 1997 Water Level in 100-HR-3 Extraction, Injection and Monitoring Wells. 3-82
3-7. 100-HR-3 Interim Remedial Action Monitoring Schedule. 3-83
3-8. Chromium Results Used to Make Chromium Distribution Map for the 100-D Area. 3-85
3-9. Chromium Results Used to Make Chromium Distribution Map for the 100-H Area. 3-86
3-10. 100-H Area Monitoring Wells with Groundwater Having Co-Contaminants Exceeding the Relevant Standard. 3-87
3-11. Quality Control and Quality Assurance for 100-HR-3 OU Chromium. 3-88

CONTENTS (continued)

3-12. Quality Control and Quality Assurance for 100-HR-3 OU Co-Contaminants. 3-89
4-1. Extraction/Injection Well Identification and Rates. 4-46
4-2. IX Vessel Operational Data. 4-47
4-3. Waste Designation Results for Used IX Resin. 4-48
4-4. 100-KR-4 Pump-and-Treat System Interim Action Design and Operational Performance Against Criteria. 4-49
4-5. Drawdown and Buildup Data and December 1997 Water Level in 100-KR-4 Extraction, Injection, and Monitoring Wells. 4-50
4-6. 100-KR-4 Interim Action Monitoring Schedule. 4-51
4-7. Results of Discrete Interval Sampling for Chromium in Compliance Well 199-K-117A. 4-53
4-8. Chromium Results Used to Make Chromium Distribution Map for the 100-K Area. 4-54
4-9. 100-K Area Monitoring Wells with Groundwater Having Co-Contaminants Exceeding the Relevant Standard. 4-55
4-10. Quality Control and Quality Assurance for 100-KR-4 OU Chromium Results. 4-56
4-11. Quality Control and Quality Assurance for 100-KR-4 OU Co-Contaminants. 4-57
5-1. Cost Summary for the 100-HR-3 Pump-and-Treat System. 5-7
5-2. Cost Summary for the 100-KR-4 Pump–and-Treat System. 5-8

ACRONYMS

AWQC	Ambient Water Quality Criterion
BLAN	Bechtel Local Area Network
CERCLA	*Comprehensive Environmental Restoration, Compensation, and Liability Act*
CMS	Corrective Measures Study
COC	contaminant of concern
CWC	Central Waste Complex
DQO	data quality objectives
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
HDPE	high density polyethylene
HEIS	Hanford Environmental Information Systems
IRM	interim remedial measure
IX	ion exchange
MCL	maximum contaminant level
MS	matrix spike
MSD	matrix spike duplicate
OIC	operator interface computer
OU	operable unit
PLC	programmable logic controller
PVC	polyvinylchloride
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act*
RDR/RAWP	Remedial Design Report and Remedial Action Work Plan
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigations/Feasibility Studies
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
TCLP	toxicity characteristic leaching procedure
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*

1.0 INTRODUCTION

Groundwater interim remedial actions are being executed to remediate groundwater at the 100-HR-3 and 100-KR-4 Operable Units (OUs) as stipulated in *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units* (ROD) (EPA 1996). Human health risks are minimized by maintaining institutional controls that prevent access to contaminated groundwater. However, a qualitative ecological risk assessment concluded that chromium in groundwater could cause chromium concentrations in the river substrate to exceed the U. S. Environmental Protection Agency's (EPA) Ambient Water Quality Criterion (AWQC) of 11 μg/L for protection of freshwater aquatic species. Therefore, this interim remedial action is focused on the protection of ecological receptors where groundwater from these OUs discharges along the Hanford Reach of the Columbia River. Prior to the startup of the interim action, groundwater in these OUs exceeded the AWQC by one to two orders of magnitude (EPA 1996). The ROD requires the hexavalent chromium contaminant levels in the aquifer be reduced through an interim remedial action such that the hexavalent chromium concentrations are below 22 μg/L at the compliance wells. Based on the anticipated dilution occurring between the compliance wells and the point of discharge into the Columbia River, attainment of this concentration at the compliance wells would ensure that chromium levels in the river substrate do not exceed 11 μg/L.

The selected alternative for this interim remedial action was the installation of pump-and-treat systems at the 100-HR-3 and 100-KR-4 OUs that will extract groundwater from selected wells, treat the water to remove chromium, then inject the treated water back into the aquifer (EPA 1996). The initial phase of the 100-HR-3 and 100-KR-4 interim action has been focused on target areas that were identified using past water quality data obtained from monitoring well groundwater and river substrate pore water samples (DOE-RL 1996).

1.1 Purpose and Objectives

This performance evaluation report is the first of several reports required by the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (RDR/RAWP) (DOE-RL, 1996), to evaluate the performance of the treatment systems at the 100-HR-3 and 100-KR-4 OUs. Specifically, this performance evaluation report includes a summary and evaluation of the treatment process data, water level data, and hydrochemical data collected from the July 1, 1997 through January 1998, and from October 1, 1997 through January 1998 for the 100-HR-3 and 100-KR-4 pump-and-treat systems, respectively. At the startup of operations, the unconfined aquifer characteristics were unusual due to extreme flood conditions (50-year flood event) of the Columbia River. The data collected over these time periods reflect the unusual conditions and are not indicative of normal conditions. This report provides follow on recommendations that could improve the system

performance, such as modifications to the target areas, alternate pumping strategies, treatment system modifications, or alternate sampling parameters and frequencies. This report satisfies the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) milestone M-16-06C. This milestone requires the U. S. Department of Energy, Richland Operations Office (RL) to submit a performance evaluation report for each of the OUs to the EPA and the Washington State Department of Ecology (Ecology) by April 30, 1998. To meet this objective and as a cost saving measure, the evaluation of the 100-HR-3 and 100-KR-4 treatment systems have been combined into a single report.

1.2 Location

The 100-HR-3 pump-and-treat facility is located in the north central part of the Hanford Site along a section of the Columbia River know as the "Hanford Reach" (Figure 1-1). The 100-HR-3 OU represents the groundwater underlying the source OUs associated with the 100-D/DR and 100-H Reactor Areas and the 600 Area in between. In response to the ROD (EPA 1996), groundwater extraction systems have been installed at both reactor areas with a common treatment facility in a surplus building located near the 100-H Reactor. All treated groundwater is injected at the 100-H Area. A schematic showing the general location of the extraction well fields and treatment facility in relation to the chromium plumes are shown in Figure 1-2 and Figure 1-3.

The 100-KR-4 OU (Figure 1-4) is also located along the Columbia River, several miles southwest of 100-HR-3. The 100-KR-4 OU is one of three OUs associated with the 100-K Area and includes the groundwater underlying the 100-KR-1 and 100-KR-2 source OUs. The 100-KR-4 treatment system and injection/extraction well field in relation to the chromium plume is located northeast of the KE Reactor and adjacent to the 116-K-2 Mile Long Disposal Trench as shown in Figure 1-5.

1.3 Interim Action Project Background

In accordance with Tri-Party Agreement requirements, hazardous substances and constituents in the soil and groundwater at the 100-H and 100-D Areas are being identified and appropriate response actions are being developed and implemented. The following sections briefly describe the key events leading up to the issuance of the groundwater interim action ROD for each of the OUs.

1.3.1 100-HR-3 OU

Significant events leading to the interim ROD for 100-HR-3 OU are summarized below.

September 1992 The *Resource Conservation and Recovery Act* (RCRA) Facility Investigation/Corrective Measures Study (RFI/CMS) work plan (DOE-RL 1992a) was approved. This work plan established the

OU setting, objectives, procedures, tasks, and schedule for conducting the RFI/CMS for the 100-HR-3 OU.

September 1994 The limited field investigation report (DOE-RL 1993), including the qualitative risk assessment was completed. This report did not recommend an interim remedial measure (IRM) to mitigate human health risk. However, chromium was identified as a contaminant of concern (COC) for ecological receptors in the river.

August 1995 The focused feasibility study (DOE-RL 1995a) and the proposed plan (DOE-RL 1995c) were finalized. The proposed plan recommended a pump-and-treat IRM to address chromium migration into the river.

December 1995 The pilot-scale treatability test summary report (DOE-RL 1995e) for the 100-HR-3 OU was issued. The report indicated that removing chromium from extracted groundwater in the 100-HR-3 OU using ion exchange (IX) was viable.

April 1996 An interim ROD (EPA 1996) for the pump-and-treat system in the 100-HR-3 OU was issued. The ROD specified installation of a pump-and-treat system in the 100-HR-3 OU and 100-KR-4 OU to intercept portions of the chromium plumes that impact the Columbia River.

September 1996 The remedial design report and remedial action work plan (DOE-RL 1996) were issued. The plan identified the design and work to accomplish the interim action.

June 30, 1997 Construction and startup of the 100-HR-3 pump-and-treat system was completed.

July 1, 1997 Full-time operations of the treatment system were initiated (satisfied Tri-Party Agreement Milestone M-16-06B).

1.3.2 100-KR-4 Operable Unit

The 100-KR-4 *Comprehensive Environmental Restoration Compensation and Liability Act* (CERCLA) process followed a similar path as discussed earlier for the 100-HR-3. Significant events leading to the operation of the pump-and-treat system are summarized below:

September 1992 The RFI/CMS work plan was approved (DOE-RL 1992a). This work plan established the OU setting, objectives, procedures,

	tasks, and schedule for conducting the RFI/CMS for the 100-KR-4 OU.
July 1994	The limited field investigation report (DOE-RL 1994), including the qualitative risk assessment was completed. The report concluded that an IRM was not warranted based on human health risk, but that IRMs could be justified for ecological concerns related to chromium.
October 1995	The focused feasibility study (DOE-RL 1995b) and proposed plan (DOE-RL 1995d) were completed. The proposed plan recommended a pump-and-treat IRM to address chromium migration into the river.
April 1996	An interim ROD for the pump-and-treat system in the 100-KR-4 OU was issued (EPA 1996). The ROD specified installation of a pump-and-treat system in the 100-KR-4 OU and 100-HR-3 OU to intercept the portions of the chromium plumes that impact the Columbia River.
September 1996	The remedial design report and remedial action work plan (DOE-RL 1996) were issued. The plan identified the design and work to accomplish the interim action.
September 30, 1997	Construction and startup of the 100-KR-4 pump-and-treat system was completed.
October 1, 1997	Full-time operations of the treatment system were initiated (satisfied Tri-Party Agreement Milestone M-16-06C).

1.4 Data Collection and Evaluation

The *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE-RL 1997) describes the specific data required to support future performance evaluations. This interim action monitoring plan was based on the guidelines and stipulations in the ROD, RDR/RAWP and on discussions and agreements resulting from the data quality objectives (DQO) process. The interim action monitoring plan requires collection of data from water level monitoring, groundwater sampling and analysis, operational sampling and analysis, and operations.

In addition to the requirements specified in the interim action monitoring plan, other ongoing groundwater monitoring efforts in the 100-HR-3 and 100-KR-4 OUs help define the overall extent of contamination in the OUs. Monitoring is performed under several programs including CERCLA, RCRA, and site-wide environmental surveillance. Specific locations within the OUs where groundwater is being monitored include the

former 183-Solar Evaporation Basins, 100-D Ponds, and K-East and K-West Fuel Storage Basins.

Other information used to help evaluate the performance of the systems includes:

- Geologic and sediment characterization based on information gathered during the construction of each of the pump-and-treat well fields,
- Vertical profiling in selected compliance wells to determine the hydraulic variability and the vertical distribution of the chromium in the aquifer,
- Capture zone analysis to estimate the containment of the target plume areas,
- Installation of additional aquifer sampling tubes along the river shore to determine potential contaminated groundwater that discharges into the river at the shoreline,
- Development and implementation of a project-specific database to effectively organize pump-and-treat data.

1.5 Report Organization

Nine sections, including this introduction, make up this performance evaluation report. Section 2.0 discusses the remedial action objectives and performance criteria. Section 3.0 evaluates the performance of the 100-HR-3 treatment system. This evaluation includes the efficiency and effectiveness of the treatment facility to meet the remedial action objective (RAO) as well as the impact of the treatment system on the uppermost aquifer. Section 4.0 discusses the 100-KR-4 treatment system, which includes a similar evaluation as discussed in Section 3.0. Section 5.0 discusses the treatment costs for each of the treatment systems. Sections 6.0, 7.0 and 8.0 contain the conclusions, recommendations, and references, respectively.

There are also two Appendices, A. Aquifer Response Data and B. Development of Finite Element Mesh for Water Table Contour Maps and Velocity Fields, both of which support information discussed in the main body of the text.

Figure 1-1. 100-HR-3 OU (DOE-RL 1996).

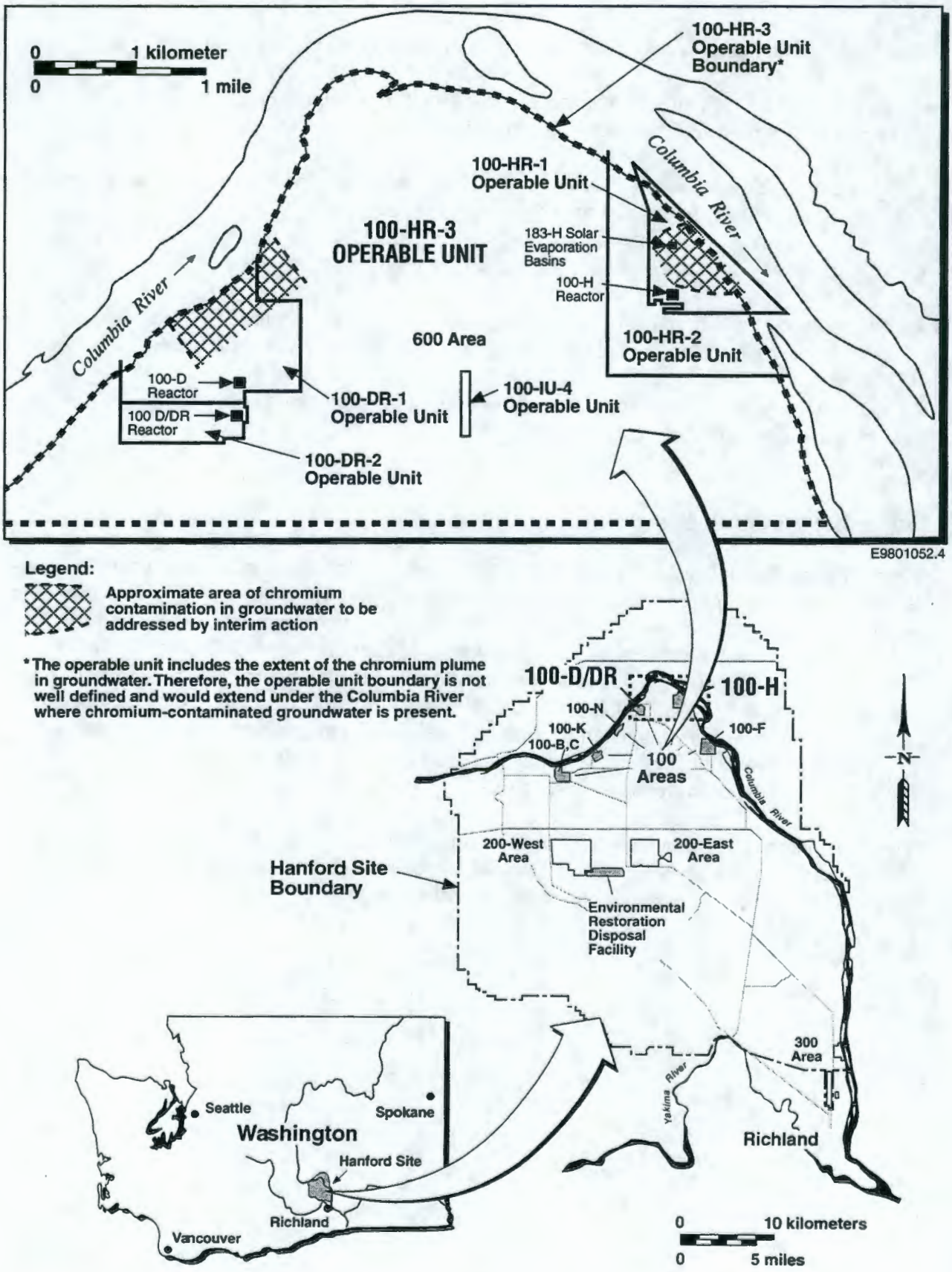
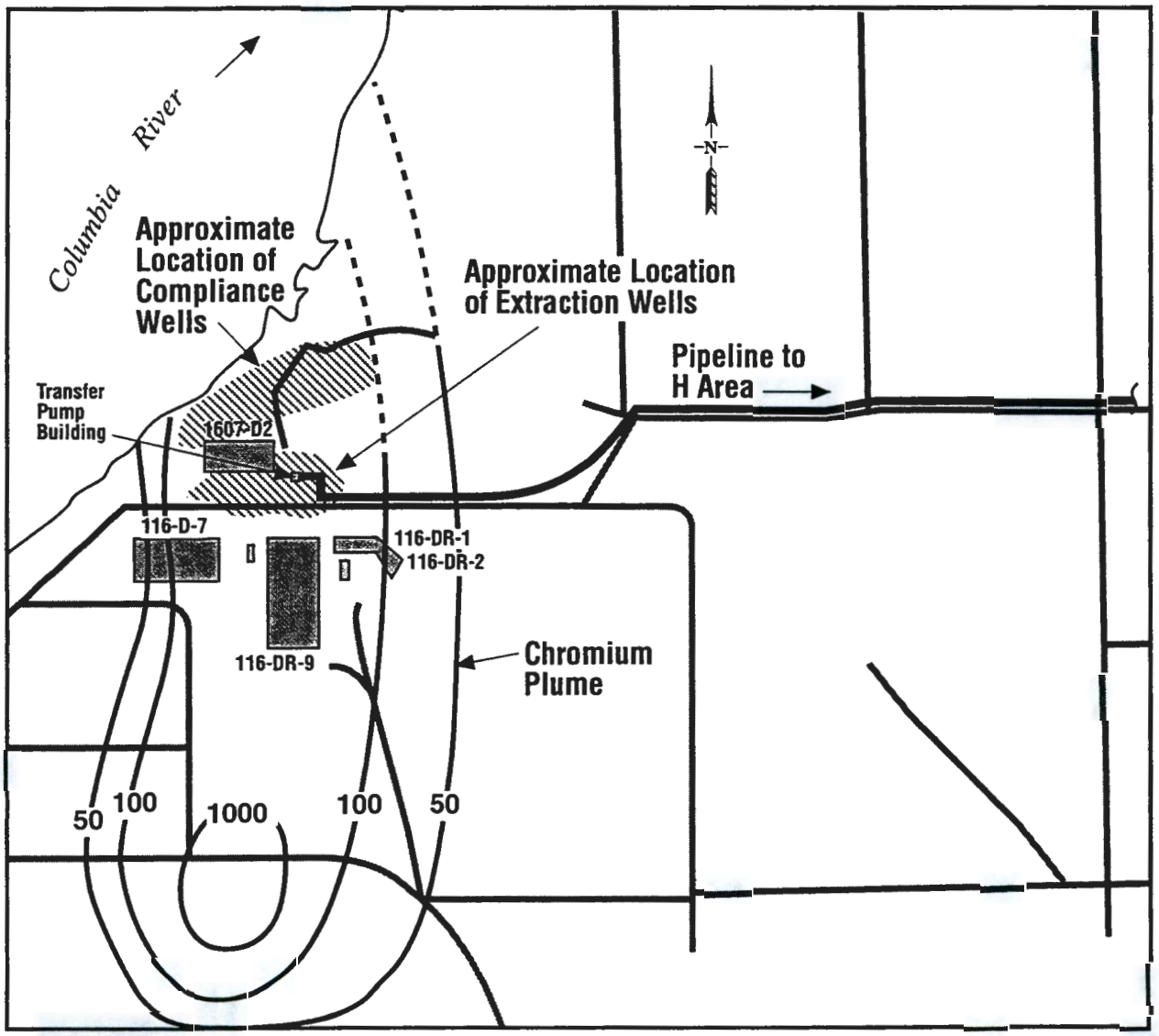


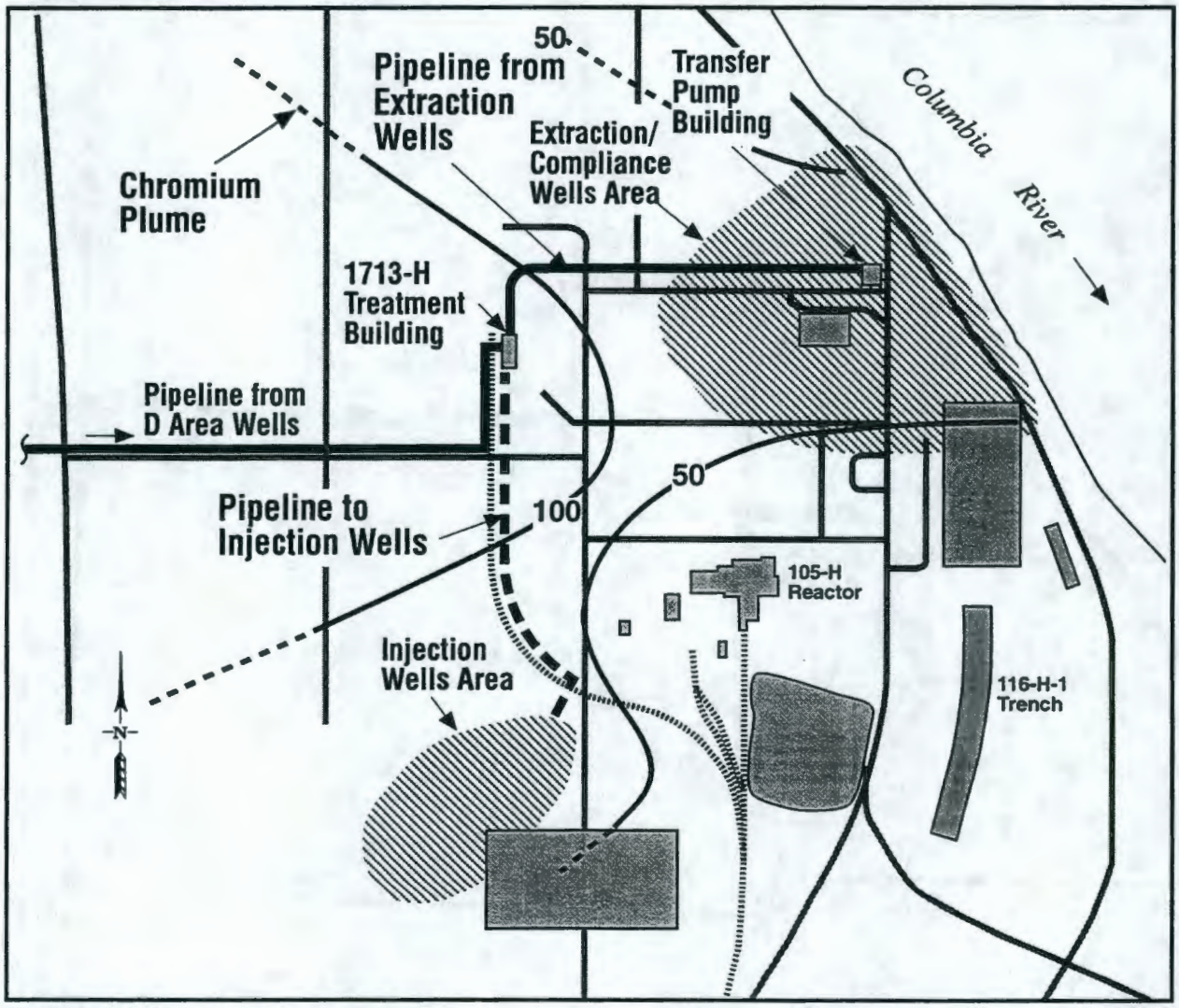
Figure 1-2. 100-D Target Area (DOE-RL 1996).



(DOE-RL 1996)

E980105z.1

Figure 1-3. 100-H Target Area (DOE-RL 1996).



(DOE-RL 1996)

E9801052.2

Figure 1-4. 100-KR-4 OU (DOE-RL 1996).

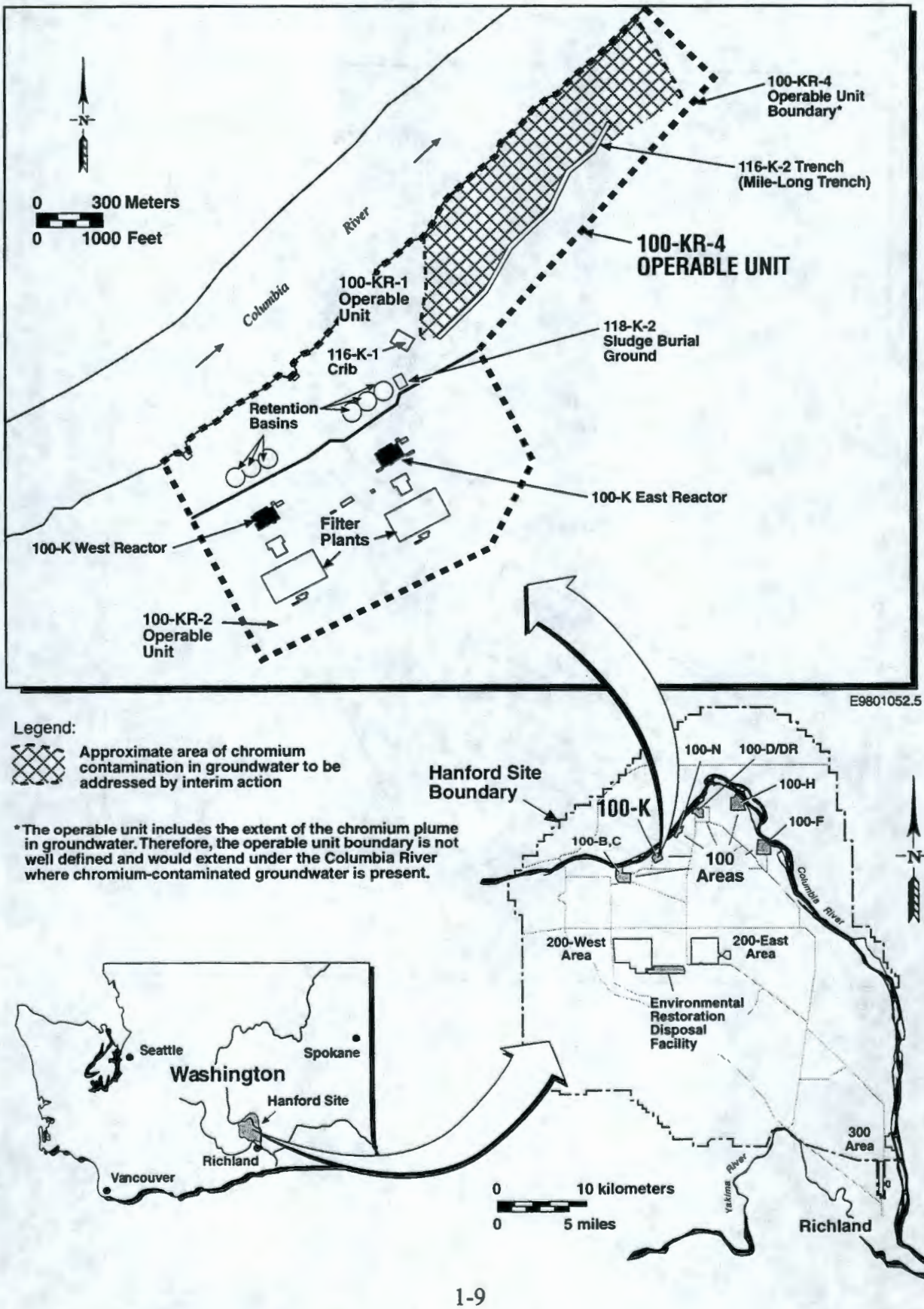
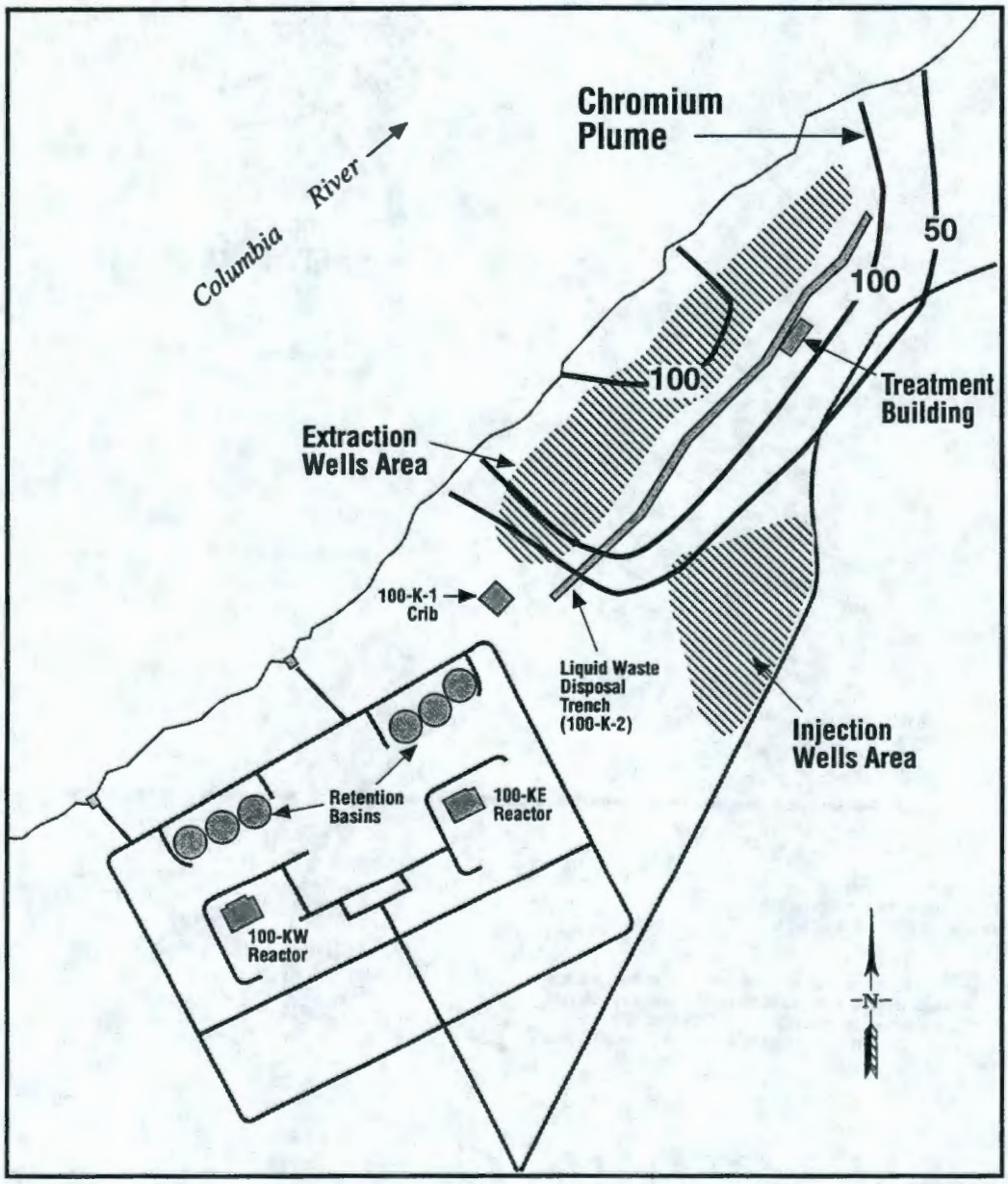


Figure 1-5. 100-K Target Area (DOE-RL 1996).



(DOE-RL 1996)

E9801052.3

2.0 REMEDIAL ACTION OBJECTIVES AND PERFORMANCE CRITERIA

The 100-HR-3 and 100-KR-4 pump-and-treat interim remedial actions were designed to achieve three RAOs described in the interim remedial action ROD (EPA 1996). The three RAOs are:

RAO #1: Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River,

RAO #2: Protection of human health by preventing exposure to contaminants in the groundwater,

RAO #3: Provide information that will lead to the final remedy.

How these RAOs will be met along with other design performance criteria as defined in the ROD are summarized in Table 2-1. In addition to these objectives, the RDR/RAWP (DOE-RL 1996) defines the requirements for the continuation or termination of the pump-and-treat system. These requirements are summarized below:

- The pump-and-treat system will continue until the selected final action has been implemented or,
- It is demonstrated to EPA's and Ecology's satisfaction that termination (or intermittent operation) is appropriate based on:
  - Sampling indicates that chromium is below the compliance value and other site data indicate it will remain below the compliance value,
  - The effectiveness of the treatment technology does not justify further operations,
  - An alternate treatment technique is evaluated and proves to be more effective, less costly, and is consistent with the RAOs.

Table 2-1. Interim Action Design and Performance Criteria Required by the Interim Action Record of Decision.

Requirements	Plan for Meeting Requirements
Remedial Action Objectives	
1. Protection of aquatic receptors.	Extraction and treatment of groundwater to remove chromium.
2. Protection of human health.	Institutional controls, groundwater monitoring, and groundwater use notification.
3. Provide information that will lead to final remedy.	Monitoring and reporting of treatment costs, system efficiency, hydraulic impacts, and effectiveness of contaminant removal. Maintain data in HEIS and project-specific database.
Operational Performance Criteria	
Treatment system will reduce the effluent chromium concentrations of groundwater to the maximum extent practicable. No chromium discharge above 50 μg/L.	Testing to determine the level of treatment technically feasible; monitoring to ensure the 50 μg/L is not exceeded.
Design should provide for flexibility following startup to accommodate changes in plume characteristics, or different understanding of actual or perceived responses of the aquifer/plume to the pump-and-treat system.	Adjustable-frequency drive pumps provide for flexible pumping rates; compliance monitoring wells can be connected to provide additional pumping capability; the treatment system has extra capacity.
The system shall be designed such that if one or several of the wells are down, the rest of the system can continue operating.	Some extraction wells are on separate conveyance laterals allowing for independent operations.
Wastes generated during the remedial action, disposed principally at the Environmental Restoration Disposal Facility, or at other on site or off site facilities as appropriate.	Waste disposal is managed in accordance with the waste management plan.
The extraction and treatment system shall run on an essentially continuous basis so that resin changes and maintenance can be performed with minimal impact to system operations.	The system has been designed to run on an essentially continuous basis.
The system should be winterized so that winter does not cause extended shutdowns.	Exposed piping and tanks are heat traced. Buildings are insulated and heated. High-density polyethylene conveyance piping not susceptible to freeze damage while in operations.
Aquifer Performance Criteria	
Verify system and aquifer effectiveness and efficiency.	Monitor water levels, sample wells and treatment system in accordance with performance monitoring plan.
Establish baseline aquifer conditions 3 to 4 times prior to full-time operations.	Monthly sampling for first three months.
Sampling at multiple depth intervals.	Multilevel sampling in new compliance wells and sampling of existing nested wells.
Sampling conducted when dilution by river water is minimal.	Samples are taken at regular intervals to determine when dilution is minimal.
The analyte list shall include hexavalent chromium, conductivity, and infrequent basis co-contaminants.	Analytes will be measured during the interim action in accordance with the performance monitoring plan.
After treatment, water will be injected into the upper aquifer using injection wells located up gradient of the existing plume.	Monitor water levels and perform capture analysis to verify whether injection water being captured by extraction wells.

3.0 100-HR-3 GROUNDWATER INTERIM ACTION

3.1 Pump-and-Treat Operations

This section describes the design and operation of the 100-HR-3 pump-and-treat system. Presented is an evaluation of the treatment system with respect to the RAOs and performance criteria identified in Table 2-1. The evaluation is based on approximately seven months of performance monitoring data collected during the operation of the 100-HR-3 pump-and-treat system. Data are stored and maintained in the 100-HR-3/100-KR-4 Project-Specific Database.

3.1.1 Facility and Well Design

The pump-and-treat system consists of extraction and injection wells, treatment modules, and the balance of plant equipment. A schematic of the treatment system, extraction wells, and injection wells is included in Figure 3-1 and Figure 3-2. Groundwater is withdrawn from the aquifer at the extraction wells, pumped to the treatment facility where chromium is removed, and then injected into an upgradient portion of the aquifer.

3.1.1.1 Treatment System. The main components of the treatment system are process tanks, pumps, IX treatment skids, and piping and electrical/control systems. Feed pumps pump contaminated water from the influent storage tank, through the IX system and into the effluent storage tank. All extraction wells, except 199-H3-2A, discharge to one of two 34,800-L storage tanks located at the 100-D and 100-H- Area transfer station buildings. Each transfer tank has two transfer pumps that deliver extracted water to a 11,400-L influent storage tank in the treatment facility located at the 1713-H Treatment Building. Well 199-H3-2A discharges directly to the influent storage tank.

The treatment system is sized for a maximum processing rate of 1,515 L/min and to accommodate up to 758 L/min each from the 100-D Area and 100-H Area extraction wells. An IX process is used to remove chromium from extracted groundwater. Four separate IX skids, each with 379 L/min capacity, are housed in the 1713-H Treatment Building. The IX skids are referred to as H-IX-A, H-IX-B, H-IX-C, and H-IX-D, respectively. Each IX skid consists of four IX vessels in a series. The vessels are identified by numbers 1 through 4. The four vessels are connected with piping and valves that allow a combination of three or four vessels to be in service at one time. In the four-vessel IX skid configuration, water passes through a lead vessel, first lag vessel, second lag vessel, and into a polishing vessel before discharge. In the three-vessel IX skid configuration, water passes through a lead vessel, a single lag vessel, and into the polishing vessel before discharge. Each vessel holds 2.3 m^3 of Dowex™ 21K IX resin. At peak system flows, the residence time in each IX vessel is approximately 6 minutes. Currently, only H-IX-A and H-IX-B are online. IX skids H-IX-C and H-IX-D are currently not in use but are available should the pump-and-treat system capacity be increased.

Flowmeters are used to monitor the flow from each extraction well, through each IX skid, and into each injection well. Sample points are available for collecting process samples from each extraction well, the combined influent, each IX vessel, and the combined process effluent from the treatment system (water ready for injection). Adjustable-frequency drive pumps provide adjustable pumping rates and pumping capacity. This fulfills the performance criteria specifying that the system be flexible enough to accommodate changes in plume characteristics.

Exposed components of the system are heat traced and insulated to prevent freezing. The exception to this is the high-density polyethylene (HDPE) pipe used to transport water. HDPE pipe is not subject to damage due to freezing. The IX treatment skids are housed in the heated 1713-H Treatment Building, which protects the treatment system from the elements. This design satisfies the performance criterion requiring the pump-and-treat system to be winterized such that extended system outages due to components broken by freezing do not occur.

The pump-and-treat control system consists of three programmable logic controllers (PLCs) and radio telecommunications equipment to automatically control the well pumps and treatment system. Process control is based on water levels, flowrates, and other process monitoring information that is monitored by the PLCs. The PLCs are located in the 100-D Area Transfer Pump Station, the 100-H Area Transfer Pump Station, and the 1713-H Treatment Building. The PLCs are controlled through an operator interface computer (OIC) located at the 1713-H Treatment Building. The OIC is the man/machine interface between the operators and the pump-and-treat system. Through the OIC, the operators can set the operation parameters for the equipment; monitor the status of all tanks, pumps, and alarms; and review/store historical data on the treatment system operations.

3.1.1.2 Extraction/Injection System. Groundwater extraction systems are installed at both 100-H and 100-D/DR Reactor Areas. Extraction wells include wells 199-D-53, 199-D-54A, 199-H3-2A, 199-H4-7, 199-H4-11, 199-H4-12A and 199-H4-15A. These systems discharge to the common treatment facility at the 100-H Area. All treated groundwater is injected at the 100-H Area. Each extraction/injection well is designed to be operated independently of the others. Each well has its own pump (injection wells excluded), water level transducers, and well head assembly including pressure sensors, heat tracing, and flowmeters. In this way, the performance criterion for continued extraction/injection during well maintenance outages is fulfilled.

100-H Area wells are constructed with DN150 (6-in. diameter) stainless steel well screens and riser casing. Well screens are 4.5-m long with 0.5 mm slot screen. The 100-D Area wells are constructed with approximately 6.1-m long, DN100 (4-in. diameter) stainless steel well screens and casing. Extraction well pump intakes are typically set 2 to 3 m below the top of the water table. Extraction well pumps typically discharge through DN40 (1 ½ in.) pipe that is connected to a pipe expansion that joins it to a DN50 (2 in.) polyvinylchloride (PVC) pipe. The PVC pipe is routed through the

well head assembly before it is coupled with a DN50 (2 in.) HDPE transfer pipe leading to the transfer storage tank. Water from the transfer storage tanks is pumped to the treatment facility through DN100 (4 in.) (from 100-D Area) and DN80 (3 in.) (from 100-H Area) HDPE transfer pipe to the system influent storage tank.

Injection wells include wells 199-H3-3, 199-H3-4, and 199-H3-5. Treated water is discharged from treatment system effluent storage tanks to injection wells via DN100 (4 in.) HDPE transfer pipes. At the injection well head, the HDPE pipe is joined to DN80 (3 in.) PVC pipe via a reducer. The PVC pipe end is perforated at the end, below the water table, to minimize the introduction of air into the aquifer during effluent injection. A schematic of a typical extraction and injection well is provided in Figure 3-3. Details of the well construction are found in the document *Well Summary Report: 100-HR-3 and 100-KR-4 Interim Remedial Action Wells* (BHI 1997c).

Table 3-1 identifies the extraction and injection wells and their extraction/injection rates. Prior to startup of the pump-and-treat system, short-term pumping tests were conducted to determine extraction and injection well capacity. This information is also shown in the table.

3.1.1.3 Operational Monitoring. Water levels, flowrates, pressures, component status (on or off), and other process information is monitored and recorded by the PLCs and OIC. An automatic shutdown is initiated if operational parameters fall outside of normal operating ranges. In this way, the system is protected should a component failure occur. The operational data are recorded by the OIC and automatically downloaded on a daily basis. The data are then exported to the 100-HR-3/100-KR-4 Project-Specific Database, an Access™ database, maintained on the Bechtel Local Area Network (BLAN) in Richland, Washington. In addition to system parameters recorded by the OIC, operators sample process water to monitor hexavalent chromium levels. Process water is analyzed regularly (typically two to three days a week). The data are recorded in site field logbooks and in electronic form by manual entry at the OIC. The data can then be downloaded with other system data. Information downloaded into the database is used to address system performance criteria such as determining system downtime, availability, and efficiency.

3.1.2 Process Sampling and Analysis

Operational samples are collected and analyzed in order to monitor the performance of the pump-and-treat system and assure that it is effectively meeting the requirements of the ROD (EPA 1996). Operational samples are taken from four categories of sources for the pump-and-treat system: extraction wells, combined influent to the treatment system, combined effluent from the treatment system, and samples after each of the IX vessels in use. This section briefly describes the sampling and analysis requirements for the treatment portion of the system (combined influent, treatment system, combined effluent). The results of extraction well sampling are discussed in Section 3.2.2.2.

™ Access is a registered trademark of the Microsoft Corporation, Seattle, Washington.

The specific sample points are identified below:

- Combined influent, sample collection point HP-10
- H-IX-1A vessel #1 effluent, sample collection point SC-1A
- H-IX-2A vessel #2 effluent, sample collection point SC-2A
- H-IX-3A vessel #3 effluent, sample collection point SC-3A
- H-IX-4A vessel #4 effluent, sample collection point SC-4A
- H-IX-1B vessel #1 effluent, sample collection point SC-1B
- H-IX-2B vessel #2 effluent, sample collection point SC-2B
- H-IX-3B vessel #3 effluent, sample collection point SC-3B
- H-IX-4B vessel #4 effluent, sample collection point SC-4B
- Combined effluent, sample collection point HP-14

Water from each sample point is sampled and field analyzed during manned operations to monitor hexavalent chromium levels. Field sample analysis is done using a DR 2000 Chrome Analyzer™ and a modified version of the Hach™ method ("Determination of Hexavalent Chromium in Water and Wastewater by the Hach™ DR/2000 Spectrophotometer at 100-HR-3 Pump-and-Treat", Procedure 3.1, BHI-EE-05, Field Screening Procedures 1.17). The modified Hach™ method is a three-point calibration procedure that provides a detection limit of 5 µg/L. Field screening results are recorded in the 100-HR-3/100-KR-4 Project-Specific Database and are discussed in the sections that follow.

Semi-annually, influent (sample collection point HP-10) and effluent (sample collection point HP-14) are sampled and analyzed off site for hexavalent chromium, conductivity, and co-contaminants (DOE-RL 1996). This satisfies the performance criteria analytical requirements for sampling of the treatment system. Analysis is performed by a state-certified laboratory using EPA approved methods. The chromium analyses provide correlation data for comparison to field analytical methods. Since pump-and-treat operation could effect co-contaminant migration, analysis of co-contaminants is required to determine if co-contaminants are becoming COCs. The co-contaminants could potentially accumulate on used resin at levels that would change the resin waste designation. The co-contaminants that are analyzed are nitrate, Sr-90, Tc-99, tritium, and uranium.

The Hach™ method has been used to reduce operational costs and provide process data to operators in real-time. Semi-annual samples are sent to an independent off site laboratory to assess the performance of the Hach™ method. Currently, the 100-HR-3 project does not have enough data to establish or refute any correlation between the Hach™ method and off site analysis.

™The DR 2000/2010 Chrome Analyzer is a registered trademark of the Hach Company, Loveland, Colorado.

Analysis for co-contaminants has indicated the presence of Tc-99 into extraction well 199-H4-7. Radionuclide co-contaminants have been detected at levels of concern (i.e., co-contaminant levels that effect operations). This issue is discussed further in the sections that follow.

A Bran+Luebbe Monitor 90™ automated chrome analyzer is in the process of being installed and brought on-line at the pump-and-treat system. The analyzer is an in-line calorimetric analyzer designed to measure chrome levels in the process water. The analyzer mixes precise volumes of sample and reagents to produce a colored compound with intensity proportional to the concentration of chrome in the sample. The analyzer's computer automatically corrects for any sample-related drift effects and records the concentration. To avoid any contamination of the following sample, every measurement starts with a rinsing cycle.

At the pump-and-treat system, the chrome analyzer will be connected to 18 sample locations, the process influent, each of the 16 vessels of the IX skids, and the process effluent. The sample tubes between each sample location and the analyzer will be continuously flushed to ensure representative samples at the analyzer. The chrome analyzer's computer will communicate with the treatment system PLC to record the sampling data. The recorded data are downloaded to the process database.

3.1.3 System Operations

This section briefly summarizes system operations. The construction and acceptance testing of the pump-and-treat system was completed in late June 1997. Extraction and processing of groundwater was initiated on July 1, 1997. Figure 3-4 depicts a plot of the operational data, which are monitored by the PLC, and shows the treatment system operation from July 1, 1997 through January 31, 1998. Figure 3-5 depicts a plot of the volume processed and mass of hexavalent chromium removed from July 1, 1997 through January 31, 1998.

3.1.3.1 Extraction Wells. Table 3-2 identifies the extraction and injection wells and major changes in their extraction/injection rates between startup of continuous operations on July 1, 1997 and January 1, 1998. All extraction wells were in service at the start of operations. During this time, flows from wells 199-H4-11, 199-H4-12A, and 199-H4-15 have been gradually increased from 57 L/min (15 gal/min) to 76 L/min (20 gal/min) during operations. On October 16, 1997, well 199-H4-7 was removed from service due to the accumulation of Tc-99 on spent IX resin believed to be caused primarily by contaminated water from the well. The impact of radionuclide accumulation on the IX resin is discussed in detail in the sections that follow.

3.1.3.2 Ion Exchange Skids. Since operations began (July 1, 1997), five IX vessels on H-IX-A and five IX vessels on H-IX-B have undergone resin replacement. Figure 3-6, Figure 3-7, and Table 3-3 graphically present IX vessel operational life cycles and

™ Trademark of BRAN+LUEBBE Gmhb, Norderstedt, Germany

history. The number following the vessel designation represents the batch of resin in the vessel at the time of resin replacement. For example, vessel H-IX-A1-1 is a vessel that has not had resin replaced (first batch), vessel H-IX-A1-2 in the same IX skid, has undergone resin replacement once (second batch). Based on data taken from those vessels reaching at least 67% of saturation (vessel effluent concentration has reached 67% of the influent concentration), the average vessel has the capacity to absorb 1500 g of chromium.

Resin replacement typically occurs when resin in the lead vessel has reached 70% saturation (one IX vessel from each treatment train, usually every 30 days). Typically, columns from both IX skids are realigned within days of one another. As the resin in one vessel becomes exhausted, the IX vessels are realigned to place the lag vessel in the lead position. The exhausted vessel can be taken out of service and the resin removed as a slurry for dewatering outside of the vessel. Exhausted resin is dewatered in a drain box and prepared for final disposal in resin totes. New resin is then slurried into the empty vessel, which is typically placed back into service as the polishing vessel.

On October 22, 1997, IX vessels H-IX-A3-1 and H-IX-B3-1 underwent resin replacement. After being loaded with clean resin, the vessels (H-IX-A3-2 and H-IX-B3-2) were placed back into the lead vessel position where they had been previously aligned. The result of this was accelerated hexavalent chromium loading on vessels H-IX-A3-2 and H-IX-B3-2 (lead vessels). This also resulted in a chemical equilibrium shift in the first and second lag vessels. This equilibrium shift is apparent in the temporary decline in the breakthrough curves for vessels H-IX-A4-1, H-IX-A2-2 (Figure 3-6), H-IX-B4-1, and H-IX-B2-2 (Figure 3-7). Chromium concentrations in the effluent stream were less than detectable due to the fact the polishing vessel was absorbing any hexavalent chromium that bled from the first and second lag vessel during the temporary equilibrium shift. However, this did result in chromium loading of the polishing vessel. On December 29, 1997, treatment system effluent levels started increasing as the polishing vessel approached the breakthrough point. During the days that followed, the system was operated in a three-vessel configuration during resin change out. When the system was returned to a four-vessel configuration, the chromium concentrations in the effluent stream were again less than detectable.

3.1.3.3 Injection Wells. Table 3-2 identifies the extraction and injection wells and major changes in their extraction/injection rates between startup of continuous operations on July 1, 1997 and January 1, 1998. All injection wells were in service at the start of operations and have remained in service for the duration of operations.

3.1.4 System Availability and Performance

This section discusses the treatment system availability, resin performance, and waste management. Information presented is relevant to RAO #2 (effluent less than 50 μg/L) and RAO #3 (final remedy/treatment system effectiveness). Performance criteria concerning continuous operations, system chromium discharge levels, and waste management is discussed. As of January 31, 1998, a total of 164,785,692 liters has been

treated and 14,189 g of hexavalent chromium has been removed from the aquifer. This equates to a yearly production rate of 282,490,000 liters treated and 24,320 g of chromium removed based on the previous 7 months of data (July 1, 1997 – January 31, 1998). This value may increase when well 199-H4-7 is returned to service.

3.1.4.1 Treatment System Availability. The extraction wells, treatment system, and injection wells were operated 24 hours/day, seven days/week, except when taken offline for resin change out, system maintenance, or an automatic shutdown due to operational parameters falling outside of normal operational range. Figure 3-4 depicts a plot of the operational data and indicates when a system shutdown has occurred. Since Figure 3-4 shows the average daily system flow rate, outages that lasted less than 24 hours are characterized by a drop in the average daily system flow rate. The reasons for each system outage are noted in the figure. For the period between July 1, 1997 and January 31, 1998, the availability of the pump-and-treat system is 88.9%. System operating availability is determined from the percentage of time the treatment plant operates divided by the total time available for operation.

Worth noting is the system outage that occurred from August 25, 1997 to September 4, 1997. Pump-and-treat system operations were suspended during this period to identify and repair a grounding problem associated with the PLC communication system. During this time period, some manual operation of the system did occur; however, it was not recorded because the communication system was not powered. It was determined that the PLC communications antennas were not properly grounded. When lightning struck at the Hanford reservation on the early morning of August 25, the communication system was damaged. By September 4, 1997, all antennas were properly grounded and one electrical board of one of the PLCs had been replaced.

On December 30, 1997, influent tank T-H01 overflowed due to the malfunction of solenoid valves on the 100-D Area transfer lines. On the night of December 30, 1997, the feed pumps (PT-D01 and PT-H01) shut down due to high differential pressure across the IX skid in use. This caused transfer storage tanks to fill up, and eventually the 100-D and 100-H transfer pumps were shut down due to high tank level. The 100-D transfer lines have solenoid valves installed that close when the float switch in influent tank T-H01 is tripped due to high water level. Because of the difference in elevation between 100-D and 100-H areas, water from 100-D gravity drains to 100-H unless the solenoid valves close. The solenoid valve did not close completely on December 30, 1997, and influent tank T-H01 overflowed. The plant was subsequently shut down for a day to identify and correct the problems with the malfunctioning solenoid valves. Both solenoid valves were disassembled and pieces of construction debris were found in the valves that likely prevented the valves from closing. The pump-and-treat system was returned to service by the end of the next day.

As previously stated, the system availability has been calculated to be 88.9%. This is high, as the first six months of system operation are considered startup operations. Typically, system availability is lower during initial operations. The outage associated with the grounding problem is unique and very unlikely to reoccur. In addition,

procedures for operating the IX skids in a three-vessel configuration during resin change out have been developed. These new procedures will minimize the system down time associated with resin change outs. It is anticipated that, as operations continue, the system availability will increase. The system runs on essentially a continuous basis and satisfies the performance criteria for continuous operations.

3.1.4.2 Resin Performance. Figure 3-8 depicts the chromium concentration in the influent and effluent streams with the volume processed. The chromium removal efficiency for the treatment system is greater than 95%. Chromium removal efficiency is determined based on the percentage of total chromium removed by the treatment system during the period between July 1, 1997 and January 31, 1998. This efficiency is determined by comparing the treatment system influent and effluent levels (in μg/L) and multiplying by the volume processed (liters) to determine mass removed versus mass processed. The chromium removal efficiency is based on the assumption that non-detectable effluent concentrations are equal to Hach™ DR 2010 Chrome Analyzer™ detection limit (5 μg/L). The actual chromium removal efficiency is higher due to the fact that effluent concentrations below the DR 2010 detection limit were not used to determine removal efficiency. Chromium removal efficiency has not been effected by the variations in chromium concentrations in the influent. Chromium removal efficiency decreased slightly when chromium was detected in the polishing vessel effluent in late December 1997 (refer to discussion in Section 3.1.3.2). Chromium concentrations in the effluent stream are currently being measured by operators using the DR 2010 Chrome Analyzer™ (detection limit of 5 μg/L). A hexavalent chromium concentration of 6 μg/L was measured in the effluent of the polishing vessel just prior to vessel realignment in early January 1998. The realignment was done to place a vessel containing new resin online as a polishing vessel, thus, reestablishing a system chromium concentration that was less than detectable in the effluent stream. Since operations commenced, the reading of 6 μg/L is the highest chromium concentration measured in the effluent stream. The treatment system has chromium concentrations in the effluent stream to below the required 50 μg/L hexavalent chromium concentration (performance criteria).

Waste designation samples of spent resin have indicated the presence of nitrates and Tc-99 in the resin. Nitrate is not considered a COC. Hexavalent chromium is preferentially absorbed by the resin, replacing nitrates from the active sites of the resin. The presence of nitrates in the water does not seem to have an adverse effect on resin performance. Technicium-99 is a concern as it effects the waste designation of the resin. Tc-99 has been measured in the extraction well water and in spent IX resin. This would seem to indicate that the co-contaminant, Tc-99 is also removed from the groundwater by the treatment system. The phenomenon is still under study to determine the impacts it will have on operations. The impact on waste management activities is discussed in Section 3.1.4.3.

3.1.4.3 Waste Management. As of January 31, 1998, 23 m^3 of spent IX resin have been generated and sampled for waste designation. Waste designation sample results are indicated in Table 3-4. Spent resin can only be disposed of at the Hanford Environmental Restoration Disposal Facility (ERDF) if; (1) the waste is treated to meet the federal land

disposal restriction (LDR) standard and (2) an exemption is received for the state LDR standard that prohibits disposal of organic/carbonaceous dangerous waste. The resin exhibits the toxicity characteristic if the toxicity characteristic leaching procedure (TCLP) indicates leachate from the spent resin contains chromium at levels above 5 mg/L (WAC 173-303-090[8][a]). Spent resin from H-IX-B3-2 was found to contain chromium at levels above the 5 mg/L leachate limit. Consequently, resin from H-IX-B3-2 is designated as a hazardous waste and will be transferred to the Hanford Central Waste Complex (CWC) for appropriate management until it can be treated to meet LDR standards.

Analysis for co-contaminants has indicted the presence of Tc-99 in extraction well 199-H4-7. As a result, some of the used resin at the 100-HR-3 pump-and-treat system may be classified as unsuitable for off site regeneration because of trace levels of radionuclides in the resin. Tc-99 levels as high as 2300 pCi/g have been measured in the spent resin. Because of Tc-99 in the resin, regeneration of resin is not possible at this time. Efforts are currently underway to develop appropriate waste designation criteria to determine when spent resin is to be classified as radiologically contaminated verses classified as suitable for off site regeneration.

The performance criteria specify that waste generated (spent resin in particular) is to be disposed of at the appropriate facilities. Contaminated resin having a chromium leachate concentration less than 5 mg/L will be disposed of at ERDF. Radiologically contaminated resin having a chromium leachate concentration equal to or greater than 5 mg/L will be transferred to CWC. In the future, non-radiologically contaminated resin may be regenerated by an off site vendor, pending resolution of radiological contamination issues.

3.1.5 Discussions

Table 3-5 summarizes the performance criteria for the pump-and-treat system. Information downloaded into the database has been used to address system performance criteria such as determining system downtime, availability, and efficiency. RAO #2 specifies human health will be protected by preventing exposure to contaminants in the groundwater. When combined with institutional controls limiting groundwater use, the pump-and-treat system fulfills this RAO by reducing hexavalent chromium levels in treated groundwater to well below 50 μg/L.

RAO #3 specifies that information will be provided that will lead to a final remedy. The full evaluation of the pump-and-treat remedial action with respect to RAO #3 requires an assessment of the chromium removal efficiency, impact to the aquifer, and long-term cost effectiveness. The pump-and-treat system has been shown to be effective at removing hexavalent chromium from extracted groundwater. The evaluation of the pump-and-treat remedial action with respect to the impact to the aquifer and long-term cost effectiveness are presented in the sections that follow.

The operation of the pump-and-treat system on a continuous basis has resulted in the maximum productivity within the given operational constraints (e.g., extraction well production rates). System availability will be increased by procedures for operating the IX skids in a three-vessel configuration during resin change out. This will minimize the system down time associated with resin change outs. However, the vessel change out should be completed within a 24-hour period to ensure that chromium concentrations in the effluent stream are maintained as low as practical. After resin replacement, to maximize the absorption capacity of the resin, vessel realignment should occur sequentially. For example, the first lag vessel replaces the lead vessel, second lag vessel replaces the first, polishing vessel replaces the second lag, a polishing vessel containing new resin is put into service. In this manner, excessive loading of the polishing vessel will be avoided.

Full evaluation of waste designation results requires more data. Data at this point tend to indicate that the mass of chromium absorbed by the IX resin may be related to TCLP leachate concentrations. If the amount of chromium in a vessel can be maintained below 1100 g, the spent resin might not produce a TCLP leachate above the 5 mg/L limit. The spent resin could then be disposed of at ERDF and thus provide cost savings over disposal at CWC. This is discussed in further detail in Section 5.0.

Currently, no correlation between radionuclide concentrations in the spent resin and system operation can be made. Radionuclides are not sampled on routine basis, thus, a mass balance calculation to determine IX resin removal efficiency cannot be done. More data will be required to determine the best means to control radionuclide accumulation in the resin. This evaluation would require testing of the resin under carefully monitored conditions. For field testing, extended operations of the lead IX vessel, coupled with daily sampling of vessel influent and effluent, could provide useful data to determine the effect of trace radionuclides on the treatment system. Operations would have to be maintained so that system parameters such as pressure and flow rate are kept within normal operating range. However, field testing of the IX resin is not highly recommended since significant changes in water chemistry and operational parameters could invalidate the data. Laboratory scale bench testing may be more appropriate as it is more controlled and will yield more reliable data.

3.2 Aquifer Responses At 100-HR-3

Water level, hexavalent and total chromium concentration, and other groundwater chemistry measurements have been made at wells located in both the 100-D and 100-H Areas of the 100-HR-3 OU as part of RCRA, CERCLA, and interim remedial action performance monitoring. Monitoring requirements specific to the interim remedial action are listed in DOE-RL 1996 and DOE-RL 1997. One purpose of the monitoring program is to determine the aquifer response to the pump-and-treat system. In 100-D Area, the automated water level network collects hourly data from two extraction wells, three compliance wells, three performance monitoring wells, and one river station. In 100-H Area, the automated water level network collects hourly data from five extraction wells,

three injection wells, four compliance wells, nine performance monitoring wells, and one river station. In addition, depth-to-water tape measurements were collected monthly during pre-startup and startup from eleven other performance monitoring wells. During regular operations, the tape measurements are collected quarterly.

All water level information used in the hydraulic evaluation was collected by the automated water level monitoring network, the pump-and-treat system transducers with data loggers, or the semi-annual water level measurement program. Figure 3-9 shows the wells included in the evaluation located in 100-D Area, and Figure 3-10 shows the wells located in 100-H Area.

Section 3.2.1 gives details of the measured hydraulic responses. The main points discussed include:

- where the extraction wells provide hydraulic control along the river, and
- where groundwater is captured by the extraction wells.

The 100-HR-3 pump-and-treat facilities are situated near the Columbia River. Evaluating the impact of the treatment system on the aquifer requires distinguishing water level changes caused by the treatment facility from water level changes caused by the river stage. One method to distinguish these changes from one another is to correlate water level data collected from wells impacted by the pump-and-treat system to water level data collected from the river station or wells outside the direct influence of the pump-and-treat system. Offsets in the correlation corresponding to pump startup or shutdown provide a measure of the drawdown or buildup caused by the extraction or injection.

Evaluation of the areal responses of the aquifer to the pump-and-treat systems required minimizing the effects of the river stage fluctuations on the data. The location of extraction wells near the Columbia River results in unsteady capture zones. Because of the abnormally high flows in the Columbia River during the spring and summer of 1997, the average river stage elevation exceeded the average elevation of the water table near the river. Consequently, the capture zones of the near river extraction wells extended primarily upgradient toward the river. During November and December 1997, the river stage was at its lowest sustained elevation (Figure 3-11 and Figure 3-12). Also, during this period, the trends and amplitudes of the river stage remained stable compared to other periods of the year. Capture zones reversed direction and extended primarily upgradient inland from the river. At such times, the greatest annual flow of groundwater typically enters the river. Analyzing the response of the aquifer to the pumping during this period provides the best indication of the system's effectiveness in reducing groundwater discharges into the river.

Groundwater samples are collected and analyzed for contaminants according to the schedule established in DOE-RL 1996 and DOE-RL 1997. Extraction, compliance, and performance monitoring well samples are collected and analyzed for hexavalent chromium concentration quarterly, monthly, and semi-annually. In compliance well

199-D8-70, groundwater samples are collected and analyzed from multiple depths in the aquifer to detect changes in the vertical distribution of the hexavalent chromium concentration. Groundwater samples are collected from the extraction wells semi-annually and the compliance wells annually and analyzed for the identified co-contaminants in each area: Sr-90 and tritium in 100-D Area, and Sr-90, tritium, nitrate, Tc-99, and uranium in the 100-H Area.

Section 3.2.2 gives details of the measured chemical responses to the pump-and-treat system and the methodology used to develop the plume maps shown in Figure 3-21 through Figure 3-24 and Figure 3-38 and Figure 3-39.

3.2.1 Hydraulic Responses

The pump-and-treat system in the 100-HR-3 OU primarily addresses hexavalent chromium contamination in the unconfined aquifer to protect aquatic receptors in the Columbia River substrate. In both 100-D and 100-H Areas, the Ringold Mud Unit forms the base of the unconfined aquifer. In 100-D Area, and especially in the vicinity of the extraction wells, most of the unconfined aquifer is contained within Hanford formation sands and gravel (BHI 1996b). Point dilution tracer testing confirmed the presence of greatly differing high and low conductivity zones at individual wells, most likely occurring because of sand and silt interbeds within the Hanford formation. However, the data were not sufficiently conclusive to map the zones areally from well to well. Results of aquifer testing and Ferris analysis indicate that the transmissivity around the two extraction wells ranges between 1,000 and 4,000 m^2/d, with the resulting hydraulic conductivity ranging between 200 and 800 m/d.

In 100-H Area, the unconfined aquifer is also mostly contained within Hanford formation sands and gravel situated above the Ringold Mud Unit (BHI 1996b). In general, the contact between the Ringold and Hanford formations slopes from west to east, but a narrow subsurface or ridge-like feature in the Ringold Formation exists in the eastern part of 100-H Area (DOE-RL 1996). The ridge is oriented approximately parallel to the river and the three near river extraction wells in 100-H are located between the ridge and the river. The other two extraction wells are located farther inland on the other side of the ridge. Ferris analysis on data collected from the line of wells including extraction wells 199-H4-12A, 199-H4-7, and 199-H3-2A indicated that the transmissivity was 122 m^2/d (DOE-RL 1996).

3.2.1.1 Extraction/Injection Wells. Water level measurements were recorded hourly in the extraction and injection wells. Figure 3-11 through Figure 3-13 shows the hydrographs for the 100-D and 100-H Area extraction wells and the 100-H Area injection wells, respectively. Table 3-6 presents drawdown, buildup and pumping rate information collected during periods of typical operation of the pump-and-treat system and illustrates the overall performance of the well field. The two 100-D Area extraction wells maintained flow rates between 137 and 140 L/min, with about 0.21 m of drawdown occurring in well 199-D8-53 and about 0.23 m of drawdown occurring in well 199-D8-54A. Drawdown in these wells was calculated based on the correlation of the

water level data collected in these wells to the river stage (Figure 3-14). The near river extraction wells in 100-H Area maintained flow rates between 73 and 76 L/min, with drawdown measuring 0.36 – 0.38 m in well 199-H4-11, 0.73 – 0.78 m in well 199-H4-12A, and 0.28 – 0.29 m in well 199-H4-15A (water level in the wells correlated to the river stage, Figure 3-15). At well 199-H4-7, pumping ceased in October 1997 so only one set of pumping and drawdown data is presented in Table 3-6. While pumping occurred at well 199-H4-7, the well maintained a flow rate of 103 L/min with drawdown measuring 0.68 m. At well 199-H3-2A, pumping occurred at two different flow rates, 151 and 76 L/min, with drawdown measuring 0.010 and 0.057 m, respectively (Figure 3-16).

Very little buildup occurs in the 100-H Area injection wells. Water turbulence and unsteady injection rates in the wells introduced scatter into the water level data that makes calculating buildup difficult. Buildup was calculated using water level data collected from well 199-H4-49 as a baseline and assuming that complete recovery occurred during two periods when the injection system was not operating. Prior to the shutdown on November 4, 1997, water was being injected into wells 199-H3-3, 199-H3-4, and 199-H3-5 at rates of 177, 170, and 207 L/min, respectively. Buildup in the three wells measured 0.08 m, 0.05 m, and 0.07 m, respectively (Figure 3-17). Prior to the shutdown occurring on November 29, 1997, water was being injected into wells 199-H3-3, 199-H3-4, and 199-H3-5 at rates of 178, 171, and 205 L/min, respectively. Buildup in the three wells then measured 0.08 m, 0.10 m, and 0.05 m, respectively.

3.2.1.2 Observation Wells. Observation well hydrograph data show the effect of the pump-and-treat system on the aquifer at specific locations away from the extraction and injection wells. Drawdown in these wells was determined by correlating the water level measured in these wells to water level data collected from the river stations or wells outside the direct influence of the pump-and-treat extraction and injection. In most cases, discernable effects of the pump-and-treat operations were limited to observation wells located closest to the extraction and injection wells.

At 100-D Area, effects of the pump-and-treat system away from the extraction wells were difficult to detect at the observation wells; however, the data do indicate that measurable drawdown occurs at well 199-D8-71. Well 199-D8-71 is located between the two extraction wells, 60 m from well 199-D8-54A and 57 m from well 199-D8-53. When both extraction wells operated, drawdown measured 0.01 – 0.03 m at well 199-D8-71 (Figure 3-18). Drawdown data collected in other monitoring wells (199-D8-68, 199-D8-69, and 199-D8-70) were inconclusive and unquantifiable, although the data suggest that drawdown may be occurring at those wells (Figure 3-18). The regression line analysis used to analyze the data showed an offset between the data collected during pumping and during outages, but overlap in the data greatly exceeded the offset. Effects of the pump-and-treat system were not detected in well 199-D8-54B, which is located closest to well 199-D8-54A and screened below the mud unit at 100-D Area.

Drawdown resulting from operation of the near river extraction wells 199-H4-12A and 199-H4-15A was detected in the B wells of those clusters. The B wells are screened

deeper in the aquifer than the A wells, but they are screened in the same unconfined aquifer. At 199-H4-15B, which is located 8 m from well 199-H4-15A, drawdown measured 0.06 m. At 199-H4-12B, which is located 8 m from well 199-H4-12A, drawdown averaged 0.05 m. No apparent drawdown was detected in the C wells of the 199-H4-12 and 199-H4-15 well clusters, which are screened below the Ringold Mud Unit. No apparent drawdown was observed in the monitoring wells located nearest to well 199-H4-11.

Drawdown was also detected in the monitoring wells located near the extraction wells and injection wells located farther inland. At well 199-H4-8, which is located 64 m away from extraction well 199-H4-7, drawdown during operations measured 0.02 m. At the 199-H3-2 well cluster, when pumping occurred at 151 L/min, drawdown in well 199-H3-2B measured 0.072 m (Figure 3-20). When pumping occurred at 76 L/min, drawdown in well 199-H3-2B measured 0.045 m. No apparent drawdown was detected in well 199-H3-2C because it is screened below the Ringold Mud Unit. At well 199-H5-1A, which is located about 200 m from the injection well field, buildup measured 0.02 m (Figure 3-20).

3.2.1.3 100-HR-3 Areal Hydraulic Responses. The water table maps presented in Figure 3-21 through Figure 3-24 were developed based on water level data collected in December 1997 while the 100-HR-3 pump-and-treat system was operating (Table 3-6). The analysis included data collected by the automated water level monitoring network and the semi-annual water level measurement program. Water level contours were determined by assuming linear hydraulic gradients existed between the operations and monitoring wells. Hydraulic head data were then interpolated along the triangular mesh constructed from the well coordinates. To compensate for the sparse and irregular spacing of the wells, drawdown and buildup resulting from extraction and injection was determined using the Theim steady state drawdown/buildup equation (see Appendix B). Using the Theim equation to superimpose the drawdown and buildup around the extraction and injection wells prevented the linear interpolation scheme from grossly exaggerating the radial extent of the localized drawdown and buildup.

Streamtraces identify the direction of groundwater flow in the aquifer, the corresponding capture zones, and the areas of hydraulic containment resulting from operation of the pump-and-treat system. Generating the hydraulic velocity fields required interpolating the irregular finite element mesh onto a rectangular finite difference grid and calculating the hydraulic head gradient between adjacent grid points (see Appendix B). The hydraulic head gradient combined with the aquifer hydraulic conductivity (determined from the transmissivity) and specific yield (assumed to equal 0.15) determines the hydraulic velocity field.

The transmissivity distribution used in the 100-H Area capture analysis was based on data presented in DOE-RL 1996 and updated to include data collected during operations; the transmissivity distribution used in the 100-D Area model was updated to include more recent aquifer test and analysis results. The capture zone illustrates the area from which the extraction wells remove groundwater, thus defining the area of the aquifer

from which the extraction wells draw water for treatment. The streamtrace plots illustrate the lateral extent to which the pumping wells intercept flow headed toward the river, thus defining the length and continuity of the hydraulic barrier created by pumping in the extraction wells. Current plume contours are included in Figure 3-21 through Figure 3-24 to orient the hydraulic impacts of the pump-and-treat system to the chromium plume. Development of the plume contours shown on the figures is discussed in Section 3.2.2.6 and Section 3.2.2.7

The capture area formed by extraction wells 199-D8-53 and 199-D8-54A extends almost directly southward toward the high chromium concentrations detected at wells 199-D5-14 and 199-D5-15 (Figure 3-21). Because of the very high transmissivity, and consequently high groundwater velocity of the 100-D Area aquifer near the river, the capture zones of the extraction wells extend predominantly upgradient rather than laterally. The capture zone around well 199-D8-54A appears to intersect the river shore, indicating that pumping in that well does induce some river recharge. The combined width of the capture zones around the two wells is about 400 m. Pumping in the two extraction wells contains groundwater along the river shore near compliance wells 199-D8-68 and 199-D8-69, and inland toward compliance well 199-D8-70. The curve of the hydraulic containment line results in the hydraulic control occurring along the river shore extending for about 400 m (Figure 3-22).

Figure 3-23 illustrates the hydraulic capture occurring in 100-H Area. Figure 3-24 shows that the pump-and-treat system succeeds in providing an almost continuous line of capture (or hydraulic control occurs) between wells 199-H4-15A and 199-H4-12A. The capture occurring around well 199-H4-11 appears to be isolated from the capture of the other extraction wells and groundwater flow may pass between wells 199-H4-12A and 199-H4-11 to the river. However, because of the injection occurring in wells 199-H3-3, 199-H3-4, and 199-H3-5 and the extraction occurring in well 199-H3-2A, the area between wells 199-H4-11 and 199-H4-12A is hydraulically isolated from the groundwater containing concentrations of chromium over 22 μg/L. Groundwater discharging into the river between wells 199-H4-11 and 199-H4-12A originates either from an area where baseline concentrations were below the compliance level of 22 μg/L in the groundwater, or from the treated water injected in the injection wells.

3.2.2 Hydrochemical Responses

This section summarizes and interprets analytical results taken from groundwater wells included in the interim remedial action monitoring program supporting the 100-HR-3 OU pump-and-treat system. The ROD (EPA 1996) requires the hydrochemical responses in the aquifer to be monitored from pre-system startup (October 1996) through the operating stage. The hydrochemical response data will be used to evaluate the performance of the interim remedial action to meet the remedial action goals as stated in Section 2.0.

Before discussing the hydrochemical responses, it should be noted that two chemical species of chromium (trivalent and hexavalent) are found in the environment. The trivalent species is immobile and is associated with soil particles. The hexavalent species

is mobile and travels with the groundwater. However, because hexavalent chromium can be easily reduced to trivalent chromium, the holding time for hexavalent chromium in a groundwater sample is short (24 hours) and analysis for hexavalent chromium should be done very quickly after taking the sample. Field screening groundwater samples for hexavalent chromium easily accomplishes through the use of a Hach™ Kit.

For groundwater samples sent to the laboratory, it is often not possible to meet the short holding time for hexavalent chromium and the sample is analyzed for total chromium instead of hexavalent chromium with the assumption that total chromium will be the only chromium species present because of its mobility. This assumption is correct for filtered samples, but not necessarily correct for unfiltered samples because some trivalent chromium may be adsorbed onto silt particles present in an unfiltered sample. The remedial action monitoring program requires the samples taken for total chromium to be filtered. However, other monitoring programs on site may not have this requirement. In this section no distinction is made between hexavalent chromium and total chromium. Both are referred to as chromium.

Hydrochemical responses were determined by examining trends in water level, chromium, and specific conductance data; and by comparison of current chromium distribution to the baseline distribution of chromium contamination. The effects of the interim remedial action as well as the effects of the unusually high Columbia River water levels on the chemistry of the aquifer are examined in this section.

3.2.2.1 Baseline Chromium Contaminant Distribution. The baseline time period extends from October 1996 until just prior to system startup. The baseline contaminant distribution maps presented in this section are the maps given in the RDR/RAWP (DOE-RL 1996). Significant changes in the contaminant distribution that occurred prior to the startup of the pump-and-treat system are discussed in the text. A brief description of the baseline contaminant distribution from the RDR/RAWP is given here. For a more complete description, please see the following documents:

- *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Operable Units' Interim Action* (DOE-RL 1996),

- *Conceptual Site Models for Groundwater Contamination at the 100-BC-5, 100-KR-4, 100-HR-3, and 100 FR-3 Operable Units* (BHI 1996b).

3.2.2.1.1 100-D Area. The baseline chromium contamination for 100-D Area of the 100-HR-3 OU interim remedial action is given in Figure 3-25. The chromium contamination consisted of a known plume that was centered to the northeast of the 100-D Reactor Building and extended northward past the retention basins. The highest chromium was found at wells 199-D5-14 and 199-D5-15, with both of these wells having an average chromium value greater than 1300 μg/L (DOE-RL 1997). Wells 199-D8-53 and 199-D8-54A, located north of the retention basins, down gradient and closer to the Columbia River, had chromium concentrations in groundwater exceeding 300 μg/L. The location for the 50 and 100 μg/L isopleths is not well known due to the lack of well

control north and east of well 199-D8-53. Sampling of 100-D Area Columbia River substrate pore water close to wells 199-D8-53 and 199-D8-54A suggested that chromium at concentrations greater than 11 μg/L was being released to the Columbia River (BHI 1996a) from the groundwater. Additionally, substrate pore water sampling results indicated another chromium plume might exist, located upgradient from the original chromium plume. The existence of the upgradient plume was confirmed in 1997 (BHI 1996a, BHI 1997b).

In the spring of 1997, and still prior to the startup of the pump-and-treat system, the chromium distributions were evaluated using more recently collected data. The following changes since the baseline plume was generated are noted here. For the 100-D Area, the overall chromium concentration in the groundwater was lower. A comparison between the original baseline and chromium concentrations measured in the groundwater prior to startup shows chromium dropping from 1385 to 727 μg/L at well 199-D5-14, from 420 to 120 μg/L at well 199-D4-54A, and from 330 to 126 μg/L at well 199-D8-53. Additionally, chromium trends in wells 199-D5-13, 199-D8-4, and 199-D8-6 are rising. The rise in chromium concentrations in these wells is related to the cessation of filter backwash water from the 183-D Water Treatment Plant to D-Ponds, which was apparently diluting the chromium concentration in the groundwater near D-Ponds.

3.2.2.1.2 100-H Area. The baseline chromium contamination for 100-H Area of the 100-HR-3 OU interim remedial action is given in Figure 3-26. Here, the chromium distribution is centered about the former 183-H Solar Evaporation Basins and the 107-H Retention Basins. Chromium concentrations ranging from 50 to 100 μg/L were measured in wells in the vicinity of these facilities. Additionally, wells located in the western part of the area (wells 199-H3-2A and 199-H5-1A) along with wells located west of the area (wells 699-96-43 and 699-97-43) indicate that chromium-contaminated groundwater is moving eastward from the 100-D Area to the Columbia River by 100-H Area. Evaluation of the more recently collected chromium data prior to the startup of the interim action indicates the chromium plume in the 100-H Area is displaced to the south.

3.2.2.2 Sampling and Analysis. Details of the sampling and analysis for hydrochemical responses are given in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE-RL 1997). The monitoring plan includes the following three elements and their corresponding objectives:

1. **Compliance Monitoring.** The objective of compliance monitoring is to perform the appropriate sampling, analysis, and data evaluation to show whether the requirements of the interim action ROD are met.

2. **Performance Monitoring**. The objective of performance monitoring is to obtain water level and water quality data necessary to optimize the performance of the groundwater extraction system and to document chromium plume response to pumping and injection, and to obtain supplemental data to support the final remedy selection.

3. **Operational Monitoring.** The objective of operational monitoring is to conduct appropriate sampling and analysis necessary for safe operation of the groundwater extraction, treatment, and injection system and to ensure that effluent with a chromium concentration above 50 μg/L is not discharged.

Table 3-7, taken from the monitoring plan, lists the monitoring wells and the minimum requirements for sample frequency and analyses. Well locations and type of well (injection, extraction, performance monitoring, and compliance monitoring) are given in Figure 3-27 for the 100-D Area (a) and the 100-H Area (b). All chromium analytical results from the monitoring program are available through 100-HR-3/100-KR-4 Pump-and-treat Project-Specific Database and HEIS. In addition to the sampling schedule, the extraction wells (Table 3-7) for the 100-HR-3 OU were monitored on a weekly basis for hexavalent chromium (field screening analysis) by the operators of the pump-and-treat system. Groundwater samples were also analyzed for co-contaminants (off site analysis). At the 100-D Area, the co-contaminants are Sr-90 and tritium. In the 100-H Area, the co-contaminants are nitrate, Sr-90, Tc-99, tritium, and uranium. At each sampling event, the field parameters (pH, specific conductance, temperature, and turbidity) are also measured.

3.2.2.3 Hydrochemical Responses in Extraction Wells. There are two extraction wells (Table 3-7) in the 100-D Area and five extraction wells in the 100-H Area. The data evaluated in the section are based on review of trend plots of chromium in each well. During the evaluation, analytical outliers were removed from the data evaluated. The chemical trend plots given in this section were subjected to this review process.

3.2.2.3.1 100-D Area. The upper left and right trend plots on Figure 3-28 gives the chromium sampling results for the injection wells, 199-D8-53 and 199-D8-54A, respectively. In addition to the chromium, trends for specific conductance in nearby compliance wells (wells 199-D8-68 and 199-D8-70) and the average weekly water levels (calculated from the hourly water level measurement taken from nearby compliance wells) are also given. At the start of the interim action in the 100-D Area, it appeared that the chromium levels in the aquifer were already below the remedial action goal of 22 μg/L. However, since the start of the interim action, the chromium levels in both of these wells have trended upward. Groundwater samples from well 199-D8-53 had a low chromium measurement of 11 μg/L in late June 1997 and a high measurement of 288 μg/L in early January 1998. Groundwater samples from well 199-D8-54A had a low chromium measurement of 19 μg/L in mid July 1997 and a high measurement of 269 μg/L in mid December 1997.

The rise in the chromium level in the aquifer can be directly attributed to the abnormal water year that occurred in 1997. The snow pack in the mountains in 1997 was unusually high. The snow melt that took place in late spring and early summer caused the Columbia River's water level to reach a fifty-year high. This caused river water to flow into the aquifer. This influx of river water elevated the water table, and displaced the chromium in the aquifer inland at the time of the startup of the interim remedial action. There is also a dilution effect seen at the interface between river water and groundwater

where contaminants in the groundwater mix with river water moving into the aquifer and thereby diluting the contaminant levels. The dilution and displacement effect can be seen in these trend plots by examining sampling results for specific conductance. Groundwater has a higher specific conductance than river water. As river level rises, river water moves into the unconfined aquifer. The low-specific conductance river water mixes with and dilutes the higher specific conductance groundwater. This causes the specific conductance measured at the compliance wells to drop. Additionally, another reason for the drop and rise of chromium levels is the groundwater gradients are reversed during times of high water on the Columbia River. This reversal of gradients causes the chromium plume to be displaced inward away from the near river wells. As the Columbia River drops, the groundwater gradient returns to the more normal condition of groundwater flowing toward the river and the chromium levels in the monitoring wells rise as the chromium plume returns to pre-flood conditions.

3.2.2.3.2 100-H Area. Trend plots for chromium at the extraction wells at 100-H Area are given on Figure 3-28 (wells 199-H3-2A and 199-H4-7) and Figure 3-29 (wells 199-H4-11, 199-H4-12A, and 199-H4-15A). Specific conductance and average water table elevations from nearby compliance wells are superimposed on these trend plots. In the near river extraction wells 199-H4-11, 199-H4-12A, and 199-H4-15A, the same pattern observed for the 100-D Area extraction wells emerges. Again, just prior to the startup of the interim remedial action, the measured levels of chromium were below the remedial action goal of 22 μg/L with the chromium values rising to approximately the same values observed during the pre-startup phase (October 1996) as the water table drops.

At extraction wells 199-H3-2A and 199-H4-7, located further inland of the river, the chromium concentrations also trend upward after the start of the interim remedial action. However, at the most inland extraction well (199-H3-2A), the measured chromium reaches a peak of 91 μg/L in late August, followed by a steady downward trend to 37 μg/L by early January 1998. This is the only extraction well in the 100-HR-3 OU that shows a downward chromium trend by January 1998. The decline in chromium levels at well 199-H3-2A may be the result of the interim remedial action. However, at this time, a determination cannot be made whether the downward trend at this well is due to the interim remedial action or to the stress placed on the aquifer by the unusual water year. Extraction well 199-H4-7 may have the same trend as well 199-H3-2A, but was turned off as an extraction well in October because of the possibility that Tc-99 found in groundwater at this well was contaminating the treatment resin.

3.2.2.4 Hydrochemical Responses in Compliance Monitoring Wells. There are seven compliance wells (Table 3-7), three in the 100-D Area and four in the 100-H Area. The trend plots for chromium, specific conductance, and water levels for 100-D Area and 100-H Area compliance monitoring wells are given in Figure 3-30 and Figure 3-31, respectively.

3.2.2.4.1 100-D Area. The compliance monitoring wells were sampled more frequently than the extraction wells prior to the startup of the interim remedial action. With the

increase in the number of samples, the inverse correlation between water levels and the measured chromium and specific conductivity in the 100-D Area compliance wells is clearly evident in these trend plots. As the water level rose in late spring and early summer, the measured chromium and specific conductance levels dropped. By December 1997, the water levels in the compliance monitoring wells had dropped; returning to levels observed prior to late spring-early summer flooding of the Columbia River. As the water levels dropped, the chromium and specific conductance levels at compliance wells 199-D8-68 and 199-D8-70 returned to concentration levels observed prior to the high water. However, at compliance well 199-D8-69 for the same time period, the chromium levels have not returned to concentration levels observed prior to the high water and start up of operations. This could possibly indicate the pump-and-treat operation is reducing chromium levels in the aquifer, but more data are necessary to be certain. In January 1998, measured chromium values in all of the 100-D Area compliance monitoring wells were above the remedial action goal of 22 μg/L. Given the rapid change in conditions caused by the high Columbia River stage, this is not unexpected.

In addition to monitoring chromium levels at the water table, different depths in the aquifer were monitored for chromium using a discrete interval sampler at the compliance well 199-D8-70. Chromium levels in the groundwater were measured at 15.25 m, 16.46 m, and 18.90 m below ground surface. The deepest sample was 3.65 m below the top sample. The water level at the startup was approximately 13.4 m below ground surface, but by December 1997, it was 15 m below ground surface. At the start of operations in June and July, the chromium levels were approximately the same throughout the depths sampled. However, from September through November, a trend emerges in which the deepest sample is approximately 30 μg/L higher in chromium than the shallower samples. For this time period, the deep sample probably reflects the true chromium concentrations in the aquifer. The lower chromium concentration observed in the shallower samples is most likely due to dilution as the high water caused by the flooding drains from the vadose zone directly above the water table. As the aquifer returns to more normal conditions, the difference in chromium concentrations between the deep sample and the shallow samples should become smaller. This observation is reflected in the December round of sampling. In December, the difference between the chromium levels from samples taken at depth and the shallow samples had dropped from 30 μg/L (taken in November) to 7 μg/L (taken in December). The vertical profile for specific conductance was also examined. However, no vertical trends for specific conductance emerged from the data evaluation.

3.2.2.4.2 100-H Area. As with the 100-D Area, a strong inverse correlation exists between the water level and the chromium concentration in the 100-H Area compliance wells. The chromium levels drop as the water level rises and then rise as the water level drops. Well 199-H4-4 also shows this inverse correlation with the specific conductance, but the other compliance wells do not. It should be noted that the specific conductance of the groundwater downgradient of the former 183-H Solar Evaporation Basins is high relative to other groundwater because the major component of wastes placed in the basins was nitric acid neutralized by sodium hydroxide. In January 1998, the chromium levels

measured in each of the compliance wells were above the remedial action goal of 22 μg/L.

3.2.2.5 Hydrochemical Responses in Performance Wells. There are twenty-one performance monitoring wells (Table 3-7) in the 100-HR-3 OU (3 at 100-D Area and 18 at 100-H Area). These wells are sampled semi-annually and not enough chemical data have been collected to clearly discern a trend for chromium over time.

3.2.2.5.1 100-D Area. Figure 3-32 plots the chromium, specific conductance, and average weekly water level for the 100-D Area performance monitoring wells. All of the performance monitoring wells at the 100-D Area show a decline in chromium from October 1996 to July 1997, and then a rise in chromium from July 1997 to the end of the year. This pattern is typical to trends shown for the compliance monitoring and extraction wells. For performance monitoring wells in the unconfined aquifer (199-D8-3 and 199-D8-71), the last sample taken from the 100-D Area had measured chromium values above the remedial action goal of 22 μg/L. The performance monitoring well completed in the underlying confined aquifer (199-D8-54B) has never shown filtered chromium values above the remedial action goal of 22 μg/L.

3.2.2.5.2 100-H Area. Figure 3-33 through Figure 3-35 plot the chromium, specific conductance, and average weekly water level (when available) for the performance monitoring wells. All of these wells, with the exception of wells 199-H4-14, 199-H4-16, 199-H4-46, 199-H4-48, 199-H4-49, and 199-H5-1A, show a decline in chromium from October 1996 to July 1997 and then a rise in chromium from July 1997 to the end of the year. This pattern is typical to trends shown for the compliance monitoring and extraction wells.

For the wells that showed an exception to the typical trend, wells 199-H4-14, 199-H4-16, and 199-H4-46 showed an increasing trend from October 1996 to July 1997 and had not been sampled by the end of the year. Well 199-H4-48 had measured chromium levels that remain constant from October 1996 to July 1997 and then drop sharply in October 1997. Wells 199-H4-49, and 199-H5-1A have shown a drop in measured chromium levels October 1996 to November 1997. These wells probably show different trends than the other performance monitoring wells because they are further inland from the river.

3.2.2.6 Changes in Chromium Distribution 100-D Area. Figure 3-38 gives the 100-D Area chromium distribution for the last quarter of 1997 (compare to baseline chromium distribution given in Figure 3-25). The chromium values used to make this map are given in Table 3-8. Past sampling events from wells not included in the monitoring program were also used in creating this plume map. The following values used for contour were selected by taking the most recent filtered value. If there was more than one sample from the well, the highest value was chosen. If a filtered sample was not available, a non-filtered sample was used.

The following summarizes the differences between the plume distribution given here and the baseline plume distribution:

1. Well 199-D8-69 forces the 100 μg/L contour line to the west to intersect the Columbia River. In the baseline plume distribution the contour line extends to the north and does not intersect the river close to the 100-D Area.

2. Chromium concentrations have dropped significantly at wells 199-D5-20, 199-D5-14 and 199-D5-15. However, data evaluated before the interim remedial action started show this drop occurred before the high water during the summer.

3. Chromium concentrations have gone up in wells 199-D5-13, 199-D8-4, and 199-D8-6. The rise in chromium concentrations in these wells is probably related to the cessation of filter backwash water from the 183-D Water Treatment Plant to D-Ponds, which was apparently diluting the chromium concentration in the groundwater near D-Ponds.

4. The chromium distribution to the east and northeast is speculative because of the lack of data in that area. The contour lines shown are dashed to represent that uncertainty. However, 600 Area wells (699-96-43 and 699-97-43), closer to the 100-H Area, indicate chromium there could be coming from the 100-D Area. This is also consistent with known groundwater flow patterns between these two areas.

5. The chromium plume west of the 100-D/DR Reactor is better defined due to the new wells and sampling that has taken place in that area (BHI 1997b).

The comparison between the baseline chromium distribution (Figure 3-25) and the chromium distribution given in Figure 3-38 does show that hydrochemical changes have taken place in the aquifer since the startup of the interim action. However, it appears that these changes cannot be attributed to the interim action, but are more likely due to naturally occurring events such as the high water in the Columbia River.

3.2.2.7 Changes in Chromium Distribution 100-H Area. Figure 3-39 gives the 100-H Area chromium distribution for the last quarter of 1997 (compare to baseline chromium distribution given in Figure 3-26). Past sampling events from wells not included in the monitoring program were also used in creating this plume map. The sampling dates and the chromium values used to make this map are given in Table 3-9. The criteria used to select the values used in making the 100-H Area chromium contour map are the same as used for the 100-D Area.

The following summarizes the differences between the most recent chromium plume distribution described here (Figure 3-39) and the baseline plume distribution (Figure 3-26):

1. The general shape and area between the map given in Figure 3-39 and the baseline plume map are approximately the same.

2. Chromium concentrations have almost doubled in wells 199-H4-3, 199-H4-8, 199-H4-9, 199-H4-14, and 199-H4-18.

3. Chromium concentration in well 699-97-43 has dropped significantly. This causes the 100 μg/L contour line extending back toward the 100-D Area to move to the south.

4. Chromium concentrations have dropped at extraction well 199-H3-2A. The drop in concentration at this well could be due to a number of hypotheses: (1) the interim remedial action has affected the chromium concentrations, (2) displacement of the plume due to the changes in the water table brought on by high water, and (3) injection wells upgradient are affecting the concentrations at this well.

The comparison between the most recent chromium map and the baseline does indicate that hydrochemical changes have taken place in the aquifer since the startup of the interim remedial action. The rise in chromium values at the compliance wells is probably due to the displacement and movement of the plume during the high water event on the Columbia River and subsequent return to more normal water levels later in the year. At the present time it is not possible to separate the hydrochemical responses from the effects of the high water and the pump-and-treat system.

3.2.2.8 Co-Contaminants. In the 100-D Area, the only co-contaminants monitored were Sr-90 and tritium. Of these co-contaminants, only Sr-90 was found above the maximum contaminant level (MCL) of 8 pCi/L at well 199-D8-68. Two samples from well 199-D8-68 have been analyzed for Sr-90. The other sample taken at well 199-D8-68 was below the MCL. All other wells in the 100-D Area were below the MCL for both Sr-90 and tritium. In the 100-H Area, groundwater was monitored for the following co-contaminants: nitrate, Sr-90, Tc-99, tritium, and uranium. Table 3-10 lists maximum values for nitrate, Sr-90, Tc-99, and uranium for all the wells containing these co-contaminants above the MCL or the Hanford Standard since the start of the interim action monitoring program. Trend plots for these wells are given in Appendix A. Tritium was not above the MCL in any of the 100-H Area wells and is not included in this table. In October, extraction well 199-H4-7 was taken offline because it was suspected that Tc-99 from this well was contaminating the treatment resin. At the present time, the trend plots show there is insufficient data to predict Tc-99 behavior in the aquifer. The most likely source for Tc-99 was waste leaking from the former 183-H Solar Evaporation Basins as there are no other suspected sources in the 100-H Area.

3.2.2.9 Quality Assurance/Quality Control. Field replicates, field/off site laboratory splits, off site laboratory replicates, and off site laboratory splits are quality control samples collected to assess the precision of chemical analyses. The quality control sample analyses are presented by well and sample numbers in Table 3-11 and Table 3-12. Some results were not available because data had not yet been entered into HEIS. These data are identified on the tables as "NA".

Establishing precision of samples analyzed by field screening consisted of comparing analyses of field replicates and field/off site laboratory splits. The range of variability of an analyte was determined by dividing one of a pair of replicate concentrations into the other. Variability in chromium concentrations in the field was 4%, based on replicate data. Variability of field/off site laboratory chromium concentrations was about 17%.

The precision of off site laboratory replicates was established by comparing analyses of two samples collected from the same location collected on the same day and sent to the same laboratory. The maximum variability of total Sr-90 concentrations based on off site laboratory replicates was approximately 26%. The variability of off site laboratory splits could not be determined because most off site results are not yet available.

The matrix spike (MS) and matrix spike duplicate (MSD) were used to establish the accuracy of chromium analyses for field screening. The spike concentrations were set at 25 μg/L, and the analyses of the MS/MSD samples resulted in 16 and 17 μg/L of chromium, respectively. These values correspond to an accuracy of 64% for the MS and 68% for the MSD.

3.2.3 Discussions

3.2.3.1 100-HR-3 Hydraulic Containment. The two extraction wells located in 100-D Area are aligned almost parallel to the river shore. The flow divide and the change in the river course at 100-D Area result in the two extraction wells being aligned more parallel to the prevailing groundwater hydraulic gradient than perpendicular to it. Pumping in well 199-D8-54A appears to induce some river recharge and extract groundwater from the vicinity of well 199-D8-68. However, most of the groundwater entering the well appears to originate from the upgradient area of the aquifer parallel to the river and from almost due south of the well (Figure 3-21). The capture zone appears to encompass the entire area between those two lines. Because of the hydraulic interference caused by pumping in well 199-D8-54A, pumping in well 199-D8-53 also appears to induce some river recharge from along the shoreline in the vicinity of well 199-D8-68. However, pumping does not appear to extract water from as far north as either compliance well 199-D8-69 or 199-D8-70. Most of the water extracted from well 199-D8-53 appears to originate from the upgradient area of the aquifer located south of the well. Combined pumping in the two wells provides a continuous area of hydraulic capture that extends laterally about 400 m from well 199-D8-53, westward to the river shore, and indefinitely southward toward wells 199-D5-14, 199-D5-15, and 199-D5-16.

Pumping in the two extraction wells results in the line of hydraulic containment existing along the river shore near compliance wells 199-D8-68 and 199-D8-69, and then curving inland toward compliance well 199-D8-70 (Figure 3-22). The curve in the hydraulic containment line results from the two extraction wells being aligned somewhat parallel to the prevailing groundwater hydraulic gradient. In general, groundwater between the river and the extraction wells is prevented from discharging into the river while the pumps operate. Pumping in the extraction wells hydraulically isolates the groundwater in this area from the high concentration area of the plume identified around wells 199-D5-14, 199-D5-15, and 199-D5-16.

At 100-H Area, three of the extraction wells are located near the river, but none of the wells appear to induce any river recharge. The capture zone around well 199-H4-15A extends from the well to a line parallel to and just north of wells 199-H4-7 and 199-H3-2A. Pumping in well 199-H4-12A results in a capture zone extending between the capture zone around well 199-H4-7 and the line between well 199-H4-12A and the injection well field. While most of the water extracted by these wells originates from the inland upgradient area of the aquifer, they do appear to extract groundwater from the aquifer near the river. Pumping in well 199-H4-11 exerts the least lateral capture of any of the extraction wells, and most of the water entering that well originates from the injection well field area directly upgradient. The capture zone exerted by pumping in well 199-H3-2A extends from the upgradient area west-southwest of the well and down to the injection well field.

The network of near river extraction wells provides an almost continuous area of capture 400 m wide between well 199-H4-15A to the north and well 199-H4-12A to the south. Pumping in well 199-H4-7 forces more of the capture to occur laterally around wells 199-H4-12A and 199-H4-15A, thus enhancing the removal of groundwater from near the river. Pumping in well 199-H4-11 appears to capture very little groundwater from near the river, but the pumping does extend the line of hydraulic containment along the river. With extraction occurring in the three near river wells, the line of hydraulic containment extends almost continuously between well 199-H4-15A to the north and well 199-H4-11 to the south.

3.2.3.2 Effectiveness and Removal of Hexavalent Chromium from the Aquifer. With approximately 14 kg of chromium being removed from the aquifer since the start of operations, the interim remedial action for 100-HR-3 OU has been effective at reducing the total mass of hexavalent chromium from the aquifer. However, its impact on reducing the chromium concentration levels within the aquifer cannot be determined at this time because of the impacts a fifty-year flood on the Columbia River had on the unconfined aquifer. This fifty-year flood had the following impacts on the unconfined aquifer:

- Influx of river water into the unconfined aquifer causes the water table to rise to unusually high levels and reverses the groundwater gradient.

- Influx of river water diluted chromium and specific conductance levels within the aquifer occurred in late June and early July. At the start of the interim action, concentrations at many of the compliance wells were below the remedial action goal of 22 μg/L.

- Reversal of groundwater gradient displaces the chromium plume inland, which also reduces chromium levels at near-river compliance monitoring wells.

- As the water level dropped, chromium concentrations at the compliance well rose to levels at or above those observed before the flood event.

3.2.4 Summary of Pump-and-Treat Impacts on the Aquifer

By the end of January 1998, the chromium concentrations in all compliance and extraction wells for the 100-HR-3 OU were above the remedial action goal of 22 μg/L. At the present time, the impacts the Columbia River has on the aquifer are much greater than the impacts of the interim remedial action. The present monitoring plan for the interim remedial action is sufficient to show the impacts the interim remedial action has on the aquifer over a longer period of time (several years) in which the impacts of the Columbia River are averaged out.

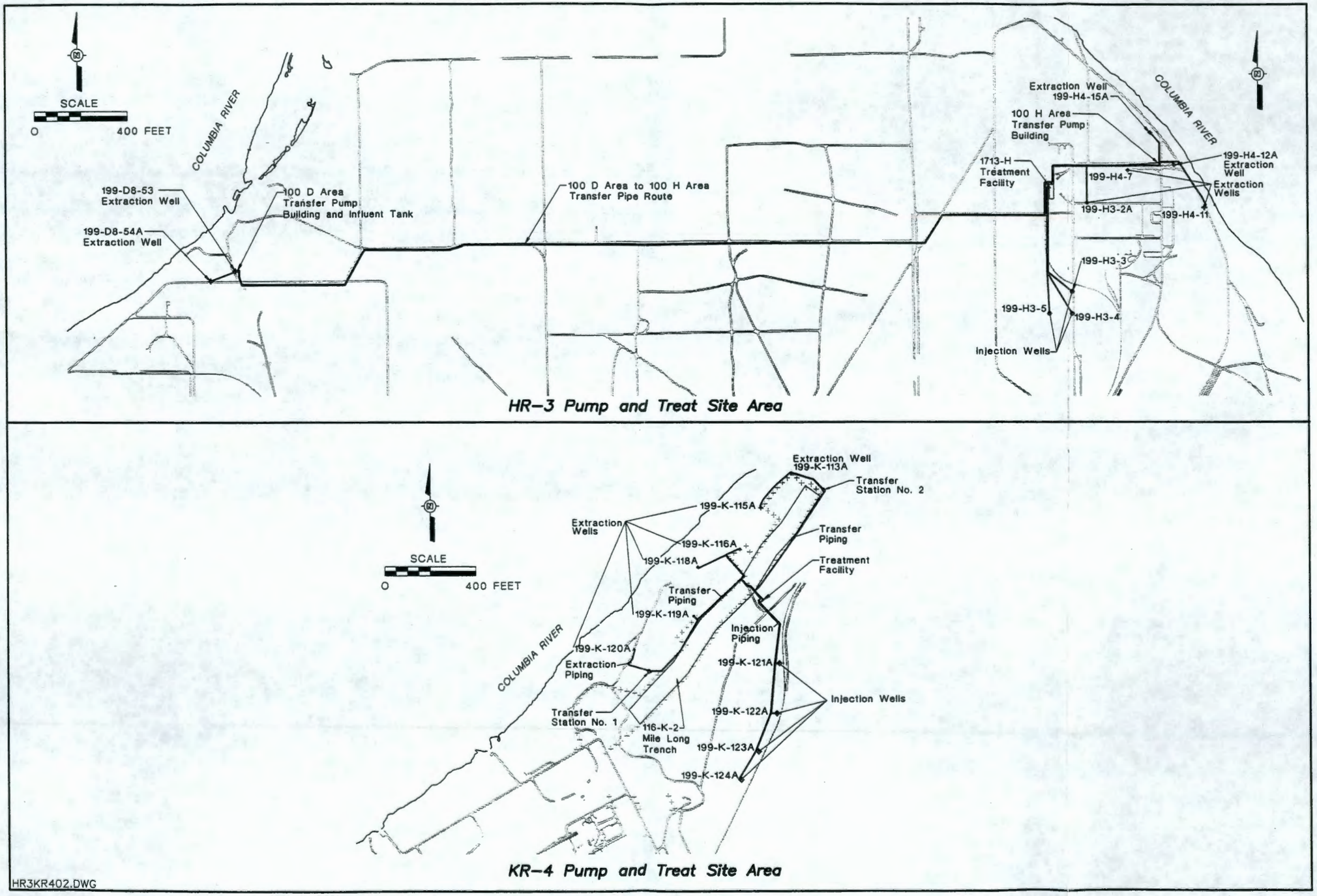
However, the present monitoring program is insufficient to evaluate the interim remedial action over a relatively short period of time (less than a year). The present monitoring plan does not address either the short-term impacts of the daily and seasonal cycles of the Columbia River on the unconfined aquifer or the short-term impacts caused by changes in the operation of the interim remedial action. To evaluate these impacts, a short-term monitoring program with more frequent sampling should be established to separate the effects due to the groundwater-river interaction and the effects due to the interim remedial action. This sampling would include, but would not be limited to, installation of real-time specific conductance probes at the compliance and extraction wells, daily sampling of chromium from compliance wells, real-time monitoring of chromium at the extraction wells, and more frequent sampling of Tc-99 at the extraction wells. Additionally, aquifer sample tubes were installed along the river's edge in these areas in the fall of 1995 and 1997. Sampling from the aquifer sample tubes in the target areas should be added to the present monitoring program since this will provide information close to the river on the effectiveness of the remedial action.

The hydraulic capture and containment resulting from operation of the 100-HR-3 pump-and-treat system has reduced the flux of groundwater entering the Columbia River in both 100-D and 100-H Areas. In 100-D Area, the capture zone extends laterally across from well 199-D8-53 to the river (about 400 m) and southward toward wells 199-D5-14, 199-D5-15, and 199-D5-16. Pumping in the extraction wells hydraulically contains the aquifer along the shoreline of the river between compliance wells 199-D8-68 and 199-D8-69 for about 400 m. Discharge of groundwater to the river in this area (identified as the approximate location of compliance wells in Figure 1-2) has been reduced because the pumping has reduced the hydraulic gradient between the aquifer and the river. Based

on the streamtrace analysis, pumping in both extraction wells appears to be inducing some river recharge. Furthermore, pumping in wells 199-D8-53 and 199-D8-54A hydraulically isolates the area between those wells and the river from the high concentration of the chromium plume identified around wells 199-D5-14, 199-D5-15, and 199-D5-16.

In 100-H Area, the capture zone extends laterally about 250 m near the river from the vicinity of extraction well 100-H4-15A in the north to the vicinity of extraction well 199-H4-12A in the south. The capture zone extends primarily towards the injection well field. The hydraulic effects of pumping well 199-H4-11 appear limited to the area directly upgradient from the well. Pumping in the near-river extraction wells hydraulically contains most of the aquifer along the shoreline of the river between wells 199-H4-15A and 199-H4-11, which includes most of the area identified in Figure 1-3 as the extraction/compliance wells area. Discharge of groundwater to the river in this area has been reduced because the pumping in the near-river extraction wells has reduced the hydraulic gradient between the aquifer and the river.

Figure 3-1. 100-HR-3 and 100-KR-4 Pump-and-Treat System Plot Plan.



THIS PAGE INTENTIONALLY
LEFT BLANK

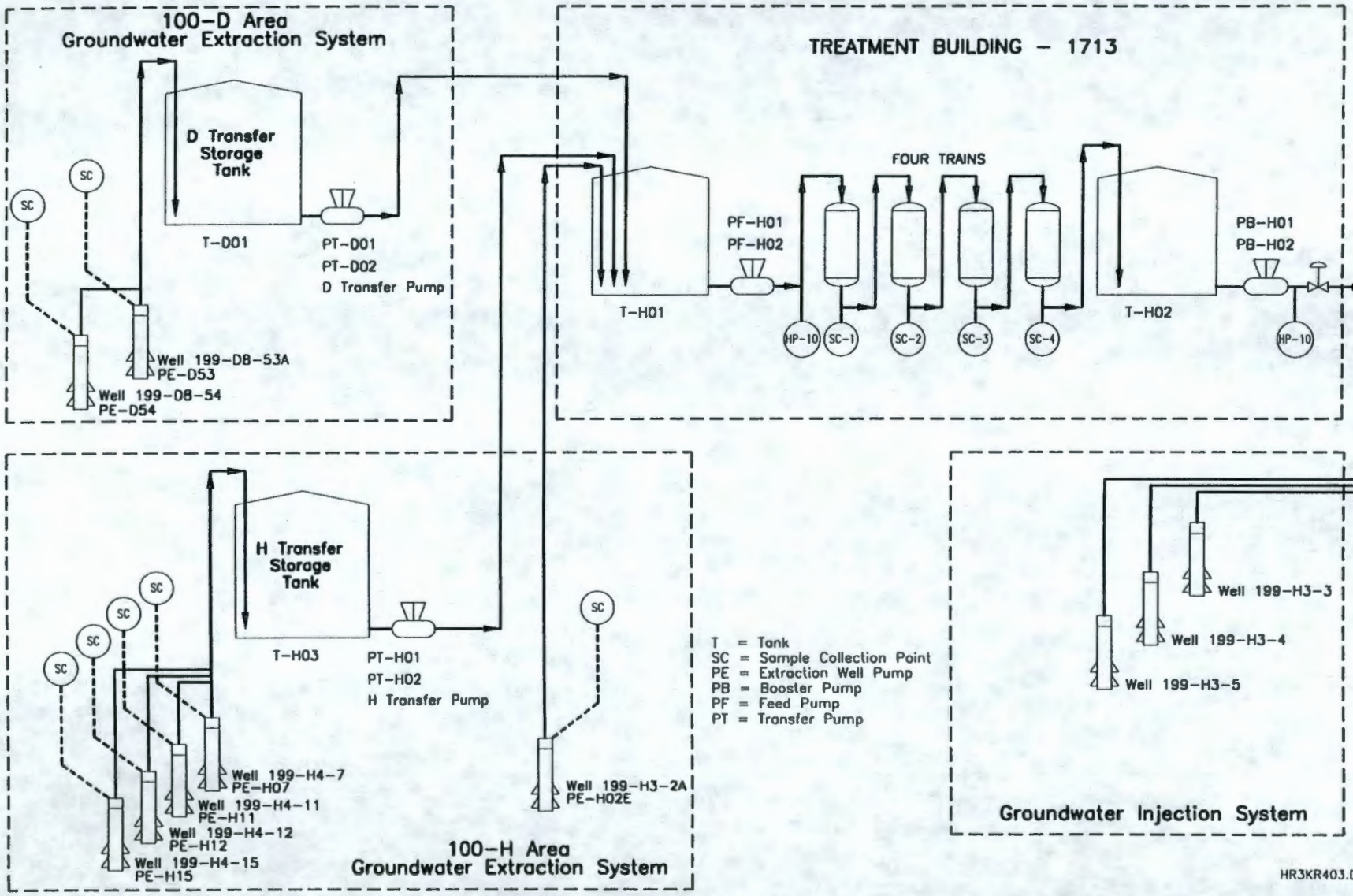
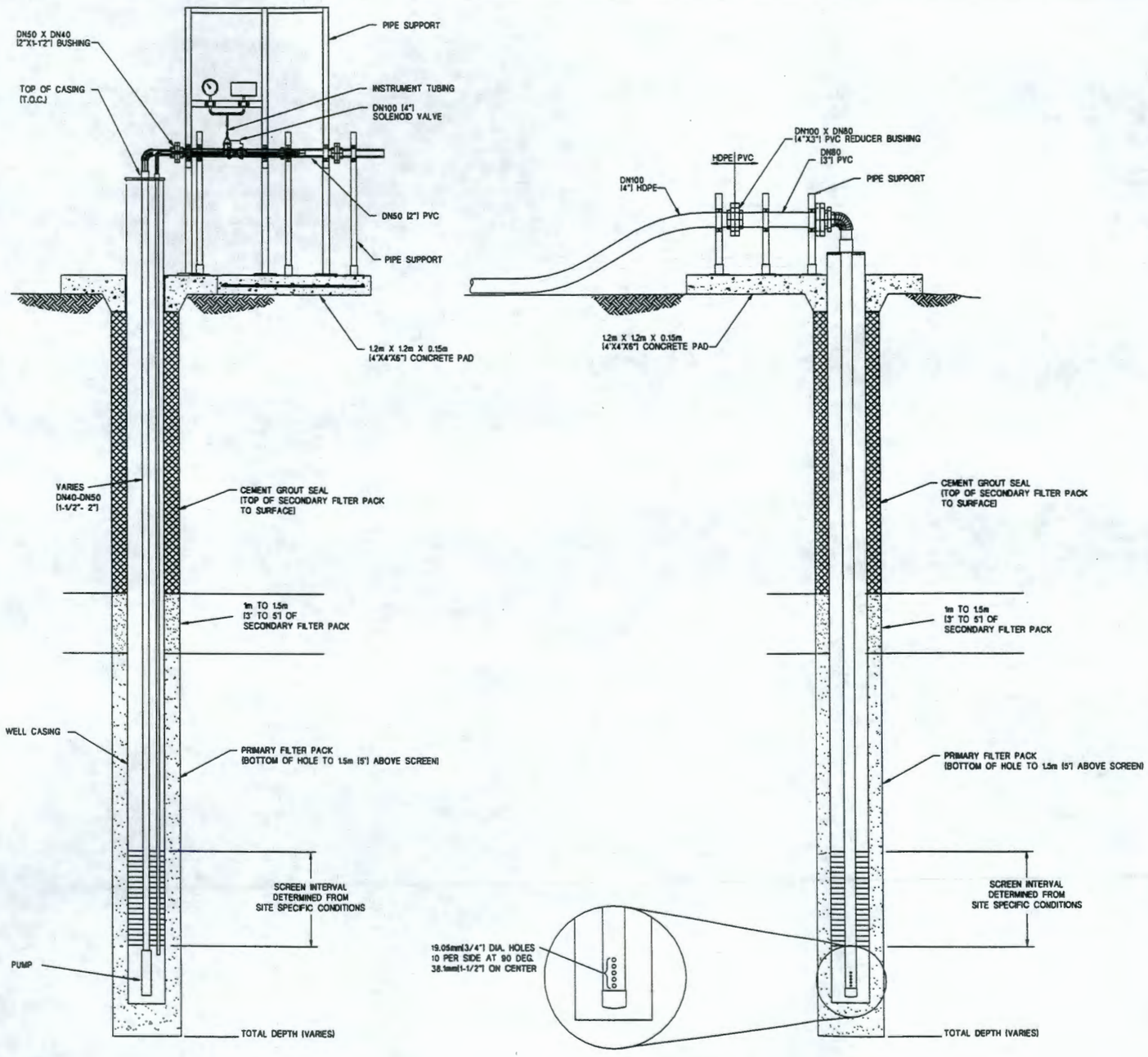


Figure 3-2. Pump-and-Treat System Schematic.

Figure 3-3. Typical Extraction and Injection Well.



HR-3 EXTRACTION WELLS

TABLE 1

WELL NO.	DEPTH TO BOTTOM OF PUMP	RETURN PIPE DEPTH	WELL CASING DIA.	PUMP DISCHARGE PIPE DIA.
199-D8-53	16.15M[53.0 FT.]	9.14M[30.0 FT.]	DN100 [4 IN.]	DN40 [1-1/2 IN.]
199-D8-54A	15.39M[50.5 FT.]	9.14M[30.0 FT.]	DN100 [4 IN.]	DN40 [1-1/2 IN.]
199-H4-07	16.15M[53.0 FT.]	9.14M[30.0 FT.]	DN150 [6IN.]	DN40 [1-1/2 IN.]
199-H4-11	15.39M[50.5 FT.]	9.14M[30.0 FT.]	DN150 [6IN.]	DN40 [1-1/2 IN.]
199-H4-12A	14.63M[48.0 FT.]	9.14M[30.0 FT.]	DN150 [6IN.]	DN40 [1-1/2 IN.]
199-H4-15A	12.19M[40.0 FT.]	9.14M[30.0 FT.]	DN150 [6IN.]	DN40 [1-1/2 IN.]
199-H3-2A	14.78M[48.5 FT.]	9.14M[30.0 FT.]	DN150 [6IN.]	DN50 [2 IN.]

DEPTHS SHOWN T.O.C.

HR-3 INJECTION WELLS

TABLE 2

WELL NO.	WELL DEPTH	DISCHARGE PIPE
199-H3-3	19.20M[63.0 FT.]	18.59M[61.0 FT.]
199-H3-4	20.12M[66.0 FT.]	19.51M[64.0 FT.]
199-H3-5	21.34M[70.0 FT.]	20.73M[68.0 FT.]

KR-4 EXTRACTION WELLS

TABLE 3

WELL NO.	DEPTH TO BOTTOM OF PUMP	RETURN PIPE DEPTH	WELL CASING DIA.
199-K-113A	19.20M[63.0 FT.]	9.14M[30.0 FT.]	DN150 [6 IN.]
199-K-115A	19.20M[63.0 FT.]	9.14M[30.0 FT.]	DN150 [6 IN.]
199-K-116A	22.55M[74.0 FT.]	9.14M[30.0 FT.]	DN150 [6 IN.]
199-K-118A	22.55M[74.0 FT.]	9.14M[30.0 FT.]	DN150 [6 IN.]
199-K-119A	28.95M[95.0 FT.]	9.14M[30.0 FT.]	DN150 [6 IN.]
199-K-120A	17.98M[59.0 FT.]	9.14M[30.0 FT.]	DN150 [6 IN.]

DEPTHS SHOWN T.O.C.

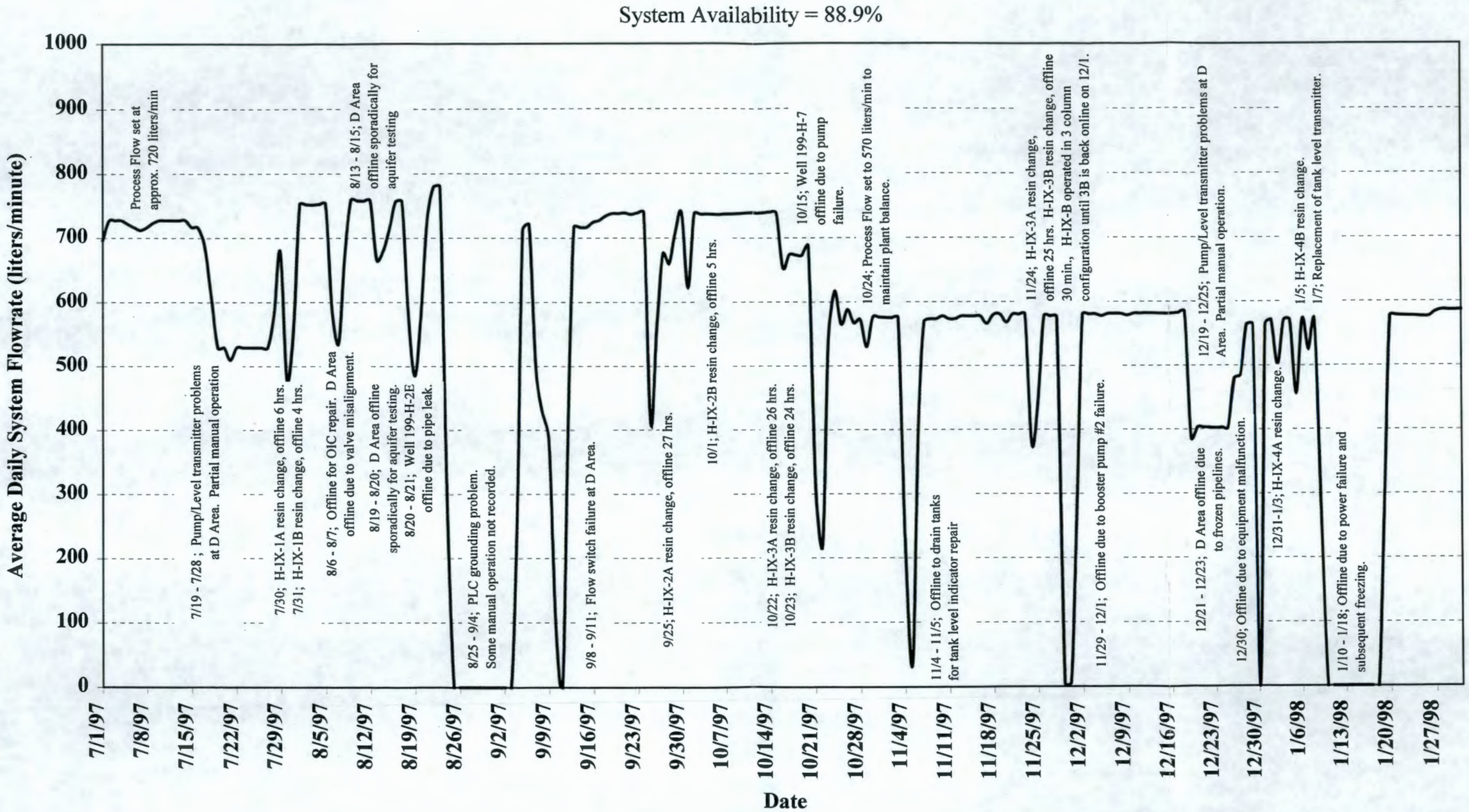
KR-4 INJECTION WELLS

TABLE 4

WELL NO.	WELL DEPTH	DISCHARGE PIPE
199-K-121A	28.04M[92.0 FT.]	27.43M[90.0 FT.]
199-K-122A	28.95M[95.0 FT.]	28.35M[93.0 FT.]
199-K-123A	28.95M[95.0 FT.]	28.35M[93.0 FT.]
199-K-124A	29.26M[96.0 FT.]	28.65M[94.0 FT.]

HR3KR401.DWG

Figure 3-4. 100-HR-3 Treatment System Operation.



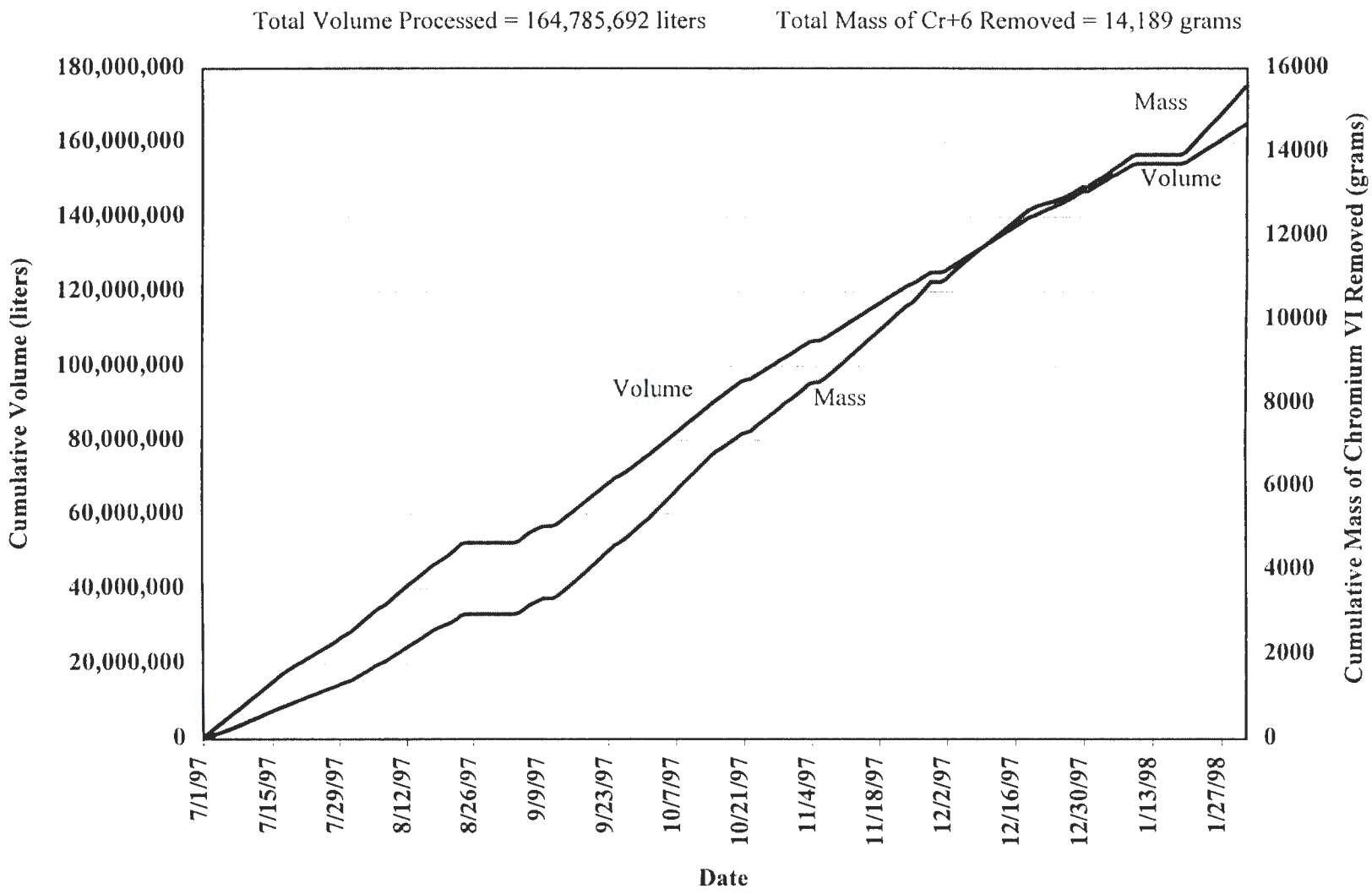


Figure 3-5. 100-HR-3 Treatment System Operation, Cumulative Volume Processed and Mass Removed vs. Time.

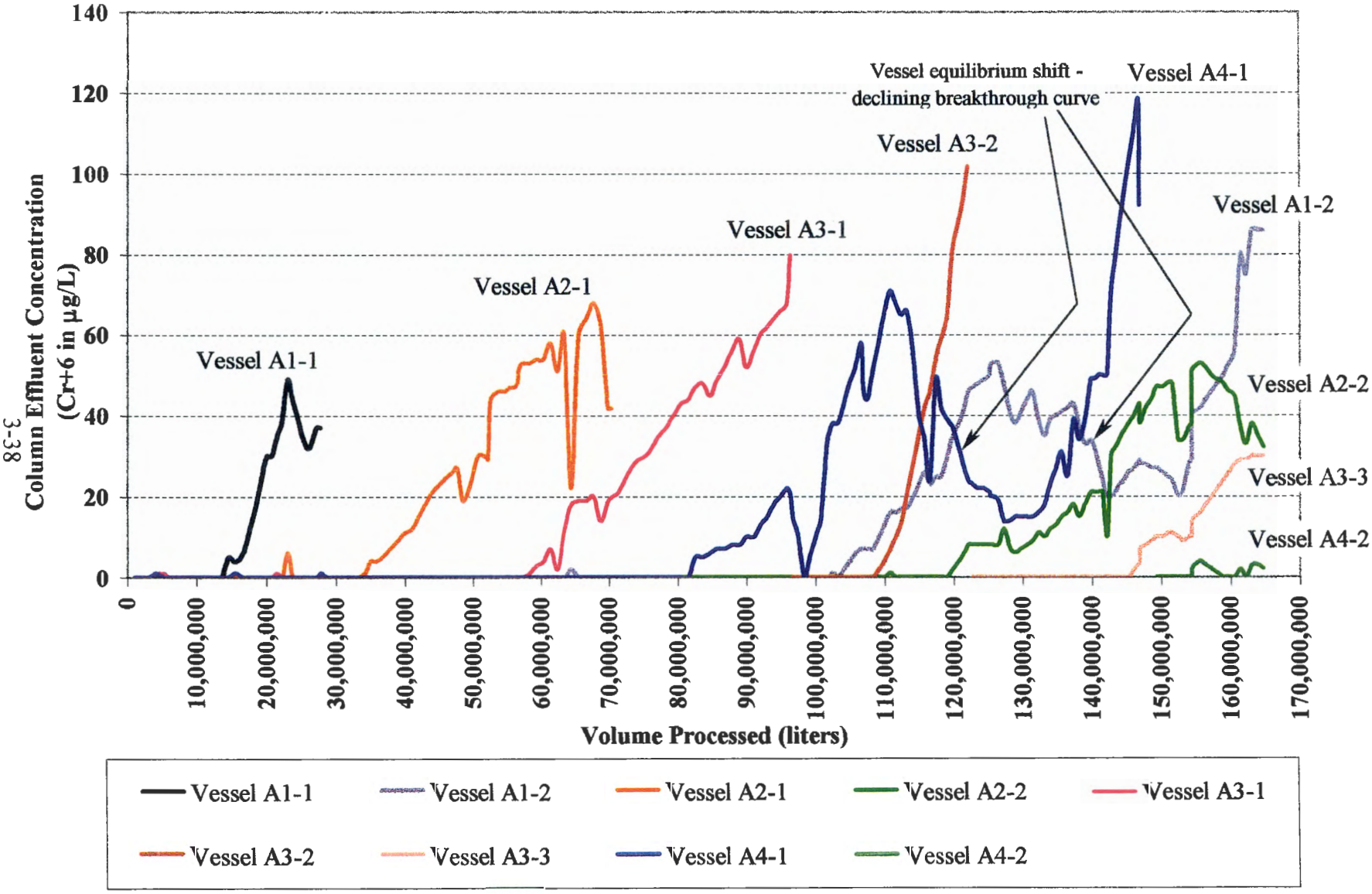


Figure 3-6. Ion Exchange Breakthrough Curves for H-IX-A.

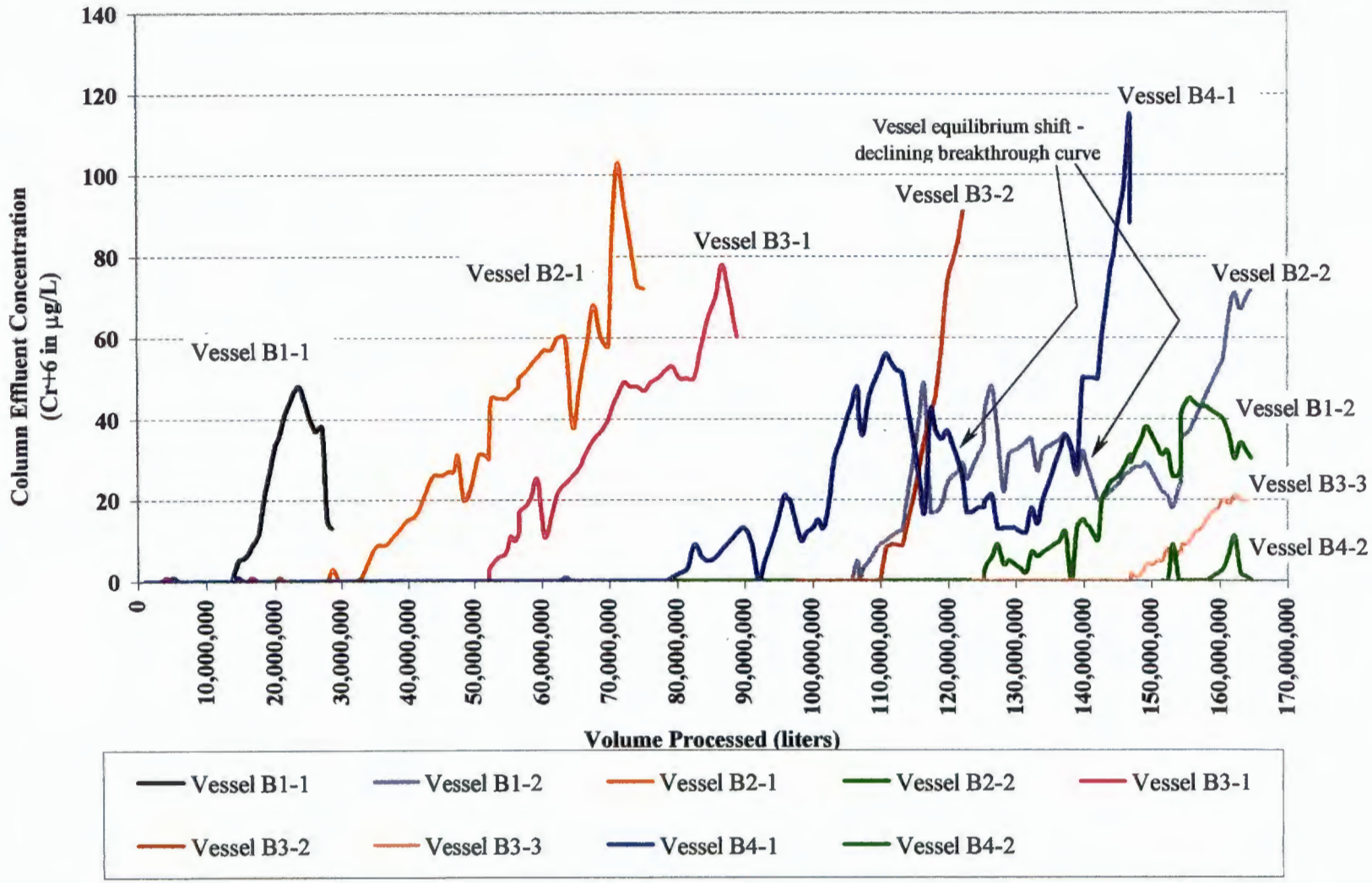
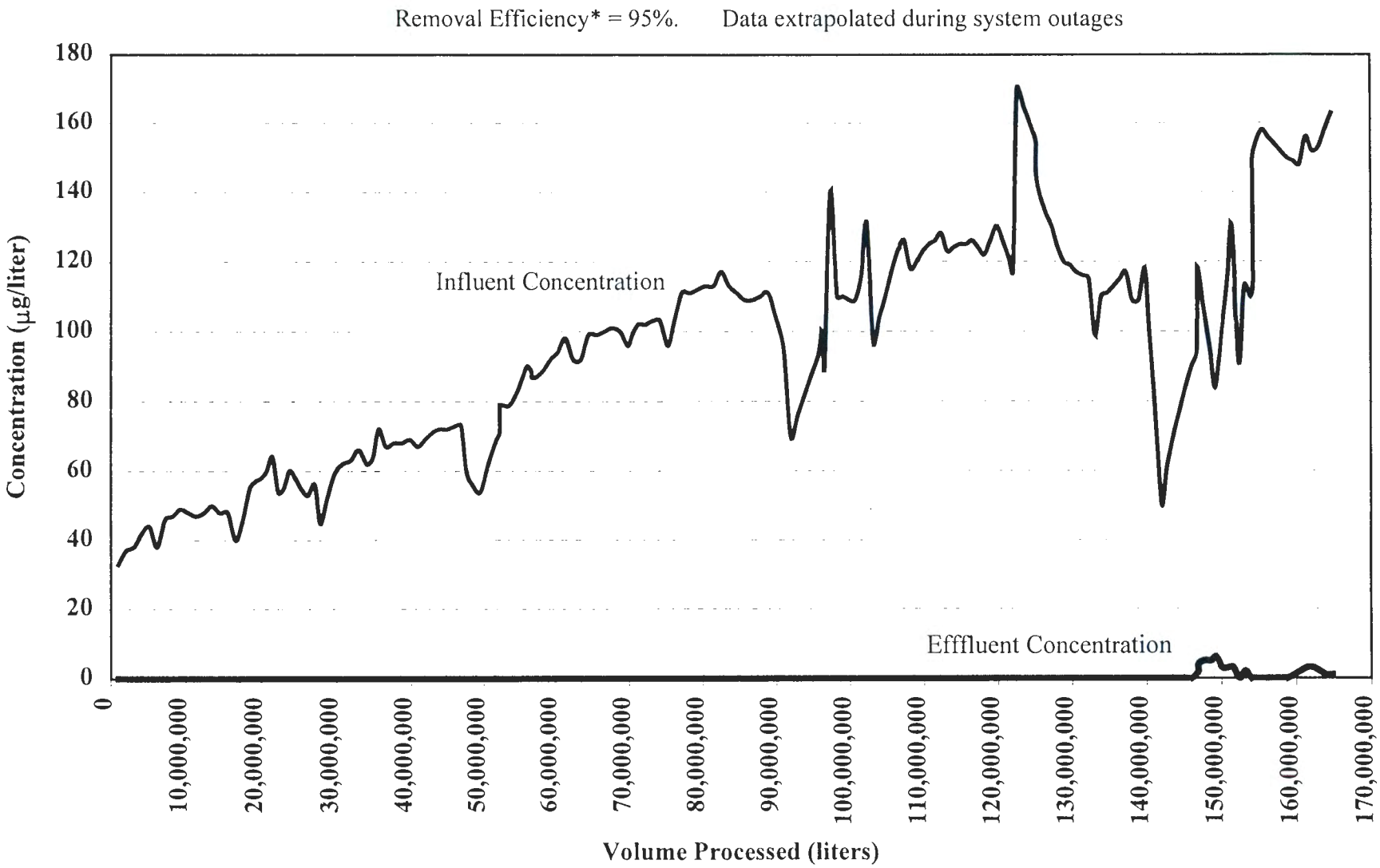


Figure 3-7. Ion Exchange Breakthrough Curves for H-IX-B.

Figure 3-8. 100-HR-3 Pump-and-Treat System Influent and Effluent.



* Based on effluent concentration equal to the Hach 2100 Chrome Analyzer detection limits (5 µg/L)

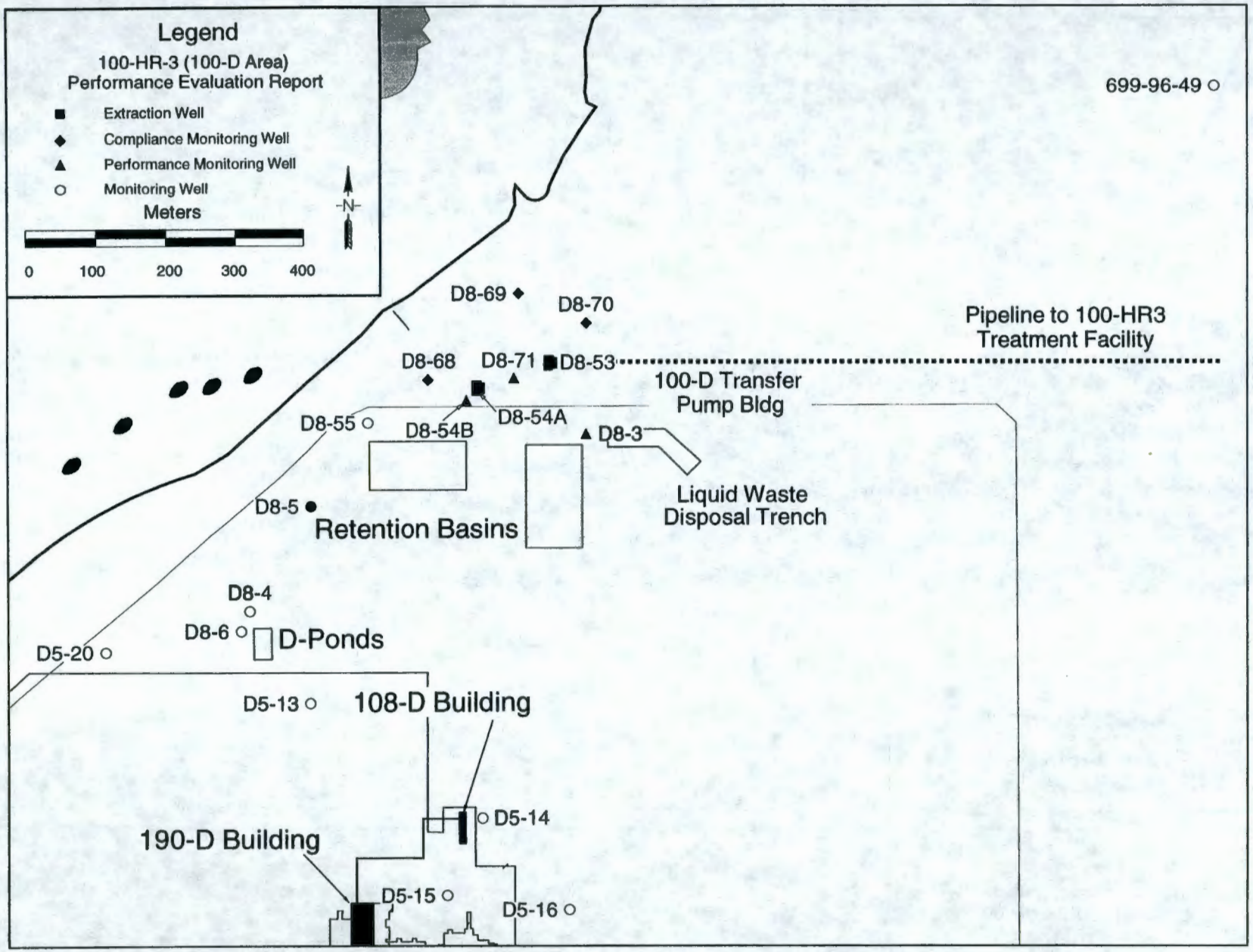


Figure 3-9. 100-HR-3 OU 100-D Area Layout of Wells.

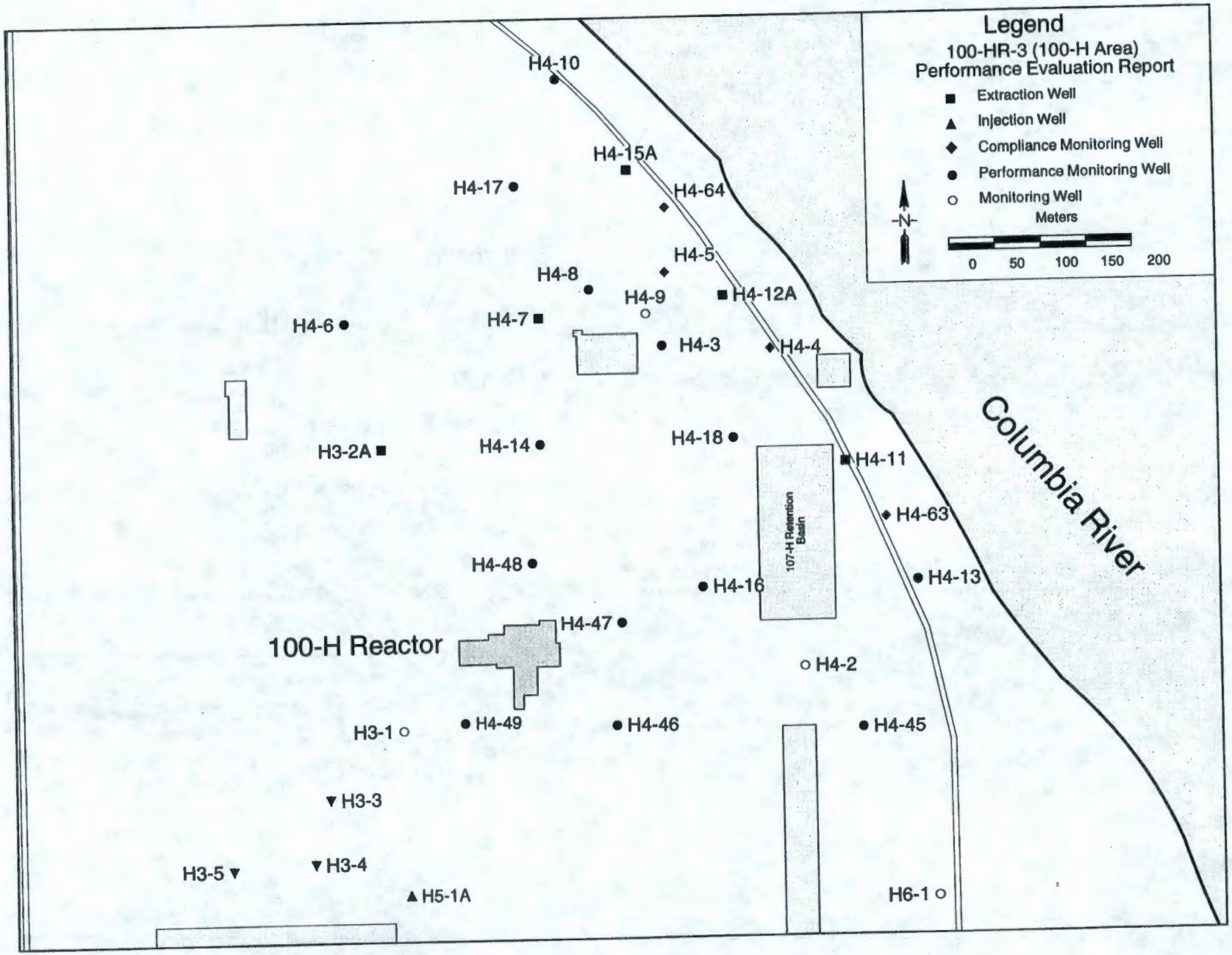


Figure 3-10. 100-HR-3 OU 100-H Area Layout of Wells.

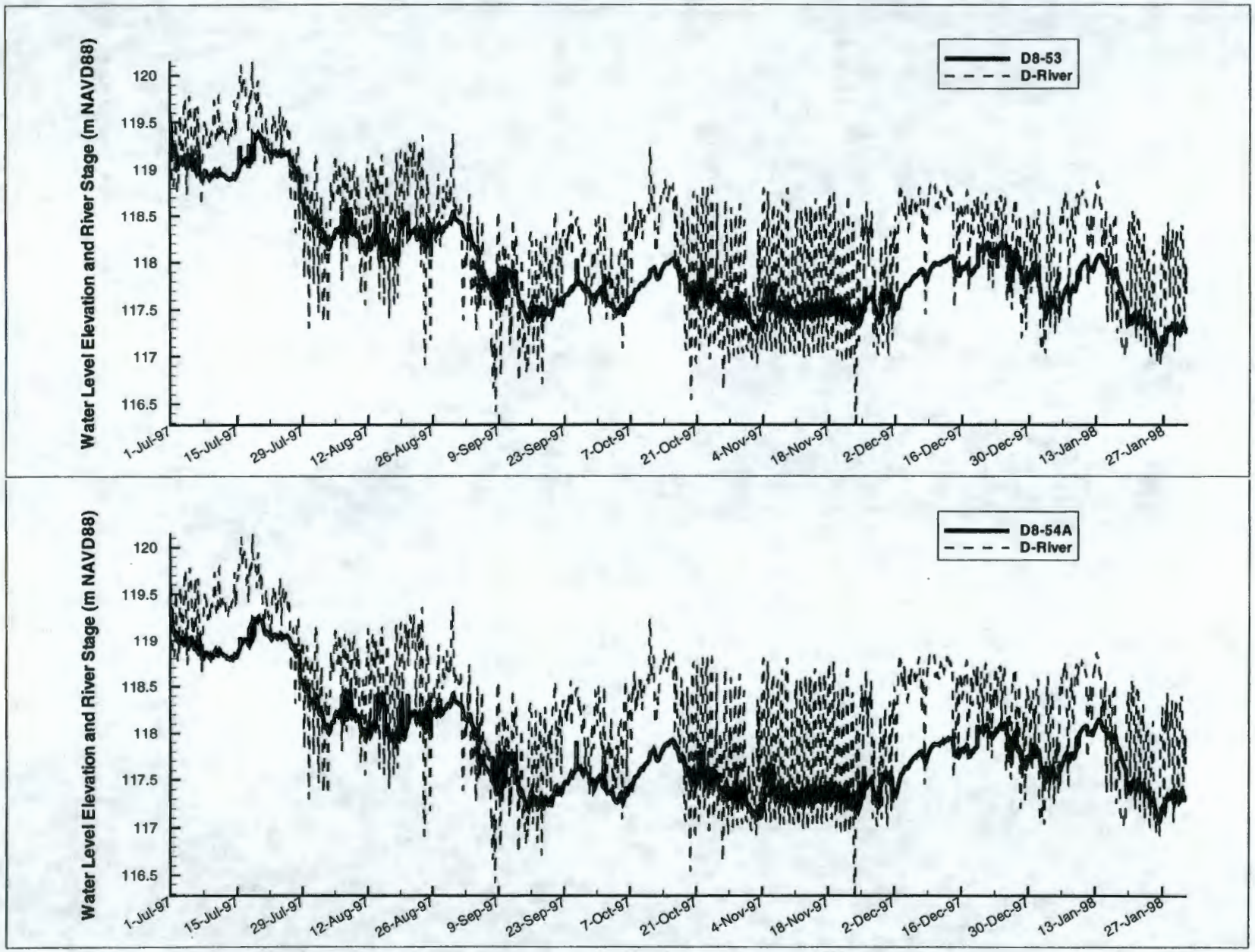


Figure 3-11. 100-HR-3 OU 100-D Area Composite Hydrographs of Extraction Wells.

Figure 3-12. 100-HR-3 OU 100-H Area Composite Hydrographs of Injection Wells. Page 1 of 2

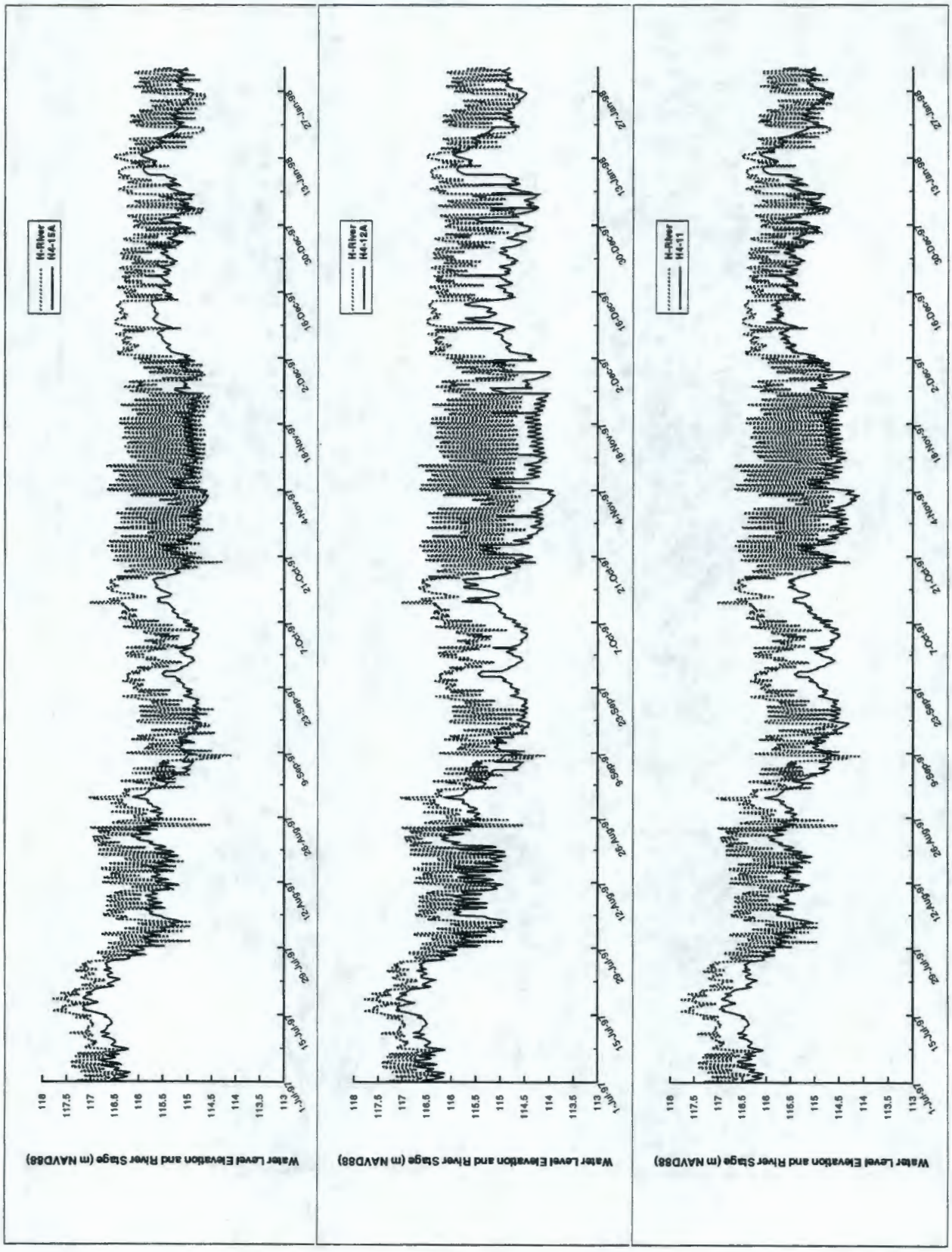


Figure 3-12. 100-HR-3 OU 100-H Area Composite Hydrographs of Injection Wells. Page 2 of 2

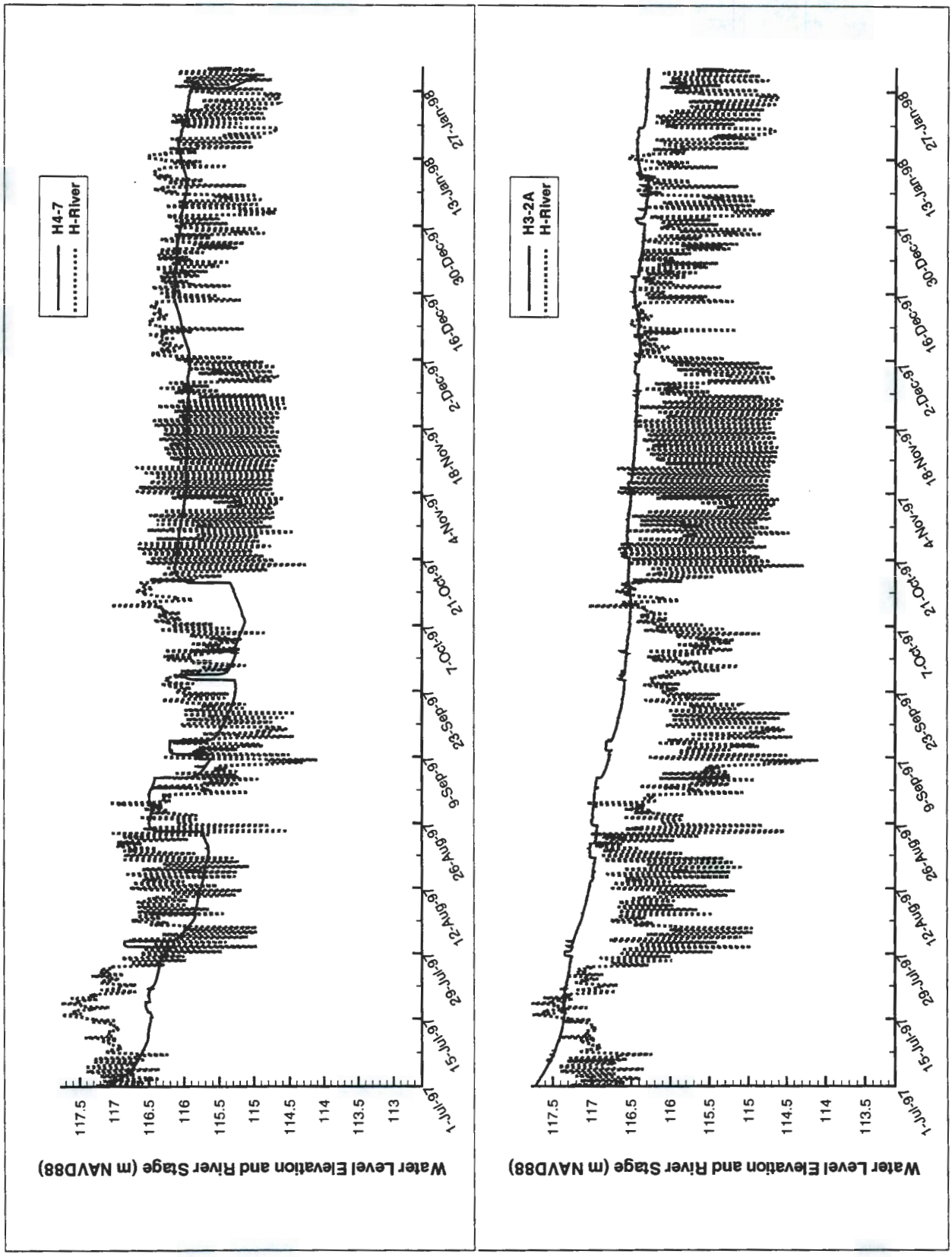


Figure 3-13. 100-HR-3 OU 100-H Area Composite of Hydrographs of Injection Wells.

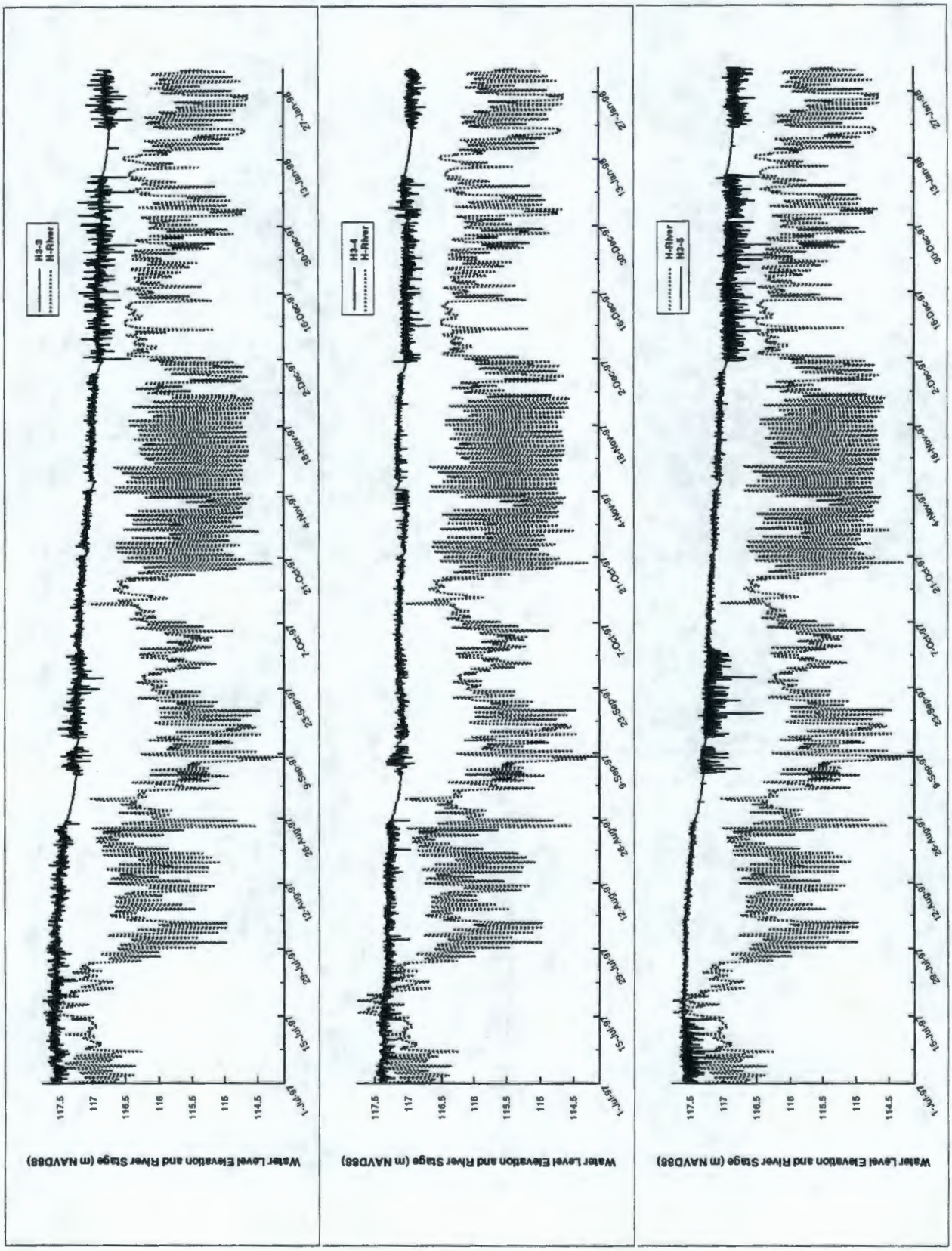


Figure 3-14. River Stage Correlation and Drawdown Measured in 100-HR-3 OU 100-D Area Extraction Wells.

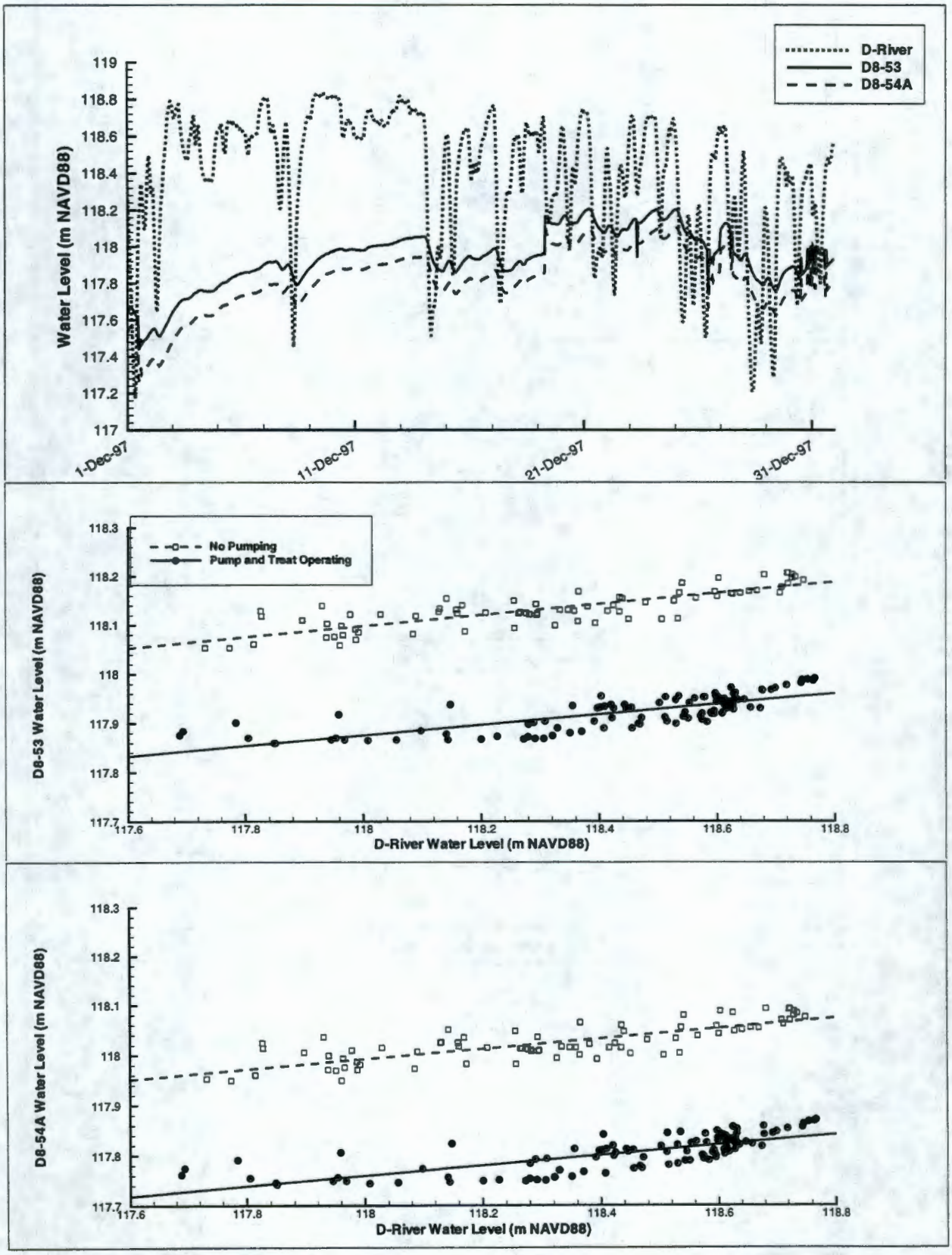


Figure 3-15. River Stage Correlation and Drawdown Measured in 100-HR-3 OU 100-H Area Near River Extraction Wells.

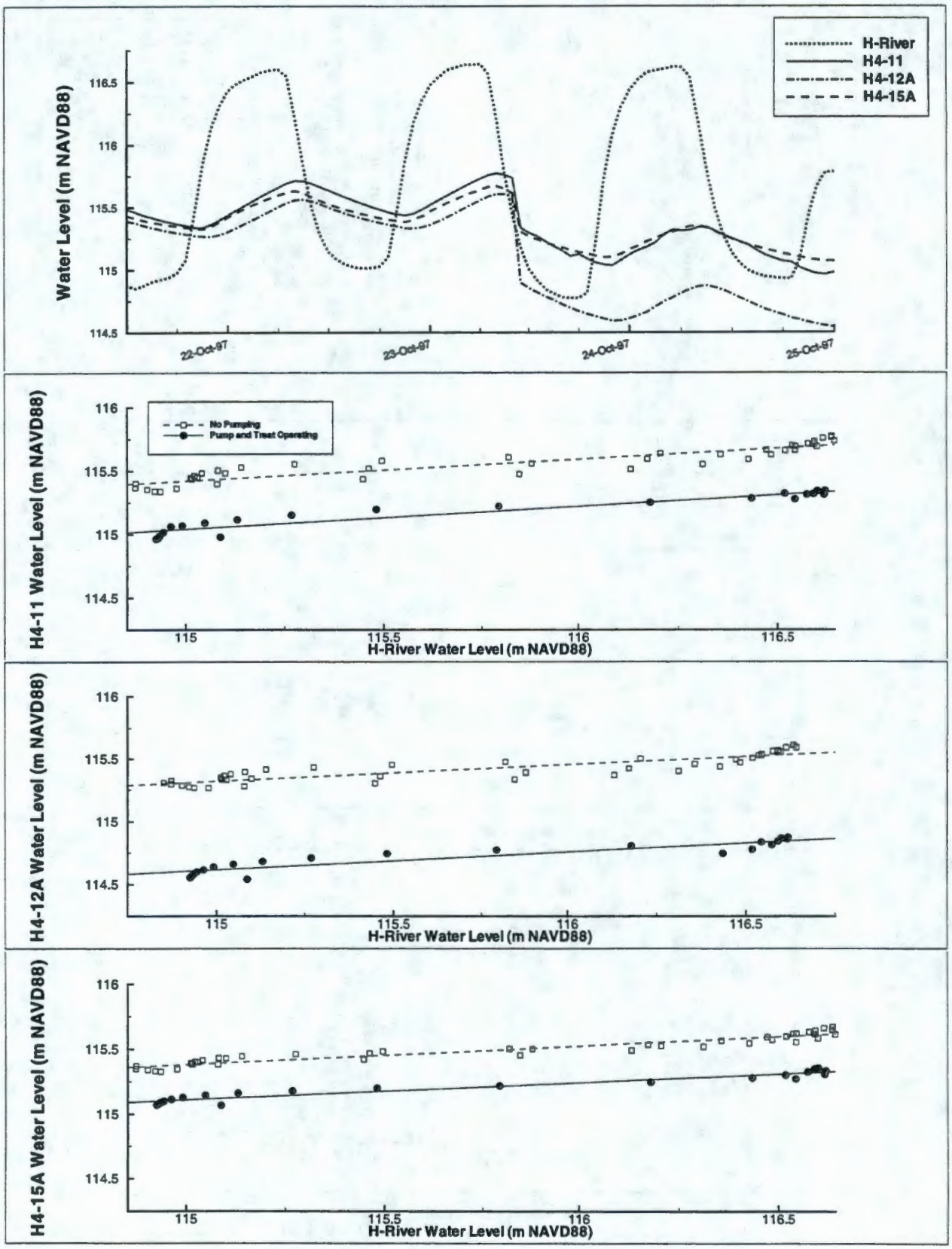


Figure 3-16. Drawdown Measured in 100-HR-3 OU 100-H Area Inland Extraction Wells.

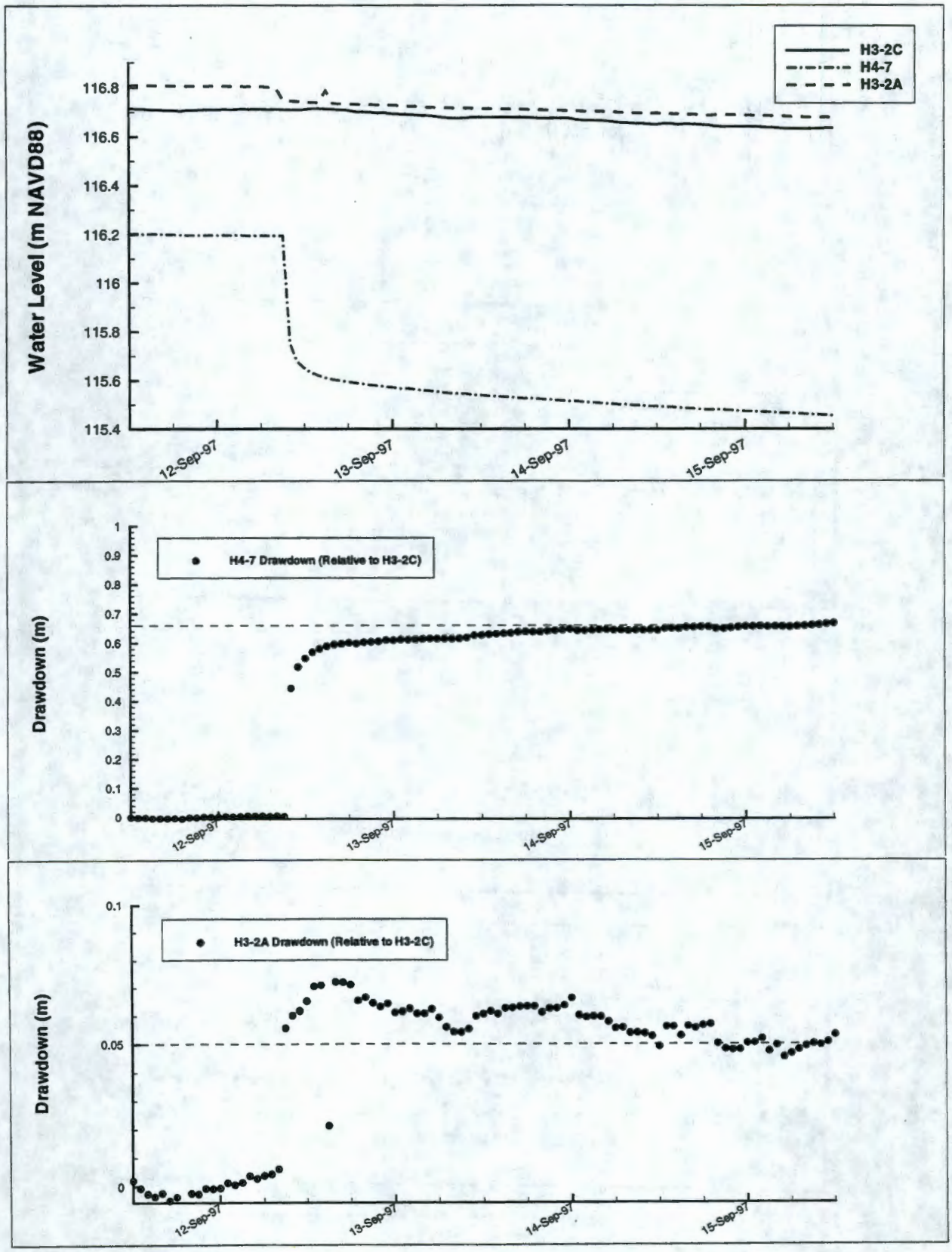


Figure 3-17. Buildup Measured in 100-HR-3 OU 100-H Injection Wells.

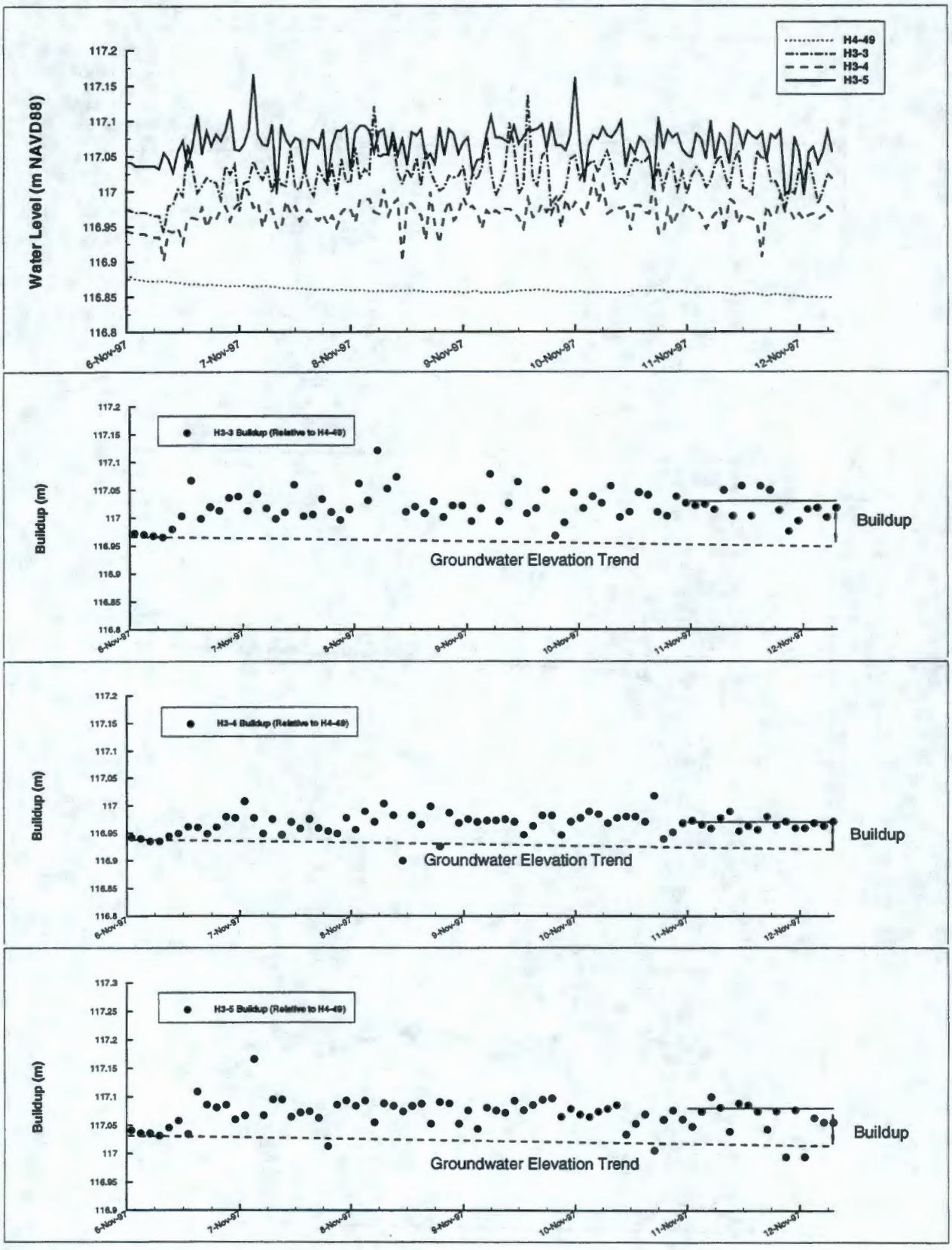


Figure 3-18. River Stage Correlation and Downdraw Measured in 100-HR-3 OU 100-D Area Compliance and Monitoring Wells. Page 1 of 2

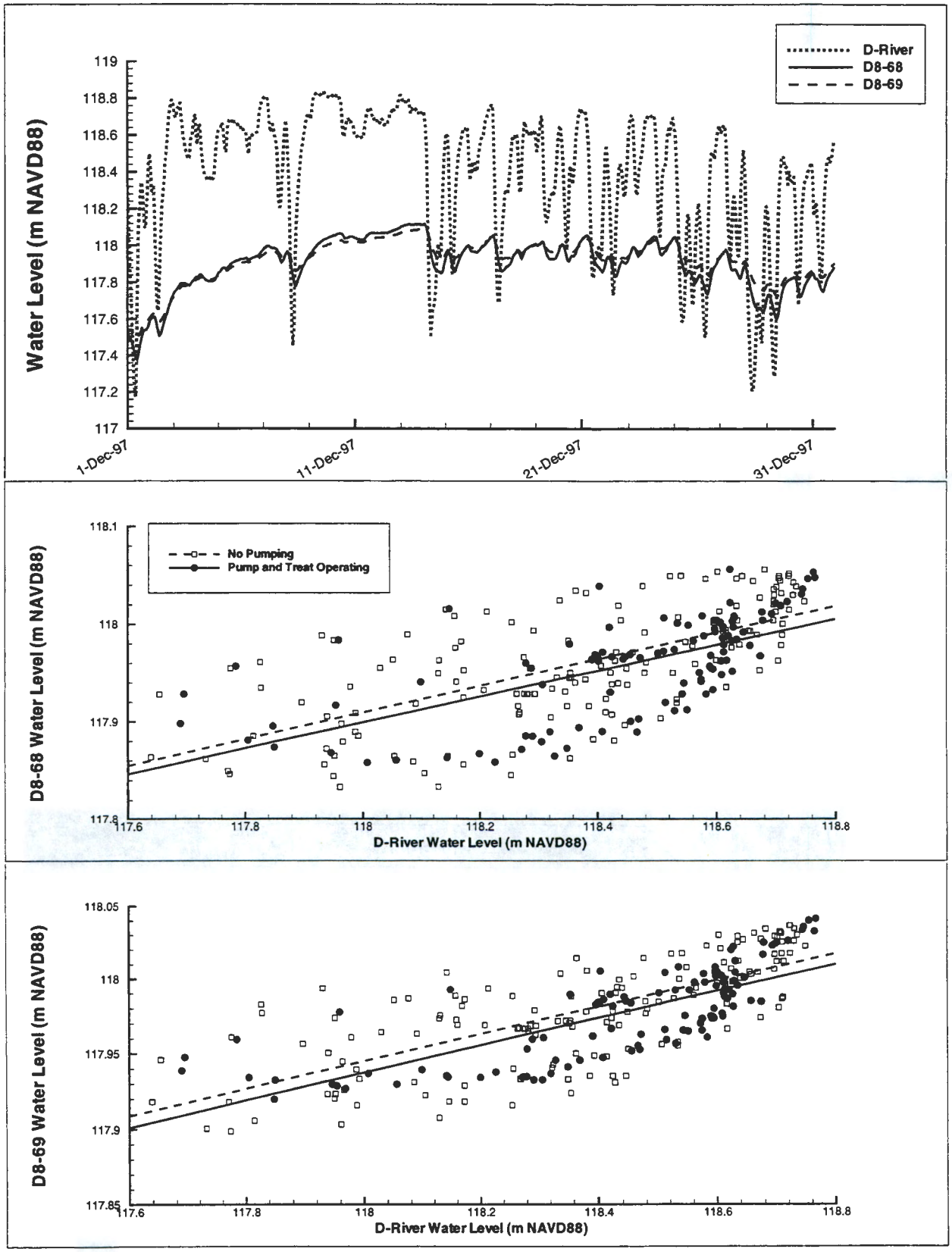


Figure 3-18. River Stage Correlation and Downdraw Measured in 100-HR-3 OU 100-D Area Compliance and Monitoring Wells. Page 2 of 2

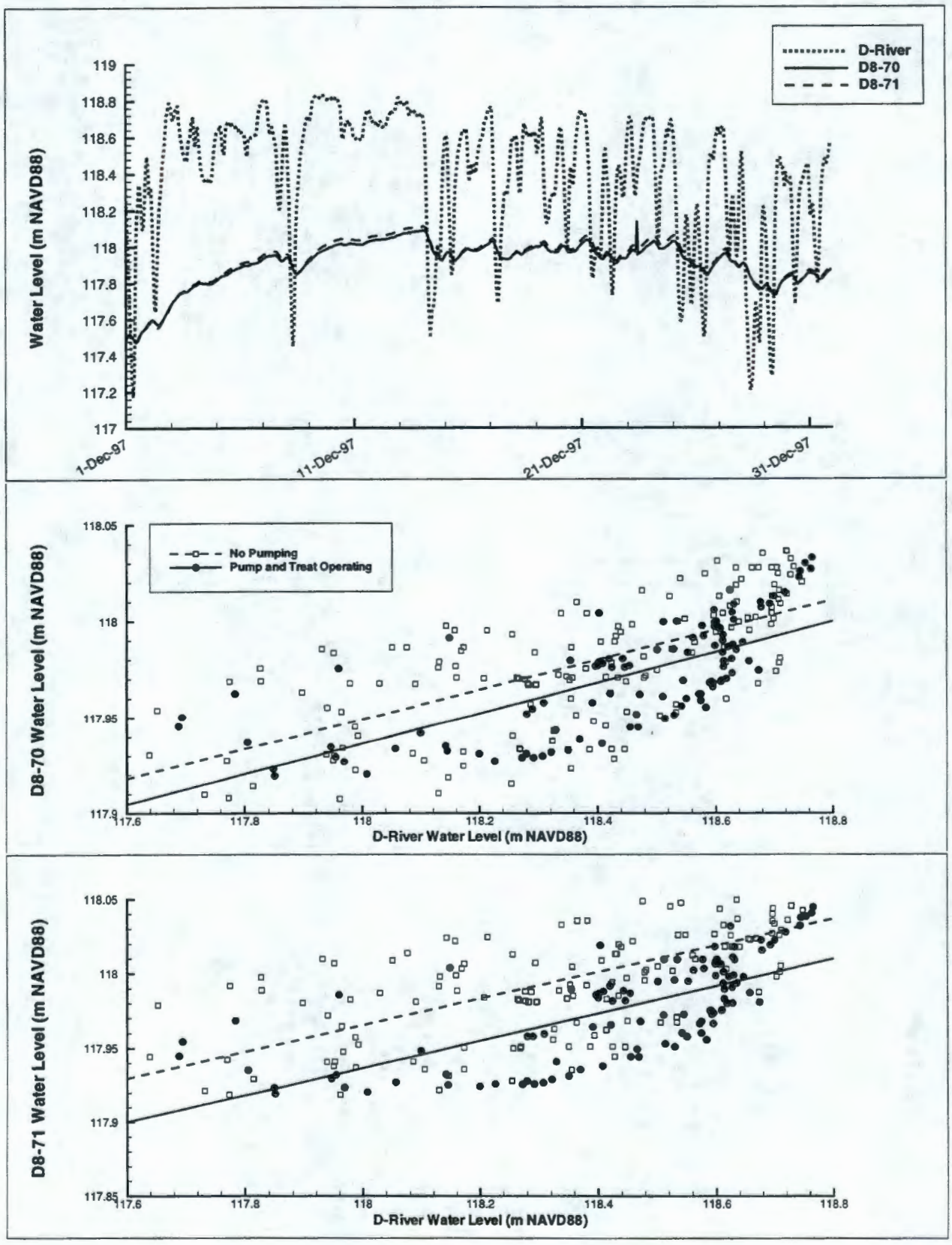


Figure 3-19. River Stage Correlation and Drawdown Measured in 100-HR-3 OU 100-H Area Near River Compliance and Monitoring Wells.

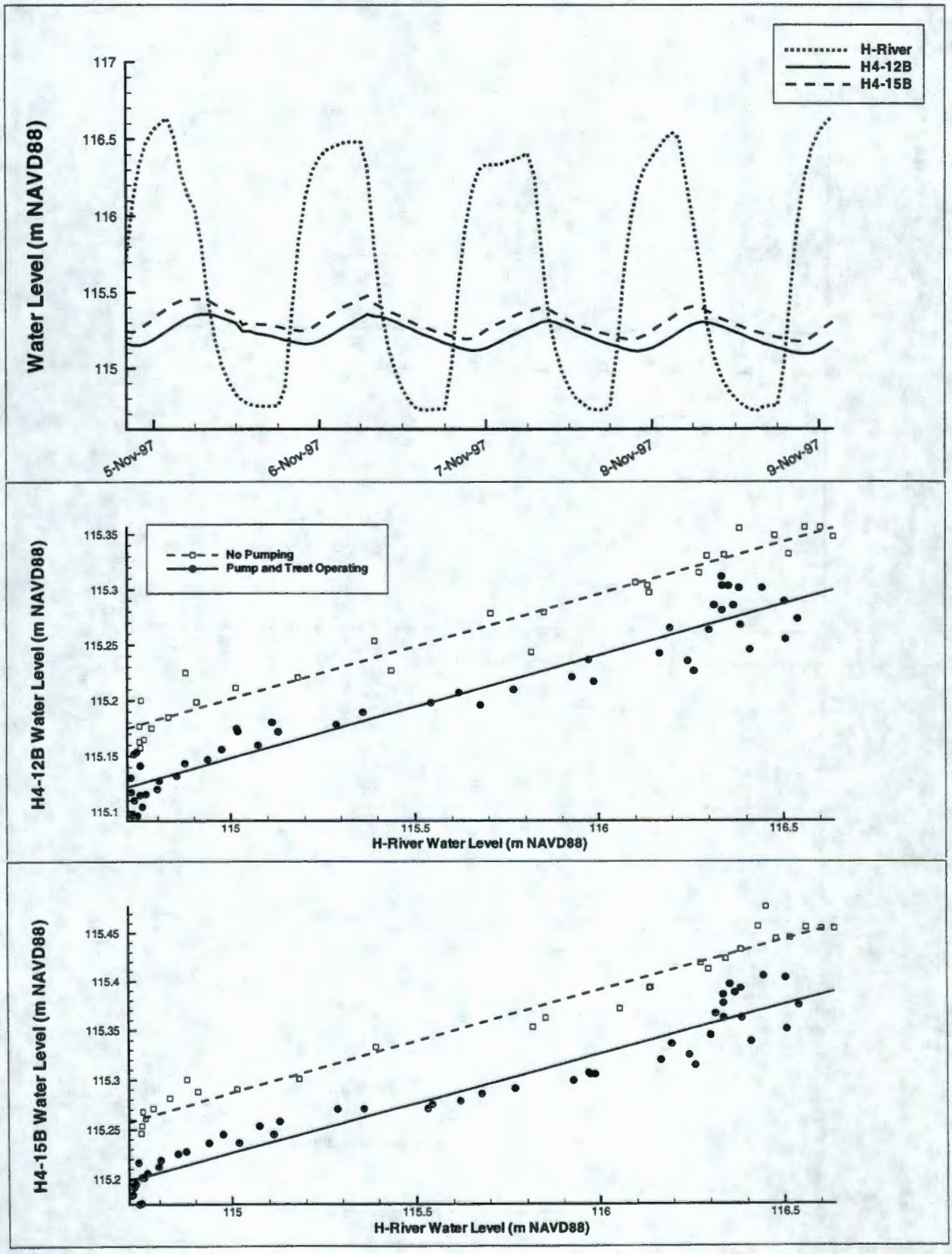


Figure 3-20. Drawdown and Buildup Measured in 100-HR-3 OU 100-H Area Inland Monitoring Wells.

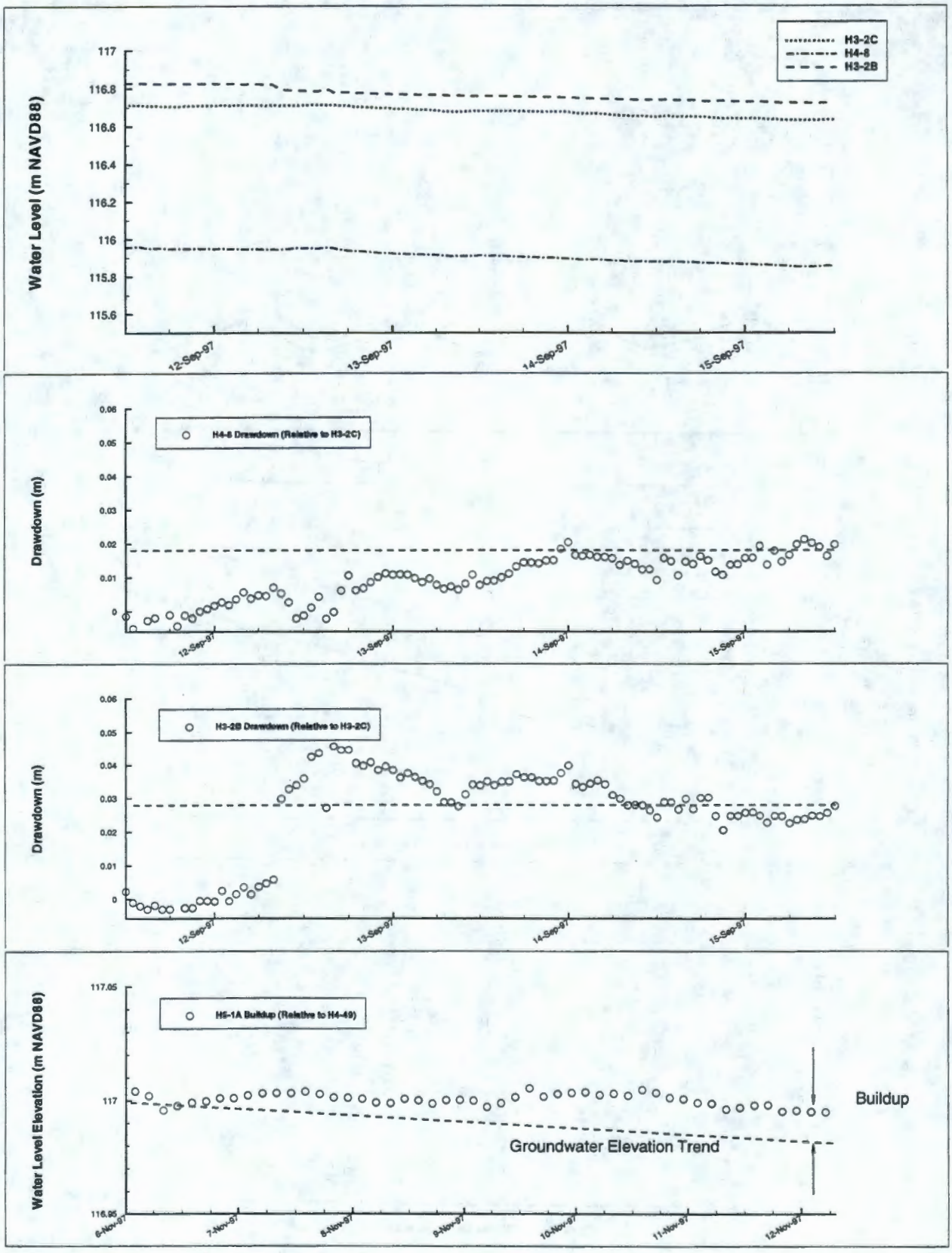
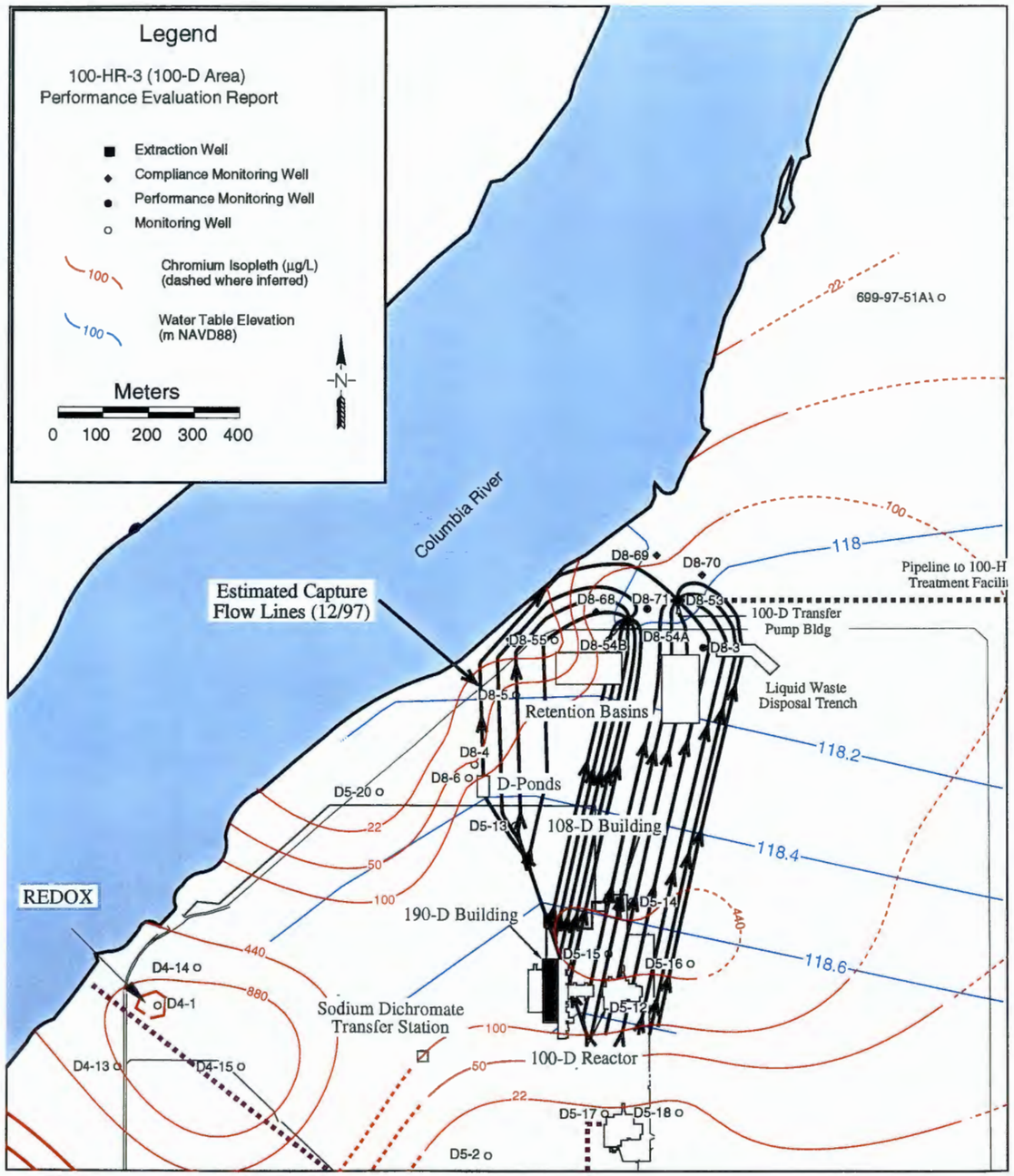
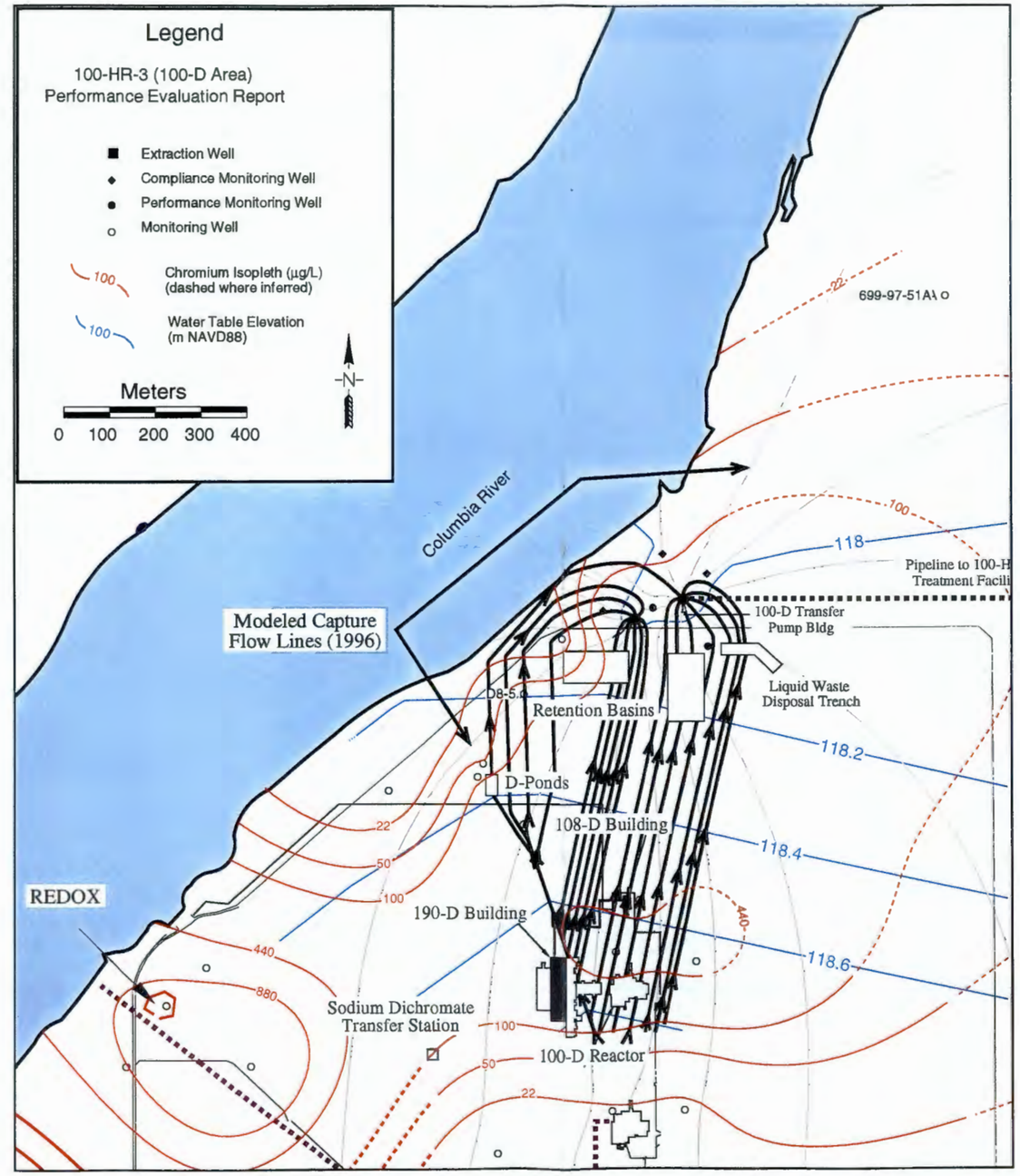


Figure 3-21. Hydraulic Capture Zone Developed by 100-HR-3 OU 100-D Area Extraction Wells and Comparison to Modeled Flow Lines from DOE-RL 1996.





THIS PAGE INTENTIONALLY
LEFT BLANK

Figure 3-22. Hydraulic Containment Developed by 100-HR-3 OU 100-D Area Extraction Wells.

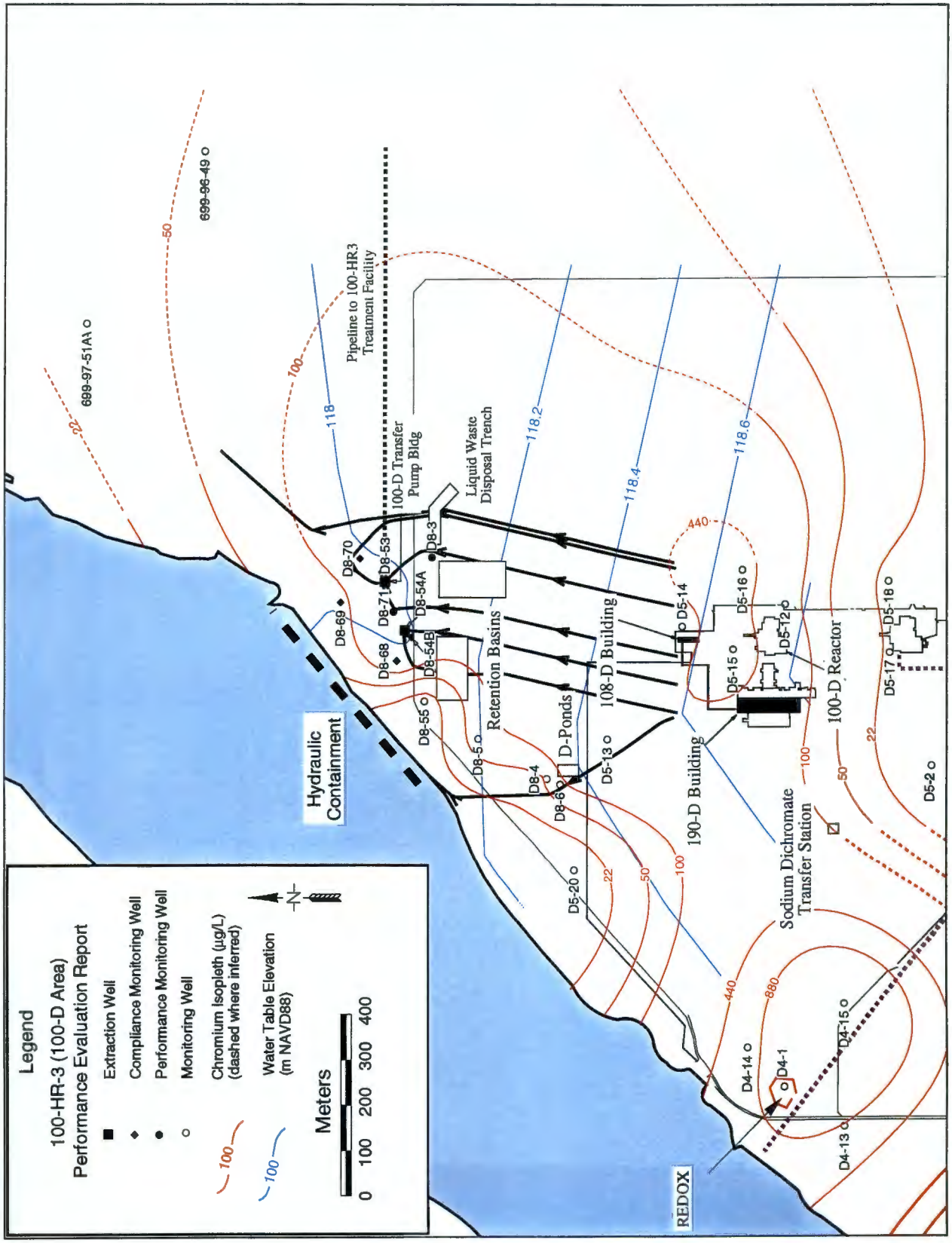
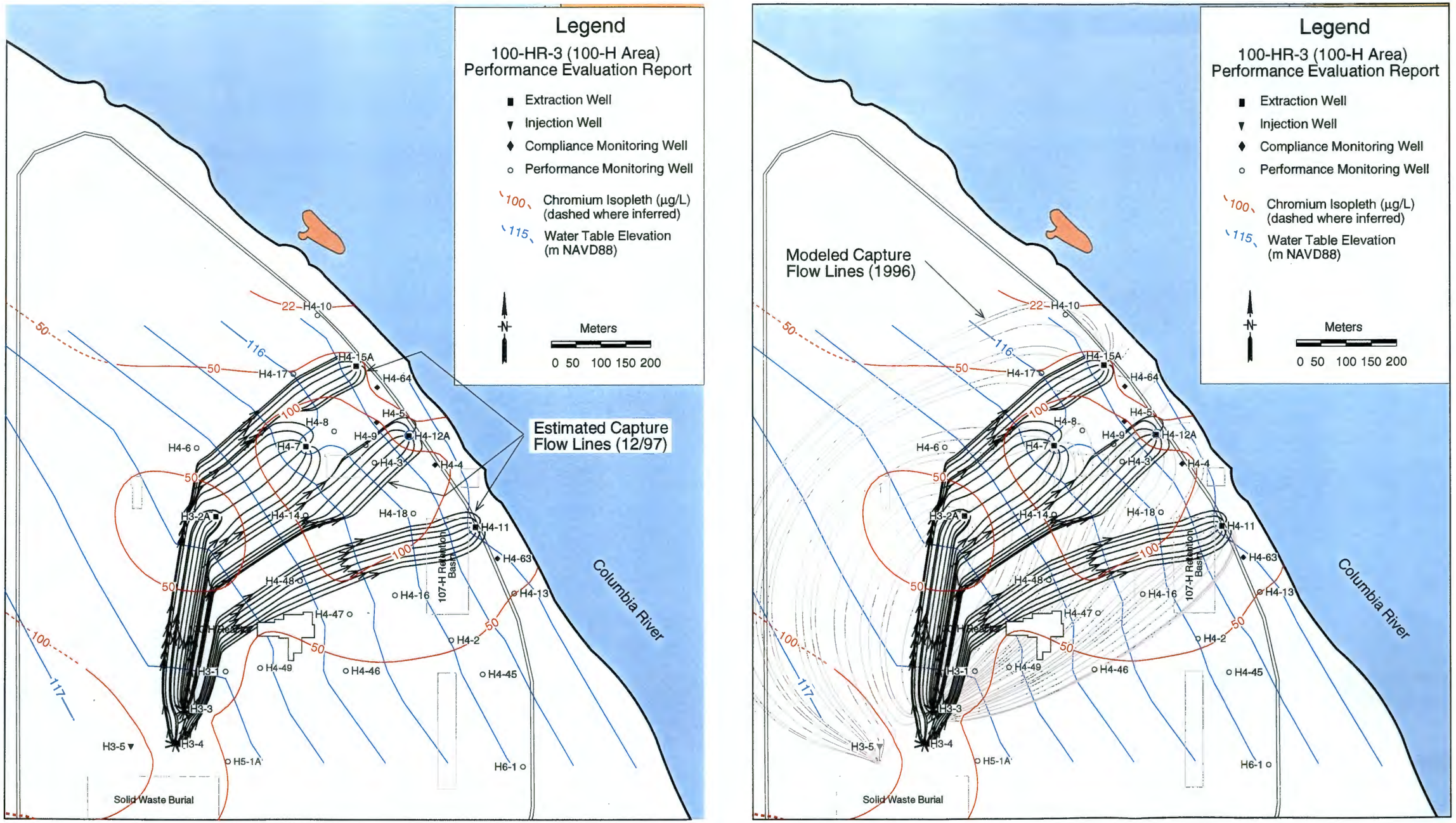


Figure 3-23. Hydraulic Capture Zone Developed by 100-HR-3 OU 100-H Area Extraction Wells and Comparison to Modeled Flow Lines from DOE-RL 1996.



THIS PAGE INTENTIONALLY
LEFT BLANK

Figure 3-24. Hydraulic Containment Developed by 100-HR-3 OU 100-H Area Extraction Wells.

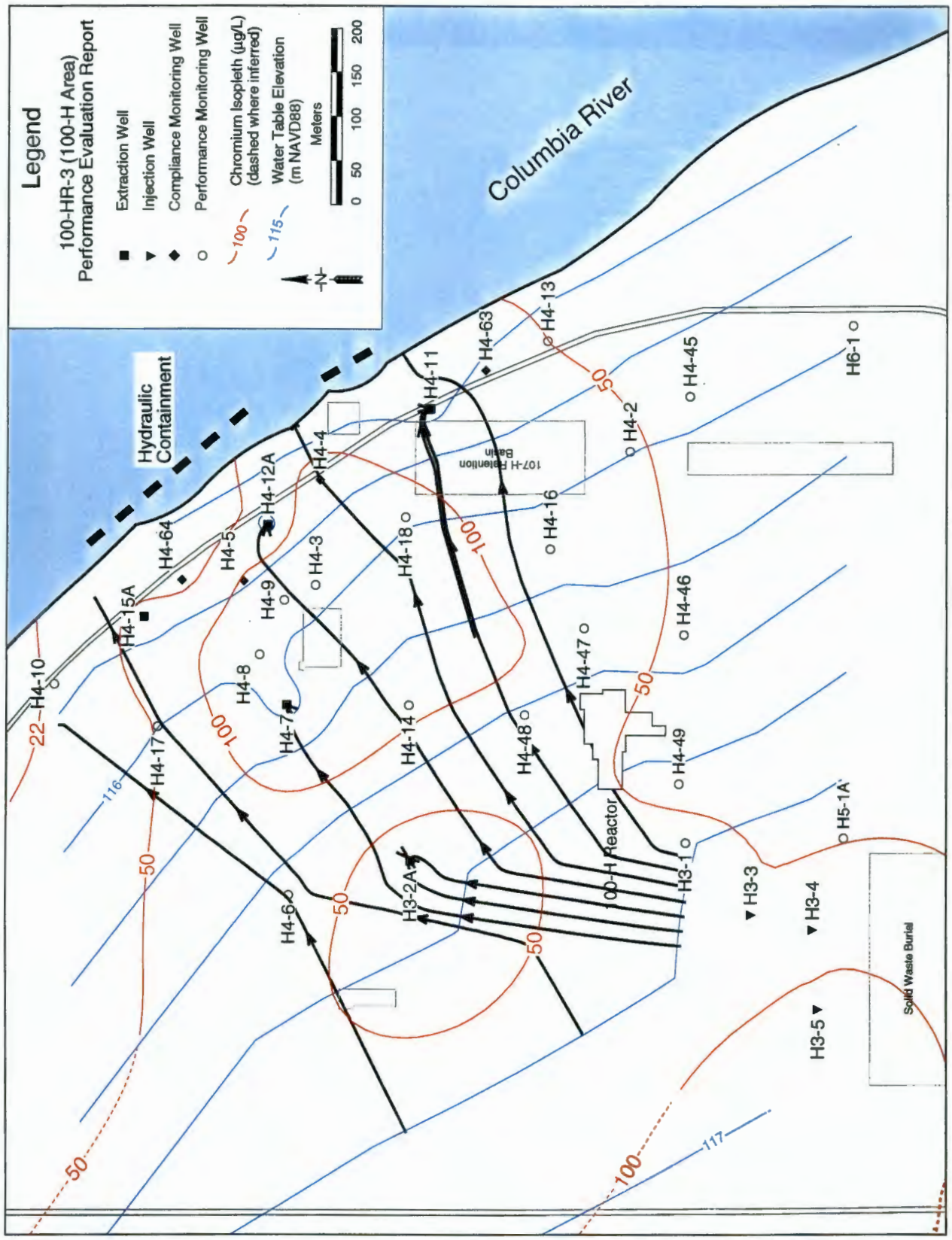
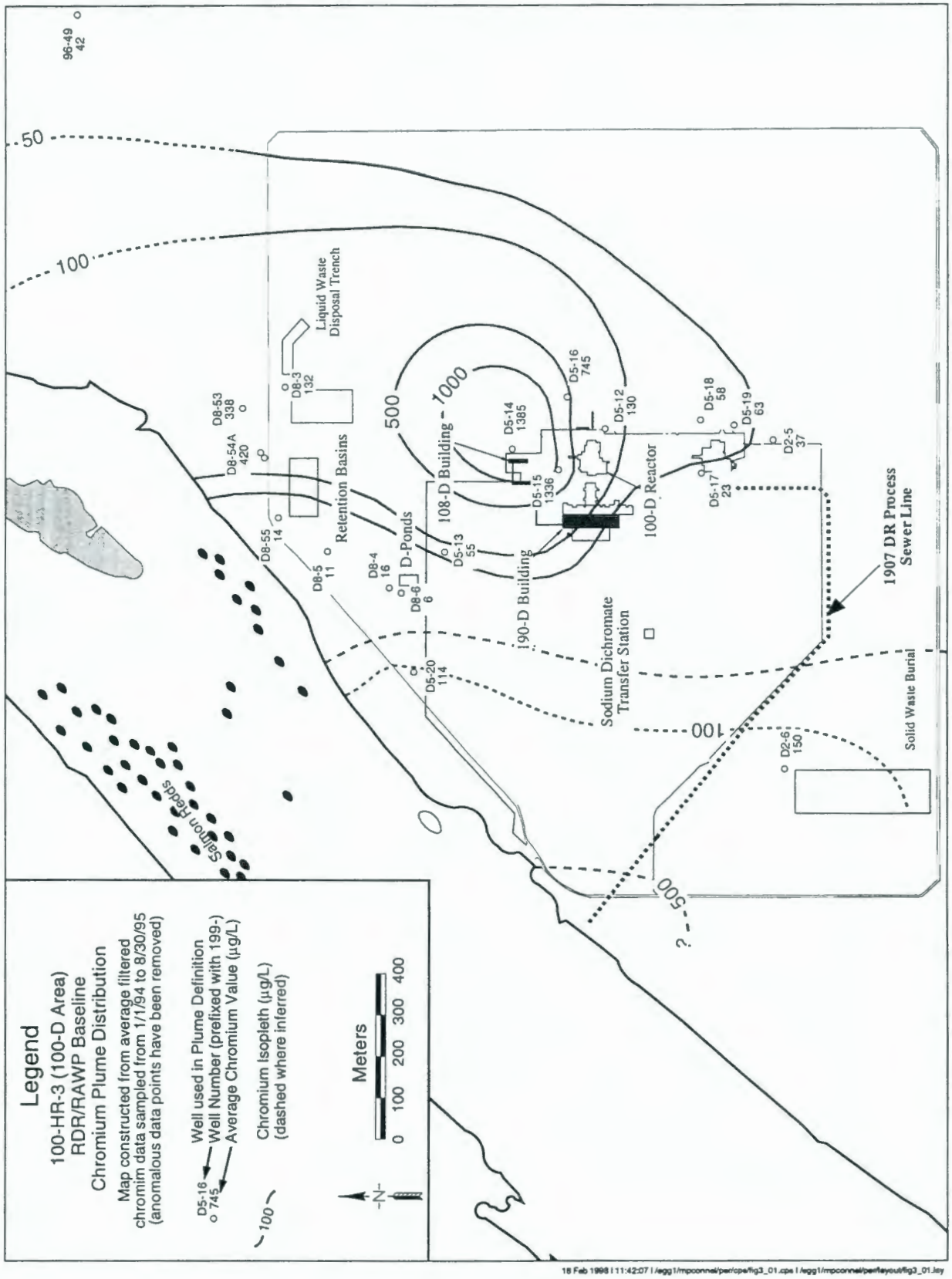
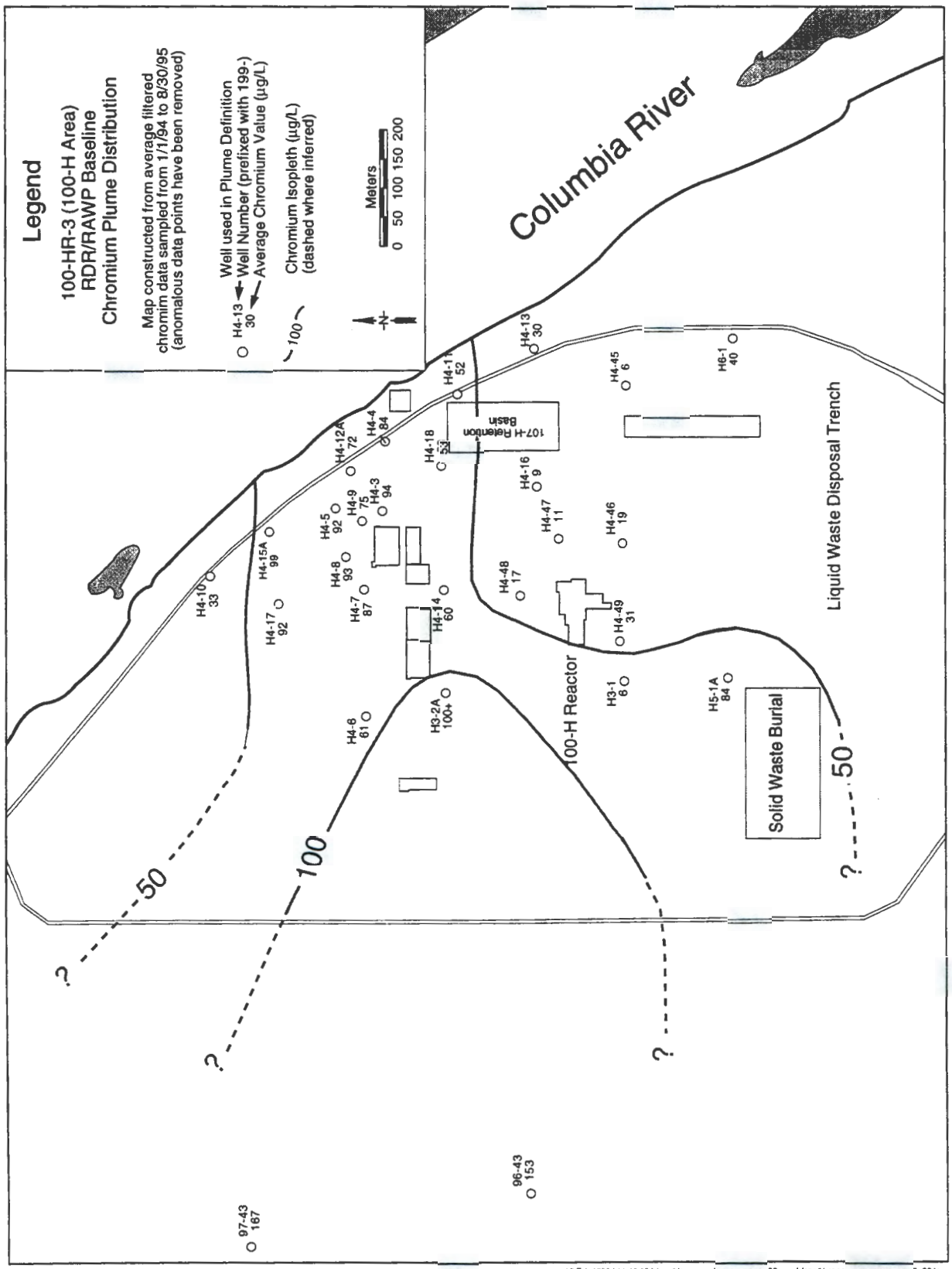


Figure 3-25. Baseline Chromium Distribution for the 100-D Area Taken From the RDR/RAWP.



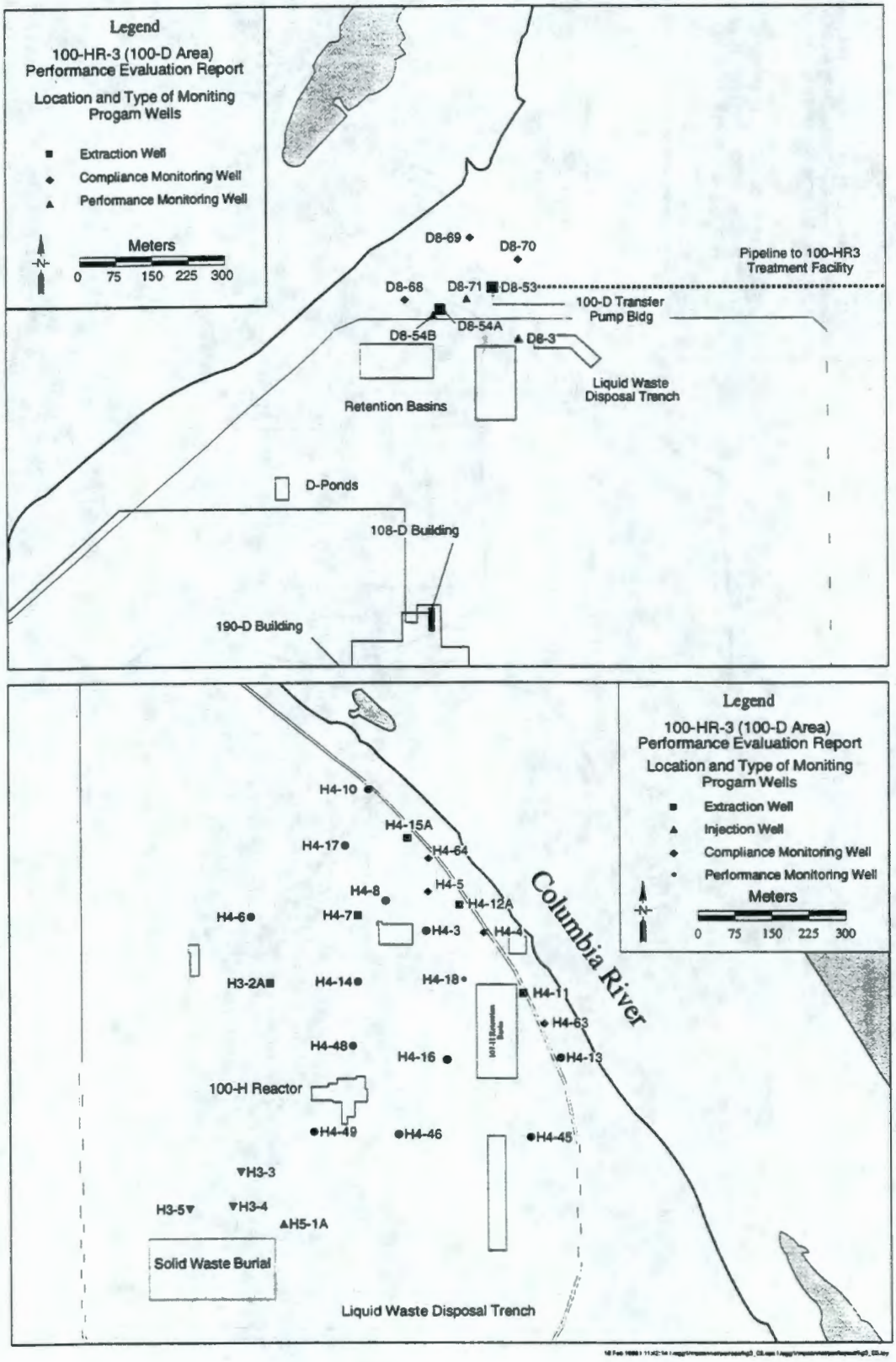
18 Feb 1998 I 11:42:07 I /egg1/mpconnel/per/cps/fig3_01.cps I /egg1/mpconnel/per/layout/fig3_01.lay

Figure 3-26. Baseline Chromium Distribution for the 100-H Area Taken From the RDR/RAWP.



18 Feb 1998 | 11:42:10 | /egg1/mpconnel/

Figure 3-27. Location Map Showing the Extraction Wells, Injection Wells, Compliance Monitoring Wells and Performance Monitoring Wells for the 100-HR-3 OU.



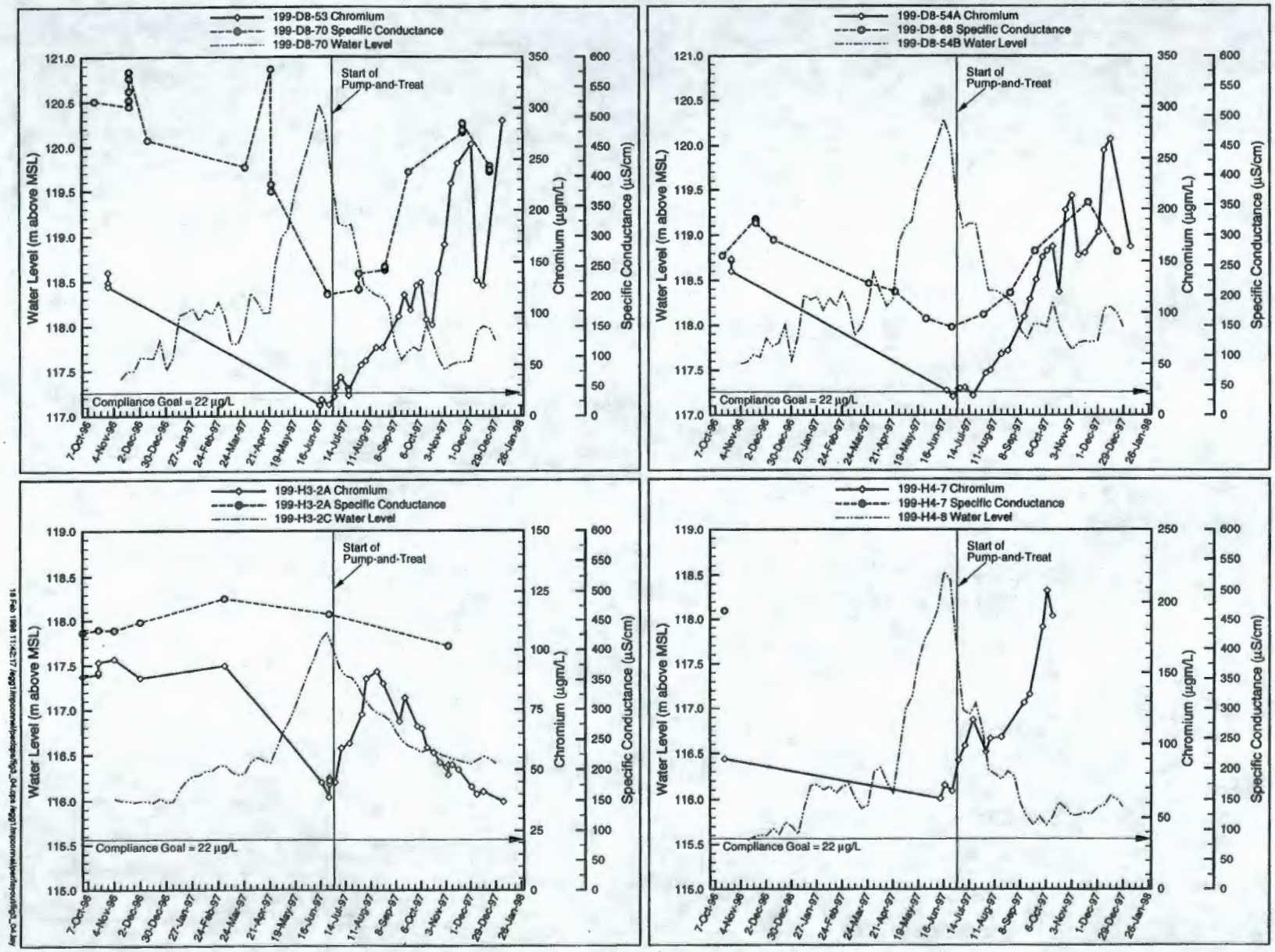


Figure 3-28. Trend Plots for Chromium Measured at the Extraction Wells 199-D8-53, 199-D8-54A, 199-H3-2A, and 199-H4-7.

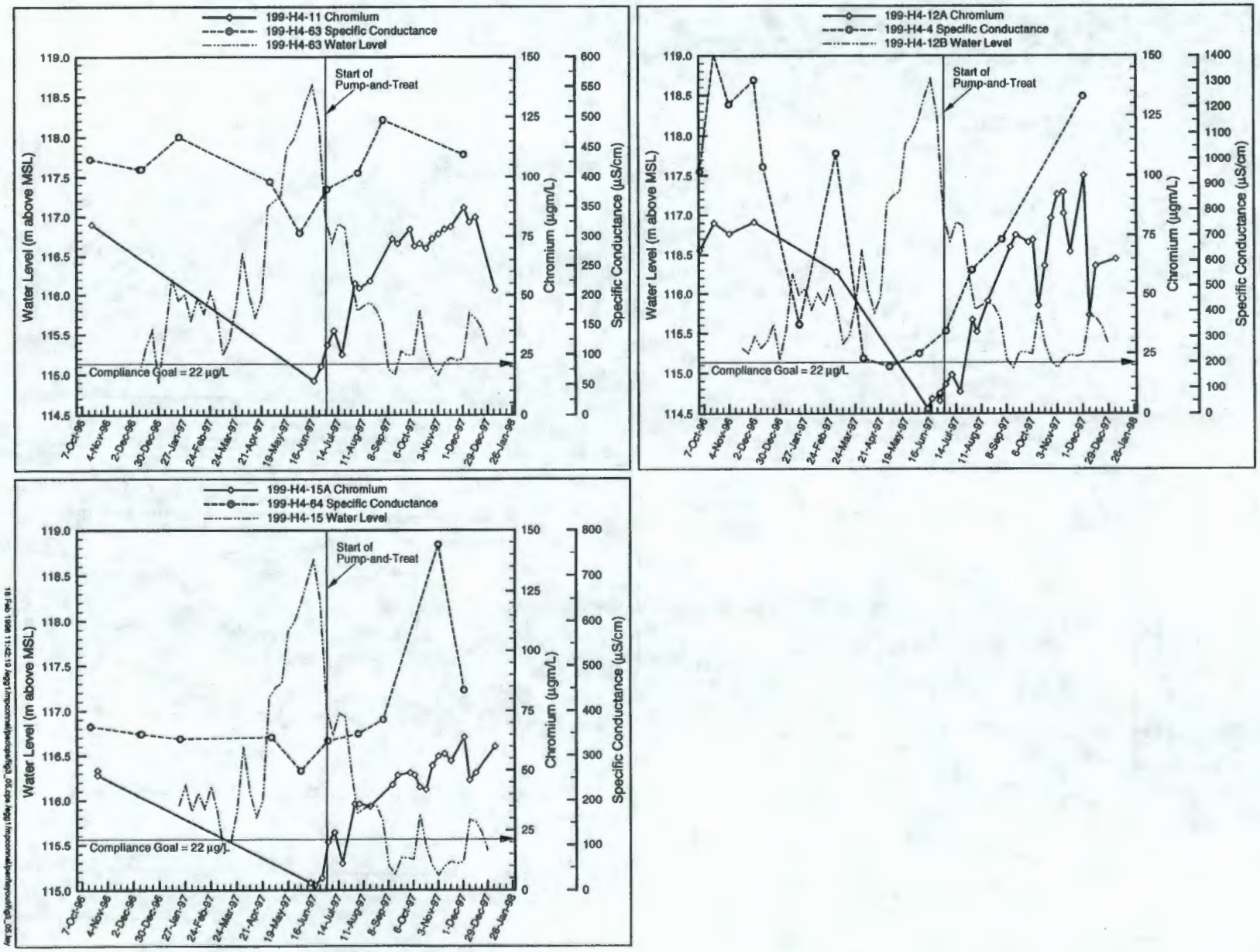


Figure 3-29. Trend Plots For Chromium Measured at the Extraction Wells 199-H-11, 199-H-12A, and 199-H4-15A.

Figure 3-30. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance Monitoring Wells 199-D8-68, 199-D8-69, and 199-D8-70.

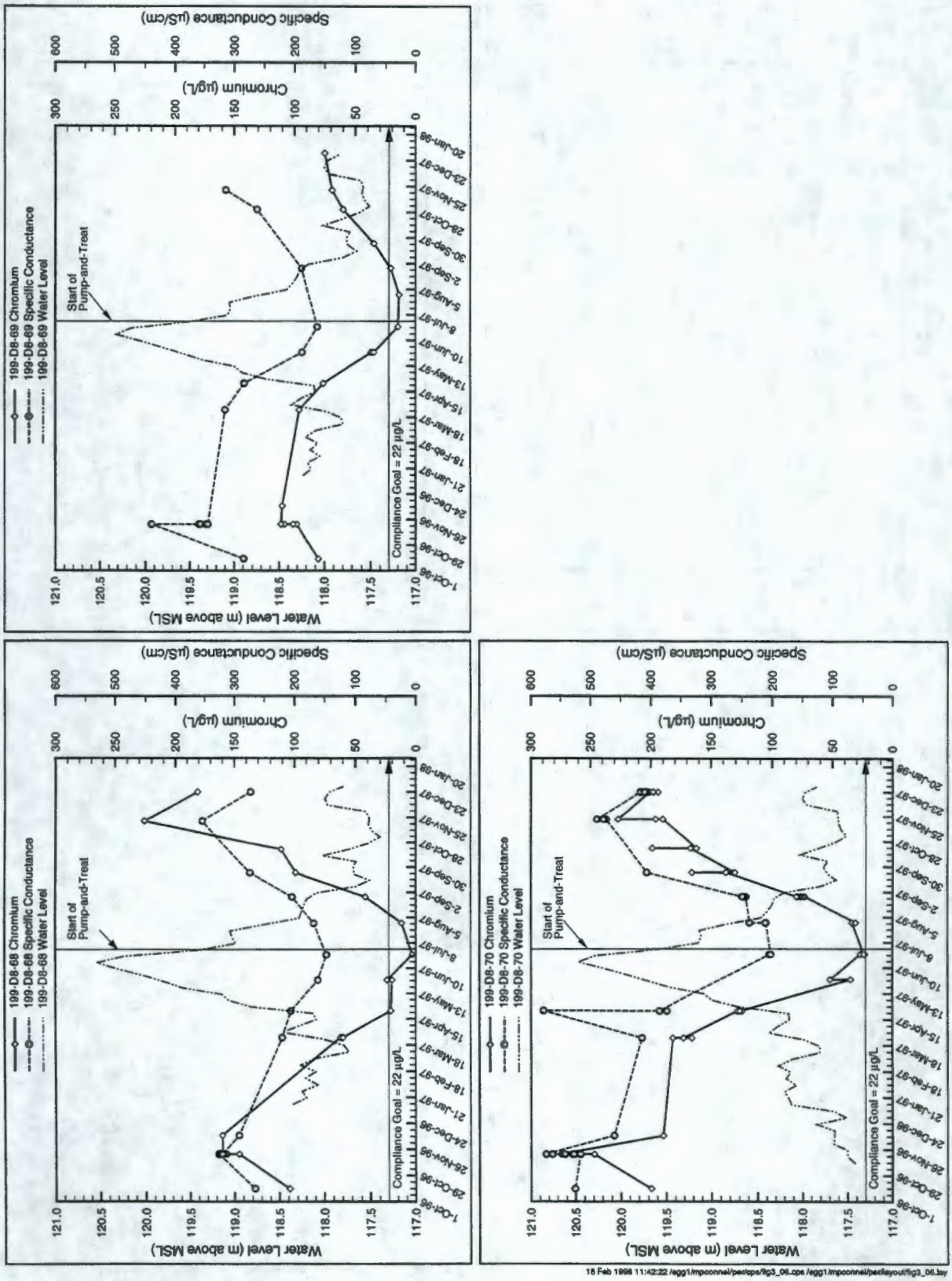


Figure 3-31. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance Monitoring Wells 199-H4-4, 199-H4-5, 199-H4-63 and 199-H4-64.

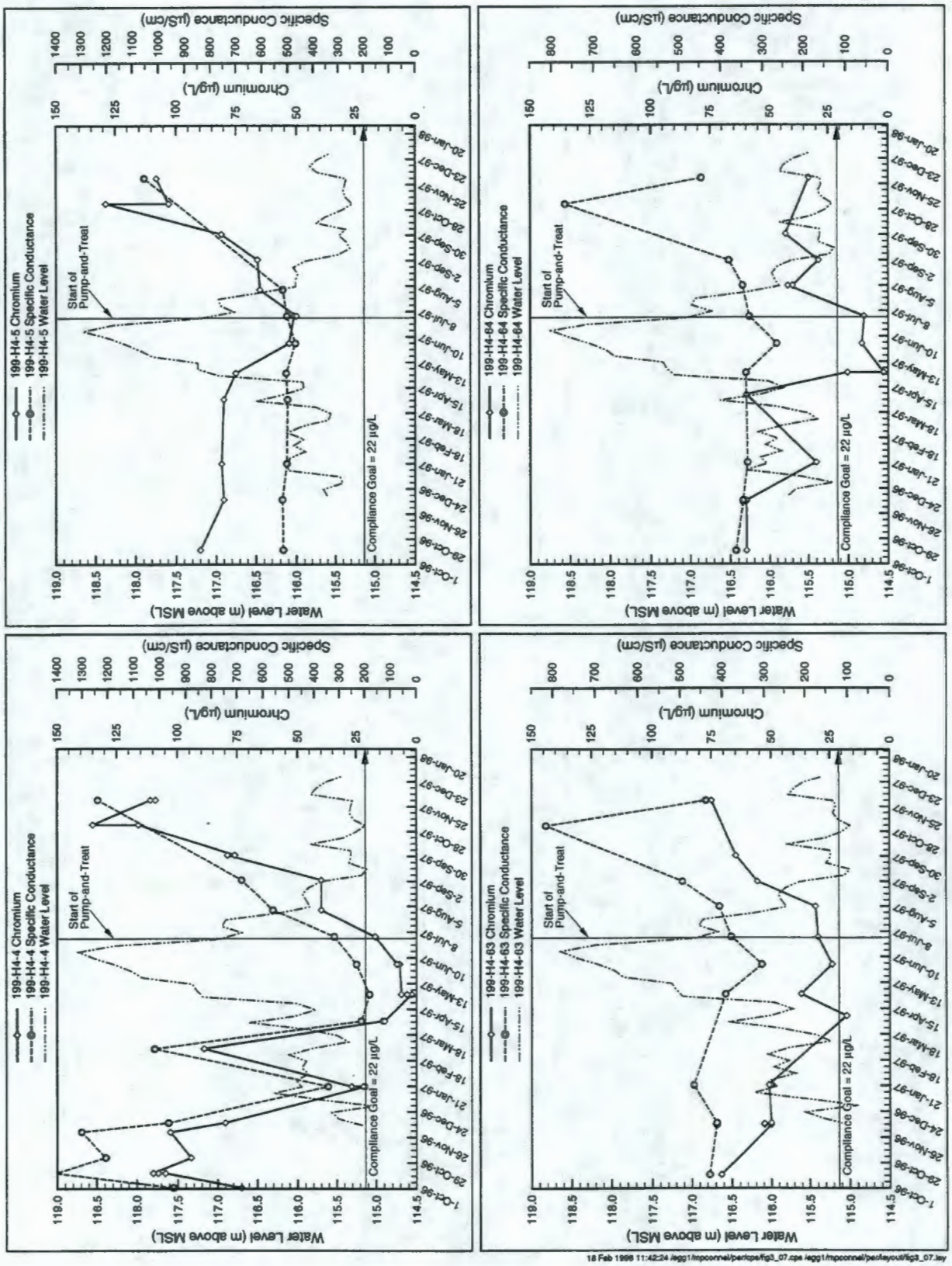


Figure 3-32. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Performance Monitoring Wells 199-D8-3, 199-D8-54B, and 199-D8-71.

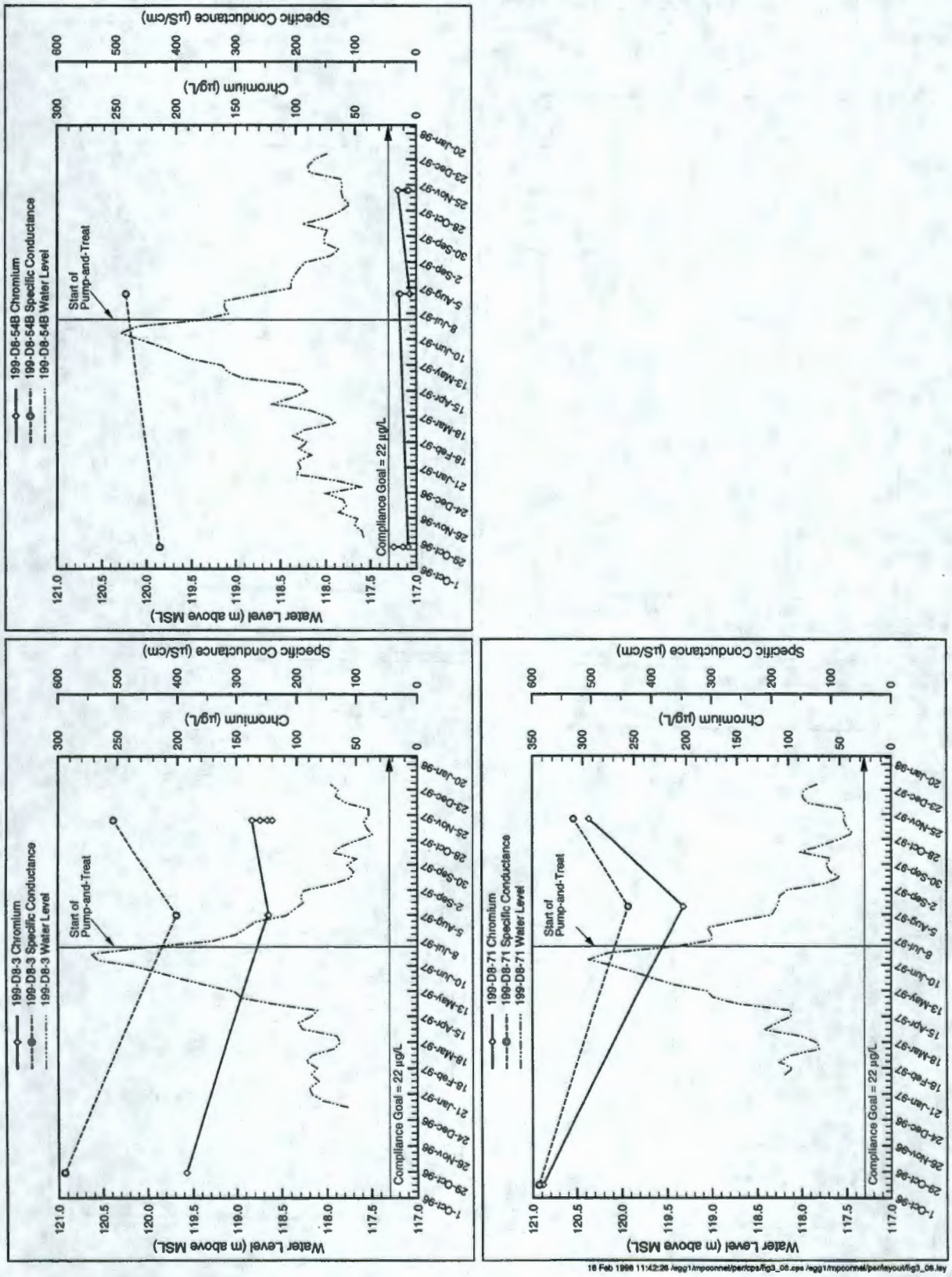


Figure 3-33. Trend Plots for Chromium and Specific Conductance Measured at the Performance Monitoring Wells 199-H4-3 and 199-H4-6. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Performance Monitoring Wells 199-H4-8 and 199-H4-10.

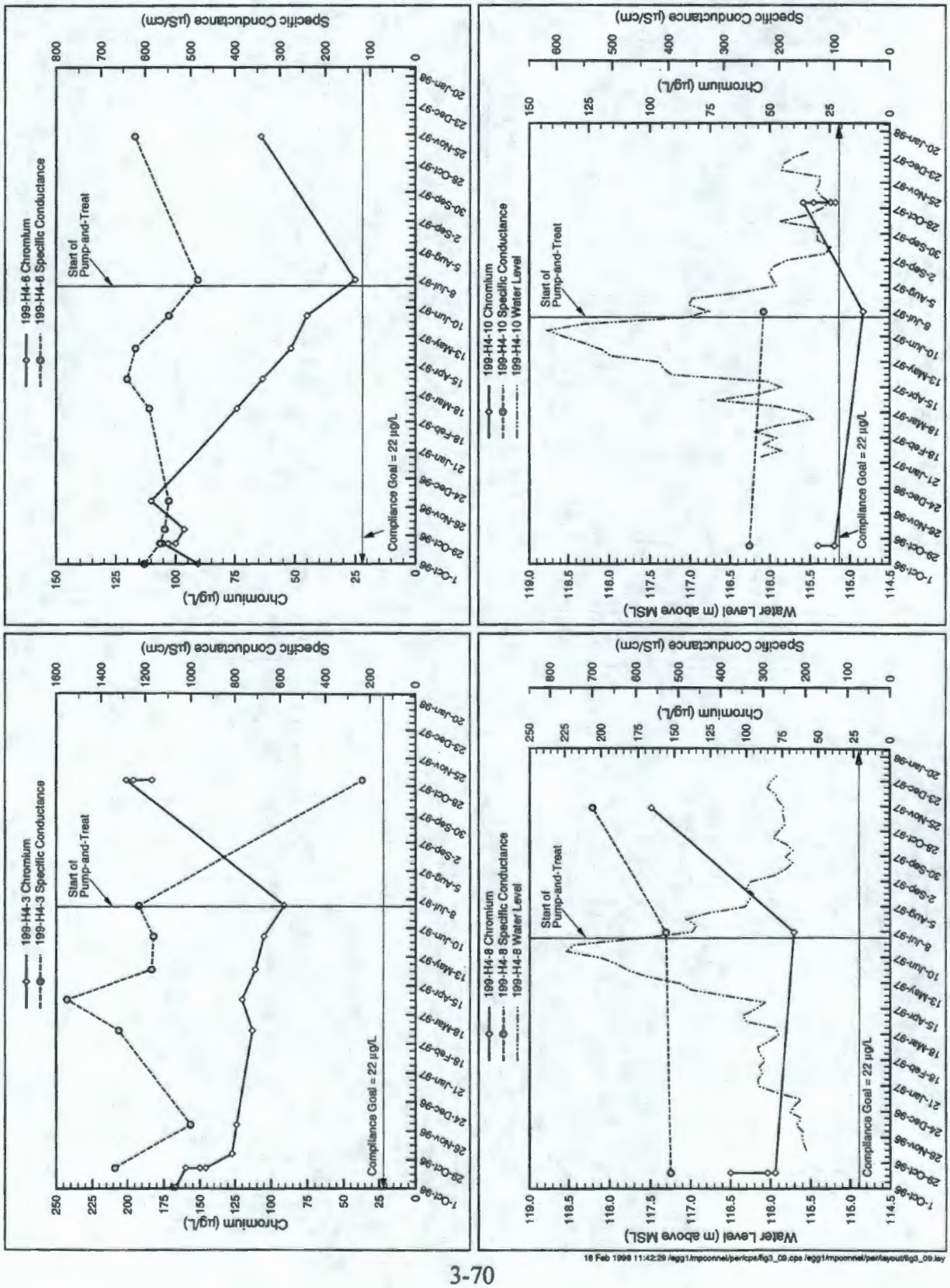
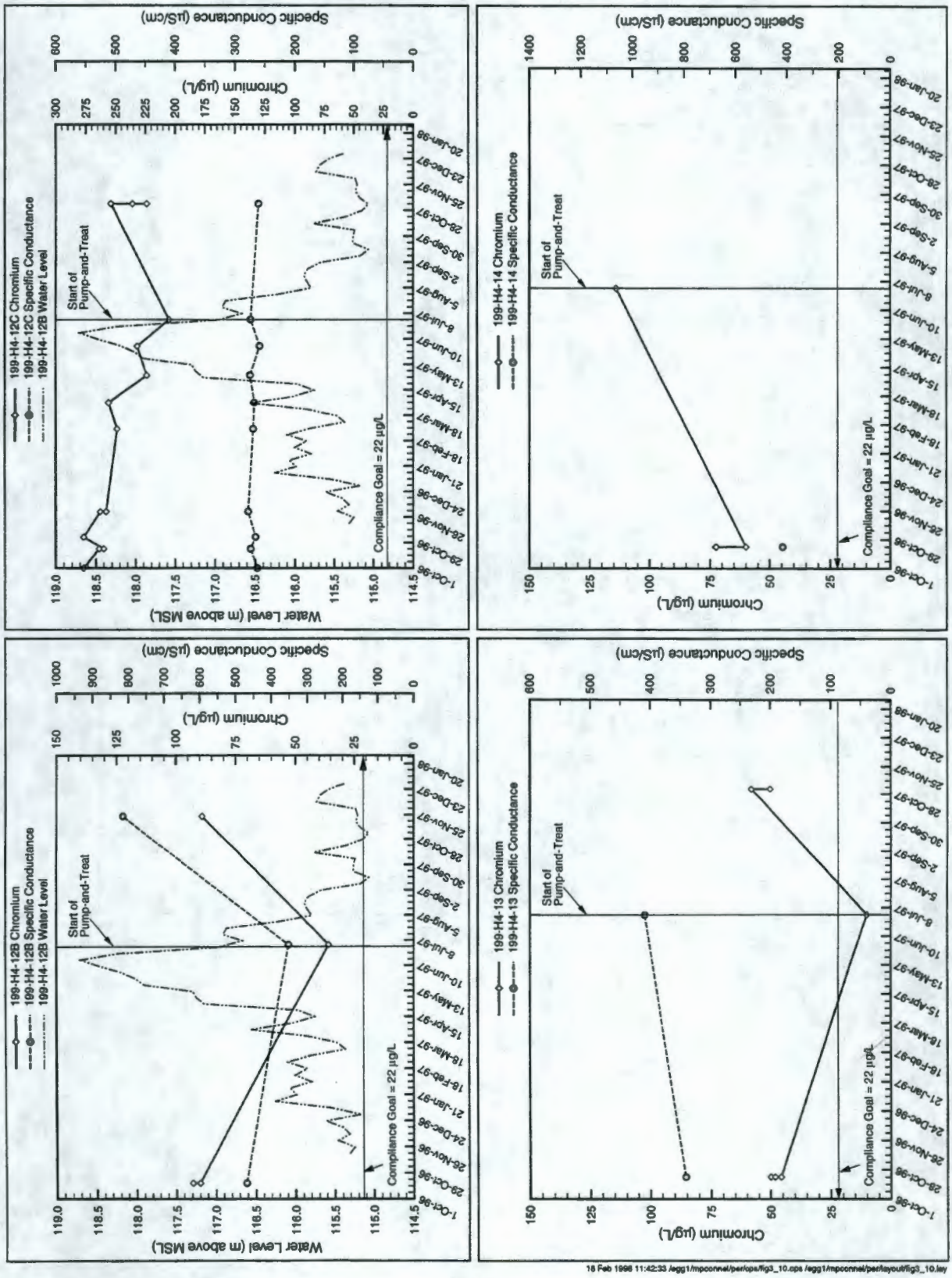


Figure 3-34. Trend Plots For Chromium, Specific Conductance and Average Weekly Water Elevation at Performance Monitoring Wells 199-H4-12B and 199-H4-12C. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-H4-13 and 199-H4-14.



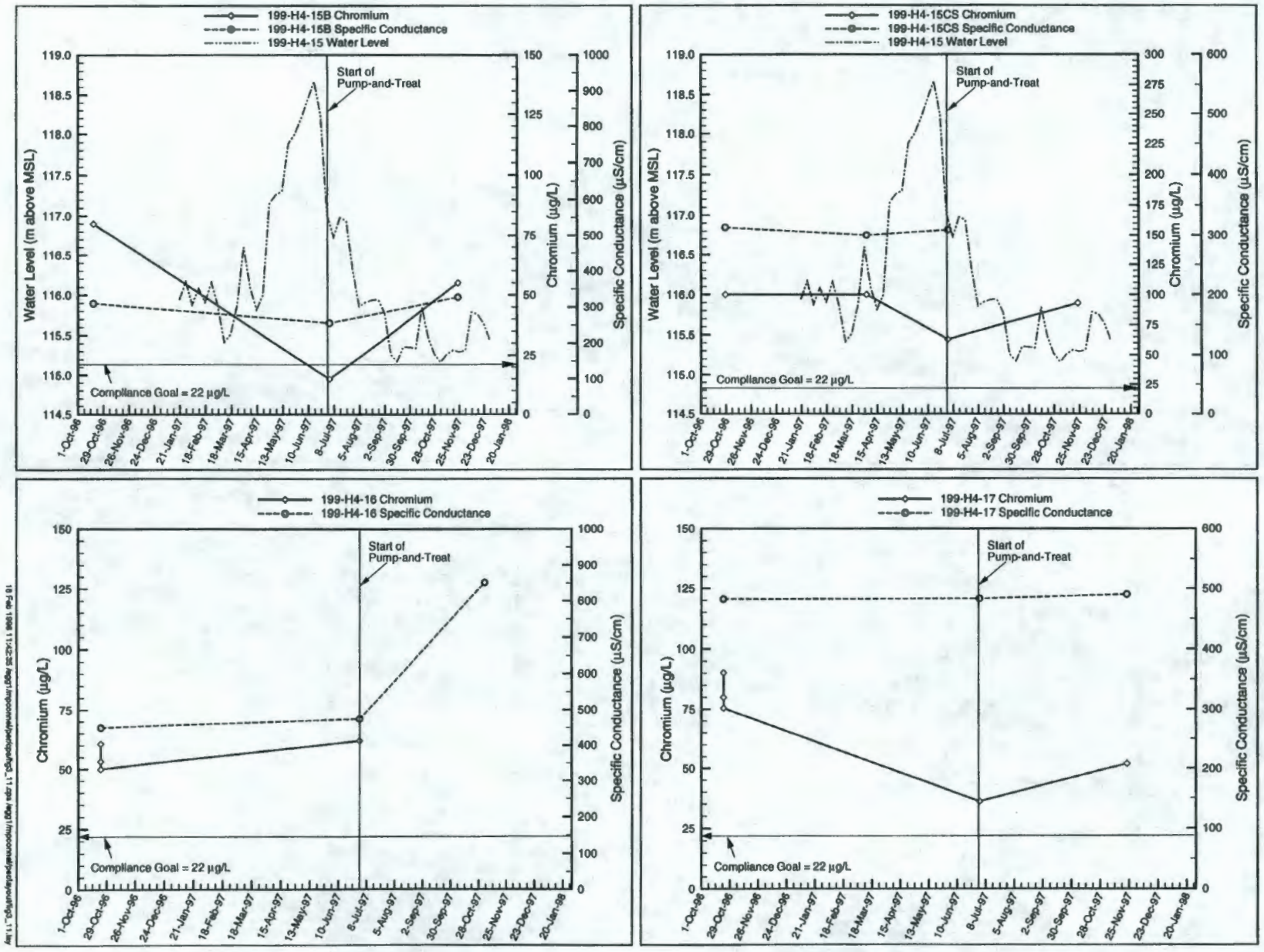


Figure 3-35. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation at Performance Monitoring Wells 199-H4-15B and 199-H4-15CS. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-H4-16 and 199-H4-17.

Figure 3-36. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-H4-18, 199-H4-45, 199-H4-46 and 199-H4-48.

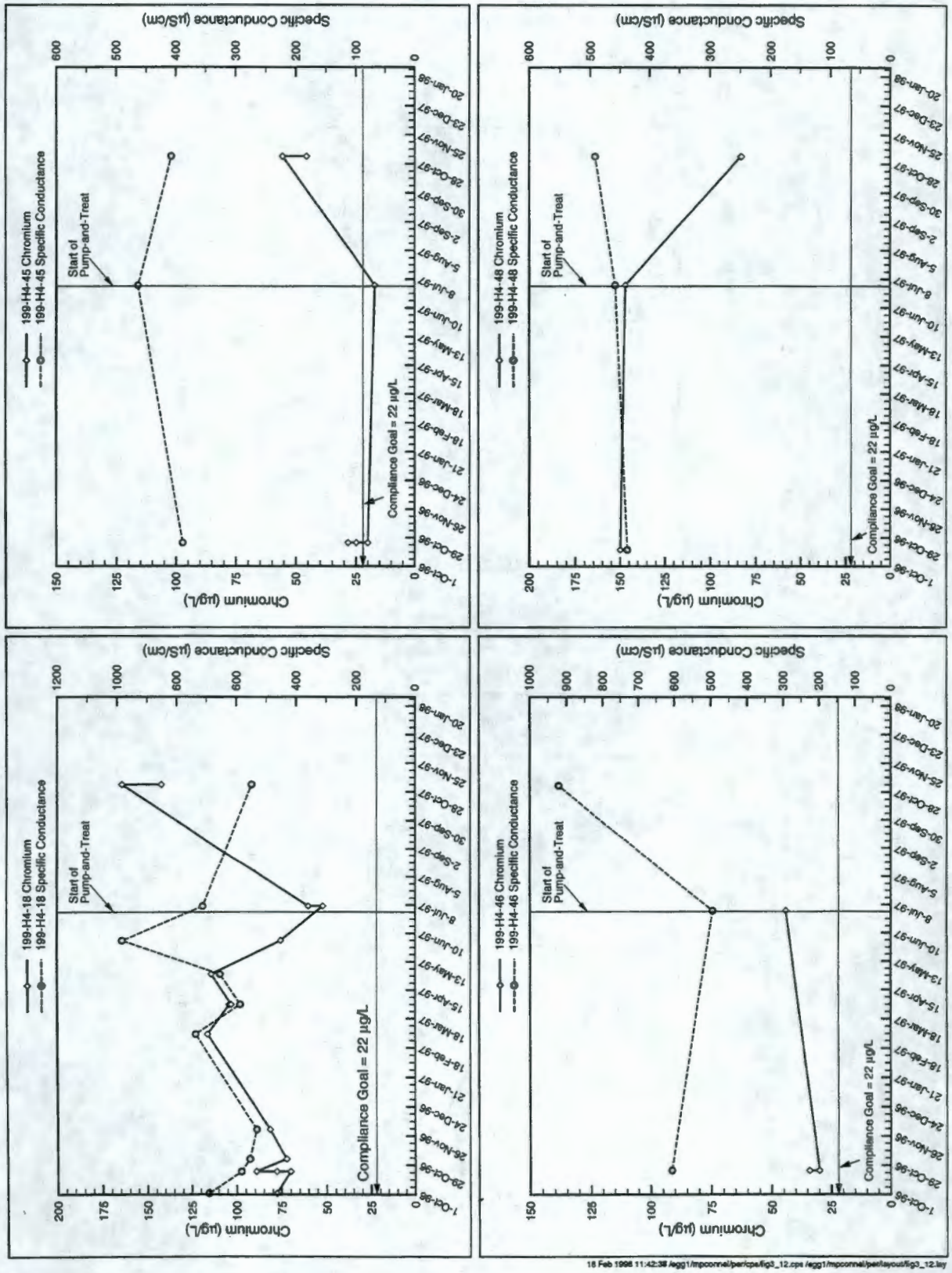
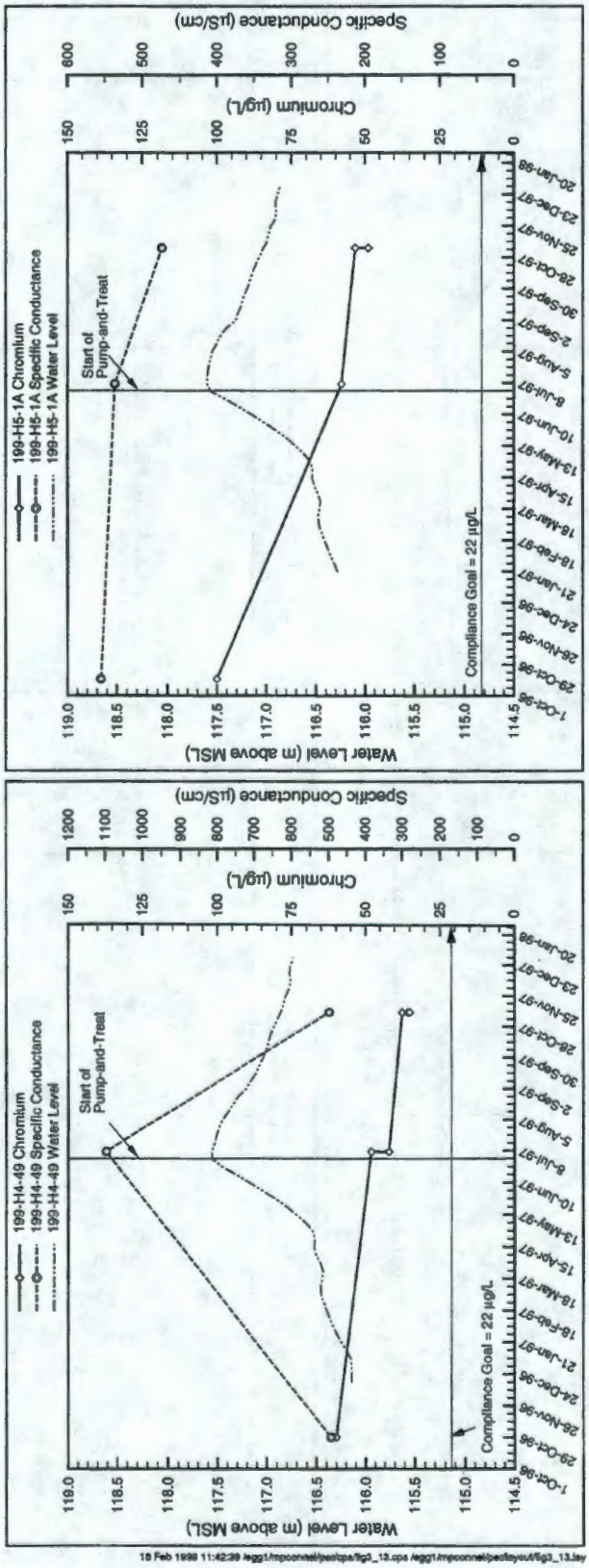


Figure 3-37. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Performance Monitoring Wells 199-H4-49 and 199-H5-1A.



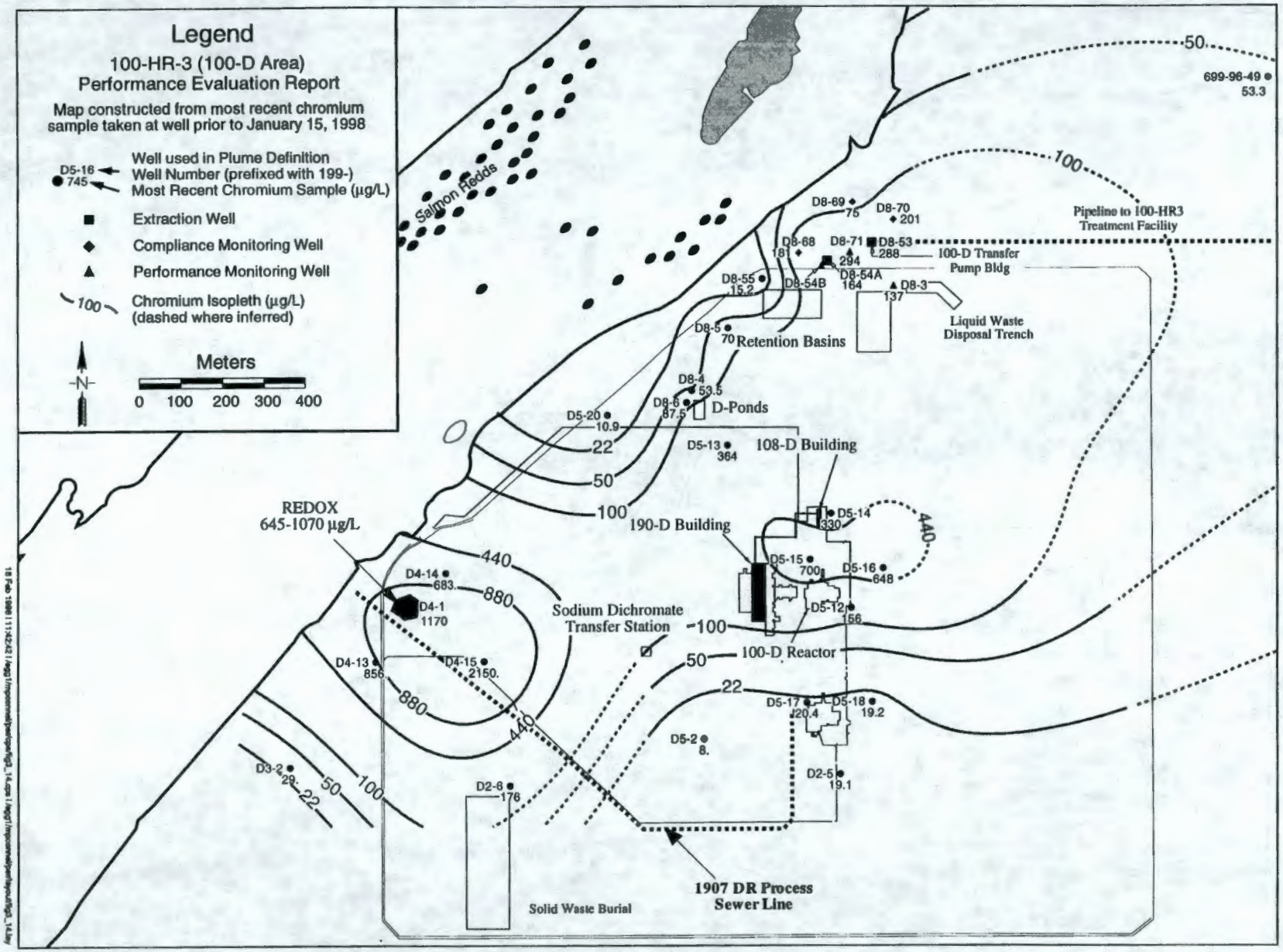


Figure 3-38. 100-D Area Chromium Plume Distribution for the Last Quarter of 1997.
(See Table 3-8 for List of Wells Used and Sampling Results).

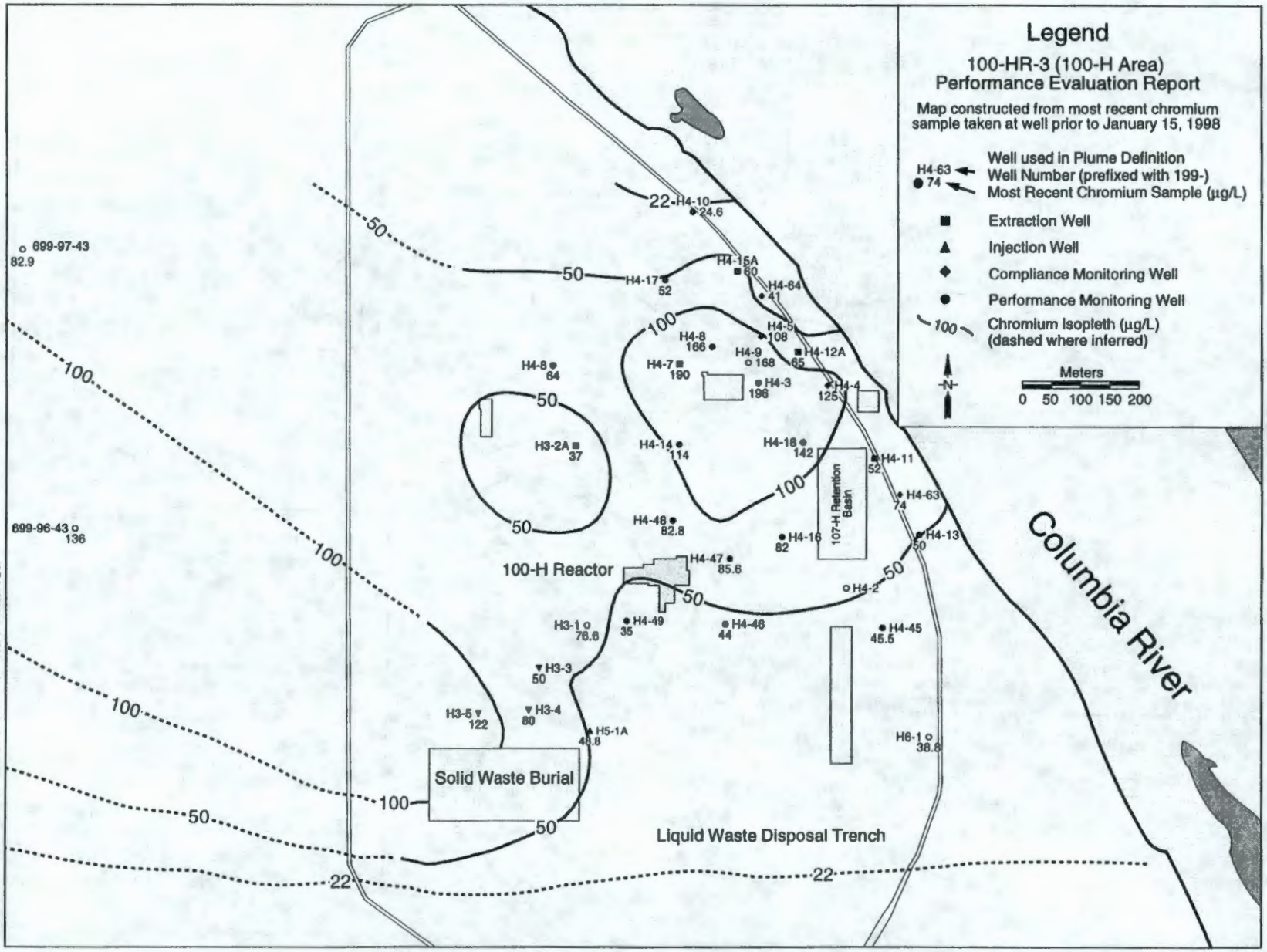


Figure 3-39. 100-H Area Chromium Plume Distribution for the Last Quarter of 1997.
(See Table 3-9 for List of Wells Used and Sampling Results).

Table 3-1. Extraction/Injection Well Identification and Rates.

Well Identification	Extraction/Injection Rates		Notes
	Original Estimate in L/min (gal/min)[a]	As of 1/1/98 in L/min (gal/min)[b]	
199-D8-53	151 (40)	79 (21)	D Area Extraction Well
199-D8-54A	151 (40)	83 (22)	D Area Extraction Well
199-H3-2A	151 (40)	184 (48)	H Area Extraction Well
199-H4-7	76 (20)	0 (0)	H Area Extraction Well
199-H4-11	38 (10)	76 (20)	H Area Extraction Well
199-H4-12A	38(10)	76 (20)	H Area Extraction Well
199-H4-15A	38 (10)	76 (20)	H Area Extraction Well
199-H3-3	757 (200)	165 (44)	Injection Well
199-H3-4	757 (200)	140 (37)	Injection Well
199-H3-5	757 (200)	183 (48)	Injection Well

[a] Data from the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*, DOE/RL-96-90 (DOE-RL 1997)
[b] Data from the *100-HR-3/100-KR-4 Project Specific Database*

Table 3-2. Extraction/Injection Well Operations.

Well Identification	Extraction/Injection Rates[a] in L/min (gal/min)			
	7/1/97	10/16/97	10/23/97	As of 1/1/98
199-D8-53	151 (40)	161 (43)	158 (42)	79 (21)
199-D8-54A	151 (40)	158 (42)	158 (42)	83 (22)
199-H3-2A	151 (40)	152 (40)	152 (40)	184 (48)
199-H4-7	105 (28)	0 (0)	0 (0)	0 (0)
199-H4-11	57 (15)	72 (19)	76 (20)	76 (20)
199-H4-12A	57 (15)	63 (17)	76 (20)	76 (20)
199-H4-15A	57 (15)	72 (19)	76 (20)	76 (20)
199-H3-3	298 (79)	265 (70)	260 (69)	165 (44)
199-H3-4	190 (50)	257 (68)	269 (71)	140 (37)
199-H3-5	196 (52)	162 (43)	162 (43)	183 (48)

[a] Data from the *100-HR-3/100-KR-4 Project Specific Database*

Table 3-3. IX Vessel Operational Data.

IX Vessel Identification [a]	Volume Processed at Breakthrough (liters)	Cr+6 Absorbed[b] at Breakthrough at 50 μg/L (grams)	Volume Processed at Final Realignment (liters)	Cr+6 Absorbed[b] at Final Realignment (liters)	Percent Saturation at Final Realignment
H-IX-A1-1 [c]	Offline prior to breakthrough		13,912,500	443	82%
H-IX-B1-1 [c]	Offline prior to breakthrough		14,313,500	446	25%
H-IX-A2-1	Offline prior to breakthrough		35,238,000	1100	42%
H-IX-B2-1	28,345,500	809	37,644,500	1085	75%
H-IX-A3-1	42,872,500	1028	48,174,500	1189	80%
H-IX-B3-1	43,405,000	1026	48,332,000	1174	67%
H-IX-A3-2 [c]	10,313,250	1028	12,875,500	1137	87%
H-IX-B3-2 [c]	10,918,800	1100	13,035,000	1200	56%
H-IX-A4-1	52,585,000	439	149,912,000	1161	78%
H-IX-B4-1	55,173,000	395	149,912,000	1226	75%
H-IX-A1-2	48,702,000	342	see note below	see note below	see note below
H-IX-B1-2	48,920,500	296	see note below	see note below	see note below
H-IX-A2-2	see note below	see note below	see note below	see note below	see note below
H-IX-B2-2	see note below	see note below	see note below	see note below	see note below
H-IX-A3-3	see note below	see note below	see note below	see note below	see note below
H-IX-B3-3	see note below	see note below	see note below	see note below	see note below
H-IX-A4-2	see note below	see note below	see note below	see note below	see note below
H-IX-B4-2	see note below	see note below	see note below	see note below	see note below

Note: Data for the IX vessel is not yet available, vessel operations have not yet reached this stage.

[a] The number following the vessel designation represents the batch of resin in the vessel at the time of resin replacement. For example, vessel H-IX-A1-1 is a vessel that has not had resin replaced (first batch), vessel H-IX-A1-2 is the same vessel, and has undergone resin replacement once (second batch). Vessels are listed in the order used based on the dates the vessels were online.

[b] Cr+6 Absorbed refers to the mass of hexavalent chromium absorbed by the vessel.

[c] Indicates a lead vessel only during operational life of the vessel. Vessel realignment did not occur for this IX vessel.

Table 3-4. Waste Designation Results for Used IX Resin.

Resin Source (vessel)	TCLP Results for Cr+6 (mg/L)	Nitrate (mg/kg)	Tritium (pCi/g)	Sr-90 (pCi/g)	Tc-99 (pCi/g)	U-233/234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
H-IX-A1-1	3.82	10000	0.77	0.016 U	420	0.23 J	0.016 J	0.16 J
H-IX-B1-1	2.67	92000	0.76	0.008 U	2300	13	1.7	10
H-IX-A2-1	3.54	12 U	1.5	0.0 U	650	0.22 J	0.022 J	0.20 J
H-IX-B2-1	3.29	120 U	1.7	0.0 U	280	0.35	0.25 J	0.03 J
H-IX-A3-1	3.41	2800	1.5	0.038U	16	0.075U	0.018U	0.11J
H-IX-B3-1	4.58	3200	1.6	-0.071U	17	0.11J	0.018U	0.094U
H-IX-A3-2	4.5	3.65	2.09	0.011 U	312	4.71	0.239	3.84
H-IX-B3-2	5.3	2.69	2.31	0.0493 U	600	21.5	1.34	16.3
H-IX-A4-1	2.7	4.42	1.98J	results pending	61.3	0/297	.00365U	0.221
H-IX-4-1	3.5	2.85	1.93J	results pending	7.6	0.-249U	0.00205U	0.0218U

U = analyte not detected or below instrument detection range
J = estimated value

Table 3-5. 100-HR-3 Pump-and-Treat System Interim Action Design and Operational Performance Against Criteria.

Requirements (Performance Criteria)	How Met?
Treatment system will reduce the effluent chromium concentrations of groundwater to the maximum extent practical. No chromium discharge above 50 μg/L.	The treatment system has reduced effluent concentrations to well below the 50 μg/L hexavalent chromium concentration limit. The chromium removal efficiency for the treatment system is 95%.
The extraction and injection system will be designed to run on an essentially continuous basis such that resin change out and maintenance can be conducted with minimal impact to system operations.	The system runs on essentially a continuous basis (88.9% availability). The system is winterized such that extended system outages due to frozen or broken components does not occur. Availability of the system will increase with the conclusion of startup activities and improvements in resin change out procedures.
The analyte list shall include hexavalent chromium, conductivity, and on an infrequent basis, co-contaminants.	Semi-annually, influent and effluent are sampled for hexavalent chromium, conductivity, and co-contaminants.
Design should provide flexibility following startup to accommodate changes in plume characteristics, or a different understanding of actual or perceived responses of the aquifer/plume to the pump-and-treat system.	Adjustable-frequency drive pumps provide for flexible pumping rates and additional pumping capacity to accommodate changes in plume characteristics.
Wastes generated during the remedial action shall be disposed of principally at ERDF, or at other on site or off site facilities as appropriate.	All waste management strategies (disposal at ERDF or CWC, or resin regeneration) fulfill the performance criteria for waste management.
The system shall be designed such that if one or several of the wells are down, the rest of the system can continue operating.	Each well has its own pump (extraction wells excluded), water level transducers, and well head assembly including pressure sensors, heat tracing, and flowmeters. Continued extraction/injection during well maintenance outages is fulfilled.

Table 3-6. Drawdown and Buildup Data and December 1997 Water Level in 100-HR-3 Extraction, Injection and Monitoring Wells.

	Time Frame	Pumping Rate (L/min)	Measured Drawdown(-)/ Buildup(+) (m)	Time Frame	Pumping Rate (L/min)	Measured Drawdown(-)/ Buildup(+) (m)
100-HR-3						
100 D Area Extraction Wells						
199-D8-53	11/5/97 - 11/8/97	138	-0.19	12/15/97 - 12/25/97	139	-0.22
199-D8-54A	11/5/97 - 11/8/97	137	-0.24	12/15/97 - 12/25/97	140	-0.23
100 H Area Near River Extraction Wells						
199-H4-11	10/21/97 - 10/25/97	75	-0.38	11/4/97 - 11/9/97	75	-0.36
199-H4-12A	10/21/97 - 10/25/97	76	-0.70	11/4/97 - 11/9/97	76	-0.80
199-H4-15A	10/21/97 - 10/25/97	76	-0.28	11/4/97 - 11/9/97	73	-0.26
100 H Area Inland Extraction Wells						
199-H4-7	9/11/97 - 9/15/97	103	-0.66			
199-H3-2A	9/11/97 - 9/15/97	151	-0.10	11/6/97 - 11/28/97	76	-0.06
100 H Area Injection Wells						
199-H3-3	11/6/97 - 11/12/97	177	0.08	11/29/97 - 12/1/97	178	0.08
199-H3-4	11/6/97 - 11/12/97	170	0.05	11/29/97 - 12/1/97	171	0.10
199-H3-5	11/6/97 - 11/12/97	204	0.07	11/29/97 - 12/1/97	205	0.05
100 D Area Observation Wells						
199-D8-71	11/5/97 - 11/8/97		-0.01	12/15/97 - 12/25/97		-0.03
100 H Area Observation Wells						
199-H4-12B	10/21/97 - 10/25/97		-0.05	11/4/97 - 11/9/97		-0.04
199-H4-15B	10/21/97 - 10/25/97		-0.06	11/4/97 - 11/9/97		-0.06
199-H4-8	9/11/97 - 9/15/97		-0.02			
199-H3-2B	9/11/97 - 9/15/97		-0.03	11/6/97 - 11/28/97		-0.04
199-H5-1A	11/6/97 - 11/12/97		0.01	11/29/97 - 12/1/97		0.02

100-HR-3 December 1997 Water Level Elevation

Well	Water Level Elevation (m NAVD88)	Well	Water Level Elevation (m NAVD88)	Well	Water Level Elevation (m NAVD88)	Well	Water Level Elevation (m NAVD88)
199-D8-53	117.85	199-D5-14	118.71	199-H3-3	116.92	199-H4-15B	116.69
199-D8-54A	117.85	699-97-51A	117.76	199-H3-4	116.87	199-H4-49	116.77
199-D8-68	118.01	699-96-49	117.93	199-H3-5	116.91	199-H4-63	115.63
199-D8-69	118.01			199-H3-2B	116.47	199-H4-64	115.75
199-D8-70	118.00	199-H3-2A	116.45	199-H4-4	115.69	199-H5-1A	116.91
199-D8-71	118.01	199-H4-7	116.13	199-H4-5	115.78	699-96-43	117.21
199-D8-3	117.99	199-H4-11	115.50	199-H4-8	116.03	699-97-43	117.24
199-D8-4	118.36	199-H4-12A	114.90	199-H4-10	115.75		
199-D5-13	118.46	199-H4-15A	115.51	199-H4-12B	115.62		

Table 3-7. 100-HR-3 Interim Remedial Action Monitoring Schedule.
Page 1 of 2

Sample Group	Pre-Startup October 1996 to March 1997			Startup April 1997 through June 1997			Operations July 1997 to End		
	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]
Extraction Wells									
D8-53	M	X	X	T	M	--	T	Q	SA
D8-54A	M	X	X	T	M	--	T	Q	SA
H3-2A	M	X	X	T	M	--	T	Q	SA
H4-7	M	X	X	T	M	--	T	Q	SA
H4-11	M	X	X	T	M	--	T	Q	SA
H4-12A	M	X	X	T	M	--	T	Q	SA
H4-15A	M	X	X	T	M	--	T	Q	SA
Injection Wells									
H3-3	M	X	X	T	--	--	T	--	--
H3-4	M	X	X	T	--	--	T	--	--
H3-5	M	X	X	T	--	--	T	--	--
Compliance Wells									
D8-68	T	Q	--	T	M	--	T	M	A
D8-69	T	Q	--	T	M	--	T	M	A
D8-70	T	Q	--	T	M	--	T	M	A
H4-4	T	Q	--	T	M	--	T	M	A
H4-5	T	Q	--	T	M	--	T	M	A
H4-63	T	Q	--	T	M	--	T	M	A
H4-64	T	Q	--	T	M	--	T	M	A
Performance Wells									
D8-3	T	X	--	T	--	--	T	SA	--
D8-54B	T	X	--	T	--	--	T	SA	--
D8-71	T	X	--	T	--	--	T	SA	--
H4-3	M	X	--	M	--	--	Q	SA	--
H4-6	M	X	--	M	--	--	Q	SA	--

Table 3-7. 100-HR-3 Interim Remedial Action Monitoring Schedule.
Page 2 of 2

Sample Group	Pre-Startup October 1996 to March 1997			Startup April 1997 through June 1997			Operations July 1997 to End		
	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]
H4-8	T	X	--	T	--	--	T	SA	--
H4-10	T	X	--	T	--	--	T	SA	--
H4-12B	T	X	--	T	--	--	T	SA	--
H4-12C	M	X	--	M	--	--	Q	SA	--
H4-13	M	X	--	M	--	--	Q	SA	--
H4-14	M	X	--	M	--	--	Q	SA	--
H4-15B	T	X	--	T	--	--	T	SA	--
H4-15CS	M	X	--	M	--	--	Q	SA	--
H4-16	M	X	--	M	--	--	Q	SA	--
H4-17	M	X	--	M	--	--	Q	SA	--
H4-18	M	X	--	M	--	--	Q	SA	--
H4-45	M	X	--	M	--	--	Q	SA	--
H4-46	M	X	--	M	--	--	Q	SA	--
H4-48	M	X	--	M	--	--	Q	SA	--
H4-49	T	X	--	T	--	--	Q	SA	--
H5-1A	T	X	--	T	--	--	Q	SA	--
H River	T	--	--	T	--	--	T	--	--
D River	T	--	--	T	--	--	T	--	--
Treatment System									
Influent	--	--	--	--	CM	--	--	CM	SA
Effluent	--	--	--	--	CM	--	--	CM	SA

[a] 100-H Area: Nitrate, strontium-90, technetium-99, tritium, and uranium 100-D Area: strontium-90 and tritium

Note: Field parameters: pH, temperature, specific conductance, and turbidity will be taken during sampling at all wells. Transducers may be eliminated and replaced with manual measurements during operations period.

D = Daily Q = Quarterly T = Transducer X = One-time event
M = Monthly SA=Semiannually A = Annually CM = Chromium Monitor (daily)

Table 3-8. Chromium Results Used to Make Chromium Distribution Map for the 100-D Area.

Well	Sample Number	CAS	Sampling Date	Chromium µg/L	Filtered
199-D2-5	B0KB75	7440-47-3	24-Apr-97	19.1	Y
199-D2-6	B0M8B5	7440-47-3	19-Nov-97	176	Y
199-D3-2	BOM116	7440-47-3	19-Sep-97	29	Y
199-D4-1	B0KB79	7440-47-3	28-Apr-97	1170	Y
199-D4-13	B0M118	7440-47-3	19-Sep-97	856	Y
199-D4-14	B0M164	7440-47-3	19-Sep-97	683	Y
199-D4-15	B0M166	7440-47-3	19-Sep-97	2150	Y
199-D5-12	B0M8D7	7440-47-3	25-Nov-97	156	Y
199-D5-13	B0M8D9	7440-47-3	19-Nov-97	364	Y
199-D5-14	B0M8F1	18540-29-9	19-Nov-97	330	Y
199-D5-15	B0M867	18540-29-9	19-Nov-97	700	Y
199-D5-16	B0M833	7440-47-3	19-Nov-97	648	Y
199-D5-17	B0M835	7440-47-3	18-Nov-97	20.4	Y
199-D5-18	B0JDT9	7440-47-3	5-Nov-96	19.2	Y
199-D5-2	PSDB		25-Jun-97	8	
199-D5-20	B0M841	7440-47-3	19-Nov-97	10.9	Y
199-D8-3	B0M845	7440-47-3	19-Nov-97	137	Y
199-D8-4	B0M847	7440-47-3	18-Nov-97	53.5	Y
199-D8-5	B0M849	7440-47-3	18-Nov-97	70	Y
199-D8-53	PSDB		6-Jan-98	288	
199-D8-54A	PSDB		6-Jan-98	164	
199-D8-55	B0M855	7440-47-3	19-Nov-97	15.2	Y
199-D8-6	B0M052	7440-47-3	23-Sep-97	87.5	Y
199-D8-68	B0MDL6	18540-29-9	23-Dec-97	181	Y
199-D8-69	B0MDL7	18540-29-9	31-Dec-97	75	Y
199-D8-70	B0MDM7	18540-29-9	23-Dec-97	201	Y
199-D8-71	B0M7Y1	18540-29-9	21-Nov-97	294	Y
699-96-49	B0JDY2	7440-47-3	24-Oct-96	53.3	Y
699-97-51A	B0M831	7440-47-3	6-Nov-97	31.5	Y

Table 3-9. Chromium Results Used to Make Chromium Distribution Map for the 100-H Area.

Well	Sample Number	CAS	Sampling Date	Chromium µg/L	Filtered
199-H3-1	B0M857	7440-47-3	5-Nov-97	76.6	Y
199-H3-2A	B0MPX8		6-Jan-98	37	
199-H3-3	B0JCL1	18540-29-9	25-Oct-96	50	N
199-H3-4	B0JCL3	18540-29-9	25-Oct-96	80	N
199-H3-5	B0JCS8	18540-29-9	25-Oct-96	122	N
199-H4-10	B0M863	7440-47-3	3-Nov-97	24.6	Y
199-H4-11	B0MPX9		6-Jan-98	52	
199-H4-12A	B0MPY0		6-Jan-98	65	
199-H4-13	B0M873	7440-47-3	3-Nov-97	50	Y
199-H4-14	B0LFR7	18540-29-9	1-Jul-97	114	Y
199-H4-15A	B0MPY1		6-Jan-98	60	
199-H4-16	B0LFT0	18540-29-9	1-Jul-97	62	Y
199-H4-17	B0M804	18540-29-9	23-Nov-97	52	Y
199-H4-18	B0M877	7440-47-3	4-Nov-97	142	Y
199-H4-2	B0LW76	7440-47-3	3-Sep-97	2.7	Y
199-H4-3	B0M9T6	7440-47-3	3-Nov-97	196	Y
199-H4-4	B0MLM2	18540-29-9	5-Jan-98	125	Y
199-H4-45	B0M883	7440-47-3	4-Nov-97	45.5	Y
199-H4-46	B0LFT6	18540-29-9	2-Jul-97	44	Y
199-H4-47	B0M885	7440-47-3	5-Nov-97	85.6	Y
199-H4-48	B0M887	7440-47-3	4-Nov-97	82.8	Y
199-H4-49	B0M812	18540-29-9	10-Nov-97	35	Y
199-H4-5	B0MLM3	18540-29-9	5-Jan-98	108	Y
199-H4-6	B0M813	18540-29-9	23-Nov-97	64	Y
199-H4-63	B0MLM4	18540-29-9	5-Jan-98	74	Y
199-H4-64	B0MLM6	18540-29-9	5-Jan-98	41	Y
199-H4-7	B0M464		13-Oct-97	190	
199-H4-8	B0M814	18540-29-9	23-Nov-97	166	Y
199-H4-9	B0M894	7440-47-3	4-Nov-97	168	N
199-H5-1A	B0M895	7440-47-3	5-Nov-97	48.8	Y
199-H6-1	B0M897	7440-47-3	4-Nov-97	38.8	Y
699-96-43	B0JDQ4	7440-47-3	24-Oct-96	136	Y
699-97-43	B0M8B3	7440-47-3	6-Nov-97	82.9	Y

Table 3-10. 100-H Area Monitoring Wells with Groundwater Having Co-Contaminants Exceeding the Relevant Standard.

Co-Contaminant Standard → Standard Value → Well ↓	Nitrate Wa GWQ = 45,000 μg/L	Sr-90 Wa GWQ = 8 pCi/L	Tc-99 Hanford 900 pCi/L	Uranium Hanford 59 μg/L
199-H4-3	230,193		2,080	226
199-H4-4	522,362	10.8	1,640	113
199-H4-5	347,946		1,130	
199-H4-7	540,069		2,080	106
199-H4-11	108,900	26.1		
199-H4-12A	187,253		524*	
199-H4-13	67,287	32.4		
199-H4-16		10.4		
199-H4-18	224,439			
199-H4-45	45,153			
199-H4-46	58,876			
199-H4-49	54,450			
199-H4-63	72,378	51.2		
199-H4-64	50,002			

*Included because it is an extraction well and there is a Tc-99 problem.

Table 3-11. Quality Control and Quality Assurance for 100-HR-3 OU Chromium.

FIELD SCREEN REPLICATES						
Well Number	**199-H4-12A**		**199-H4-4**		**199-H4-10**	
Sample Number	BOMC91	BOMD22	BOM331	BOM332	BOM7Y2	BOM7Y3
Hex Chrome (mg/L)	0.083	0.084	0.076	0.079	0.018	0.018
Well Number	**199-H4-12C**		**199-H4-4**		**199-D8-3**	
Sample Number	BOM7Y5	BOM7Y6	BOMDL9	BOMDM0	BOM824	BOM825
Hex Chrome (mg/L)	0.232	0.231	0.109	0.111	0.124	0.12
	FIELD SCREEN/OFF SITE LAB SPLITS					
Well Number	**199-H4-12A**		**199-D8-68**		**199-H4-63**	
Sample Location	Field	Laboratory	Field	Laboratory	Field	Laboratory
Sample Number	BOMC91	BOMD21	BOM5B4	BOM5B5	BOMDM2	BOMDM3
Hex Chrome (mg/L)	0.083	0.093	0.111	0.108	0.075	0.044
Well Number	**199-H4-13**		**199-H4-3**		**199-D8-54B**	
Sample Location	Field	Laboratory	Field	Laboratory	Field	Laboratory
Sample Number	BOM7Y7	BOM7Y8	BOM806	BPM807	BOM826	BOM827
Hex Chrome (mg/L)	0.047	0.052	NA	0.209	0.005	U

Table 3-12. Quality Control and Quality Assurance for 100-HR-3 OU Co-Contaminants.

	OFF SITE LAB REPLICATES	
Well/Seep Number	199-H4-12A	
Sample Number	BOMC90	BOMD23
Sr-89/90 (pCi/L)	0.742	0.748
H-3 (pCi/L)	1670	1550
Tc-99 (pCi/L)	665	657
Ur (total) µg/L	54.8	55.3
Hex Chrome (µg/L)	--	--
Gross alpha (pCi/L)	--	--
Gross beta (pCi/L)	--	--
N03-N	--	--

4.0 100-KR-4 GROUNDWATER INTERIM ACTION

4.1 Pump-and-Treat Operations

This section describes the design and operation of the 100-KR-4 pump-and-treat system. Also presented is an evaluation of the treatment system with respect to the RAOs and performance criteria identified in Table 2-1. The evaluation is based on approximately four months of performance monitoring data that has been collected during the operation of the pump-and-treat system. Data are stored and maintained in the 100-HR-3/100-KR-4 Project-Specific Database.

4.1.1 Facility and Well Design

The pump-and-treat system consists of extraction and injection wells, treatment modules, and the balance of plant equipment. A schematic of the treatment system, extraction wells, and injection wells is included in Figure 3-1 and Figure 4-1. Groundwater is withdrawn from the aquifer at the extraction wells, pumped to the treatment facility where chromium is removed, and then injected into an upgradient portion of the aquifer.

4.1.1.1 Treatment System. The main components of the treatment system are process tanks, pumps, IX treatment skids, and piping and electrical/control systems. Feed pumps pump contaminated water from the effluent storage tank, through the IX system and into the effluent storage tank. Four of six extraction wells discharge to either one of two 11,400-L storage tanks located at the transfer station buildings. Each transfer tank has a transfer pump which delivers extracted water to a 11,400-L influent storage tank at the treatment facility. Wells 199-K-116A and 199-K-118A discharge directly to the influent storage tank. The treatment facility is located in a new metal, pre-engineered building.

The treatment system is sized for a maximum processing rate of 757 L/min. An IX process is used to remove chromium from extracted groundwater. Two separate IX skids, each with 379 L/min capacity, are housed in the 100-KR-4 Treatment Building. The IX skids are referred to as K-IX-A and K-IX-B. Each IX skid consists of four IX vessels in a series. The vessels are identified by numbers 1 through 4. The four vessels are connected with piping and valves that allow a combination of three or four vessels to be in service at one time. In the four-vessel IX skid configuration, water passes through a lead vessel, first lag vessel, second lag vessel, and into the polishing vessel before discharge. In the three-vessel IX skid configuration, water passes through a lead vessel, a single lag vessel, and into a polishing vessel before discharge. Each vessel holds 2.3 m^3 of Dowex™ 21K IX resin. At peak system flows, the residence time in each IX vessel is approximately 6 minutes. Currently, both K-IX-A and K-IX-B are online and processing at 69% capacity.

Flowmeters are used to monitor the flow from each extraction well, through each IX skid, and into each injection well. Sample points are available for collecting process samples

from each extraction well, the combined influent to the IX vessels, effluent from each IX vessel, and the combined process effluent from the treatment system (water ready for injection). Adjustable-frequency drive pumps provide adjustable pumping rates and pumping capacity. This fulfills the performance criteria specifying that the system be flexible enough to accommodate changes in plume characteristics.

Exposed components of the system are heat traced and insulated to prevent freezing. The exception to this is the HDPE pipe used to transport water. HDPE pipe is not subject to damage due to freezing. The IX treatment skids are housed in the heated 100-KR-4 Treatment Building, which protects the treatment system from the elements. This design satisfies the performance criterion requiring the pump-and-treat system to be winterized such that extended system outages, due to components broken by freezing, do not occur.

The pump-and-treat control system consists of three PLCs and radio telecommunications equipment to automatically control the well pumps and treatment system. Process control is based on water levels, flowrates, and other process monitoring information that is monitored by the PLCs. The PLCs are located in the two transfer pump stations and the 100-KR-4 Treatment Building. The PLCs are controlled through an OIC located at the 100-KR-4 Treatment Building. The OIC is the man/machine interface between the operators and the pump-and-treat system. Through the OIC, the operators can set the operation parameters for the equipment; monitor the status of all tanks, pumps, and alarms; and review/store historical data on the treatment system operations.

4.1.1.2 Extraction/Injection System. Groundwater extraction systems are installed on the northwest side of the 116-K-2 Mile Long Liquid Disposal Trench in the 100-K Reactor Area. These systems discharge to the treatment facility on the southeast side of the 116-K-2. All treated groundwater is injected in an area of the aquifer south of the treatment facility. Each extraction/injection well is designed to be operated independently of the others. Each well has its own pump (injection wells excluded), water level transducers, and well head assembly including pressure sensors, heat tracing, and flowmeters. In this way, the performance criterion for continued extraction/injection during well maintenance outages is fulfilled.

Wells are constructed with DN150 (6-in. diameter) stainless steel well screens and riser casing. The final well screen and riser casing lengths have been determined from site-specific conditions. Well screens straddle the full saturated thickness of the aquifer present, allowing for increases to average high-level conditions. Extraction wells are equipped with approximately 14 m of well screen and 11 to 17 m of riser casing. Extraction well pump intakes are typically set 10 to 12 m below the top of the water table. Extraction well pumps typically discharge through DN50 (2 in.) PVC pipe. The PVC pipe is routed through the well head assembly before it is coupled with a DN50 (2 in.) HDPE transfer pipe leading to the transfer storage tank. Water from the transfer storage tanks is pumped to the treatment facility through DN80 (3 in.) HDPE transfer pipe to the system influent storage tank.

Treated water is discharged from treatment system effluent storage tanks to injection wells via DN80 (3 in.) HDPE transfer pipes. At the injection well head, the HDPE pipe is joined to DN80 (3 in.) PVC pipe via a flange. The PVC pipe end is perforated at the end, below the water table, to minimize the introduction of air into the aquifer during effluent injection. A schematic of a typical extraction and injection well is provided in Figure 3-3. Details of the well construction are found in the document *Well Summary Report: 100-HR-3 and 100-KR-4 Interim Remedial Action Wells* (BHI 1997c).

Table 4-1 identifies the extraction and injection wells and their extraction/injection rates. Prior to startup of the pump-and-treat system, short-term pumping tests were conducted to determine extraction and injection well capacity. This information is also shown in the table.

4.1.1.3 Operational Monitoring. Water levels, flowrates, pressures, component status (on or off), and other process information is monitored and recorded by the PLCs and OIC. An automatic shutdown is initiated if operational parameters fall outside of normal operating ranges. In this way, the system is protected should a component failure occur. The operational data are recorded by the OIC and automatically downloaded on a daily basis. The data are then exported to the 100-HR-3/100-KR-4 Project-Specific Database, an Access™ database, maintained on the BLAN in Richland, Washington. In addition to system parameters recorded by the OIC, operators sample process water to monitor hexavalent chromium levels. Process water is analyzed regularly (two to three times a week). The data are recorded in site field logbooks and in electronic form by manual entry at the OIC. The data can then be downloaded with other system data. Information downloaded into the database is used to address system performance criteria such as determining system downtime, availability, and efficiency.

4.1.2 Process Sampling and Analysis

Operational samples are collected and analyzed in order to monitor the performance of the pump-and-treat system and assure that it is effectively meeting the requirements of the ROD (EPA 1996). Operational samples are taken from four categories of sources for the 100-KR-4 pump-and-treat system: extraction wells, combined influent to the treatment system, combined effluent from the treatment system, and samples after each of the IX vessels in use. This section briefly describes the sampling and analysis requirements for the treatment portion of the system (combined influent, treatment system, combined effluent). The results of extraction well sampling are discussed in Section 4.2.2.1.

The specific sample points are identified below:

- Combined influent, sample collection point HP-10
- K-IX-1A vessel #1 effluent, sample collection point SC-1A
- K-IX-2A vessel #2 effluent, sample collection point SC-2A
- K-IX-3A vessel #3 effluent, sample collection point SC-3A
- K-IX-4A vessel #4 effluent, sample collection point SC-4A

- K-IX-1B vessel #1 effluent, sample collection point SC-1B
- K-IX-2B vessel #2 effluent, sample collection point SC-2B
- K-IX-3B vessel #3 effluent, sample collection point SC-3B
- K-IX-4B vessel #4 effluent, sample collection point SC-4B
- Combined effluent, sample collection point HP-14

Water from each sample point is sampled and field analyzed during manned operations to monitor hexavalent chromium levels. Field sample analysis is typically done using a DR 2000 Chrome Analyzer™. On October 7, 1997, use of a DR 2010 Chrome Analyzer™ was initiated. A modified Hach™ method that provides a detection limit of 10 μg/L is used to measure hexavalent chromium levels with the DR 2010 Chrome Analyzer™. ("Determination of Hexavalent Chromium in Water and Wastewater by the Hach™ DR/2010 Spectrophotometer at 100-KR-4 Pump-and-Treat", Procedure 3.4, BHI-EE-05). The DR 2010 Chrome Analyzer™ is considered adequate for field screening at the pump-and-treat system. Field screening results are recorded in the 100-HR-3/100-KR-4 Project-Specific Database and are discussed in the sections that follow.

Semi-annually, influent (sample collection point HP-10) and effluent (sample collection point HP-14) are sampled and analyzed off site for hexavalent chromium, conductivity, and co-contaminants (DOE-RL 1996). This satisfies the performance criteria analytical requirements for sampling of the treatment system. Analysis is performed by a state certified laboratory using EPA approved methods. The chromium analyses provides correlation data for comparison to field analytical methods. Since pump-and-treat operation could effect co-contaminant migration, analysis of co-contaminants is required to determine if co-contaminants are becoming COCs. The co-contaminants could potentially accumulate on used resin at levels that would change the resin waste designation. The co-contaminants that are analyzed are Sr-90, and Tc-99.

The Hach™ method has been used to reduce operational costs and provide process data to operators in real-time. Semi-annual samples are sent to an independent off site laboratory to assess the performance of the Hach™ method. Currently, the 100-KR- project does not have enough data to establish or refute any correlation between the Hach™ method and off site analysis. Analysis for co-contaminants has not indicated the presence of co-contaminants in any extraction wells.

4.1.3 System Operations

This section briefly summarizes system operations. The construction and acceptance testing of the pump-and-treat system was completed in September 1997. Extraction and processing of groundwater was initiated on October 1, 1997. Figure 4-2 depicts a plot of the operational data, which are monitored by the PLC, and shows the treatment system operation from October 1, 1997 through January 31, 1998. Figure 4-3 depicts a plot of the volume processed and mass of hexavalent chromium removed from October 1, 1997 through January 31, 1998.

4.1.3.1 Extraction Wells. There were no major changes in extraction rates between startup of continuous operations on October 1, 1997 and January 1, 1998. All extraction wells were in service at the start of operations. During this time, flows from the extraction wells have been maintained at approximately 95 L/min. During system startup and acceptance testing in September 1997, well 199-K-118A was removed from service due to continued clogging of the extraction well water filter. Sand intrusion at 199-K-118A made continued extraction and filtering of water impractical. Excessive sediment in the water has the capability of fouling IX resin. Well 199-K-118A was taken offline on September 26, 1997, during system acceptance testing.

4.1.3.2 Ion Exchange Skids. Since operations began (October 1, 1997), two IX vessels on K-IX-A and two IX vessels on K-IX-B have undergone resin replacement. Figure 4-4, Figure 4-5, and Table 4-2 graphically present IX vessel operational life cycles and history. The number following the vessel designation represents the batch of resin in the vessel at the time of resin replacement. For example, vessel K-IX-A1-1 is a vessel that has not had resin replaced (first batch), vessel K-IX-A1-2 in the same IX skids has undergone resin replacement once (second batch). Based on data taken from those vessels reaching at least 69% of saturation (vessel effluent concentration has reached 69% of the influent concentration), the average vessel has the capacity to absorb 2,200 g of chromium.

Resin replacement typically occurs when resin in the lead vessel has reached 70% saturation (one IX vessel from each treatment train, usually every 30 days). Typically, vessels from both IX skids are realigned within days of one another. As the resin in one vessel becomes exhausted, the IX vessels are realigned to place the lag vessel in the lead position. The exhausted vessel can be taken out of service and the resin removed as a slurry for dewatering outside of the vessel. Exhausted resin is dewatered in a drain box and prepared for final disposal in resin totes. New resin is then slurried into the empty vessel, which is typically placed back into service as the polishing vessel.

From November 7, 1997 to December 17, 1997, lead vessel K-IX-B1-1 was placed in the standby position to undergo resin replacement. During this time, the IX skid was reconfigured for three-vessel operation. On December 22, 1997, second lag vessel, K-IX-A4, was placed in the standby position and the IX skid was reconfigured for three-vessel operation.

4.1.3.3 Injection Wells. All injection wells were in service at the start of operations and have remained in service for the duration of operations. Injection rates are indicated in Table 4-1.

4.1.4 System Availability and Performance

This section discusses the treatment system availability, resin performance, and waste management. Information presented is relevant to RAO #2 (effluent less than 50 μg/L) and RAO #3 (final remedy/treatment system effectiveness). Performance criteria concerning continuous operations, system chromium discharge levels, and waste

management is also discussed. As of January 31, 1998, a total of 76,007,707 L of effluent has been treated and 9445 g of hexavalent chromium has been removed from the aquifer. This equates to a yearly production rate of 228,023,000 L and 28,340 g of chromium removed based on the previous 4 months of data (October 1, 1997 – January 31, 1998).

4.1.4.1 Treatment System Availability. The extraction wells, treatment system, and injection wells were operated 24 hours/day, seven days/week, except when taken offline for resin change out, system maintenance, or an automatic shutdown due to operational parameters falling outside of normal operational range. Figure 4-2 depicts a plot of the operational data and indicates when a system shutdown has occurred. Since Figure 4-2 shows the average daily system flow rate, outages that lasted less than 24 hours are characterized by a drop in the average daily system flow rate. The reasons for each system outage are noted in the figure. For the period between October 1, 1997 and January 31, 1998, the availability of the pump-and-treat system is 93.0%. System operating availability is determined from the percentage of time the treatment plant operates divided by the total time available for operation.

Worth noting is the system outage that occurred from December 13, 1997 to December 15, 1997. A power failure on Saturday, December 13, 1997, had resulted in a loss of OIC programming. The OIC programming was re-installed on Monday, December 15, 1997, however; some components remained shut down due to ice formation in the HDPE pipe. Stagnant water in the HDPE pipe had frozen over the weekend outage. By December 16, 1997, the weather had been warm enough to thaw frozen pipelines and normal operations were resumed. None of the system components or piping had been damaged by the freezing conditions.

As previously stated, the system availability has been calculated to be 93.0%. This is high, as the first six months of system operation are considered startup operations. Typically, system availability is lower during initial operations. Procedures for operating the IX skids in a three-vessel configuration during resin change out have been developed. These new procedures will minimize the system down time associated with resin change outs. It is anticipated that, as operations continue, the system availability will increase. The system runs on essentially a continuous basis and satisfies the performance criteria for continuous operations.

4.1.4.2 Resin Performance. Figure 4-6 depicts the chromium concentrations in the influent and effluent streams with the volume processed. The chromium removal efficiency for the treatment system is 92%. Chromium removal efficiency is determined based on the percentage of total chromium removed by the treatment system during the period between October 1997, and January 31, 1998. This efficiency is determined by comparing the treatment system influent and effluent levels (in μg/L) and multiplying by the volume processed (liters) to determine mass removed verses mass processed. The chromium removal efficiency is based on the assumption that non-detectable effluent concentrations are equal to Hach™ method detection limit. For the Hach™ DR 2000 Chrome Analyzer™, used prior to October 7, 1997, the detection limit is 5 μg/L. For the

Hach™ DR 2010 Chrome Analyzer™, used after October 7, 1997, the detection limit is 10 μg/L. The actual chromium removal efficiency is higher due to the fact that effluent concentrations below the Hach™ method detection limit were not used to determine removal efficiency. Chromium removal efficiency has not been effected by the variations in chromium concentrations in the influent stream. Chromium concentrations in the effluent stream are currently measured by operators using the DR 2010 Chrome Analyzer™ (detection limit of 10 μg/L). Hexavalent chromium has not been detected in any of the system effluent at any time during the operational history of the system. The treatment system has consistently reduced chromium concentrations in the effluent stream to below the required 50 μg/L hexavalent chromium concentration (performance criteria).

Waste designation samples of spent resin have indicated the presence of nitrates in the resin. Nitrate is not considered a COC. Hexavalent chromium, due to its high valence state, is preferentially absorbed by the resin, replacing nitrates from the active sites of the resin. The presence of nitrates in the water does not seem to have an adverse effect on resin performance.

4.1.4.3 Waste Management. As of January 31, 1998, 9.2 m^3 of spent IX resin have been generated and sampled for waste designation. Waste designation sample results are indicated in Table 4-3. Some of the waste has been designated as toxic and characteristic waste as its TCLP leachate concentration exceeds the 5 mg/L toxic characteristic limit (WAC 173-303-090[8][a]). Analysis for co-contaminants has indicted no accumulation of radionuclides in the spent resin at regulated levels. The performance criteria specify that waste generated (spent resin in particular) is to be disposed of at the appropriate facilities. Spent resin is currently stored on site. When a sufficient quantity of spent resin has been generated to constitute a full shipment, the resin will be shipped to an offsite vendor for regeneration. The toxic characteristic designation of some of the spent resin may result in the shipment being regulated as a hazardous materials shipment, but it does not impact the actual regeneration process. This is worth noting since spent resin designated as toxic characteristic would require transfer to the CWC for appropriate management should regeneration of spent resin be discontinued.

4.1.5 Discussions

Table 4-4 summarizes the performance criteria for the pump-and-treat system. Information downloaded into the database has been used to address system performance criteria such as determining system downtime, availability, and efficiency. The pump-and-treat system helps minimize the potential risk to the environment by reducing hexavalent chromium level in treated groundwater well below to 50 μg/L and reducing the overall mass of the contaminant plume.

RAO #3 specifies that information will be provided that will lead to a final remedy. The full evaluation of the pump-and-treat remedial action with respect to RAO #3 requires an assessment of the chromium removal efficiency, impact to the aquifer, and long-term cost effectiveness. The pump-and-treat system has been shown to be effective at removing

hexavalent chromium from extracted groundwater. The evaluation of the pump-and-treat remedial action with respect to the impact to the aquifer and long-term cost effectiveness are presented in the sections that follow.

The operation of the pump-and-treat system on a continuous basis has resulted in the maximum productivity within the given operational constraints (e.g., extraction well production rates). System availability will be increased by procedures for operating the IX skids in a three-vessel configuration during resin change out. These new procedures will minimize the system down time associated with resin change outs. However, the vessel change out should be completed within a 24-hour period to ensure that chromium concentrations in the effluent stream are maintained as low as practical. Furthermore, field screening using a DR 2010 Chrome Analyzer™ and a modified version of the Hach™ method should be resumed. The 5 μg/L detection limit available using the DR 2000 Chrome Analyzer™ and modified Hach™ method would provide an earlier warning of vessel breakthrough than current field analytical methods.

Full evaluation of waste designation results requires more data. Data at this point tend to indicate that the mass of chromium may be related to TCLP leachate concentrations. If the amount of chromium in a vessel can be maintained below 1200 g, the spent resin might not produce a TCLP leachate above the 5 mg/L limit. Although TCLP leachate chromium concentration is irrelevant when resin is regenerated, if for some reason regeneration is discontinued, disposal at ERDF would be the next viable option. If the spent resin is to be disposed of at ERDF, TCLP leachate chromium levels must be maintained below the 5 mg/L limit.

4.2 Aquifer Responses at 100-KR-4

Water level, hexavalent and total chromium concentration and other groundwater chemistry measurements have been made at wells located in the 100-KR-4 OU as part of RCRA, CERCLA, and interim remedial action performance monitoring. Monitoring requirements specific to the interim remedial action are listed in DOE-RL 1996 and DOE-RL 1997. One purpose of the monitoring program is to determine the aquifer response to the pump-and-treat system. In 100-K Area, the automated water level network collects hourly data from the six original extraction wells, four injection wells, three compliance wells, seven performance monitoring wells, and one river station located in 100-N. Four other wells in 100-K Area are also equipped with automated water level network equipment for other programs: 199-K-30, 199-K-32A, 199-K-32B, and 199-K-37. In addition, depth-to-water tape measurements were collected monthly during pre-startup and startup from two other performance monitoring wells. During regular operations, the tape measurements are collected quarterly.

All water level information used in the hydraulic evaluation was collected by the automated water level monitoring network, other wells equipped with automated water level network equipment, the pump-and-treat system transducers with data loggers, or the semi-annual water level measurement program. Figure 4-7 shows the wells included in the evaluation located in 100-K Area.

Section 4.2.1 give details of the measured hydraulic responses. The main points are to show:

- where wells currently included in the extraction network provide hydraulic control along the river, and
- where groundwater is captured by the extraction wells.

The 100-KR-4 pump-and-treat facility is situated near the Columbia River. Evaluating the impact of the treatment system on the aquifer requires distinguishing water level changes caused by the treatment facility from water level changes caused by the river stage. One method to distinguish these changes from one another is to correlate water level data collected from wells impacted by the pump-and-treat system to water level data collected from the river station or wells outside the direct influence of the pump-and-treat system. Offsets in the correlation corresponding to pump startup or shutdown provide a measure of the drawdown or buildup caused by the extraction or injection.

Evaluation of the areal responses of the aquifer to the pump-and-treat systems required minimizing the effects of the river stage fluctuations on the data. During November and December 1997, the river stage was at its lowest sustained elevation (Figure 4-8). Also, during this period, the trends and amplitudes of the river stage remained stable compared to other periods of the year. At such times, the greatest annual flow of groundwater typically enters the river. Analyzing the response of the aquifer to the pumping during this period provides the best indication of the system's effectiveness in reducing groundwater discharges into the river.

Groundwater samples are collected and analyzed for contaminants according to the schedule established in DOE-RL 1996 and DOE-RL 1997. Extraction, compliance, and performance monitoring well samples are collected and analyzed for hexavalent chromium concentration quarterly, monthly, and semi-annually. In compliance well 199-K-117A, groundwater samples are collected and analyzed from multiple depths in the aquifer to detect changes in the vertical distribution of the hexavalent chromium concentration. Groundwater samples are collected from the extraction wells semi-annually and the compliance wells annually and analyzed for co-contaminants Sr-90 and Tc-99. Section 4.2.2 gives details of the measured chemical responses to the pump-and-treat system.

4.2.1 Hydraulic Responses

The pump-and-treat in the 100-KR-4 OU primarily addresses hexavalent chromium contamination in the unconfined aquifer to protect aquatic receptors in the Columbia River substrate. In 100-K Area, the Ringold Mud Unit forms the base of the unconfined aquifer. The unconfined aquifer is contained within Ringold Formation Unit E sandy gravel and gravelly sand beds, with minor sand and silty interbeds (BHI 1996b). Point dilution tracer testing confirmed the presence of greatly differing high and low

conductivity zones at individual wells, most likely occurring because of sand and silt interbeds within the Ringold Formation. However, the data were not sufficiently conclusive to map the zones areally from well to well. Analysis of well development indicates that the transmissivity around the extraction wells ranges between 25 and 900 m^2/d, with the resulting hydraulic conductivity ranging between 5 and 60 m/d. Around the injection wells, the transmissivity appears to be about 25 m^2/d.

4.2.1.1 Extraction/Injection Wells. Figure 4-8 and Figure 4-9 show composite hydrographs of the extraction and injection well water level data. The extraction wells in 100-K Area operated at approximately the same flow rate of 95 L/min, but drawdown measured in the wells varied from 0.06 to 2.19 m (Figure 4-10). Because of equipment and sanding problems encountered at well 199-K-118A, drawdown data collected from that well were inconclusive. The greatest drawdown occurred in well 199-K-113A (2.19 m), which is the extraction well located farthest north. Drawdown measured 0.91 m in well 199-K-115A, which is located about 200 m southwest of well 199-K-113A. Less than 0.10 m of drawdown was measured in well 199-K-116A, which appears to be screened in a localized highly transmissive section of the aquifer near the midpoint of the 116-K-2 Trench. Drawdown measured 1.59 m in well 199-K-119A and 0.32 m in well 199-K-120A, which are located near the southern end of the trench.

Water turbulence and unsteady injection rates in the wells introduced scatter into the water level data collected in the 100-K Area injection wells. Buildup was calculated assuming that complete recovery occurred during two periods when the injection system was not operating. Because the water-level data exhibited no definite trends during these periods, no baseline water level data were necessary. Prior to the shutdown on November 3, 1997, water was being injected into wells 199-K-121A, 199-K-122A, 199-K-123A, and 199-K-124A at average rates of 119 L/min, 142 L/min, 144 L/min, and 97 L/min, respectively (Figure 4-11). Buildup in the four wells measured 1.53 m, 1.13 m, 1.88 m, and 2.73 m, respectively. Prior to the shutdown occurring on December 14, 1997, water was being injected into wells 199-K-121A, 199-K-122A, 199-K-123A, and 199-K-124A at rates of 89, 154, 154, and 89 L/min, respectively. Buildup in the four wells then measured 1.55 m, 1.75 m, 2.86 m, and 3.71 m, respectively. As evidenced by the hydrographs, the scatter in the water level data obscures the amount of buildup occurring in the wells.

4.2.1.2 Observation Wells. Except possibly for compliance well 199-K-114A, drawdown data collected in the compliance and performance monitoring wells was not directly attributable to pumping in a single extraction well. At well 199-K-114A, 0.05 m of drawdown was observed and this was assumed to be a direct result of pumping in well 199-K-113A (Figure 4-12). No observation well is located within 75 m of an extraction well, and most are essentially equidistant from at least two extraction wells. Drawdown occurring because the entire extraction well network was observed in some of the observation wells. At well 199-K-20, which is located downgradient of well 199-K-119A and across gradient from well 199-K-120A, drawdown measured 0.03 m. At well 199-K-21, which is located between wells 199-K-116A and 199-K-118A, drawdown measured 0.06 m (Figure 4-12).

4.2.1.3 100-KR-4 Areal Hydraulic Responses. The water table maps presented in Figure 4-13 and Figure 4-14 were developed based on water level data collected in December 1997, while the 100-KR-4 pump-and-treat was operating. The analysis included data collected by the automated water level monitoring network and the semi-annual water level measurement program. Water level contours were determined by the same method described for 100-D and 100-H Areas. The transmissivity distribution used in the 100-K Area model was based on data presented in DOE-RL 1996. Table 4-5 includes the measured hydraulic head at each of the measurement locations and the modeled value used to determine the water level contours.

Figure 4-13 shows that the largest capture areas occur around wells 199-K-113A and 199-K-115A, where the largest drawdown was measured. The capture area around well 199-K-116A is very small because the aquifer is highly transmissive around this well. Drawdown in this well measured less than 0.10 m. Consequently, the capture zone of well 199-K-116A is limited to streamtraces almost exactly upgradient from the well, with virtually no lateral capture occurring. Current plume contours are included in Figure 4-13 and Figure 4-14 to orient the hydraulic impacts of the pump-and-treat system to the chromium plume. Development of the plume contours shown on the figures is discussed in Section 4.2.2.7.

The hydraulic containment illustrates the effectiveness of the hydraulic barrier created by the line of extraction wells (Figure 4-14). The hydraulic barrier extends northward to a point almost halfway between wells 199-K-113A and 199-K-112A, the northernmost compliance well. Between wells 199-K-116A and 199-K-113A, almost no groundwater originating from the trench passes by the extraction wells without being captured. Without well 199-K-118A operating, essentially no hydraulic barrier exists between well 199-K-116A and 199-K-118A, and groundwater flow appears to occur unimpeded toward the river. South of well 199-K-118A and extending to well 199-K-18, the extraction wells create an almost continuous barrier to flow, although the streamtraces indicate that some groundwater may pass uncaptured between wells 199-K-120A and 199-K-119A.

4.2.2 Hydrochemical Responses

This section summarizes and interprets analytical results taken from groundwater wells included in the interim action monitoring program supporting the 100-KR-4 OU pump-and-treat system. The remedial action goals for the 100-KR-4 OU are the same as those for the 100-HR-3 OU (Section 2.0). For the same reasons given in Section 3.2.2 both hexavalent chromium and total chromium are referred to in this section as chromium.

4.2.2.1 Baseline Chromium Contaminant Distribution. The baseline time period extends from October 1996, until just prior to system startup. The baseline contaminant distribution map presented in this section is the plume distribution map for 100-K Area given in the RDR/RAWP. Significant changes in the contaminant distribution that

occurred prior to the startup of the pump-and-treat system are discussed in the text. A brief description of the 100-KR-4 baseline contaminant distribution in the RDR/RAWP is given here. For a more complete description, please see the following documents:

- *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Operable Units' Interim Action* (DOE-RL 1996),
- *Conceptual Site Models for Groundwater Contamination at the 100-BC-5, 100-KR-4, 100-HR-3, and 100 FR-3 Operable Units* (BHI 1996b).

The baseline chromium contamination for the 100-KR-4 OU interim remedial action is given in Figure 4-15. Chromium is widely distributed in the groundwater in the vicinity of 116-K-2 Trench. Monitoring wells are placed more or less along a single line between the trench and the river, so the chromium isopleths represent a general area of contamination. There are two places where chromium is found above levels of concern in the groundwater in the 100-K Area. One of these areas is centered about the groundwater monitoring wells 199-K-107A and 199-K-108A, while the other is centered about groundwater well 199-K-36. This interim remedial action is designed to remediate the chromium in the groundwater around 116-K-2 Trench.

Groundwater flows to the northwest and toward the Columbia River. There are no available riverbed substrate sampling data or shallow subsurface shoreline data for chromium. Samples of the riverbank seepage revealed chromium concentrations of approximately 65 μg/L (DOE-RL 1992b). Chromium was not detected in near-shore river water adjacent to the seepage site.

In the spring of 1997 and still prior to the startup of the pump-and-treat system, the most recent sampling data were evaluated. The following changes, since the baseline plume was generated, are noted here. The installation of the injection wells provided information on chromium in the groundwater halfway between well 199-K-117A and well 699-78-62. The chromium concentration in the groundwater at injection well 199-K-121 was 150 μg/L. This indicates the chromium plume extended further inland than the original conceptualization given in the RDR/RAWP. Additionally, the chromium concentration in the groundwater at well 199-K-36 has risen from 520 μg/L to 1605 μg/L and from 33 μg/L to 50 μg/L at well 199-K-23. This indicates the chromium plume centered about groundwater well 199-K-36 now extends further to the northwest and includes 199-K-23.

4.2.2.2 Sampling and Analysis. Details of the sampling and analysis for hydrochemical responses are given in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE-RL 1997). The three elements of the monitoring plan (i.e., compliance, performance, and operational monitoring) are applicable to the 100-KR-4 system.

Table 4-6 is taken from the monitoring plan, lists the monitoring wells, and the minimum requirements for sample frequency, and analyses. Well locations and type of well

(injection, extraction, performance monitoring, and compliance monitoring) are given in Figure 4-16 for the 100-KR-4 OU. All chromium analytical results from the monitoring program are available through 100-HR-3/100-KR-4 Project Specific Database and HEIS. In addition to the sampling schedule given in Table 4-1, the extraction wells (Table 4-6) for the 100-KR-4 OU were monitored on a weekly basis for hexavalent chromium by the operators of the pump-and-treat system. Groundwater samples were also analyzed for co-contaminants. For the 100-KR-4 OU, the co-contaminants are Sr-90 and Tc-99. At each sampling event, the field parameters (pH, specific conductance, temperature, and turbidity) are also measured.

4.2.2.3 Hydrochemical Responses in Extraction Wells. There are six extraction wells for the 100-KR-4 OU (Table 4-6). However, extraction well 199-K-118A was taken off line in early October because sand in the well was clogging filters. The data evaluated in this section are based on review of trend plots of chromium in each well. During the evaluation, analytical outliners were removed from the data evaluated. The chemical trend plots given in this section were subjected to this review process. Trend plots (Figure 4-17 and Figure 4-18) of the hexavalent chromium were prepared for all of these wells. In addition to the chromium, trends for specific conductance in nearby compliance wells, and the average weekly water levels (calculated from the hourly water level measurement taken from nearby compliance wells) are also given. At the start of the interim remedial action in the 100-K Area, measured chromium in the groundwater at all wells was above the remedial action goal of 22 μg/L. Since the start of the interim remedial action, a number of the wells (199-K-113A, 199-K-115A, and 199-K-120A) have had chromium levels dipping below the remedial action goal, but the chromium levels do not stay below the remedial action goal. It is also obvious after examining these figures, that unlike the 100-HR-3 wells, there is no discernable chromium correlation with the water level or the specific conductance. In January 1998, chromium levels in the groundwater at all extraction wells were above the remedial action goal 22 μg/L. This is not unexpected since the remedial action has been in operation for only four months.

4.2.2.4 Hydrochemical Responses in Compliance Monitoring Wells. There are five compliance wells (Table 4-6) in the 100-KR-4 OU. The trend plots for chromium, specific conductance, and water levels for 100-KR-4 OU compliance monitoring wells are given in Figure 4-19 and Figure 4-20. Chromium levels at the compliance well 199-K-18 seem to be fairly constant ranging 30 to 40 μg/L from pre-startup through November 1997, but then showing an upward trend toward the end of 1997. At well 199-K-20, overall chromium levels have had a downward trend from October 1996 through December 1997. Neither 199-K-18 nor 199-K-20 shows a direct correlation between chromium levels and specific conductance or inverse correlation to water levels. However, at compliance wells 199-K-112A, 199-K-114A, and 199-K-117A, the chromium trends do show a direct correlation between chromium levels and specific conductance and an inverse correlation with the water level. This is similar to the trends observed within the 100-HR-3 OU. In January 1998, the chromium levels measured in the compliance wells were still above the remedial action goal of 22 μg/L. This is not unexpected since the interim action has only been in operation for four months.

In addition to monitoring chromium levels at the water table, different depths in the aquifer were monitored for chromium using a discrete interval sampler at the compliance well 199-K-117A. Chromium levels in the groundwater were measured at 9.15 m, 12.19 m, 16.46 m, and 19.50 m below ground surface. The water level was approximately 9.1 m below ground surface in September 1997 and 8.8 m below ground surface in December 1997. The deepest sample was 10.35 m below the top sample. Unlike the vertical interval sampling at well 199-D8-70, no clear trends have emerged. The deepest sample did not always contain the highest chromium and more data are needed before an interpretation can be made. Table 4-7 gives the results for the discrete interval sampling for well 199-K-117A.

4.2.2.5 Hydrochemical Responses in Performance Wells. There are four performance monitoring wells (Table 4-6) in the 100-KR-4 OU. These wells are sampled semi-annually and insufficient data has been collected to clearly discern a trend for chromium over time. Figure 4-21 plots the chromium, specific conductance, and average weekly water level (when available) for the performance monitoring wells. These wells have shown a drop in chromium levels over the past year. However, the interim remedial action had been in operation for only forty-five days before the last sampling event at these wells. It is unknown if the drop is due to the interim remedial action or other factors. The last chromium sample taken from each of the performance monitoring wells was above the remedial action goal of 22 μg/L. Again, this is not unexpected because the pump-and-treat system had been in operation for only a short period of time when these samples were taken.

4.2.2.6 Changes in Chromium Distribution. Figure 4-22 gives the chromium distribution for the 100-KR-4 OU. The chromium values used to make this map are given in Table 4-8. The following values used for contour were selected by taking the most recent filtered value. If there was more than one sample from the well, the highest value was chosen. If a filtered sample was not available, a non-filtered sample was used. The following summarizes the differences between the baseline plume distribution map and the most recent one:

- Comparison of January 1998 conditions to the baseline and pre-startup conditions reveals chromium levels have dropped by approximately half at well 199-K-19 and have dropped slightly for wells 199-K-20, 199-K-21, 199-K-22 and 199-K-37. Levels have risen slightly at well 199-K-18. The high chromium value found at well 199-K-36 for the baseline distribution has dropped significantly. This is probably due to water with a low specific conductivity moving into the vicinity of this well and diluting the chromium normally found at this well.

The comparison between the baseline chromium distribution and the chromium distribution given in Figure 4-22 shows very few differences between the two, with the overall shape and areas of contamination remaining approximately the same. The differences between the two are more likely the result of having more wells available in the vicinity of the 116-K-2 Trench than changes brought about by the interim remedial action.

4.2.2.7 Co-Contaminants. For the 100-KR-4 OU, the only co-contaminants monitored were Sr-90 and tritium. Tritium was found at levels above the MCL at two wells (199-K-120A and 199-K-18) and Sr-90 was found at levels above the MCL at six wells (199-K-19, 199-K-21, 199-K-22, 199-K-113A, 199-K-114A, and 199-K-115A). Table 4-9 lists maximum value for Sr-90 and tritium for all wells containing these co-contaminants above the MCL since the start of the interim remedial action monitoring program. Summary statistics and trend plots for wells with these co-contaminants exceeding the MCL are given in Appendix A.

4.2.2.8 Quality Assurance/Quality Control. Field replicates, field/off site laboratory splits, off site laboratory replicates, and off site laboratory splits are quality control samples collected to assess the precision of chemical analyses. The quality control sample analyses are presented by well and sample numbers in Table 4-10 and Table 4-11. Some results were not available because data had not yet been entered into HEIS. These data are identified on the tables as "NA".

Establishing precision of samples analyzed by field screening consisted of comparing analyses of field replicates and field/off site laboratory splits. The range of variability of an analyte was determined by dividing one of a pair of replicate concentrations into the other. Variability in chromium concentrations in the field was 4%, based on replicate data. Variability of field/off site laboratory chromium concentrations was about 17%.

The precision of off site laboratory replicates was established by comparing analyses of two samples collected from the same location collected on the same day and sent to the same laboratory. The maximum variability of total Sr-90 concentrations based on off site laboratory replicates was approximately 26%. The variability of off site laboratory splits could not be determined because most off site results are not yet available.

The MS and MSD were used to establish the accuracy of chromium analyses for field screening. The spike concentrations were set at 25 µg/L, and the analyses of the MS/MSD samples resulted in 16 and 17 µg/L of chromium, respectively. These values correspond to an accuracy of 64% for the MS and 68% for the MSD.

4.2.3 Discussions

4.2.3.1 100-KR-4 Hydraulic Containment. Pumping in the 100-KR-4 extraction wells appears to result in river recharge occurring in two of the five wells that currently operate. The two extraction wells located farthest to the north, wells 199-K-113A and 199-K-115A, both appear to induce river recharge and extract groundwater from the aquifer near the river. Because of the depth of the aquifer and the high transmissivity around well 199-K-116A, the capture zone resulting from pumping in that well is very small compared to the capture zones surrounding the other extraction wells. The flow lines indicate that continuous capture occurs between wells 199-K-113A and 199-K-116A, and mostly continuous between wells 199-K-119A and 199-K-120A. The line of hydraulic containment extends almost the entire length of extraction wells, except

around well 199-K-118A where some groundwater probably passes unimpeded between the two operating extraction wells. Wells 199-K-119A and 199-K-120A were both situated farther from the river than the other extraction wells because of cultural concerns. Consequently, neither of these extraction wells appears to induce river recharge, although both appear to draw some groundwater from near the river.

With approximately 9.4 kg of chromium having been removed from the aquifer since the startup, the interim remedial action for 100-KR-4 OU has been effective at reducing the total mass of hexavalent chromium from the aquifer. However, it has only been in operation since October, which is not sufficient time to make an adequate assessment on its effectiveness at reducing chromium concentration levels within the aquifer. The sampling results since then have been highly variable in the extraction wells and less variable in the compliance monitoring wells.

The impact of the fifty-year flood stage on the Columbia River can be seen in wells 199-K-112A, 199-K-114A, and 199-K-117A. However, the monitoring results from compliance wells 199-K-18 or 199-K-20 do not show the impact of the high water. The impact of the high water is not as evident for the 100-KR-4 OU as it was for the 100-HR-3 OU. This could be more due to the timing and frequency of collecting samples rather than to differences between the aquifers in the OUs. The startup of the 100-KR-4 interim remedial action occurred several months after the startup of the 100-HR-3 interim remedial action and after the flood event. Since the startup occurred later, the more frequent sampling that took place at the 100-HR-3 OU during the flood event did not take place at the 100-KR-4 OU.

4.2.4 Summary of Pump-and-Treat Impacts on the Aquifer

By the end of January 1998, the pump-and-treat system for the 100-KR-4 OU had been operating for approximately four months and the chromium levels measured in the groundwater at all compliance monitoring wells were above the remedial action goal of 22 μg/L. Since the start of operations, the chromium trends have been rising in all of the compliance monitoring wells, except 199-K-20. This rise is probably due to the return to normal conditions as the Columbia River receded from flood conditions. The present monitoring plan for the interim remedial action is sufficient to show the impacts the interim remedial action has on the aquifer over a longer period of time (several years) in which the impacts of the Columbia River are averaged out.

However, the present monitoring program is insufficient to evaluate the interim remedial action over a relatively short period of time (less than a year). The present monitoring plan does not address either the short-term impacts of the daily and seasonal cycles of the Columbia River on the unconfined aquifer or the short-term impacts caused by changes in the operation of the interim remedial action. To evaluate these impacts, a short-term monitoring program with more frequent sampling should be established to separate the effects due to the ground water-river interaction and the effects due to the interim remedial action. This sampling would include, but would not be limited to, installation of real-time specific conductance probes at the compliance and extraction wells, daily

sampling of chromium from compliance wells, and real-time monitoring of chromium at the extraction wells. Additionally, aquifer sample tubes were installed along the river's edge in these areas in the fall of 1995 and 1997. Sampling from the aquifer sample tubes in the target areas should be added to the present monitoring program since this will provide information close to the river on the effectiveness of the remedial action.

The hydraulic capture and containment resulting from operation of the 100-KR-4 pump-and-treat system has reduced the flux of groundwater entering the Columbia River in 100-K Area. Because of the removal of well 199-K-118A from the extraction well network, operation of the pump-and-treat system has resulted in two distinct areas of hydraulic capture and containment. One capture zone extends laterally about 500 m near the river from about halfway between compliance wells 199-K-112A and 199-K-114A in the north to about halfway between extraction well 199-K-115A and compliance well 199-K-117A in the south. Pumping in wells 199-K-113A and 199-K-115A appears to induce some river recharge. This capture zone extends primarily inland toward the injection well field, although some water extracted by well 199-K-113A may originate from farther inland to the north. The second capture zone extends laterally about 500 m from around extraction well 199-K-119A to compliance well 199-K-18 and inland toward the injection well field although containment was not totally achieved without well 199-K-118A operating. However, replacing well 199-K-118A with a similarly located extraction well and boosting the flowrate from 95 L/min to 190 L/min at well 199-K-116A should extend continuous hydraulic capture and containment between extraction wells 199-K-116A and 199-K-120A.

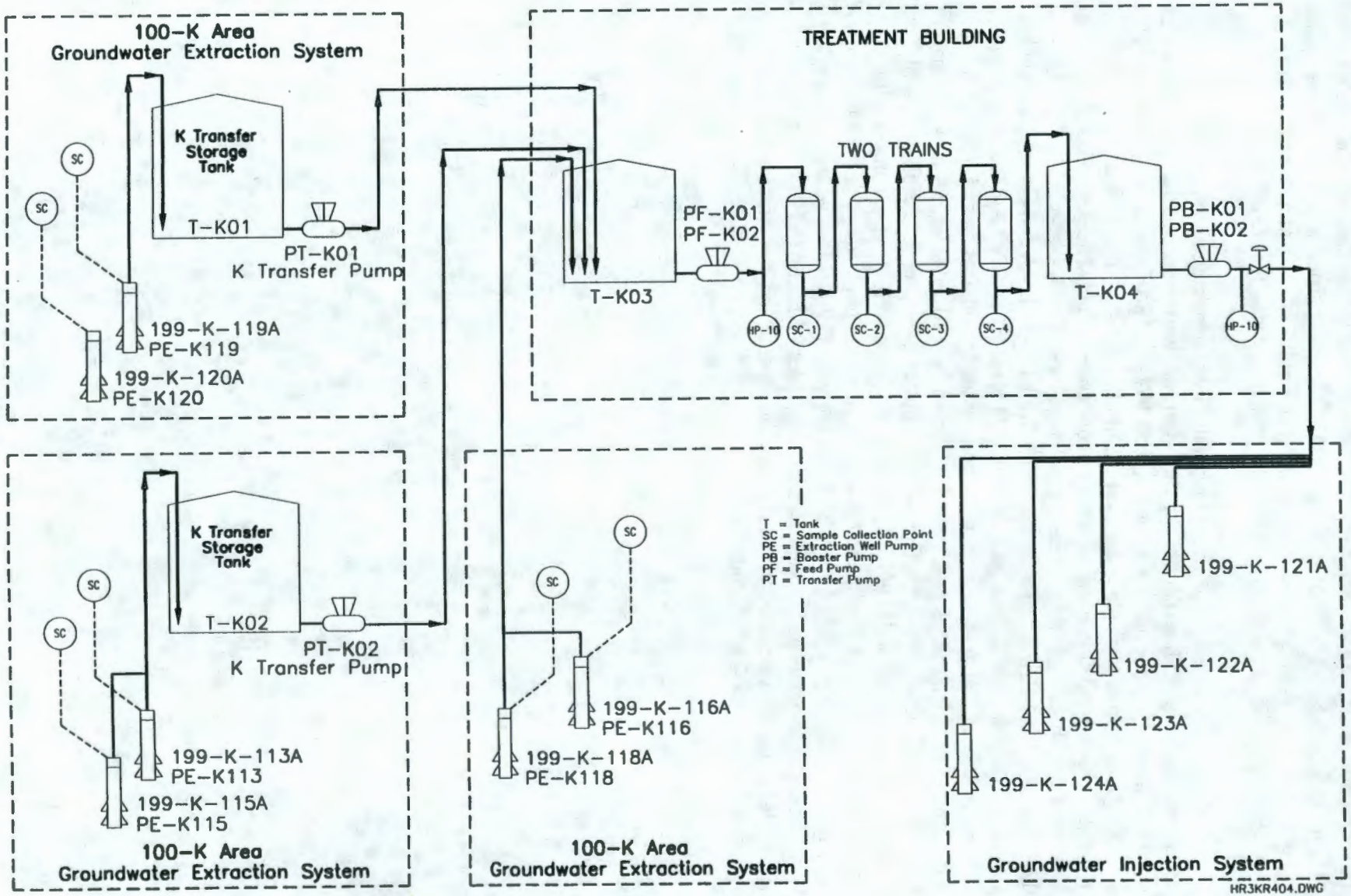
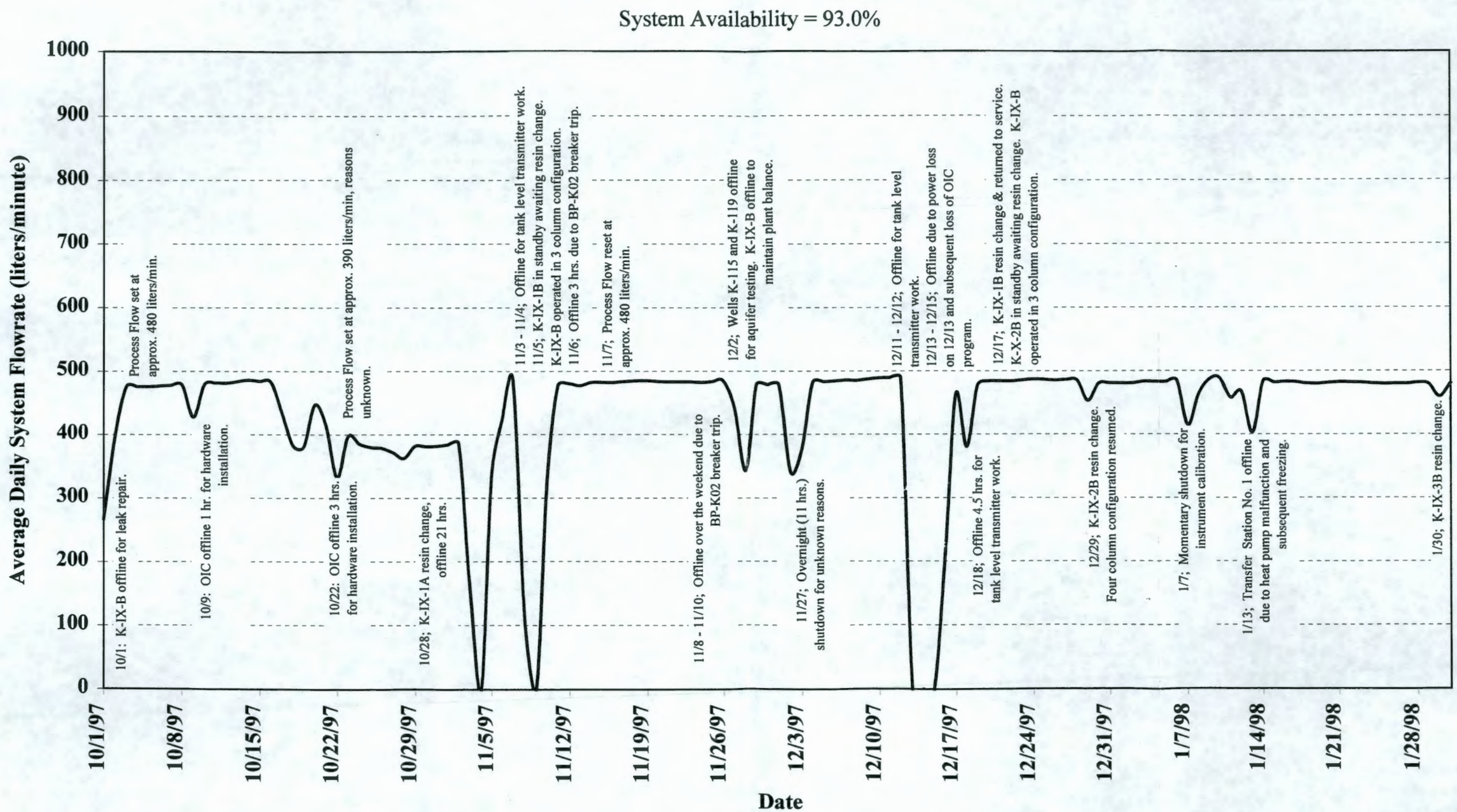


Figure 4-1. 100-KR-4 Pump-and-Treat System Schematic.

Figure 4-2. 100-KR-4 Treatment System Operation.



THIS PAGE INTENTIONALLY
LEFT BLANK

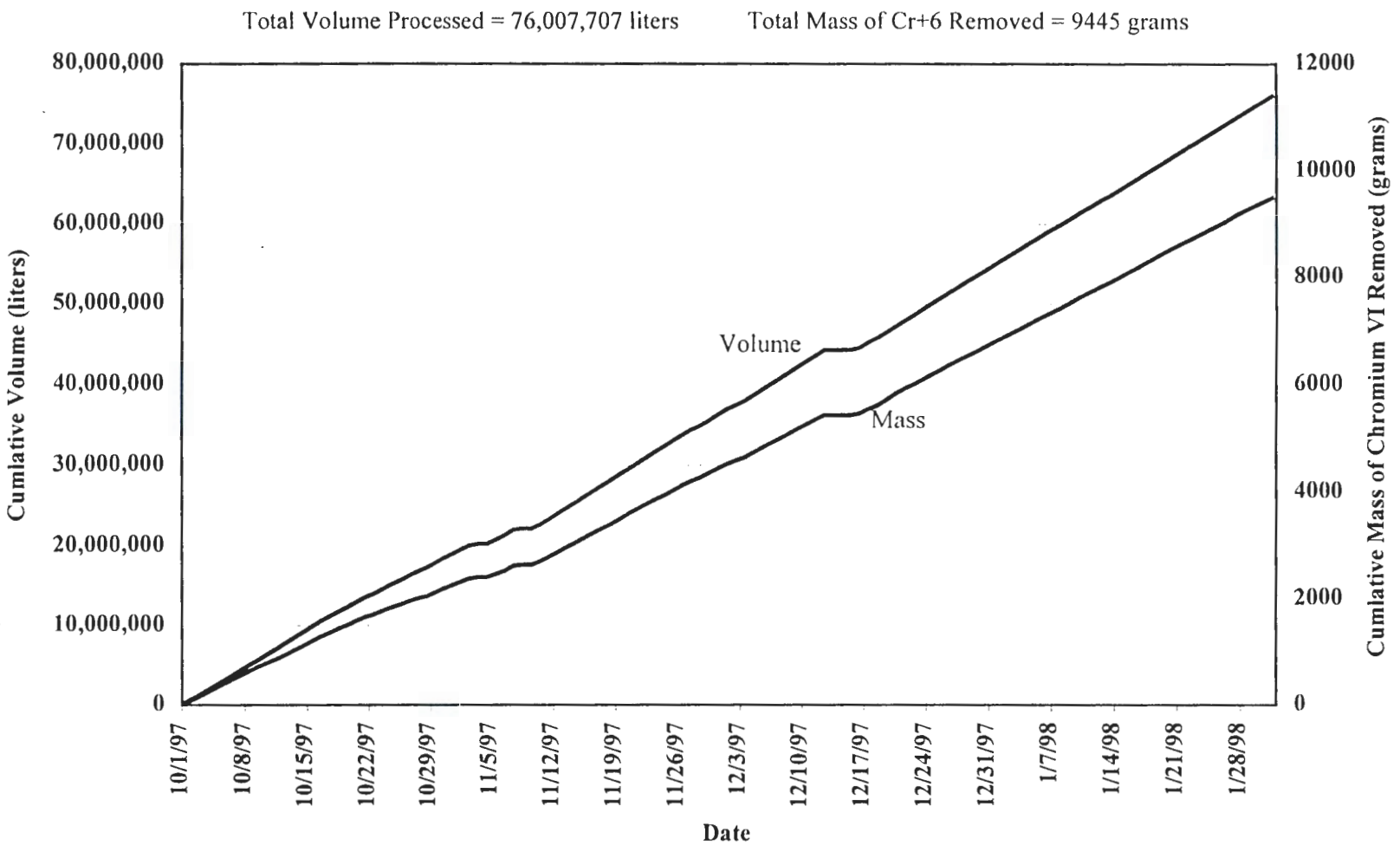
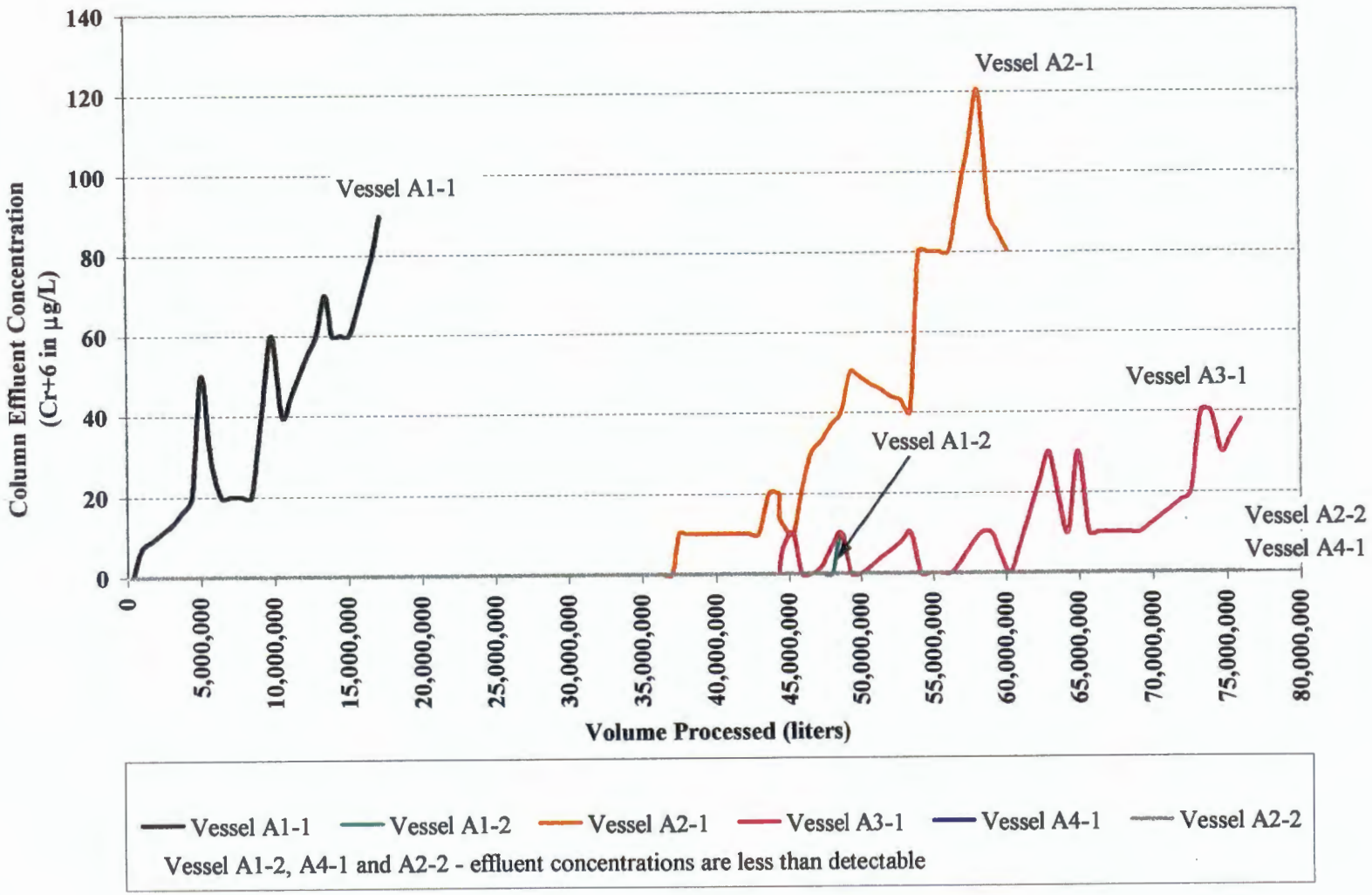


Figure 4-3. 100-KR-4 Treatment System Operation, Cumulative Volume Processed and Mass Removed vs. Time.

Figure 4-4. Ion Exchange Breakthrough Curves for K-IX-A.



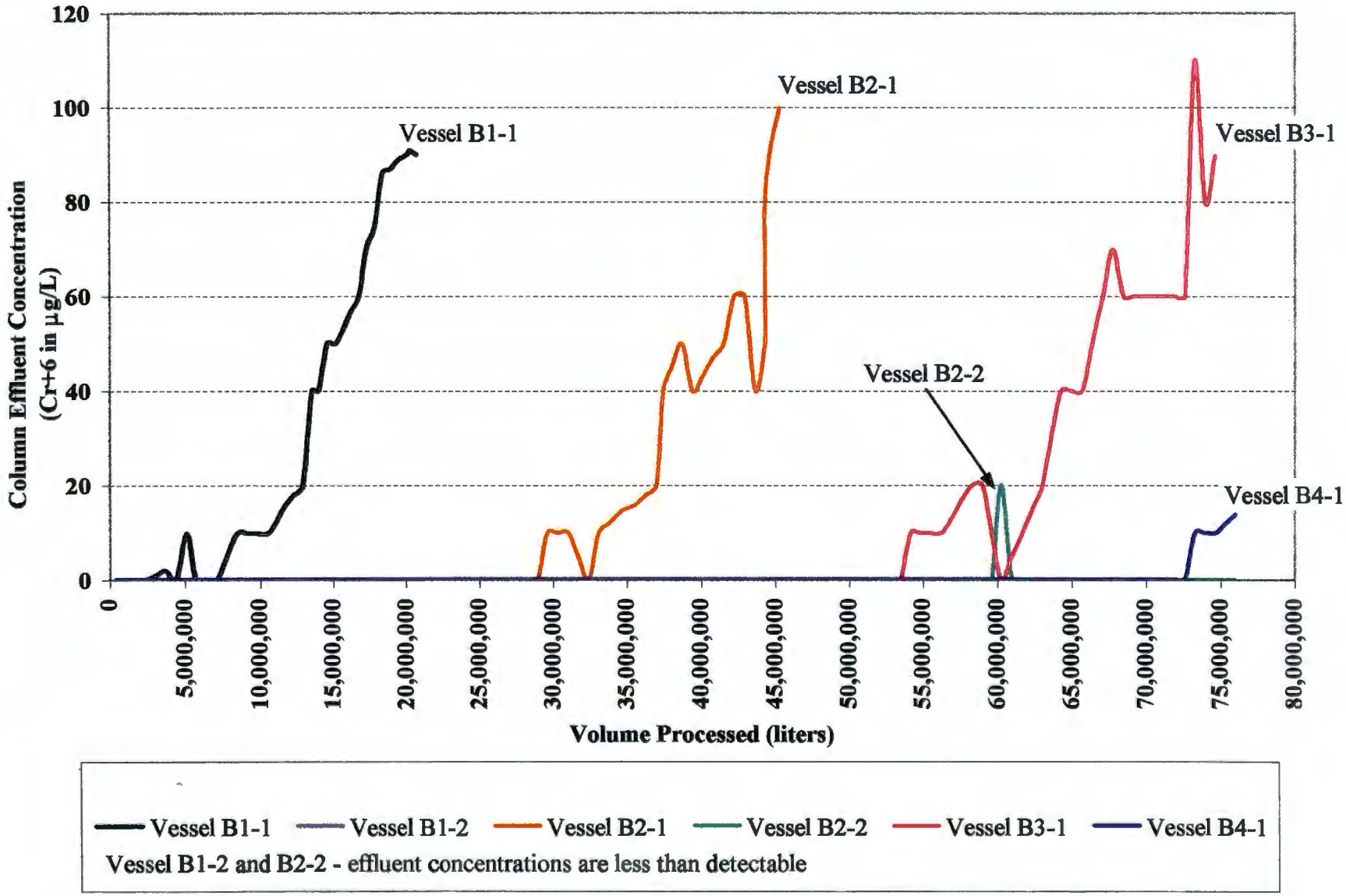


Figure 4-5. Ion Exchange Breakthrough Curves for K-IX-B.

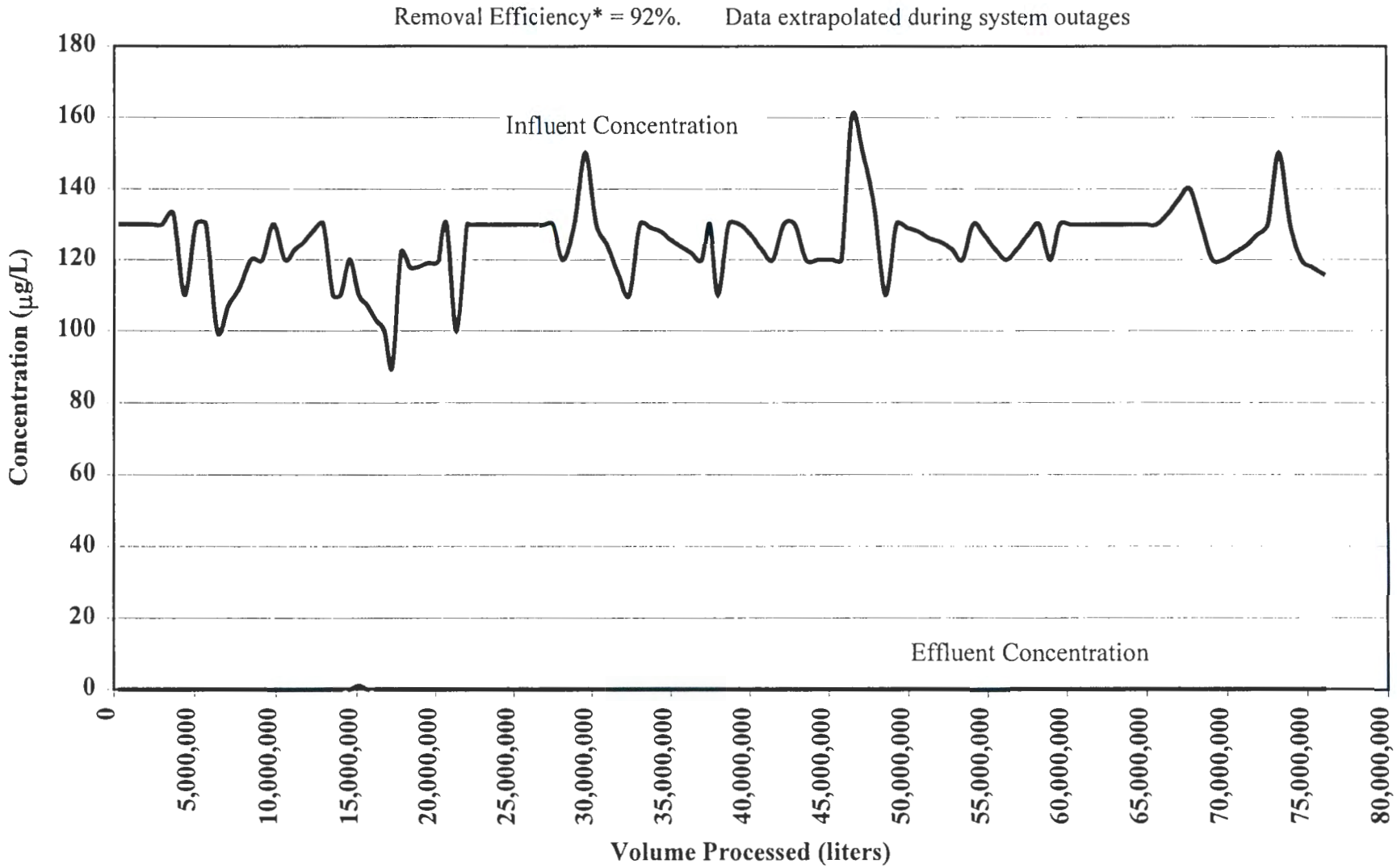


Figure 4-6. 100-KR-4 Pump-and-Treat System Influent and Effluent.

* Based on effluent concentration equal to the Hach 2010 Chrome Analyzer detection limits (10 µg/L)

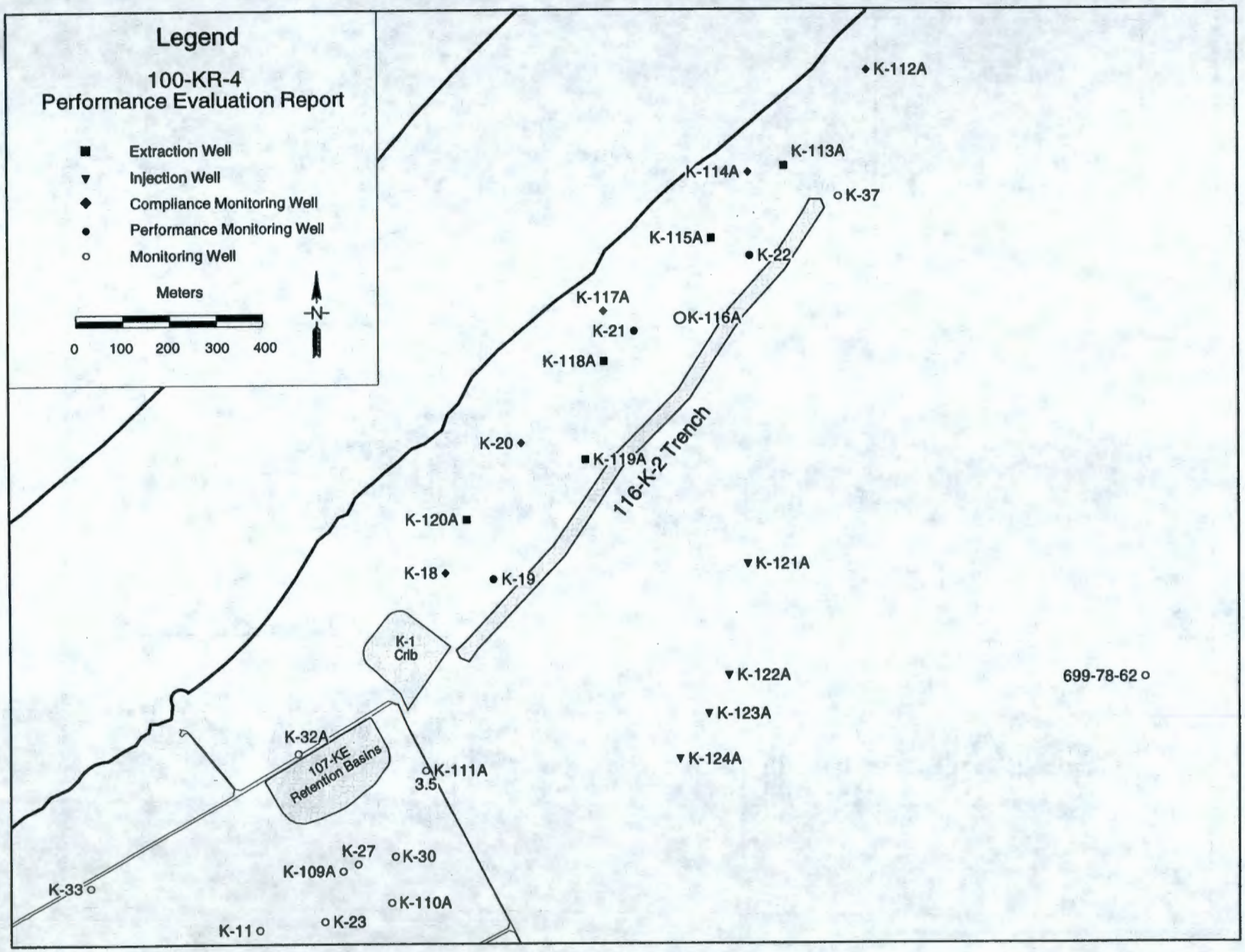


Figure 4-7. 100-KR-4 Area Layout of Wells.

Figure 4-8. 100-KR-4 Area Composite Hydrographs of Extraction Wells.
Page 1 of 2

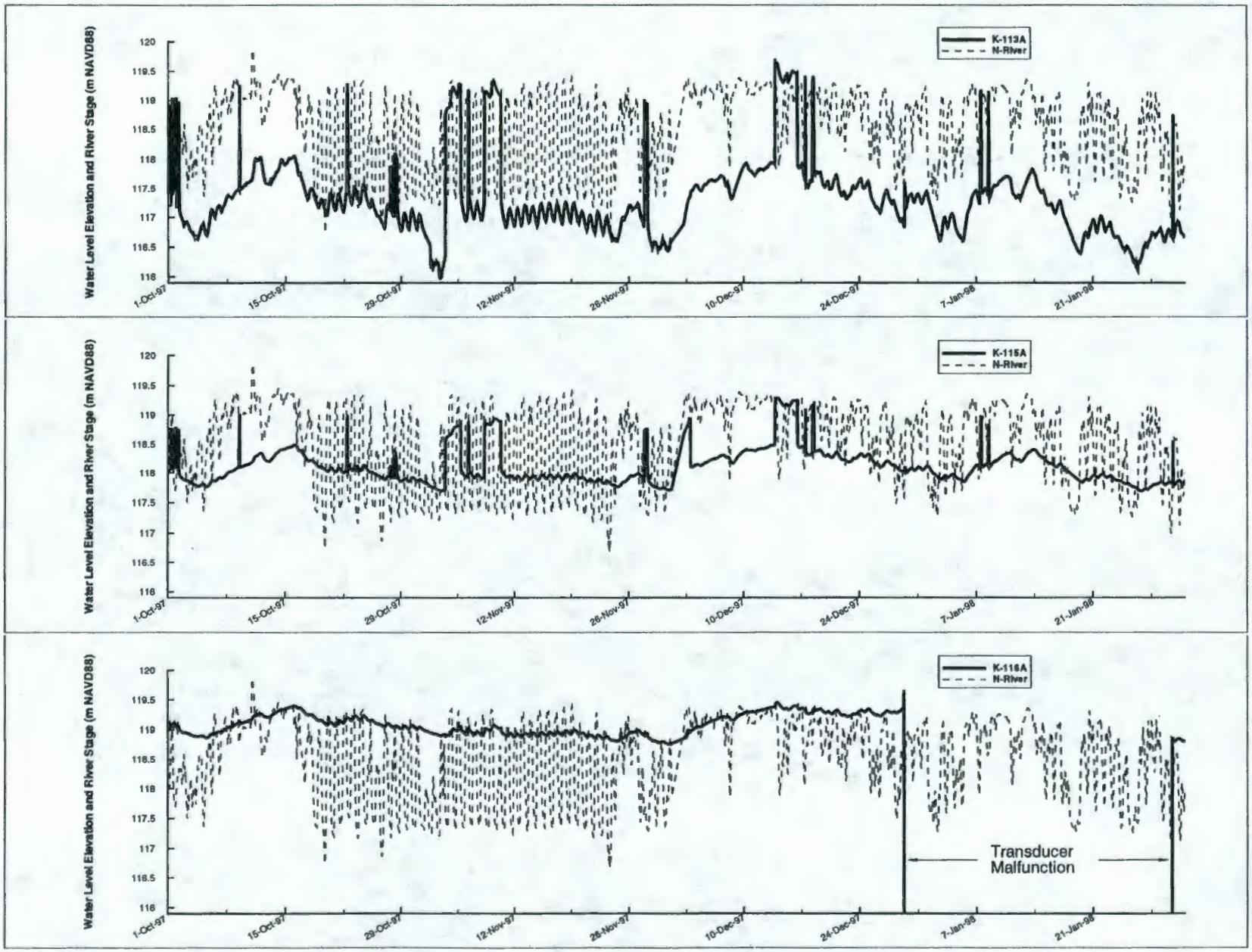


Figure 4-8. 100-KR-4 Area Composite Hydrographs of Extraction Wells. Page 2 of 2

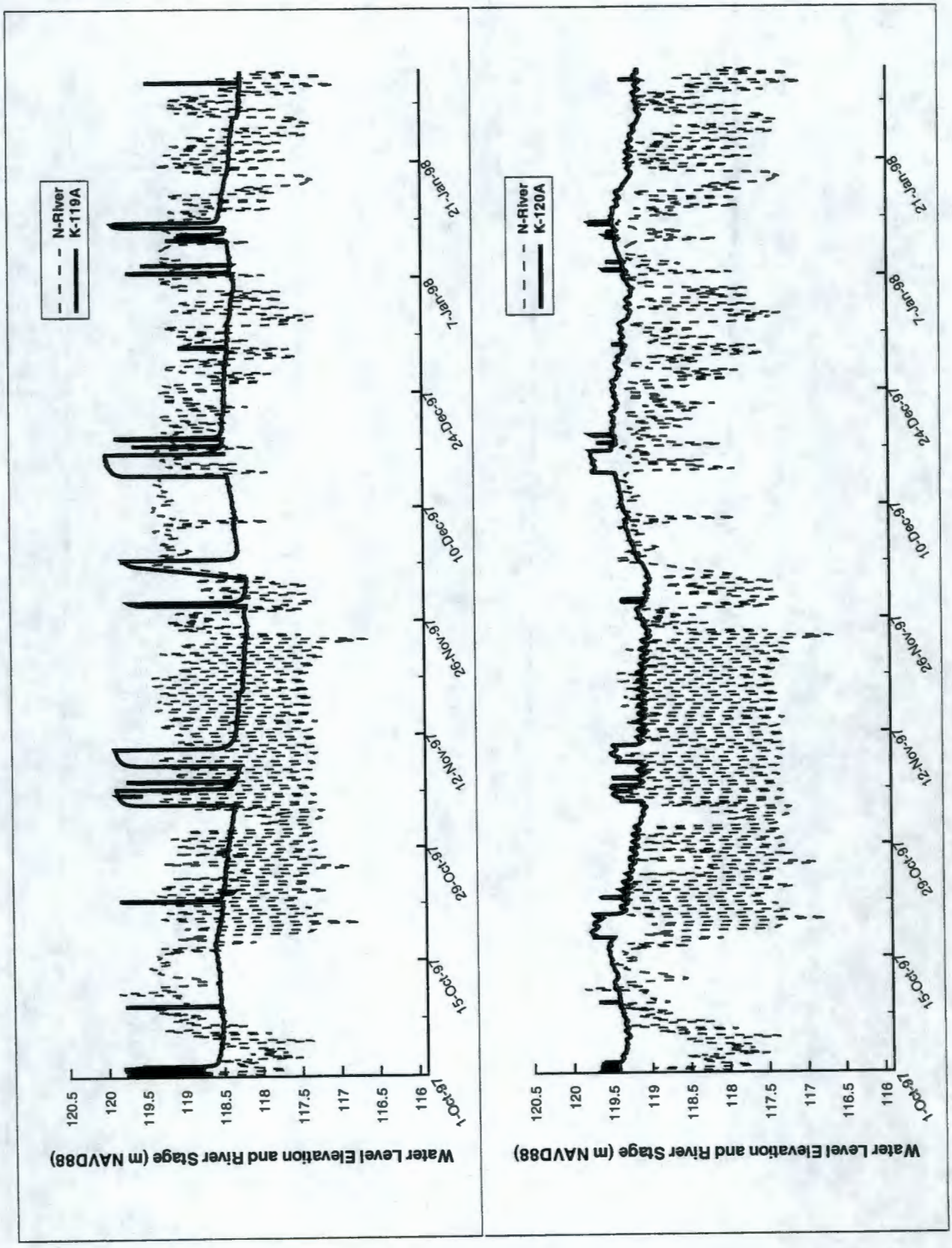


Figure 4-9. 100-KR-4 Area Composite Hydrographs of Injection Wells.
Page 1 of 2

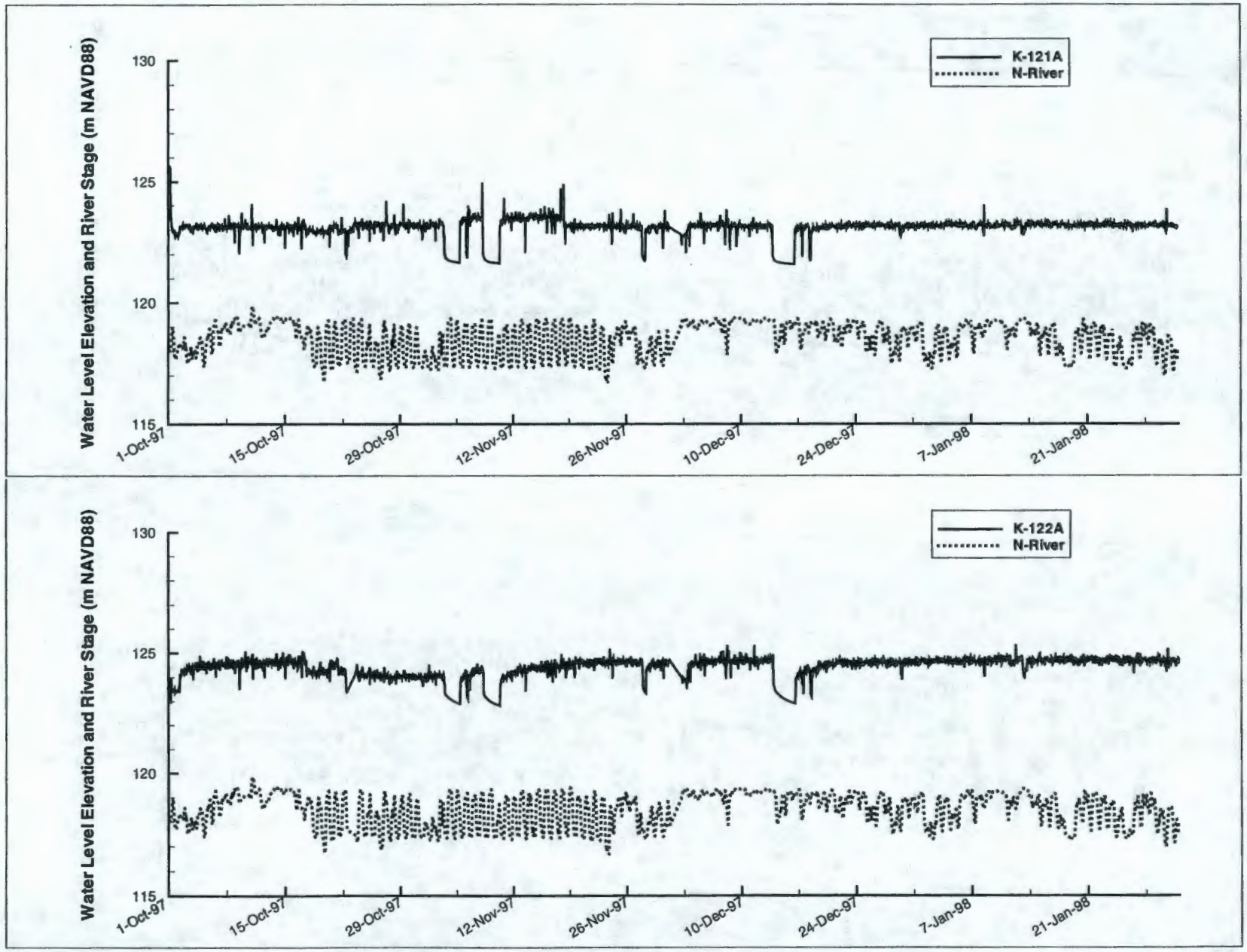


Figure 4-9. 100-KR-4 Area Composite Hydrographs of Injection Wells.
Page 2 of 2

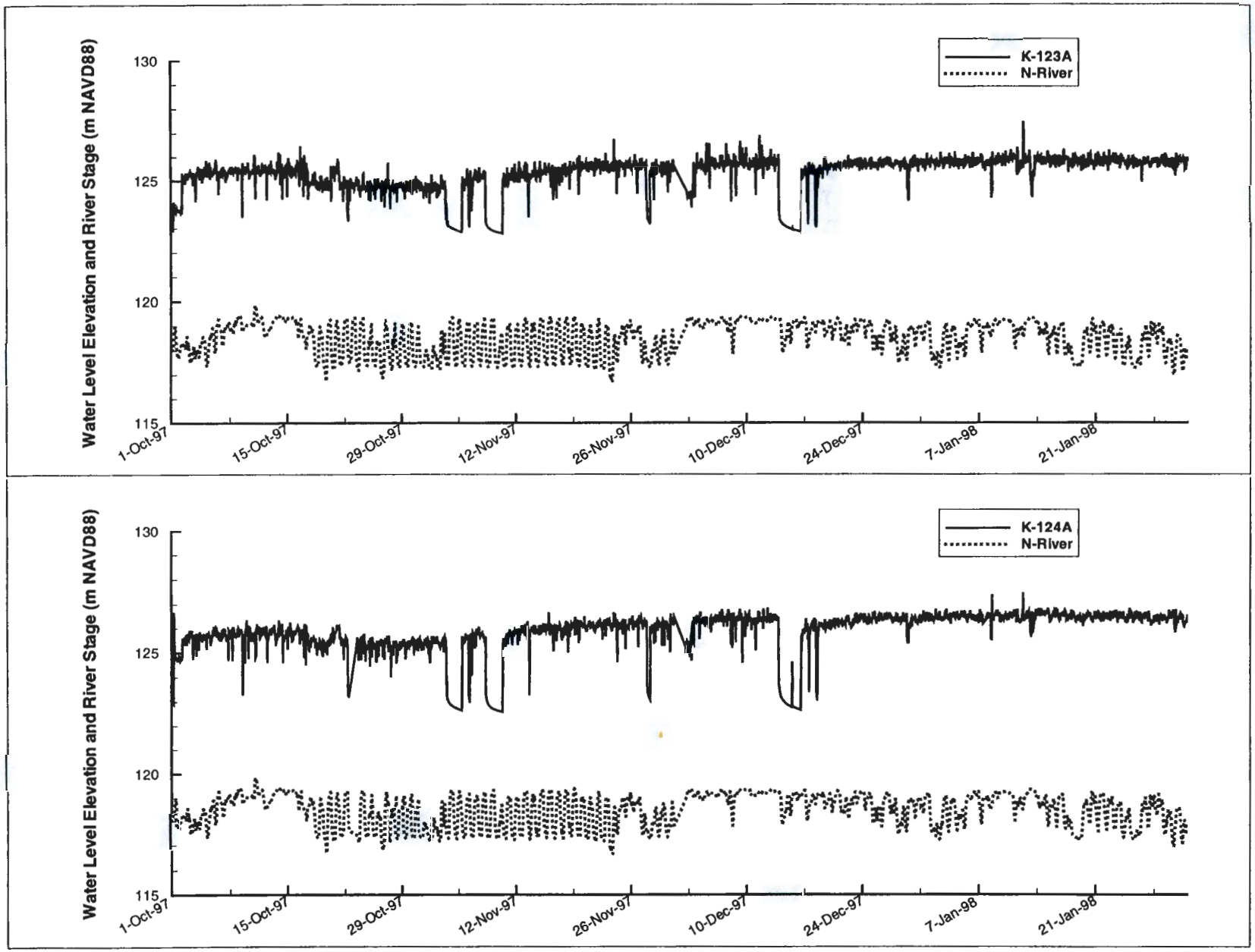


Figure 4-10. River Stage Correlation and Drawdown Measured in 100-KR-4 Area Extraction Wells.
Page 1 of 2

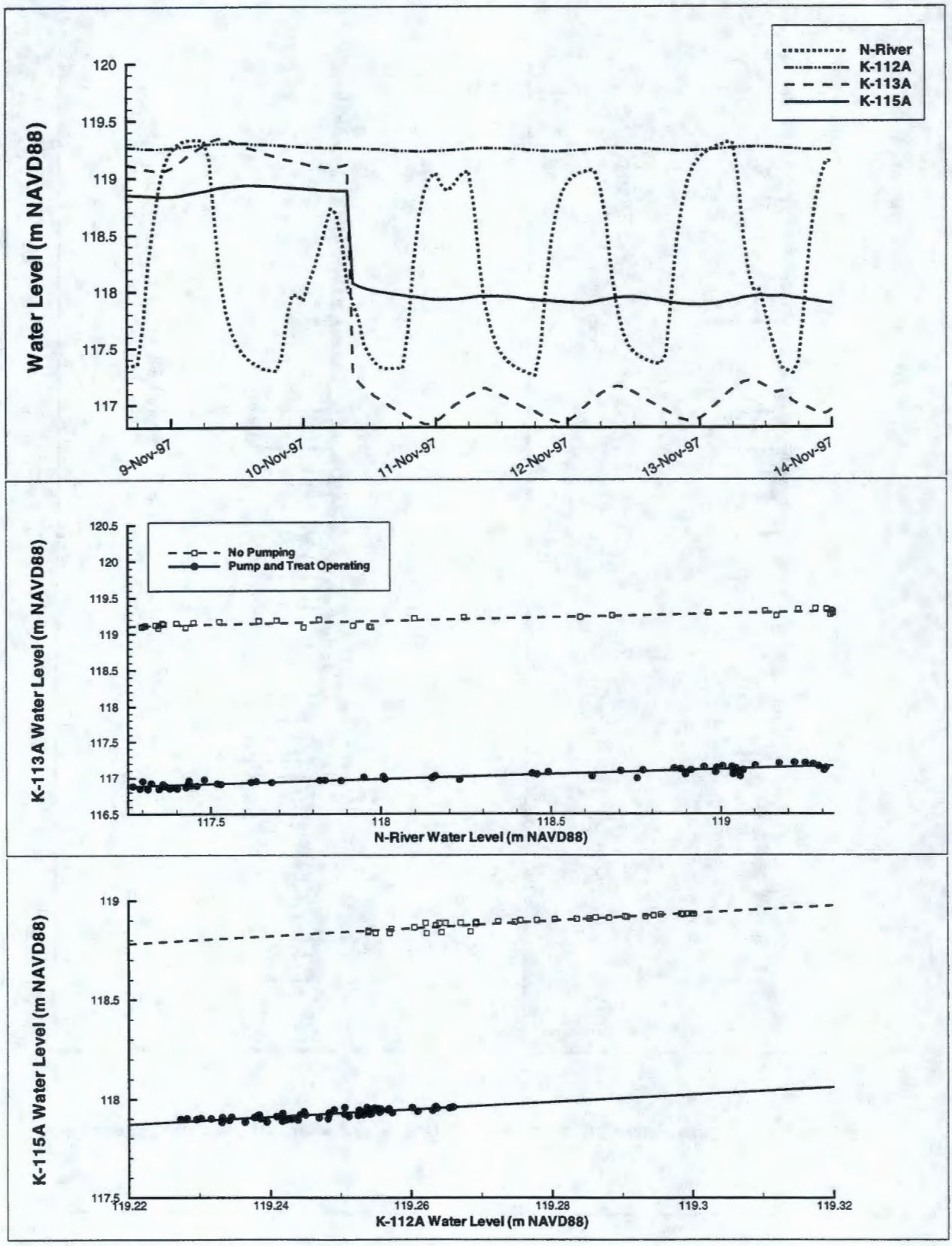


Figure 4-10. River Stage Correlation and Drawdown Measured in 100-KR-4 Area Extraction Wells.
Page 2 of 2

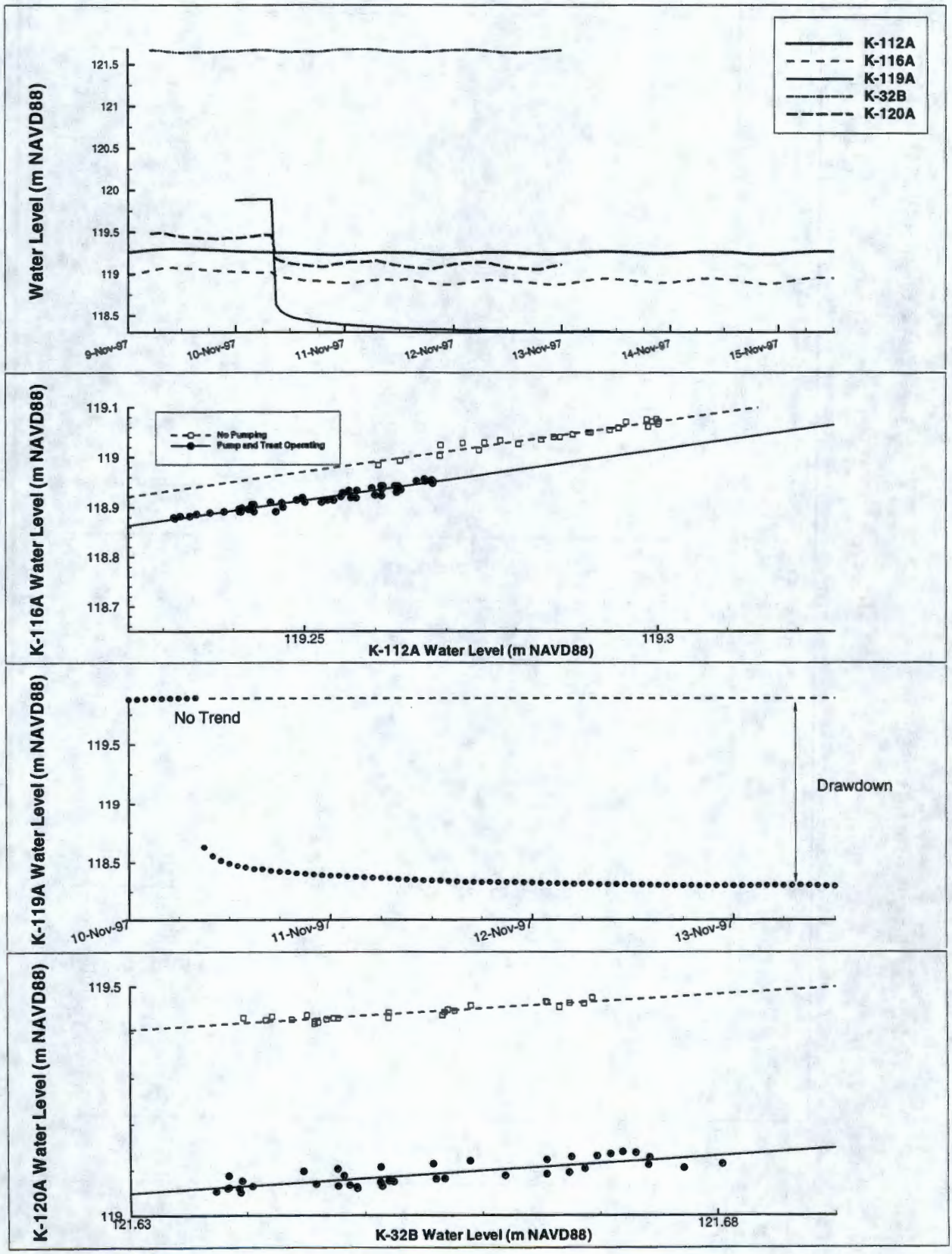
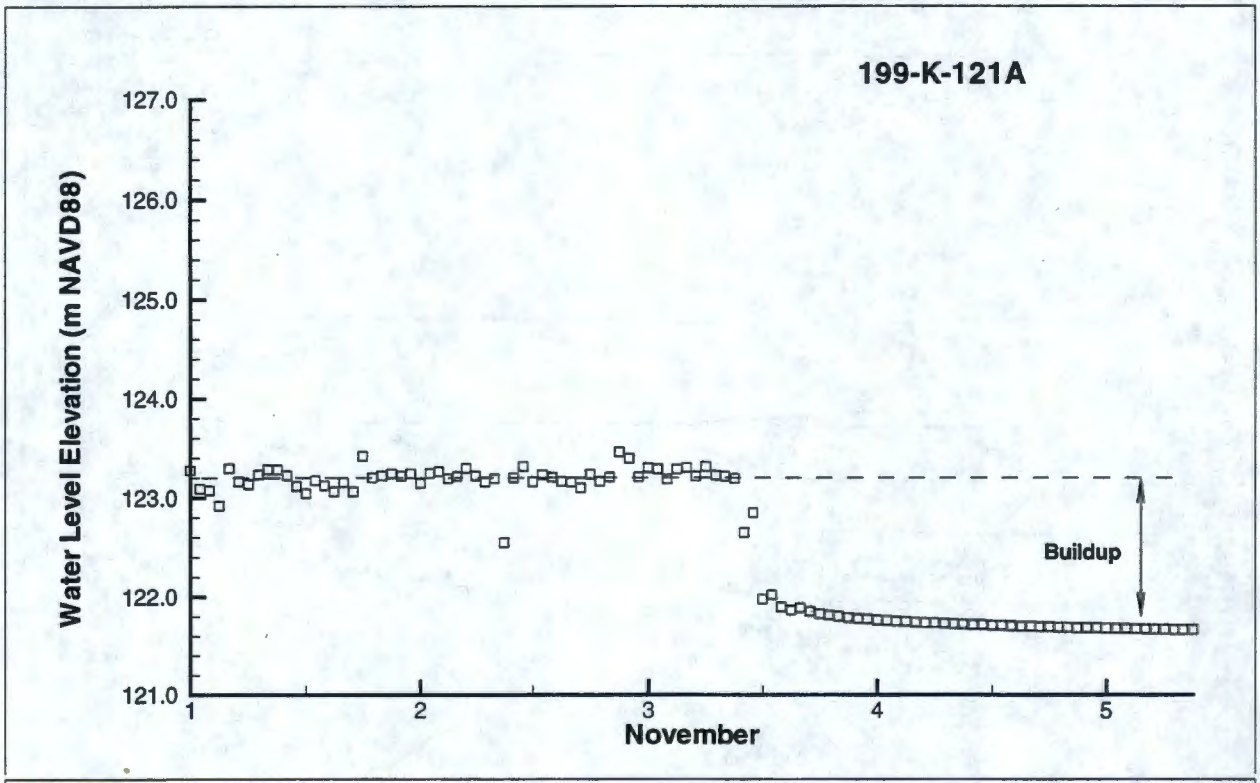


Figure 4-11. Buildup Measured in 100-KR-4 Injection Wells.
Page 1 of 2



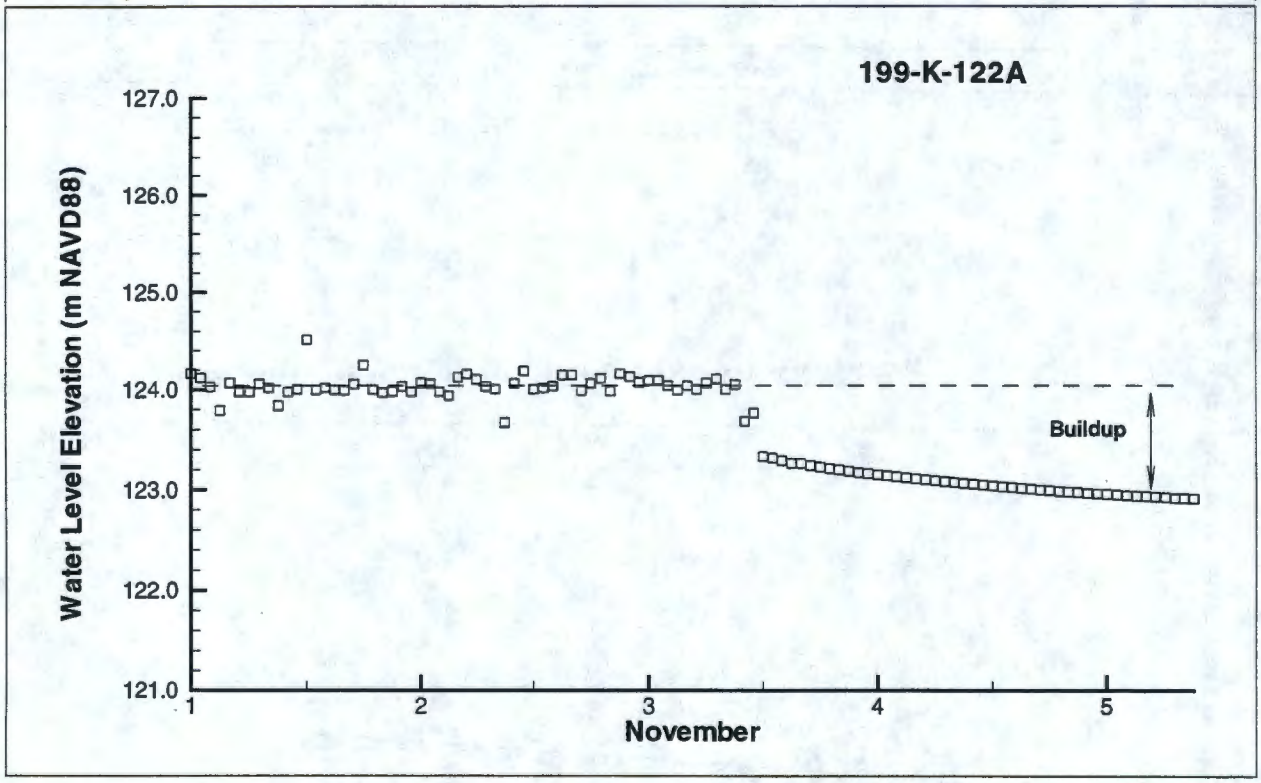


Figure 4-11. Buildup Measured in 100-KR-4 Injection Wells.
Page 2 of 2

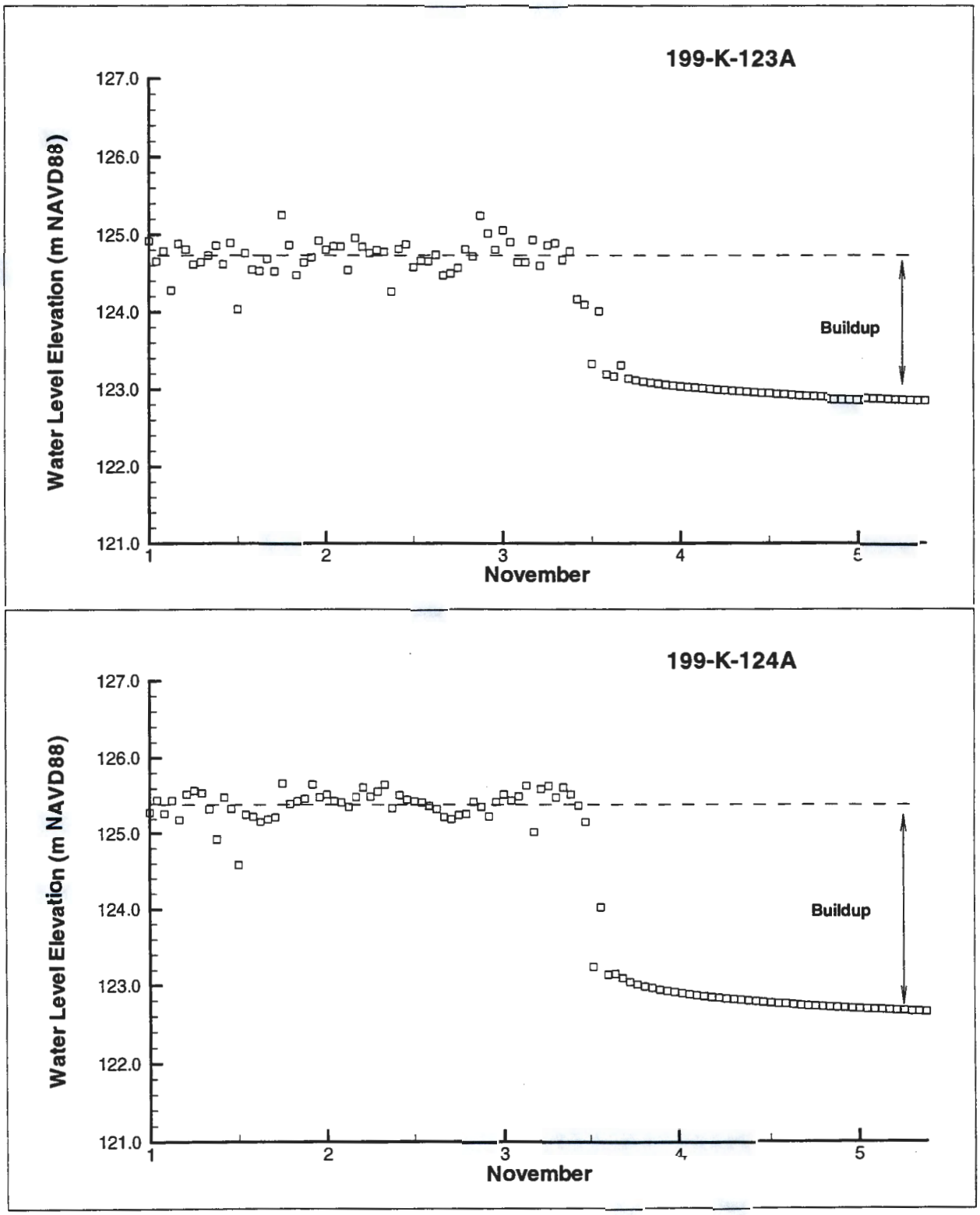


Figure 4-12. River Stage Correlation and Drawdown Measured in 100-KR-4 Area Compliance and Monitoring Wells.

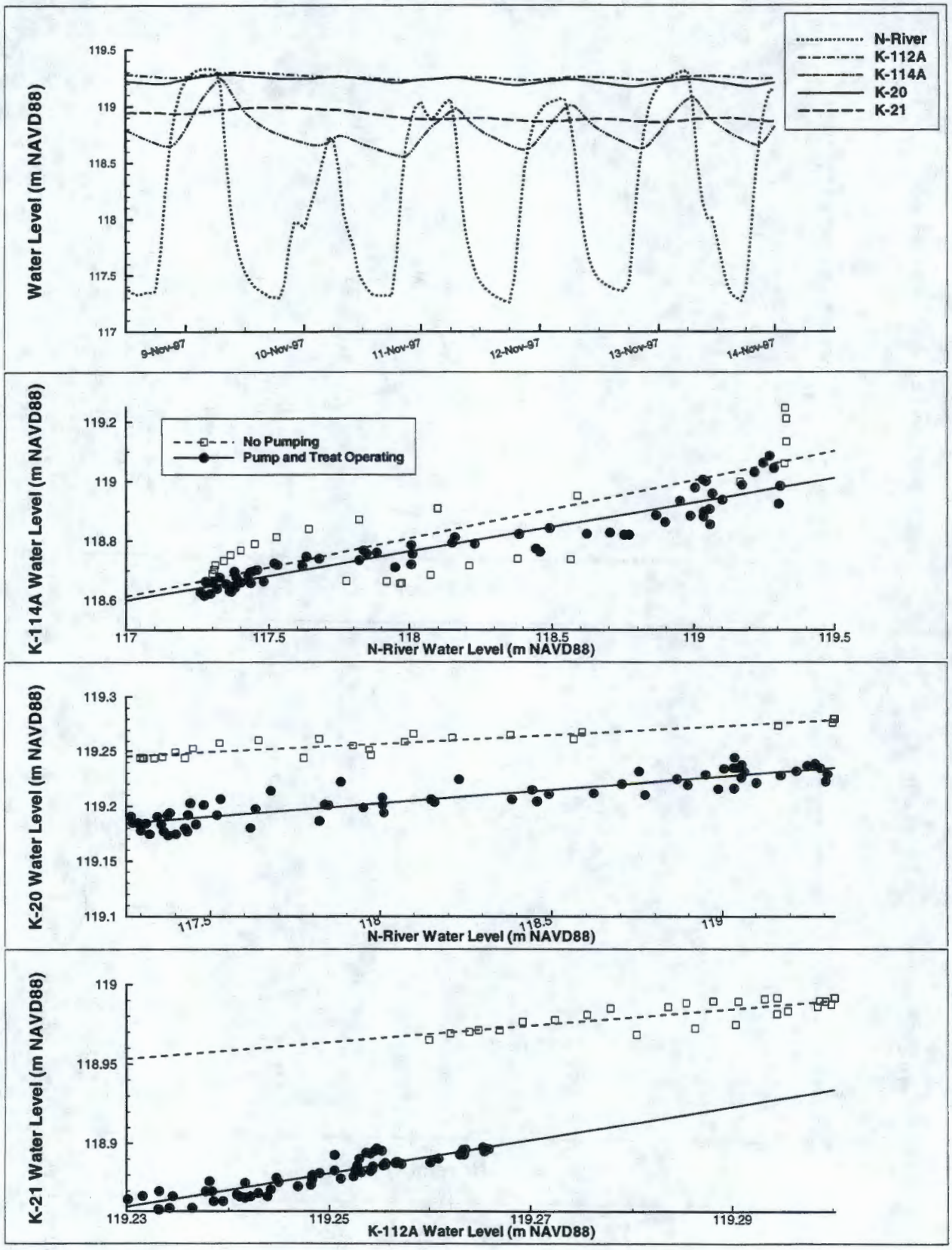
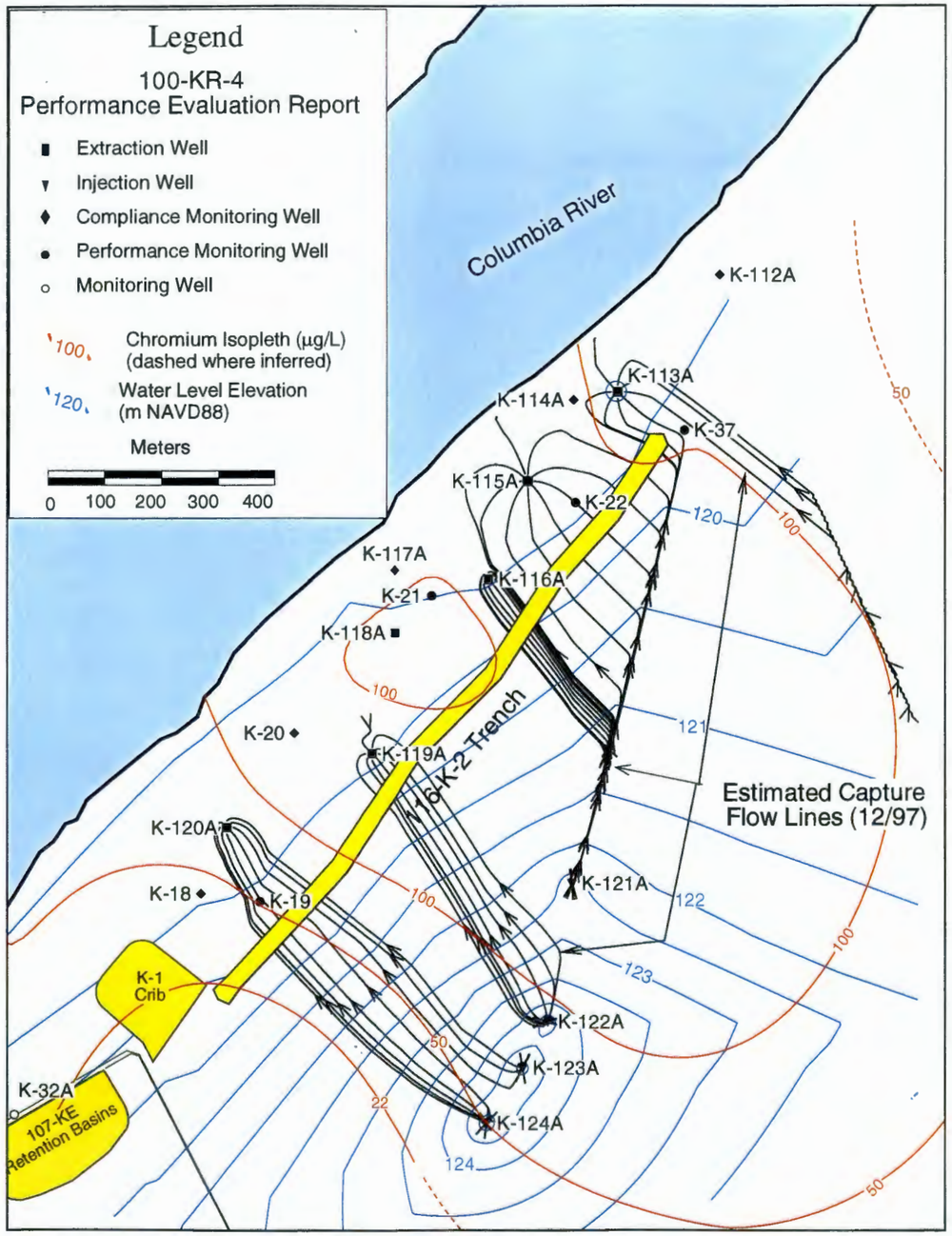
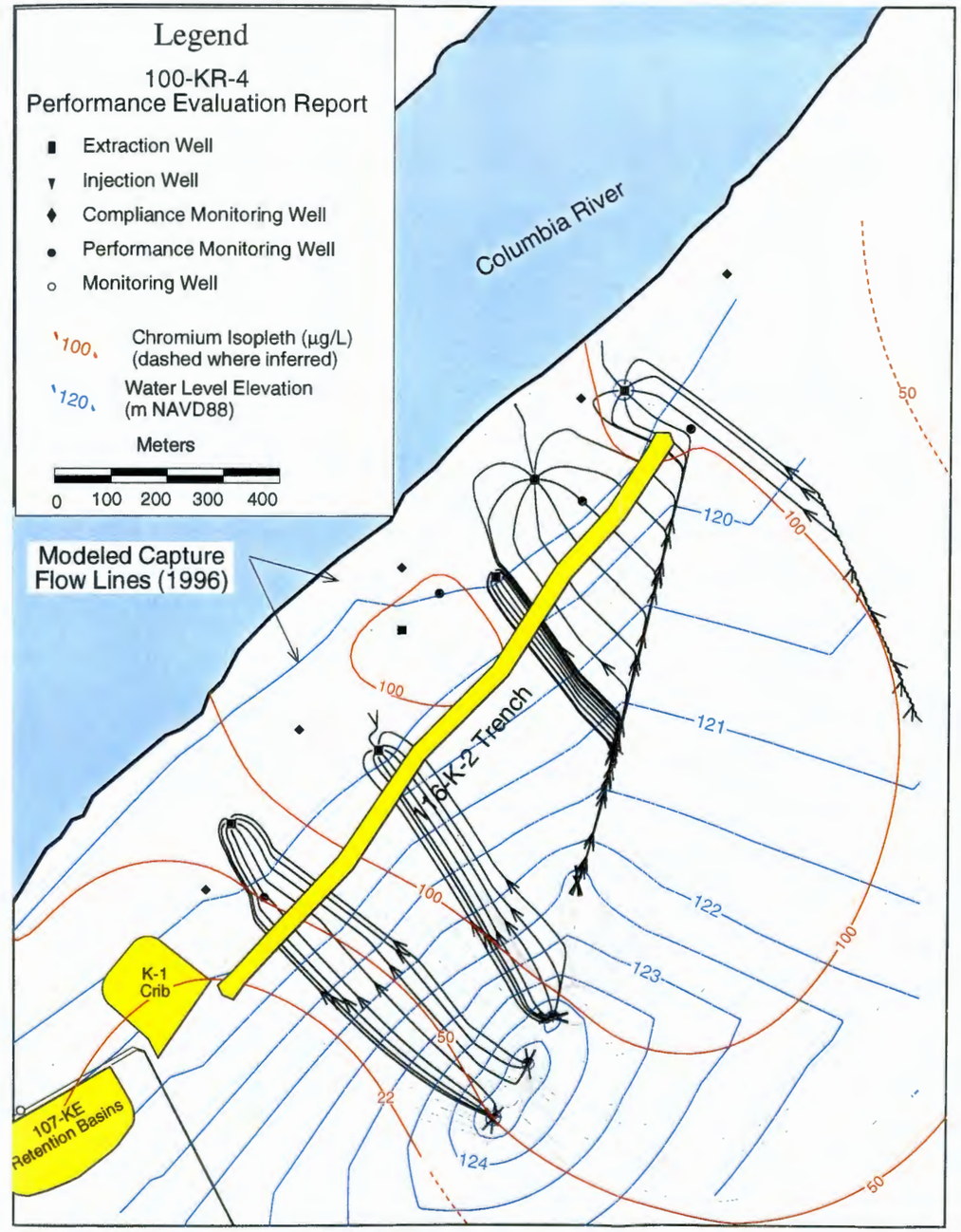


Figure 4-13. Hydraulic Capture Zone Developed by 100-KR-4 Area Extraction Wells and Comparison to Modeled Flow Lines from DOE-RL 1996.





THIS PAGE INTENTIONALLY
LEFT BLANK

Figure 4-14. Hydraulic Containment Developed by 100-KR-4 Area Extraction Wells.

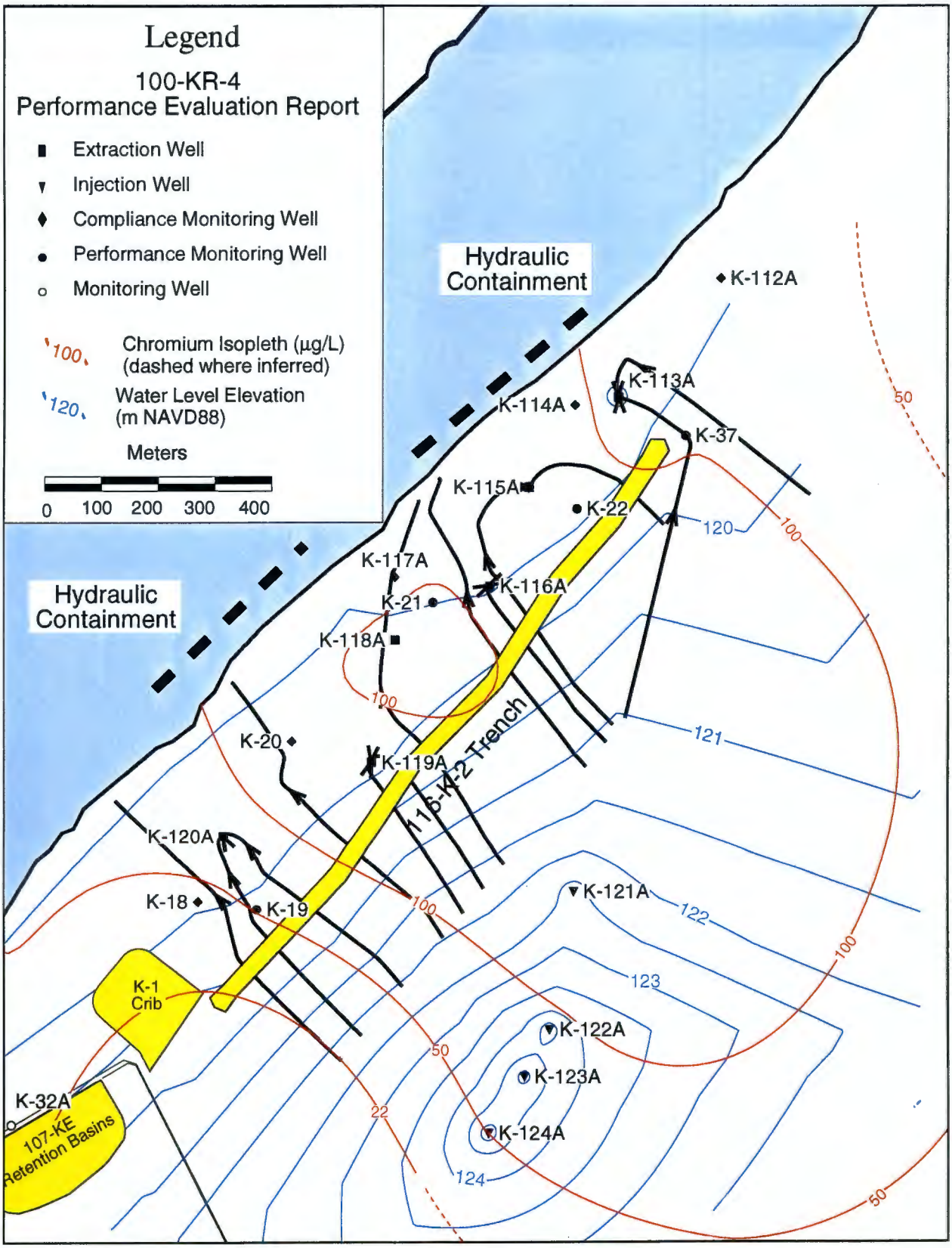


Figure 4-15. Baseline Chromium Distribution for the 100-K Area Taken From the RDR/RAWP.

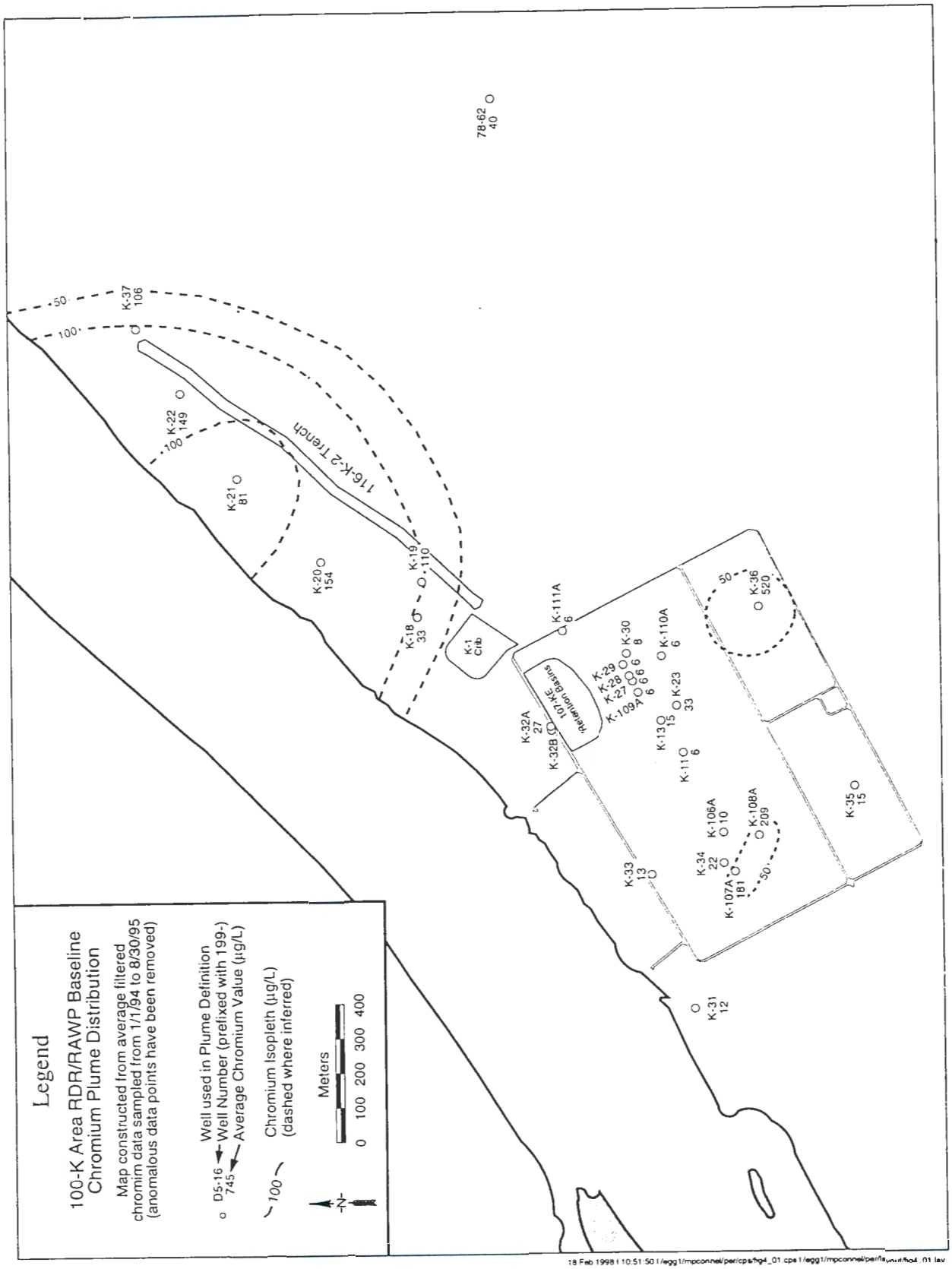
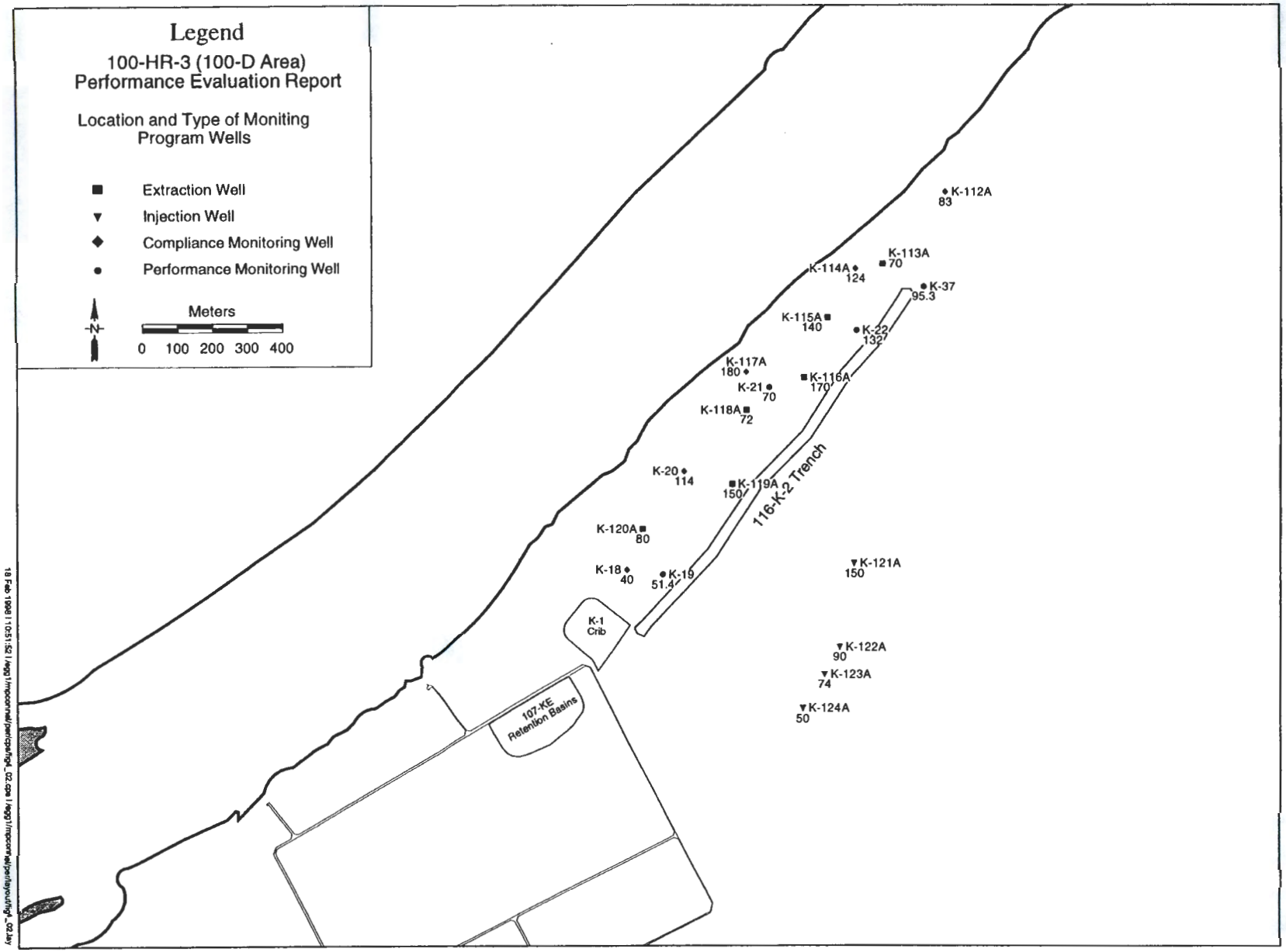


Figure 4-16. Location Map Showing the Extraction Wells, Injection Wells, Compliance Monitoring Wells and Performance Monitoring Wells for the 100-KR-4 OU.



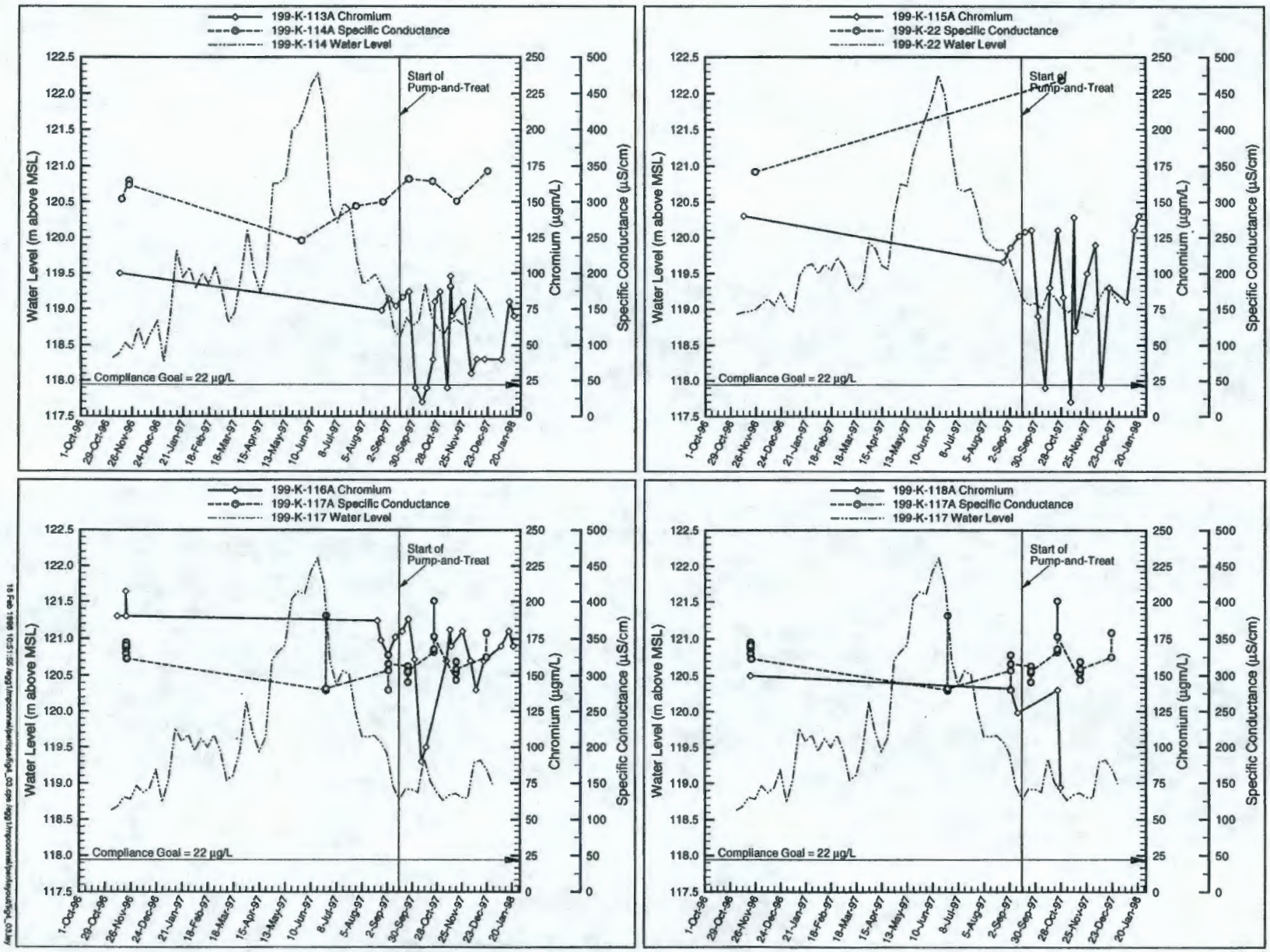
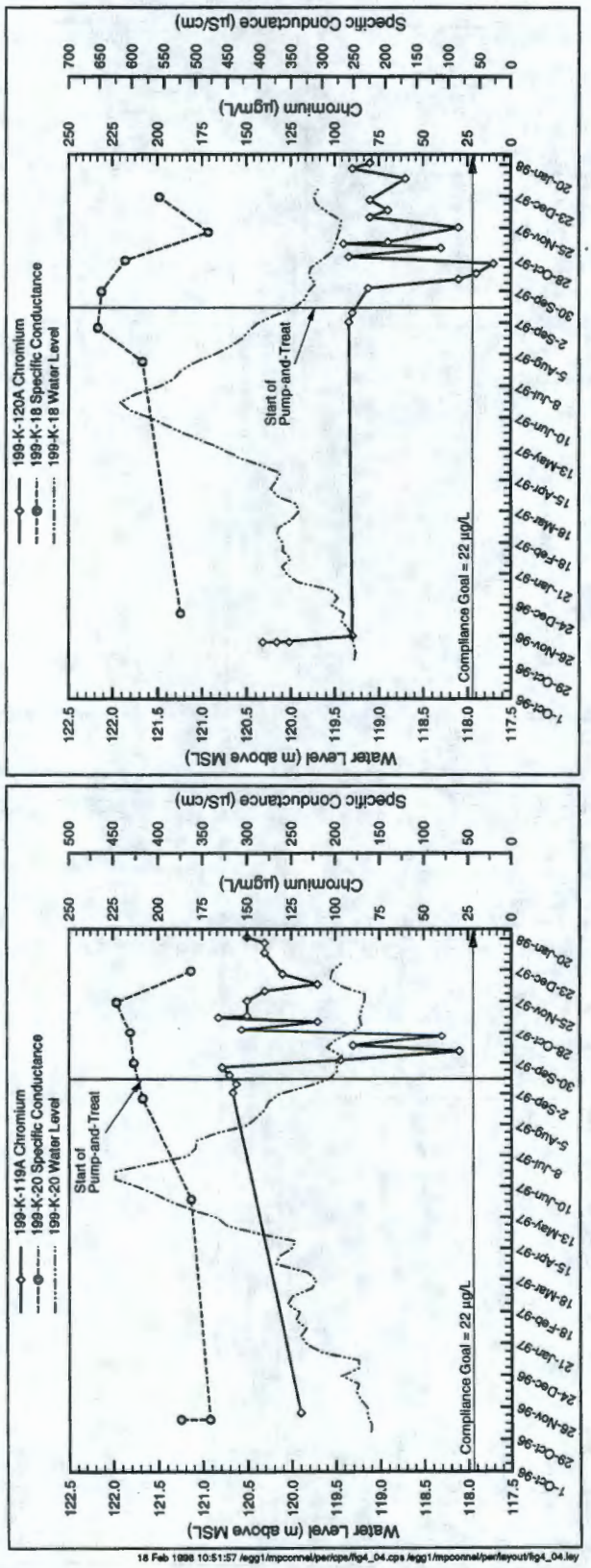


Figure 4-17. Trend Plots for Chromium Measured at the Extraction Wells 199-K-113A, 199-K-115A, 199-K-116A, And 199-K-118A.

Figure 4-18. Trend Plots for Chromium Measured at the Extraction Wells 199-K-119A and 199-K-120A.



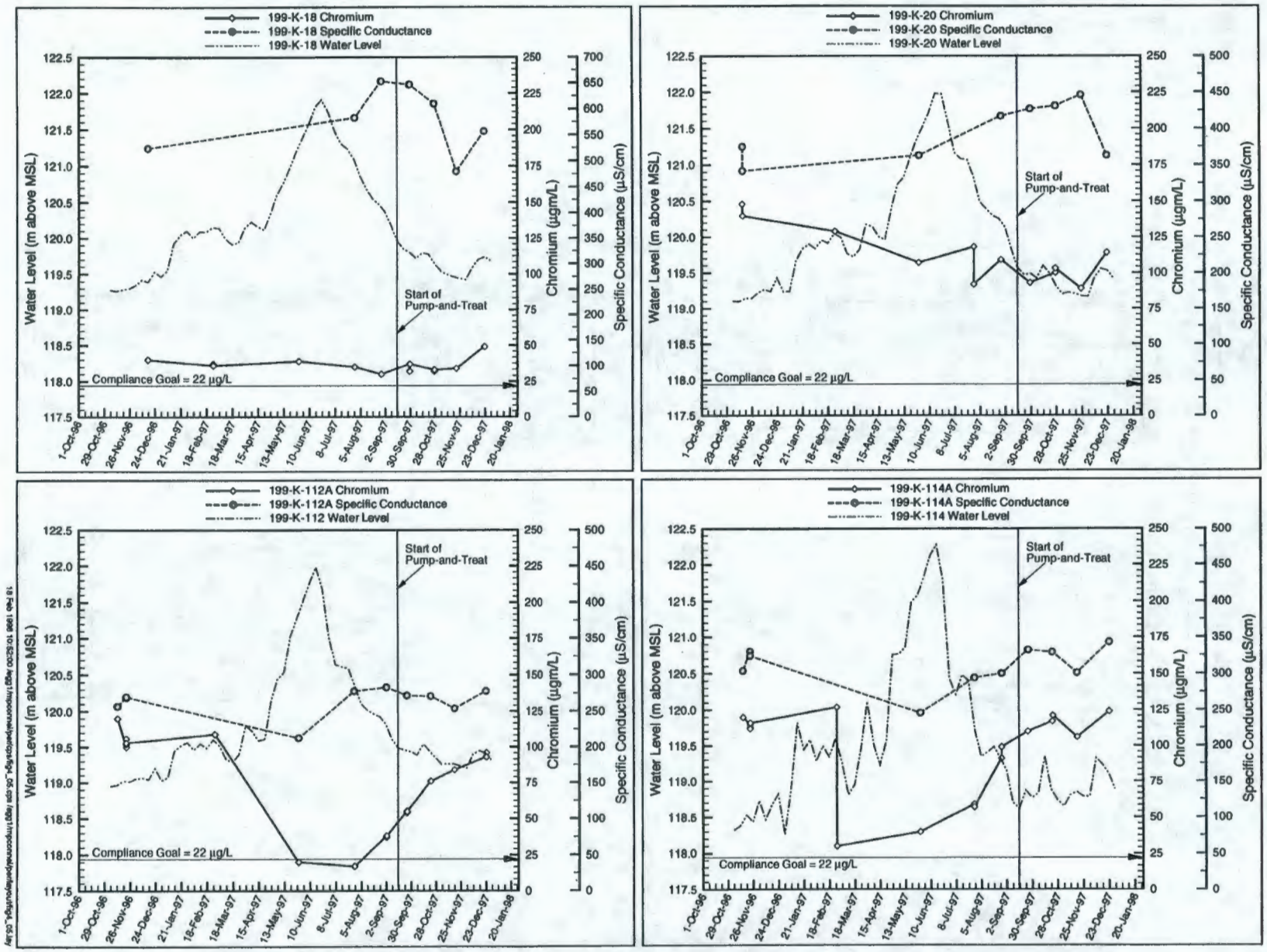
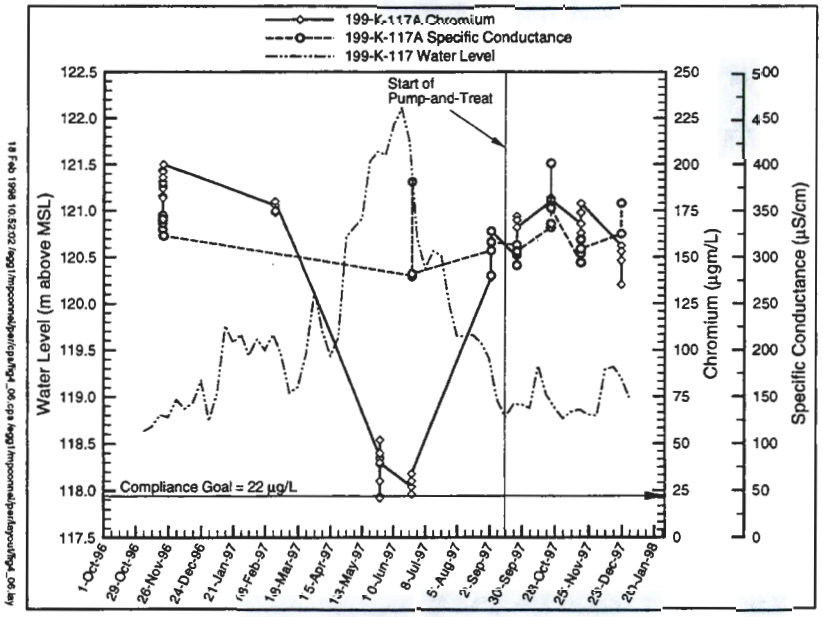


Figure 4-19. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance Monitoring Wells 199-K-18, 199-K-20, 199-K-112A and 199-K-114A.

Figure 4-20. Trend Plot for Chromium, Specific Conductance and Average Weekly Water Elevation Measured at the Compliance Monitoring Well 199-K-117A.



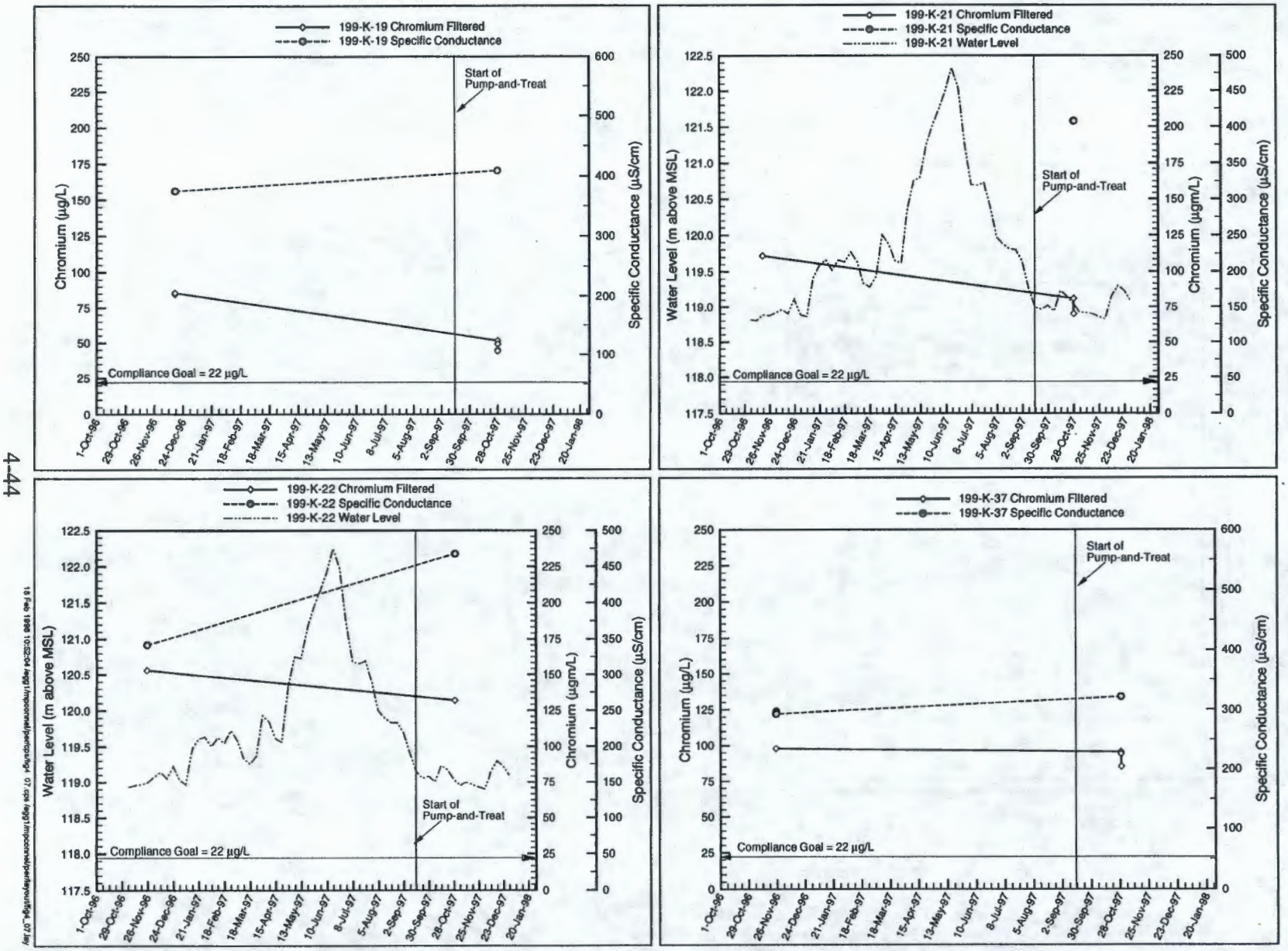


Figure 4-21. Trend Plots for Chromium and Specific Conductance at Performance Monitoring Wells 199-K-19 and 199-K-37. Trend Plots for Chromium, Specific Conductance and Average Weekly Water Elevation at Performance Monitoring Wells 199-K-21 and 199-K-22.

Figure 4-22. 100-K Area Chromium Plume Distribution for the Last Quarter of 1997.

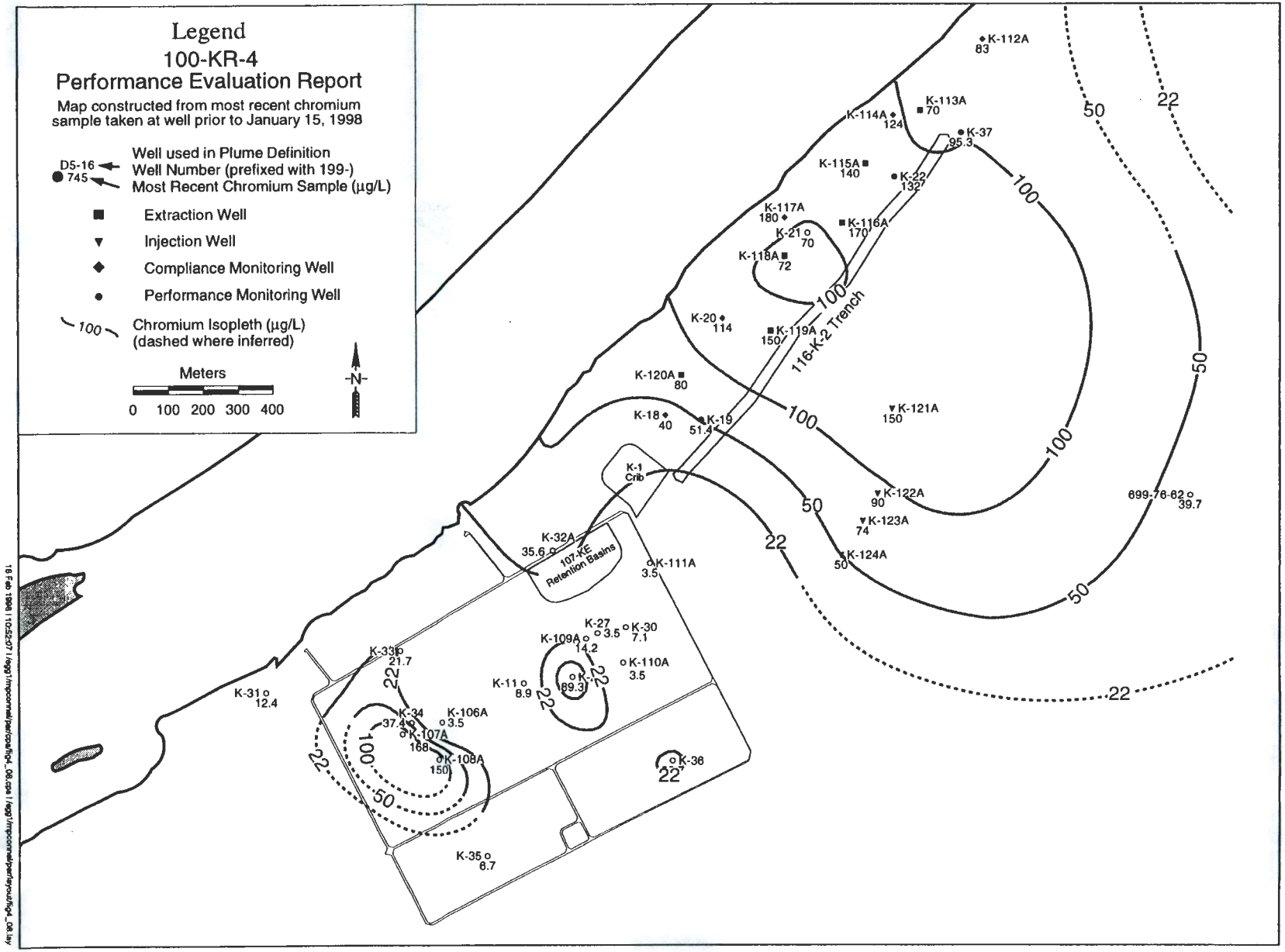


Table 4-1. Extraction/Injection Well Identification and Rates.

Well Identification	Extraction/Injection Rates		Notes
	Original Estimate in L/min (gal/min)[a]	As of 1/1/98 in L/min (gal/min)[b]	
199-K-113A	95 (25)	95(25)	Extraction Well
199-K-115A	95 (25)	95 (25)	Extraction Well
199-K-116A	95 (25)	95 (26)	Extraction Well
199-K-118A	95 (25)	0 (0)	Extraction Well
199-K-119A	95 (25)	95 (25)	Extraction Well
199-K-120A	95 (25)	95 (25)	Extraction Well
199-K-121A	190 (50)	113 (30)	Injection Well
199-K-122A	190 (50)	190 (50)	Injection Well
199-K-123A	190 (50)	190 (50)	Injection Well
199-K-124A	190 (50)	113 (30)	Injection Well

[a] Data from the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*, DOE-RL 1997

[b] Data from the *100-HR-3/100-KR-4 Project Specific Database*

Table 4-2. IX Vessel Operational Data.

IX Vessel Identification [a]	Volume Processed at Breakthrough (liters)	Cr+6 Absorbed[b] at Breakthrough at 50 µg/L (grams)	Volume Processed at Final Realignment (liters)	Cr+6 Absorbed[b] at Final Realignment (liters)	Percent Saturation at Final Realignment
K-IX-A1-1 [c]	4,755,000	486	8,635,500	680	80%
K-IX-B1-1 [c]	7,284,500	808	10,364,500	927	69%
K-IX-A2-1	24,648,00	2231	30,130,000	2520	92%
K-IX-B2-1	19,354,000	1343	22,636,000	2520	83%
K-IX-A3-1	39,040,000	1360	see note below	see note below	see note below
K-IX-B3-1	33,178,500	1492	see note below	see note below	see note below
K-IX-A4-1	see note below	see note below	see note below	see note below	see note below
K-IX-B4-1	see note below	see note below	see note below	see note below	see note below
K-IX-A1-2	see note below	see note below	see note below	see note below	see note below
K-IX-B1-2	see note below	see note below	see note below	see note below	see note below
K-IX-A2-2	see note below	see note below	see note below	see note below	see note below
K-IX-B2-2	see note below	see note below	see note below	see note below	see note below

Note: Data for the IX vessel is not yet available, vessel operations have not yet reached this stage.

[a] The number following the vessel designation represents the batch of resin in the vessel at the time of resin replacement. For example, vessel K-IX-A1-1 is a vessel that has not had resin replaced (first batch), vessel K-IX-A1-2 is the same vessel, and has undergone resin replacement once (second batch). Vessels are listed in the order used based on the dates the vessels were online.

[b] Cr+6 Absorbed refers to the mass of hexavalent chromium absorbed by the vessel.

[c] Indicates a lead vessel only during operational life of the vessel. Vessel realignment did not occur for this IX vessel.

Table 4-3. Waste Designation Results for Used IX Resin.

Resin Source (vessel)	TCLP Results for Cr+6 (mg/L)	Nitrate (mg/kg)	Tritium (pCi/g)	Sr-90 (pCi/g)	Tc-99 (pCi/g)	U-233/234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
K-IX-A1-1	3.84	4800	11	-0.16 U	0.28	0.77 B	0.048 U	0.64
K-IX-B1-1	3.82	1.98	10.2 J	0.00508 U	0.391	1.32	0.00367 U	1.05
K-IX-A2-1	6.1	1.1	8.89 J	results pending	0.128	0.109	0.00841 U	0.0897
K-IX-B2-1	3.8	3.62	10.3J	results pending	0.0578U	0.107	0.00697 U	0.0784

U = analyte not detected or below instrument detection range
J = estimated value
B = analyte detected in blank

Table 4-4. 100-KR-4 Pump-and-Treat System Interim Action Design and Operational Performance Against Criteria.

Requirements (Performance Criteria)	How Met?
Treatment system will reduce the effluent chromium concentrations of groundwater to the maximum extent practical. No chromium discharge above 50 μg/L.	The treatment system has reduced effluent concentrations to well below the 50 μg/L hexavalent chromium concentration limit. The chromium removal efficiency for the treatment system is 92%.
The extraction and injection system will be designed to run on an essentially continuous basis such that resin change out and maintenance can be conducted with minimal impact to system operations.	The system runs on essentially a continuous basis (93.0% availability). The system is winterized such that extended system outages due to frozen or broken components does not occur. Availability of the system will increase with the conclusion of startup activities and improvements in resin change out procedures.
The analyte list shall include hexavalent chromium, conductivity, and on an infrequent basis, co-contaminants.	Semi-annually, influent and effluent are sampled for hexavalent chromium, conductivity, and co-contaminants.
Design should provide flexibility following startup to accommodate changes in plume characteristics, or a different understanding of actual or perceived responses of the aquifer/plume to the pump-and-treat system.	Adjustable-frequency drive pumps provide for flexible pumping rates and additional pumping capacity to accommodate changes in plume characteristics.
Wastes generated during the remedial action, shall be disposed of principally at ERDF, or at other on site or off site facilities as appropriate.	All waste management strategies (disposal at ERDF or CWC, or resin regeneration) fulfill the performance criteria for waste management.
The system shall be designed such that if one or several of the wells are down, the rest of the system can continue operating.	Each well has its own pump (extraction wells excluded), water level transducers, and well head assembly including pressure sensors, heat tracing, and flowmeters. Continued extraction/injection during well maintenance outages is fulfilled.

Table 4-5. Drawdown and Buildup Data and December 1997 Water Level in 100-KR-4 Extraction, Injection, and Monitoring Wells.

	Time Frame	Pumping Rate (L/min)	Measured Drawdown(-)/ Buildup(+) (m)	Time Frame	Pumping Rate (L/min)	Measured Drawdown(-)/ Buildup(+) (m)
100-KR-4						
100 K Area Extraction Wells						
199-K-113A	11/9/97 - 11/14/97	95	-2.19	12/4/97 - 12/13/97	97	-1.81
199-K-115A	11/9/97 - 11/14/97	96	-0.92	12/4/97 - 12/13/97	98	-0.88
199-K-116A	11/9/97 - 11/14/97	97	-0.06	12/4/97 - 12/13/97	98	-0.10
199-K-119A	11/9/97 - 11/14/97	96	-1.58	12/4/97 - 12/13/97	96	-1.60
199-K-120A	11/9/97 - 11/14/97	97	-0.36	12/4/97 - 12/13/97	98	-0.28
100 K Area Injection Wells						
199-K-121A	11/4/97 - 11/6/97	118	1.53	11/29/97 - 12/1/97	89	1.55
199-K-122A	11/4/97 - 11/6/97	142	1.13	11/29/97 - 12/1/97	154	1.75
199-K-123A	11/4/97 - 11/6/97	144	1.88	11/29/97 - 12/1/97	154	2.86
199-K-124A	11/4/97 - 11/6/97	97	2.73	11/29/97 - 12/1/97	89	3.71
100 K Area Observation Wells						
199-K-114A	11/9/97 - 11/14/97		-0.05			
199-K-20	11/9/97 - 11/14/97		-0.05	12/4/97 - 12/13/97		-0.09
199-K-21	11/9/97 - 11/14/97		-0.08	12/4/97 - 12/13/97		-0.07

100-KR-4 December 1997 Water Level Elevation

Well	Water Level Elevation (m NAVD88)	Well	Water Level Elevation (m NAVD88)
199-K-113A	117.67	199-K-18	119.72
199-K-115A	118.29	199-K-20	119.61
199-K-116A	119.21	199-K-21	119.31
199-K-119A	118.32	199-K-22	119.30
199-K-120A	119.28	199-K-30	121.61
199-K-121A	123.15	199-K-32A	120.27
199-K-122A	124.64	199-K-37	119.60
199-K-123A	125.71	199-K-112A	119.43
199-K-124A	126.32	199-K-114A	119.19
		199-K-117A	119.27

Table 4-6. 100-KR-4 Interim Action Monitoring Schedule.
Page 1 of 2

Sample Group	Pre-Startup November 1996 to June 1997			Startup July 1997 through September 1997			Operations October 1997 to End		
	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]
Extraction Wells									
K-113A	M	X	X	T	M	--	T	Q	SA
K-115A	M	X	X	T	M	--	T	Q	SA
K-116A	M	X	X	T	M	--	T	Q	SA
K-118A	M	X	X	T	M	--	T	Q	SA
K-119A	M	X	X	T	M	--	T	Q	SA
K-120A	M	X	X	T	M	--	T	Q	SA
Injection Wells									
K-121A	M	X	X	T	--	--	T	--	--
K-122A	M	X	X	T	--	--	T	--	--
K-123A	M	X	X	T	--	--	T	--	--
K-124A	--	--	--	--	--	--	--	--	--
Compliance Wells									
K-18	T	Q	--	T	M	--	T	M	A
K-20	T	Q	--	T	M	--	T	M	A
K-112A	T	Q	--	T	M	--	T	M	A
K-114A	T	Q	--	T	M	--	T	M	A
K-117A	T	Q	--	T	M	--	T	M	A

Table 4-6. 100-KR-4 Interim Action Monitoring Schedule.
Page 2 of 2

Sample Group	Pre-Startup November 1996 to June 1997			Startup July 1997 through September 1997			Operations October 1997 to End		
	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]	Water Level	Chromium Field	Co-contaminants[a]
Performance Wells									
K-19	M	X	--	M	--	--	Q	SA	--
K-21	T	X	--	T	--	--	T	SA	--
K-22	T	X	--	T	--	--	T	SA	--
K-37	M	X	--	M	--	--	Q	SA	--
Treatment System									
Influent	--	--	--	--	D	--	--	D	SA
Effluent	--	--	--	--	D	--	--	D	SA
H River	T	--	--	--	--	--	--	--	--

[a]Strontium-90 and tritium
Note: Field parameters: pH, temperature, specific conductance, and turbidity will be taken during sampling at all wells. Transducers may be eliminated and replaced with manual measurements during operations period.
A = Annually
D = Daily
M = Monthly
Q = Quarterly
SA = Semiannually
T = Transducer
X = One-time event

Table 4-7. Results of Discrete Interval Sampling for Chromium in Compliance Well 199-K-117A.

Date	Sample Number	Chromium µg/L	Filtered	Depth below Ground Surface (m)
26-Feb-97	B0JY82	178	Y	9.14
26-Feb-97	B0JYY1	175	Y	12.19
26-Feb-97	B0JYY2	180	Y	16.46
26-Feb-97	B0JYY3	174	Y	19.51
29-May-97	B0L020	52	Y	9.14
30-May-97	B0L021	43	Y	12.19
31-May-97	B0L022	42	Y	16.46
1-Jun-97	B0L023	40	Y	19.51
2-Jun-97	B0L024	22	Y	19.51
3-Jun-97	B0L025	21	Y	19.51
4-Jun-97	B0L026	52	Y	9.14
5-Jun-97	B0L027	45	Y	12.19
6-Jun-97	B0L028	39	Y	16.46
7-Jun-97	B0L029	30	Y	19.51
26-Jun-97	B0L7M9	23	Y	0.6096 m below Water Table
27-Jun-97	B0L7N0	27	Y	9.14
28-Jun-97	B0L7N1	30	Y	12.19
29-Jun-97	B0L7N2	27	Y	16.46
30-Jun-97	B0L7N3	34	Y	19.51
3-Sep-97	B0LNK2	139	Y	9.14
3-Sep-97	B0LNK3	154	Y	12.19
3-Sep-97	B0LNK4	159	Y	16.46
3-Sep-97	B0LNL0	164	Y	19.51
25-Sep-97	B0M0Y0	150	Y	9.14
26-Sep-97	B0M0Y1	166	Y	12.19
27-Sep-97	B0M0Y2	170	Y	16.46
28-Sep-97	B0M0Y3	172	Y	19.51
24-Oct-97	B0M766	182	Y	9.14
25-Oct-97	B0M7K8	179	Y	12.19
26-Oct-97	B0M7K9	180	Y	15.24
27-Oct-97	B0M7L0	181	Y	19.51
18-Nov-97	B0M8X4	179	Y	9.14
18-Nov-97	B0M9B4	163	Y	12.19
18-Nov-97	B0M9B5	168	Y	16.46
18-Nov-97	B0M9B6	174	Y	19.51
22-Dec-97	B0MK27	135	Y	9.14
22-Dec-97	B0MK32	153	Y	12.19
22-Dec-97	B0MK33	148	Y	16.46
22-Dec-97	B0MK34	156	Y	19.51

Table 4-8. Chromium Results Used to Make Chromium Distribution Map for the 100-K Area.

Well	Sample#	CAS	Date	Result	Filtered
199-K-11	B0JLN5	7440-47-3	35403	8.9	Y
199-K-18	B0MVK7	18540-29-9	35818	40	Y
199-K-19	B0M7D8	7440-47-3	35731	51.4	Y
199-K-20	B0MK31	18540-29-9	35786	114	Y
199-K-21	B0M777	18540-29-9	35731	70	Y
199-K-21	B0M777	18540-29-9	35731	70	Y
199-K-22	B0M7F7	7440-47-3	35732	132	Y
199-K-23	B0LBK8	7440-47-3	35641	89.3	Y
199-K-27	B0M7H3	7440-47-3	35730	3.5	Y
199-K-30	B0M7H6	7440-47-3	35727	7.1	Y
199-K-31	B0M7H9	7440-47-3	35732	12.4	Y
199-K-32A	B0M7J2	7440-47-3	35732	35.6	Y
199-K-33	B0M7J8	7440-47-3	35730	21.7	Y
199-K-34	B0KBB2	7440-47-3	35548	37.4	Y
199-K-35	B0JLR1	7440-47-3	35403	8.7	Y
199-K-36	B0M7C3	7440-47-3	35731	23.7	Y
199-K-37	B0M794	7440-47-3	35732	95.3	Y
199-K-106A	B0M7N0	7440-47-3	35730	3.5	Y
199-K-107A	B0MVL2	18540-29-9	35817	168	Y
199-K-108A	B0MVL3	18540-29-9	35817	150	Y
199-K-109A	B0M7H0	7440-47-3	35727	14.2	Y
199-K-110A	B0M7C5	7440-47-3	35730	3.5	Y
199-K-111A	B0M7C8	7440-47-3	35732	3.5	Y
199-K-112A	B0MVK3	18540-29-9	35818	83	Y
199-K-113A	B0MW81		35816	70	
199-K-114A	B0MVK4	18540-29-9	35818	124	Y
199-K-115A	B0MW82		35816	140	
199-K-116A	B0MW83		35816	170	
199-K-117A	B0MVL6	18540-29-9	35818	180	Y
199-K-118A	B0M791		35730	72	
199-K-119A	B0MW84		35816	150	
199-K-120A	B0MW85		35816	80	
199-K-121A	B0JLY0	18540-29-9	35382	150	N
199-K-122A	B0JLY2	18540-29-9	35382	90	N
199-K-123A	B0JLZ1	18540-29-9	35383	74	N
199-K-124A	B0JLY6	18540-29-9	35383	50	N
699-78-62	B0M7B3	7440-47-3	35731	39.7	Y

Table 4-9. 100-K Area Monitoring Wells with Groundwater Having Co-Contaminants Exceeding the Relevant Standard.

Co-Contaminant Standard → Standard Value → Well ↓	Sr-90 Wa GWQ = 8 pCi/L	Tritium Wa GWQ = 20,000 pCi/L
199-K-120A		92,300
199-K-18		31,300
199-K-21	28.2	
199-K-114A	27.8	
199-K-20	18.1	
199-K-115A	15.5	
199-K-19	12.9	
199-K-113A	10.6	
199-K-22	9.1	

Table 4-10. Quality Control and Quality Assurance for 100-KR-4 OU Chromium Results.

	FIELD SCREEN REPLICATES					
Well Number	**199-K-113A**		**199-K-114A**		**199-K-18**	
Sample Number	B0MBJ4	BOMBL0	BOM762	BOM763	BOM768	BOM769
Hex Chrome (mg/L)	0.091	0.09	0.117	0.121	0.032	0.033
Well Number	**199-K-112A**		**199-K-20**			
Sample Number	BOMK24	BOMK25	BOM8X5	BOM8X6		
Hex Chrome (mg/L)	0.093	0.096	0.089	0.089		

	FIELD SCREEN/OFF SITE LAB SPLITS					
Well Number	**199-K-113A**		**199-K-114A**		**199-K-18**	
Sample Location	Field	Laboratory	Field	Laboratory	Field	Laboratory
Sample Number	BOMBJ4	BOMBK9	BOM8X8	BOM8X9	BOMK28	BOMK29
Hex Chrome (mg/L)	0.091	0.098	0.106	0.094	0.049	NA
Well Number	**199-K-112A**		**199-K-19**			
Sample Location	Field	Laboratory	Field	Laboratory		
Sample Number	BOM780	BOM781	BOM772	BOM773		
Hex Chrome (mg/L)	0.076	NA	0.045	0.044		

Table 4-11. Quality Control and Quality Assurance for 100-KR-4 OU Co-Contaminants.

OFF SITE LAB REPLICATES						
Well/Seep Number	**199-K-113A**		**199-K-114A**		**199-K-18**	
Sample Number	BOMBY7	BOMBJ3	BOM764	BOM765	BOM770	BOM771
Sr-89/90 (pCi/L)	7.03	10.6	26.6	27.8	0.346	0.266
H-3 (pCi/L)	334	u	261	142	--	--
Tc-99 (pCi/L)	--	--	--	--	--	--
Ur (total) µg/L	--	--	--	--	--	--
Hex Chrome (µg/L)	--	--	--	--	--	--
Gross alpha (pCi/L)	--	--	--	-	--	--
Gross beta (pCi/L)	--	--	--	--	--	--
N03-N	--	--	--	--	--	--

OFF SITE LAB SPLITS		
Well/Seep Number	**199-K-112A**	
Sample Number	BOM782	BOM783
Hex Chrome (µg/L)	--	--
Sr-90 (pCi/L)	U	2.19
NO3-N (mg/L)	--	--
Gross alpha (pCi/L)	--	--
Gross beta (pCi/L)	--	--
H-3 (pCi/L)	--	--

5.0 PUMP-AND-TREAT SYSTEM COST DATA

Actual costs for the 100-HR-3 pump-and-treat system and 100-KR-4 pump-and-treat system were recorded in Bechtel Hanford, Inc. *Code of Accounts Database*. Cost accruals are recorded, sorted by activity, and summed bimonthly in the database. The data can then be used to determine the actual capital and labor costs associated with a specific activity over a given period of time. This data has been used to estimate actual project costs (burdened) and projected future costs (based on actual costs to date). Specific activities are briefly described below:

- **Design:** This includes all labor and necessary activities required to develop a Request for Proposal for the construction of the pump-and-treat system. This includes all design activities such as the development of a material requisition, scope, schedule, and specifications, drawings and related design documents. It also includes site permitting, design criteria development, aquifer response modeling, peer reviews, quality assurance, and all other design documentation such as the RDR/RAWP.

- **Treatment System Capital Construction:** This includes all fees paid to the construction subcontractor for capital equipment and construction of the pump-and-treat system. This includes all Environmental Restoration Contractor labor required for the oversight and support of facility installation

- **Well Capital Construction:** This includes all fees paid to the construction subcontractor for capital equipment and construction of the new wells, and redevelopment of existing wells. This includes all ERC labor required for the oversight and support of well installation.

- **Project Support:** This includes project coordination related activities and technical consultation as required during the course of the facility design, construction and acceptance testing.

- **Initial Resin Purchase:** This is the cost of the initially purchased IX resin used in the IX vessels.

- **Operations:** This cost represents facility supplies (resin excluded), labor and craft supervision costs associated with operating the facility. It also includes costs associated with routine field screening.

- **Maintenance:** This cost represents capital, labor and craft supervision costs associated with maintenance activities at the facility.

- **System Sampling & Reporting:** This includes all system sampling and sample analysis as required in accordance with the *Interim Action Monitoring Plan* (DOE-RL 1997).

- **Groundwater Monitoring:** This includes all groundwater sampling and sample analysis as required in accordance with the *Interim Action Monitoring Plan* (DOE-RL 1997). It also includes the development of this performance evaluation report and subsequent reports as required by *Interim Action Monitoring Plan* (DOE-RL 1997).

- **Architecture & Engineering Support:** This includes engineering support as required during the course of the pump-and-treat operation and periodic maintenance.

- **Yearly Resin & Disposal Costs:** This is the estimated cost for the purchase and disposal of IX resin based on the current rate of IX resin consumption and current waste management strategy.

- **Waste Management:** This is the estimated cost for the management of spent resin in accordance with the applicable laws for suspect hazardous, toxic, and regulated wastes. It includes waste designation sampling and analysis.

All projected costs are burdened and are based on operating costs to date. Resin replacement and disposal costs are based on a use rate of two IX vessels (4.6 m^3 of Dowex™ 21K IX resin) per month for each pump-and-treat system. Projected project support costs for 1999 and beyond are from the detailed work plan.

5.1 100-HR-3 Pump-and-Treat System Costs

Costs for the 100-HR-3 pump-and-treat system are summarized in Table 5-1 and displayed by percent of total costs in the pie charts in Figure 5-1 and Figure 5-2. The present worth cost of the system has been estimated at $26,603,861, assuming a 10-year operating life. The present worth cost is found by escalating future cost by 3% and discounting the escalated cost by 9%. Assuming a yearly production rate of 282,490,000 L and 24,320 g of chromium removed per year, these treatment costs equate to 0.9¢/L or $109/g of hexavalent chromium removed (based on the present worth of the system).

Examination of Figure 5-2 indicates that the majority of operating costs over the life of the pump-and-treat system are associated with resin purchase and disposal. This is due in part to the assumption that under the current waste management strategy, half of the spent resin will be disposed of at ERDF ($8,500/yr) and half at CWC ($356,214/yr). Furthermore, replacement costs for the resin ($406,231/yr) make up over half of the costs associated with resin purchase and disposal. This equates to an annual IX resin purchase and disposal cost of approximately $770,900.

On the average, operations conduct a resin change out when an IX vessel has reached approximately 69% of saturation. This corresponds to a resin consumption rate of two IX vessels (4.6 m^3) of resin every 30 days (basis of the cost estimate). Extending the

operational life of an IX vessel until it reaches 100% saturation could reduce the resin use rate to two IX vessels (4.6 m^3) every 40 days. Data currently available indicates that extending the lead vessel operational life to 100% saturation would not increase system effluent levels. This resin consumption rate assumes a 1500 g IX vessel absorption capacity and no change in influent water chemistry. Unfortunately, any cost savings would be offset if all spent resin is designated as a toxic substance that requires disposal at CWC.

Disposal at CWC has been identified for contaminated resin containing quantities of hexavalent chromium sufficient to warrant its designation as a toxic waste (e.g., TCLP leachate chromium concentration is greater than 5 mg/L). If resin saturation levels can be controlled such that spent resin chromium levels do not result in a toxic waste designation, a cost savings may be realized by disposal of the resin at ERDF instead of CWC. Analytical data thus far indicate that if absorbed chromium exceeds 1,100 g, chromium concentrations in the TCLP leachate are likely to exceed the 5 mg/L toxic characteristic limit. Conceivably, operations could be modified such that vessel absorption could be tracked daily and the vessel could be removed from service when the chromium absorption reaches 1,100 g. Since the resin consumption rate under this scenario would remain relatively unchanged from current conditions (two IX vessels of resin every 30 days, assuming no change in influent water chemistry), additional resin purchases and disposal would not be required. The cost savings realized by disposing of all waste at ERDF could be as high as 40%. Some of the cost savings would be offset for the need to develop procedures to track IX vessels using daily field screening and process volume data to calculate mass absorption.

Resin regeneration by an offsite recycler could be purchased to significantly reduce resin purchase and disposal costs. Regeneration could result in cost savings of 60% over purchasing new resin for a one-time use as is currently done. The option to regenerate spent resin is contingent upon spent resin being non-radioactive. As discussed in Section 3.1.6, more data will be required to determine the best means to control radionuclide accumulation in the resin. Because of the potential cost savings, such efforts may be worthwhile.

Examination of Figure 5-2 indicates that the system sampling and reporting costs over the life of the pump-and-treat system are associated with 19% of the operations costs. Generally, cost savings can be realized by reducing the sampling frequency and analytical requirements. However, this is not recommended at this time as the effect of co-contaminants (radionuclides) on the treatment system and waste designation is still under evaluation. It is recommended that the need for sampling be revisited on a regular basis to determine the extent of sampling that is warranted by the performance criteria.

5.2 100-KR-4 Pump-and-Treat System Costs

Costs for the 100-KR-4 pump-and-treat system are summarized in Table 5-2 and displayed by percent of total costs in the pie charts in Figure 5-3 and Figure 5-4. The

present worth cost of the system has been estimated at $19,502,880, assuming a 10-year operating life. The present worth cost is found by escalating future cost by 3% and discounting the escalated cost by 9%. Assuming a yearly production rate of 228,023,000 L and 28,340 g of chromium removed, these treatment costs equate to 0.9¢/L or $72/g of hexavalent chromium removed (based on the present worth of the system).

Examination of Figure 5-4 indicates that system sampling and reporting represents the majority of operations costs over the life of the pump-and-treat system. Generally, cost savings can be realized by reducing the sampling frequency and analytical requirements. However, this is not recommended at this time as the effect of co-contaminants (radionuclides) on the treatment system and waste designation is still under evaluation. It is recommended that the need for sampling be revisited on a regular basis to determine the extent of sampling that is truly warranted by the performance criteria.

Examination of Figure 5-4 indicates that 16% of operating costs over the life of the pump-and-treat system are associated with resin purchase and disposal. This is due to a forecasted resin consumption rate of two IX vessels (4.6 m^3) of resin every 30 days (basis of the cost estimate). At this resin consumption rate, vessel change out generally occurs when an IX vessel has reached approximately 70% of saturation. Extending the operational life of an IX vessel until it reaches 100% saturation could reduce the resin consumption rate to two IX vessels (4.6 m^3) every 45 days. Data currently available indicate that extending the lead vessel operational life to 100% saturation would not increase system effluent levels. This resin consumption rate assumes a 2200 g IX vessel absorption capacity and no change in influent water chemistry. Unfortunately, any cost savings would be offset if spent resin is designated as a radiologically contaminated substance that requires disposal at CWC or ERDF. Resin regeneration must remain the primary means of disposal in order to realize the cost savings associated with extending the operational life of an IX vessel.

Figure 5-1. 100-HR-3 Capital and Construction Costs.

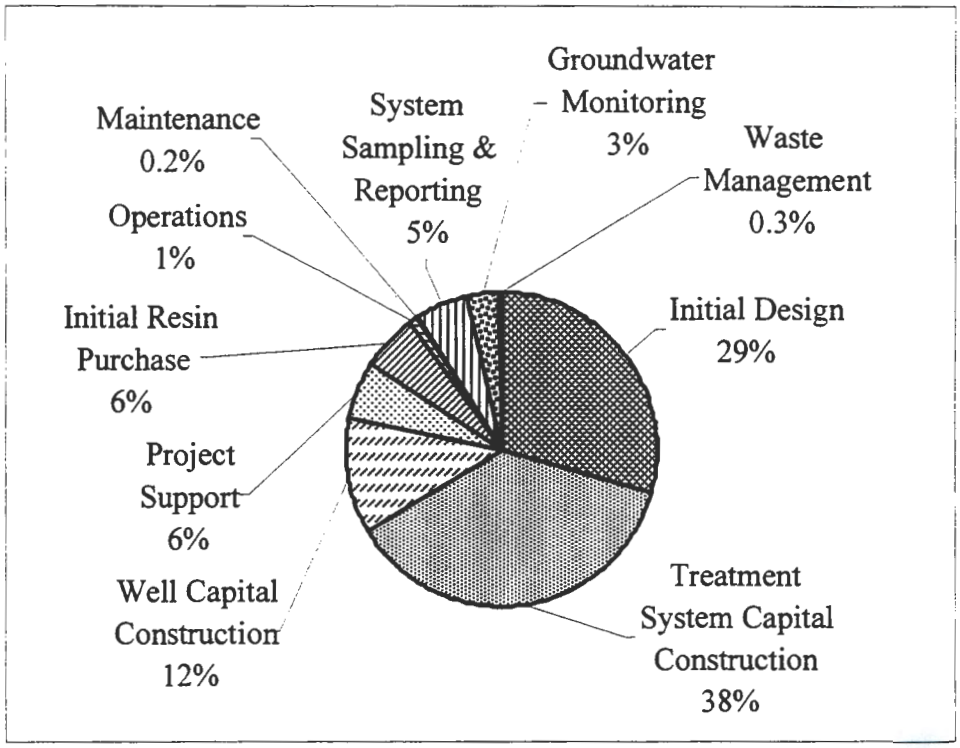


Figure 5-2. 100-HR-3 Projected Operating Costs.

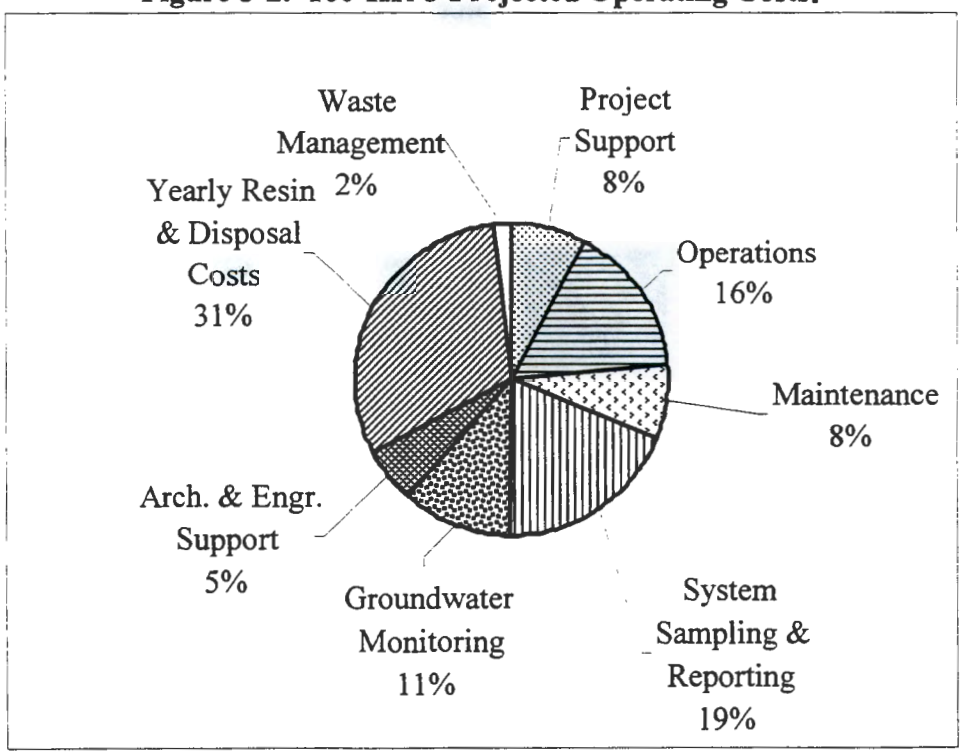


Figure 5-3. 100-KR-4 Capital and Construction Costs.

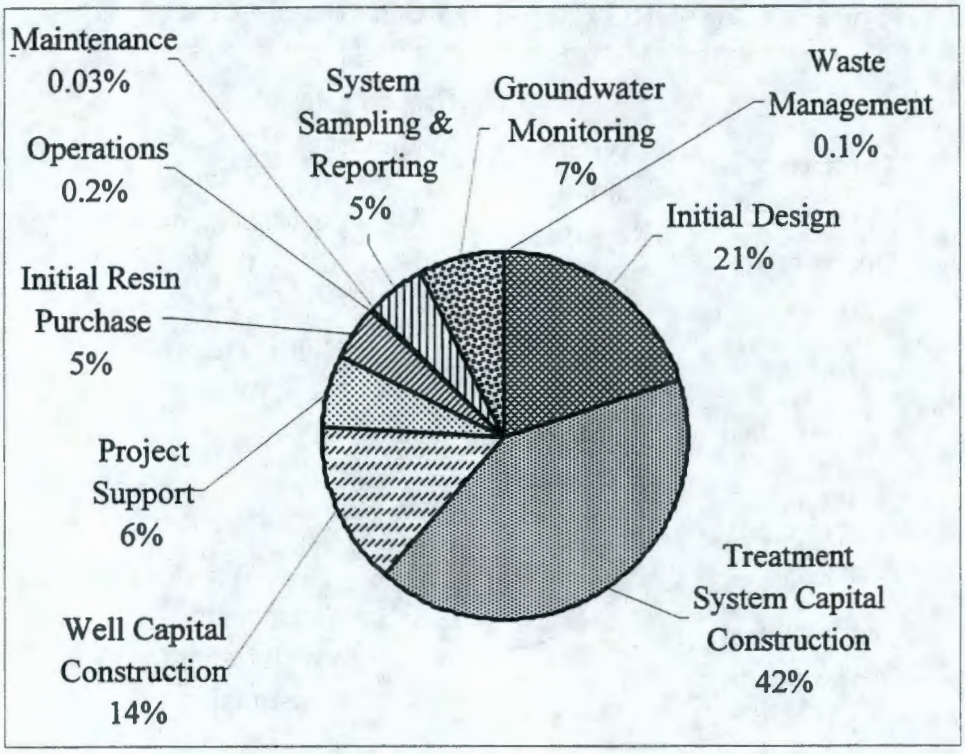


Figure 5-4. 100-KR-4 Projected Operating Costs.

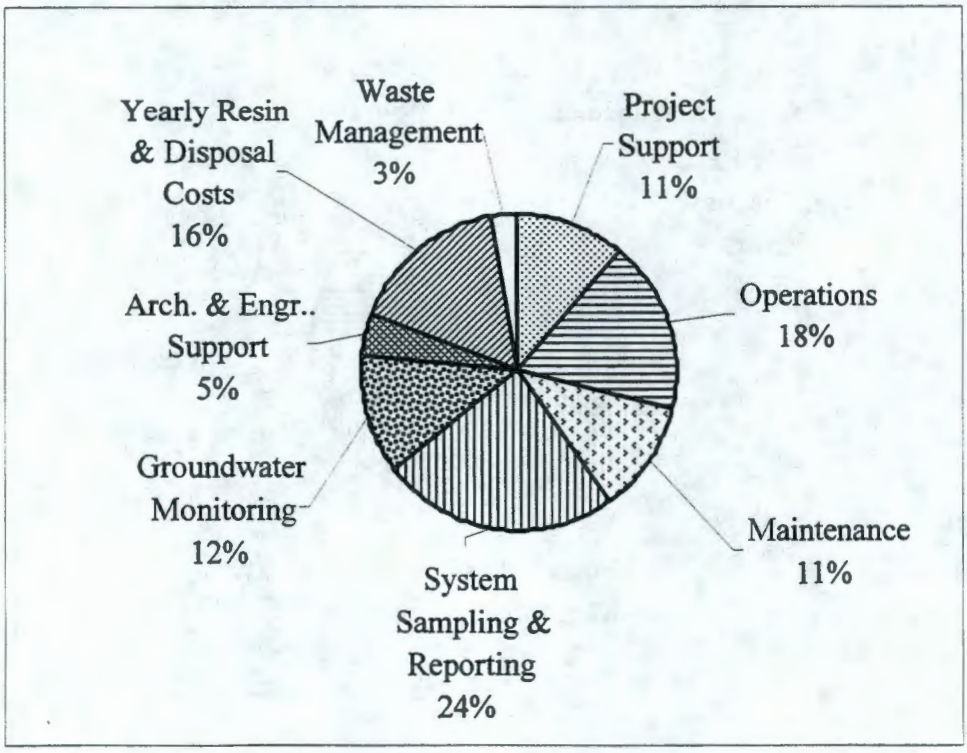


Table 5-1. Cost Summary for the 100-HR-3 Pump-and-Treat System.

Description	Actual Costs X 1000			Projected Costs X 1000									
	1995	1996	1997	1998*	1999	2000	2001	2002	2003	2004	2005	2006	2007
Initial Design	$104	$1,817	$296										
Treatment System Capital Construction		$229	$2,537	$31									
Well Capital Construction		$899											
Project Support			$441	$189	$189	$189	$189	$189	$189	$189	$189	$189	$189
Initial Resin Purchase			$458										
Operations			$60	$382	$382	$382	$382	$382	$382	$382	$382	$382	$382
Maintenance			$12	$187	$187	$187	$187	$187	$187	$187	$187	$187	$187
System Sampling & Reporting			$393	$466	$466	$466	$466	$466	$466	$466	$466	$466	$466
Groundwater Monitoring			$259	$277	$277	$277	$277	$277	$277	$277	$277	$277	$277
Architecture & Engineering Support			$0	$132	$132	$132	$132	$132	$132	$132	$132	$132	$132
Yearly Resin & Disposal Costs			$0	$551	$771	$771	$771	$771	$771	$771	$771	$771	$771
Waste Management			$22	$49	$49	$49	$49	$49	$49	$49	$49	$49	$49
Total	$104	$2,945	$4,478	$2,264	$2,453	$2,453	$2,453	$2,453	$2,453	$2,453	$2,453	$2,453	$2,453
GRAND TOTAL													**$31,869**

* Notes:
The estimate for FY 1998 is based on the 1998 Forecast dated 1/8/98 status date 12/29/97.
With the following changes: No resin will be regenerated. The labor will not change.
New resin (4.6 cubic meters [6.0 cubic yards]) is purchased each month.
Disposal cost are broken down with 50 % going to ERDF & 50% going to CWC.
Disposal to CWC will start in Feb 98 & to ERDF in Mar 98.
The Project Support Costs for 1999 & beyond are from the Detailed Work Plan (See Estimate for Year 2000).

Table 5-2. Cost Summary for the 100-KR-4 Pump-and-Treat System.

	Actual Costs X 1000			Projected Costs X 1000									
Description	**1995**	**1996**	**1997**	**1998***	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Initial Design		$874	$163										
Treatment System Capital Construction		$198	$1,926	$32									
Well Capital Construction		$752											
Project Support			$327	$226	$198	$198	$198	$198	$198	$198	$198	$198	$198
Initial Resin Purchase			$254										
Operations			$13	$304	$330	$330	$330	$330	$330	$330	$330	$330	$330
Maintenance			$2	$161	$208	$208	$208	$208	$208	$208	$208	$208	$208
System Sampling & Reporting			$276	$444	$444	$444	$444	$444	$444	$444	$444	$444	$444
Groundwater Monitoring			$382	$217	$217	$217	$217	$217	$217	$217	$217	$217	$217
Architecture & Engineering Support			$0	$85	$83	$83	$83	$83	$83	$83	$83	$83	$83
Yearly Resin & Disposal Costs			$0	$251	$304	$304	$304	$304	$304	$304	$304	$304	$304
Waste Management			$7	$46	$49	$49	$49	$49	$49	$49	$49	$49	$49
Total		$1,823	$3,349	$1,767	$1,833	$1,833	$1,833	$1,833	$1,833	$1,833	$1,833	$1,833	$1,833
GRAND TOTAL													**$23,437**

* Notes:
The estimate for FY 1998 is based on the 1998 Forecast dated 1/8/98 status date 12/29/97.
Resin (4.6 cubic meters [6.0 cubic yards]) is regenerated and re-used each month.
The estimate for most of FY 1999 was made by taking an average of the last 6 months of the 1998 Forecast and multiplying this by 12, except for Performance & Compliance Monitoring which remain constant. This was done since the plant was not in operation at the first of the 1998 year.
The Project Support Costs for 1999 & beyond are from the Detailed Work Plan (See Estimate for Year 2000).

6.0 CONCLUSIONS

This report evaluated the initial performance of the 100-HR-3 and 100-KR-4 pump-and-treat systems. The evaluation is based on data collected while operating the treatment system at 100-HR-3 and 100-KR-4 OUs for 7 and 4 months, respectively. These conclusions address the effectiveness of the pump-and-treat operations in the goals of the remedial action objectives and performance criteria each of the interim remedial actions.

6.1 100-HR-3 Interim Remedial Action Pump-and-Treat System

Remedial Action Objectives

RA0 #1: Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River

- The pump-and-treat facility is effective at removing chromium (hexavalent) from the groundwater using Dowex™ resin as the ion exchange (IX) media. The performance monitoring data indicate that the treatment system is greater than 95% efficient in removing chromium from the influent stream. The existing system operation has been treating the groundwater such that hexavalent chromium concentrations are less than 5 μg/L[2] at an average treatment rate of approximately 600 L/min and at an average influent concentration of 100 μg/L.

- In both 100-HR-3 Reactor Areas, groundwater flux to the river in the targeted plume areas has been reduced due to hydraulic containment resulting from the operation of the extraction well field. In the 100-D Area, capture analysis coupled with water level data indicate that the combined overlapping width of the capture zone created by the two extractions wells is approximately 400 m resulting in a hydraulic containment of approximately 400 m along the targeted shoreline. In the 100-H Area, capture analysis coupled with water level data essentially show that continuous hydraulic capture (and containment along the targeted shoreline) occurs between the general vicinity of well 199-H4-15A and 199-H4-12A (a combined width of approximately 250 m). Only localized capture and containment occurs in the vicinity of extraction well 199-H4-11. Therefore, a portion of the groundwater within the targeted plume may continue discharging into the Columbia River.

- The Columbia River was at a very high flood stage (50-year) at the start of the interim remedial action pump-and-treat operation. Since the unconfined aquifer is hydraulically connected to the river, the high-river levels have skewed the sampling results such that at the startup of full time operations, chromium levels were typically

[2] Based on instrument detection limit of 5μg/L.

below the remedial action goal of 22 μg/L at the compliance wells. Since that time, the concentrations have risen well above the goal (e.g., as high as approximately 230 μg/L in the 100-D Area and 125 μg/L in the 100-H Area) as the unconfined aquifer returns to more normal conditions. Because of this abnormal river condition, it is difficult to ascertain the overall hydrochemical impact of the pump-and-treat interim remedial action on the aquifer system.

- The pump-and-treat system is reducing the toxicity, mobility, and volume of contaminants moving to the river by reducing the mass of hexavalent chromium contamination in the groundwater. Process monitoring data indicate that approximately 14,189 g of chromium have been removed in the first 7 months (estimated annual removal rate of 24,320 g). Based on current trends, the removal rate will increase in the short term in response to a return to normal aquifer conditions, and then will decrease in the long term in response to the interim remedial action.

RAO #2: Protection of human health by preventing exposure to contaminants in the groundwater

- Human health risks are minimized by maintaining institutional controls that prevent access to contaminated groundwater.

RAO #3: Provide the information that will lead to the final remedy.

- Relevant information is being collected and analyzed in preparation for the upcoming final 100-Area RI/FS activities. The information is accessible to the regulators via the HEIS database, and monthly, quarterly and annual performance evaluation reports.

- The treatment system has reduced concentrations of chromium in the effluent stream to the maximum extent practicable (e.g., less than 5 μg/L), which is well below the 50 μg/L chromium concentration performance criterion.

- Over the 7-month operating period, the system availability was approximately 88.9%. The downtime was attributed to system refinements, unexpected weather conditions, and fine tuning resin changeout procedures.

- Based on the initial operations, the cost per liter and cost per gram of treated groundwater, assuming an annual treatment rate of 282 million L and 24,320 g of chromium removed, is approximately 0.9 ¢/L or $109/g (present worth), respectively.

OPERATIONAL AND AQUIFER PERFORMANCE

Operational Performance

- The average treatment rate over the period of evaluation was 600 L/min.

- The treatment system has reduced effluent concentrations to the maximum extent practicable (e.g., less than 5 μg/L) which is well below the 50 μg/L chromium concentration performance criterion.

- Over the 7-month operating period, the system availability was approximately 88.9%. The downtime was attributed to system refinements, unexpected weather conditions, and fine tuning resin changeout procedures.

- Trace levels of radionuclides in the groundwater at 100-H Area have resulted in some of the used resin at the 100-HR-3 pump-and-treat system to be classified as unsuitable for off site regeneration. Since the majority of the operating costs over the life of the facility are associated with resin purchase and disposal, lower disposal costs can be realized by ascertaining the best means to control radionuclide accumulation. Limiting the spent resin concentration of chromium below the toxic characteristic limit of 5 mg/L will allow the disposal of resin at ERDF instead of the more costly disposal at CWC.

Aquifer Performance

- The data collection program as described in the RDR/RAWP and the performance monitoring plan is intended to provide information to evaluate the effectiveness of the treatment system on the aquifer system and whether performance criteria were met as listed in Section 2.0. However, the present monitoring program is ineffective to evaluate the interim action over a relatively short period of time, because it cannot be determined if the analytical results from monitoring are influenced by either the interim action or the daily and seasonal fluctuations of the Columbia River.

- During the evaluation period, the concentrations of the chromium in the compliance wells ranged from less than 5 μg/L to 230 μg/L at the 100-D Area and from less than 5 μg/L to 125 μg/L at the 100-H Area.

- The chromium distribution to the east and northeast in the 100-D Area is speculative because of the lack of data in that area.

6.2 100-KR-4 Interim Remedial Action Pump and Treat System

RAO #1: Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River

- The pump-and-treat facility is effective at removing chromium from the groundwater using Dowex™ resin as the IX media. The performance monitoring data indicate that the treatment system is greater than 92% efficient in removing chromium from the influent stream. The existing system operation has been treating the groundwater such that hexavalent chromium concentrations are less than 10 μg/L[3] at an average treatment rate of approximately 450 L/min and at an average influent concentration of 125 μg/L.

- Groundwater flux to the river along the targeted shoreline has been reduced due to hydraulic containment from the extraction well field. However, capture analysis coupled with water level data indicate that part of the targeted chromium plume in the vicinity of well 199-K-118A and between wells 199-K-199A and 199-K-120A was not contained by the network because well 199-K-188A was not put into service due to continued clogging of the extraction well filters.

- Since operating the pump-and-treat system four months, the chromium levels measured by the end of January at the compliance wells are above the remedial action goal of 22 μg/L (e.g., ranged from 50 to 155 μg/L). In general, during this period, chromium concentrations have risen due to the return of the aquifer to more normal conditions as the Columbia River recedes from flood conditions.

- The pump-and-treat system is reducing the toxicity, mobility, and volume of contaminants moving to the river by reducing the mass of hexavalent contamination in the groundwater. Process monitoring data indicate that approximately 9,445 g of chromium have been removed in the first 4 months (an estimated initial annual removal rate of 28,340 g). Based on current trends, the removal rate will increase in the short term in response to a return to normal aquifer conditions, and then will decrease in the long term in response to the interim remedial action.

RAO #2: Protection of human health by preventing exposure to contaminants in the groundwater

- Human health risks are minimized by maintaining institutional controls that prevent access to contaminated groundwater.

RAO #3: Provide the information that will lead to the final remedy.

- Relevant information is being collected and analyzed in preparation for the upcoming final 100-Area RI/FS activities. The information is accessible to the regulators via

[3] Based on instrument detection limit of 10μg/L.

the HEIS database, and monthly, quarterly and annual performance evaluation reports.

- The cost per liter and cost per gram of treated groundwater, assuming an annual treatment rate of 228 million L and 28,340 g of chromium removed, is approximately 0.9 ¢/L or $72/g (present worth).

OPERATIONAL AND AQUIFER PERFORMANCE

Operational Performance

- The average treatment rate over the period of evaluation was 450 L/min. This treatment rate will be slightly higher when well 199-K-118A is replaced by a new extraction well in Fiscal Year 1998.

- The treatment system has reduced concentrations of chromium in the effluent stream to the maximum extent practicable (e.g., less than 10 μg/L), which is well below the 50 μg/L chromium concentration performance criterion.

- Over the 4-month operating period, the system availability was approximately 93.0%. The downtime was attributed to additional system refinements, unexpected weather conditions, and fine tuning resin changeout procedures.

- Only 16% of the operating costs over the life of the facility are associated with resin purchase and disposal. Lower disposal costs will be maintained if radionuclides do not accumulate on the resin as changes in water chemistry occur.

Aquifer Performance

- The data collection program as described in the RDR/RAWP and the performance monitoring plan is intended to provide information to evaluate the effectiveness of the treatment system on the aquifer system and whether performance criteria were met as listed in Section 2.0. However, the present monitoring program is ineffective to evaluate the interim action over a relatively short period of time, because it cannot be determined if the analytical results from monitoring are influenced by either the interim action or the daily and seasonal fluctuations of the Columbia River.

- During the evaluation period, the concentrations of the chromium in the compliance wells ranged from approximately 50 to 155 μg/L.

- The chromium distribution downstream from compliance well 199-K-112A is speculative because of insufficient groundwater data in that area.

7.0 RECOMMENDATIONS

This evaluation indicates that the significant portions of the targeted areas are being captured and the mass of chromium is being reduced. However, since these systems have only been operational for a short period of time, the overall effectiveness of the pump-and-treat system on the protection of aquatic receptors cannot be assessed without more performance monitoring data. Per the RDR/RAWP (DOE-RL 1996), the systems will operate until one of the following criteria for termination of the interim remedial action has been met: (1) successful completion of the interim action is demonstrated, (2) the interim action is no longer effective, or (3) a final remedy is selected. Recommended modifications to the treatment systems and performance monitoring activities are listed below:

- Continue to operate to the initial injection/extraction well field configuration as defined in the RDR/RAWP (DOE-RL 1996).

- Replace extraction well 199-K-118A with another extraction well at the same location to meet the original design objectives defined in the RDR/RAWP (DOE-RL 1996).

- Operate at the following nominal flow rates (±20 L/m) for the 100-HR-3 extraction wells in order to provide optimal hydraulic control and containment:

  199-D8-53: 151 L/min
  199-D8-54A: 151 L/min
  199-H3-2A: 151 L/min
  199-H4-7: 76 L/min
  199-H4-11: 133 L/min[4]
  199-H4-12A: 76 L/min
  199-H4-15A: 76 L/min.

- Operate at the following nominal flow rates (±20 L/m) for the 100-KR-4 extraction wells in order to provide optimal hydraulic control and containment:

  199-K-113A: 95 L/min
  199-K-115A: 95 L/min
  199-K-116A: 190 L/min[4]
  199-K-118A (replacement well): 95 L/min
  199-K-119A: 95 L/min
  199-K-120A: 95 L/min.

- Install an additional groundwater monitoring well downstream from compliance well 199-K-112A to better define the lateral boundary of the chromium plume.

- Conduct a full evaluation of chromium, co-contaminant and resin IX processes/kinetics to determine the optimum operating and monitoring procedures

[4] Prior to implementing design modifications for well 199-H4-11 and 199-K-116A, testing should be conducted to determine sustainable yield at recommended higher rates.

and/or parameters for the 100-HR-3 pump-and-treat system. This information is needed to determine if a change to operations can be used to isolate the radionuclides from chromium and thusly limit the amount of radioactive or mixed waste produced.

- Install an additional monitoring well in the 100-D Area, downstream from monitoring well 199-D8-70. In this area, the northeasterly extent of the chromium plume is poorly defined.

- Conduct groundwater sampling over a short period of time at the extraction and compliance wells at both 100-HR-3 and 100-KR-4 OUs. This data will be used to separate the influences caused by either the interim action or the daily and seasonal fluctuations of the Columbia River.

- Continue to monitor aquifer-sampling tubes to routinely monitor chromium concentrations in the river substrate in the targeted plume areas at both OUs. This information, along with the performance monitoring data, will help in understanding the relationship between near river and pore water contaminant concentrations.

8.0 REFERENCES

BHI, 1996a, *Chromium in River Substrate Pore Water and Adjacent Groundwater: 100-D/DR Area, Hanford Site, Washington*, BHI-00778, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1996b, *Conceptual Site Models for Groundwater Contamination at the 100-BC-5, 100-KR-4, 100-HR-3, and 100 FR-3 Operable Units*, BHI-00917, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1997a, *Assessment of the Chromium Plume West of the 100-D/DR Reactor Areas,* BHI-00967, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1997b, *Chromium Plume West of the 100-D/DR Reactor Areas -- A Data Supplement,* BHI-01131, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1997c, *Code of Accounts Database,* Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1992a, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-3 Operable Unit, Hanford Site, Richland, Washington,* DOE/RL-88-36, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992b, *Sampling and Analysis at 100-Area Springs*, DOE/RL-92-12, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993, *Limited Field Investigation Report for the 100-HR-3 Operable Unit,* DOE/RL-93-43, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994, *Limited Field Investigation Report for the 100-KR-4 Operable Unit*, DOE/RL-93-79, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995a, *100-HR-3 Operable Unit Focused Feasibility Study,* DOE/RL-94-6, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995b, *100-KR-4 Operable Unit Focused Feasibility Study,* DOE/RL-94-48, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995c, *Proposed Plan for Interim Remedial Measure at the 100-HR-3 Operable Unit,* DOE/RL-94-102, Rev. 1, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995d, *Proposed Plan for Interim Remedial Measure at the 100-KR-4 Operable Unit,* DOE/RL-94-113, Rev. 1, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995e, *The Pilot-Scale Treatability Test Summary for the 100-HR-3 Operable Unit,* DOE/RL-95-83, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action,* DOE/RL-96-84, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units,* DOE/RL-96-90, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1990, 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.

EPA, 1996, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units,* U. S. Environmental Protection Agency, Washington, D. C.

WAC 173-303, 1990, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

APPENDIX A

AQUIFER RESPONSE DATA

Statistics for the Real Time Monitoring Network in the 100-HR-3 and 100-KR-4 Operable Units During the Month of July 1997.

Station	Distance to River (m)	Totals for July, 1997					
		Average Elv (m)	Hours Online	Minimum Elv. (m)	Maximum Elv. (m)	Range (m)	Std. Dev
D-Area River		119.30	744	117.30	120.15	2.85	0.424
D8-3	324.61	119.05	744	118.62	119.75	1.13	0.256
D8-54A	176.78		Presently Off Line				
D8-54B	176.78	119.03	744	116.42	119.28	2.86	0.221
D8-68	117.36	118.95	744	118.32	119.25	0.93	0.197
D8-69	94.76	119.01	744	118.53	119.39	0.86	0.170
D8-70	188.5	119.08	744	118.58	119.49	0.90	0.178
D8-71	187.93	118.97	744	118.44	119.30	0.85	0.172
H-Area River		116.94	744	114.96	117.77	2.81	0.432
H3-2B	513.59	117.42	744	117.26	117.76	0.50	0.121
H3-2C	513.59	117.39	744	117.19	117.66	0.47	0.106
H4-4	92.96	116.68	744	115.72	117.32	1.60	0.349
H4-5	140.21	116.79	744	116.10	117.23	1.13	0.249
H4-8	214.88	116.97	744	116.49	117.39	0.90	0.185
H4-10	92.96	116.76	744	115.86	117.36	1.50	0.333
H4-12A	108.2		Presently Off Line				
H4-12B	108.2	116.65	744	115.74	117.27	1.53	0.341
H4-12C	105.16	116.78	744	115.76	117.32	1.55	0.306
H4-15B	112.78	116.72	744	115.85	117.32	1.47	0.333
H4-49	611.12	117.53	744	117.46	117.58	0.11	0.032
H4-63	61.93	116.65	744	115.66	117.26	1.61	0.343
H4-64	75.43	116.72	744	115.76	117.34	1.57	0.340
H5-1A	768.1	117.59	744	117.55	117.62	0.06	0.014
K-18	254.51	121.32	744	119.68	121.73	2.05	0.188
K-20	166.12	121.08	744	120.64	121.54	0.90	0.178
K-21	182.88	120.65	744	120.13	121.11	0.97	0.191
K-22	274.32	120.63	744	120.14	121.12	0.98	0.181
K-112	92.11	120.57	744	120.20	120.88	0.68	0.150
K-114	75.81	120.18	744	119.05	120.95	1.91	0.391
K-117	77.64	120.36	744	119.65	120.98	1.33	0.289
N-Area River		119.96	744	117.55	121.00	3.45	0.549

Statistics for the Real Time Monitoring Network in the 100-HR-3 and 100-KR-4 Operable Unit During the Month of August 1997.

Station	Distance to River (m)	Totals for August, 1997					
		Average Elv (m)	Hours Online	Minimum Elv. (m)	Maximum Elv. (m)	Range (m)	Std. Dev
D-Area River		118.55	744	116.91	119.39	2.47	0.481
D8-3	324.61	118.34	744	118.20	118.62	0.42	0.087
D8-54A	176.78		Presently Off Line				
D8-54B	176.78	118.35	744	118.11	118.56	0.45	0.105
D8-68	117.36	118.24	744	117.96	118.54	0.58	0.116
D8-69	94.76	118.33	744	118.15	118.61	0.46	0.091
D8-70	188.5	118.38	744	118.20	118.66	0.46	0.091
D8-71	187.93	118.28	744	118.08	118.55	0.47	0.088
H-Area River		116.18	744	114.52	117.06	2.54	0.489
H3-2B	513.59	117.08	744	116.94	117.25	0.32	0.078
H3-2C	513.59	117.00	744	116.90	117.20	0.29	0.076
H4-4	92.96	115.90	744	115.44	116.40	0.96	0.217
H4-5	140.21	116.01	744	115.85	116.26	0.41	0.100
H4-8	214.88	116.28	744	116.18	116.48	0.31	0.058
H4-10	92.96	115.97	744	115.56	116.45	0.89	0.193
H4-12A	108.2		Presently Off Line				
H4-12B	108.2	115.85	744	115.39	116.35	0.96	0.214
H4-12C	105.16	116.02	744	115.51	116.45	0.94	0.213
H4-15B	112.78	115.92	744	115.47	116.39	0.91	0.192
H4-49	611.12	117.35	744	117.21	117.47	0.26	0.071
H4-63	61.93	115.86	744	115.30	116.38	1.08	0.238
H4-64	75.43	115.93	744	115.45	116.42	0.97	0.216
H5-1A	768.1	117.47	744	117.31	117.56	0.25	0.069
K-18	254.51	120.62	744	120.39	121.00	0.61	0.164
K-20	166.12	120.35	744	120.17	120.64	0.47	0.109
K-21	182.88	119.85	744	119.66	120.14	0.48	0.102
K-22	274.32	119.88	744	119.70	120.14	0.44	0.098
K-112	92.11	119.99	744	119.85	120.24	0.39	0.087
K-114	75.81	119.40	744	118.84	120.01	1.17	0.291
K-117	77.64	119.63	744	119.34	120.01	0.67	0.158
N-Area River		118.90	744	117.07	119.90	2.83	0.544

Statistics for the Real Time Monitoring Network in the 100-HR-3 and 100-KR-4 Operable Unit During the Month of September 1997.

Station	Distance to River (m)	Totals for September, 1997					
		Average Elv (m)	Hours Online	Minimum Elv. (m)	Maximum Elv. (m)	Range (m)	Std. Dev
D-Area River		117.87	720	116.41	118.73	2.32	0.461
D8-3	324.61	117.84	720	117.62	118.31	0.69	0.179
D8-54A	176.78		Presently Off Line				
D8-54B	176.78	117.98	720	117.67	118.31	0.64	0.129
D8-68	117.36	117.68	720	117.31	118.22	0.90	0.175
D8-69	94.76	117.79	720	117.52	118.26	0.74	0.153
D8-70	188.5	117.78	720	117.51	118.30	0.79	0.168
D8-71	187.93	117.73	720	117.44	118.25	0.81	0.168
H-Area River		115.60	720	114.10	116.39	2.29	0.477
H3-2B	513.59	116.74	720	116.59	116.96	0.37	0.113
H3-2C	513.59	116.67	720	116.55	116.91	0.35	0.100
H4-4	92.96	115.27	720	114.92	115.84	0.92	0.182
H4-5	140.21	115.45	720	115.24	115.98	0.75	0.170
H4-8	214.88	115.87	720	115.70	116.27	0.57	0.157
H4-10	92.96	115.37	720	115.12	115.93	0.80	0.156
H4-12A	108.2		Presently Off Line				
H4-12B	108.2	115.23	720	114.92	115.83	0.90	0.176
H4-12C	105.16	115.41	720	115.00	115.97	0.97	0.191
H4-15B	112.78	115.32	720	115.04	115.94	0.91	0.174
H4-49	611.12	117.11	720	117.03	117.21	0.18	0.051
H4-63	61.93	115.18	720	114.71	115.82	1.10	0.216
H4-64	75.43	115.31	720	115.02	115.88	0.86	0.168
H5-1A	768.1	117.25	720	117.19	117.31	0.13	0.035
K-18	254.51	120.01	720	119.71	120.40	0.69	0.194
K-20	166.12	119.66	720	119.41	120.20	0.78	0.221
K-21	182.88	119.13	720	118.87	119.70	0.83	0.215
K-22	274.32	119.24	720	119.00	119.76	0.76	0.213
K-112	92.11	119.54	720	119.32	119.85	0.53	0.115
K-114	75.81	118.76	720	118.37	119.28	0.91	0.181
K-117	77.64	118.94	720	118.65	119.52	0.87	0.173
N-Area River		118.33	720	116.65	119.22	2.57	0.576

Statistics for the Real Time Monitoring Network in the 100-HR-3 and 100-KR-4 Operable Unit During the Month of October 1997.

Station	Distance to River (m)	Totals for October 1997					
		Average Elv (m)	Hours Online	Minimum Elv. (m)	Maximum Elv. (m)	Range (m)	Std. Dev
D-Area River		118.03	744	116.54	119.24	2.69	0.603
D8-3	324.61	117.77	744	117.53	118.03	0.50	0.131
D8-54A	176.78		Presently Off Line				
D8-54B	176.78	118.00	744	117.65	118.36	0.71	0.181
D8-68	117.36	117.72	744	117.31	118.15	0.84	0.214
D8-69	94.76	117.79	744	117.48	118.12	0.65	0.165
D8-70	188.5	117.79	744	117.48	118.13	0.65	0.168
D8-71	187.93	117.75	744	117.42	118.12	0.69	0.180
H-Area River		115.82	744	114.28	117.03	2.76	0.604
H3-2B	513.59	116.55	744	116.52	116.63	0.11	0.018
H3-2C	513.59	116.53	744	116.45	116.58	0.12	0.024
H4-4	92.96	115.44	744	115.04	116.07	1.02	0.274
H4-5	140.21	115.53	744	115.27	115.91	0.64	0.175
H4-8	214.88	115.84	744	115.68	116.00	0.32	0.096
H4-10	92.96	115.52	744	115.18	116.05	0.86	0.238
H4-12A	108.2		Presently Off Line				
H4-12B	108.2	115.36	744	114.97	115.95	0.98	0.273
H4-12C	105.16	115.52	744	115.04	116.07	1.03	0.276
H4-15B	112.78	115.46	744	115.10	116.03	0.93	0.257
H4-49	611.12	116.97	744	116.90	117.04	0.14	0.034
H4-63	61.93	115.34	744	114.85	115.97	1.13	0.312
H4-64	75.43	115.47	744	115.10	116.05	0.95	0.263
H5-1A	768.1	117.13	744	117.05	117.20	0.15	0.040
K-18	254.51	119.73	744	119.56	119.85	0.29	0.070
K-20	166.12	119.45	744	119.21	119.67	0.46	0.116
K-21	182.88	119.08	744	118.86	119.35	0.50	0.126
K-22	274.32	119.11	744	118.95	119.35	0.40	0.107
K-112	92.11	119.43	744	119.24	119.60	0.36	0.083
K-114	75.81	118.93	744	118.47	119.70	1.23	0.299
K-117	77.64	119.01	744	118.67	119.50	0.82	0.217
N-Area River		118.48	744	116.74	119.86	3.12	0.709

Statistics for the Real Time Monitoring Network in the 100-HR-3 and 100-KR-4 Operable Unit During the Month of November 1997.

Station	Distance to River (m)	Totals for November, 1997					
		Average Elv (m)	Hours Online	Minimum Elv. (m)	Maximum Elv. (m)	Range (m)	Std. Dev
D-Area River		117.76	720	116.28	118.79	2.51	0.618
D8-3	324.61	117.53	720	117.40	117.62	0.22	0.049
D8-54A	176.78		Presently Off Line				
D8-54B	176.78	117.79	720	117.57	118.02	0.44	0.095
D8-68	117.36	117.48	720	117.19	117.74	0.55	0.120
D8-69	94.76	117.56	720	117.37	117.74	0.37	0.078
D8-70	188.5	117.57	720	117.39	117.77	0.38	0.072
D8-71	187.93	117.49	720	117.28	117.69	0.40	0.079
H-Area River		115.45	720	114.56	116.67	2.10	0.627
H3-2B	513.59	116.46	720	116.42	116.53	0.11	0.032
H3-2C	513.59	116.44	720	116.38	116.49	0.11	0.028
H4-4	92.96	115.26	720	114.88	115.62	0.74	0.154
H4-5	140.21	115.36	720	115.19	115.47	0.28	0.060
H4-8	214.88	115.84	720	115.80	116.02	0.22	0.036
H4-10	92.96	115.35	720	115.09	115.57	0.47	0.108
H4-12A	108.2		Presently Off Line				
H4-12B	108.2	115.16	720	114.85	115.43	0.58	0.127
H4-12C	105.16	115.32	720	114.77	115.71	0.94	0.195
H4-15B	112.78	115.25	720	114.95	115.49	0.54	0.123
H4-49	611.12	116.84	720	116.77	116.91	0.13	0.033
H4-63	61.93	115.12	720	114.67	115.50	0.82	0.186
H4-64	75.43	115.30	720	114.99	115.58	0.59	0.137
H5-1A	768.1	116.98	720	116.90	117.05	0.16	0.034
K-18	254.51	119.47	720	119.39	119.57	0.17	0.040
K-20	166.12	119.19	720	119.09	119.28	0.20	0.043
K-21	182.88	118.89	720	118.74	118.99	0.25	0.050
K-22	274.32	118.95	720	118.84	119.07	0.22	0.045
K-112	92.11	119.24	720	119.14	119.30	0.16	0.035
K-114	75.81	118.75	720	118.31	119.25	0.94	0.201
K-117	77.64	118.80	720	118.58	119.04	0.47	0.109
N-Area River		118.20	720	116.67	119.40	2.73	0.712

Statistics for the Real Time Monitoring Network in the 100-HR-3 and 100-KR-4 Operable Unit During the Month of December 1997.

Station	Distance to River (m)	Totals for December, 1997					
		Average Elv (m)	Hours Online	Minimum Elv. (m)	Maximum Elv. (m)	Range (m)	Std. Dev
D-Area River		118.39	744	117.17	118.83	1.66	0.359
D8-3	324.61	117.83	744	117.47	118.18	0.70	0.138
D8-54A	176.78		Presently Off Line				
D8-54B	176.78	118.11	744	117.66	118.33	0.66	0.127
D8-68	117.36	117.90	744	117.38	118.12	0.74	0.142
D8-69	94.76	117.92	744	117.49	118.09	0.60	0.119
D8-70	188.5	117.91	744	117.48	118.14	0.66	0.125
D8-71	187.93	117.89	744	117.45	118.09	0.64	0.133
H-Area River		116.05	744	114.86	116.50	1.64	0.362
H3-2B	513.59	116.42	744	116.36	116.48	0.12	0.030
H3-2C	513.59	116.44	744	116.38	116.50	0.11	0.032
H4-4	92.96	115.65	744	115.07	116.02	0.95	0.208
H4-5	140.21	115.68	744	115.27	115.94	0.67	0.155
H4-8	214.88	115.96	744	115.87	116.07	0.20	0.057
H4-10	92.96	115.70	744	115.19	116.02	0.83	0.189
H4-12A	108.2		Presently Off Line				
H4-12B	108.2	115.57	744	115.04	115.93	0.89	0.204
H4-12C	105.16	115.72	744	115.11	116.03	0.92	0.191
H4-15B	112.78	115.63	744	115.11	115.96	0.85	0.191
H4-49	611.12	116.76	744	116.73	116.79	0.06	0.015
H4-63	61.93	115.58	744	114.94	115.94	1.00	0.226
H4-64	75.43	115.70	744	115.14	116.04	0.91	0.204
H5-1A	768.1	116.89	744	116.85	116.92	0.07	0.016
K-18	254.51	119.65	744	119.38	119.75	0.37	0.103
K-20	166.12	119.45	744	119.08	119.59	0.51	0.118
K-21	182.88	119.15	744	118.73	119.36	0.62	0.150
K-22	274.32	119.16	744	118.83	119.35	0.52	0.127
K-112	92.11	119.37	744	119.14	119.50	0.36	0.079
K-114	75.81	119.13	744	118.52	119.52	1.00	0.239
K-117	77.64	119.17	744	118.59	119.47	0.88	0.188
N-Area River		118.90	744	117.48	119.39	1.91	0.416

Statistics for the Real Time Monitoring Network in the 100-HR-3 and 100-KR-4 Operable Units During the Month of January 1998.

Station	Distance to River (m)	Totals for January, 1998					
		Average Elv (m)	Hours Online	Minimum Elv. (m)	Maximum Elv. (m)	Range (m)	Std. Dev
D-Area River		118.00	743	116.94	118.85	1.92	0.540
D8-3	324.61		Presently Off Line				
D8-54A	176.78		Presently Off Line				
D8-54B	176.78	118.02	743	117.63	118.32	0.69	0.159
D8-68	117.36	117.68	743	117.22	118.10	0.88	0.210
D8-69	94.76	117.75	743	117.41	118.06	0.65	0.163
D8-70	188.5	117.74	743	117.40	118.06	0.67	0.168
D8-71	187.93	117.73	743	117.34	118.10	0.76	0.191
H-Area River		115.66	743	114.63	116.52	1.89	0.541
H3-2B	513.59	116.36	743	116.30	116.43	0.13	0.043
H3-2C	513.59	116.33	743	116.26	116.41	0.16	0.043
H4-4	92.96	115.41	743	114.94	115.97	1.03	0.251
H4-5	140.21	115.51	743	115.26	115.84	0.58	0.159
H4-8	214.88	115.82	743	115.61	115.96	0.35	0.089
H4-10	92.96	115.47	743	115.12	115.96	0.84	0.214
H4-12A	108.2		Presently Off Line				
H4-12B	108.2	114.31	743	113.90	114.89	0.99	0.247
H4-12C	105.16	114.44	743	113.94	114.98	1.03	0.255
H4-15B	112.78	115.43	743	115.04	116.00	0.96	0.245
H4-49	611.12	116.67	743	116.63	116.73	0.10	0.032
H4-63	61.93	115.30	743	114.72	115.94	1.22	0.298
H4-64	75.43	115.47	743	115.06	116.02	0.96	0.237
H5-1A	768.1	116.80	743	116.74	116.87	0.13	0.038
K-18	254.51	119.60	743	119.43	119.74	0.31	0.079
K-20	166.12	119.37	743	119.18	119.59	0.41	0.116
K-21	182.88	118.97	743	118.73	119.24	0.51	0.144
K-22	274.32	118.98	743	118.79	119.21	0.41	0.117
K-112	92.11	119.25	743	119.10	119.43	0.33	0.094
K-114	75.81	118.84	743	118.30	119.50	1.20	0.291
K-117	77.64	118.90	743	118.51	119.39	0.88	0.221
N-Area River		118.49	743	117.28	119.36	2.08	0.594

Well Data Evaluation Summary Report, All Data
199-H4-3, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-3
Constituent : Nitrate (ug/L)

Samples Taken between 10/2/96 and 11/3/97

Number of Samples: 10 **Number of Detects:** 10

Minimum Detected Value: 230193.6 on 12/2/96

Maximum Detected Value: 637459.2 on 10/2/96

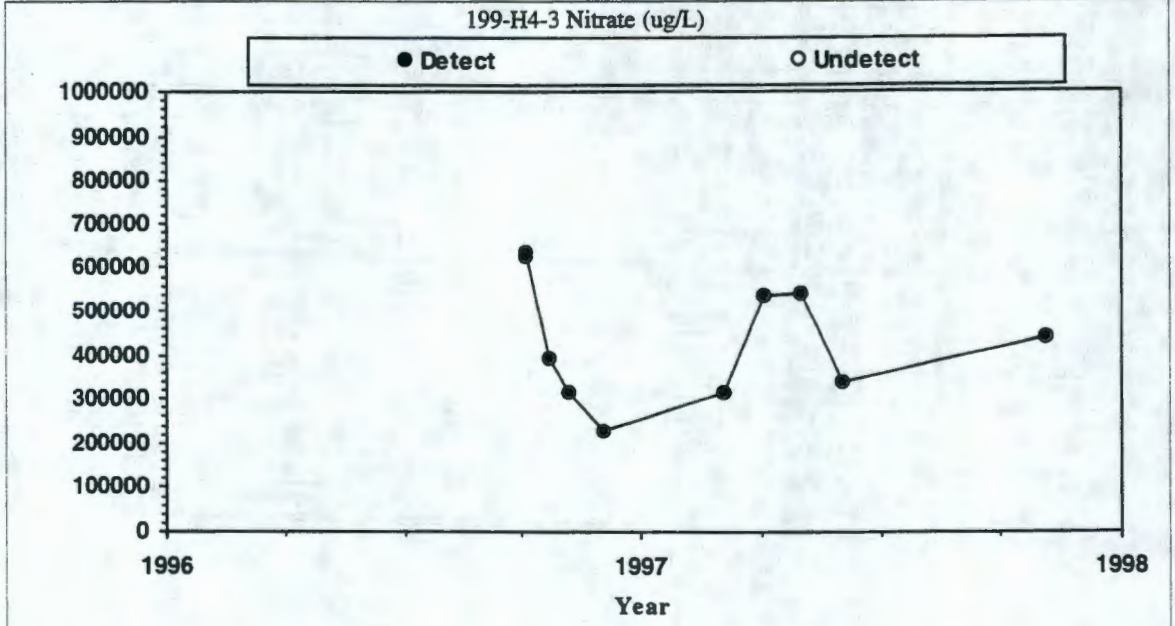
Average of Detected Values: 438872.95

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-4, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-4
Constituent : Nitrate (ug/L)

Samples Taken between 10/2/96 and 11/4/97

Number of Samples: 10 **Number of Detects:** 10

Minimum Detected Value: 3629.976 on 5/1/97

Maximum Detected Value: 522362.4 on 10/18/96

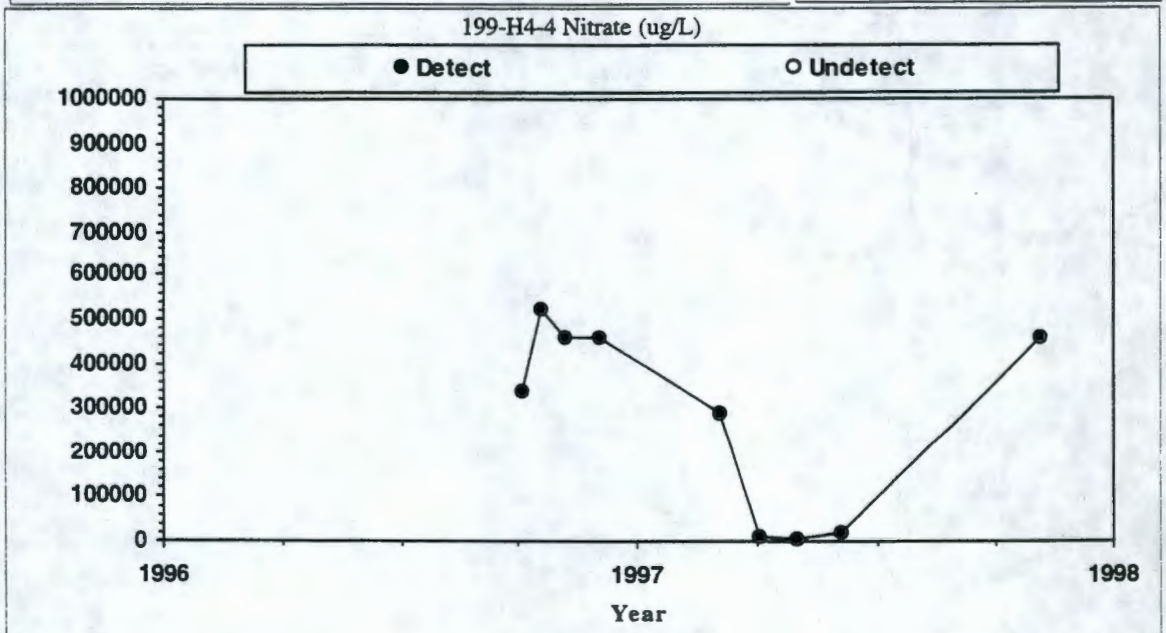
Average of Detected Values: 257020.01

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-5, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-5
Constituent : Nitrate (ug/L)

Samples Taken between 10/17/96 and 11/4/97

Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 39442.788 on 10/17/96

Maximum Detected Value: 347946.48 on 11/4/97

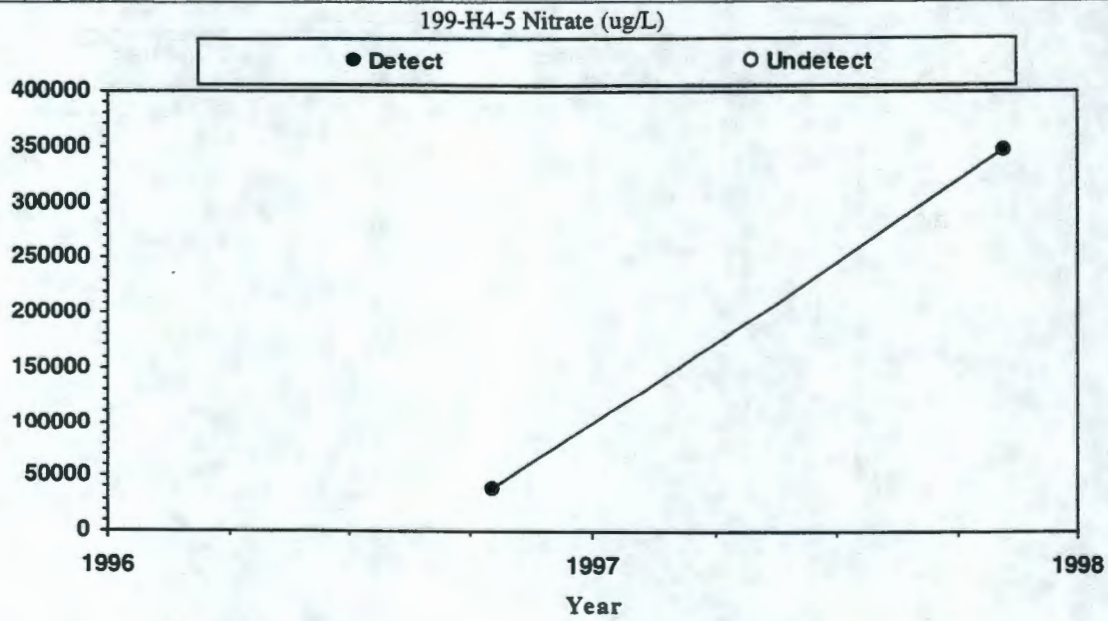
Average of Detected Values: 193694.63

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-7, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-7
Constituent : Nitrate (ug/L)
Samples Taken between 10/17/96 and 7/18/97

Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 25409.832 on 10/17/96

Maximum Detected Value: 540069.6 on 7/18/97

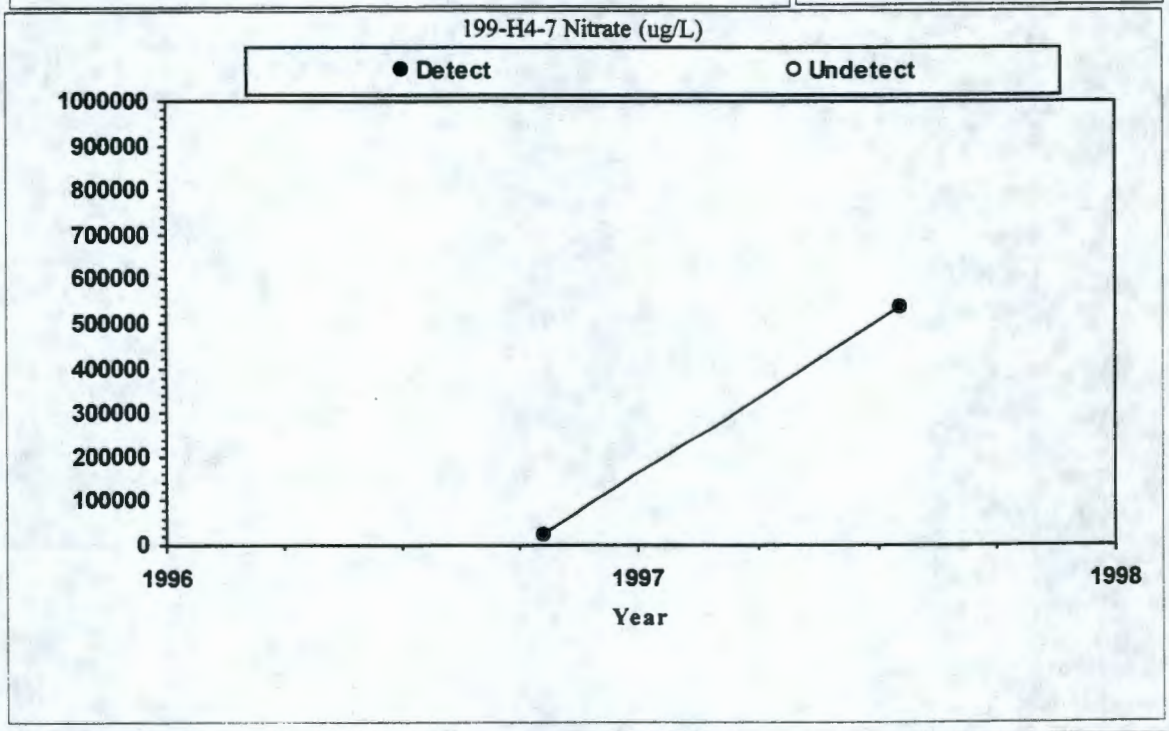
Average of Detected Values: 282739.72

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-11, Nitrate (ug/L)

19-Feb-98

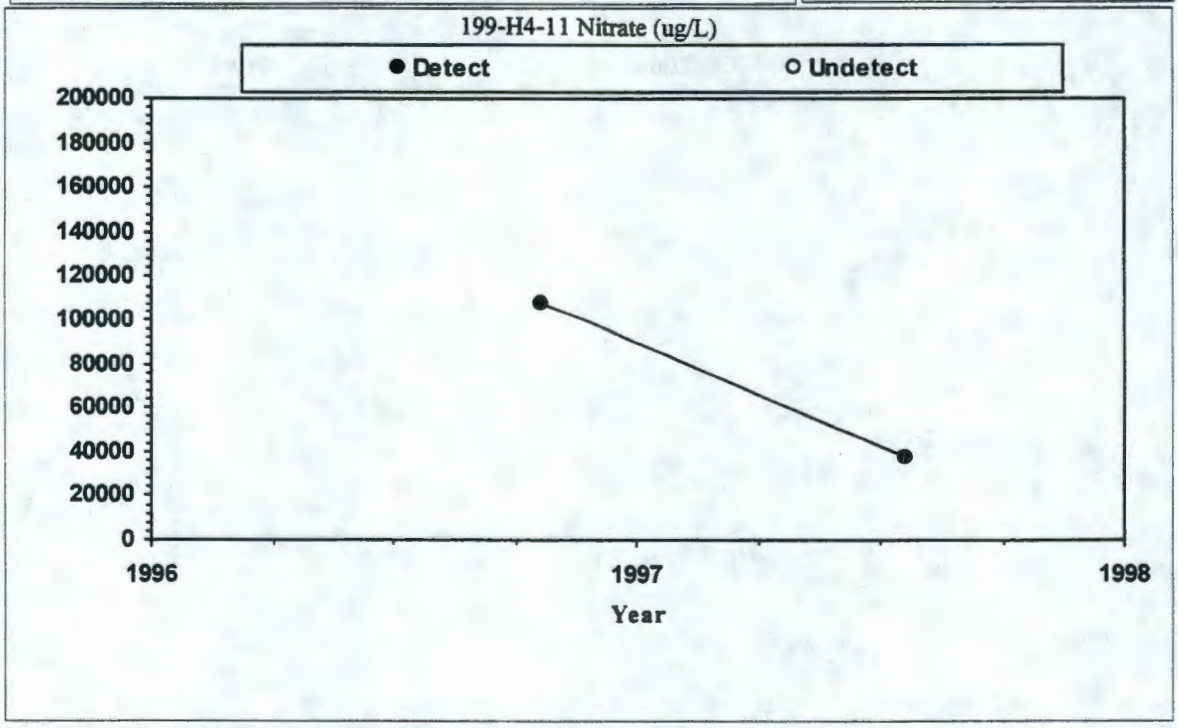
Statistical Summary for : Well 199-H4-11
Constituent : Nitrate (ug/L)
Samples Taken between 10/18/96 and 7/18/97

Number of Samples: 2 **Number of Detects:** 2
Minimum Detected Value: 37627.8 on 7/18/97
Maximum Detected Value: 108899.28 on 10/18/96
Average of Detected Values: 73263.54
Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-12A, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-12A
Constituent : Nitrate (ug/L)

Samples Taken between 10/2/96 and 11/6/97

Number of Samples: 10 **Number of Detects:** 10

Minimum Detected Value: 24214.596 on 7/18/97

Maximum Detected Value: 187253.64 on 11/6/97

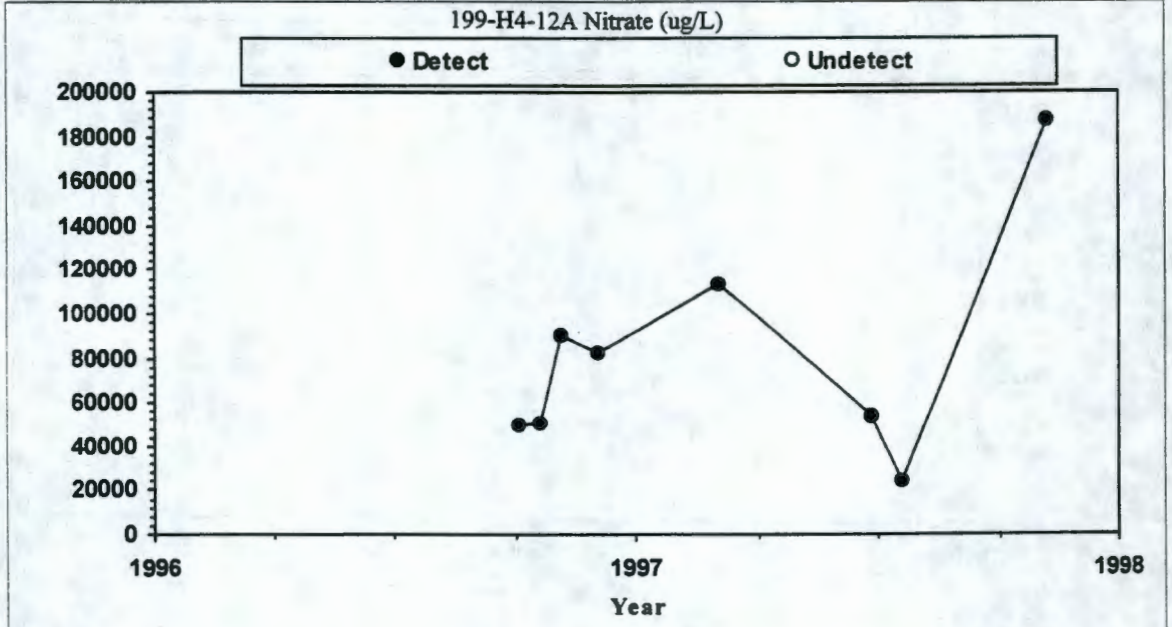
Average of Detected Values: 75906.34

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-13, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-13
Constituent : Nitrate (ug/L)
Samples Taken between 10/22/96 and 11/3/97

Number of Samples: 3 **Number of Detects:** 2

Minimum Detected Value: 62417.88 on 11/3/97

Maximum Detected Value: 67287.36 on 10/22/96

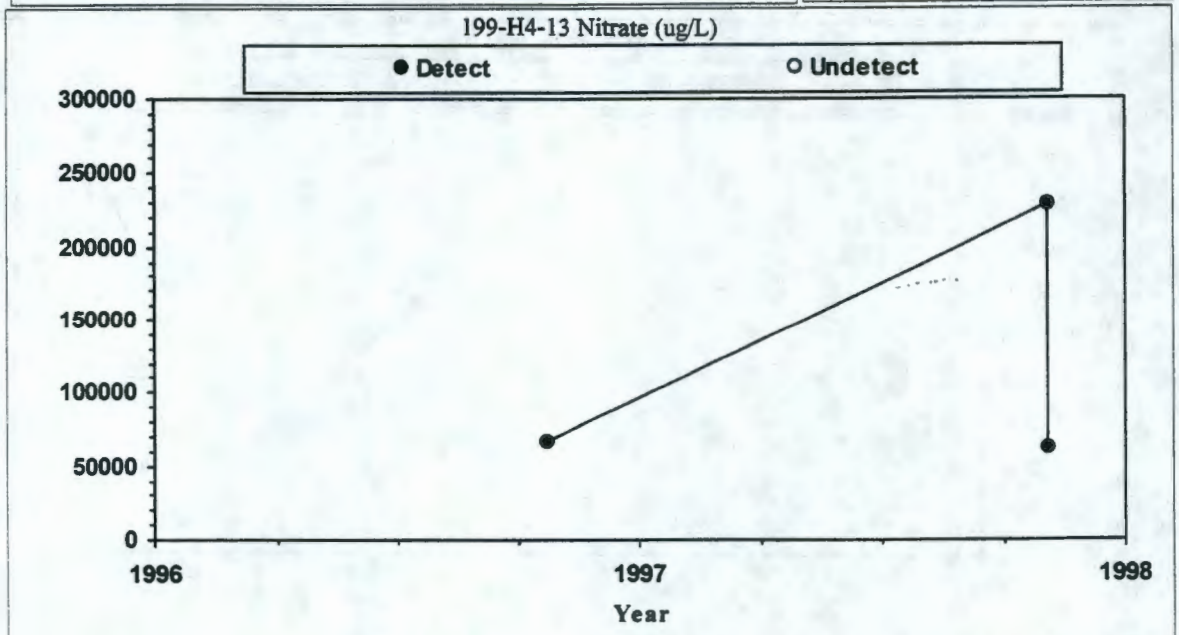
Average of Detected Values: 64852.62

Number of Rejected Values: 1

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-18, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-18
Constituent : Nitrate (ug/L)
Samples Taken between 10/2/96 and 11/4/97

Number of Samples: 10 **Number of Detects:** 10

Minimum Detected Value: 58433.76 on 12/2/96

Maximum Detected Value: 224438.76 on 6/3/97

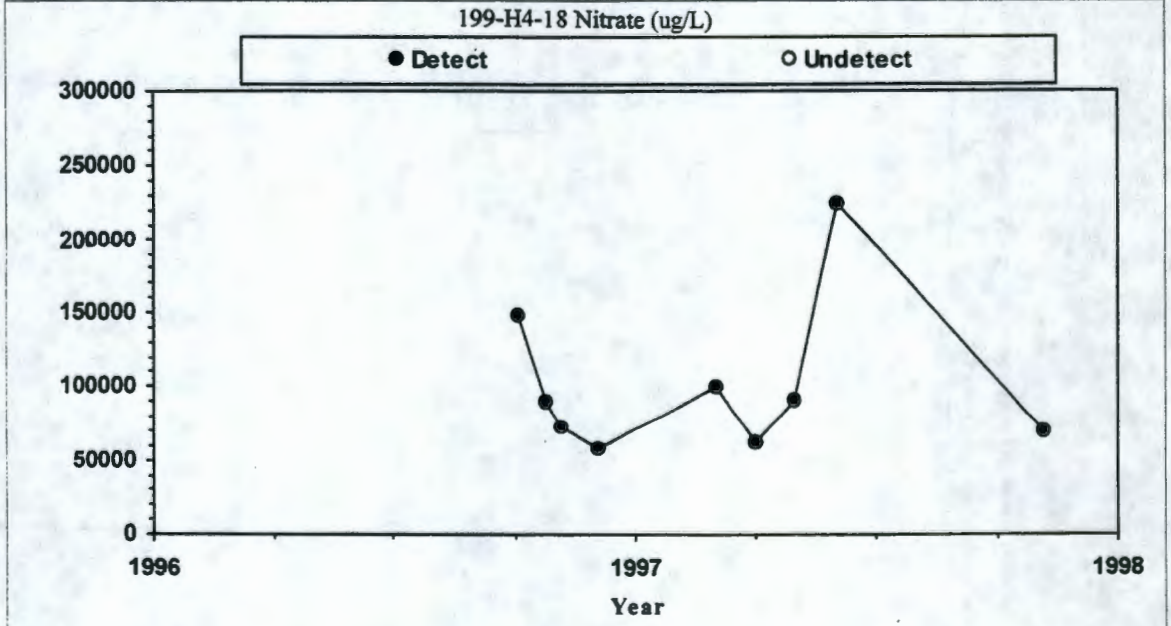
Average of Detected Values: 98053.62

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-45, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-45
Constituent : Nitrate (ug/L)
Samples Taken between 10/24/96 and 11/4/97

Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 44710.68 on 11/4/97

Maximum Detected Value: 45153.36 on 10/24/96

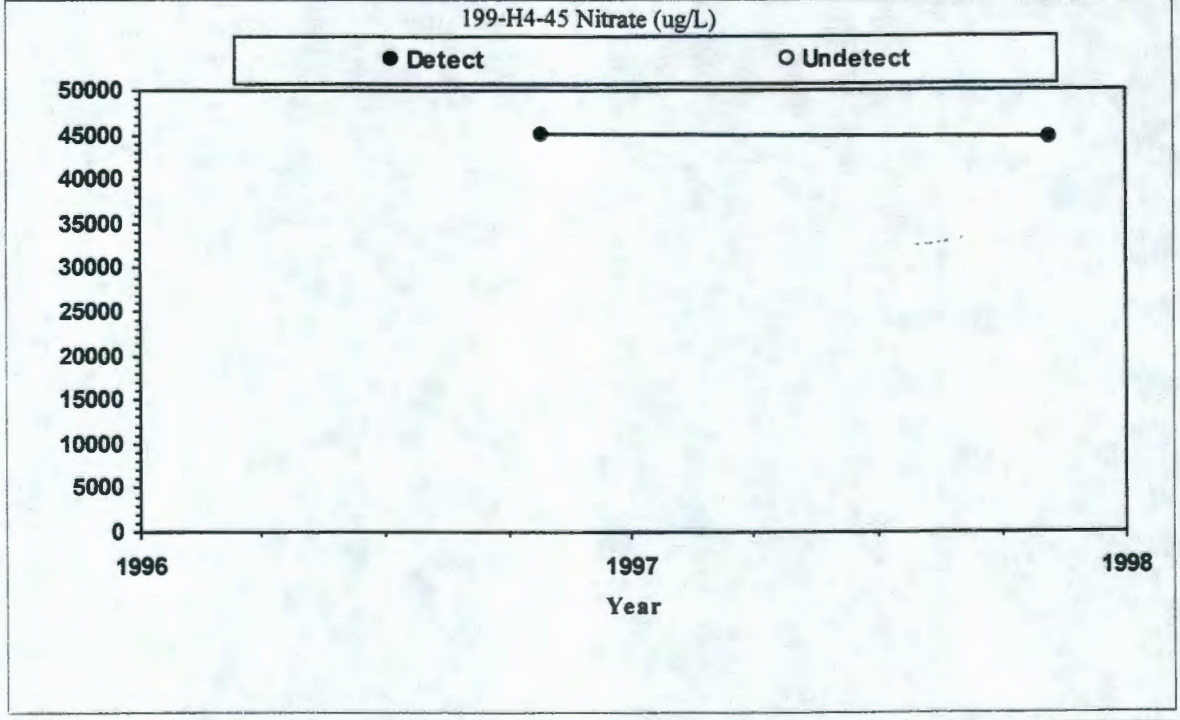
Average of Detected Values: 44932.02

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-46, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-46
Constituent : Nitrate (ug/L)
Samples Taken between 10/24/96 and 10/24/96

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 58876.44 on 10/24/96

Maximum Detected Value: 58876.44 on 10/24/96

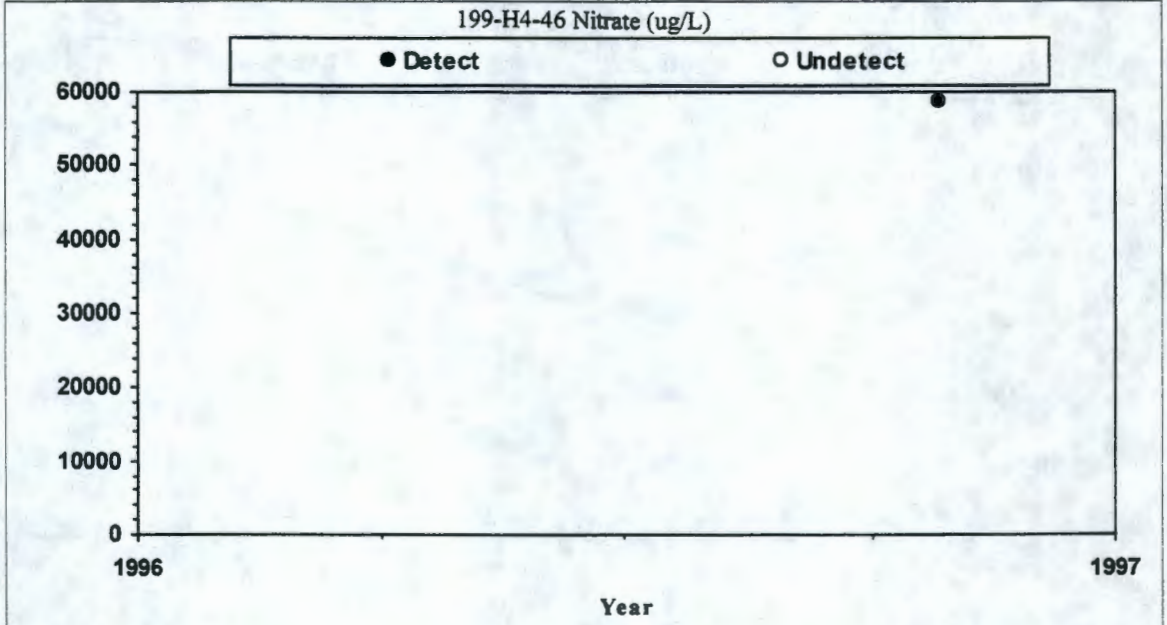
Average of Detected Values: 58876.44

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-49, Nitrate (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-49
Constituent : Nitrate (ug/L)
Samples Taken between 10/29/96 and 11/10/97

Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 32271.372 on 10/29/96

Maximum Detected Value: 54449.64 on 11/10/97

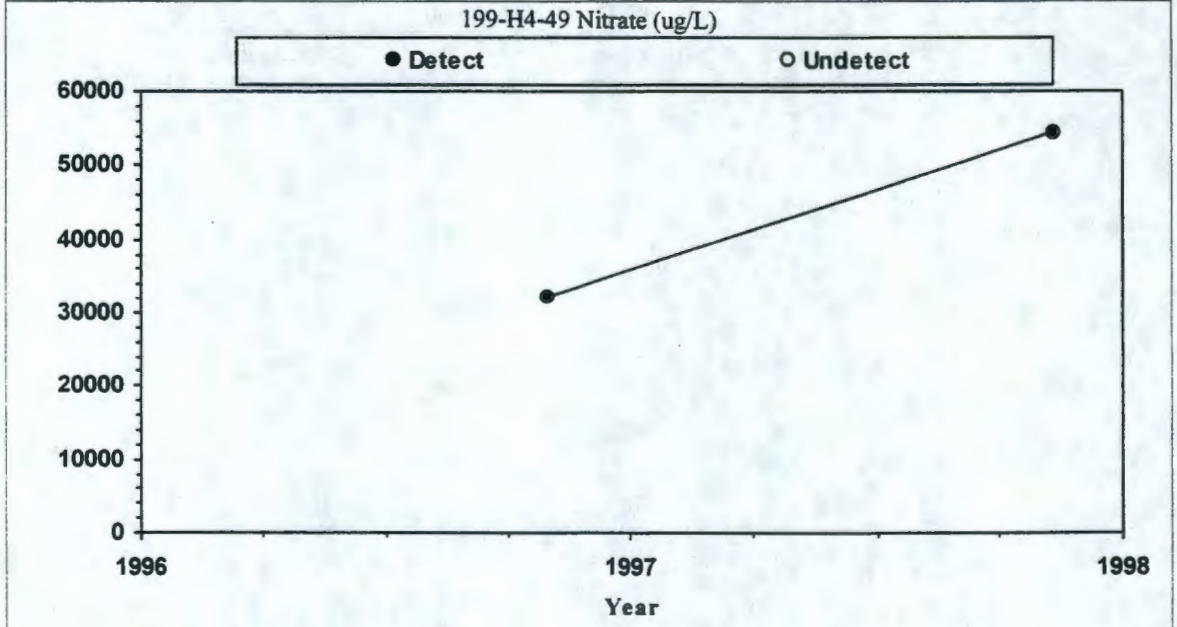
Average of Detected Values: 43360.51

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-63, Nitrate (ug/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-H4-63
Constituent : Nitrate (ug/L)
Samples Taken between 10/16/96 and 11/3/97

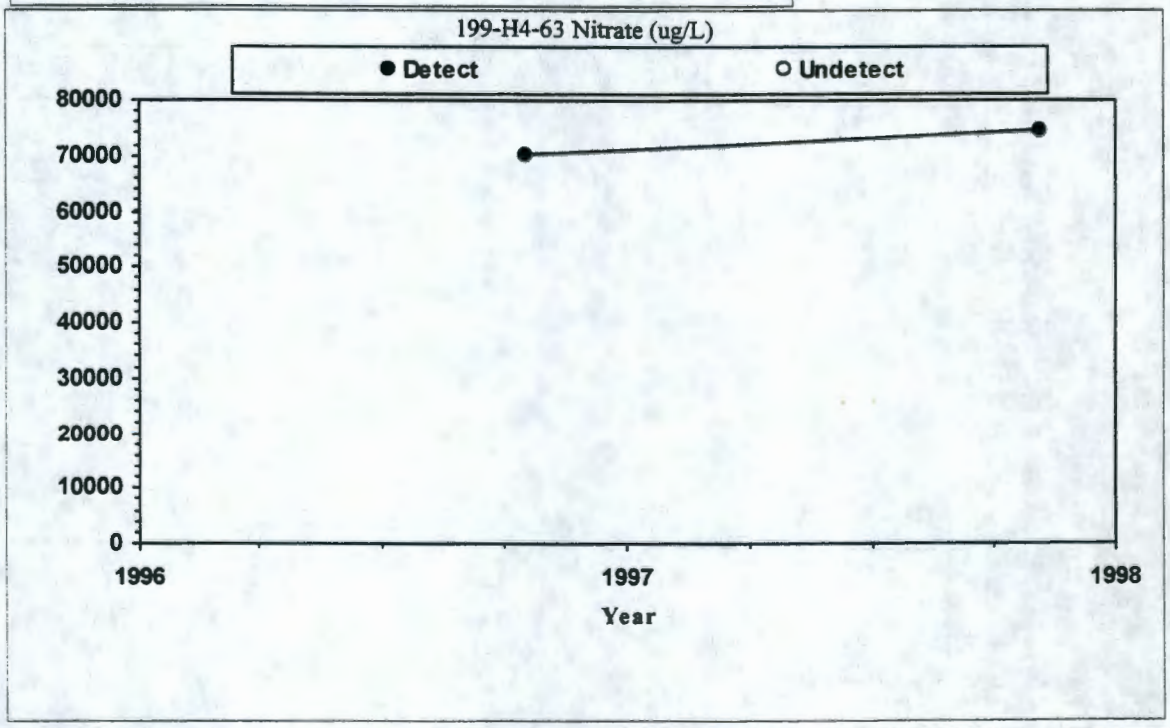
Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 70386.12 on 10/16/96

Maximum Detected Value: 74370.24 on 11/3/97

Average of Detected Values: 72378.18

Number of Rejected Values: 0



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit. Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-64, Nitrate (ug/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-H4-64
Constituent : Nitrate (ug/L)
Samples Taken between 10/16/96 and 11/3/97

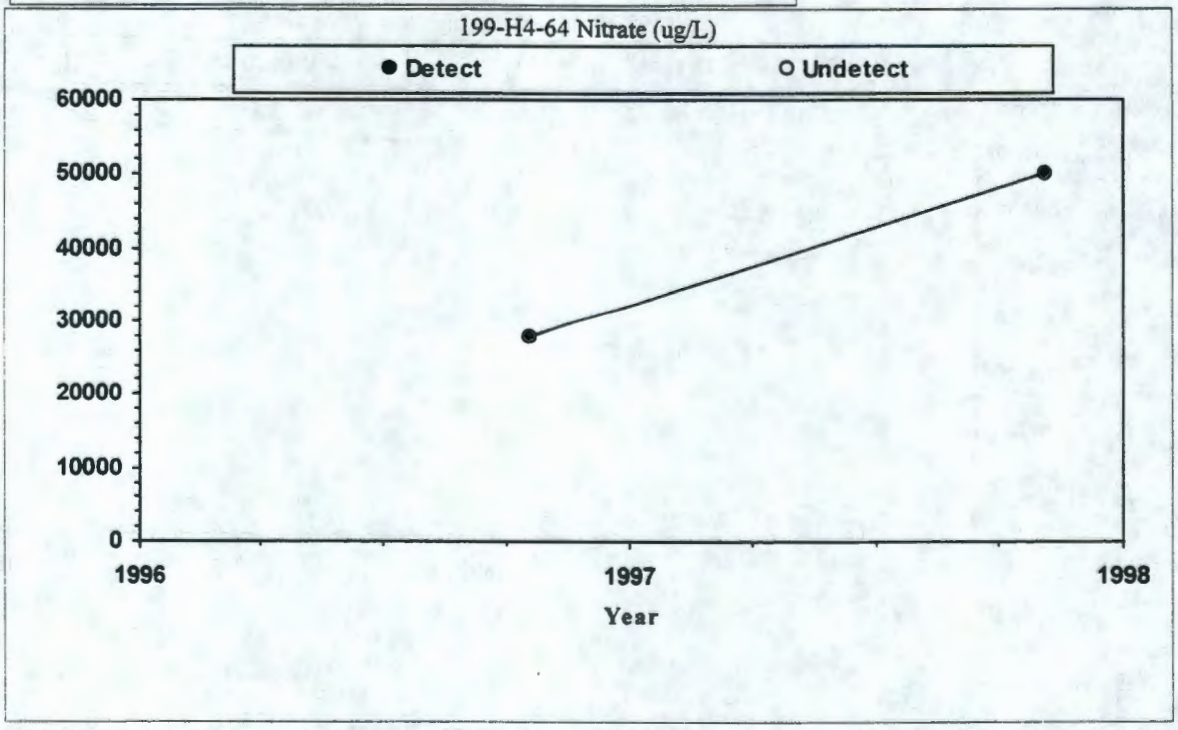
Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 27888.84 on 10/16/96

Maximum Detected Value: 50022.84 on 11/3/97

Average of Detected Values: 38955.84

Number of Rejected Values: 0



Relevant Contaminant Standards for: Nitrate (ug/L)

Fed WQ:	45000	**MCL-NBS69:**	NA	**MTCA-C:**	56000	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	NA	**SMCL:**	NA		
MCL:	45000	**MTCA-B:**	25600	**Wa GWQ:**	45000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit. Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria. MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-D8-68, Strontium-90 (pCi/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-D8-68
Constituent : Strontium-90 (pCi/L)
Samples Taken between 10/15/96 and 11/21/97

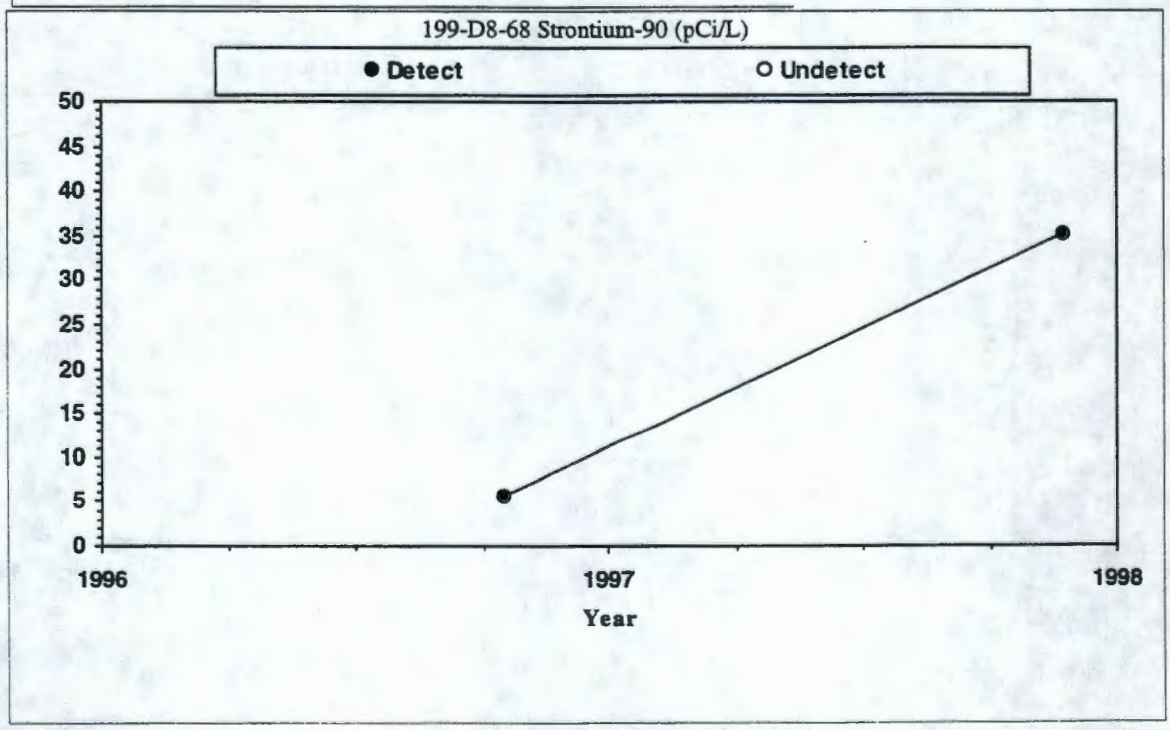
Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 5.51 on 10/15/96

Maximum Detected Value: 35.2 on 11/21/97

Average of Detected Values: 20.36

Number of Rejected Values: 0



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-4, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-4
Constituent : Strontium-90 (pCi/L)
Samples Taken between 11/4/97 and 11/4/97

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 10.8 on 11/4/97

Maximum Detected Value: 10.8 on 11/4/97

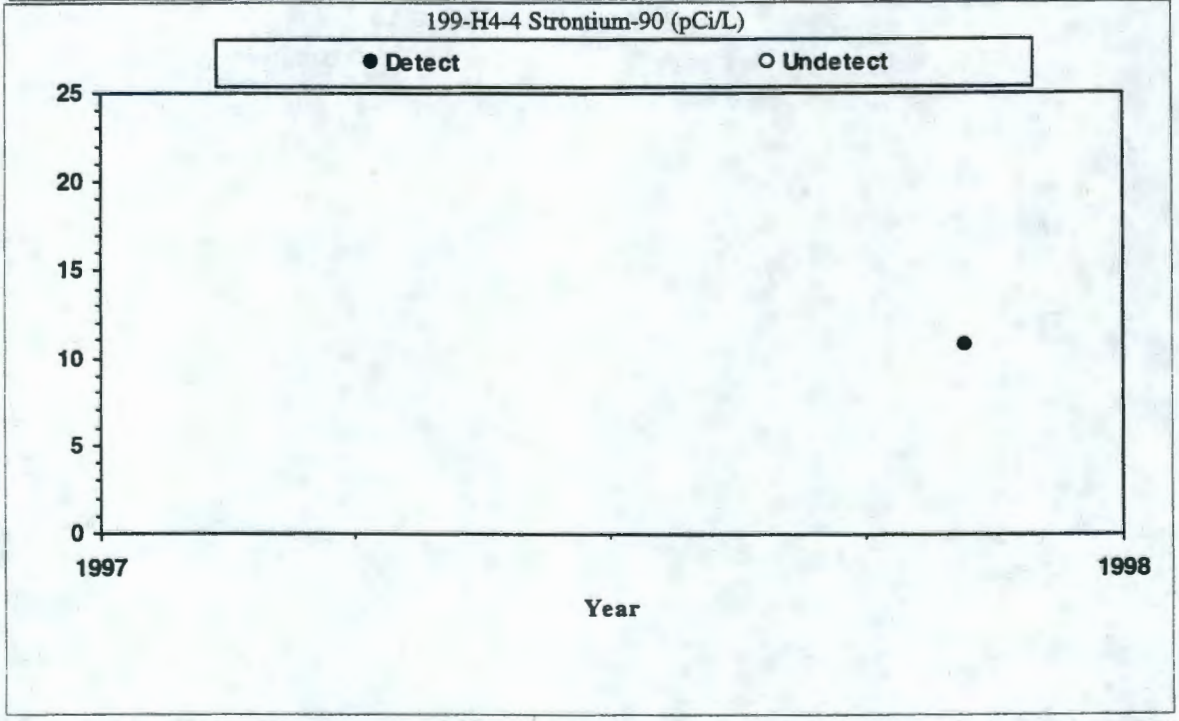
Average of Detected Values: 10.80

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-11, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-11
Constituent : Strontium-90 (pCi/L)
Samples Taken between 10/18/96 and 7/18/97

Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 21 on 7/18/97

Maximum Detected Value: 26.1 on 10/18/96

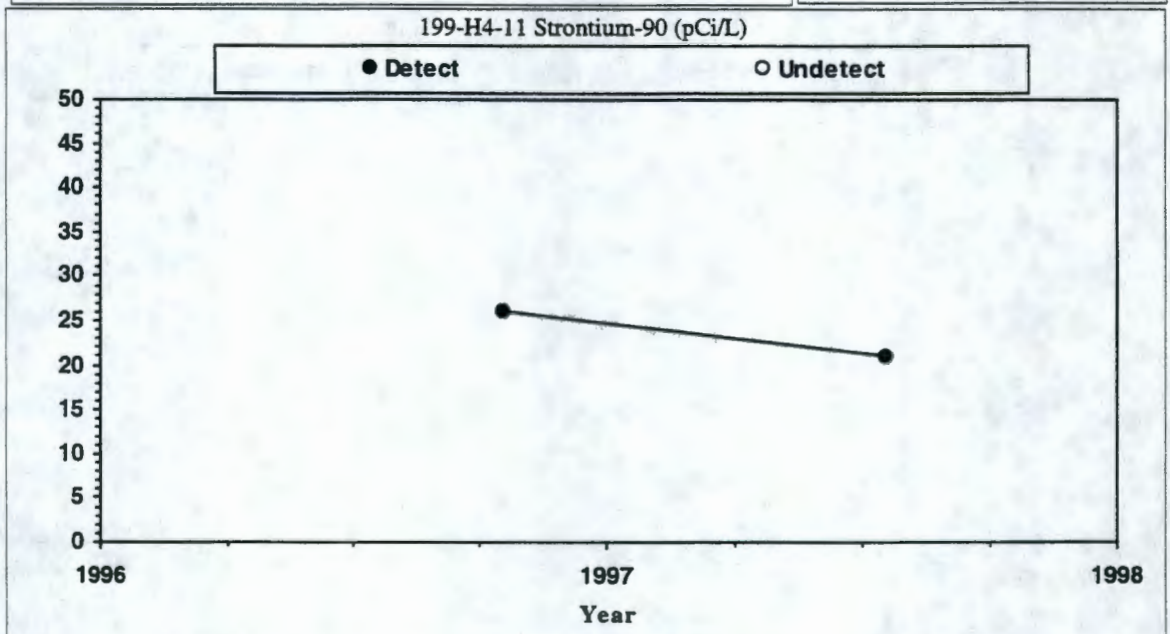
Average of Detected Values: 23.55

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-13, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-13
Constituent : Strontium-90 (pCi/L)
Samples Taken between 10/22/96 and 10/22/96

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 32.4 on 10/22/96

Maximum Detected Value: 32.4 on 10/22/96

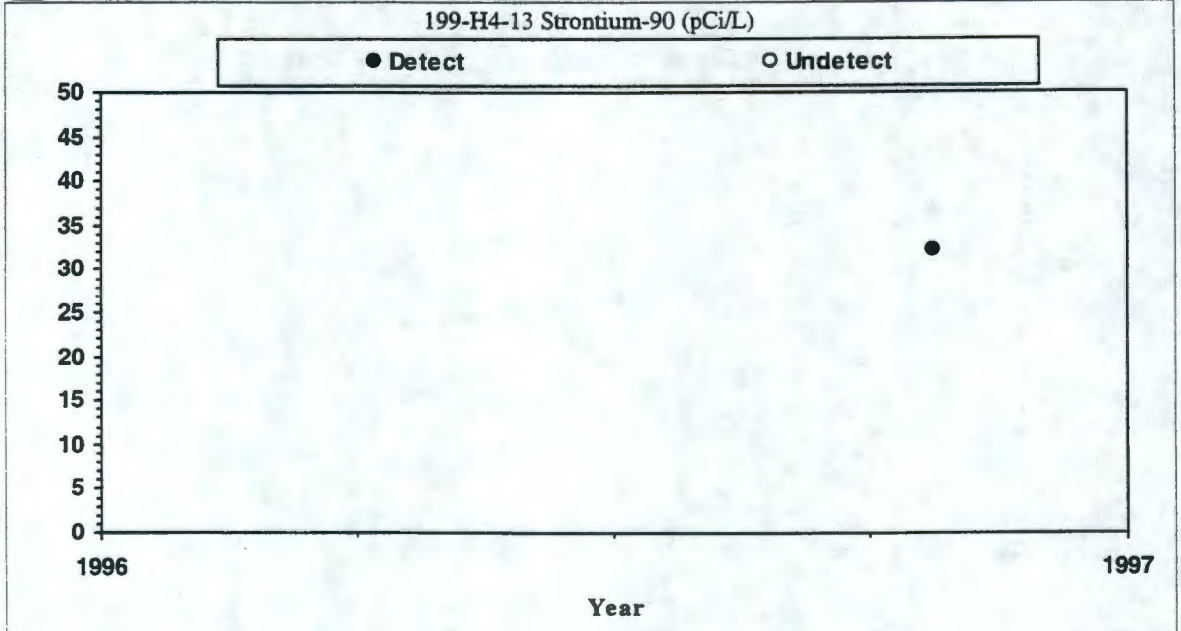
Average of Detected Values: 32.40

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-16, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-16
Constituent : Strontium-90 (pCi/L)
Samples Taken between 10/23/96 and 10/23/96

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 10.4 on 10/23/96

Maximum Detected Value: 10.4 on 10/23/96

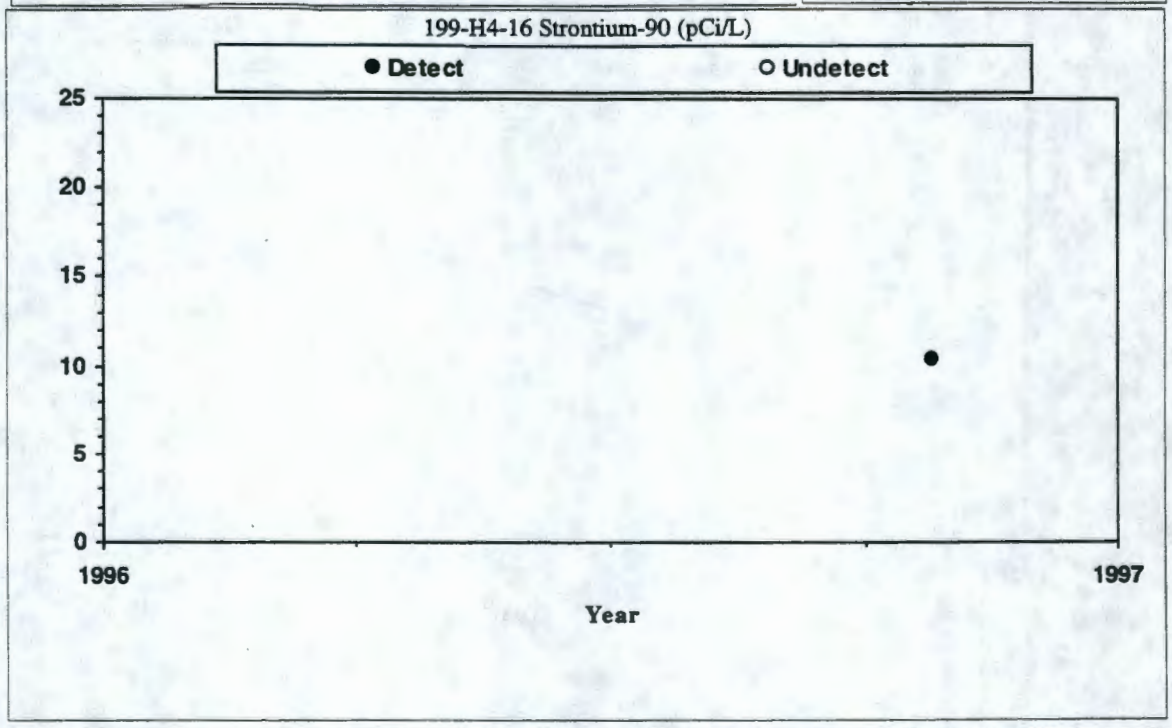
Average of Detected Values: 10.40

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL-- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-63, Strontium-90 (pCi/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-H4-63
Constituent : Strontium-90 (pCi/L)
Samples Taken between 10/16/96 and 11/3/97

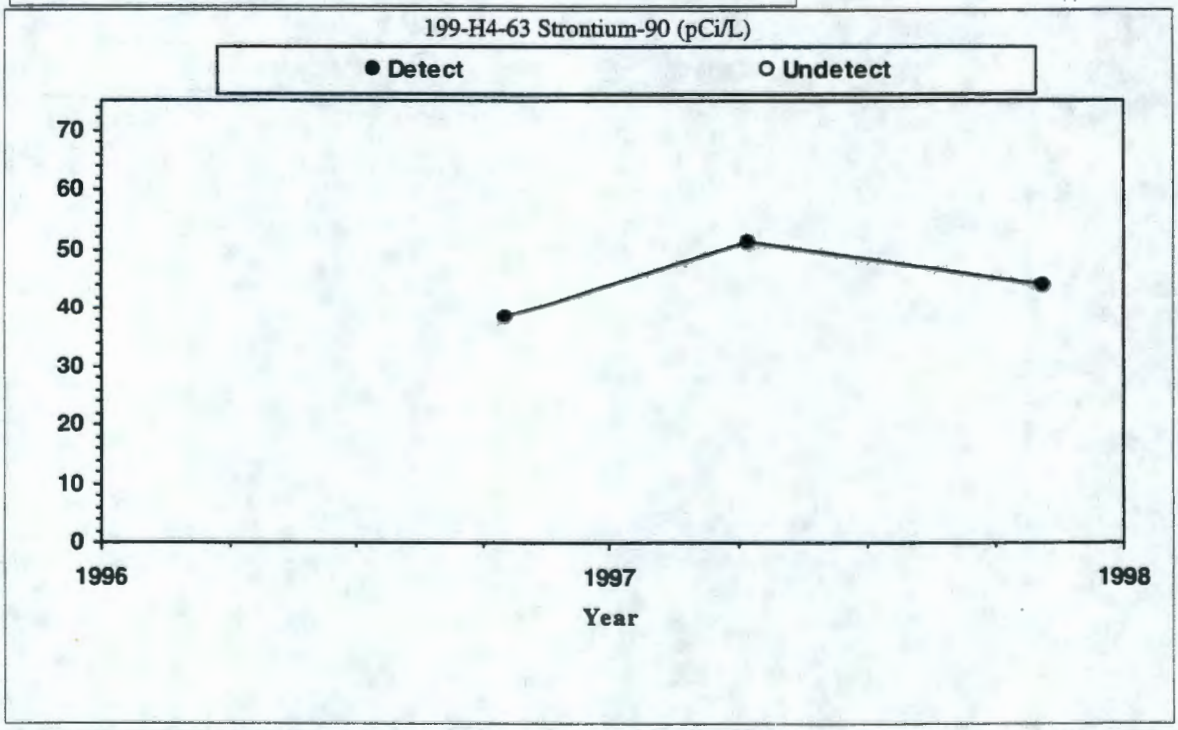
Number of Samples: 3 **Number of Detects:** 3

Minimum Detected Value: 38.7 on 10/16/96

Maximum Detected Value: 51.2 on 4/7/97

Average of Detected Values: 44.70

Number of Rejected Values: 0



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-19, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-K-19
Constituent : Strontium-90 (pCi/L)
Samples Taken between 12/16/96 and 12/16/96

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 12.9 on 12/16/96

Maximum Detected Value: 12.9 on 12/16/96

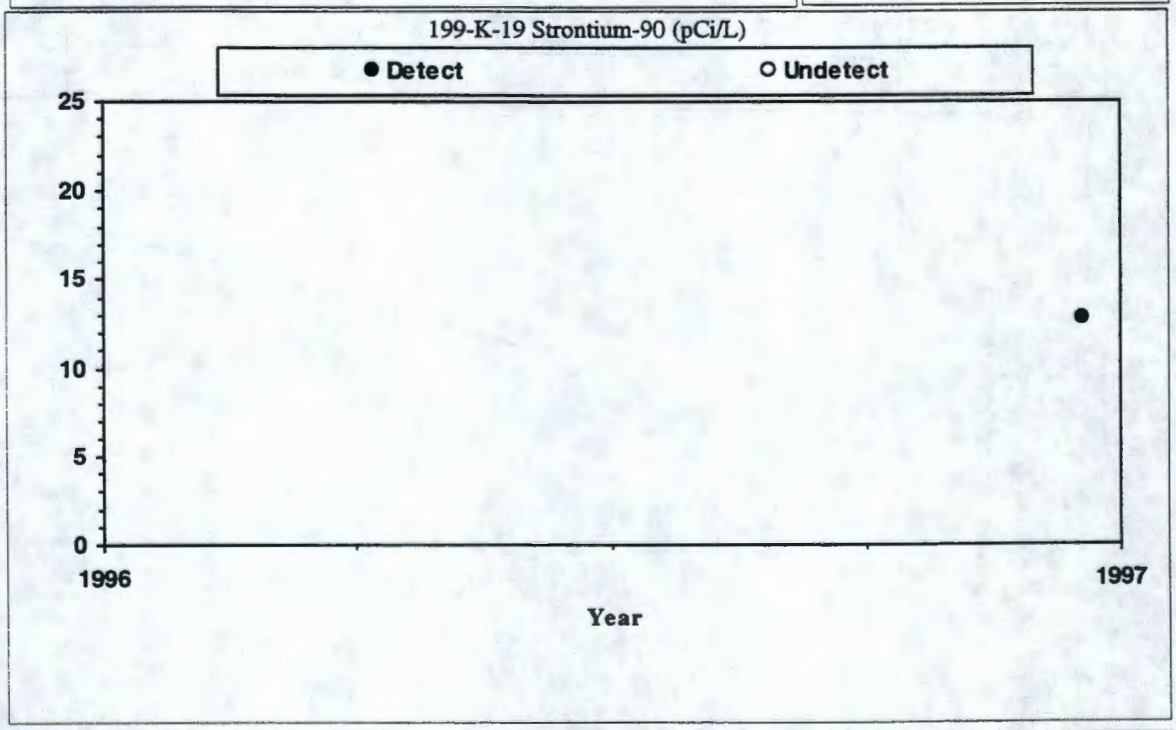
Average of Detected Values: 12.90

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-20, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-K-20
Constituent : Strontium-90 (pCi/L)
Samples Taken between 11/15/96 and 10/27/97

Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 11.2 on 11/15/96

Maximum Detected Value: 18.1 on 10/27/97

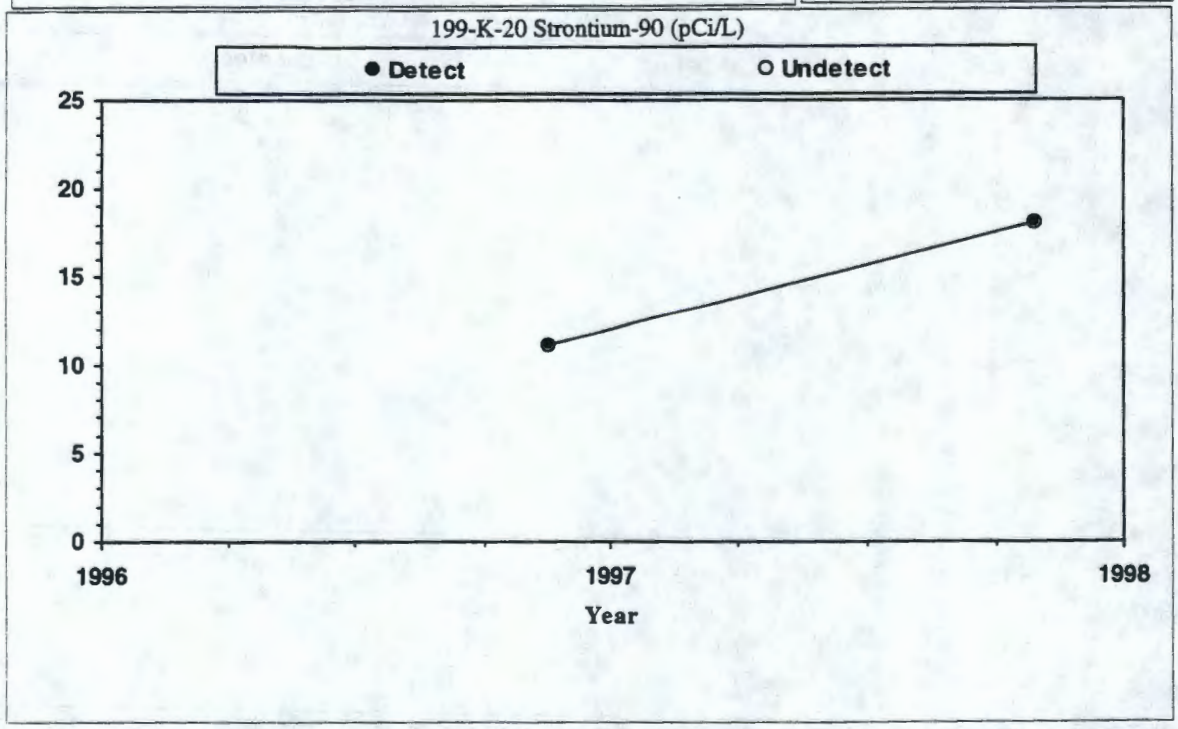
Average of Detected Values: 14.65

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-21, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-K-21
Constituent : Strontium-90 (pCi/L)
Samples Taken between 11/18/96 and 11/18/96

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 28.2 on 11/18/96

Maximum Detected Value: 28.2 on 11/18/96

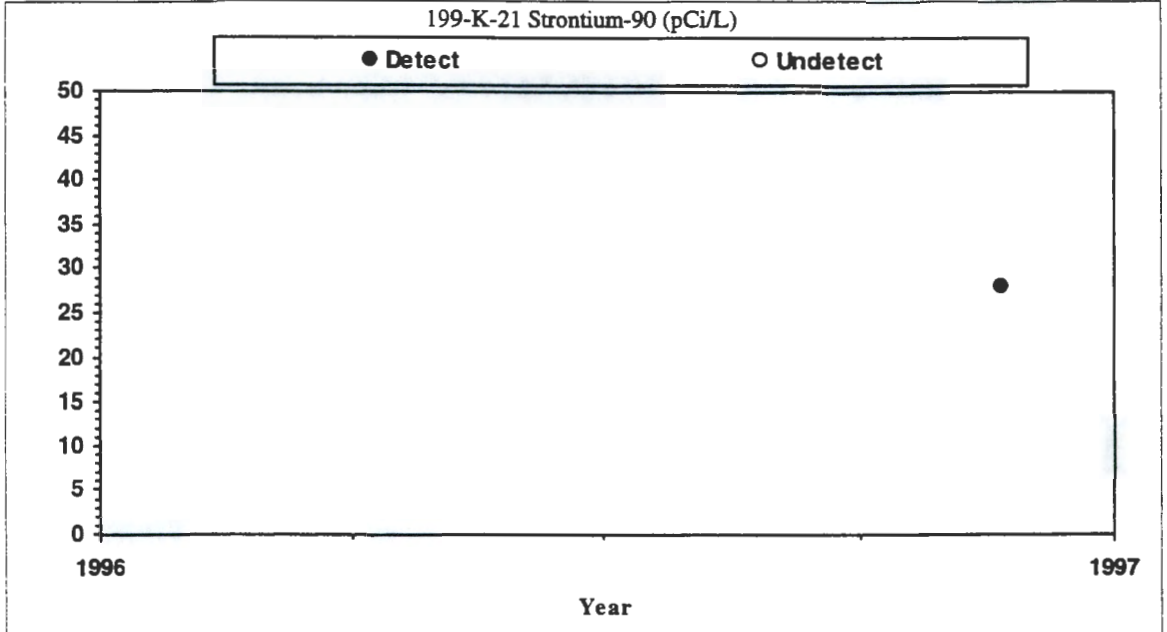
Average of Detected Values: 28.20

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-22, Strontium-90 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-K-22
Constituent : Strontium-90 (pCi/L)
Samples Taken between 11/25/96 and 11/25/96

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 9.1 on 11/25/96

Maximum Detected Value: 9.1 on 11/25/96

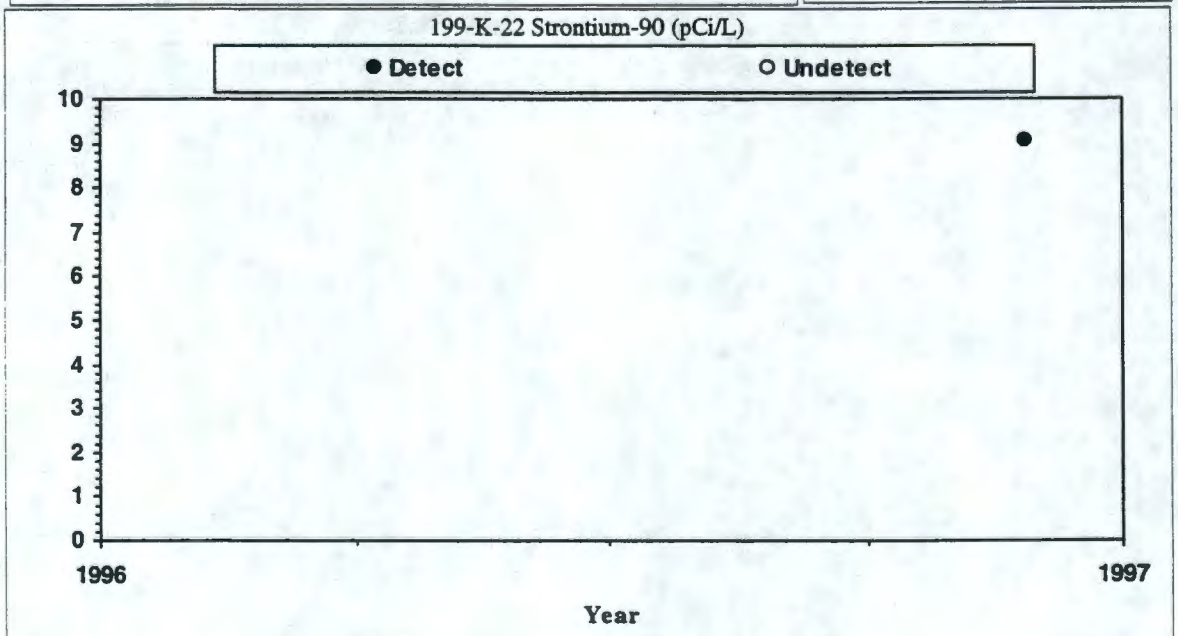
Average of Detected Values: 9.10

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-113A, Strontium-90 (pCi/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-K-113A
Constituent : Strontium-90 (pCi/L)
Samples Taken between 11/12/96 and 11/11/97

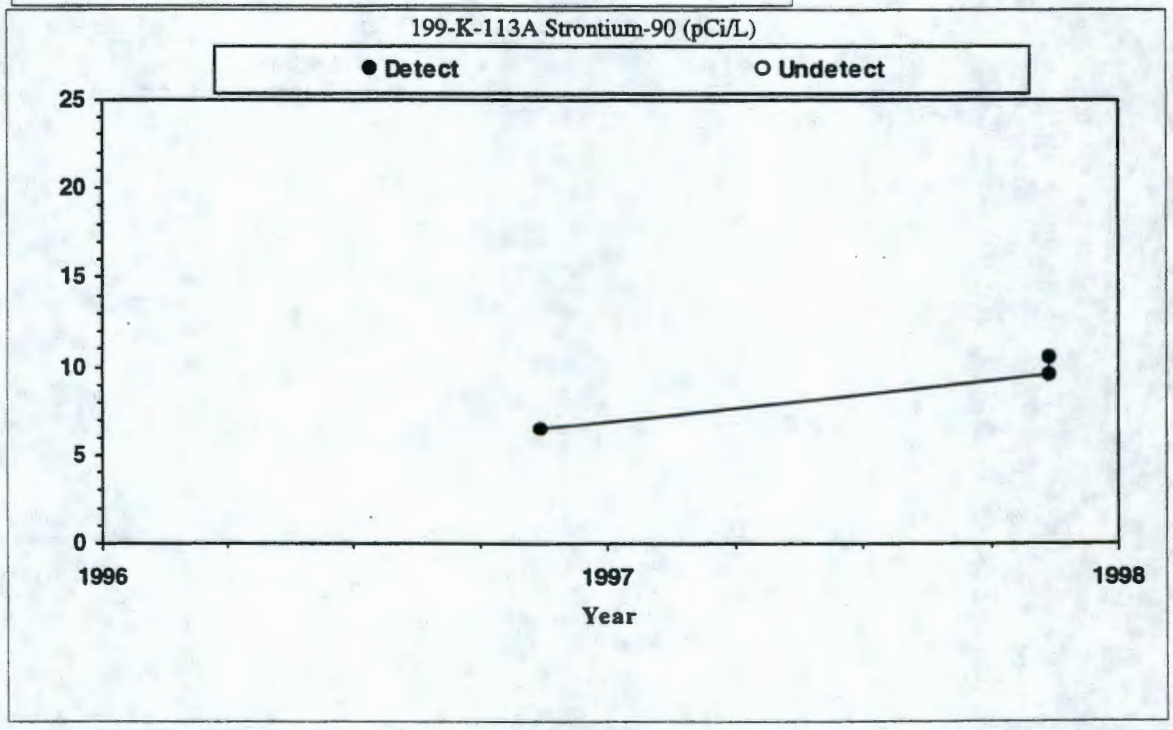
Number of Samples: 3 **Number of Detects:** 3

Minimum Detected Value: 6.57 on 11/12/96

Maximum Detected Value: 10.6 on 11/11/97

Average of Detected Values: 8.92

Number of Rejected Values: 0



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-114A, Strontium-90 (pCi/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-K-114A
Constituent : Strontium-90 (pCi/L)
Samples Taken between 11/14/96 and 10/22/97

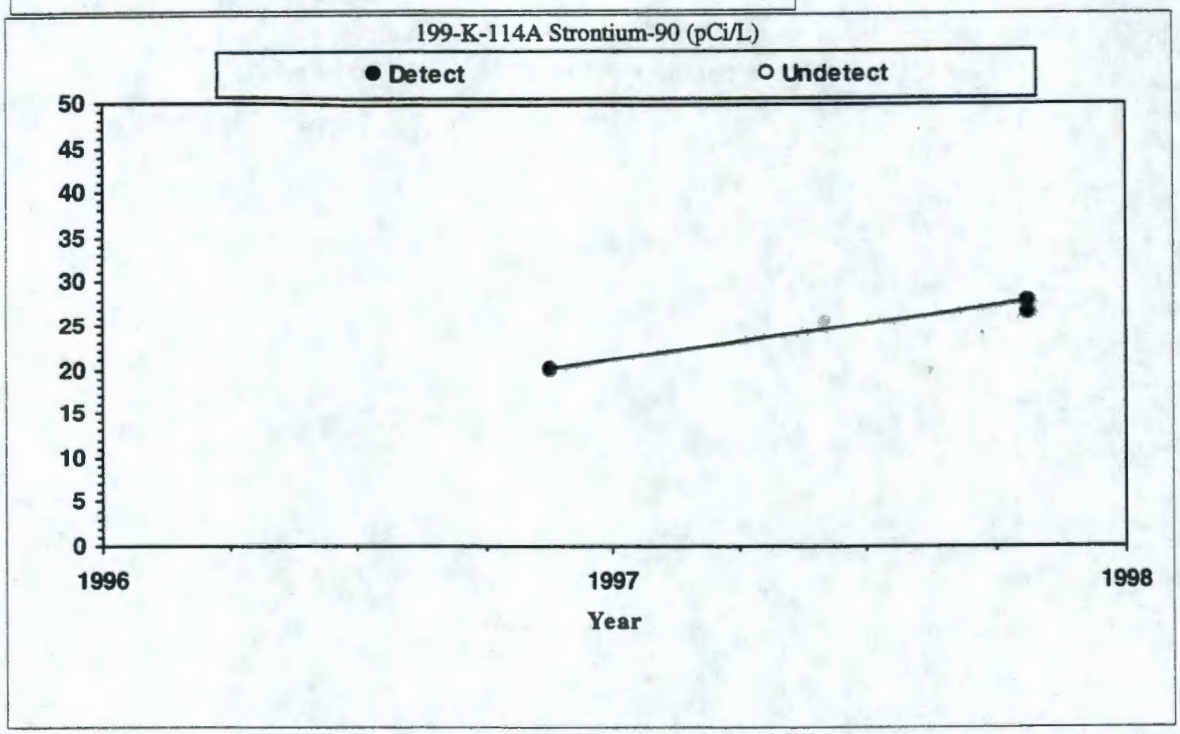
Number of Samples: 3 **Number of Detects:** 3

Minimum Detected Value: 20.1 on 11/14/96

Maximum Detected Value: 27.8 on 10/22/97

Average of Detected Values: 24.83

Number of Rejected Values: 0



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-115A, Strontium-90 (pCi/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-K-115A
Constituent : Strontium-90 (pCi/L)
Samples Taken between 11/12/96 and 11/11/97

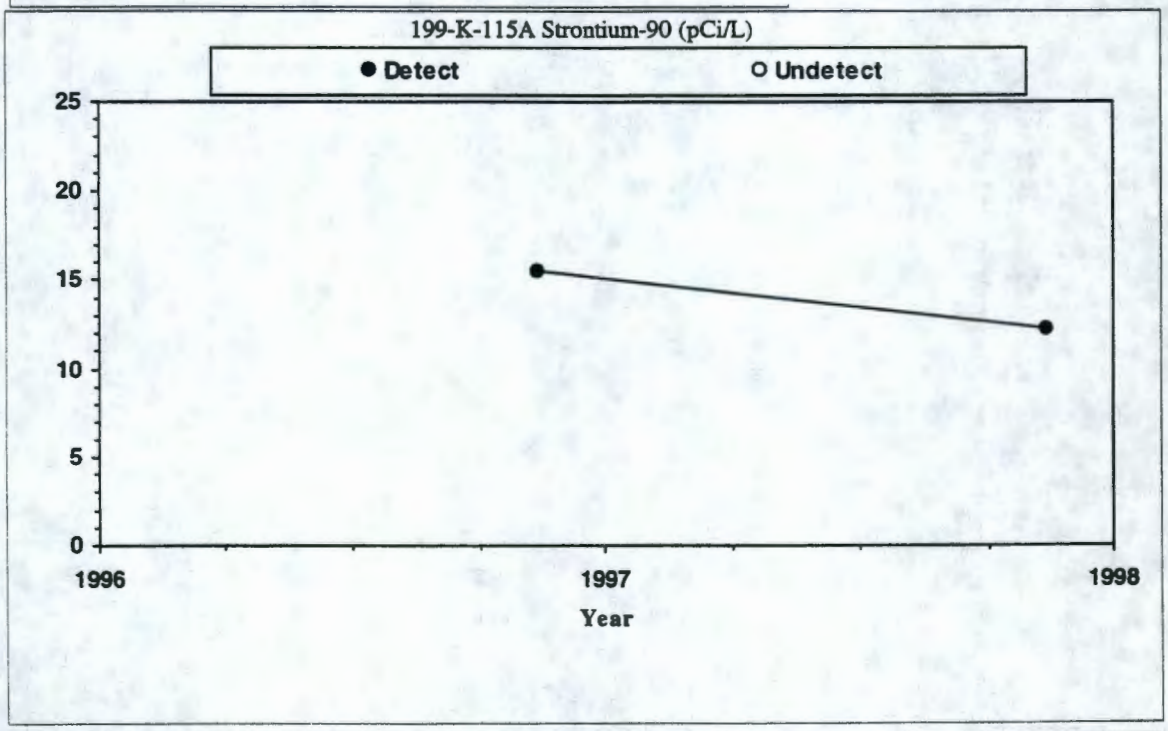
Number of Samples: 2 **Number of Detects:** 2

Minimum Detected Value: 12.2 on 11/11/97

Maximum Detected Value: 15.5 on 11/12/96

Average of Detected Values: 13.85

Number of Rejected Values: 0



Relevant Contaminant Standards for: Strontium-90 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	42	**SMCL:**	NA		
MCL:	8	**MTCA-B:**	NA	**Wa GWQ:**	8		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-3, Technetium-99 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-3
Constituent : Technetium-99 (pCi/L)
Samples Taken between 10/2/96 and 11/3/97

Number of Samples: 10 **Number of Detects:** 10

Minimum Detected Value: 544 on 12/2/96

Maximum Detected Value: 2080 on 4/2/97

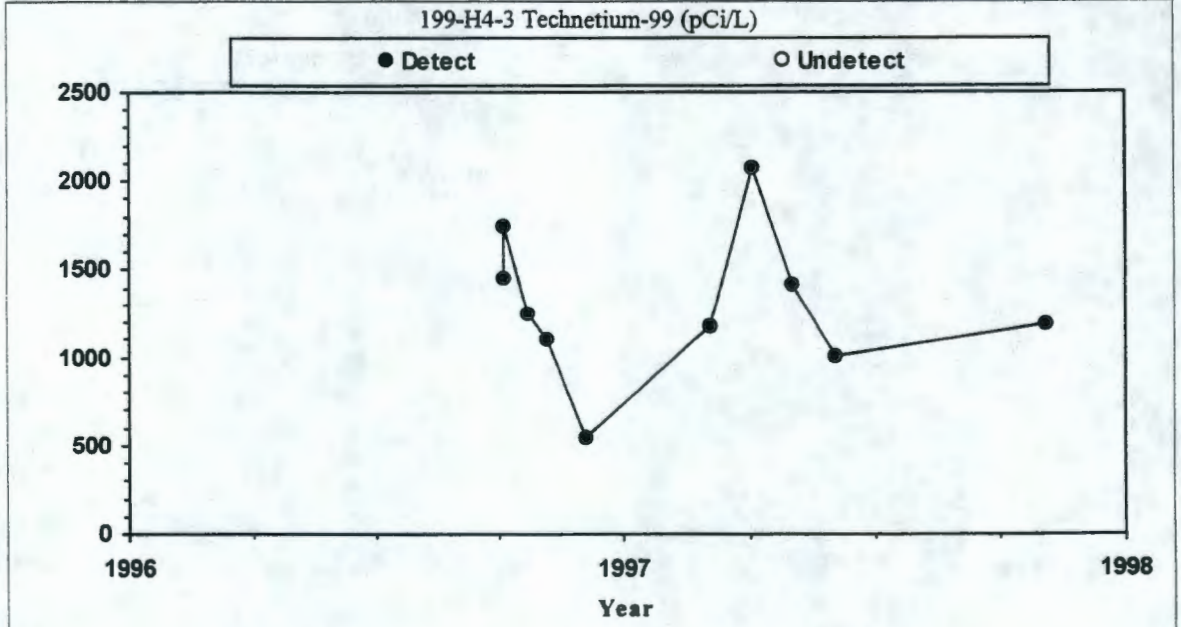
Average of Detected Values: 1299.40

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Technetium-99 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	727	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	900	**MCL-Prop:**	3790	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria. MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-4, Technetium-99 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-4
Constituent : Technetium-99 (pCi/L)
Samples Taken between 10/2/96 and 11/4/97

Number of Samples: 9 **Number of Detects:** 7

Minimum Detected Value: 4.63 on 5/1/97

Maximum Detected Value: 1640 on 11/4/96

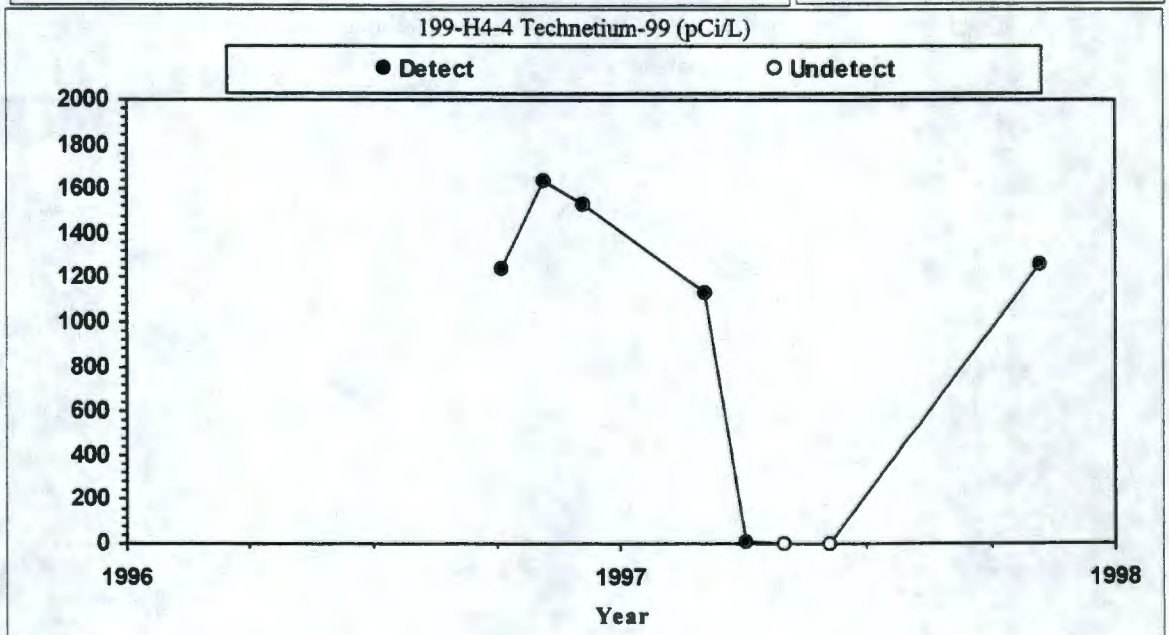
Average of Detected Values: 975.23

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Technetium-99 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	727	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	900	**MCL-Prop:**	3790	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit. Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-5, Technetium-99 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-5
Constituent : Technetium-99 (pCi/L)
Samples Taken between 10/17/96 and 11/4/97

Number of Samples: 2 **Number of Detects:** 1

Minimum Detected Value: 1130 on 11/4/97

Maximum Detected Value: 1130 on 11/4/97

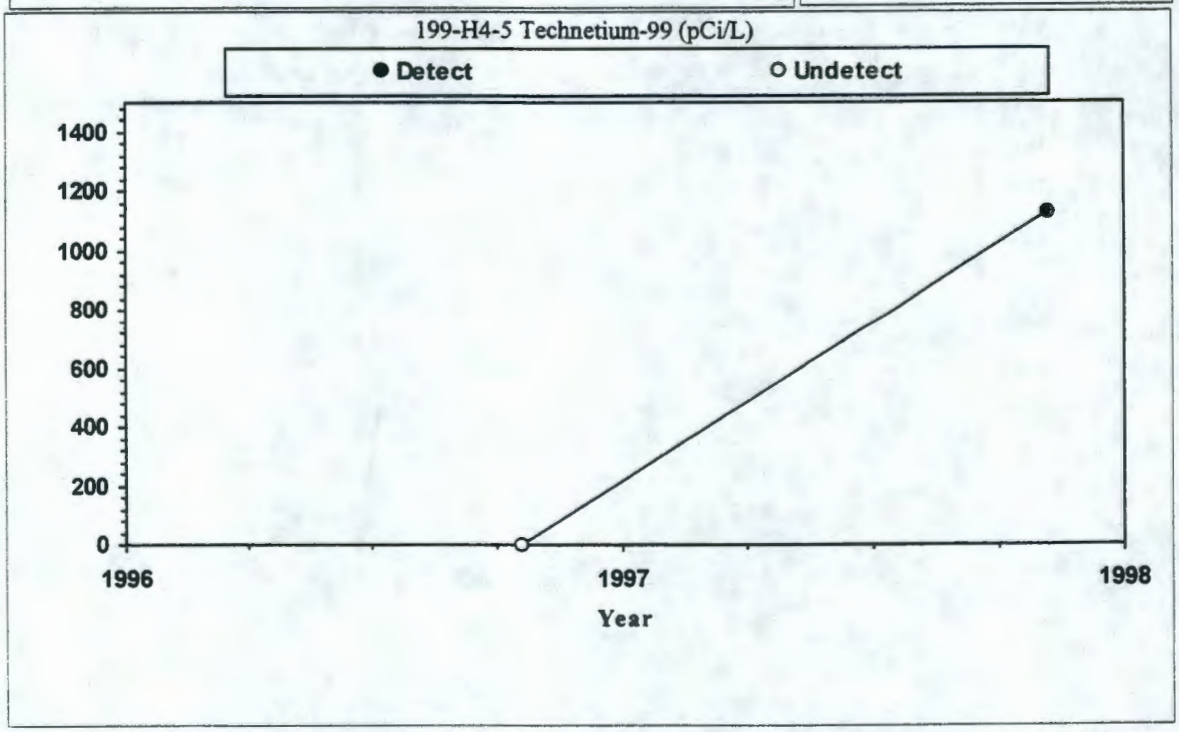
Average of Detected Values: 1130.00

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Technetium-99 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	727	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	900	**MCL-Prop:**	3790	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-7, Technetium-99 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-7
Constituent : Technetium-99 (pCi/L)
Samples Taken between 10/17/96 and 7/18/97

Number of Samples: 2 **Number of Detects:** 1

Minimum Detected Value: 2080 on 7/18/97

Maximum Detected Value: 2080 on 7/18/97

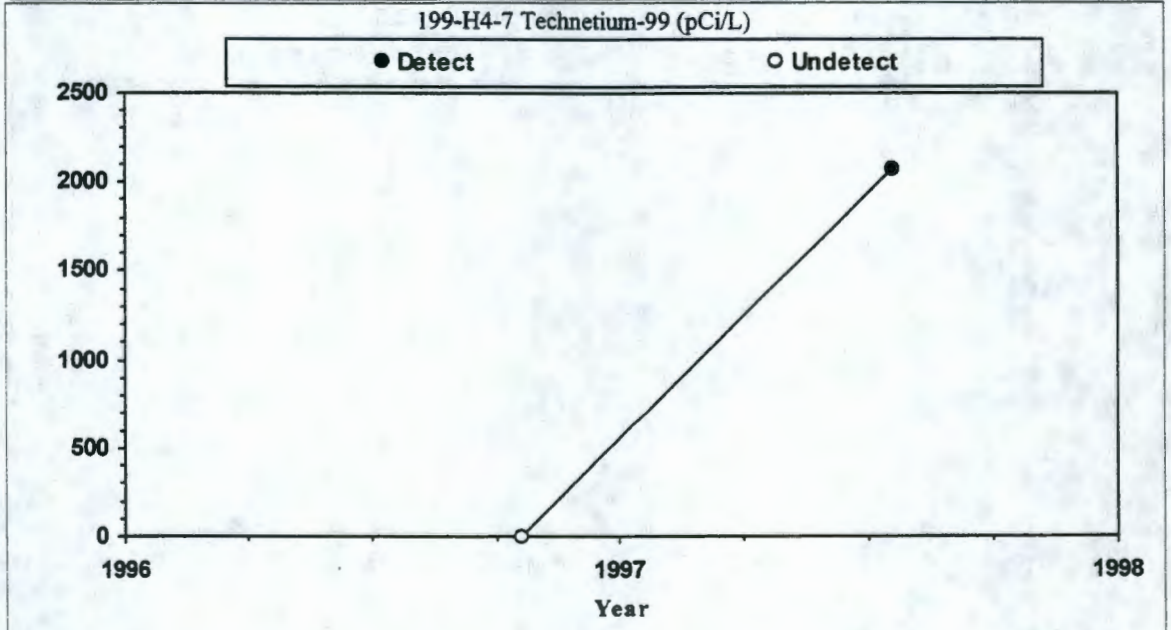
Average of Detected Values: 2080.00

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Technetium-99 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	727	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	900	**MCL-Prop:**	3790	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-12A, Technetium-99 (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-H4-12A
Constituent : Technetium-99 (pCi/L)
Samples Taken between 10/2/96 and 11/6/97

Number of Samples: 10 **Number of Detects:** 7

Minimum Detected Value: 4.11 on 7/18/97

Maximum Detected Value: 524 on 11/6/97

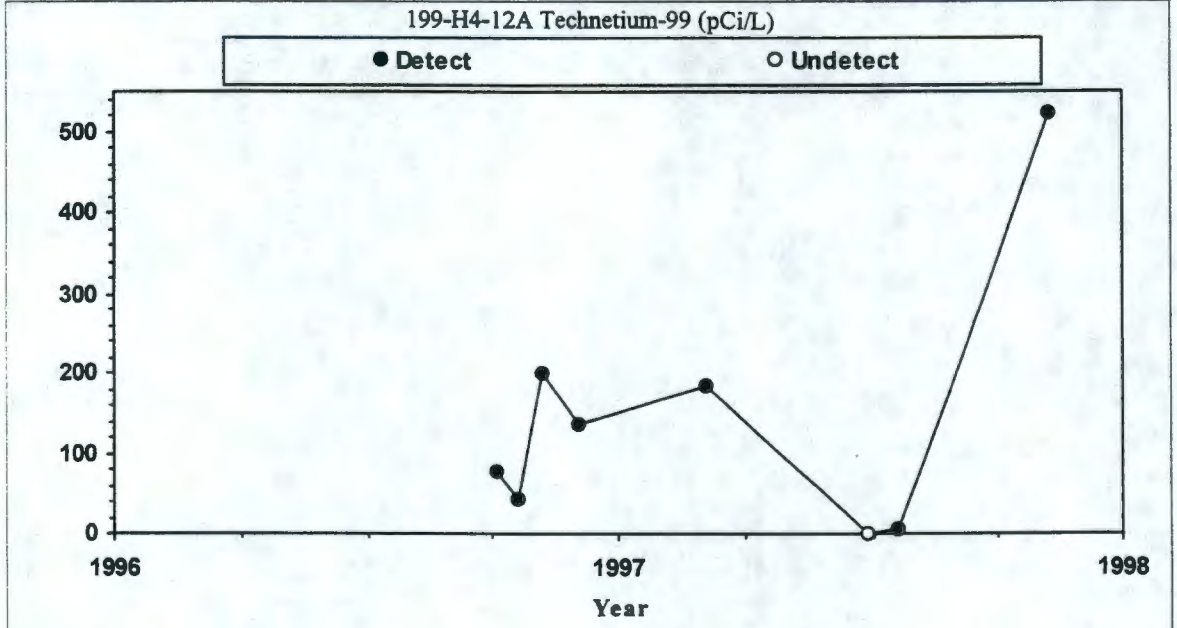
Average of Detected Values: 167.29

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	Yes
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Technetium-99 (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	727	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	900	**MCL-Prop:**	3790	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-18, Tritium (pCi/L)

19-Feb-98

Statistical Summary for : Well 199-K-18
Constituent : Tritium (pCi/L)
Samples Taken between 12/16/96 and 10/27/97

Number of Samples: 4 **Number of Detects:** 4

Minimum Detected Value: 15800 on 10/27/97

Maximum Detected Value: 31300 on 5/29/97

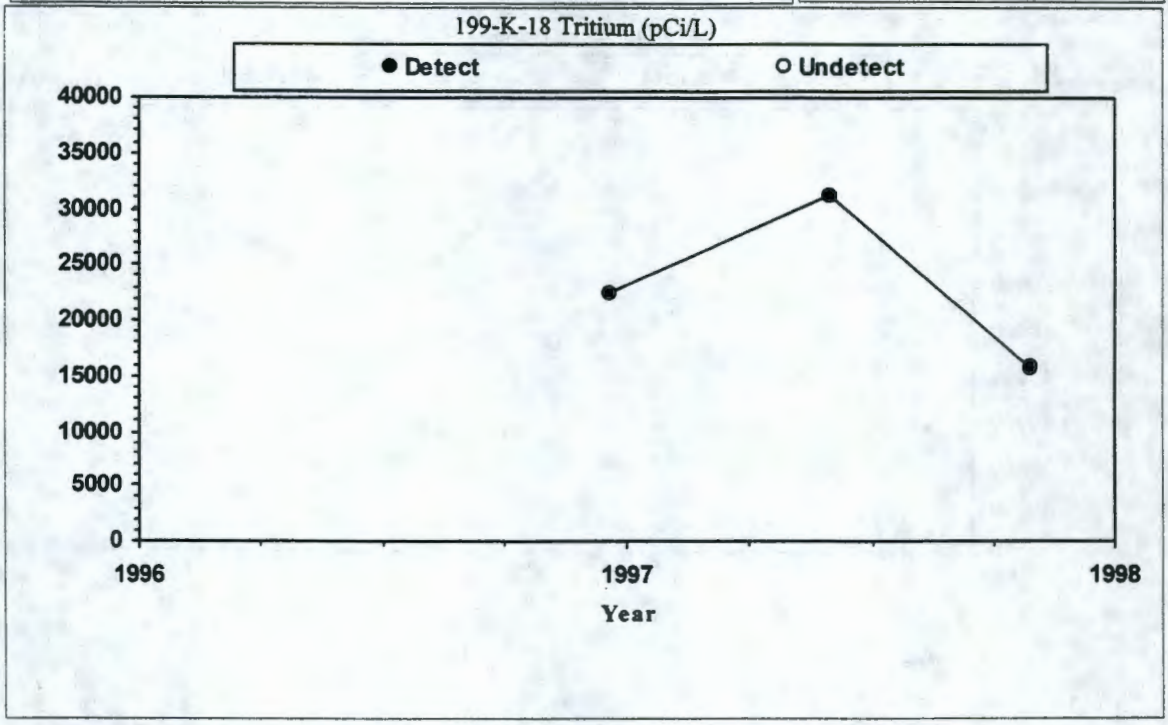
Average of Detected Values: 21375.00

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Tritium (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	60900	**SMCL:**	NA		
MCL:	20000	**MTCA-B:**	NA	**Wa GWQ:**	20000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-K-120A, Tritium (pCi/L)

19-Feb-98

Well Information

Statistical Summary for : Well 199-K-120A
Constituent : Tritium (pCi/L)
Samples Taken between 11/26/96 and 11/11/97

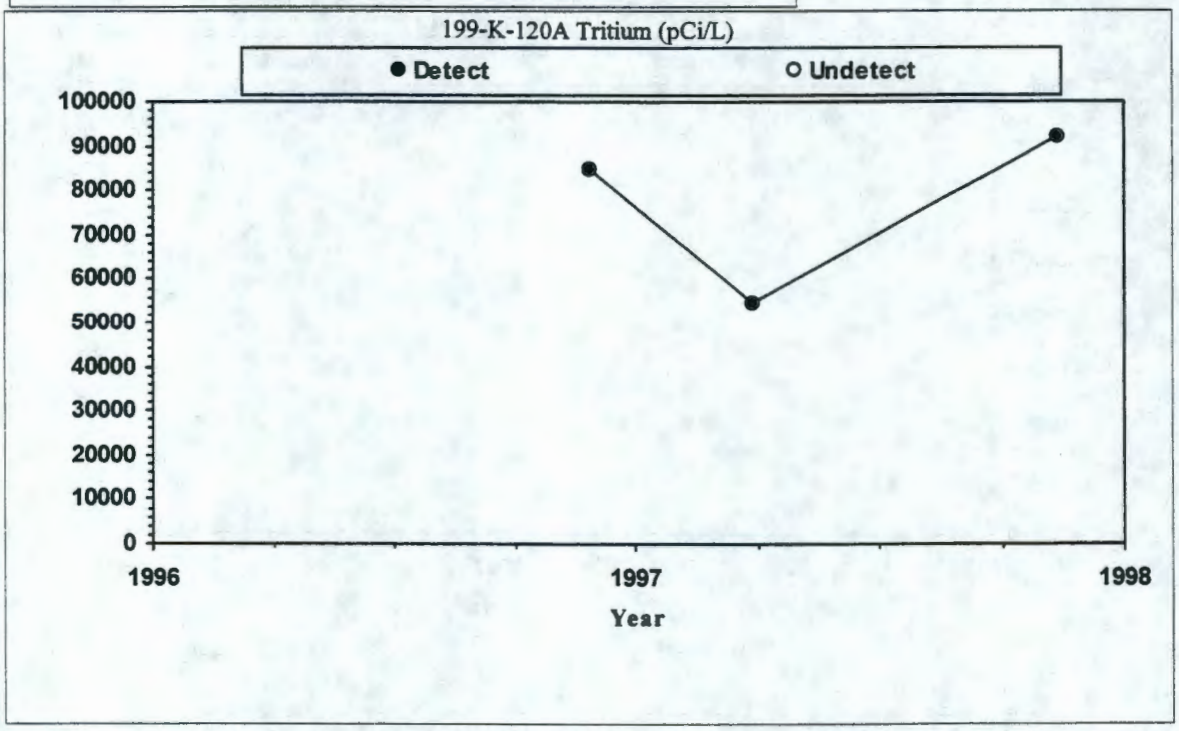
Number of Samples: 3 **Number of Detects:** 3

Minimum Detected Value: 55000 on 3/27/97

Maximum Detected Value: 92300 on 11/11/97

Average of Detected Values: 77466.67

Number of Rejected Values: 0



Relevant Contaminant Standards for: Tritium (pCi/l)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	NA	**MCL-Prop:**	60900	**SMCL:**	NA		
MCL:	20000	**MTCA-B:**	NA	**Wa GWQ:**	20000		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-3, Uranium (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-3
Constituent : Uranium (ug/L)
Samples Taken between 10/2/96 and 11/3/97

Number of Samples: 10 **Number of Detects:** 10

Minimum Detected Value: 99.1 on 12/2/96

Maximum Detected Value: 226 on 10/2/96

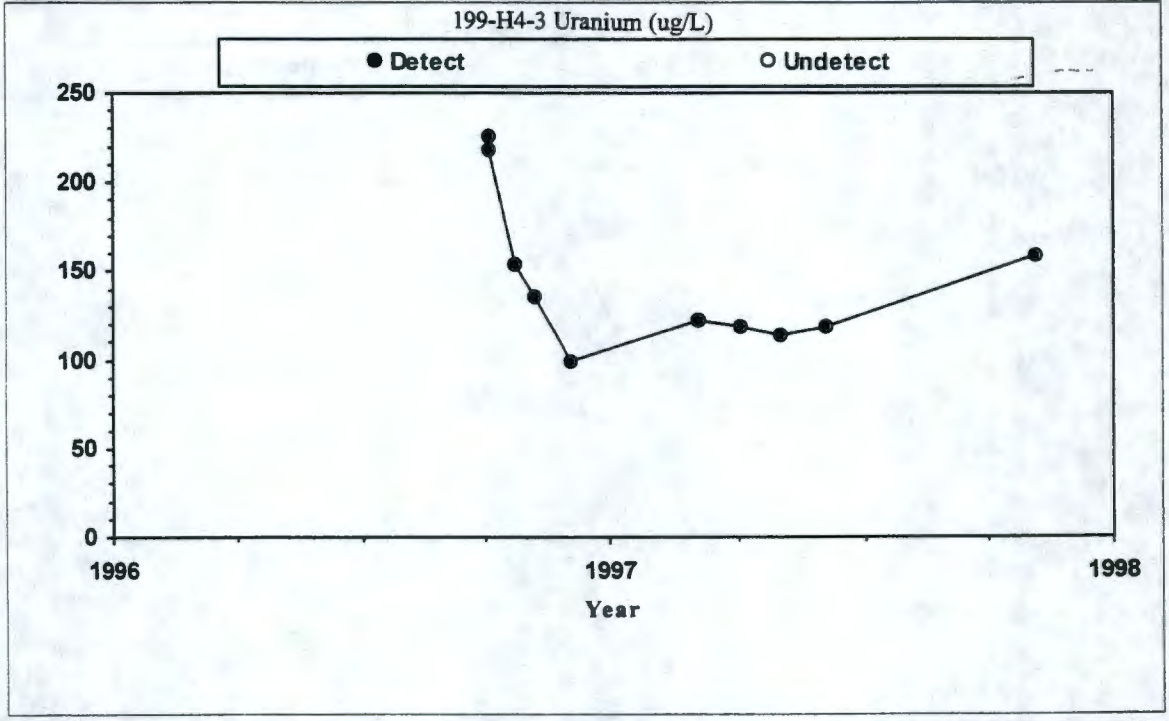
Average of Detected Values: 146.81

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Uranium (ug/L)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	59	**MCL-Prop:**	20	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-4, Uranium (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-4
Constituent : Uranium (ug/L)
Samples Taken between 10/2/96 and 11/4/97

Number of Samples: 9 **Number of Detects:** 9

Minimum Detected Value: 1.24 on 6/3/97

Maximum Detected Value: 113 on 11/4/97

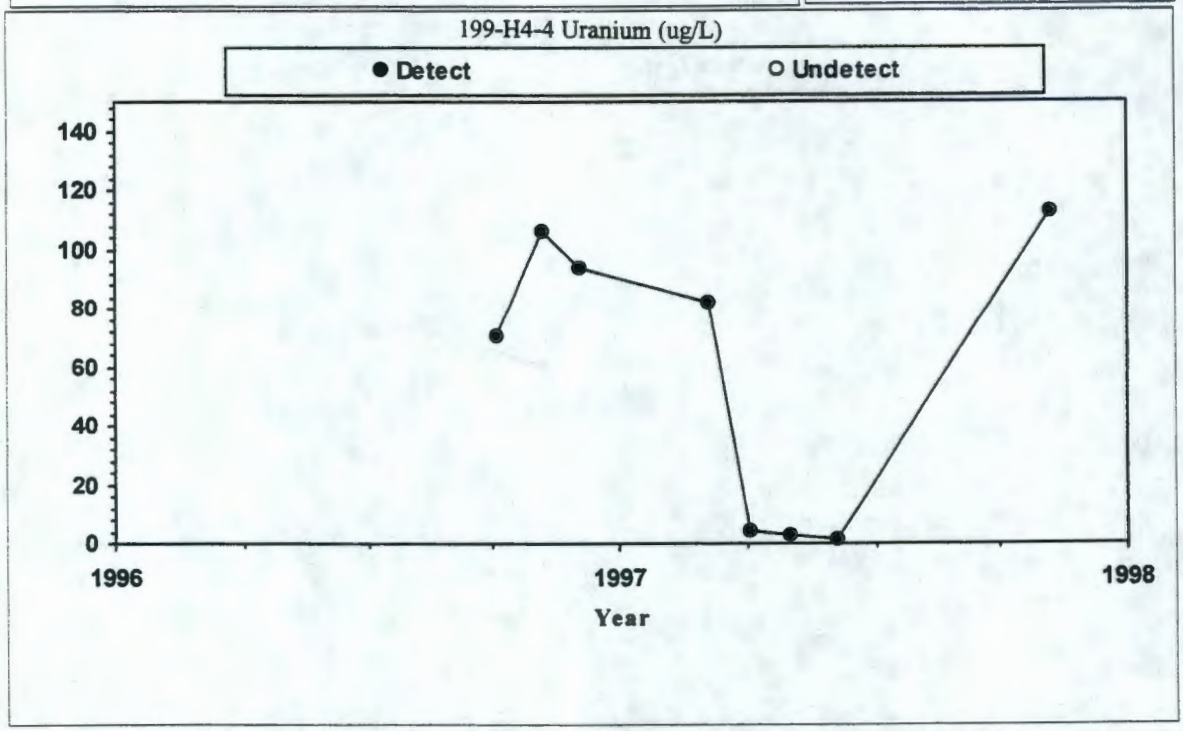
Average of Detected Values: 52.91

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Uranium (ug/L)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	59	**MCL-Prop:**	20	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL-- Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

Well Data Evaluation Summary Report, All Data
199-H4-7, Uranium (ug/L)

19-Feb-98

Statistical Summary for : Well 199-H4-7
Constituent : Uranium (ug/L)
Samples Taken between 7/18/97 and 7/18/97

Number of Samples: 1 **Number of Detects:** 1

Minimum Detected Value: 106 on 7/18/97

Maximum Detected Value: 106 on 7/18/97

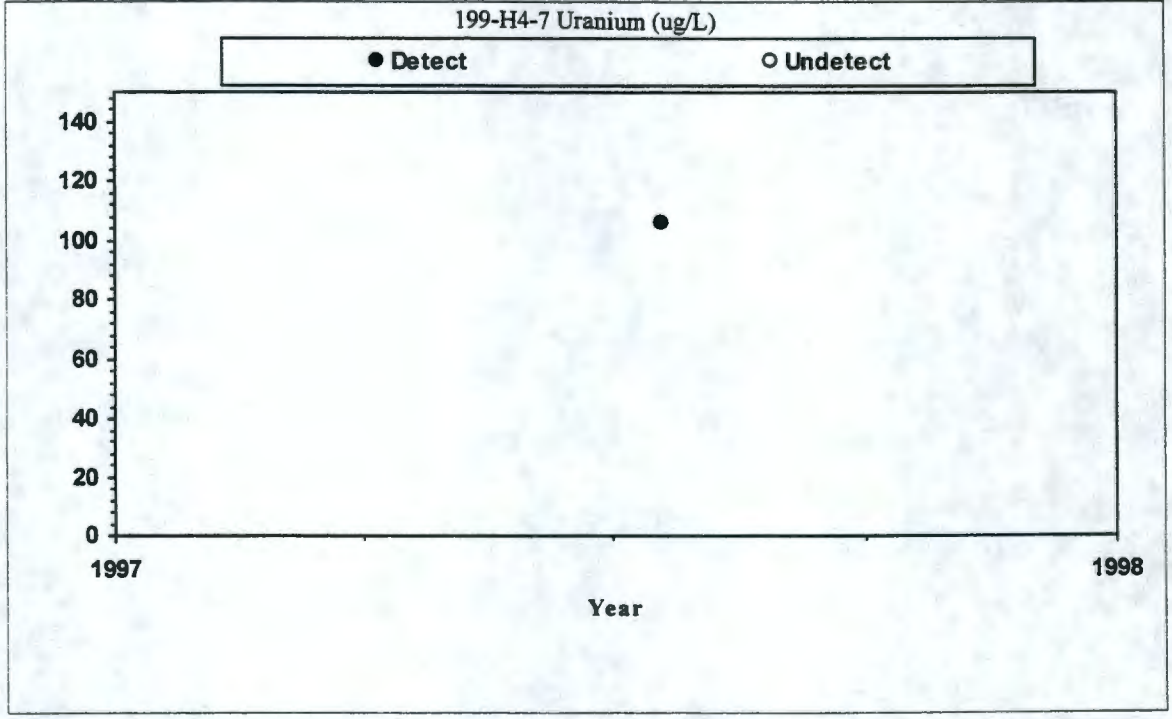
Average of Detected Values: 106.00

Number of Rejected Values: 0

Well Information

Deep Well:	No
River Influence:	No
Anomalous Chem:	No
Anomalous Head:	No
Anomalous Const:	No
Injection Well:	No
Extraction Well:	No
Screen in Formation X:	No
Screen in Formation Y:	No
No Recent Data:	No
Not Used in Plumes:	No
Well Dry:	No
Inf. by Pump+Treat:	No

Data Under Construction



Relevant Contaminant Standards for: Uranium (ug/L)

Fed WQ:	NA	**MCL-NBS69:**	NA	**MTCA-C:**	NA	**Wa SWQ:**	NA
Hanford :	59	**MCL-Prop:**	20	**SMCL:**	NA		
MCL:	NA	**MTCA-B:**	NA	**Wa GWQ:**	NA		

MCL - Maximum Contaminant Limit, Fed WQ - Federal Water Quality, MTCA - Model Toxics Control Act, Wa SWQ - Washington Surface Water Quality, SMCL - Secondary Maximum Contaminant Limit, Wa GWQ - Washington Groundwater Quality, MCL-Prop - Proposed MCL, Hanford - Hanford Specific Criteria, MCL-NBS69 - Maximum Contaminant Level ??

APPENDIX B

DEVELOPMENT OF FINITE ELEMENT MESH FOR WATER TABLE CONTOUR MAPS AND VELOCITY FIELDS

Development of Finite Element Mesh for Water Table Contour Maps and Velocity Fields

- Water table contours were developed from a triangular mesh constructed from the well survey coordinates. Hydraulic head data collected at each well were interpolated along the mesh.

  The hydraulic head around the extraction and injection wells was calculated using the Theim equation. The Theim equation estimates the steady state drawdown around an extraction or injection well (Lohman, 1979[5]):

$$s_r = s_w - \frac{2.3\,Q \log(r/r_w)}{2\pi T}$$

  where s_r is the drawdown at a distance r from the well, s_w is the drawdown measured at the well, Q is the extraction or injection rate, r_w is the well radius, and T is the aquifer transmissivity.

  Using the Theim equation prevented the linear interpolation of the hydraulic head data from grossly exaggerating the radial extent of the localized drawdown.

- Generating the velocity field required interpolating the irregular finite element mesh onto a rectangular finite difference grid and calculating hydraulic head gradient between adjacent grid points. The x and y velocity components at any point in the grid are then

$$V_x = -\frac{K}{\phi}\frac{(H_{i+1} - H_{i-1})}{(X_{i+1} - X_{i-1})}$$

  and

$$V_y = -\frac{K}{\phi}\frac{(H_{j+1} - H_{j-1})}{(Y_{j+1} - Y_{j-1})}$$

  where K is the hydraulic conductivity, ϕ is the aquifer porosity, H is the hydraulic head, x and y are coordinates, and i and j are the grid indices.

  The velocity field can be used to show the streamtraces and capture zones resulting from the operation of the pump-and-treat system.

---

[5] Lohman, 1979, *Ground-Water Hydraulics,* U. S. Geological Survey Professional Paper 708, U. S. Geological Survey, Washington D.C.

DISTRIBUTION

ONSITE
58 (Copies)

U.S. Environmental Protection Agency

L. E. Gadbois	B5-01

Washington State Department of Ecology

W. W. Soper	B5-18

U. S. Department of Energy
Richland Operations Office

A. C. Tortoso(20)	H0-12
K. M. Thompson	H0-12
DOE-RL Public Reading Room	H2-53

ERC Team

M. A. Buckmaster	H0-19
D. B. Blumenkranz	H9-02
M. P Connelly	H9-03
R. L. Jackson (10)	H0-03
A. J. Knepp	H0-19
M. R. Knudsen	H9-01
W. J. McMahon	H9-03
C. R. Strode	H0-19
L. C. Swanson	H9-02
P. B. Tolley	H9-03
R. C. Wilson	H9-01

Document and Information Services (4)	H0-09
Administrative Record (9)	H0-09
Hanford Technical Library	P8-55

THIS PAGE INTENTIONALLY
LEFT BLANK