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Date: November 15, 2005
Refer To: ER2005-0872

Mr. David Gregory, Federal Project Director
Department of Energy, MS A316
Los Alamos Site Office
Los Alamos, NM 87545

SUBJECT: WELL SCREEN ANALYSIS REPORT

Dear Mr. Gregory,

Attached please find the "Well Screen Analysis Report," which was prepared at the request of Mr. Mathew Johansen. The report provides an assessment of the geochemical conditions in individual well screens for 33 groundwater wells, primarily those constructed under the Hydrogeologic Workplan.

If you have any questions regarding this report, please contact Ardyth Simmons at 665-3935 (asimmons@lanl.gov) or Jean Dewart at 665-0239 (dewart@lanl.gov).

Sincerely,

for David J. McInroy
Deputy Program Director
Environmental Remediation & Surveillance
Los Alamos National Laboratory

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Enclosure: Well Screen Analysis Report (ER2005-0841)

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Well Screen Analysis Report

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Prepared by
Environmental Stewardship Division–
Environmental Remediation and Surveillance Program

Executive Summary

This report evaluates the reliability and representativeness of groundwater chemistry data for samples collected from 33 characterization wells, most of which were installed under Los Alamos National Laboratory's Hydrogeologic Workplan. The evaluation covers 64 functional screens of the 82 screens in these wells, which were completed in the regional aquifer and perched intermediate zones. The scope of the evaluation is limited to identifying which of these screens are capable of producing reliable water-quality data and which may have been impacted by residual drilling fluids. This report does not examine if the use of drilling fluids may have impacted the characterization objectives of the Hydrogeologic Workplan, nor whether these wells are suitable to use as monitoring wells under the March 1, 2005, Compliance Order on Consent signed by the New Mexico Environment Department, U.S. Department of Energy, and the University of California.

Drilling fluids include organic drilling fluids or additives, mainly consisting of EZ-MUD® and QUIK-FOAM®, for all of the 64 screens, as well as sodium bentonite drilling mud for 12 of the 64 screens. Twenty solutes and field parameters are defined as indicator species for identifying the presence or absence of residual drilling fluids and additives and of their effects on water chemistry.

The assessment is conducted by comparing the most recent three sampling rounds of surveillance and characterization data, where available, against the threshold levels of the 20 indicator species, with the threshold levels defined based on those measured in background groundwaters within perched intermediate zones and the regional aquifer. A tiered process is used to evaluate water samples from each screen and to indicate which screens are providing water-quality data that are reliable and representative of the saturated zone. The results of a time-series evaluation also indicate which screens are in the process of cleaning up over time and the extent to which they have cleaned up, and which screens do not appear to be improving with time. Some recently completed wells have water-quality data available for fewer than three sampling events. For these wells the outcome of the evaluation is considered preliminary.

Single-screen Wells

The 16 single-screen wells that were assessed by the tiered method are CdV-16-1i, MCOBT-4.4, and R-6i in intermediate perched zones, and R-1, R-2, R-4, R-6, R-9, R-11, R-13, R-15, R-18, R-21, R-23, R-28, and R-34 at the regional water table. Three of these single-screen wells were drilled using bentonite mud in addition to organic drilling fluids; the 13 remaining wells were drilled using organic drilling fluids alone.

The following key points resulted from application of the tiered analysis for identifying water-quality impacts from the use of bentonite drilling mud in R-2, R-4, and R-6:

- All three wells have returned to background concentrations for those solutes leached from residual bentonite mud.
- All three wells pass the assessment criteria that indicate their ability to detect strontium-90 and uranium isotopes in groundwater.
- All three wells pass the criterion for indicating their ability to measure strongly adsorbing metals/trace elements and radionuclides, including cobalt-60 and cesium-137, in groundwater.
- Because a suitable analogue is not available, the three wells could not be evaluated for very strongly adsorbing radionuclides, including isotopes of americium, cerium, plutonium, and radium.

- Because site-specific sorption data are not available, the three wells could not be reliably evaluated for the more highly sorbing high-explosive species and for a large proportion of the organic analytes of interest.

All 16 single-screen wells were evaluated for the effects of residual organic drilling fluids and for the presence of aerobic conditions that are representative of predrilling conditions. The following key points result from application of the tiered analysis for identifying water-quality impacts from the use of organic drilling fluids:

- Fifteen of the 16 single-screen wells do not contain detectable quantities of residual organic drilling fluids, with the exception of CdV-16-1i in an intermediate perched zone.
- Ten of the 16 single-screen wells currently produce oxidizing groundwater.
- The nine single-screen wells that meet all criteria are capable of providing reliable and representative data for all analytes of interest, with exceptions as noted for the three bentonite wells.

Multiscreen Wells

The 48 screens in 18 multiscreen wells that were assessed by the tiered method include nine in intermediate perched zones (R-5 Screen 2; R-9i Screens 1 and 2; R-12 Screen 1; R-19 Screen 2; R-25 Screens 1, 3 and 4; and R-26 Screen 1), with the remaining 39 in the regional aquifer. Nine of the multiscreen wells were in intervals drilled using bentonite mud in addition to organic drilling fluids; all of the remaining screens are in intervals drilled using organic drilling fluids alone.

The following key points resulted from application of the tiered analysis for identifying water-quality impacts from the use of bentonite drilling mud in nine screens (R-14 Screen 2; R-16 Screens 2, 3, and 4; R-20 Screens 1, 2, and 3; R-32 Screens 1 and 2):

- Five screens have returned to background concentrations for those solutes leached from residual bentonite mud. The four screens that did not pass the test criteria are R-16 Screens 3 and 4 and R-20 Screens 1 and 2.
- Five screens pass the assessment criterion that indicates their ability to detect uranium isotopes. The four exceptions are R-14 Screen 2, R-20 Screens 2 and 3, and R-32 Screen 3.
- Eight screens pass the assessment criterion that indicates their ability to detect strontium-90. The exception is R-20 Screen 1.
- All screens pass the criterion for indicating their ability to measure strongly adsorbing metals/trace elements and radionuclides, including cobalt-60 and cesium-137.
- Because a suitable analogue is not available, the nine screens could not be evaluated for very strongly adsorbing radionuclides, including isotopes of americium, cerium, plutonium, and radium.
- Because site-specific sorption data are not available, the nine screens could not be evaluated for the more highly sorbing high-explosive species and for a large proportion of the organic analytes of interest.

All 48 screens in the multiscreen wells were evaluated for the effects of residual organic drilling fluids and for the presence of oxidizing conditions that are representative of predrilling conditions. The following key points result from application of the tiered analysis for identifying water-quality impacts from the use of organic drilling fluids:

- Twenty-seven of the 48 screens do not contain detectable quantities of residual organic drilling fluids, indicating that these fluids have been adequately removed. Those that failed these test criteria include six of the nine screens in intervals drilled using bentonite.
- Only seven of the 48 screens can be shown with moderate to high confidence to produce aerobic groundwater at the present time (R-5 Screen 3, R-8 Screen 1, R-22 Screen 2, R-25 Screens 6 and 7, R-32 Screen 1, and R-19 Screen 7).
- One of the nine screens (R-32 Screen 1) in intervals drilled with bentonite met all of the test criteria for oxidizing conditions; of the eight screens that did not meet the criteria for oxidizing conditions, seven of these screens did not meet at least three of the criteria. Sulfate-reducing conditions are present in these eight screens.
- Seven of the 41 screens that did not meet the test criteria for aerobic conditions failed these tests due solely to one or more of the field-based criteria used. Although several other screens also did not meet some of the field criteria, the evaluation that aerobic conditions were not present was supported by the fact that they also did not meet one or more of the analytical criteria.
- The five screens in multiscreen wells that meet all criteria are capable of providing reliable and representative data for all analytes of interest.

Overall, for the most recent sample collected,14 of the 64 screens evaluated can be shown with moderate to high confidence as producing water-quality samples that are not impacted by residual drilling fluid. Results of the tiered geochemical analysis indicate that single-screen wells generally provide the most technically defensible data.

Corrobation by Multivariate Statistical Analysis

These findings are largely corroborated by a principal-component analysis (PCA) that was conducted independently of this evaluation using a very similar data set as that used for the tiered geochemical analysis, and without knowing the results of the tiered approach. Statistical analyses were performed for 53 screens using up to four independent groups of data, distinguished by analytical data suite and field preparation: metal/trace element concentration and major ion concentration sets, each of which was made up exclusively of filtered or nonfiltered samples. Multivariate statistical analyses examined correlations among 18 geochemical species.

The results of the PCA, as presented in graphical plots, show that most of the single-screen wells plot in the same geochemical fields as do the Los Alamos County water-supply wells and local springs in White Rock Canyon (assumed to represent groundwater discharge from the regional aquifer and from perched intermediate zones); wells R-9, R-23, and R-28 are the exceptions. In contrast, most of the multiple-screen wells plot in clusters that are clearly different from those for the background springs and water-supply wells. Preliminary interpretations of the PCA results are as follows:

- Five of the single-screen wells and 17 screens in multiscreen wells have water chemistries that are consistent with the background springs or existing wells.
- Three single-screen wells and five screens in multiscreen wells show possible to slight impacts from drilling artifacts.
- Two single-screen wells and 10 screens in multiscreen wells show moderate impacts.
- One single-screen well and 11 screens in multiscreen wells show high impacts.

Preliminary conclusions reached by the two independent approaches are consistent for 45 of the 53 screens that were evaluated by both methods. Differences for most of the few cases in which the two approaches differed in outcome are attributable to the date of the sample defined as "most current" or to the different criteria used by each approach. In particular, the PCA tests did not include organic species or field data. Overall, however, the PCA method adds confidence to the tiered analysis approach and its use of background concentrations of analytes because the PCA method does not rely upon an understanding of background conditions and yet corroborates the outcome of the tiered analysis.

A high-level summary of the outcome of the well screen analysis is provided in Figure ES-1. This figure shows that, for the most recent sample collected, 33% of the screens produce water-quality samples that are not significantly impacted by residual drilling fluid. Overall, single-screen wells show the least impact from residual drilling fluids and therefore provide the most technically defensible water-quality data. Most of the single-screen wells are fully oxidizing and do not contain residual organic-based drilling fluids. Another six single-screen wells and six multiscreen wells (19% of the 64 screens) are rated as "good" for providing reliable water-quality data, meaning that they failed only one or two of the assessment criteria. On the other hand, 16 of the 48 screens in multi-screen wells are rated as "fair," insofar as they failed to meet several criteria, and 15 of the 48 screens in multi-screen wells are rated as poor.

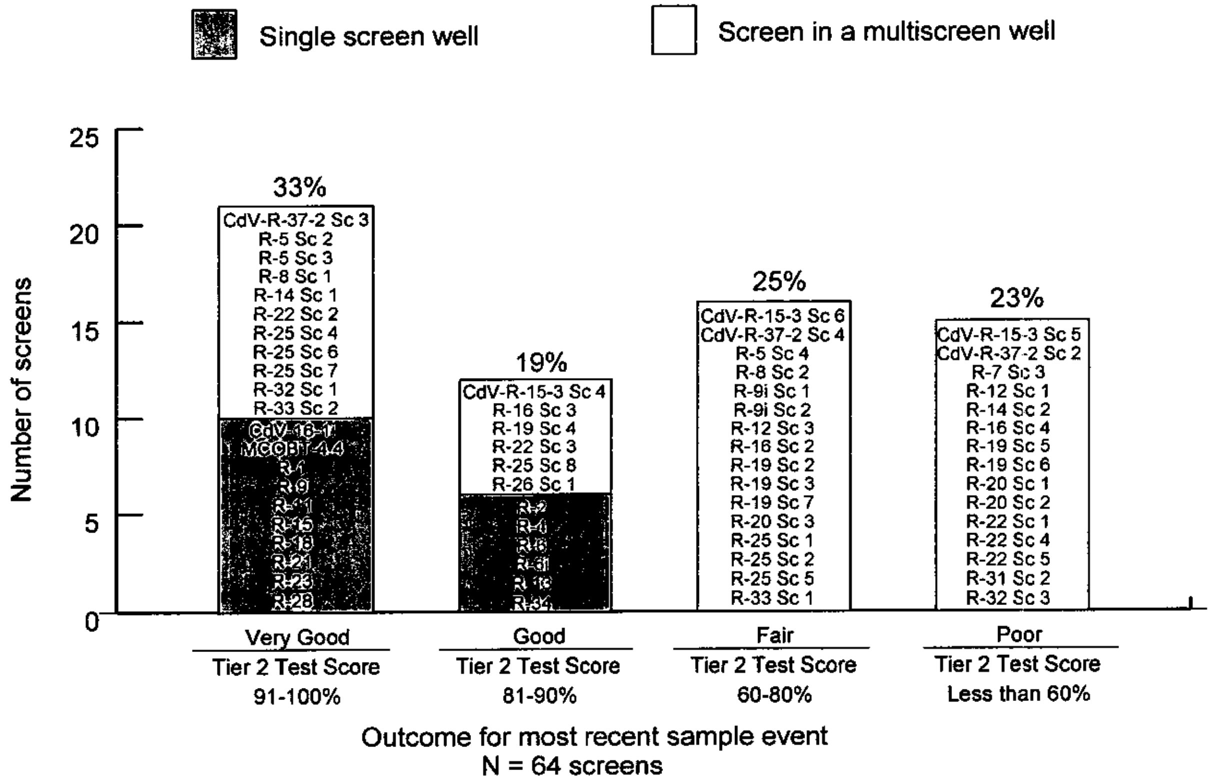

Figure ES-1. Overall condition of screens for producing reliable and representative water-quality samples

Contents

APPENDIXES

FIGURES

TABLES

Acronyms and Abbreviations

AOC	area of concern
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
CA	cluster analysis
CAS	Chemical Abstract Service
DL	detection limit
DNX	hexahydro-1,3-nitroso-5-nitro-1,3,5-triazine
DO	dissolved oxygen
DOC	dissolved organic carbon
DOE	U.S. Department of Energy
DQO	data quality objective
DRO	diesel-range organic
EES-6	Earth and Environmental Science Division–Hydrology, Geochemistry, and Geology Group (LANL)
EFDB	Environmental Fate Data Base
Eh	oxidation-reduction potential
ENV	Environmental Stewardship Division (LANL)
ENV-ECR	Environmental Characterization and Remediation Group (LANL)
ENV-ERS	Environmental Remediation and Surveillance Program (LANL)
EPA	U.S. Environmental Protection Agency
EPA/OPPT	Office of Pollution Prevention and Toxics (U.S. EPA)
ERDB	RRES-ER technical database
ER ID	environmental record identifier
ES-PPP	Environmental Stewardship Division—Pathways Protection Program (LANL)
ESP	Environmental Surveillance Program (LANL)
EXTOXNET	Extension Toxicology Network
F	filtered (sample)
GC-MS	gas chromatography-mass spectrometry
GGRL	Geochemistry and Geomaterials Research Laboratory (LANL)
GIT	Groundwater Integrating Team (LANL)
GSWSED	Groundwater, Surface Water, and Sediment Monitoring Program
HE	high explosive(s)
HEXP	high-explosive and their degradation products.
HMX	high-melting explosive
HSDB	Hazardous Substances Data Bank
ICP-MS	inductively coupled plasma-mass spectrometry
IDL	instrument detection limit
IFWGMP	Interim Facility-wide Groundwater Monitoring Plan
K_d	distribution coefficient
K_{OC}	organic carbon partition coefficient
MDA	minimum detectable activity
MDL	method detection limit
MSDS	Material Safety Data Sheet
NMED	New Mexico Environment Department
NMED-OB	New Mexico Environment Department DOE Oversight Bureau
NNMCAB	Northern New Mexico Citizen's Advisory Board
NPL	National Priority List
NTU	nephelometric turbidity unit

ORP	oxidation-reduction potential
PAH	polynuclear aromatic hydrocarbon
PC	principal component
PCA	principal component analysis
PCOC	potential contaminant of concern
PETN	pentaerythriotol tetranitrate
PIP	Pesticide Information Profile
pH	negative log of the hydrogen concentration in a solution
PZC	point of zero charge
QA	quality assurance
QAP	Quality Assurance Program
QC	quality control
QP	quality procedure
R	regional (characterization well identifier)
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)
RN	Registry Number
RPF	Records Processing Facility (LANL)
RRES	Risk Reduction and Environmental Stewardship Division (LANL) (former)
RRES-ECR	Environmental Characterization and Remediation Group (LANL)
RRES-WQH	Water Quality and Hydrology Group (LANL)
SOP	standard operating procedure
SOW	statement of work
SRC	Syracuse Research Corporation
SU	standard units
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TA	Technical Area
TKN	total Kjeldahl nitrogen
TNT	trinitrotoluene
TOC	total organic carbon
TOXNET	Toxicology Data Network
TPH	total petroleum hydrocarbon
UF	nonfiltered (sample)
USGS	United States Geological Survey
VOC	volatile organic compound
WQDB	Water Quality Database
WRC	White Rock Canyon
WWW	World Wide Web

Elemental and Chemical Nomenclature

Americium	Am	Neptunium	Np
Ammonia (as Nitrogen)	NH_3-N	Nickel	Ni
Antimony	Sb	Nitrate (as Nitrogen)	NO_3-N
Arsenic	As	Nitrite (as Nitrogen)	NO_2-N
Barium	Ba	Nitrogen	N
Beryllium	Be	Oxygen	O
Bicarbonate	HCO_3	Phosphorus	P
Boron	B	Phosphate (as Phosphorus)	PO_4-P
Bromine	Br	Plutonium	Pu
Cadmium	Cd	Potassium	K
Calcium	Ca	Radium	Ra
Calcium carbonate	$CaCO_3$	Selenium	Se
Carbon	C	Silicon	Si
Cerium	Ce	Silver	Ag
Cesium	Cs	Sodium	Na
Chlorine	Cl	Strontium	Sr
Chromium	Cr	Sulfate	SO_4
Cobalt	Co	Sulfur	S
Copper	Cu	Technetium	Tc
Carbonate	CO_3	Thallium	Tl
Europium	Eu	Thorium	Th
Hydrogen	H	Tin	Sn
Iron	Fe	Tritium	^3H
Lanthanum	La	Uranium	U
Lead	Pb	Vanadium	V
Lithium	Li	Zinc	Zn
Magnesium	Mg		
Manganese	Mn		
Mercury	Hg		
Molybdenum	Mo		
Neodymium	Nd		

1.0 INTRODUCTION

Los Alamos National Laboratory (LANL) has implemented a hydrogeologic characterization program since 1998, as described in the Hydrogeologic Workplan (LANL 1998, 59599). From 1998 through 2004, 33 wells were drilled and completed for hydrogeologic characterization beneath the Pajarito Plateau. Four of these wells were completed in perched intermediate zones, 19 have screens in the regional aquifer, and the remaining 10 have screens in both perched intermediate zones and the regional aquifer. Concerns about the reliability or representativeness of the groundwater data stem from the potential for residual drilling fluids to mask the present and future detection of contaminants, as discussed in characterization well geochemistry reports (listed in Section 7.3) and recently by Gilkeson (2004, 88728). The Laboratory responded to the concerns raised by Gilkinson (2004, 88728) by presenting hydrogeological and geochemical data collected at selected wells (LANL 2004, 88420). The U.S. Department of Energy (DOE) then requested LANL to provide an in-depth analysis of all screens in wells constructed under the Hydrogeologic Workplan that were completed within intermediate perched zones or in the regional aquifer. Subsequently, the Northern New Mexico Citizens' Advisory Board (NNMCAB) requested that the U.S. Environmental Protection Agency (EPA) review the criteria selected by the Laboratory for its tiered geochemical analysis approach. This report provides results of that analysis and evaluation. This report also addresses some of the comments and implements some of the recommendations made by EPA following its review of an early outlined version of the tiered assessment approach (Ford et al. 2005, 90545).

1.1 Purpose

The primary purpose of this report is the evaluation of whether screens in characterization wells are capable of producing data that are reliable and representative of the intermediate-depth groundwater and the regional aquifer. In so doing, this report first establishes a set of geochemical criteria against which to compare the water chemistry measured at each screen. This comparison results in a quantitative estimate of the extent to which the data are judged as being reliable or representative of predrilling groundwater geochemistry. Ratings for the most recent samples from each screen are used to define screens that produce reliable water-quality data and those for which data are potentially compromised by residual drilling artifacts. Of the impacted screens, it identifies those that appear to be cleaning up over time and those that are the most problematic.

The results of this analysis will be used as the basis of a subsequent prioritization of the wells and screens that may require corrective action, if selected for monitoring, such as more enhanced and aggressive development efforts, restrictions on data use, or abandonment. A secondary purpose of this evaluation is to provide a technical framework that can be implemented to evaluate past water-quality data, as well as for real-time evaluation of new data as they are entered into the water-quality database in the future.

1.2 Scope

This report provides a snapshot of water-quality (geochemical) data for samples collected from deep wells as of August 31, 2005. Figure 1-1 shows locations of characterization wells in the Los Alamos area that are the focus of this report. The wells evaluated in this report include 30 wells constructed under the auspices of the Hydrogeologic Workplan (LANL 1998, 59599) as well as three wells installed as part of a corrective action measure in Cañon de Valle. Within the 33 wells are 82 individual screens. Of these screens, 64 were functional and 15 were dry or plugged at the time that this analysis was conducted. Each of the functional screens was analyzed independently for this report.

The screen evaluation addresses only the impacts of fluids used in drilling. Drilling fluids can be defined as fluids—and associated drilling additives—placed or circulated in the drilled hole during drilling operations. Drilling and construction of monitoring wells within perched intermediate zones at depths greater than 100 ft or within the regional aquifer require the use of drilling fluids to ensure borehole stability and lubricity. Drilling fluids perform functions that include cleaning cuttings off of the bit and the bottom of the borehole, transporting cuttings to the surface, providing borehole stability, cooling the bit, and lubricating the drill string. Rotary drilling to these depths is not possible without the use of drilling fluids, without incurring substantial risk to the successful completion of the boreholes and installation of the wells. It is outside the scope of this report to address questions concerning the need for, or the appropriateness of, specific drilling methods and fluids.

This report does not examine whether the use of drilling fluids impacted achievement of the characterization objectives of the Hydrogeologic Workplan, nor whether these wells are suitable for use as monitoring wells under the March 1, 2005, Compliance Order on Consent (Consent Order) signed by the New Mexico Environment Department (NMED), DOE, and the University of California.

Although fluids are also used in well construction and development, this analysis does not evaluate their potential water-quality impacts. Other aspects that lie outside the scope of this report include the following:

- specifying actions to be taken for analytes judged as unreliable or not representative of predrilling conditions
- predicting when an impacted screen may be able to provide chemical data that are reliable and representative of predrilling conditions
- specifying corrective actions to be taken if a screen is judged as unlikely to produce reliable or representative water-quality samples in the foreseeable future
- discussing methods for rehabilitating impacted well screens, which is the subject of a separate evaluation

1.3 Organization of Report

Section 2 describes the methodology and sources used to locate and compile information needed to conduct this analysis, including the development of a list of relevant analytes and their chemical characteristics, well-drilling histories and screen-construction details, sampling histories, and background water-quality parameters that define predrilling groundwater conditions. Section 3 presents the assumptions used in developing and applying the geochemical criteria used to evaluate water-quality data for individual screens.

Section 4 presents the detailed tiered evaluation process. As a preface for the discussion of the evaluation criteria, Section 4.1 summarizes the well drilling, construction, and development methods that were used, and Section 4.2 describes groundwater sampling suites, sampling protocols, and sampling frequencies. Sections 4.3, 4.4, and 4.5 present the methodology used in the screen evaluation and the tiered analysis of the 64 functioning well screens placed in saturated zones. Section 4.6 provides additional assessment considerations. Section 5 presents results of an independently conducted, multivariate statistical approach to evaluating water-quality data through a principal component analysis. Finally, Section 6 summarizes the well screen analysis, conclusions of this assessment, lessons learned, and potential next steps.

Supporting data and information used to compile this report are provided in the following appendices:

- Appendix A tabulates chemical characteristics for the analytes and drilling products considered relevant to this analysis.
- Appendix B lists well and screen characteristics, including timelines for drilling, development, and sampling. This information was the basis for selecting eligible samples for this report, i.e., those that included data for a sufficient number of indicator species.
- Appendix C compiles available water-quality data for the geochemical indicator species for the last three eligible samples from each screen.
- Appendix D contains plots comparing the screen data from Appendix C against each of the geochemical criteria.
- Appendix E tabulates the results of the Tier 2 assessments for 173 samples from the 64 screens, and calculates average scores for the last three samples, as well as for the most recent sample, from each screen. These tables are used to prepare the summary figures and to identify trends discussed in Section 6.

1.4 Quality Assurance

This evaluation uses validated data that are acquired and reviewed following formal, approved quality assurance (QA) procedures as outlined in this section. All groundwater monitoring is conducted as an integrated activity that uses the same personnel, basic operating procedures, laboratory analysis contracts, and data-management systems (ES-PPP 2005, 88789). Monitoring is conducted under procedures that implement the requirements of the program-specific QA project plan, "Groundwater, Surface Water, and Sediment (GSWSED) Monitoring Program" (RRES-WQH 2004).

LANL field procedures follow guidelines from U.S. Geological Survey (USGS) water-sample collection methods and industrial standards common to environmental sample collection and field measurements, including the collection of field blanks and field duplicates. Sample collection, preservation, and measurement of field parameters for groundwater are conducted according to standard operating procedures (SOPs) and quality procedures (QPs) (current versions listed in Section 7.4). Chemical analyses of water samples use commonly accepted analytical methods required under federal regulations such as the Clean Water Act and approved by EPA. Statements of work (SOW) for contract analytical services that support monitoring activities specify QA guidelines for the contract laboratories, including specific requirements and guidelines for analyzing groundwater samples.

Chemical data are posted on the Water Quality Database (WQDB) website after receipt. These data undergo several stages of review for validation and verification, with their current review status indicated by preliminary and provisional flags in the WQDB. Data verification evaluates the completeness, correctness, consistency, and compliance of a laboratory analytical data package against a specific standard or contract; data validation involves a standardized review of the analytical data against a set of criteria (RRES-ECR 2004). These criteria are tailored to specific analytical suites and techniques, based on national guidelines for data review (EPA 1999, 66649; EPA 1994, 48639), and augmented with other guidance in the case of radionuclides. SOPs are currently used to identify the need to apply specific qualifier flags and reason codes to the reported results. The results of the validation procedure are intended to be used as general indicators of data quality and should not be misconstrued as a definitive identification of data usability (RRES-ECR 2004).

This report was prepared in accordance with QP-4.9, Document Development and Approval Process, and was reviewed following QP-3.5, Peer Review Process.

2.0 DATA INPUTS

2.1 Well Drilling and Screen Construction Information

Information on drilling methods and associated fluids or additives potentially present in individual well screen intervals is extracted from well completion reports (listed in Section 7.2). In some cases, drilling logbooks were also consulted to verify or augment information in the reports. Extracted information on drilling and screen characteristics is tabulated in Appendix B, Tables B-1, B-2, and B-4. Table B-3 describes drilling product characteristics and their typical quantities of use, based on technical specifications, Material Safety Data Sheets (MSDS), and other publicly available product-marketing literature.

2.2 Groundwater Chemistry Data for Screens

An inventory of postdevelopment sampling events and availability of water-quality data for this evaluation is tabulated in Appendix B, Table B-5. This table was compiled by searching three water-quality databases, described below, and by reviewing seven published geochemistry reports (Section 7.3). Table B-5 provided the basis for selecting sampling events with sufficient coverage of the specified water-quality indicator species so as to attain an adequate degree of confidence in the resulting assessment of the screen's current condition. The selected sampling events are marked with an asterisk in that table.

Groundwater data used in this report (Appendix C, Tables C-2 to C-7) were extracted from Environmental Stewardship (ENV) Division databases. The primary data archive and source is the WQDB (http://wqdbworld.lanl.gov/), which is a publicly accessible repository of water-chemistry data obtained as part of characterization, investigation, surveillance, and monitoring of LANL on-site operations. A limited set of water-quality data were also extracted from the RRES-ECR technical database (ERDB). This database contains water-chemistry data for various LANL solid waste management units (SWMUs) and areas of concern (AOCs). All ERDB data are in the process of being migrated into the WQDB to consolidate environmental data in a single data management system (ENV 2005). A third database is maintained by the Earth and Environmental Sciences Division–Hydrology, Geochemistry, and Geology Group (EES-6) Geochemistry and Geomaterials Research Laboratory (GGRL) for documenting its analyses of water samples conducted throughout drilling, well construction, development, and characterization phases. Finally, some field parameters (e.g., pH, turbidity, dissolved oxygen, and total carbonate alkalinity) were obtained from field notebooks and datasheets; these data are also in the process of being entered into the WQDB.

Only WQDB and ERDB report data qualifiers along with the data, and these qualifiers are limited to those data received from outside analytical facilities. Field data are not currently subjected to the same level of qualification, beyond verification of instrument calibrations and checks.

2.3 Background Groundwater Chemistry

The evaluation process used in this report compares selected geochemical indicators for each individual screen against the range of background concentrations that are assumed to encompass predrilling conditions at that screen. Water-quality data that fall outside the range may then be identified as potentially unreliable or not representative of predrilling conditions. The list of chemicals used for this comparison—about 20—is neither exhaustive nor comprehensive. The evaluation process is not intended to replace detailed geochemical evaluations such as those presented in characterization well geochemistry reports (listed in Section 7.3), but rather to provide a reasonably simple, efficient, transparent, and consistent process for identifiying analytical data that may be unreliable or nonrepresentative of predrilling conditions. Consequently, the evaluation method has been constructed by selecting key indicator analytes and parameters to test for the presence or absence of specific geochemical conditions that are known to impact water quality.

Background concentrations used for this comparison are taken from the "Groundwater Background Investigation Report" (LANL 2005, 90580). The Laboratory recently determined the range of background concentrations of inorganic and selected organic compounds (humic substances and chemicals with small molecular weights) and radionuclides within alluvial and perched intermediate groundwater and the regional aquifer. The report provides analytical results and statistical distributions for fifteen background stations that were sampled up to six times. Thirteen of the sampling stations consisted of springs discharging within the Sierra de los Valles and White Rock Canyon, supply wells, and monitoring wells completed within the regional aquifer and perched intermediate groundwater zones. The background investigation did not include sampling of any R-wells or perched intermediate wells drilled with fluids. Statistical properties including minimum, mean (average), median, maximum, first standard deviation, and coefficient of variation are provided in the background investigation for each analyte measured in the three groundwater types (alluvial, intermediate perched, and regional aquifer). Table 4-2 of this report lists background values for key indicator species used in this assessment.

The ideal approach would be to compare water-chemistry data for each individual screen against background concentrations tailored to the lithology and location of that screen. However, such a level of distinction for background groundwater chemistry does not exist at this time and is unlikely to ever exist at this level of detail. Consequently, in this report, the range of background concentrations is limited to that defined in the "Groundwater Background Investigation Report" (LANL 2005, 90580) for the regional aquifer and perched intermediate zones.

Wherever feasible, more than one chemical indicator for a specific condition is specified. For example, four indicators are used to evaluate the presence or absence of inorganic solutes leached from bentonite mud. The underlying assumption is that such use of multiple indicators is sufficiently robust to identify the presence of a condition that could impact water quality, so that the failure of a single indicator for this purpose will not negate the overall value of the tiered approach. There are several advantages to a multi-indicator approach; in fact, it is practically a necessity because of the variable quantity and quality of data available for the evaluation, and particularly so if the evaluation is to be extended to older data sets that are often sparse.

2.4 Determination of Relevant Analytes

Table 2-1 lists the potential Laboratory-relevant contaminants for each well according to the watershed in which it is located, based on operational histories and disposal practices. More comprehensive lists of relevant analytes and potential contaminants of concern (PCOCs), organized by analyte suite, are presented in Appendix A, Tables A-1 through A-8. The list of analytes is intended to be conservatively inclusive to ensure the inclusion of key indicator species as well as any PCOCs across the facility. Thus, the analyte list includes some or all of the following:

- general chemical analytes that are commonly used to characterize groundwater quality,
- analytes that are covered by regulatory standards and that have been detected consistently in sediments or water (including alluvial groundwater, springs, and surface water base flow) in watersheds affected by LANL operations,
- analytes identified by the evaluation of Laboratory SWMUs, AOCs, or other considerations, and
- analytes that are covered by regulatory standards and for which analysis has not been previously conducted or for which data are insufficient.

The median groundwater composition of the regional aquifer was used as input for speciation calculations, using the computer code MINTEQA2, for the inorganic analytes selected as relevant to this assessment (Allison et al. 1991, 49930). Regional aquifer values were reasonable to use because median values of the perched intermediate groundwater fell within the range of those in the regional aquifer. The speciation results are provided in Appendix A, Tables A-1 (general inorganic analytes), A-2 (metal analytes), and A-3 (radionuclides). These analytes have been evaluated to determine which could be impacted by drilling artifacts and under what conditions, as described in Section 4.

2.5 Chemical Characteristics of Analytes and Bentonite Drilling Mud

Information on analyte characteristics tabulated in Appendix A, such as adsorption and aqueous speciation, was retrieved from a systematic search of online databases publicly accessible through the World Wide Web (WWW), as well as standard reference documents. The user can generally search these databases by chemical or other name, chemical name fragment, Chemical Abstracts Service (CAS) Registry Number (RN), and subject terms. The following databases were searched to compile the bulk of the analyte characteristics required for this report:

- The Hazardous Substances Data Bank (HSDB) provides comprehensive, peer-reviewed toxicology data for about 5000 potentially hazardous chemicals, and is one of a cluster of actively maintained chemical databases on the National Library of Medicine's Toxicology Data Network (TOXNET) (http://toxnet.nlm.nih.gov/).
- The Environmental Fate Data Base (EFDB) is provided by the Syracuse Research Corporation (SRC). CHEMFATE (http://www.syrres.com/esc/efdb.htm) is part of EFDB and provides systematic tabulations of available data for up to 25 categories of environmental fate and physical/chemical properties of individual chemical compounds.
- The Extension Toxicology Network (EXTOXNET) Infobase (http://extoxnet.orst.edu/) develops and makes available Pesticide Information Profiles (PIPs), which include over 170 insecticides, herbicides, fungicides, and other classes of pesticides.
- The Agency for Toxic Substances and Disease Registry (ATSDR 2005, 90525) has developed Toxicological Profile Information Sheets (http://www.atsdr.cdc.gov/toxprofiles/) for over 250 hazardous substances found at National Priority List (NPL) sites as well as for other substances related to federal sites.

Searches were also augmented by obtaining review articles or research results provided in peer-reviewed publications. For example, the databases listed above do not always contain quantitative information for some of the less common organic analytes or high-explosive (HE) degradation products. Also, specific publications often contain information or data that are more directly relevant to the water-quality effects of drilling fluids. In particular, laboratory and field investigations related to the design and performance of geologic repositories have resulted in a huge dataset on the adsorption behavior of metals and radionuclides in subsurface waters, much of it specific to their adsorption onto bentonite clay.

Chemical data for bentonite, including adsorption capacity for metals and mineral composition, are provided in Appendix A, Tables A-9 through A-12.

3.0 ASSUMPTIONS

The following assumptions underlie this evaluation of the screen water-quality data:

- Groundwater within perched intermediate zones and the regional aquifer is overall oxidizing. Figure 2-1 presents a schematic of the conceptual model of natural groundwater chemistry for the Laboratory and surrounding areas. Supporting information for the assumption of oxidizing conditions for predrilling groundwater conditions includes the following from the Hydrogeologic Synthesis Report (Robinson et al., 2005):
  - the ubiquitous presence of oxidized forms of dissolved nitrogen (nitrate), sulfur (sulfate), and dissolved oxygen
  - the presence of manganese dioxide and ferric (oxy)hydroxide minerals in borehole geologic samples
  - the absence of sulfides, methane, and other dissolved forms of reduced carbon
  - low dissolved concentrations of iron and manganese (generally less than 0.2 mg/L),
  - oxidizing conditions measured in groundwater samples collected within the recharge zone (Sierra de los Valles), along groundwater flow paths (Pajarito Plateau), and from part of the discharge zone (White Rock Canyon springs)
  - detection of contaminants stable in oxidized forms, including nitrate, perchlorate, molybdate, sulfate, and uranium(VI), in groundwater at the Laboratory
- Review of the three most recent characterization and surveillance sample events for a screen yields an assessment outcome with a high level of confidence. This means that the outcome of the assessment is approximately the same for all three sample events, or that the outcomes define a consistent trend over time.
- The level of confidence in the outcome of the assessment is indicated as low or moderate if one or more of the following conditions exist: (a) data are available for less than three sampling events; (b) some key data are not available for the assessment; (c) data for the most recent sampling event were obtained over a year ago; or (d) results from the assessment are internally inconsistent.
- The suite of ionic organic analytes that adsorb onto bentonite also adsorb onto iron and manganese (oxy)hydroxides and vice versa, depending on pH and the adsorbent's point of zero charge (pzc).
- Neutral organic compounds are assumed not to adsorb onto iron and manganese (oxy)hydroxides that either contain a net negative or net positive surface charge.
- Residual bentonite mud used for drilling contains about 0.1% solid organic carbon. This assumption is made for the purpose of evaluating adsorption sites for organic contaminants.
- The effective distribution coefficient (K_d) for an organic species adsorbing onto bentonite can be estimated from its organic carbon partition coefficient (K_{oc}) by multiplying K_{oc} by 0.1% organic carbon.
- It is assumed that no organic analyte can be reliably measured if reducing conditions occur in the vicinity of the screen in the presence of residual organic drilling fluids. Organic chemicals undergo oxidation-reduction reactions under a wide range of conditions, including aerobic (oxygen present) and anaerobic (oxygen-absent) conditions. This assumption may be overly stringent because degradation kinetic rates can be extremely slow for some organic analytes in the absence of appropriate microbial populations.

- Field-based measurements of dissolved oxygen (DO), sulfide, and oxidation-reduction potential (ORP), provide reliable qualitative indicators for the presence of sulfate-reducing conditions, although not necessarily of the absence of such conditions.

4.0 TIERED ANALYSIS PROCESS TO IDENTIFY IMPACTED SCREENS

4.1 Drilling Methods and Impacts

4.1.1 Well Drilling and Construction Methods

Appendix B, Table B-1 tabulates well drilling, construction, and development histories for the wells evaluated in this report. Table B-2 briefly describes the drilling methods and materials used in each well. The earliest wells were drilled using air-rotary drilling methods with casing advance and the minimal use of fluids other than air. Because of significant problems associated with stuck casing, unstable boreholes, and lost circulation, small amounts of drilling fluids were used to improve lubricity, borehole stabilization, and cuttings circulation. Continuing drilling problems made total reliance on air-rotary drilling with casing advance impracticable for meeting drilling objectives. It became apparent that the depth of the wells and the difficult drilling environment, including substantial heterogeneity in physical rock properties, required that additional drilling techniques be employed in order to penetrate and respond to the complex hydrogeologic conditions that characterize the Pajarito Plateau. All of the drilling methods used by LANL are in accordance with standard industry practice and are described by the American Society for Testing and Materials (ASTM). The drilling methods used by LANL are also among those specified in the Consent Order.

As indicated in Appendix B, Table B-2, all of the wells used some type of downhole material to assist in drilling. Organic fluids, primarily EZ-MUD® and QUIK-FOAM®, were used in all wells. In addition, sodium-bentonite drilling mud was used in twelve well-screen intervals. A variety of other materials were also added to many of the wells (Table B-2). A description of these products, their uses, and the typical amount added per 100 gal. of injection water is provided in Table B-3.

4.1.2 Well Development Methods

Well development is the combination of processes used to mitigate borehole wall damage during well drilling. Well development removes fluids used during drilling, and can restore or improve porosity and permeability of the formation materials around the well screen. Ultimately the well, when fully developed, will yield groundwater samples that are representative of predrilling conditions. Well- development procedures at LANL are consistent with industry standards and with the Consent Order. The Laboratory also ensures that no additives are used without complete prior analytical characterization and, as of July 2000, has defined the concentration of total organic carbon (TOC) as one of the performance criteria for satisfactory well development.

SOPs for well development ensure consistent use of the development process and that water-quality parameters meet the performance criteria specified in the SOP. To monitor the effectiveness of well development, a suite of groundwater parameters is carefully and frequently measured. Parameters typically monitored for well development include temperature, pH, specific conductance, and turbidity. However, TOC was added in 2000 to identify the presence of residual drilling fluid during the well development process. Groundwater samples are collected immediately after well development and analyzed for the full suite of inorganic constituents and organic constituents, including acetate and formate, which are breakdown products of EZ-MUD®. Additional analyses are performed by external laboratories for isopropyl alcohol, the primary constituent in QUIK-FOAM®, and/or acetone (initial oxidation product of isopropyl alcohol).

New well development procedures were implemented in 2002, based on recommendations made by Powell and Schafer (2002, 90523). The new procedures emphasize development immediately following well installation in order to remove the wall cake from the borehole. Additional development techniques involved

- using packers to isolate screens to pump directly from that interval in the multiple-screened well installations,
- using standard development chemicals to break down the additives used during drilling,
- experimental jetting at well R-16, and
- removing significantly large volumes of groundwater during the pumping phase of well development. An average of 135% or more groundwater was removed than was added in the multiple-screened wells.

Polymer-based fluids, such as EZ-MUD® and TORKEASE®, have been used in all of the characterization wells within the scope of this report to provide lubrication between the casing advance system and the borehole wall. All downhole drilling products are chemically analyzed for inorganic chemicals to evaluate their potential to impact groundwater chemistry. Relatively small quantities were in use during the drilling of the earliest wells in the program. Larger quantities were used in the more recent wells because of the effectiveness of these fluids in controlling drilling problems that were encountered. Once the regional water table was encountered, the use of additives was greatly decreased so as to minimize the impact on groundwater chemistry. Well-development methods were further revised to address the use of bentonite-based drilling fluids. Additional time and effort were spent in removing residual bentonite and minimizing adverse impacts to groundwater chemistry and formation properties.

4.2 Groundwater Sampling Suites

Once a well is completed and developed, it initially undergoes characterization sampling. Analytes for characterization sampling are designed to detect changes in ambient water chemistry or the presence of Laboratory contaminants, and therefore involve generally comprehensive analytical suites. Following completion of the two to four characterization rounds, ongoing sampling is conducted in accordance with an approved monitoring plan. Analytical suites for surveillance monitoring are generally much less extensive that those analyzed during characterization sampling. Analytes are specified in the monitoring plan for each well based on possible source terms from the Laboratory. The need to monitor for a broad range of analytes is driven by detecting changes in ambient conditions, monitoring movement of environmental constituents of interest, regulatory requirements monitoring, and monitoring to assess the effectiveness of remedial actions. The frequency of sampling is also specified in the monitoring plan, and may range from quarterly to annually or even triennially.

The analytical suites for groundwater samples are periodically updated in response to information gained from site investigations and from changes in regulatory requirements. The suites currently defined in the WQDB are the following:

- Dioxins and furans—14 analytes
- Diesel-range organics (DRO)—13 analytes
- General parameters and inorganic species—58 analytes
- Herbicides—18 analytes
- HE and HE degradation products (HEXP)—24 analytes
- Metals—27 analytes

- Organochlorine pesticides and polychlorinated biphenyls (PCBs)—50 analytes
- Radionuclides—108 analytes
- Semivolatile organic compounds (SVOCs)—180 analytes
- Volatile organic compounds (VOCs)—107 analytes

The above tally of 599 analytes includes about 60 analytes that are assigned to more than one analytical suite. All of the analytes in the dioxin/furan suite, as well as many of those in the herbicide, HE, and pesticide/PCB suites, are also part of the SVOC/VOC suites. SVOC and VOC suites overlap with one another, as do the DRO compounds and herbicide suites. Several analytes are measured or reported under more than one description, e.g., as an individual chemical as well as part of a total concentration for a particular category. Thus, even though a sample might not have been submitted for analysis of a particular analytical suite, analytes from that suite may still have been measured.

4.3 Water-Quality Assessment Methodology

This section describes the technical basis for the methodology used to evaluate groundwater chemistry data for representativeness relative to background and/or predrilling conditions. Speciation calculations were useful in evaluating groundwater chemistry in terms of natural and contaminant composition and contaminant mobility. Speciation of solutes (natural and anthropogenic) directly controls precipitation and adsorption processes.

Chemicals or contaminants representative of site conditions were also important to consider during evaluation of the well screens. These include both anthropogenic chemicals, such as tritium, research department explosive (RDX), trinitrotoluene (TNT), and technetium-99, as well as naturally occurring chemicals that are processed and discharged at the Laboratory, such as nitrate, sulfate, barium, chloride, bromide, molybdenum, perchlorate, and uranium. Several soluble constituents, including sulfate, barium, and uranium, are also present at high concentrations in bentonite drilling mud (see Table A-10).

During the course of evaluating the potential presence of residual drilling fluid and their chemical and biochemical reactions with groundwater and aquifer material, a series of questions and criteria were developed to determine whether specific groundwater samples collected from single and multiscreen wells were representative of predrilling conditions. The ability of a given well to detect the presence of contaminants, without interference from residual drilling fluids, is also an essential end point to this analysis.

4.3.1 Tier 1 Analysis

The drilling fluids and additives are divided into two categories for the evaluation conducted for this report: bentonite mud and organic drilling fluids. Figure 4-1 outlines the sequence in which assessment criteria are applied to each sampling round for each well screen. Table 4-1 presents Tier 1 screening questions, assessment criteria, and consequence of "no" response for both bentonite mud and organic drilling fluids. The process defines the applicable tier of followup questions for the drilling fluids: Tier 2.1 for residual bentonite and Tier 2.2 for both residual EZ-MUD® and QUIK-FOAM®. This first tier in the assessment process determines if drilling fluids were used during well drilling. The consequence of response applies to numerous analytes and/or PCOCs that may be affected by residual drilling fluid. If drilling fluids were not used, then it is not necessary to proceed to Tier 2 questions. If drilling fluids were used, then it is necessary to address all Tier 2 questions.

The screen assessment is completed, and no further evaluation is needed if (a) drilling fluids were not used in the screen interval, or (b) if leaching or adsorption indicators for residual bentonite are absent, if indicators of residual organic drilling fluids are absent, and if oxidizing conditions prevail. Otherwise, data flags are assigned in this report to those groundwater constituents that are impacted by residual bentonite or organic drilling fluids.

oxidizing conditions prevail. If this is the case, then the screen assessment is completed, and no further evaluation is needed.

4.3.2 Tier 2 Analysis

Tier 2 analysis focuses on geochemical and biochemical interactions occurring between residual drilling fluid, including bentonite (Tier 2.1) and organic substances (Tier 2.2), groundwater, and aquifer material. Tier 2 also includes screening questions, assessment criteria, and consequence of response for bentonite and organic drilling fluids. Chemical criteria provided in Tiers 2.1 and 2.2 are compared to background concentrations of inorganic, radionuclide, and natural organic solutes characteristic of perched intermediate zones and the regional aquifer (Table 4-2). Table 4-3 describes validation flag codes used in this report to indicate that the analyte concentration may not be representative of predrilling conditions if impacted by residual drilling fluid.

4.4 Tier 2.1 Analysis for Residual Bentonite

Tier 2.1 addresses the presence of residual bentonite in a given well screen and asks the primary question:

> *Has residual bentonite been sufficiently removed such that it does not interfere with transport of contaminants into the screen interval?*

This section first outlines how bentonite drilling mud can affect water quality. This conceptual model then serves as the basis for specifying geochemical criteria that can be used to test for the presence or absence of those effects. The criteria are then applied to 38 water samples from the 12 screens drilled using bentonite mud to determine which samples are reliable and representative of predrilling groundwater chemistry and which may be impacted by residual bentonite mud.

4.4.1 Conceptual Model of Impacts

Figure 4-2 depicts the geochemical conceptual model for the impacts of bentonite mud on water quality. The two major processes of interest are (1) desorption (leaching) of soluble inorganic constituents associated with bentonite and (2) adsorption of metals, radionuclides, and organic compounds. The bentonite mud used to drill LANL wells, and in fact used for the majority of wells throughout the United States, is derived from Wyoming bentonite, which contains about 75% montmorillonite clay (Table A-9). Wyoming bentonite has a large specific surface area on the order of 600 m^2/g and a cation exchange capacity of about 80 milliequivalents per 100 grams (Lajudie et al. 1995, 90542; Langmuir 1997, 56037). Over half of the ion-exchange sites are occupied by sodium cations (Table A-9). When this bentonite is mixed with water to form the drilling mud, large quantities of sodium and the counter-ions sulfate, nitrate, and chloride are leached into solution. Assuming a make-up rate of 25 lb of bentonite per 100 gal. of water, the initial concentration of the mud would be on the order of 775,000 mg/L, which is more than 2000 times greater than that of groundwater in the regional aquifer. One of the objectives of well development is to retrieve as much of these solutes as possible from the saturated zone.

In addition to providing a source of inorganic species to the groundwater, bentonite also affects groundwater quality by removing solutes from solution through adsorption (Figure 4-2). Cationic metals that adsorb onto bentonite include aluminum, beryllium, cadmium, chromium(III), cobalt, copper, iron, lead, manganese, mercury, nickel, silver, strontium, uranium, and zinc. Many organic constituents also adsorb strongly onto bentonite or partition onto the small but significant fraction of organic carbon compounds that commonly coat parts of the clay surface. Table 4-4 summarizes information on the adsorptive behavior of inorganic and organic adsorbates onto sodium bentonite drilling mud. An adsorbate having a K_d less than 1 mL/g is considered as not adsorbing onto bentonite and as not impacted by its presence in the screen interval.

4.4.2 Selection of Indicator Species and Test Criteria

Screening questions, assessment criteria, and consequence of response for Tier 2.1 are provided in Figure 4-3 and Table 4-5.

Bentonite used as a drilling fluid serves as both a source of (Tier 2.1-1) and sink for (Tier 2.1-2) inorganic chemicals and radionuclides. Boron, sulfate, sodium, and uranium leach or desorb from bentonite, and the presence of these chemicals above background provides evidence for desorption processes taking place with residual bentonite, provided that these constituents are not present at a given well site caused by Laboratory discharges. The technical basis for selecting these four geochemical indicators is provided by Table A-10, which lists soluble inorganic analytes that were leached from a sample of the sodium-bentonite drilling mud using deionized water. Sodium and sulfate alone accounted for 80% of the total mass of soluble ions leached from the mud. Furthermore, their estimated concentrations in the drilling mud mix exceed average groundwater concentrations in the regional aquifer by factors of 18 (for sodium) and 53 (for sulfate) (Table A-10). Thus, both of these ions are considered useful geochemical indicators of the extent to which species leached from the bentonite mud may be affecting groundwater quality in a particular screen. Two other geochemical indicators—boron and uranium—are also selected as indicators of the presence of bentonite-leaching products because natural variability in sodium and sulfate concentrations might otherwise mask its presence. Calculated initial concentrations for boron and uranium in the drilling mud exceed those in the regional aquifer, on average, by factors of 11 (boron) and 19 (uranium). This initial increase above background concentrations is illustrated by the geochemical trend plots for sulfate, sodium, and uranium in Screens 2, 3, and 4 of characterization well R-16 (Figure 4-4). This multiscreen well was drilled with bentonite mud. Concentrations at background levels indicate that solutes leached from the bentonite mud were removed from Screen 2 during well development. Screen 3 shows increases in sulfate, sodium, and uranium, which are slowly returning to background values, although at very different rates because of dilution and other geochemical processes.

The high adsorption capacity of bentonite for cations is addressed in Tier 2.1 (Table 4-5), which considers uranium and strontium as key analytes for evaluating the adsorption capacity of bentonite for inorganic (cationic) chemicals. Concentrations of analytes that are less than their respective minimum background levels for predrilling conditions may suggest that adsorption processes have taken place with residual bentonite.

Zinc was selected as a conceptually conservative analogue for evaluating the adsorption of cesium-137 onto residual bentonite, based on a literature-derived mean K_d of 2400 mL/g for zinc and 1900 mL/g for cesium (Table A-11) (Sheppard and Thibault 1990, 90541). Zinc is stable as Zn^{2+}, which adsorbs to a greater extent than monovalent cations, including Cs^{+}. These adsorption data were compiled for clay-rich soil. Zinc is typically analyzed using inductively couple plasma (argon)-mass spectrometry (ICP-MS), and this analyte is detected in groundwater samples. If dissolved zinc is detected in groundwater and it adsorbs stronger than cesium based on literature derived K_d values, then it is reasonable to assume that cesium-137 has not been removed from solution because of adsorption onto residual bentonite. Cesium also adsorbs onto naturally occurring clay minerals present in aquifer material; however, this process is not included in the conceptual model in order to place conservatism in the analysis.

Radionuclides, including americium-241, cerium-139/141/144, plutonium-238/239/240, and radium-226/228 strongly adsorb onto bentonite (Table A-12). Consequently, we could not identify any indicators or analogues whose absence from a groundwater sample would indicate that detection of these radionuclides would not be masked by the presence of residual bentonite mud.

Adsorption or partitioning of HE compounds and degradation products onto residual bentonite is addressed in Tier 2.1-3. These anthropogenic chemicals having K_d values greater than 1 mL/g are considered to adsorb onto residual bentonite, assuming that the organic carbon content associated with bentonite is 0.1% or higher. Table 4-4 shows that HE compounds with K_d values >1 mL/g are high-melting explosive (HMX), pentaerythriotol tetranitrate (PETN), tetryl, and TNT. Solid organic carbon is considered to be the dominant adsorbent for these hydrophobic compounds. Appendix A, Table A-4 provides information on organic carbon partition coefficient (K_{OC}) and K_d values for HE compounds and related degradation products.

Similar screening questions and assessment criteria are also provided for herbicides, pesticides, PCBs, dioxins, and furans in Tier 2.1-4 and for VOCs and SVOCs in Tier 2.1-6. Tier 2.1-5 addresses DRO compounds, including long-chain aliphatic hydrocarbons (number of carbon atoms greater than six), aromatic compounds, and polynuclear aromatic compounds. Appendix A, Table A-5, provides information on K_{OC} and K_d values for dioxins, furans, pesticides, and PCBs and shows that all of these have K_d values >1 mL/g and are considered to be impacted by residual bentonite through adsorption processes.

Most herbicides are not considered to adsorb or partition onto solid organic carbon or bentonite, based on literature-derived K_d values (<1 mL/g) provided in Appendix A, Table A-6. These constituents generally are not impacted by residual bentonite through adsorption processes. Glyphosate, paraquat, picloram, T[2,4,5-], and TP[2.4.5-], however, have calculated K_d values >1 mL/g, and adsorption onto solid organic carbon-bentonite is a reasonably conservative assumption.

Constituents of diesel fuel, including polynuclear aromatic hydrocarbons (PAHs), are considered to adsorb or partition onto both solid organic carbon and bentonite, based on literature-derived K_d values provided in Appendix A, Table A-7. These constituents are potentially impacted by residual bentonite through adsorption processes.

Adsorption parameters (K_{OC} and K_d) for VOCs and SVOCs are provided in Appendix A, Table A-8. Most of these organic compounds are characterized by K_d values less than one, and adsorption onto residual bentonite is not significant. Several compounds, including meta-dichlorobenzene[1,3-], para-dichlorobenzene[1,4-], trichlorobenzene[1,2,3 and 1,2,4-], benzidine, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, carazole, chloronaphalene[2-], and other organic compounds, however, have K_d values >1 mL/g. These compounds are predicted to adsorb onto solid organic carbon and bentonite.

4.4.3 Application of Tier 2.1 Criteria to Water-Quality Samples

Water-quality data from sampling events in the 12 screens drilled using bentonite mud were compared against the Tier 2.1 criteria listed in Table 4-5. The details of this comparison are tabulated in Table E-1 and summarized in Table 4-6. Figure 4-5 summarizes the results of this analysis for the 12 screens that were drilled using bentonite mud. Key findings for the most recent sample event include the following:

- Bentonite leaching indicators (sulfate, sodium, and uranium) are absent from 75% of the wells (three single-screen wells, five screens in multiscreen wells).
- Ninety-three percent of the wells (three single-screen wells, eight multiscreen) provide reliable detection of strontium and therefore, strontium-90, if present, should be detected.
- Fifty-seven percent of the wells (three single-screen wells, three multiscreen) provide reliable uranium data.

- Because of the absence of a suitable analogue, we were not able to evaluate the well-screen intervals drilled using bentonite for detections of strongly adsorbing radionuclides.
- One hundred percent of the well screens provide reliable detections of metals.
- Oxidizing conditions are present in one single-screen well.
- Reducing conditions occur in two of the single-screen intervals and all of the nine multiscreen intervals drilled with bentonite.

4.5 Tier 2.2 Analysis for Water-Quality Impacts of Organic Drilling Fluids

Tier 2.2 addresses the presence of residual organic drilling fluid in a given well screen and asks the primary question:

> *Have the effects of residual organic drilling fluids been sufficiently removed such that groundwater samples are reliable and representative of the groundwater?*

Tier 2.2 addresses the presence of residual EZ-MUD® and QUIK-FOAM® based on concentrations of dissolved organic carbon and/or total organic carbon (TOC), total Kjehldahl nitrogen (TKN), and ammonium representative of EZ-MUD® and 2-propanol for QUIK-FOAM®.

4.5.1 Conceptual Model of Impacts

Figure 4-6 shows a geochemical conceptual model for the water-quality impacts of organic polymer-based drilling fluid. In general, organic drilling fluids have the potential to impact water quality by causing elevated organic carbon and organic nitrogen concentrations, and by influencing the oxidation-reduction (redox) state of the drilling fluid, as well as that of the reactive solids present in aquifer material and in groundwater in the near vicinity of the well. The two dominant drilling fluids used in LANL wells are EZ-MUD® and QUIK-FOAM®. EZ-MUD® consists of a high molecular-weight copolymer made up of a carbon framework containing nitrogen functional groups (Longmire 2002, 72800). QUIK-FOAM® largely consists of isopropyl alcohol or 2-propanol. Acetone is an oxidation product of 2-propanol and is routinely analyzed as part of VOC analysis using gas chromatography-mass spectrometry (GC-MS).

Table 4-7 provides information on selected theoretical redox couples that are relevant to the screen assessment, either as indicator species (dissolved oxygen, nitrate, manganese, iron, sulfate, and bicarbonate) of in situ conditions, or as PCOCs affected by the presence of reducing conditions. Table 4-8 classifies inorganic and organic solutes according to the type of reducing condition that would affect their concentrations. Strongly reducing conditions, for example those observed during sulfate reduction to hydrogen sulfide, impact a greater number of inorganic and organic analyte suites, whereas aerobic conditions (oxygen present) representative of natural and site conditions have the least impact on analyte suites.

The following discussion focuses on redox processes that both occur naturally and in the presence of residual organic drilling fluid. Redox reactions provide essential information on evaluating geochemical and biochemical impacts from EZ-MUD® and QUIK-FOAM® on groundwater chemistry and aquifer mineralogy. Evaluation of redox chemistry provides important insight to the extent that groundwater is approaching predrilling conditions.

Plausible oxidation-reduction reactions occurring under natural conditions and during the breakdown or oxidation of EZ-MUD® are shown in Figures 4-7a and 4-7b. Redox criteria for assessing screens containing residual EZ-MUD® are provided in Figure 4-8. Overall oxidizing conditions are characterized by positive Eh values and overall reducing conditions are characterized by negative Eh values. Dissolved oxygen, nitrate, manganese, iron, and sulfate are naturally occurring solutes that undergo reduction in the presence of in situ aerobic and anaerobic microbes and different forms of dissolved and suspended organic carbon. The solubility of naturally occurring minerals present in aquifer material, including manganese dioxide and ferric (oxy)hydroxide, increases under reducing conditions in the presence of organic carbon. As in situ microbes consume residual EZ-MUD® and QUIK-FOAM® that serve as a food source. A sequence of geochemical events is initiated as follows:

1) Initially, dissolved oxygen is reduced to water.
2) Nitrate is reduced to nitrogen gas (denitrification).
3) Manganese dioxide is reduced to dissolved manganese(II).
4) Ferric (oxy)hydroxide is reduced to dissolved iron(II).
5) Finally, sulfate is reduced to dissolved sulfide (in the forms of hydrogen sulfide and hydrogen bisulfide, depending on the pH).

This conceptual model is illustrated by the geochemical trends plotted for wells R-15 and R-22 in Figure 4-9. Well R-15 provides consistent results for iron, nitrate, and sulfate because there are little or no residual fluids remaining in the well that influence redox chemistry of aquifer material and groundwater. Well R-22 (screen 4) shows both nitrate and sulfate below background. Concentrations of total iron remain significantly elevated above background in screen 4. Reduction of iron(III), nitrate, and sulfate has taken place because of the presence of residual organic drilling fluids in well R-22 (screen 4).

Sulfate reduction represents the strongest reducing conditions observed in wells impacted by organic drilling fluid. Under this condition, nearly all of the analyte suites (general chemistry, metals, radionuclides, HE compounds, and other organic suites) are significantly impacted (Table 4-7). The list of affected analytes is slightly shortened under the less severe condition of iron and manganese reduction (Table 4-7). Nitrate and dissolved oxygen reduction have most analyte suites not impacted by residual organic drilling fluid, excluding part of the general inorganic suite and all SVOC and VOC suites. A completely restored well produces water with measurable dissolved oxygen (>2 mg/L), dissolved iron and manganese concentrations near or below the detection limit, and nitrate and sulfate concentrations within the range of background or representative of site conditions. Under these aerobic conditions, none of the various analyte suites are expected to be compromised by any residual organic drilling fluid (Table 4-7).

Organic components of EZ-MUD® eventually oxidize to bicarbonate, producing elevated alkalinity. Field measurements of dissolved oxygen and analyses of total carbonate alkalinity, dissolved nitrate, manganese, uranium, iron, and sulfate support the sequence of these redox reactions. These various indicators provide direct and quantitative evidence for the breakdown of organic-based drilling fluid and the well's progress toward restoring its predrilling geochemical conditions. Total carbonate alkalinity is denoted as alkalinity in this report.

Analytical results for organic contaminants, such as chlorinated solvents, aromatic hydrocarbons, HE compounds, aliphatic hydrocarbons, and PAHs, that may undergo biological transformations induced by residual drilling fluid may not provide representative results (Table 4-7). Native microbes use residual organic carbon from drilling fluids as a substrate or food source, in the form of an electron donor, and anthropogenic organic compounds listed above can serve as terminal electron acceptors. The electron acceptors become reduced as the residual organic drilling fluid oxidizes to carbonate alkalinity. These include chlorinated aliphatic hydrocarbons and HE compounds.

In situ microbes also consume organic contaminants directly, in which the organic compounds eventually oxidize to total carbonate alkalinity and water. These include PAHs, benzene, toluene, xylene isomers, and ethylbenzene. Organic contaminants affected by biodegradation induced by residual organic drilling fluid would decrease in concentration over time. Predrilling conditions occur when mobile organic contaminants and carbonate alkalinity show consistent trends in groundwater.

4.5.2 Selection of Indicator Species and Test Criteria

Screening questions, assessment criteria, and the consequence of response for Tier 2.2 are provided in Figure 4-10 and Table 4-8.

EZ-MUD® and QUIK-FOAM® undergo oxidation reactions that result in the reduction of dissolved oxygen, nitrate, manganese(IV), iron(III), uranium(VI), and sulfate, creating anaerobic conditions around the well. This process has been described above. Evaluation of oxidation of both residual EZ-MUD® and QUIK-FOAM® and their impact on groundwater requires a comprehensive suite of inorganic and organic analytes that are common constituents that laboratories measure during analyses.

4.5.3 Application of Tier 2.2 Criteria to Water Samples

As summarized in the lower half of Figure 4-11, the outcome of applying the Tier 2.2-1 assessment to the latest sample events shows that 66% of the screen intervals do not contain residual organic-based drilling fluids. Other key points in Figure 4-11 for the most recent sample events are as follows:

- Sixty-six percent of all (64) screens (15 single-screen wells, 27 screens in multiscreen wells) do not contain residual organic drilling fluids. Thirty-four percent of all screens (1 single-screen well, 21 multiscreen) contain residual organic drilling fluid.

- Fifty percent of 12 screen intervals drilled using bentonite mud do not contain additional organic drilling fluids (all 3 single-screen wells, 3 multiscreen). Fifty percent of the 12 screen intervals (all multiscreen) contain residual organic drilling fluid.

- Sixty-nine percent of 52 screen intervals drilled using organic fluids alone do not contain residual organic drilling fluids (11 single-screen wells, 24 multiscreen). Twenty-nine percent of 52 screen intervals (1 single-screen, 15 multiscreen) contain residual organic drilling fluid.

- Sixty-seven percent of 12 intermediate wells (one single-screen, 7 multiscreen) do not contain residual organic drilling fluids. Twenty-three percent of 12 intermediate wells (2 single-screen, 2 multiscreen) contain residual organic drilling fluid.

- Sixty-three percent of 52 regional aquifer wells (13 single-screen wells, 20 multiscreen) do not contain residual organic drilling fluids. Thirty-four percent of 52 regional aquifer wells (all multiscreen) contain residual organic drilling fluid.

As summarized in the lower half of Figure 4-12, the outcome of applying the Tier 2.2-2 assessment for redox conditions to the latest sample events shows that 27% of the screen intervals are presently oxidizing (predrilling conditions). Other key points in Figure 4-12 for the most recent sample events are as follows:

- Twenty-seven percent of all (64) screens (10 single-screen, 7 multiscreen) are characterized by oxidizing conditions. Seventy-three percent of all screens (6 single-screen, 41 multiscreen) are not characterized by oxidizing conditions.

- Seventeen percent of 12 screen intervals drilled using bentonite mud are characterized by oxidizing conditions (1 single-screen, 1 multiscreen). Eighty-three percent of these screen intervals (2 single-screen and 8 multiscreen) are not characterized by oxidizing conditions.

- Twenty-nine percent of 52 screen intervals drilled using organic fluids are characterized by oxidizing conditions (9 single-screen, 6 multiscreen). Seventy-one percent of 52 screen intervals (4 single-screen and 33 multiscreen) are not characterized by oxidizing conditions.

- Seventeen percent of 12 intermediate wells (2 single-screen) are characterized by oxidizing conditions. Eighty-three percent of 12 intermediate wells (1 single-screen, 9 multiscreen) are not characterized by oxidizing conditions.

- Twenty-nine percent of 52 regional aquifer wells (8 single-screen, 7 multiscreen) are characterized by oxidizing conditions. Seventy-one percent of 52 regional aquifer wells (5 single-screen, 32 multiscreen) are not characterized by oxidizing conditions.

4.6 Additional Assessment Considerations

As stated previously, the Tier 2 evaluation process is not intended to replace detailed geochemical evaluations such as those presented in characterization well geochemistry reports (Section 7.3), but rather to provide a reasonably simple, efficient, transparent, and consistent process for identifying analytical data that may be unreliable or non-representative of predrilling conditions. The tradeoff for such simplicity, however, is the increased likelihood that some reliable analytical data may be inadvertently called into question. Consequently, a review of those data that fail a Tier 2 geochemical criterion by a person knowledgeable about site conditions may be warranted before any action is taken in response to data flagged in this report. This section identifies some initial assessment outcomes which may deserve a closer evaluation as to the appropriateness of specific assumptions or numerical thresholds that underlie the Tier 2 assessment process.

The only well screen that appears to have failed Tier 2 criteria because of the presence of a contaminant plume rather than drilling fluids is R-6i. The water sample collected from single-screen well R-6i in August 2005 shows elevated concentrations of TOC (4.4 mg/L), sulfide (0.011 mg/L), and alkalinity (75 mg/L as $CaCO_3$). These geochemical indicators are used in Tier 2.2 to test for residual organic drilling fluids and anaerobic conditions. At least the first one of these geochemical criteria (TOC) is not relevant to R-6i because of the presence of groundwater contaminants in this perched intermediate zone. Indicators of contaminants in the groundwater at R-6i are elevated levels of nitrate (3.5 mg/L as N), perchlorate (7 µg/L), and tritium (>3500 pCi/L), all of which are major contaminants of concern for this well (Kleinfelder Inc. 2005, completion report for R-6/6i, p. A-2). Well R-6i was drilled to the east of inactive sewage lagoons at Technical Area (TA) 21. The sewage effluent contains organic compounds as evidenced by the elevated concentration of TOC. VOC analysis did not show the presence of acetone and isopropyl alcohol, which would have indicated the presence of residual organic drilling fluids. However, the cause of the elevated sulfide and alkalinity was not evaluated in this report, and the preliminary assumption is that these analytes may reflect the impact of residual organic drilling fluids.

Because a suitable analogue is not available, the screen intervals drilled with bentonite mud could not be evaluated for very strongly adsorbing radionuclides, including isotopes of americium, cerium, plutonium, and radium. However, a strong argument can be made that these manmade radionuclides can assumed to be absent from the groundwater if modern tritium is absent. Tritium is commonly used to determine whether or not any young (post-1943) groundwater is present. Of the 12 screen intervals drilled with bentonite, tritium is less than 0.7 pCi/L (i.e., no modern water is present) in at least seven cases: R-2, R-14 Screen 2, R-16 Screens 2, 3, and 4; R-20 Screen 1; and R-32 Screen 1.

5.0 MULTIVARIATE STATISTICAL ANALYSIS TO IDENTIFY IMPACTED SCREENS

Several investigations using multivariate statistical methods for the determination of sources of groundwaters have been published. Groundwater commonly inherits chemical signatures from hydrogeological materials with which they react. In newly drilled wells, additional changes to the chemistry may temporarily occur as a result of residual drilling fluids, drilling additives, or "skin effects" from physical and chemical damage to the penetrated rock. In some newly drilled wells, drilling-related impacts to water chemistry may be more pronounced than natural variability.

An exploratory use of multivariate statistical methods was made to determine if wells showing residual well-drilling impacts could be identified. Differences in chemical signatures were investigated in newly drilled wells from springs and long-established wells at the Laboratory using a suite of nine major ions and 11 metals/trace elements. Multivariate statistics, specifically principal component analysis (PCA) and cluster analysis (CA), were used to reduce the large amounts of geochemical data to decipher patterns within the data that otherwise might not be observed.

5.1 Data Set Used in the Analyses

Selected regional aquifer water-quality data for the years 2000–2005 were pulled from the WQDB. The retrieval included data for samples from 28 R-wells, 16 White Rock Canyon springs, and 15 long-established wells (10 municipal supply wells and 5 regional aquifer test wells). Eleven of the R-wells are constructed using single-screened intervals, and 17 are equipped with multiple screens. In total, R-well results from 49 discrete screens were considered. All but four of the R-wells had been sampled more than once and many had four complete rounds of chemical characterization data. All rounds were used in the assessment to capture the full extent of water-quality variability in the wells.

Results from the White Rock Canyon springs, municipal water-supply wells, and test wells help in the identification of wells that contain residual drilling fluids. All the spring data are from filtered samples and represent regional aquifer quality unaffected by drilling. The test wells were installed in the early 1960s without drilling muds using cable-tool casing-advance methods. Only major ion chemistry results from the test wells were used in the statistical analyses because the metals data are suspect as a result of oxidation and partial dissolution of casing materials used (hardened steel). The municipal water supply wells were installed in the 1970s and 1980s with drilling muds. Because of the age of the supply wells and large pumpage volumes, however, there should be minimal or no residual drilling effects apparent in these wells. All data from the test and water-supply wells were from nonfiltered samples with turbidity levels below 2 nephelometric turbidity units (NTUs). Because of the low turbidity and developed nature of the wells, those data were treated as comparable to filtered data (assuming that submicron colloids are absent) and added to the filtered results from the R-wells and springs.

Statistical analyses were performed on four independent groups of data, distinguished by analytical suite and field preparation:

- Dissolved metal/trace-element concentrations—172 filtered (F) samples
- Total metal/trace-element concentrations—201 nonfiltered (UF) samples
- Dissolved major ion concentrations—166 filtered (F) samples
- Total major ion concentrations—79 nonfiltered (UF) samples

Analytes with below instrument-detection-limit (IDL) concentrations in more than half of the samples were removed from statistical analysis. Below-detection-limit concentration values were replaced with values equal to half the instrument-detection limit. The metals/trace elements included in the analyses were boron, barium, chromium, iron, manganese, molybdenum, strontium, vanadium, and zinc. The major ions included in the analyses were calcium, magnesium, sodium, potassium, chloride, sulfate, fluoride, nitrate, and total carbonate alkalinity. All of these constituents could be affected to varying extents by the presence of residual drilling fluids.

5.2 Statistical Analysis

Principal component analysis is a multivariate statistical technique for data reduction and for deciphering patterns with large sets of data (Stetzenbach et al. 2001, 90565). These data are not required to be normally distributed for the analysis. In using PCA, a large data matrix can be reduced to two smaller matrices, one consisting of principal component (PC) scores and the other containing the loadings. The scores help define the chemical signatures for each sample in the data set. The loading identifies the analytes that cause the greatest variance in the data set.

After the principal component scores were calculated, they served as input into CAs to group the results and identify groundwaters that have similar chemical signatures. PCA scores, weighted by their respective loadings, were input into the CA. All PCs with eigenvectors larger than 1 were input into the CA. The K-means cluster algorithm was used to identify similar clusters of results. For most analyses, it was empirically determined that six or seven clusters adequately represented the spread of data. The statistical software package "Statistica for Windows 7.1" (StatSoft, Inc.) was used for all PCA and CA.

5.3 Key Analytes Identified Through the Analysis

Results of the PCA are provided in Table 5-1. From the nine major ions and nine metals, the PCA identified the constituents that varied the most in concentration within each of the data sets. For each PCA analysis, the nine major ions were reduced to three PCs (groups of analytes). The nine metals/trace elements also were reduced to three PCs. Between 65 and 72 percent of the variance in the data sets was explained by the three factors. The key analytes are identified in Table 5-1, along with the proportional amount of variation in the data set that is explained by the three principal components listed in that table. There were considerable similarities between the key analytes identified for the nonfiltered and filtered samples. For metals and trace elements, the key analytes included iron, manganese, boron, strontium, zinc, and chromium.

5.4 Interpretation of the Statistical Analyses

An initial review of the water-quality data sets showed a larger range in chemical concentrations in the newly drilled wells than is typically found in the springs or long-established wells. The larger concentrations were associated with the R wells. The higher concentrations probably reflect the presence of residual drilling fluids.

Wells with possible drilling impacts were identified by examining chemical signatures established by the statistical analyses. R-wells that are compositionally similar (cluster) to the White Rock Canyon springs or the long-established wells are interpreted to have minimal residual drilling impacts. R wells that are placed in other clusters were interpreted to have possible residual drilling effects.

Figures 5-1 through 5-4 present plots of the first three PCs for each analysis. These three PCs account for the majority of variability in the original data. The PCA scores for each water sample are plotted, and groundwaters that are compositionally similar are shown in the plots as clusters (C1, C2, etc.). Highlighted on the plots are selected wells that reflect the most anomalous chemistry. The top plot in each figure shows the PCA scores grouped according to the type of groundwater source: multiscreened R wells, single-screened R wells, municipal water-supply wells, White Rock Canyon springs, or test wells.

5.5 Key Findings from Statistical Analyses

The chemical signatures of most of the water-supply samples are consistent with those of the test wells and White Rock Canyon springs. This indicates that the water-supply wells reflect the regional aquifer water quality and show no discernible residual effects from the drilling muds. Taken together, results from the springs, test wells, and water-supply wells represent the regional aquifer "baseline" water quality.

- In many cases, the single-completion wells are compositionally similar to the baseline stations. There is indication of slightly higher iron or manganese concentrations in some of the single-completion wells. Overall, the analysis indicates that there is minimal to slight residual impacts from drilling in the single-completion wells.
- The multiscreen R- wells show considerable residual drilling impacts. Significant impacts are seen in the multiscreen wells in all metals and major ion data sets analyzed. The well screens showing the most impacts include R-20 (screen 2), CdV-R-37-2 (screen 2), R-22 (screen 1), R-22 (screen 4), and R-31 (screen 2).
- The magnitude of drilling impacts was assessed by considering the similarity in chemical signatures to the "baseline" stations—the springs, test wells, and water-supply wells. Table 5-2 summarizes the preliminary interpretation of the results for the most recent data from each site.

5.6 Comparison of PCA Results with the Tiered Analysis

The two independent approaches largely produce consistent results but differ in a number of aspects. The differences include

- method objectives,
- the number of screens included in the analysis,
- the type of data used in the analysis,
- the period of coverage for samples from each screen,
- the collection dates of samples that represent the "most current" sample, and
- assumptions that underlie interpretation of the results.

Regarding method objectives, the PCA was designed primarily to test whether the screens had chemical characteristics that differed significantly from those shown by local springs and water-supply wells. The latter are assumed to represent relevant background conditions. In contrast, the tiered approach was designed to test whether the screens produced water samples that were reliable and representative of predrilling concentrations for a number of specific categories of analytes of concern, many of which are not detected in background waters.

The two methods use a similar number of inorganic indicator species: 15 for the tiered method (uranium is used with different threshold values for two tests) and 18 for the PCA method. Notably absent from the PCA input data are organic species and field-based parameters other than alkalinity. Organic-based drilling fluids, if used during drilling of supply wells, have been removed during several decades of pumping. Neither method includes any radionuclides as indicators.

Table 5-3 provides a qualitative comparison of the outcomes of both methods. The methods overlapped in coverage for 53 screens. The 11 screens that were included in the tiered analysis but excluded from the PCA method for the most part were either newly completed wells that only produced water-quality data in the past couple of months, after the PCA study had already been conducted, or older wells for which water-quality data had not yet been transferred into the WQDB from the ERDB.

In Table 5-3, shaded cells indicate those 45 screens (85%) for which both methods produced qualitatively comparable results. The two methods differed for 8 screens. The differences are traceable for the most part to just a few reasons:

- absence of consideration of organic analytes by the PCA method
- absence of consideration of most field-based data by the PCA method
- differences in the date of the sample considered "most current"
- the specification of background ranges by the tiered approach that may not reflect the full range of conditions that actually occur
- the treatment of partial data sets for which key analytes are not available (included by the tiered method, excluded from the PCA method)

6.0 SUMMARY AND CONCLUSIONS

6.1 Overview of the Tiered Assessment Approach

This evaluation covers 64 functional screens out of 82 screens in 33 wells that were completed in the regional aquifer and perched intermediate zones. The purpose of this evaluation was to identify which of these 64 screens are capable of producing water-quality data that are reliable and representative of groundwater.

Drilling fluids include organic drilling fluids or additives, mainly consisting of EZ-MUD® and QUIK-FOAM®, for all of the 64 screens, as well as sodium bentonite drilling mud for 12 of the 64 screens. Twenty solutes and field parameters were defined as indicator species for identifying the presence or absence of residual drilling fluids and additives and of their effects on water chemistry:

- four indicators for the absence of excess solutes leached or desorbed from bentonite mud: boron, sodium, sulfate, and uranium
- three naturally occurring indicators for the absence of significant adsorption onto residual bentonite: strontium, uranium, and zinc
- four indicators for absence of residual organic drilling fluids in the screen interval: acetone, ammonia, TKN, and TOC
- four analytical-laboratory indicators for fully oxidizing conditions in the screen interval: sulfate, iron, manganese, nitrate
- five field-based indicators for fully oxidizing conditions in the screen interval: pH, alkalinity, dissolved oxygen, sulfide, and ORP

The assessment was conducted by comparing the most recent three sampling rounds of surveillance and characterization data, to the extent these data were available, against the threshold levels of the 20 indicator species, with the threshold levels defined based on those measured in background groundwaters within perched intermediate zones and the regional aquifer. A tiered process was used to evaluate water samples from each screen and to indicate which screens were providing water-quality data that are reliable and representative of the saturated zone. The results of the evaluation also indicate which screens are in the process of cleaning up over time and the extent to which they have cleaned up, and which screens do not appear to be improving with time.

6.2 Outcome of Screen Analysis

6.2.1 Single-Screen Wells

The 16 single-screen wells that were assessed by the tiered method are CdV-16-1i, MCOBT-4.4, and R-6i in intermediate perched zones, and R-1, R-2, R-4, R-6, R-9, R-11, R-13, R-15, R-18, R-21, R-23, R-28, and R-34 within the regional aquifer. Three of these single-screen wells were drilled using bentonite mud (R-2, R-4, and R-6); the 13 remaining wells were drilled using organic drilling fluids alone. The following key points resulted from application of the tiered analysis for identifying water-quality impacts from the use of bentonite drilling mud (for the most current sample):

- All three wells have returned to background concentrations for those solutes leached from residual bentonite mud (data in Table C-3, shown in Figure D-1, summarized in Table E-4).
- All three wells pass the assessment criteria that indicate their ability to detect strontium-90 and uranium isotopes (data in Table C-3, summarized in Table E-4).
- All three wells pass the criteria for indicating their ability to measure strongly adsorbing metals/trace elements and radionuclides, including cobalt-60 and cesium-137 (data in Table C-3, summarized in Table E-4).
- Because a suitable analogue is not available, none of the three wells can be shown with high confidence to provide reliable data for very strongly adsorbing radionuclides, including isotopes of americium, cerium, plutonium, and radium.
- Because site-specific sorption data are not available, none of the three wells can be shown with high confidence to provide reliable data for the more strongly sorbing HE species (HMX, PETN, tetryl, and TNT) and for a large proportion of the organic analytes of interest.

All 16 single-screen wells were evaluated for residual organic drilling fluids and for the presence of fully oxidizing conditions that are representative of predrilling conditions. The following key points result from application of the tiered analysis for identifying water-quality impacts from the use of organic drilling fluids (for the most current sample):

- Fifteen of the 16 single-screen wells do not contain detectable quantities of residual organic drilling fluids, with the exception being CdV-16-1i in intermediate perched zone (data in Table C-6, shown in Figure D-2, summarized in Table E-2).
- Ten of the 16 single-screen wells are fully oxidizing at the present time (data in Tables C-4 and C-7, shown in Figures D-4, D-6, and D-8, summarized in Table E-2).
- The remaining six wells failed at least one of the test criteria for oxidizing conditions, although some of these may also be oxidizing. Uncertainties arise because of questions about the reliability of some field data and the suitability of background ranges established for some redox key indicators.
- The nine single-screen wells in the regional aquifer that meet all criteria are capable of providing reliable and representative data for all analytes of interest, with exceptions as noted for the three bentonite wells.
- The two intermediate perched wells are capable of providing reliable and representative water-quality data for all analytes of interest other than a few organic species in CdV-16-1i..
- Determination of the reliability and representativeness of water samples from the six wells that did not pass one or more of the field-based test criteria requires more detailed evaluation, which is beyond the scope of this report.

6.2.2 Multiscreen Wells

The 48 screens in 18 multiscreen wells that were assessed by the tiered method include 9 in intermediate perched zones (R-5 Screen 2, R-9i Screens 1 and 2, R-12 Screen 1, R-19 Screen 2, R-25 Screens 1, 3 and 4, and R-26 Screen 1) and the remaining 39 in the regional aquifer. Nine of the multiscreens were in intervals drilled using bentonite mud (R-14 Screen 2; R-16 Screens 2, 3, and 4; R-20 Screens 1, 2, and 3; R-32 Screens 1 and 2); all of the remaining screens were drilled using organic drilling fluids alone. The following key points resulted from application of the tiered analysis for identifying water-quality impacts from the use of bentonite drilling mud in nine screens (for the most current sample):

- Five have returned to background concentrations for those solutes leached from residual bentonite mud. This number excludes R-16 Screen 3, which passed the test criteria but for which the declining trend for sulfate clearly indicates that it is still cleaning up. The three screens that did not pass the test criteria are R-16 Screen 4, and R-20 Screens 1 and 2 (data in Table C-3, shown in Figure D-1, summarized in Table E-4).
- Five pass the assessment criterion that indicates their ability to detect uranium isotopes. The four exceptions are R-14 Screen 2, R-20 Screens 2 and 3, and R-32 Screen 3 (data in Table C-3, summarized in Table E-4). However, the presence of reducing conditions in these four screens (addressed in the next paragraph) is more likely the reason for this condition than is the bentonite mud.
- Eight pass the assessment criterion that indicates their ability to detect stronium-90. The exception is R-20 Screen 1 (data in Table C-3, summarized in Table E-4).
- All pass the criterion for indicating their ability to measure strongly adsorbing metals/trace elements and radionuclides, including cobalt-60 and cesium-137 (data in Table C-3, summarized in Table E-4).
- Because a suitable analogue is not available, none of the nine screens can be shown with high confidence to provide reliable data for very strongly adsorbing radionuclides, including isotopes of americium, cerium, plutonium, and radium.
- Because site-specific sorption data are not available, none of the nine screens can be shown with high confidence to provide reliable data for the more strongly sorbing HE species (HMX, PETN, tetryl, and 2,4,6-TNT) and for a large proportion of the organic analytes of interest.

All 48 screens in the multiscreen wells were evaluated for residual organic drilling fluids and for the presence of fully oxidizing conditions that are representative of predrilling conditions. The following key points result from application of the tiered analysis for identifying water-quality impacts from the use of organic drilling fluids (for the most current sample):

- Twenty-seven of the 48 screens (56%) do not contain detectable quantities of residual organic drilling fluids, indicating that these fluids have been adequately removed (data in Table C-6, shown in Figure D-3, summarized in Table E-2). Those that failed these test criteria include six of the nine screens in intervals drilled using bentonite.
- Only seven of the 48 screens (15%) can be shown with moderate to high confidence to be aerobic at the present time (R-5 Screen 3, R-8 Screen 1, R-19 Screen 7, R-22 Screen 2, R-25 Screens 6 and 7, and R-32 Screen 1) (data in Tables C-4 and C-7, shown in Figures D-5, D-7, and D-9, summarized in Table E-2).
- One of the nine screens in intervals drilled with bentonite (R-32 Screen 1) meets all of the test criteria for oxidizing conditions; of the eight screens that did not meet the criteria, seven of these screens did not meet at least three of the criteria. Sulfate-reducing conditions are indicated as

being present in these eight screens (data in Tables C-4 and C-7, shown in Figure D-5, summarized in Table E-2).

- Seven of the 41 screens that did not meet the test criteria for aerobic conditions failed these tests only because of one or more of the field-based criteria used. Some of these screens may also be oxidizing, but uncertainties arise as a result of questions about (a) the reliability of some of the field data (high sulfide and negative ORP in R-32 Screen 3, high pH and negative ORP in R-8 Screen 2, high pH in R-12 Screen 2, negative ORP in R-16 Screen 3) or (b) the suitability of background ranges established for pH and alkalinity in intermediate perched zones (high pH and alkalinity in R-19 Screen 2) (data in Table C-4, shown in Figures D-5, D-7, and D-9, summarized in Table E-2). Although several other screens also did not meet some of the field criteria, the evaluation that fully oxidizing conditions were not present was supported by the fact that they also did not meet one or more of the analytical criteria.
- The five screens in multiscreen wells that meet all criteria are capable of providing reliable and representative data for all analytes of interest.

6.2.3 Assessment Outcome Using Less Stringent and More Reliable Test Criteria

As an example to show the implications of the tiered assessment outcome for the ability of a screen to provide reliable and representative data, Figure 6-1 summarizes assessment outcomes for the most recent sample event from each screen, with respect to the screen's ability to measure five contaminants of interest with a high level of confidence that the concentrations reflect predrilling conditions.

- All screens are capable of providing reliable tritium data because tritium is unaffected by residual drilling fluids (water is not reduced to hydrogen gas).
- Ten single-screen wells and 17 screens in multiscreen wells (42% of all screens) are capable of providing reliable perchlorate data. The remaining six single screens and 31 multiscreens (58%) might not provide reliable perchlorate data because of indications that sulfate-reducing conditions may be present.
- All 16 single-screen wells and all but one screen in the multiscreen wells (98% of all screens) are capable of providing reliable data for strontium-90. The remaining screen might not provide reliable strontium-90 data because of indications that strontium may be adsorbing onto residual bentonite.
- Ten single-screen wells and 6 screens in multiscreen wells (27% of all screens) are capable of providing reliable data for nitrate. The remaining screens (73%) might not provide reliable nitrate data because of indications that excess solutes leached from residual bentonite drilling mud are still present (four multiscreens) and that sulfate-, iron-, manganese-, and/or nitrate-reducing conditions may be present (six single screens and 41 multiscreens).
- Twelve single-screen wells and fourteen screens in multiscreen wells (41% of all screens) are capable of providing reliable data for RDX. The remaining 4 single screens and 34 multiscreens (59%) might not provide reliable RDX data because of indications that sulfate-reducing conditions may be present.

It is suspected that at least some of the field-based data may be unreliable, and that the threshold value used to verify the absence of sulfate-reducing conditions may be overly stringent. In addition, it is highly probable that RDX can be assumed to be resistant to degradation or hydrolysis for the short time that it resides in the screen interval, with the possible exception of conditions even more reducing than sulfate. The lower plot on Figure 6-1 shows the consequence of using less stringent test criteria for the same five contaminants of concern:

- All screens are capable of providing reliable tritium data because tritium is unaffected by residual drilling fluids.
- All single-screen wells and 39 screens in multiscreen wells (86% of all screens) are capable of providing reliable perchlorate data.
- All single-screen wells and all but one screen in multiscreen wells (98% of all screens) are capable of providing reliable data for strontium-90.
- Fifteen single-screen wells and 20 screens in multiscreen wells (55% of all screens) are capable of providing reliable data for nitrate.
- All single-screen wells and 39 screens in multiscreen wells (86% of all screens) are capable of providing reliable data for RDX.

6.2.4 Comparison with Outcome of a Multivariate Statistical Analysis

A PCA was conducted independently of this evaluation, using a very similar data set as was used for the tiered geochemical analysis, and without knowing the results of the tiered approach. Statistical analyses were performed on four independent groups of data, distinguished by analytical suite and field preparation: metal/trace element concentrations and major ion concentrations, each set comprised exclusively either of filtered or nonfiltered samples. Multivariate statistical analyses examined correlations among 18 geochemical species.

The results of the PCA, as presented in Figures 5-1 through 5-4, shows that most of the single-screen wells plot in the same geochemical fields as do the Los Alamos County water supply wells and local springs in White Rock Canyon representing groundwater discharge; wells R-9, R-23 and R-28 are the exceptions. In contrast, most of the multiple-screen wells plot in clusters that are clearly different from those for the background springs and water-supply wells. Preliminary interpretations of the PCA results are as follows:

- Five of the single-screen wells and 16 screens in multiscreen wells (40% of the 53 screens evaluated) have water chemistries that are consistent with the background springs or existing wells.
- Three single-screen wells and five screens in multiscreen wells (15%) show possible to slight impacts from drilling artifacts.
- Two single-screen wells and 10 screens in multiscreen wells (22%) show moderate impacts.
- One single-screen well and 11 screens in multiscreen wells (22%) show significant impacts.

Preliminary conclusions reached by the two independent approaches are consistent for 45 (85%) of the 53 screens that were evaluated by both methods. Differences for most of the few cases in which the two approaches differed in outcome are attributable to the date of the sample defined as "most current" or to the different criteria used by each approach. In particular, the PCA tests did not include organic species or field data. Overall, however, the PCA method provided an excellent validation test of the tiered approach in that it produced very similar results.

6.3 Observed Trends

Overall, for the most recent sample collected, 7 single screens and 11 of the multiscreens (28% of all 64 screens) can be shown with moderate to high confidence as producing water-quality samples that are not significantly impacted by residual drilling fluid (Figure 6-2). Results of the tiered geochemical analysis indicate that single-screen wells show the least impact from residual drilling fluids and therefore provide the most technically defensible data. Most of the single-screen wells are aerobic and do not contain residual organic-based drilling fluids. Another five single-screen wells and six multiscreen wells (11% of the 64 screens) are rated as "good" for providing reliable water-quality data, meaning that they failed only one or two of the assessment criteria. On the other hand, one single-screen (R-6i) and 16 of 48 multiscreens (27% of the 64 screens) are rated as "fair," insofar as they failed to meet several criteria, and 15 of 48 multiscreens (23% of the 64 screens) are rated as "poor."

Upon close examination, comparison of the average assessment outcome based on three samples to the outcome for the most recent sample (Figure 6-2) shows that 10 multiscreens improved over the period of time covered by the three samples used in the assessment (which varies from less than a year, to as much as three years). For example, the proportion of screens rated as "poor" decreased from 30% (based on the average of three samples) to 23% (based on the most recent sample). Some details of the cleanup trends are more apparent in Figure 6-3, which plots the average percentage of Tier 2 criteria passed by all three samples on the *x*-axis, against the percentage passed by the most recent sample on the *y*-axis. The grey diagonal zone marks the condition in which no significant change in water-quality conditions was observed for a given screen, i.e., geochemical conditions were fairly stable (or stagnant, in the case of conditions of poor water quality) throughout the period of time covered by the three samples. Screens that plot above the diagonal zone showed improvement (cleaned up), and those few that plot below the diagonal zone showed degrading water-quality conditions.

The data points are color-coded to distinguish between single-screen and multiscreen wells, and between those drilled with bentonite and those drilled using only organic fluids. An obvious trend shown in Figure 6-3 is that all but one of the single-screen wells plot in the zone indicating good to very good conditions (more than 80% criteria passed), indicating that they attain this condition early in their postdevelopment history. The exception is R-6i, which is in a contaminant plume and its effects may not be a result of residual drilling fluids, as discussed in Section 4.6. In contrast, half of the multiscreen wells plot well below 80%, with the worst case passing less than 25% of the criteria for its most recent sample. About a third of the multiscreen wells classified as being in poor condition show signs of improvement over the time period covered by the samples. However, the six multiscreen intervals drilled with bentonite mud and rated as fair to poor condition are not progressing to clean up at a noticeable rate.

The same data are plotted in Figure 6-4, but in this case the points are colored-coded according to the zone of saturation. No trend is observed with respect to cleanup as a function of location in an intermediate perched zone, water table, or deeper in the regional aquifer, although it had been expected that intermediate perched zones would have more problems because of the difficulty in developing these zones. It is likely that hydraulic conductivity and/or pumping rate and volume are more critical characteristics for determining the effectiveness of well development and subsequent removal of residual drilling fluids, than is the zone of saturation in which the screen is located.

Finally, Figure 6-5 shows water quality in terms of percent criteria passed, as a function of time elapsed since well development. Most single screens pass most of the assessment criteria regardless of the length of time elapsed since development. However, most of the multiscreen wells appear to take significantly longer to clean up, and many still show low water-quality scores even several years following well development. Furthermore, the extremely wide scatter of data points on this graph clearly shows the difficulty associated with any attempt to project if or when a screen will clean up and produce reliable samples.

6.4 Conclusions

The 16 single-screen wells generally provide the most technically defensible water-quality data for representing predrilling conditions, based on a geochemical assessment of the most recent samples collected. Only 11 screens in 8 multiscreen wells provide moderate to high-confidence data with little or no residual drilling fluids present and with aerobic conditions.

All residual organic drilling fluids have been successfully removed or flushed from single-screen wells. However, two-thirds of the 18 multiscreen wells have screens that appear to contain residual organic drilling fluids to varying extents (20 screens, 12 wells), as evidenced by elevated concentrations of acetone, ammonia, TKN, and/or TOC. In addition, all of the multiscreens that show the presence of residual organic fluids also show the presence of conditions that are less than aerobic. Altogether, six single-screen wells and 41 screens in 17 of the 18 multiscreen wells show one or more indications of the presence of reducing conditions.

It is likely that at least some of the field-based data may be unreliable, and that the threshold value used to verify the absence of sulfate-reducing conditions may be overly stringent. If the water-quality assessment excludes the field-based criteria and assumes that sulfate-reducing conditions are only present if sulfate is below detection, then the outlook is somewhat less bleak. Assuming these less stringent conditions, all but one of the single-screen wells and 10 screens in 18 multiscreen wells would be judged as being aerobic (see Tables C-7 and E-5).

An independent analysis using principal components closely matches or agrees with the detailed geochemical assessment presented in this report. Single-screen wells provide chemical data that are consistent with long-term sampling stations, including supply wells and White Rock Canyon springs. The multiscreen wells, in part, provide chemical data that are not consistent with the single-screen wells. Analytes that are the most useful for discriminating among the different water-quality types include total carbonate alkalinity, iron, manganese, nitrate, sodium, calcium, sulfate, and strontium.

Results of this investigation strongly suggest that development of single-screen wells has been more successful at removing residual drilling fluids than has development of multiscreen wells. For multiscreen wells, probable factors affecting the success of properly developing individual screens include the efficient use of minimal drilling fluids, the hydraulic conductivity of the screened portion of the aquifer material, the screen type, the amount of time elapsed from well completion to well development, use of packers to isolate screens, pumping rates, and the duration of pumping.

6.5 Lessons Learned and Uncertainties

This section lists some of the lessons learned and uncertainties that affected the development, application, and interpretation of the assessment criteria:

- There is a strong need to expand the data set for background water in terms of sample locations and sampling frequencies. Background water chemistry along with site conditions (wells not impacted from drilling fluids) are used to quantify impacts of drilling fluid on samples collected from wells.
- Better bentonite adsorption analogues and more relevant Laboratory-specific adsorption data could narrow the list of analytes tentatively identified as having the potential to be impacted by residual drilling fluids.
- Data gaps for key geochemical indicators are common for the wells sampled during surveillance. Any attempt to review reliability with older data will have to be sufficiently robust to address this aspect. These gaps also reduce the level of confidence for the assessment outcomes.
- Apparent inconsistencies are frequently observed among redox indicators. These are probably resulting from biogeochemical reactions, mixed redox couples, and differences in reaction kinetics or electrochemical disequilibrium, especially with respect to sulfide, iron, and manganese.

Examples can be given for almost any redox parameter, but are most commonly observed with iron, manganese, sulfate, nitrate, sodium, calcium, strontium, and carbonate alkalinity.

- Contributing to this complexity are the field sulfide data and collection methods.
- The presence of detectable sulfate in combination with very low dissolved iron and manganese concentrations may give a false indication that reducing conditions are not present, if high sulfide concentrations are present (Ford et al. 2005, 90545). Flow-through sample devices will provide more reliable and accurate measurements of sulfide, pH, ORP (or Eh), temperature, specific conductance, and turbidity. Sulfide oxidation can be evaluated by stable isotopes and data-trend analysis in early stages of sample collection.
- Complexities in application of criteria for some indicator species arise because of the assignment of U flags to some of the data reported with B or J flags by the analytical laboratories.
- A large source of uncertainty is the variable reliability of field data in the WQDB, which are not currently assigned U, J, and R flags such are used routinely for other analytes.
- There is a definite need to indicate the field sample collection method in the WQDB, including the use of a flow-through cell at the wells.
- Based on the tiered assessment, it seems possible to meet the standard well development criteria (stable pH, temperature, specific conductance, low turbidity) and still fail the assessment process. This suggests that the assessment process is a better indicator of the adequacy of development for wells drilled using fluids.

6.6 Next Steps

Aspects that lie outside the scope of this report include the following:

- specifying actions to be taken for analytes judged as unreliable or not representative of predrilling conditions
- predicting when an impacted screen may be able to provide chemical data that are reliable and representative of pre-drilling conditions
- specifying corrective actions to be taken if a screen is judged as unlikely to produce reliable or representative water-quality samples in the foreseeable future
- discussing methods for rehabilitating impacted well screens, which is the subject of a separate evaluation

The only "corrective action" that can be confidently stated an as initial requirement in response to data flagged as unreliable or not representative of predrilling groundwater chemistry is to reassess the screen's data quality objectives (DQOs). DQOs define the type and quality of data to be collected from each screen. These data needs may be affected to varying degrees by residual drilling fluids, requiring a screen-specific analysis of impacts. Some data needs, such as piezometric data, are totally unaffected by drilling fluids, while others could be significantly affected. Consequently, it is not a simple or straightforward matter to specify the next corrective action step because this decision requires a level of detailed evaluation that is far beyond the scope of the evaluation of water-quality data. For example, the selection of an appropriate corrective action requires consideration of

- the significance of the screen's location relative to contaminant pathways;
- whether the screen is needed for a monitoring program;
- whether the screen meets its DQOs as specified for the characterization program;

- whether other screens in the area already satisfy any or all of the monitoring needs;
- the long-term prognosis for the screen's recovery of predrilling conditions;
- how many screens in the multiscreen well are providing reliable water-quality data;
- whether the screen is capable of providing reliable water-quality data for the specific suite of PCOCs that could credibly be present;
- whether the screened interval is located in a formation that is too tight to ever be adequately developed, or to allow adequate purging, to attain a high degree of confidence for all water-quality parameters.

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7.4 Procedures governing the collection, analysis and review of water data

- RRES-WQH-SOP-048, Groundwater Sampling Using Bladder Pumps
- RRES-WQH-SOP-049, Groundwater Sampling Using Submersible Pumps
- RRES-WQH-SOP-050, Groundwater Sampling Using Westbay System
- ENV-DO-203, Field Water Quality Analyses
- ENV-DO-206, Sample Containers and Preservation
- ENV-DO-207, Handling, Packaging, and Transporting Field Samples
- ENV-WQH-QP-029, Creating and Maintaining Chain of Custody
- ENV-ECR QP-4.4, Record Transmittal to the Records Processing Facility
- ENV-ECR SOP-05.02, Well Development
- ENV-ECR SOP-06.01, Purging and Sampling Methods for Single Completion Wells
- ENV-ECR SOP-06.03, Sampling for Volatile Organic Compounds in Groundwater
- ENV-ECR SOP-06.32, Multi-Level Groundwater Sampling of Monitoring Wells—Westbay MP System
- ENV-ECR SOP-15.01, Routine Validation of Volatile Organic Data
- ENV-ECR SOP-15.02, Routine Validation of Semivolatile Organic Data
- ENV-ECR SOP-15.03, Routine Validation of Organochlorine Pesticides and Polychlorinated Biphenyls Data
- ENV-ECR SOP-15.04, Routine Validation of High Explosives Data
- ENV-ECR SOP-15.05, Routine Validation of Inorganic Data
- ENV-ECR SOP-15.06, Routine Validation of Gamma Spectroscopy Data
- ENV-ECR SOP-15.07, Routine Validation of Chemical Separation Alpha Spectrometry, Gas Proportional Counting, and Liquid Scintillation Data
- ENV-ECR SOP-15.09, Chain of Custody for Analytical Data Packages

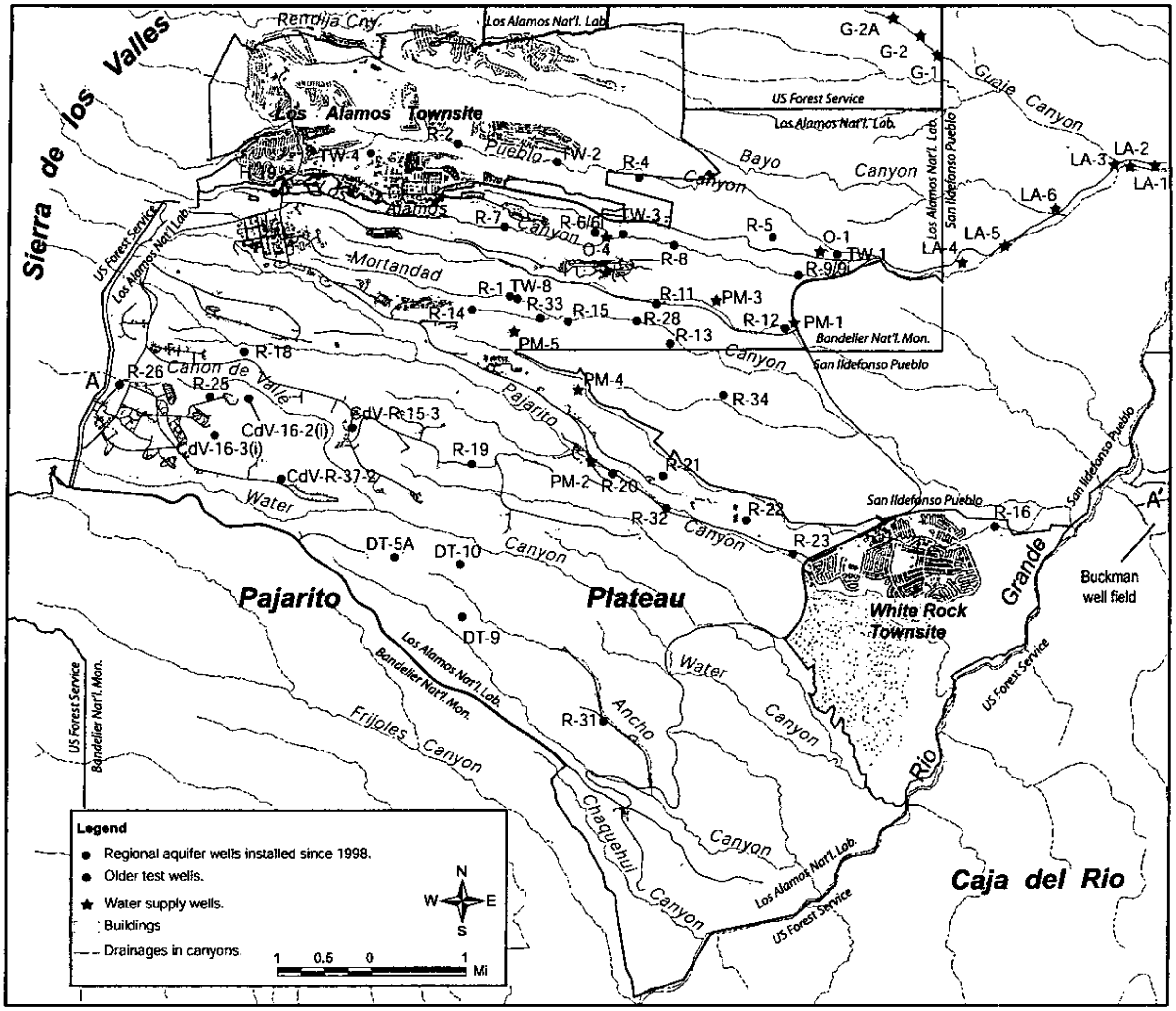


Figure 1-1. Map showing the location of characterization wells

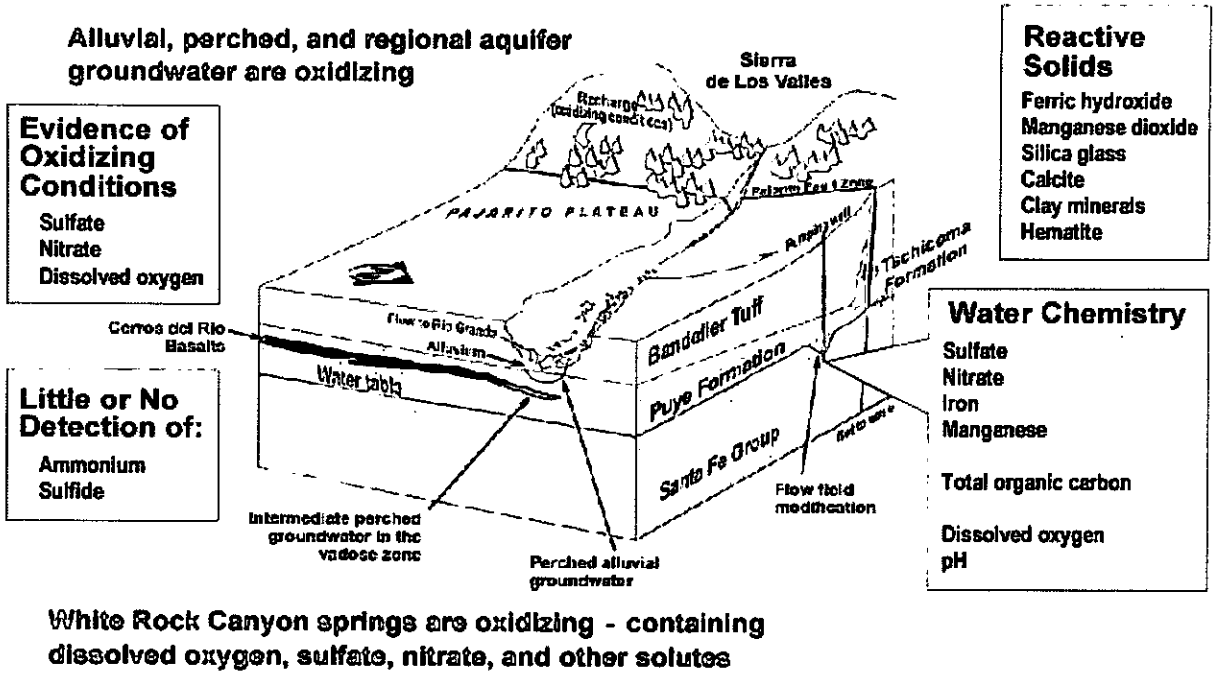
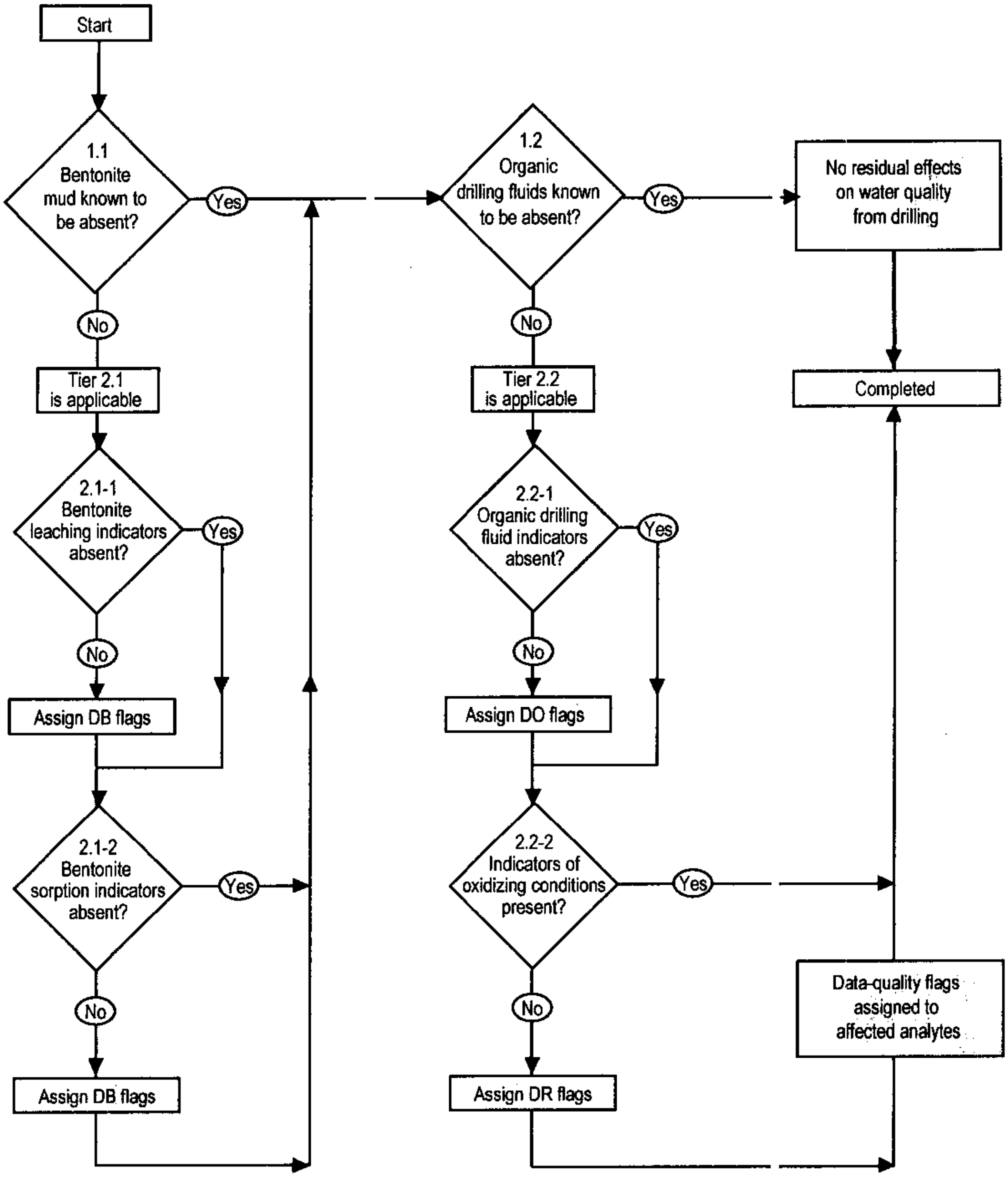


Figure 2-1. **Conceptual model of natural geochemistry of the Pajarito Plateau**



Detailed criteria for Tier 2.1 are shown in Figure 4-3

Detailed criteria for Tier 2.2 are shown in Figure 4-10

Figure 4-1. Application of assessment criteria to each sampling round for each individual well screen

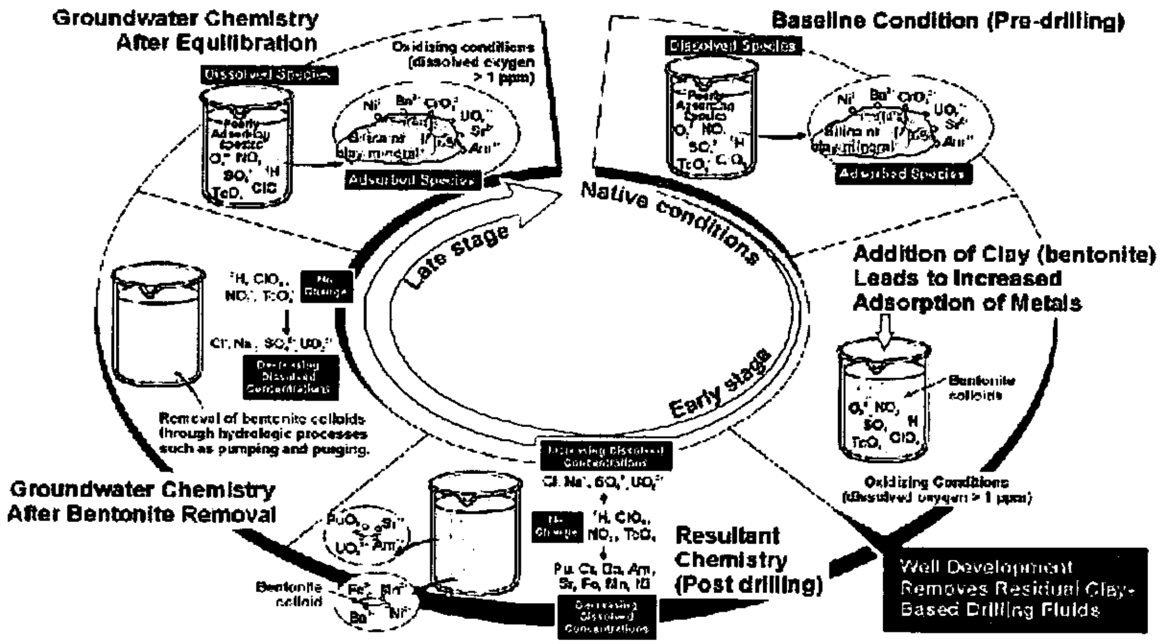


Figure 4-2. **Effects of bentonite-based drilling fluids on groundwater chemistry**

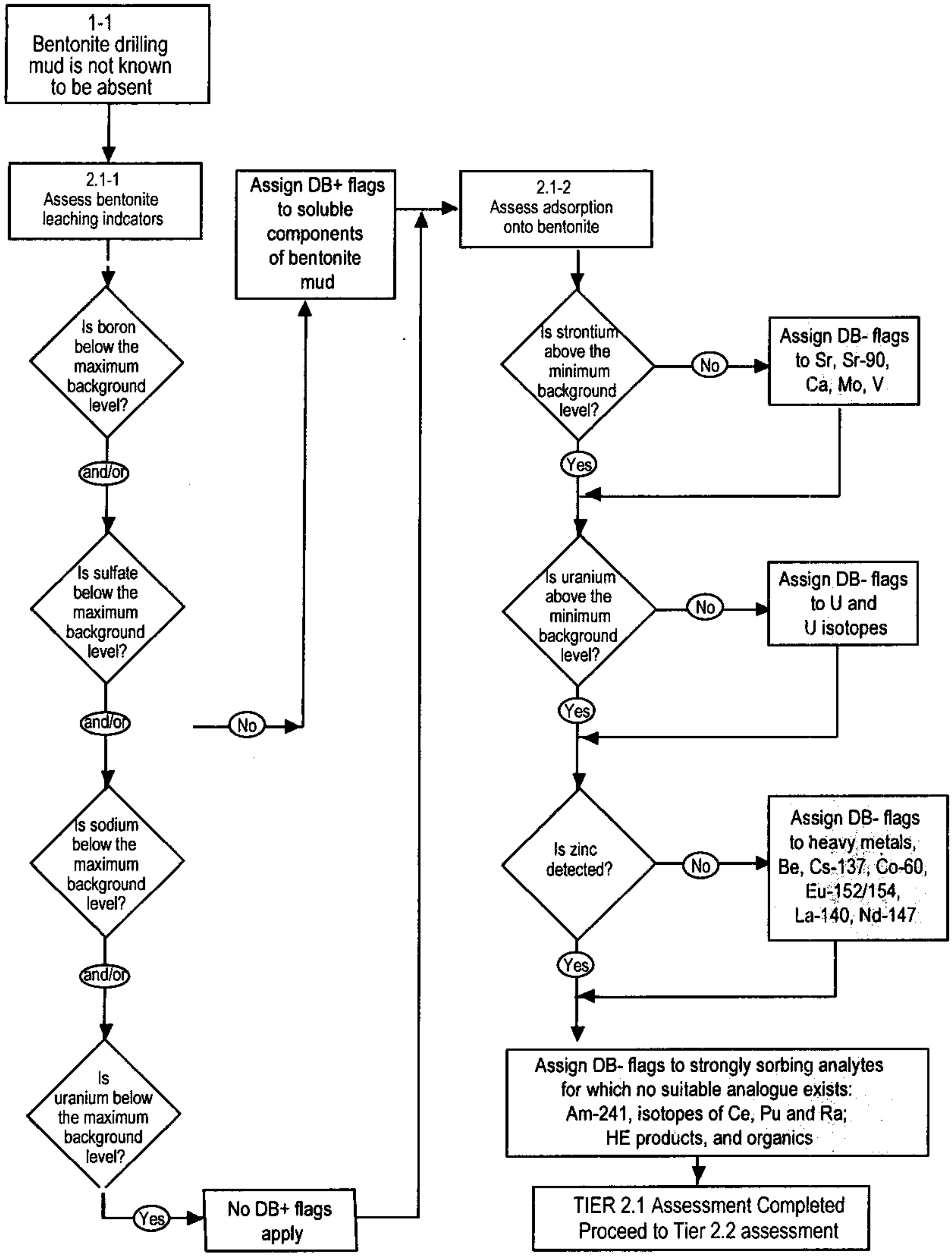


Figure 4-3. Application of assessment criteria for bentonite drilling mud (Tier 2.1)

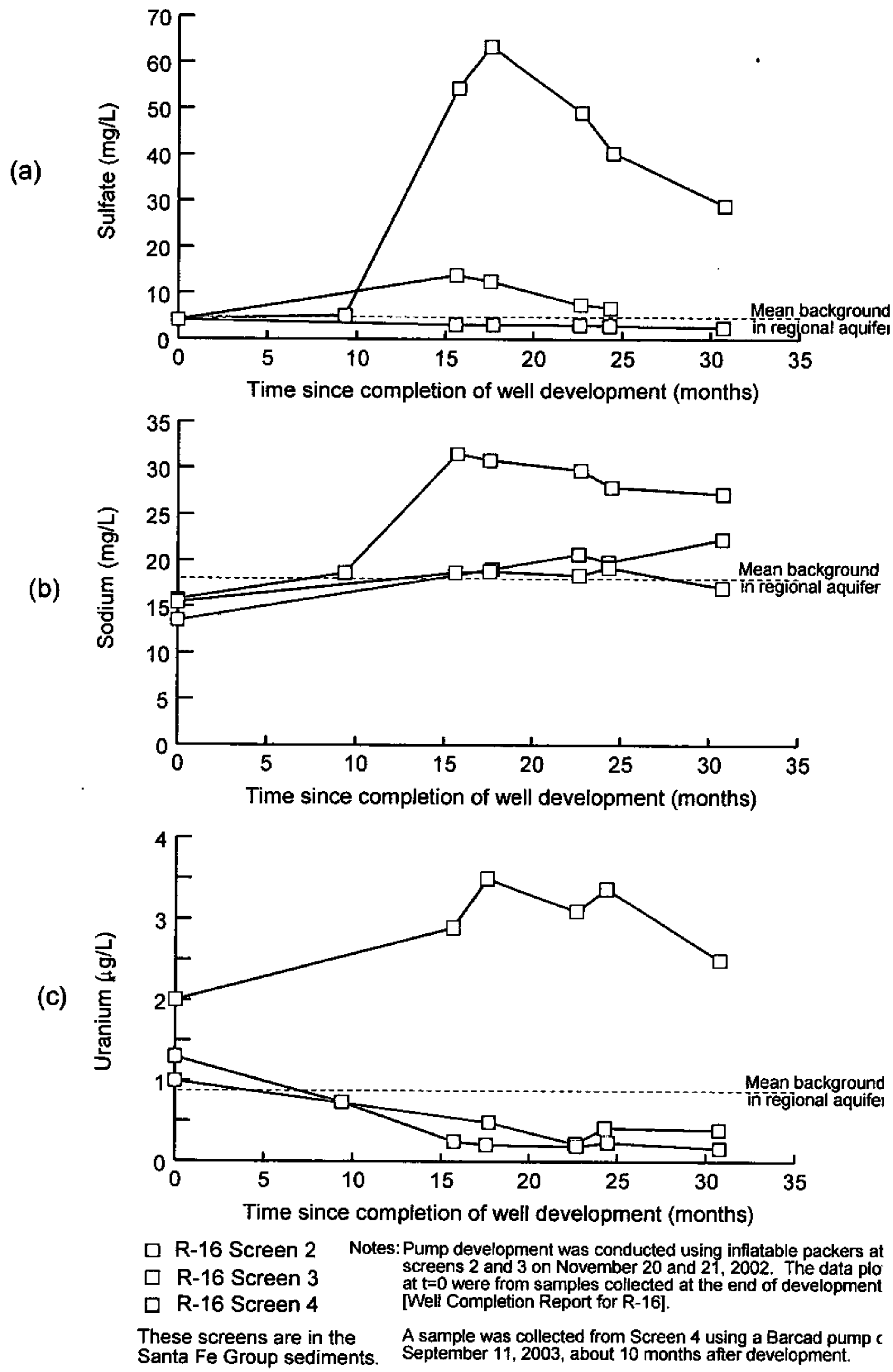


Figure 4-4. Evolution of bentonite indicators in well R-16

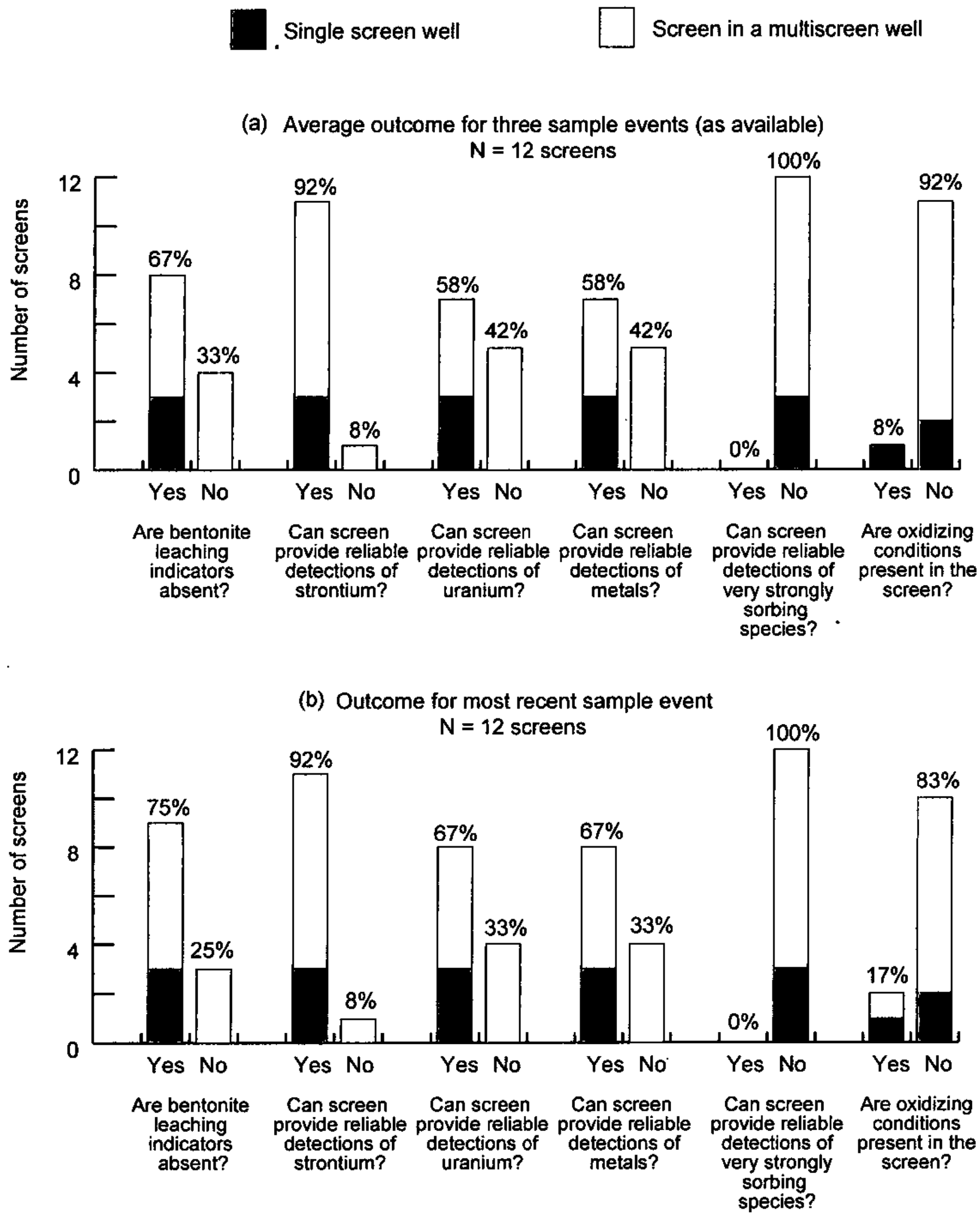


Figure 4-5. Impacts of residual bentonite drilling mud on water quality

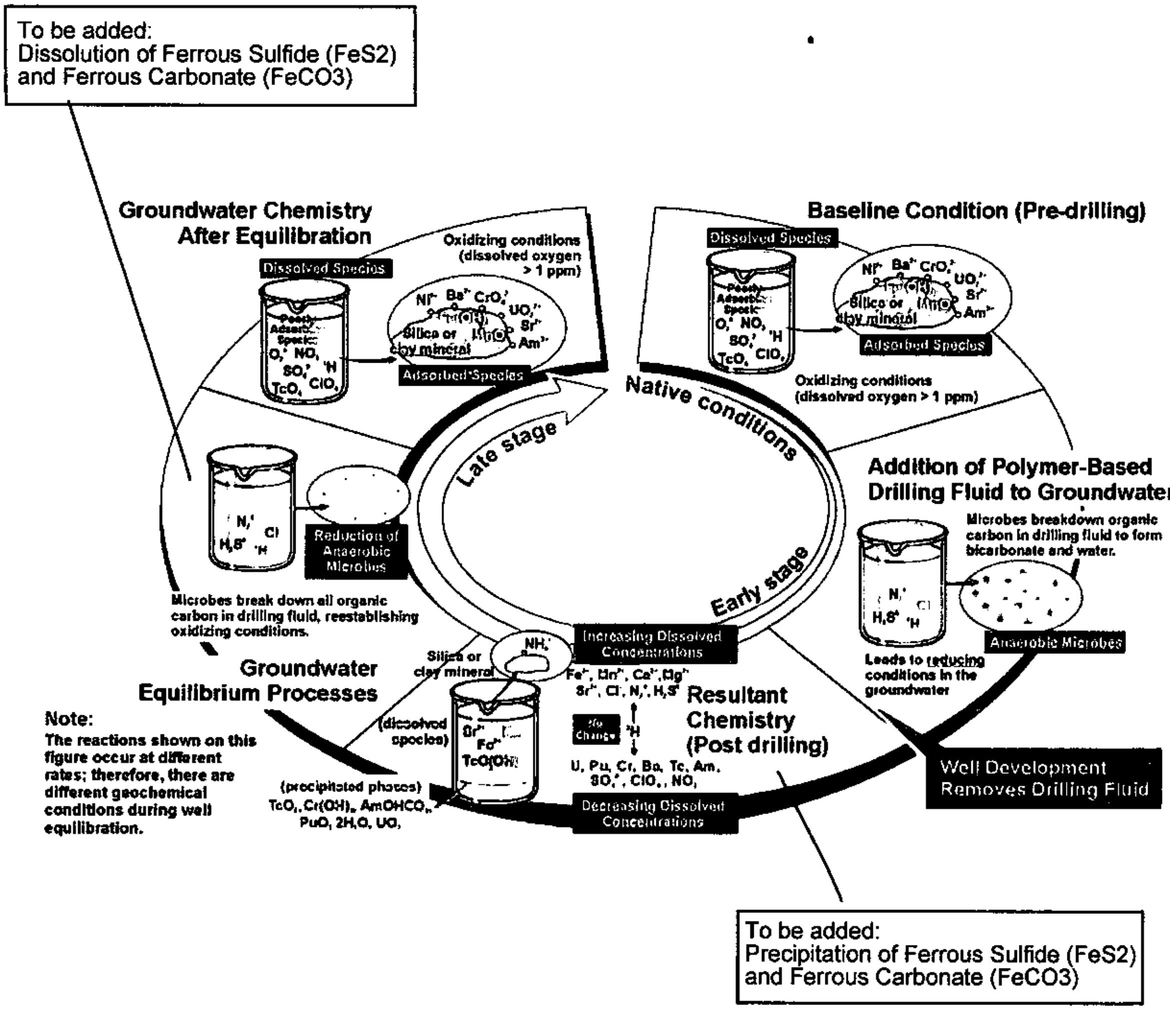


Figure 4-6. Effects of polymer-based drilling fluids on groundwater chemistry

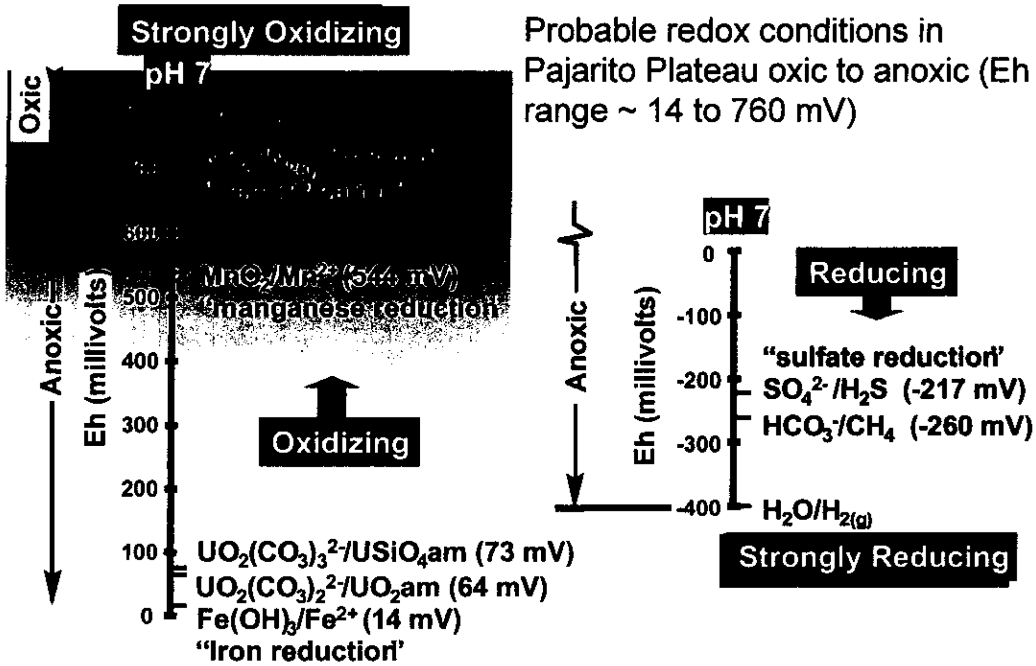


Figure 4-7(a). Selected Red ox Couples (at pH 7 and 25 C) for Pajarito Plateau and Surroundi ng Areas

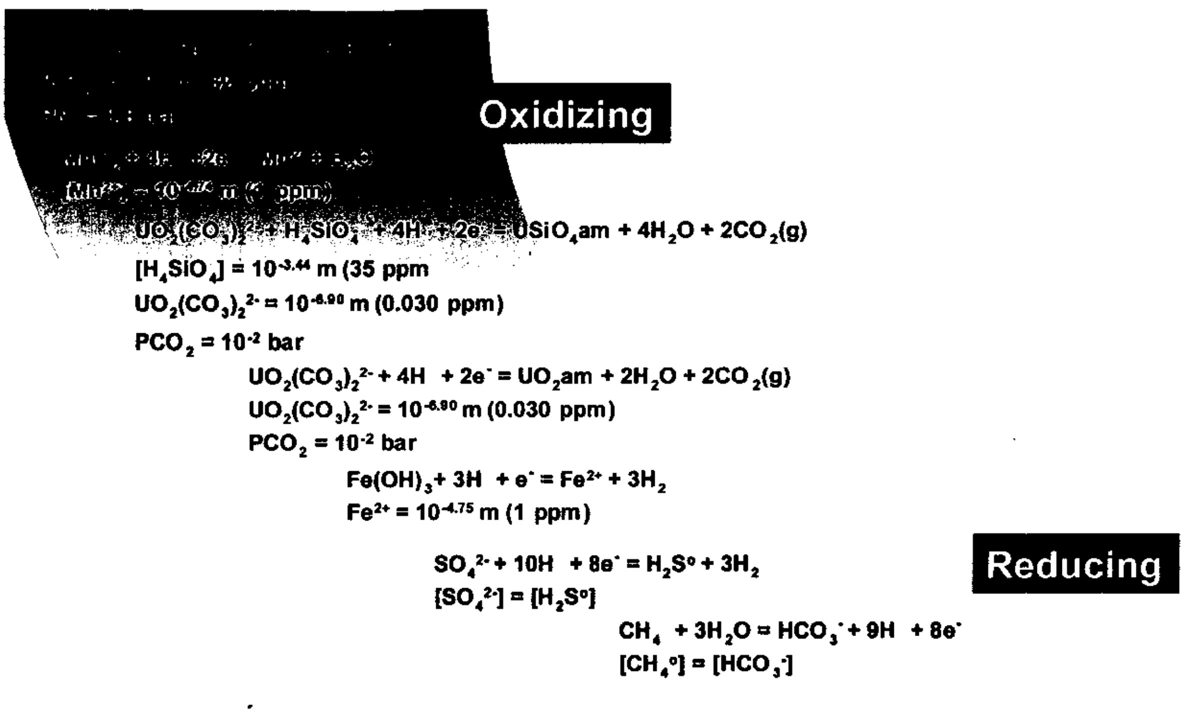


Figure 4-7(b). Selected Redox Couples (at pH 7 and 25 C) for Pajarito Plateau and Surroundi ng Areas

Figure 4-7. Selected redox couples (at pH 7 and 25 C) for Pajarito Plateau and surrounding areas

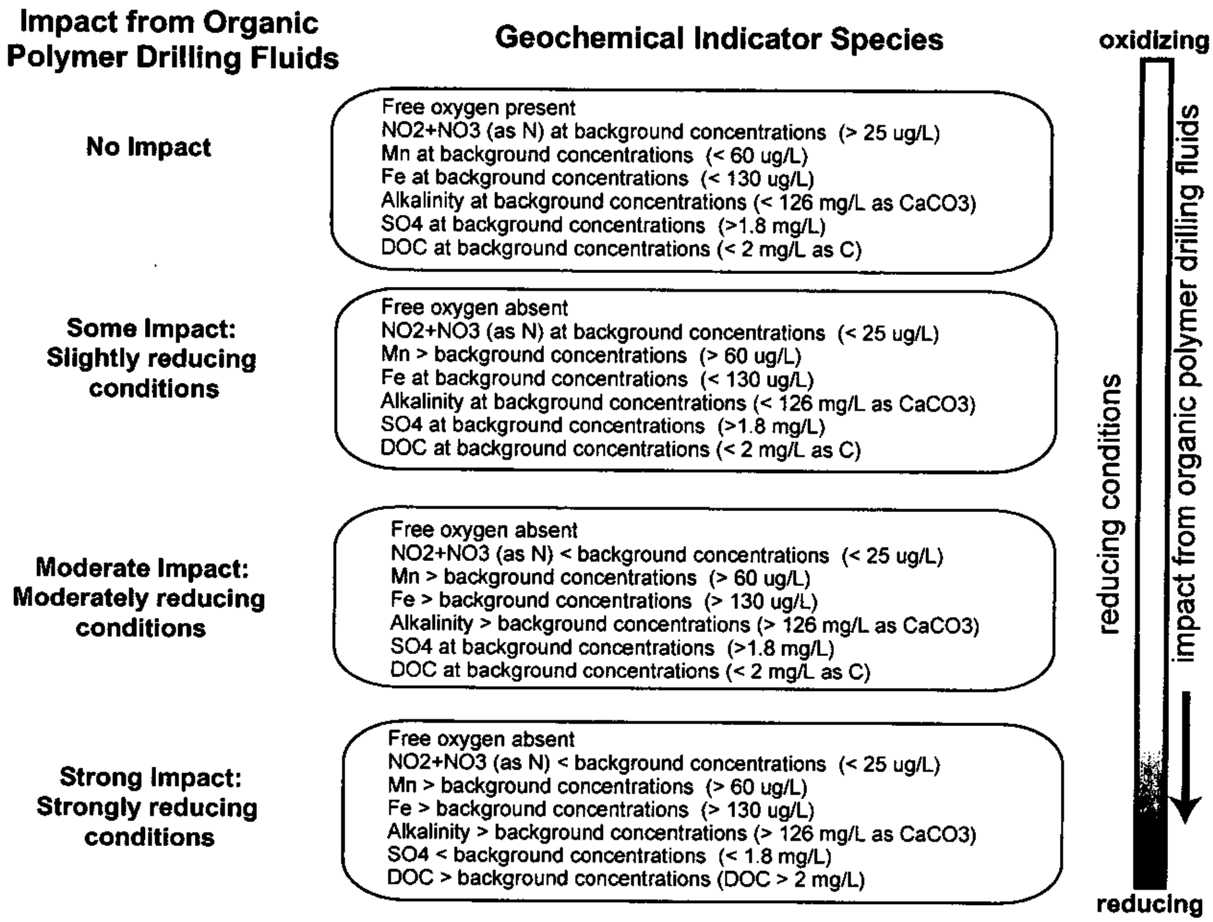


Figure 4-8. Redox criteria for assessing screens

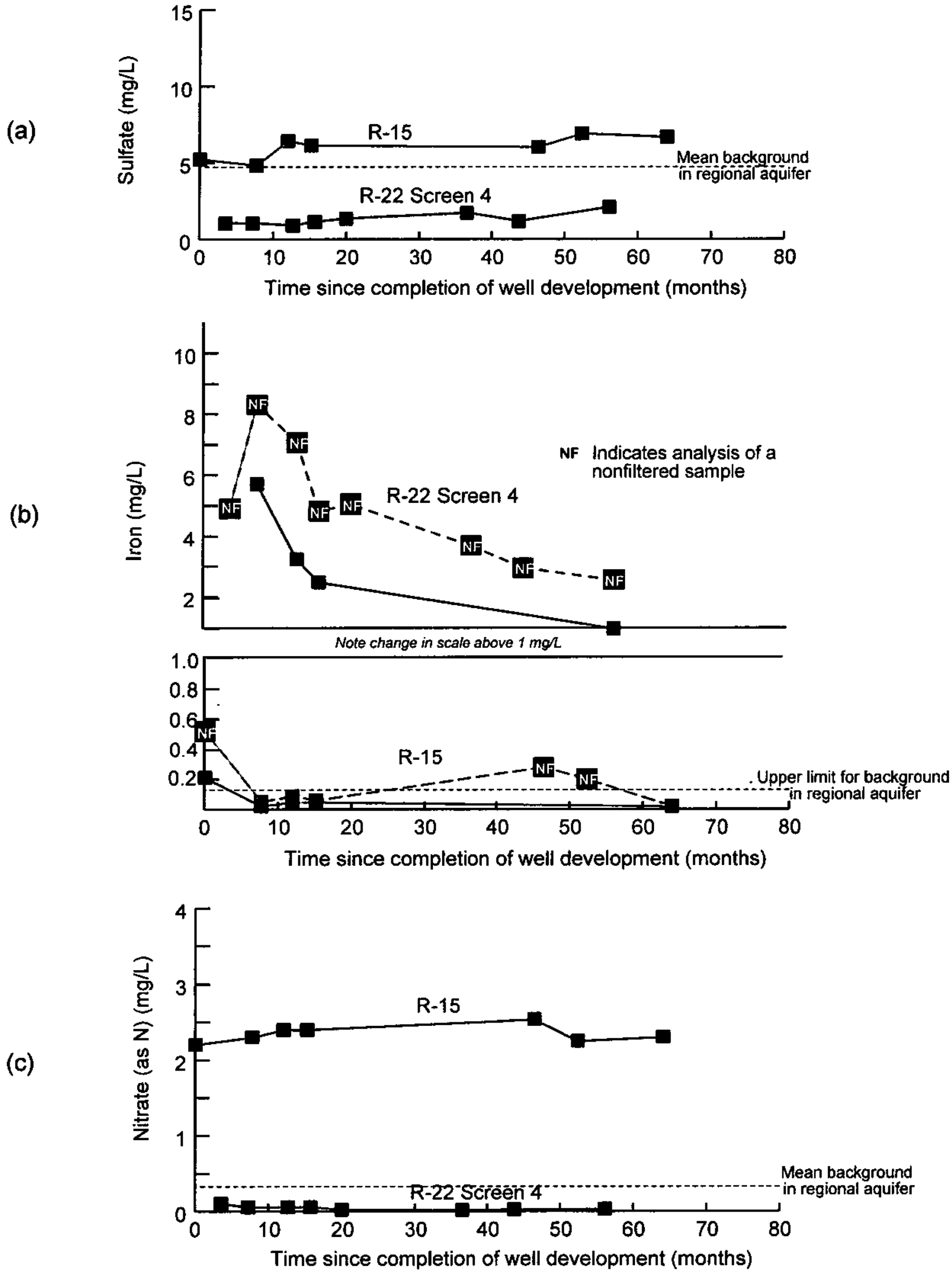


Figure 4-9. Evolution of redox indicators in wells R-15 and R-22

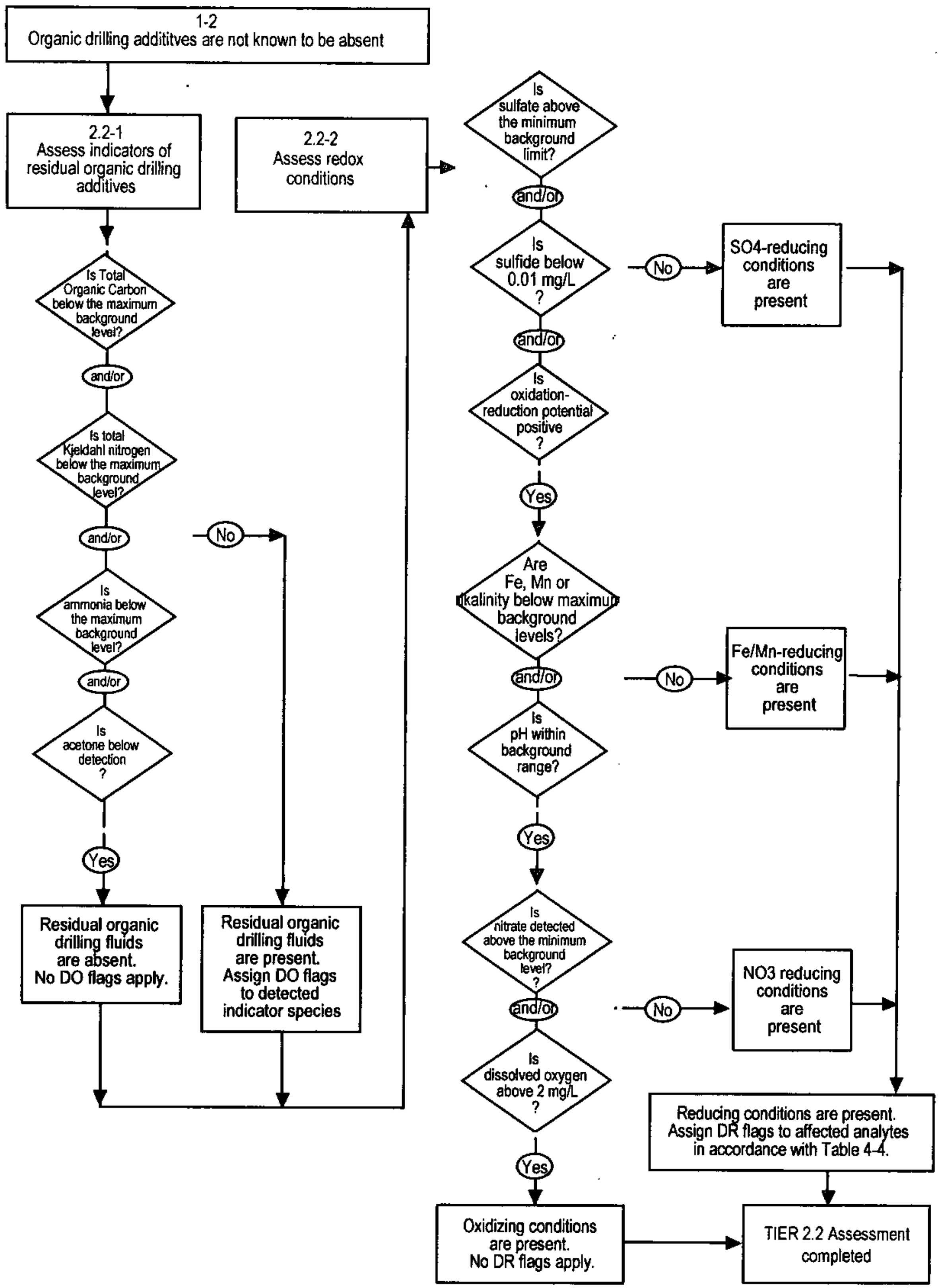


Figure 4-10. Application of assessment criteria for residual organic drilling fluids (Tier 2-2)

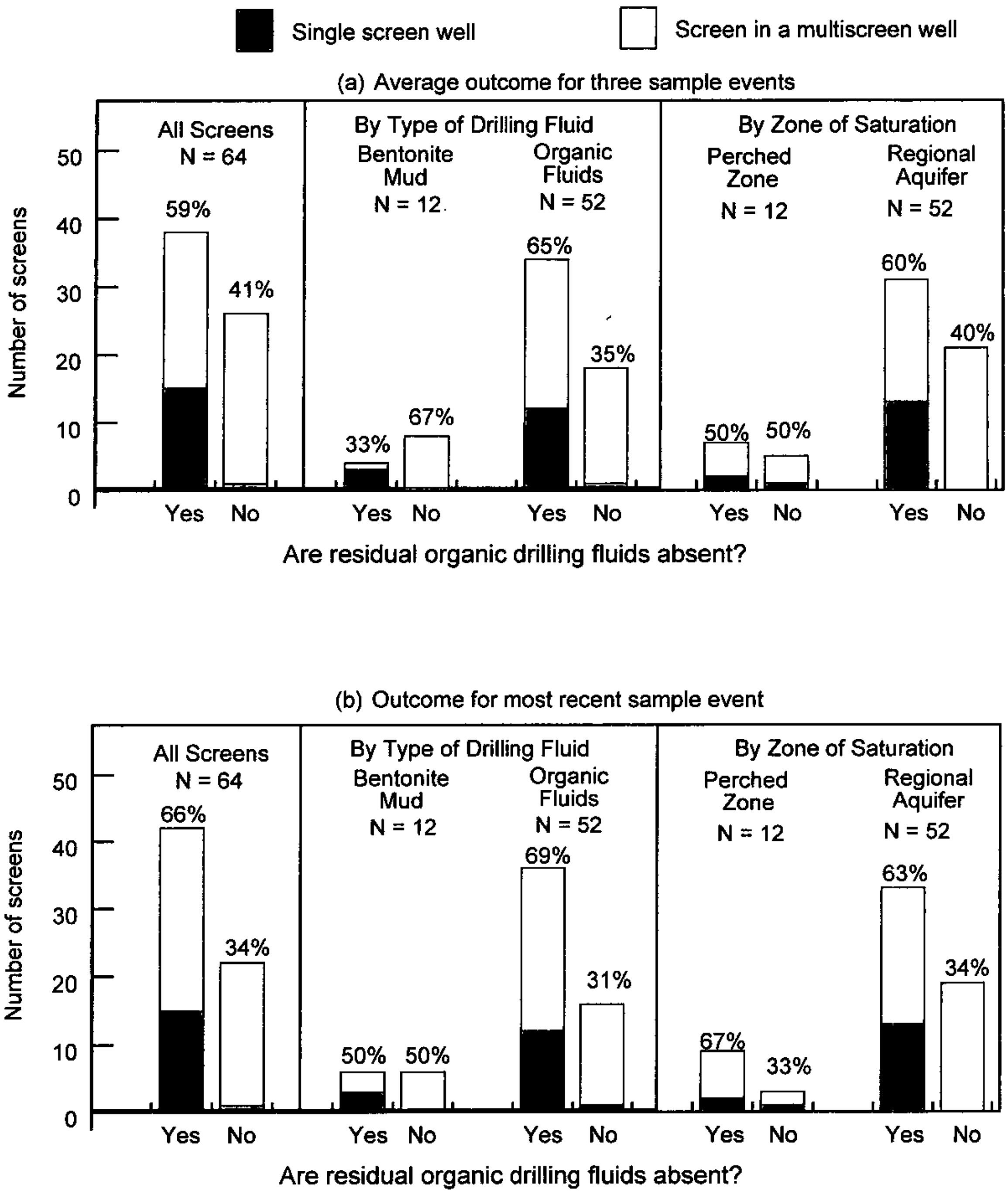


Figure 4-11. Residual organic drilling fluids in water samples

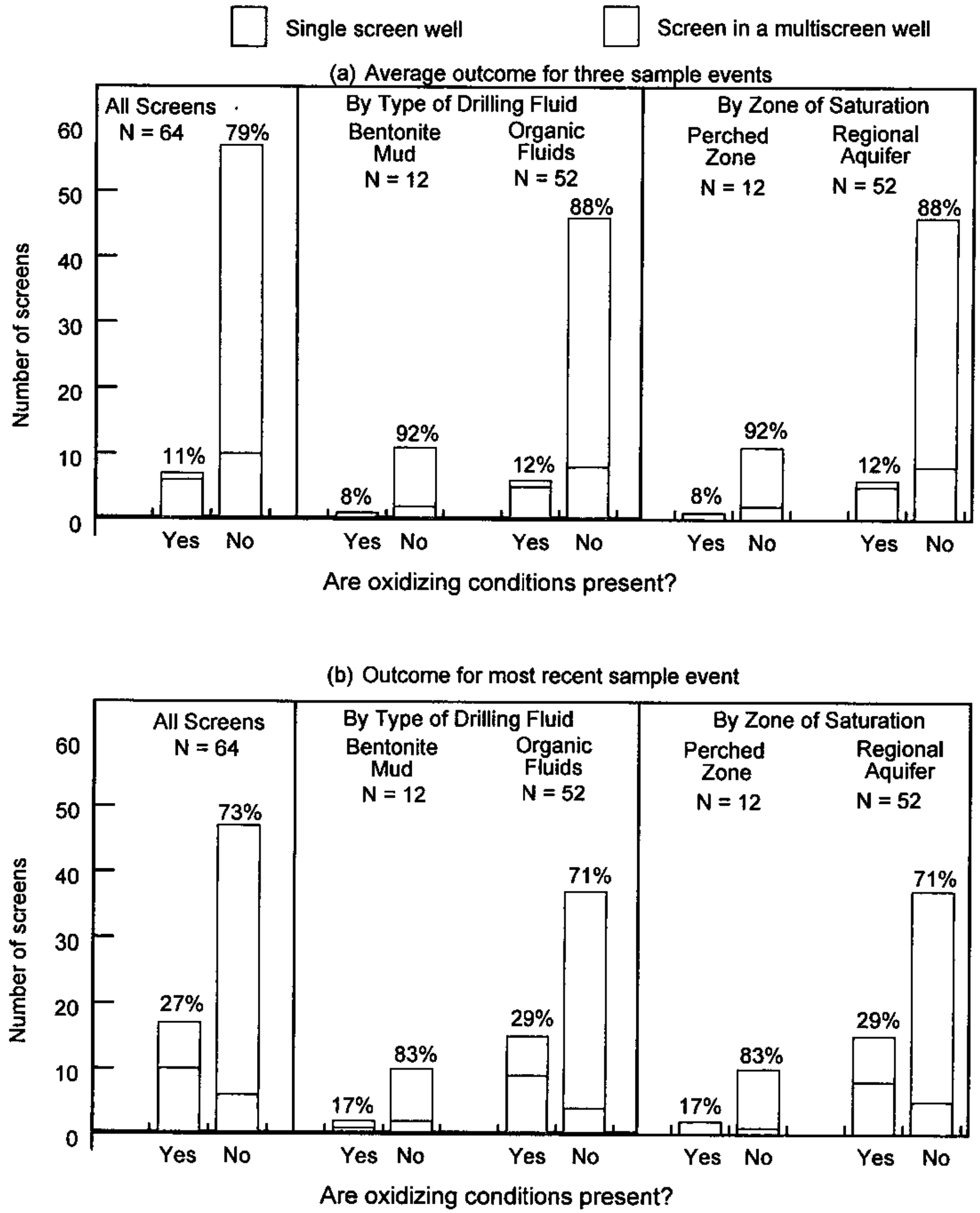
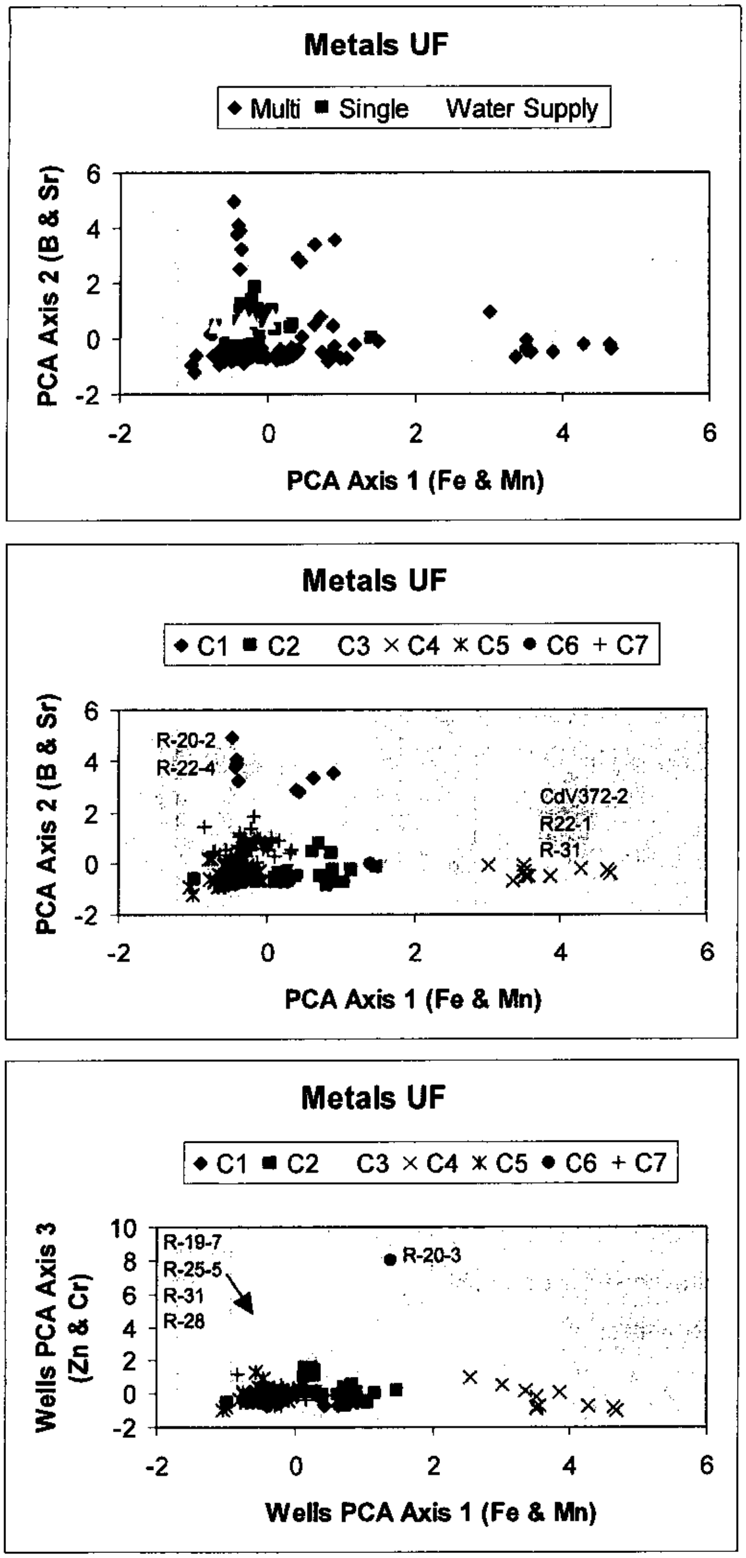


Figure 4-12. Redox conditions in water samples



Many samples from single screen-wells show compositions consistent with water supply wells. Multiscreen wells show significant differences from supply wells.

Interpretation:

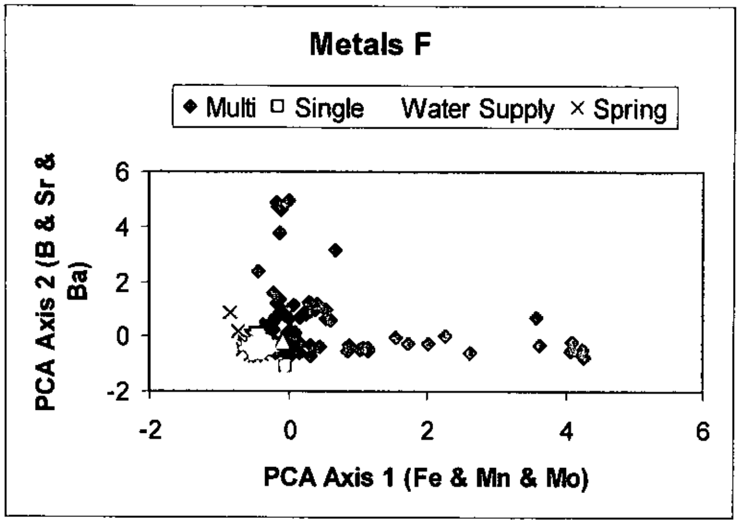
C5 = Consistent with White Rock Canyon springs or existing water-supply wells

C7 = Possible to slight impacts

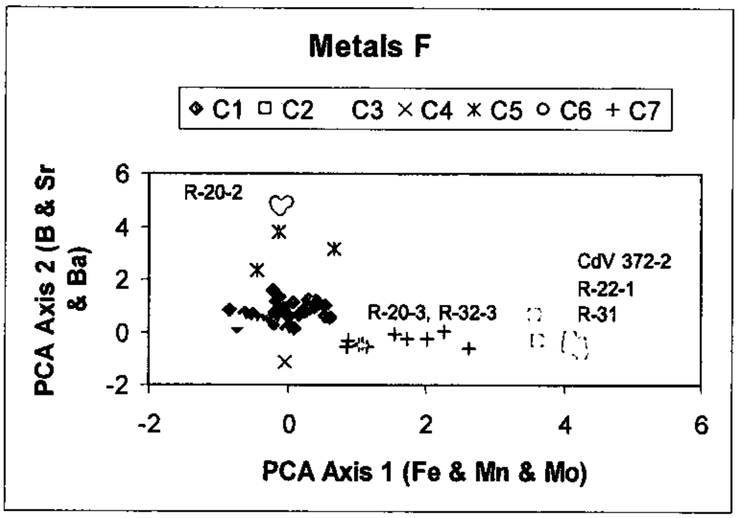
C2, C3 = Moderate impacts

C1, C4, C6 = Significant impacts

Figure 5-1. Principal component analysis of metals based on non-filtered water samples



Water supply wells consistent with springs, indicating minimal or no residual drilling impacts. Many single-screen wells consistent with springs and water-supply wells.



Interpretation:

C3 = Consistent with White Rock Canyon springs or existing water-supply wells

C1 = Possible to slight impacts

C5, C7 = Moderate impacts

C2, C4, C6 = Significant impacts

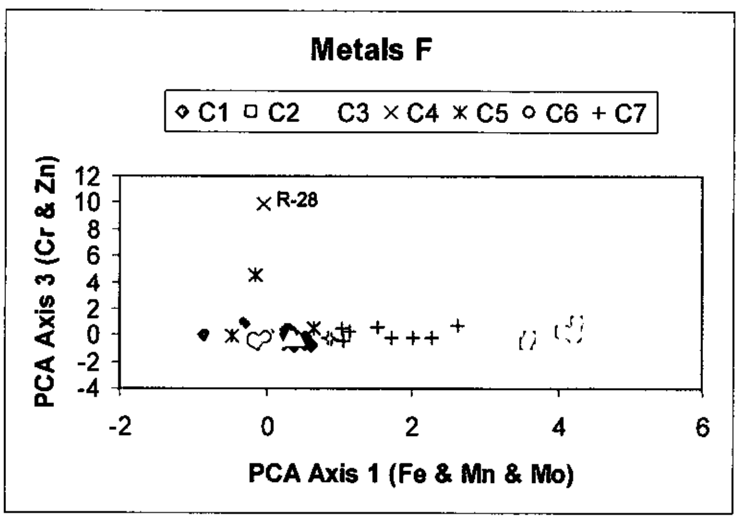
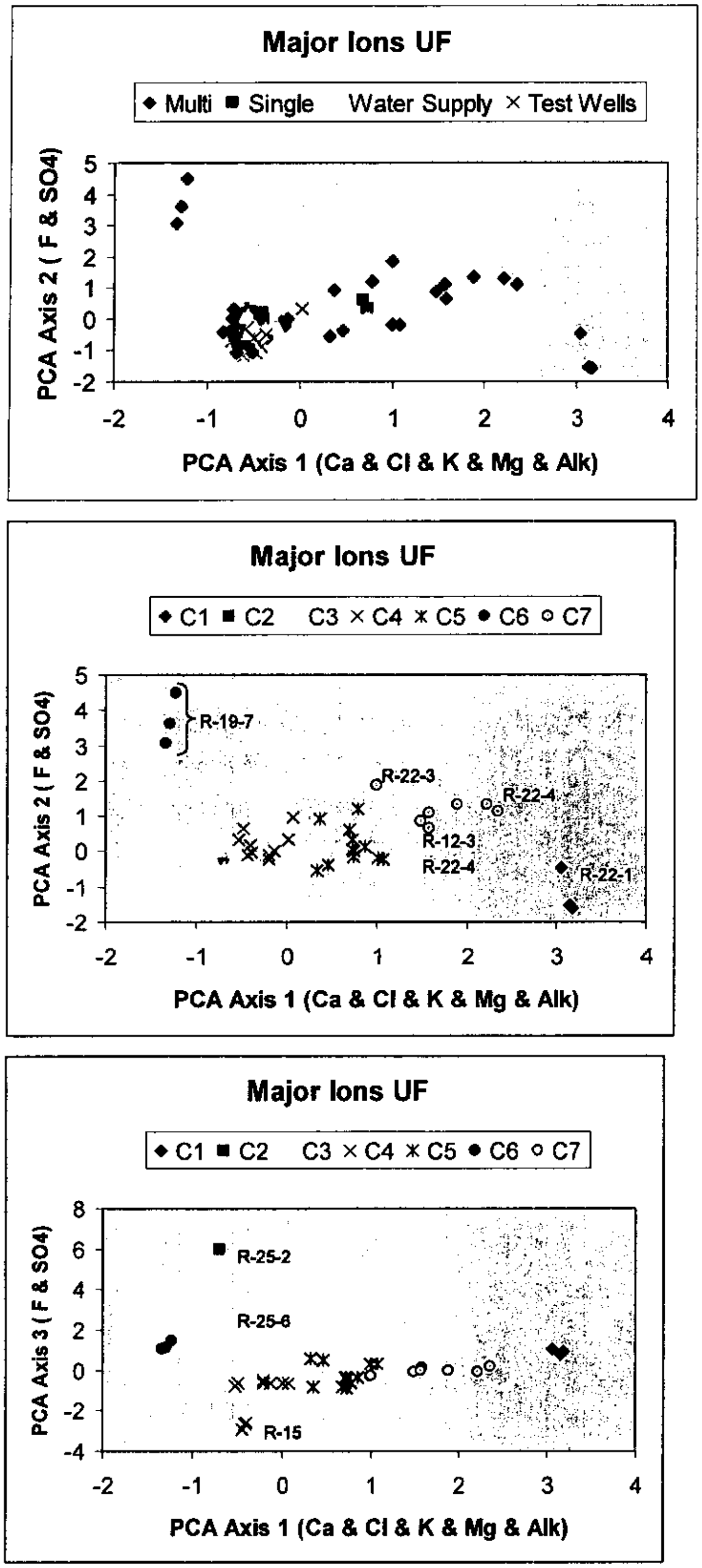


Figure 5.2. Principal component analysis of metals based on filtered water samples



The chemistries of test wells are consistent with those water supply wells. Most single-screen wells plot within chemistries represented by test and water supply wells.

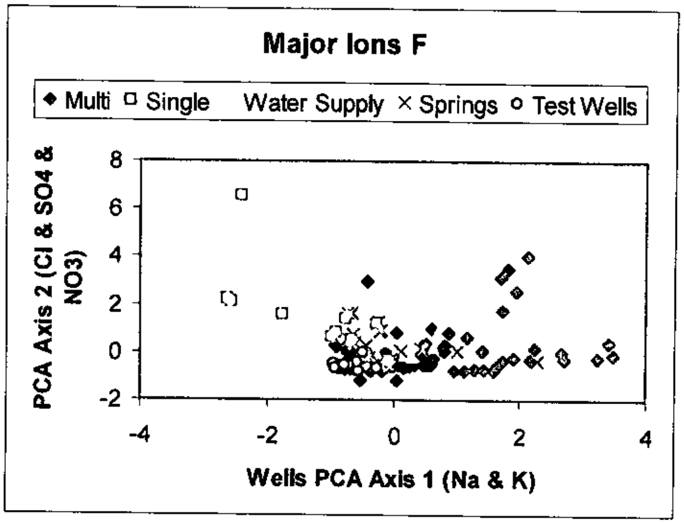
Interpretation:

C3 = Consistent with White Rock Canyon springs or existing wells

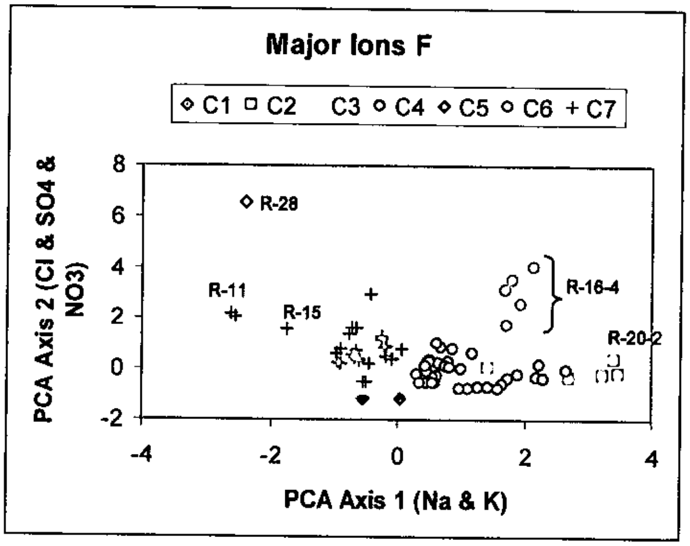
C4 = Possible or slight impacts C5, C7 = Moderate impacts

C1, C2, C6 = Significant impacts

Figure 5-3. Principal component analysis of major ions based on non-filtered water samples



Tight grouping of test well, water supply and springs samples. Most single-screen wells consistent with these "baseline" stations. A few single-screen wells show elevated nitrate concentrations, which do not appear to be drilling related.



Interpretation:

C3 = Consistent with White Rock Canyon springs or existing wells

C7 = Possible or slight impacts

C4 = Moderate impacts

C1, C2, C5, C6 = Significant impacts

R-11 and R-15 show elevated NO_3 concentrations which do not appear to be drilling related. C7 appears to reflect natural chemical variability within aquifer, rather than drilling impacts.

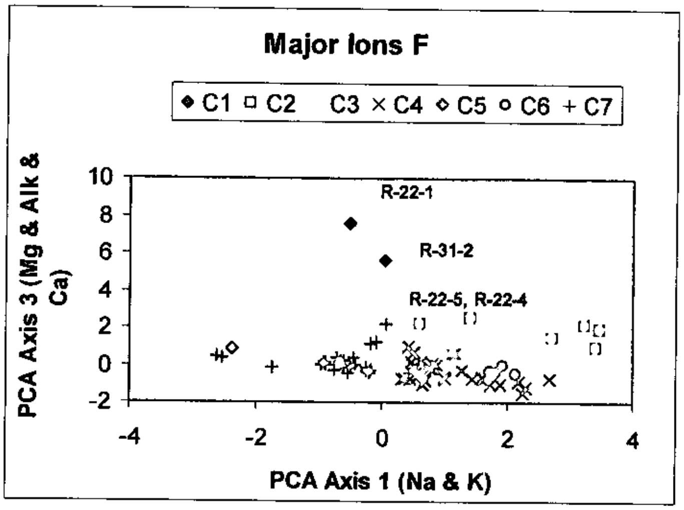


Figure 5-4. **Principal component analysis of major ions based on filtered water samples**

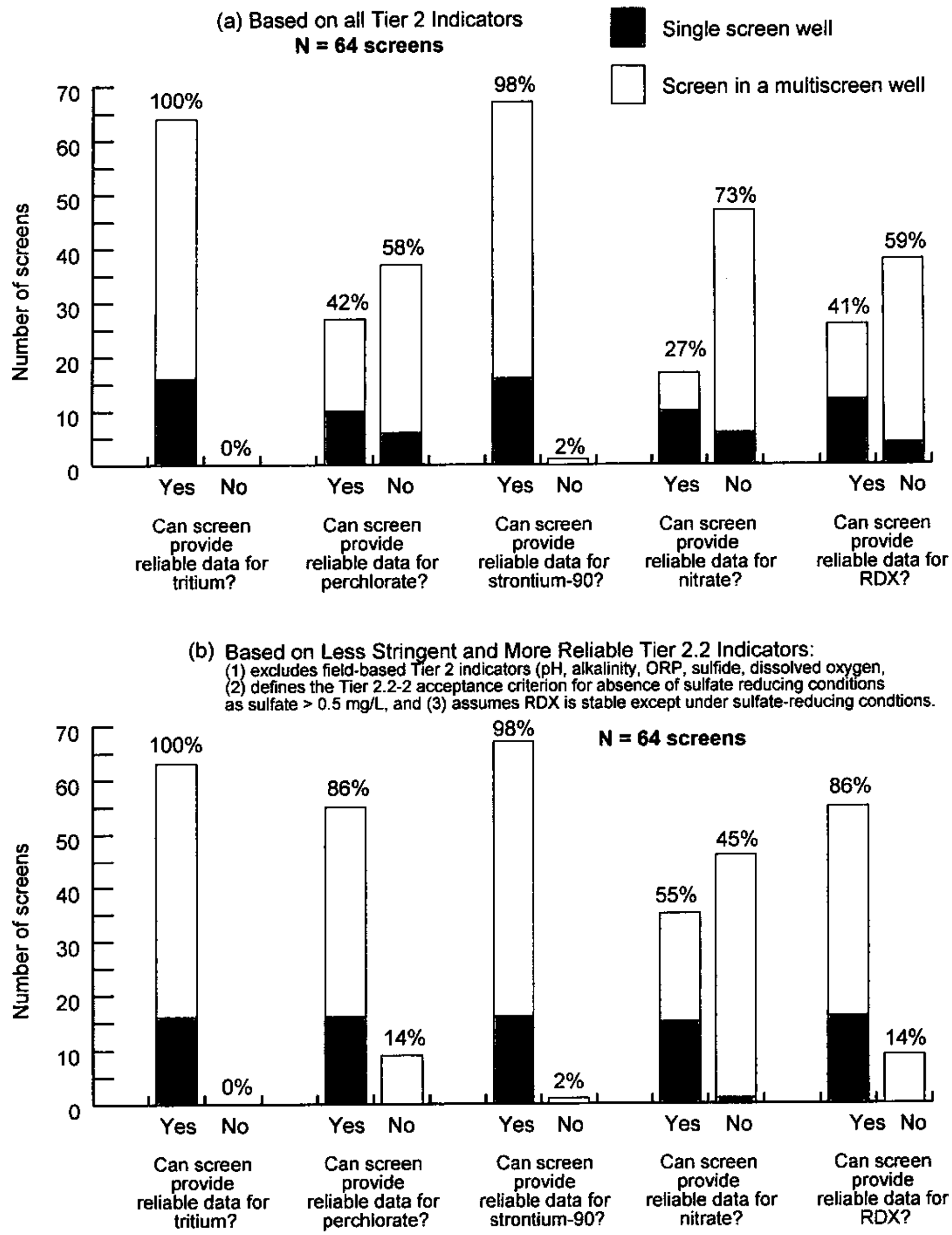


Figure 6-1. Ability of screen to provide reliable and representative water-quality data for tritium, perchlorate, strontium-90, Nitrate, and RDX: (a) based on all Tier 2 Indicators, and (b) using less stringent and more reliable Indicators, for the most recent sample. (Data source: results tabulated in appendix Tables E-1 and E-2)

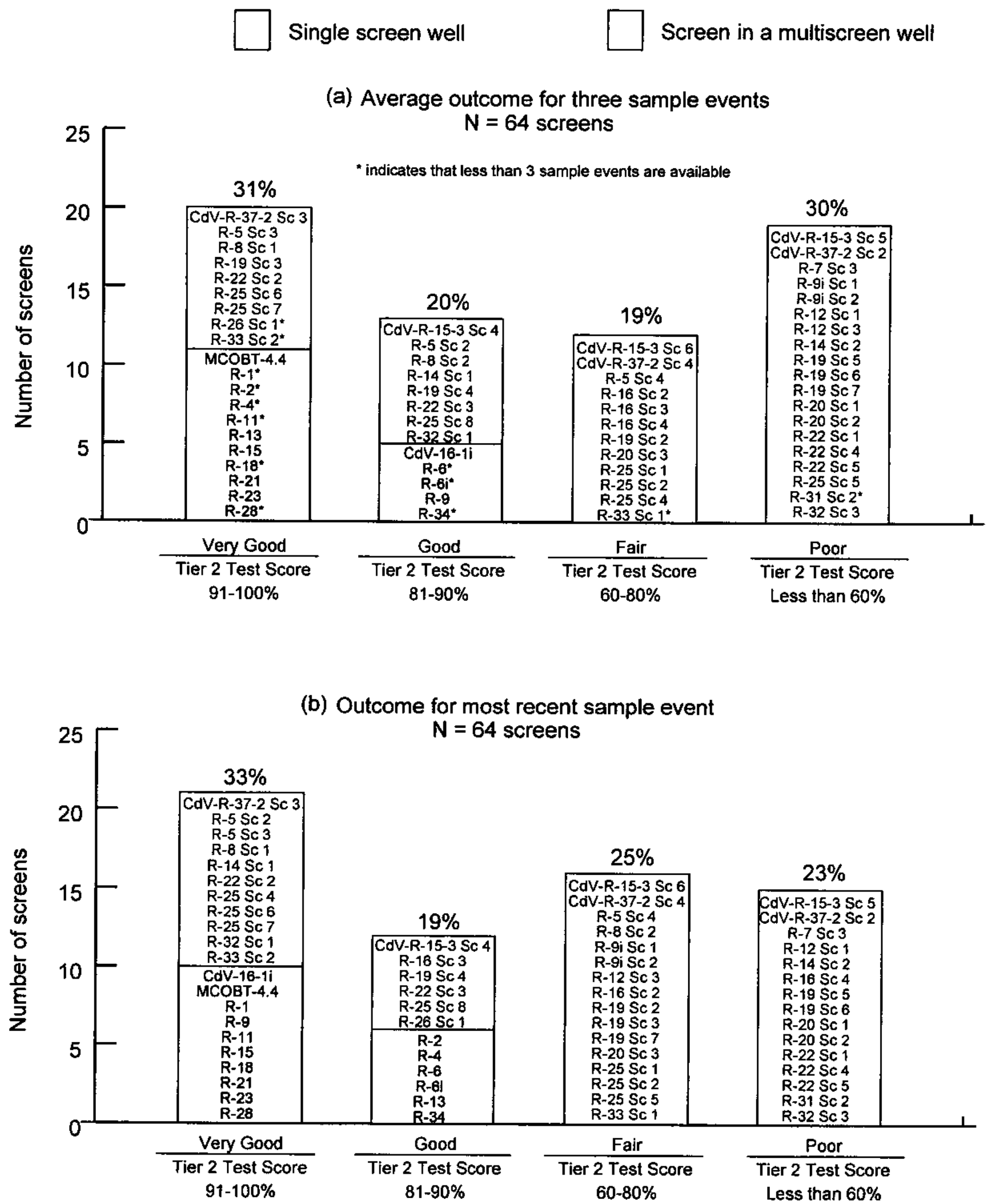


Figure 6-2. **Overall condition of screens for producing reliable and representative water-quality samples: (a) average outcome for three samples, (b) outcome for most recent sample**

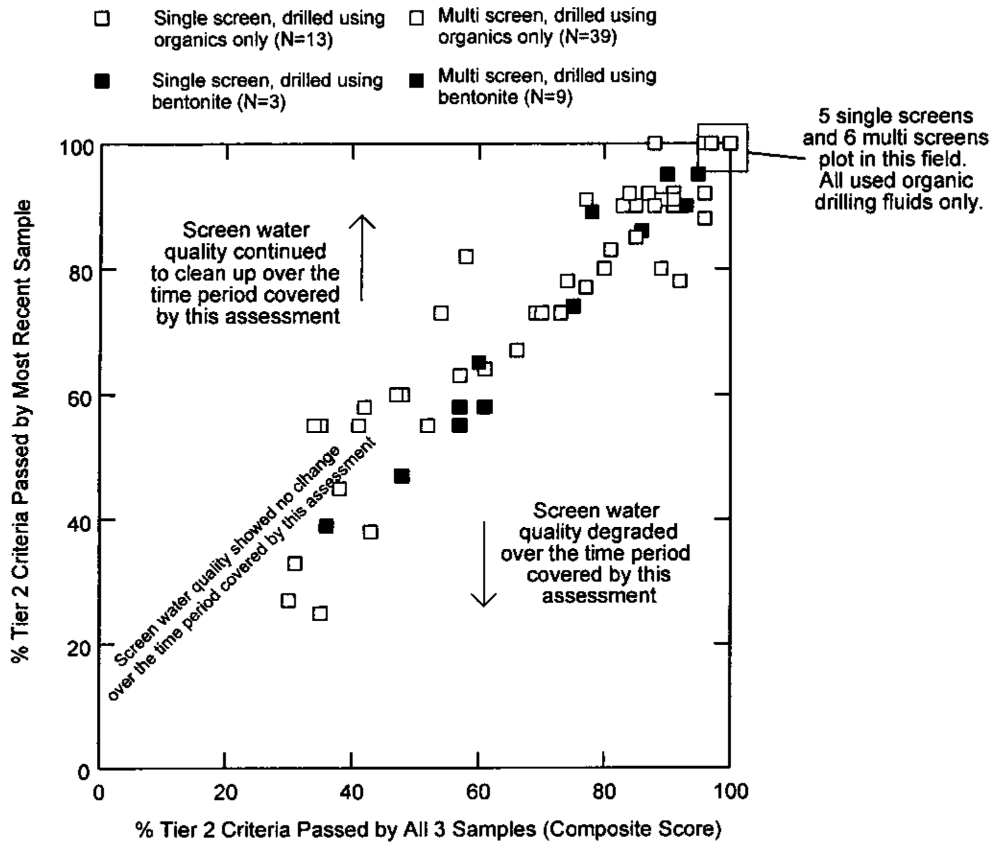


Figure 6-3. **Comparison between composite Tier 2 outcome for 3 samples and the outcome for the most recent sample, for single and multi-screen wells as a function of drilling method**

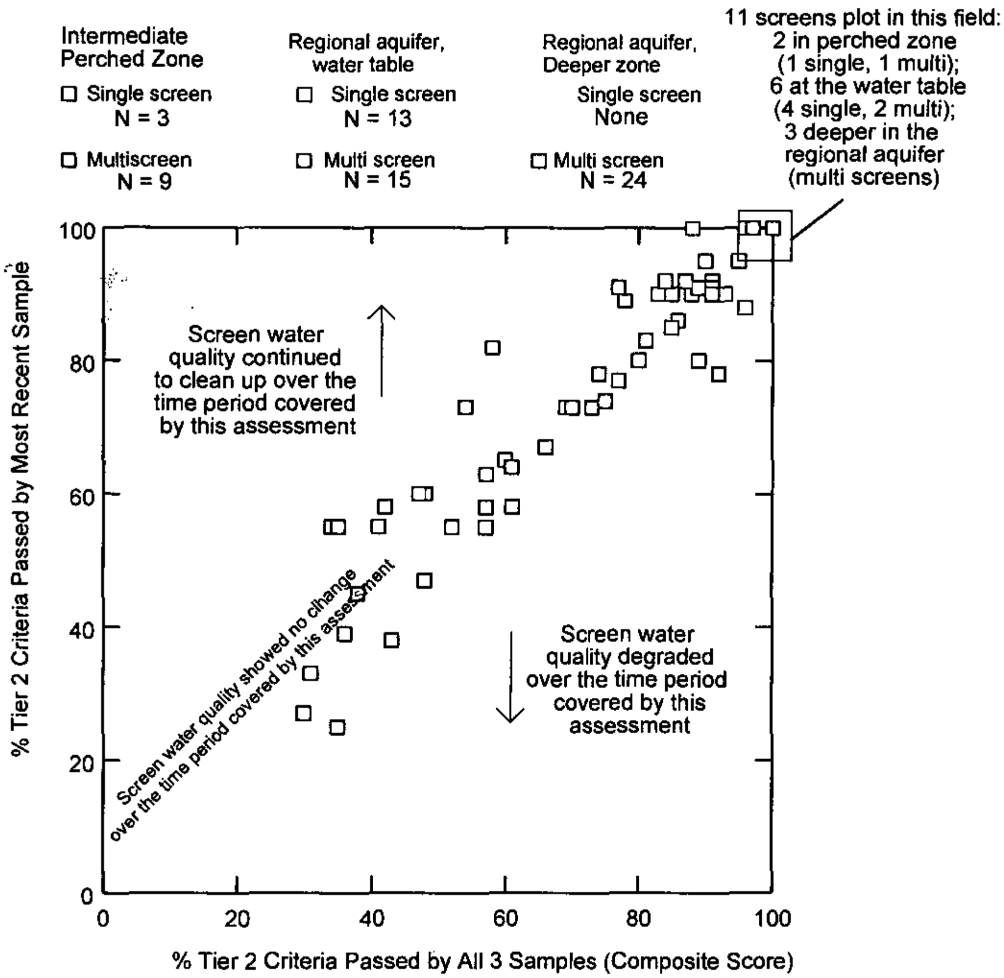


Figure 6-4. Comparison between Composite Tier 2 Outcome for 3 Samples and the Outcome for the Most Recent Sample, for single and mutli-screen wells as a function of zone of saturation

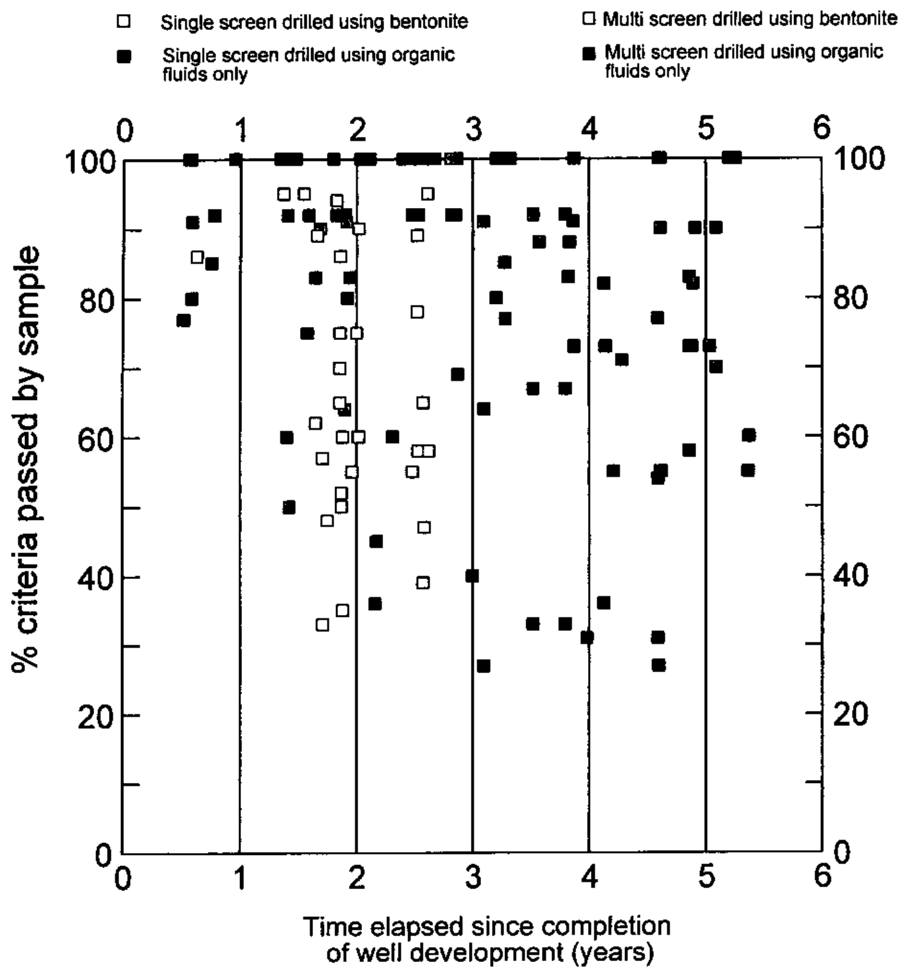


Figure 6-5. **Presence of residual drilling impacts on water quality as a function of time elapsed since completion of well development**

Table 2-1
Primary Potential Contaminants of Concern for Individual Wells

Well	Watershed	TA	Potential Contaminants in Watershed*
CdV-16-1(i)	Upper Water Canyon and Cañon de Valle	TA-16	HE compounds, barium, copper, lead, nitrate, perchlorate, organic compounds
CdV-R-15-3	Upper Water Canyon and Cañon de Valle	TA-15	HE compounds, barium, copper, lead, nitrate, perchlorate, organic compounds
CdV-R-37-2	Upper Water Canyon and Cañon de Valle	TA-37	HE compounds, barium, copper, lead, nitrate, perchlorate, organic compounds
MCOBT-4.4	Mortandad/Ten Site	TA-5	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241
R-1	Mortandad	TA-54	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241, technetium-99
R-2	Pueblo	TA-74	Nitrate, plutonium-239/240, metals (e.g., mercury), tritium, perchlorate, uranium
R-4	Pueblo	Los Alamos	Nitrate, plutonium-239/240, metals (e.g., mercury), tritium, perchlorate, uranium
R-5	Pueblo	TA-74	Nitrate, plutonium-239/240, metals (e.g., mercury), tritium, perchlorate, uranium
R-6	Los Alamos	TA-53	Tritium, cesium-137, strontium-90, nitrate, uranium, perchlorate, molybdenum
R-6i	Los Alamos	TA-53	Tritium, cesium-137, strontium-90, nitrate, uranium, perchlorate, molybdenum
R-7	Los Alamos	TA-53	Tritium, cesium-137, strontium-90, nitrate, uranium, perchlorate
R-8	Los Alamos	TA-72	Tritium, cesium-137, strontium-90, nitrate, uranium, perchlorate, molybdenum
R-9	Los Alamos	TA-72	Tritium, cesium-137, strontium-90, nitrate, uranium, perchlorate
R-9i	Los Alamos	TA-72	Tritium, cesium-137, strontium-90, nitrate, uranium, perchlorate
R-11	Sandia Canyon	TA-5	Tritium, nitrate, perchlorate, uranium, plutonium
R-12	Sandia Canyon	TA-72	Tritium, nitrate, perchlorate, uranium, plutonium
R-13	Mortandad	TA-5	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241
R-14	Mortandad	TA-5	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241, barium, lanthanides
R-15	Mortandad	TA-5	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241, lanthanides
R-16	Cañada del Buey	White Rock Overlook	Tritium, County Sewage Treatment Plant effluent (nitrate, sulfate, metals)
R-18	Pajarito	TA-14	Metals, radionuclides, HE, VOCs, nitrate, perchlorate
R-19	Pajarito/Three-mile	TA-36	HE, VOCs

Table 2-1 (continued)

Well	Watershed	TA	Potential Contaminants in Watershed*
R-20	Pajarito	TA-36	Metals, radionuclides, HE, VOCs, nitrate, perchlorate
R-21	Cañada del Buey	TA-54	Tritium, VOCs
R-22	Pajarito (mesa above canyon)	TA-54	Tritium, metals, radionuclides, VOCs, nitrate, perchlorate
R-23	Pajarito	TA-36	Metals, radionuclides, HE, VOCs, nitrate, perchlorate
R-25	Cañon de Valle (mesa above canyon)	TA-16	HE, barium, solvents, perchlorate
R-26	Cañon de Valle	TA-16	HE, barium, solvents, perchlorate
R-28	Mortandad	TA-5	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241, lanthanides, molybdenum-99
R-31	Ancho	TA-39	HE, radionuclides, metals, tritium
R-32	Pajarito	TA-36	Metals, radionuclides, VOCs, nitrate, perchlorate
R-33	Mortandad/Ten Site	TA-5	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241. lanthanides
R-34	Mortandad (Cedro)	San Ildefonso	Tritium, nitrate, perchlorate, uranium, plutonium, cesium-137, strontium-90, americium-241, lanthanides

* References: ES-PPP (2005); Hydrogeologic Workplan (LANL 1998, 59599)

Table 4-1
Tier 1 Questions and Criteria for Effects of Residual Drilling Materials

Tier 1 Issue: **Does the screen interval produce groundwater samples that are free of any residual effects from drilling fluids or muds, and that are reliable and representative of the groundwater*?**

Note: The assessment criteria in this table are applicable to the three most recent characterization and/or surveillance samples for the screen. If less than three samples are available for this purpose, then the outcome is considered "Preliminary."

Tier	Screening Question	Assessment Criteria	Consequence of "NO" response
1-1	Is residual bentonite mud known to be absent from the screen interval?	If the well was not drilled using bentonite mud, answer YES. If the well was drilled using bentonite mud, answer NO.	If NO, then tier 2.1 questions are applicable to identify the extent to which analytes or PCOCs may be affected by residual bentonite.
1-2	Is residual organic drilling fluid known to be absent from the screen interval?	If the well was not drilled using organic drilling fluids, answer YES. If the well was drilled using organic drilling fluids, answer NO.	If NO, then tier 2.2 questions are applicable to identify the extent to which analytes or PCOCs may be affected by residual organic drilling fluids or reducing conditions.
If the answer is YES for both questions, then it is concluded that the screen interval produces groundwater samples that are representative of predrilling conditions for all analytes and PCOCs. **It is not necessary to proceed to either of the Tier 2 sets of questions.**			

* In this report, "groundwater" refers only to water from perched intermediate zones or the regional aquifer. The methodology used in this report is not applicable to water from alluvial zones.

Table 4-2
Background Values for Key Indicator Species Used in this Assessment

Analyte	Units	Regional Aquifer			Intermediate Perched Zones			Used as Tier Criterion*
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	
Field parameters								
Field alkalinity (as $CaCO_3$)	mg/L	54	128	86	28	53	44	2.2-3
Field pH	SU	6.5	8.3	7.6	6.7	8.0	7.4	2.2-3
General Inorganics								
Carbon, Total Organic (TOC)	mg/L	0.27	0.60	0.42	0.47	0.69	0.55	2.2-1
Nitrogen, Ammonia (as N)	mg/L	0.25	1.10	0.35	0.25	0.265	0.25	2.2-1
Nitrogen, Nitrate and Nitrite as N (NO_3+NO_2-N)	mg/L	0.025	0.91	0.32	0.001	0.5	0.3	2.2-4
Nitrogen, Total Kjeldahl (TKN)	mg/L	0.05	0.35	0.20	0.05	0.43	0.18	2.2-1
Sodium	mg/L	9.4	31	18	4.4	36	9.2	2.1-1
Sulfate	mg/L	1.8	17.2	4.7	0.95	11.3	4.4	2.1-1, 2.2-2
Metals								
Boron	µg/L	4.6	51	23	1	13	7.4	2.1-1
Iron	µg/L	3.65	131	27	3.65	1560	170	2.2-3
Manganese	µg/L	0.025	57	4.7	0.05	9	2.4	2.2-3
Strontium	µg/L	42	510	192	42	164	76	2.1-2a
Uranium	µg/L	0.195	2.8	0.88	0.11	0.84	0.31	2.1-1, 2.1-2b
Zinc	µg/L	0.26	80	13	0.26	33	5.3	2.1-2c

SU=standard units, pH=-log[H+]

*Tier criteria are discussed in sections 4.4.2 and 4.5.2.

Source of values: Groundwater Background Investigation Report (LANL 2005, 90580), Tables 4.2-3e (for perched intermediate zone) and 4.2-4e (for regional aquifer)

Table 4-3
Validation Flag Codes to Indicate that Analyte Concentrations may not be Reliable or Representative of Groundwater Predrilling Conditions

Flag	Definition	Applicable Tier
DB+	Analyte concentration may be elevated above that in predrilling groundwater due to leaching from bentonite drilling mud	2.1
DB-	Analyte concentration may be less than that in predrilling groundwater due to adsorption onto residual bentonite drilling mud	2.1
DB	[Uranium and uranium isotopes] Analyte concentration may not be the same as that in predrilling groundwater due to effects of residual bentonite drilling mud, but nature of effect is indeterminate	2.1
DO+	Analyte concentration may be elevated above that in predrilling groundwater due to presence of residual organic drilling fluids	2.2
DR+	Analyte concentration may be elevated above that in predrilling groundwater due to reducing conditions caused by residual organic drilling fluids	2.2
DR-	Analyte concentration may be less than that in predrilling groundwater due to reducing conditions caused by residual organic drilling fluids	2.2
DR	Analyte concentration may not be representative of that in predrilling groundwater due to reducing conditions caused by residual organic drilling fluids, but nature of effect is indeterminate	2.2

Table 4-4
Adsorption Behavior of Inorganic and Organic Species on Sodium-Bentonite Drilling Mud

Analytical Suite	Tables of Relevant Analytes and Sorption Parameters	Partition Coefficient (K_d)	
		Negligible Adsorption $K_d < 1$ mL/g	Possibly Significant Adsorption $K_d > 1$ mL/g*
General Inorganics	Table A-1 Table A-11 Table A-12	Bicarbonate alkalinity, bromide, chloride, fluoride, nitrate, perchlorate, sulfate	Ammonia, calcium, magnesium, phosphates, sodium
Metals	Table A-2 Table A-11 Table A-12	Arsenic, boron, chromate, molybdenate, nickel, selenate, uranyl carbonates	Antimony, barium, beryllium, cadmium, cesium, cobalt, copper, iron, lead, manganese, mercury, silver, strontium, thallium, vanadium, zinc
Radionuclides	Table A-3 Table A-11 Table A-12	Tritium, technetium-99, uranium isotopes (234, 235, 236, 238)	Isotopes of americium, cerium, cesium, cobalt, europium, lanthanum, neodymium, plutonium, radium, sodium, strontium
High Explosives and Degradation Products (HEXP)	Table A-4	Dinitrobenzenes, dinitrotoluenes, HMX, nitrobenzenes, nitroglycerine, nitrotoluenes, RDX, trinitrobenzene	HMX, PETN, tetryl, trinitrotoluene[2,4,6-] K_d unknown: DNX, MNX, TNX
Dioxins and Furans	Table A-5	—	All chlorodibenzodioxins and chlorodibenzofurans
Pesticides and PCBs	Table A-5	—	All: Aldrin, Arochlors, BHCs, chlordanes, DDD, DDE, DDT, Dieldrin, Endosulfans, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin Ketone, Heptachlor, Heptachlor epoxide, Methoxychlor, Toxaphene
Herbicides	Table A-6	Alachlor, Atrazine, MCPA, D[2,4-], DB[2,4-], Dalapon, DBCP, Dicamba, Dichlorprop, Dinoseb, Endothall, MCPP, Picloram, T[2,4,5-], Simazine	Glyphosate, TP[2,4,5-], Diquat
Diesel Range Organics (analytes not included elsewhere)	Table A-6	—	Diesel Range Organics; Total Petroleum Hydrocarbons Diesel Range Organics (TPH-DRO)
Polynuclear Aromatic Hydrocarbons (PAHs)	Table A-7	—	All: Acenaphthene, acenaphthylene, acetylamidofluorene[2-], anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, bibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, methylcholanthrene[3-], methylnaphthalenes, naphthalene, phenanthrene, pyrene

Table 4-4 (continued)

Analytical Suite	Tables of Relevant Analytes and Sorption Parameters	Partition Coefficient (K_d)	
		Negligible Adsorption $K_d < 1$ mL/g	Possibly Significant Adsorption $K_d > 1$ mL/g
SVOAs and VOAs (analytes not included elsewhere)	Table A-8	Acetone, benzene, butanone[2-], carbon tetrachloride, chlorobenzene, chloroethane, chloroform, dichlorobenzenes, dichlorethanes, dichloroethene, dichloroethylene, ethylbenzene, MTBE, methylene chloride, tetrachloroethanes, tetrachloroethene, toluene, trichloroethanes, trichloroethene, trichlorofluoromethane, vinyl chloride, xylenes, 2-nitrophenol, 4-methylphenol, benzoic acid, bromodichloromethane, bromoform, bromomethane, dibromochloromethane, diethyl phthalate, diphenylhydrazine[1,2-], methyl-2-pentanone[4-], phenol, pyridine, trimethylbenzene	Dichlorobenzenes, trichlorobenzenes, benzidine, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, carbazole, chloronaphthalene[2-], chlorophenol[2-], dibenzofuran, dimethyl phthalate, di-n-butyl phthalate, hexachlorobutadiene, isopropyltoluene[4-], pentachlorophenol

Table 4-5
Tier-2.1 Questions and Criteria for Residual Bentonite

Tier 2.1-Issue: Has residual bentonite been sufficiently removed such that it does not interfere with transport of contaminants into the screen interval? [a]

Note: The assessment criteria in this table are applicable to the three most recent characterization and/or surveillance samples for the screen. If less than three samples are available for this purpose, then the outcome is considered "Preliminary."

Tier	Screening Question		Assessment Criteria[b]	Consequence of "NO" response[c]
2.1-1	Evaluation of bentonite as a potential source term: Have all indicators of bentonite mud been removed from the screen interval?	2.1-1a	Are concentrations of the following species all below the maximum background concentrations in groundwater? For well screens in the regional aquifer: Is boron less than 0.051 mg/L? Is sulfate less than 17 mg/L? Is sodium less than 31 mg/L? Is uranium less than 0.0028 mg/L? For well screens in intermediate perched zones: Is boron less than 0.013 mg/L? Is sulfate less than 11 mg/L? Is sodium less than 36 mg/L? Is uranium less than 0.0008 mg/L?	If NO for any analyte, then flag any <u>detections</u> of the following analytes as possibly elevated above predrilling concentrations (DB+) due to desorption from residual bentonite: General inorganic analytical suite: Alkalinity, K, Mg, Na, Br, Cl, F, NO_3, Total P, SO_4 Metals analytical suite: As, Ba, B, Cr, Cu, Hg, Mn, Mo, Ni, Sb, Se, U, V Radionuclide analytical suite: U-234, U-235, U-238
2.1-2	Evaluation of bentonite as a potential sink: Are water-quality data reliable and representative for general inorganics, metals, and radionuclides that would adsorb onto residual bentonite if present?	2.1-2a	Is the concentration of dissolved strontium above the minimum background concentration for groundwater (0.042 mg/L)?	If NO, then flag the following analytes as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: Ca, Mo, Sr, V Sr-90
		2.1.2b.	Is the concentration of dissolved uranium above the minimum background concentration for groundwater? For screens in the regional aquifer: Is uranium greater than 0.0002 mg/L? For screens in intermediate perched zones: Is uranium greater than 0.0001 mg/L?	If NO, then flag the following analytes as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: U, U-234, 235, 236, 238

Table 4-5 (continued)

Tier	Screening Question	Assessment Criteria[b]	Consequence of "NO" response[c]
2.1-2 (cont.)		2.1.2c. Is the concentration of dissolved zinc above the instrument detection limit? Note: Zn is considered here to be an appropriate indicator species for the adsorption behavior of metal cations and Cs-137, Co-60, Eu isotopes, La-140, and Nd-147.	If NO, then flag any nondetects of the following analytes as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: Metals: Ag, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Hg, Mn, Mo, Sb, Tl, Zn Radionuclides: Cs-137, Co-60, Eu-152, Eu-154, Eu-155, La-140, Nd-147
		2.1.2d. Some radionuclides adsorb so strongly to clays, including bentonite, that they are rarely detected in groundwater. Because of the absence of a suitable analogue, we assume none of the well screens drilled with bentonite provide reliable detection of strongly adsorbing radionuclides.	Flag any nondetects of the following analytes as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: Am-241, Ce-139, Ce-141, Ce-144, Pu-238,239,240, Ra-226, Ra-228
2.1-3	Are water-quality data reliable and representative for HE and HE degradation products?	NO for HE and HE degradation products with an adsorption coefficient (K_d) greater than 1 mL/g. YES for all other relevant HE and HE degradation products because these do not adsorb or partition onto bentonite.	Flag the following HE and HE degradation products as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: DNX, MNX, PETN, tetryl, TNT, TNX
2.1-4	Are water-quality data reliable and representative for Herbicides, Pesticides, PCBs, Dioxins, and Furans?	NO for pesticides, PCBs, dioxins and furans. These species are assumed to partition or adsorb onto bentonite, with K_d values much greater than 1 mL/g. YES for most herbicides (except as listed in the right-hand column). These species adsorb poorly onto bentonite, with K_d values less than 1 mL/g.	Flag all pesticides, PCBs, dioxins, and furans as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite. Flag the following herbicides as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: Diquat, glyphosate, TP[2,4,5-]
2.1-5	Are water-quality data reliable and representative for Diesel Range Organics?	NO for Diesel Range Organic species that are petroleum hydrocarbons. These long-chain aliphatic hydrocarbons are assumed to adsorb or partition strongly onto bentonite, with K_d values greater than 1 mL/g.	Flag the following DRO analytes as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: DRO, TPH-DRO

Table 4-5 (continued)

Tier	Screening Question	Assessment Criteria[b]	Consequence of "NO" response[c]
2.1-6	Are water-quality data reliable and representative for SVOAs/VOAs (LANL Specific)?	NO for SVOAs/VOAs that have an adsorption coefficient (K_d) greater than 1 mL/g. YES for all other SVOAs/VOAs because these adsorb poorly onto bentonite, with K_d values less than 1 mL/g.	Flag the following SVOAs/VOAs as possibly less than predrilling concentrations (DB-) due to adsorption onto residual bentonite: Dioxins, PCBs, and pesticides Polynuclear aromatic hydrocarbons (PAHs) Other SVOCs/VOCs not already included in other categories: Benzidine, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, carbazole, chloronaphthalene[2-], chlorophenol[2-], dibenzofuran, dichlorobenzene[1,4-], dimethyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate, hexachlorobutadiene, isopropyltoluene[4-], pentachlorophenol, trichlorobenzene[1,2,4-], trichlorobenzene[1,2,3-]

[a] In this report, "groundwater" refers only to water from perched intermediate zones or the regional aquifer. The methodology used in this report is not applicable to water from alluvial perched zones.

[b] These criteria are discussed in Section 4.4. Responses should be based on analytical results obtained for filtered samples.

[c] List of analytes affected is based on Table 4-4

Table 4-6
Selected Redox Couples Relevant to this Assessment

(Rows marked in **bold** indicate analytes used in this assessment as indicator species for in-situ redox conditions)

Analytical Suite	Redox Element		Oxidized Species	Reduced Species	Eh (mV)*
SVOA/VOA	Carbon	C(III/II)	PCA**	PCE**	1130
General Inorganics	Chloride	Cl(VII/-I)	ClO_4^-	Cl^-	976
General Inorganics	**Oxygen**	**O(0/-II)**	**$O_2(g)$**	**H_2O**	**800**
General Inorganics	**Nitrogen**	**N(V/0)**	**NO3-**	**N2(g)**	**713**
Radionuclides	Plutonium	Pu(V/IV)	PuO_2^+	PuO_2	634
SVOA/VOA	Carbon	C(II/II, 0)	PCE	TCE	580
Radionuclides	Plutonium	Pu(V/IV)	PuO_2^+	$Pu(OH)_4^0$	556
Metals	**Manganese**	**Mn(IV/II)**	**MnO2(s)**	**Mn2+**	**544**
SVOA/VOA	Carbon	C(II, 0/0)	TCE**	t-DCE**	540
Metals	Chromium	Cr(VI/III)	CrO_4^{2-}	$Cr(OH)_2^+$	500
Metals	Selenium	Se(VI/IV)	SeO_4^{2-}	SeO_3^{2-}	446
SVOA/VOA	Carbon	C(0/-II)	t-DCE**	vinyl chloride	370
Metals	Uranium	U(VI/IV)	$UO_2(CO_3)_2^{2-}$	$USiO_4(am)$	73
Metals	Uranium	U(VI/IV)	$UO_2(CO_3)_2^{2-}$	$UO_2(am)$	64
Radionuclides	Plutonium	Pu(IV/III)	PuO_2	$PuCO_3^+$	15
Metals	**Iron**	**Fe(III/II)**	**Fe(OH)3**	**Fe2+**	**14**
General Inorganics	**Sulfur**	**S(VI/-II)**	**SO42-**	**H2S(aq)**	**- 217**
Metals	Arsenic	As(V/III)	$HAsO_4^{2-}$	$H_3AsO_3(aq)$	- 249
General Inorganics	Carbon	C(IV/-IV)	HCO_3^-	$CH_4(g)$	- 260
HEXP			TNT**	2-ADNT**	- 390
General Inorganics	Hydrogen	H(I/0)	H_2O	$H_2(g)$	- 400
HEXP			TNT**	4-ADNT**	- 430

* Redox potentials at pH 7 and 25°C

** 2-ADNT = 2-Amino-4,6-dinitrotoluene; 4-ADNT = 4-Amino-2,6-dinitrotoluene; PCA = perchloroethane (hexachloroethane); PCE = perchloroethylene; TCE = trichloroethylene; t-DCE = trans-dichloroethylene; TNT = 2,4,6-trinitrotoluene

Table 4-7
Behavior of Inorganic and Organic Species under Reducing Conditions

Analytical Suite	Analytes that may not be representative of predrilling concentrations under reducing conditions				Unaffected by Redox Conditions
	Sulfate reducing conditions (SO_4 below background)	Iron-reducing conditions (Dissolved Fe concentrations elevated above background)	Manganese-reducing conditions (Dissolved Mn concentrations elevated above background)	Nitrate-reducing conditions (NO_3 below background)	
General Inorganics	Bicarbonate alkalinity, calcium, magnesium, nitrate, perchlorate, sulfate, pH	Bicarbonate alkalinity, calcium, magnesium, nitrate, pH	Bicarbonate alkalinity, calcium, magnesium, nitrate, pH	Bicarbonate alkalinity, calcium, magnesium, nitrate, pH	Bromide, chloride, fluoride, total phosphorus
Metals	Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, zinc	Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, zinc	Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, zinc	—	—
Radionuclides	Same list of analytes for Mn, Fe and SO4-reducing conditions: Americium-241, cerium isotopes (139, 141, 144), cesium-137, cobalt-60, europium isotopes (152, 154, 155), lanthanum-140, neodynium-147, plutonium isotopes (238, 239, 240), radium 226 and 228, technetium-99, uranium isotopes (234, 235, 236, 238)			—	Tritium
High Explosives and Degradation Products (HEXP)	All HEXP analytes: amino-dinitrotoluenes, dinitrobenzenes, dinitrotoluenes, nitrobenzenes, nitroglycerine, nitrotoluenes, DNX, HMX, MNX, PETN, RDX, tetryl, TNX, trinitrobenzene		—	—	—
Dioxins and Furans	Same list of analytes for all reducing conditions: All chlorodibenzodioxins and chlorodibenzofurans				—
Pesticides and PCBs	Same list of analytes for all reducing conditions: All pesticides and PCBs: Aldrin, Arochlors, BHCs, chlordanes, DDD, DDE, DDT, Dieldrin, Endosulfans, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin Ketone, Heptachlor, Heptachlor epoxide, Methoxychlor, Toxaphene				—
Herbicides	Same list of analytes for all reducing conditions: All herbicides: Alachlor, Atrazine, MCPA, D[2,4-], DB[2,4-], Dalapon, DBCP, Dicamba, Dichlorprop, Dinoseb, Diquat, Endothall, Glyphosate, MCPP, Paraquat, Picloram, Simazine, T[2,4,5-], TP[2,4,5-]				—

Table 4-7 (continued)

Analytical Suite	Analytes that may not be representative of predrilling concentrations under reducing conditions				Unaffected by Redox Conditions
	Sulfate reducing conditions (SO_4 below background)	Iron-reducing conditions (Dissolved Fe concentrations elevated above background)	Manganese-reducing conditions (Dissolved Mn concentrations elevated above background)	Nitrate-reducing conditions (NO_3 below background)	
Diesel Range Organics (if not included elsewhere)	Same list of analytes for all reducing conditions: Diesel Range Organics; Total Petroleum Hydrocarbons Diesel Range Organics (TPH-DRO)				—
Polynuclear Aromatic Hydrocarbons (PAHs)	Same list of analytes for all reducing conditions: All PAHs: Acenaphthene, acenaphthylene, acetylamidofluorene[2-], anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, bibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, methylcholanthrene[3-], methylnaphthalenes, naphthalene, phenanthrene, pyrene				—
SVOAs and VOAs (if not already included in above categories)	Same list of analytes for all reducing conditions: All SVOAs/VOAs: acetone, benzene, benzidine, benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, bromodichloromethane, bromoform, bromomethane, butanone[2-], butylbenzylphthalate, carbazole, carbon disulfide, carbon tetrachloride, chloro-3-methylphenol[4-], chlorobenzene, chloroethane, chloroform, chloromethane, chloronaphthalene[2-], chlorophenol[2-], dibenzofuran, dibromochloromethane, dichlorobenzenes, dichloroethanes, dichloroethenes, diethyl phthalate, dimethyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate, diphenylhydrazine[1,2-], ethylbenzene, hexachlorobutadiene, isopropyltoluene[4-], methyl tert-butyl ether, methyl-2-pentanone[4-], methylene chloride, methylphenol[4-], nitrophenol[2-], pentachlorophenol, phenol, pyridine, tetrachloroethane[1,1,1,2-], tetrachloroethane[1,1,2,2-], tetrachloroethene, toluene, trichlorobenzenes, trichloroethanes, trichloroethene, trichlorofluoromethane [CFC-11], timethylbenzene[1,2,4-], vinyl chloride, xylenes				—

Table 4-8
Tier-2.2 Questions and Criteria for Residual Organic Drilling Fluids

Tier 2.2 Issue: Have the effects of residual organic drilling fluids been sufficiently removed such that groundwater samples are reliable and representative of the groundwater? [a]

Note: The assessment criteria in this table are applicable to the three most recent characterization and/or surveillance samples for the screen. If less than three samples are available for this purpose, then the outcome is considered "Preliminary."

Tier	Screening Question	Assessment Criteria[b]	Consequence of "NO" response[c]
2.2-1	Have residual organic drilling fluids been removed from the screen interval?	Are all of the following conditions met the last 3 times that these analytes were measured? • Are total organic carbon (TOC) and/or dissolved organic carbon (DOC) below 2 mg/L? • Is total Kjehdahl nitrogen (TKN) less than 0.4 mg/L? • Is ammonium (as N) less than 0.07 mg/L? • Are concentrations of acetone and/or isopropyl alcohol either below the detection limit or less than 5 µg/L?	If NO, flag any detected concentrations of the following analytes as possibly greater than predrilling concentrations (DO+) due to the presence of residual organic fluids: DOC, TOC, TKN, Ammonia (as N), acetone, isopropyl alcohol Note: This flag is not applicable to any non-detects for these analytes.
2.2-2	Is sulfur present in its oxidized (SO_4) form?	Are all of the following conditions met the last 3 times that these analytes were measured? • Is sulfate present above the minimum background level (1.7 mg/L for the regional aquifer)? • Is sulfide less than 0.01 mg/L? • Is oxidation-reduction potential (ORP) greater than 0 mV?	If NO, then flag the following analytes as possibly not reliable or representative of predrilling concentrations (DR) due to chemical transformation, desorption from Fe/Mn (oxy)hydroxides, or mineral precipitation under sulfate-reducing conditions initiated by the presence of residual organic fluids: General inorganic analytical suite: Alkalinity, Ca, NO_3+NO_2-N, SO_4, ClO_4 Metals analytical suite: Ag, As, Ba, B, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, Tl, U, V, Zn Radionuclide analytical suite: Am-241, Ce-139, Ce-141, Ce-144, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, La-140, Nd-147, Pu-238,239,240, Ra-226, Ra-228, U-234,235,236,238 All HE and HE degradation products, herbicides, pesticides, PCBs, dioxins, furans, Diesel Range Organics, SVOAs and VOAs
If YES for question 2.2-2, then continue to the next question. If NO, there is no need to proceed further.			

Table 4-8 (continued)

Tier	Screening Question	Assessment Criteria[b]	Consequence of "NO" response [c]
2.2-3	Have redox conditions been restored to oxidizing conditions with respect to sulfate, iron, and manganese?	If YES for 2.2-2 (above), then are <u>all</u> of the following conditions also met? • Is field pH between 6.5 and 8.3? • Is dissolved iron less than 130 µg/L? • Is dissolved manganese less than 60 µg/L? • Is field alkalinity (as $CaCO_3$) less than 128 mg/L (for well screens in the regional aquifer) or less than 63 mg/L (for well screens in intermediate perched zones)?	If NO, then flag the following analytes as possibly not reliable or representative of predrilling concentrations (DR) due to chemical transformation, desorption from Fe/Mn (oxy)hydroxides, or mineral precipitation under reducing conditions initiated by the presence of residual organic fluids: General inorganic analytical suite: Alkalinity, Ca, NO_3+NO_2-N Metals analytical suite: Ag, As, Ba, B, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, Tl, U, V, Zn Radionuclide analytical suite: Am-241, Ce-139, Ce-141, Ce-144, Cs-137, Co-60, Eu-152, Eu-154, Eu-155, La-140, Nd-147, Pu-238,239,240, Ra-226, Ra-228, Sr-90, U-234,235,236,238 All HE and HE degradation products, herbicides, pesticides, PCBs, dioxins, furans, Diesel Range Organics, SVOAs and VOAs
If YES for question 2.2-3, then continue to the next question. If NO, there is no need to proceed further.			
2.2.4	Have redox conditions been restored to oxidizing conditions with respect to nitrate and dissolved oxygen (DO)?	If YES for 2.2-2 and 2.2-3 above, then are both of the following conditions also met? Is nitrate + nitrite detected above the minimum background level (0.025 mg/L as N)? Is field dissolved oxygen greater than 2 mg/L?	If NO, then flag the following analytes as possibly not reliable or representative of predrilling concentrations (DR) due to chemical transformation under reducing conditions initiated by the presence of residual organic fluids: General inorganic analytical suite: Alkalinity, Ca, NO_3+NO_2-N All HE and HE degradation products, herbicides, pesticides, PCBs, dioxins, furans, Diesel Range Organics, SVOAs and VOAs
If YES for <u>all</u> of the above criteria, then it is concluded that residual organic drilling fluids have been sufficiently removed, and that redox conditions have been restored, such that there are no residual impacts of these products on analytes in this screen interval.			

[a] In this report, "groundwater" refers only to water from perched intermediate zones or the regional aquifer. The methodology used in this report is not applicable to water from alluvial perched zones.

[b] These criteria are discussed in Section 4.5. Responses should be based on analytical results obtained for filtered samples.

[c] List of analytes affected is based on Table 4-7.

Table 5-1
Constituents Identified as Principal Components in Groundwater Data Sets

Data Set	PC 1	PC 2	PC 3	Total Variation Explained by PCs 1, 2,& 3
Metals UF	Fe, Mn	B, Sr	Zn, Cr	65%
Metals F	Fe, Mn, Mo	B, Sr, Ba	Cr, Zn	65%
Major ions UF	Ca, Cl, K, Mg, total alkalinity	F, SO_4	Na vs. NO_3	72%
Major ions F	Na, K	Cl, SO_4, NO_3	Mg, total alkalinity, Ca	72%

Table 5-2
Results of Principal Component Analysis for Well Screens

Well Screen	Interpretation of PCA Results for Most Recent Sampling Event: Identification of Potential Impacts			
	Metals UF (Figure 5-1)	Metals F (Figure5-2)	Major Ions UF (Figure 5-3)	Major Ions F (Figure 5-4)
CdV-15-3-4	√	√	—	√
CdV-15-3-5	Possible to Slight	Possible to Slight	—	√
CdV-15-3-6	√	√	—	√
CdV-37-2-2	Significant	Significant	—	√
CdV-37-2-3	√	√	—	√
CdV-37-2-4	√	√	—	√
R-1	√	√	—	√
R-2	√	√	—	√
R-4	√	√	—	Possible to Slight
R-5-3	Possible to Slight	√	—	Possible to Slight
R-5-4	Possible to Slight	Possible to Slight	—	Possible to Slight
R-7-3	Moderate	—	√	—
R-8-1	√	√	—	√
R-8-2	Possible to Slight	Possible to Slight	—	Moderate
R-9	Possible to Slight	—	Moderate	—
R-11	√	√	—	Possible to Slight
R-12-3	Possible to Slight	Moderate	Moderate	Possible to Slight
R-13	√	—	√	—
R-14-1	√	√	—	√
R-14-2	Moderate	Moderate	—	√
R-15	√	√	Possible to Slight	Possible to Slight
R-16-2	√	√	—	Moderate
R-16-3	√	√	—	Moderate
R-16-4	Possible to Slight	Possible to Slight	—	Significant
R-19-3	√	√	√	√
R-19-4	√	√	√	√
R-19-5	Possible to Slight	—	Moderate	—
R-19-6	√	—	√	—
R-19-7	Moderate	√	Significant	Possible to Slight
R-20-1	√	Possible to Slight	—	Possible to Slight
R-20-2	Significant	Significant	—	Significant
R-20-3	Significant	Moderate	—	Possible to Slight
R-21	√	√	—	√

Table 5-2 (continued)

Well Screen	Interpretation of PCA Results for Most Recent Sampling Event: Identification of Potential Impacts			
	Metals UF (Figure 5-1)	**Metals F (Figure5-2)**	**Major Ions UF (Figure 5-3)**	**Major Ions F (Figure 5-4)**
R-22-1	Significant	Significant	Significant	Significant
R-22-2	√	√	Possible to Slight	√
R-22-3	Possible to Slight	Possible to Slight	Moderate	Possible to Slight
R-22-4	Significant	Moderate	Moderate	Significant
R-22-5	Possible to Slight	Moderate	Moderate	Significant
R-23	√	√	—	Moderate
R-25-2	—	—	Significant	—
R-25-4	—	—	—	√
R-25-5	Moderate	Moderate	√	—
R-25-6	√	—	√	—
R-25-7	√	—	√	—
R-25-8	√	√	√	√
R-28	Significant	Moderate	—	Significant
R-31-2	Significant	Significant	—	Significant
R-32-1	√	√	—	√
R-32-3	Moderate	Moderate	—	√
R-33-1	Moderate	√	√	√
R-33-2	√	√	√	—
R-34	√	√	—	√

Source: Results plotted in Figures 5-1 through 5-4
√ Chemistry appears to be consistent with that for existing wells or White Rock Canyon springs
— Well screen samples not evaluated

Table 5-3
Comparison of Tier Analysis and PCA Results for the Most Recent Sampling Events

	Outcome of Tiered Analysis Method				
	Outcome	**Poor Rating < 60%**	**Fair Rating 60% – 80%**	**Good Rating 81% – 90%**	**Very Good Rating 91% – 100%**
Outcome of PCA Method	Not analyzed by PCA	R-12-1	R-9i-1 R-9i-2 (P) R-19-2 R-25-1	R-6[B] (P) R-6i (P)	CdV-16-1i MCOBT-4.4 R-5-2 R-18 (P)
	Consistent with WRC springs or existing wells	R-19-6 (P)	CdV-R-15-3-6 CdV-R-37-2-4 R-19-3	CdV-R-15-3-4 R-2[B](P) R-13 R-19-4 R-25-8 R-34 R-26-1	CdV-R-37-2-3 R-1 (P) R-8-1 R-14-1 R-21 R-25-4 R-25-6 (P) R-25-7 (P) R-32-1[B] R-33-2 (P)
	Possible to slight impacts	R-20-1[B] CdV-R-15-3-5	R-5-4		R-4[B](P) R-5-3 R-11 (P) R-15 R-22-2
	Moderate impacts	R-7-3 R-14-2[B] R-19-5 R-32-3[B]	R-8-2 R-12-3 R-16-2[B] R-25-5 R-33-1	R-16-3[B] R-22-3	R-9 R-23
	Significant impacts	CdV-R-37-2-2 R-16-4[B] R-20-2[B] R-22-1 R-22-4 R-22-5 R-31-2(P)	R-19-7 R-20-3[B] R-25-2		R-28 (P)

* Shaded cells indicate consistent outcomes.
B Screen interval drilled with bentonite drilling mud.
(P) Result considered preliminary either because less than 3 sample events were available or because the most recent event occurred more than 2 years ago.

Sources: Tables 5-2 and E-6.

Appendix A

LANL Relevant Analytes and PCOCs

Table A-1
General Inorganic Analytes Relevant to this Assessment[a]

Analyte	Dominant Species in Regional Aquifer[b]	Tier Criterion[c]	Tier Flag[c]
Ammonia (NH_3-N)	NH_4^+	2.2	2.2
Bicarbonate alkalinity (field)	HCO_3^-	2.2	2.1, 2.2
Bromide	Br^-	—	2.1
Calcium	Ca^{2+}	—	2.1, 2.2
Chloride	Cl^-	—	2.1
Dissolved organic carbon (DOC)	Humic and fulvic acids, small molecular weight organic acids	2.2	2.2
Dissolved oxygen (DO) (field)	O_2	2.2	2.2
Fluoride	F^-	—	2.1
Magnesium	Mg^{2+}	—	2.1
Nitrate	NO_3^-	2.2	2.1, 2.2
Perchlorate	ClO_4^-	—	2.2
pH (field)	H^+	2.2	—
Sodium	Na^+	2.1	2.1
Sulfate	SO_4^{2-}	2.1, 2.2	2.1, 2.2
Total Kjeldahl nitrogen (TKN)	Organic nitrogen compounds including acids, neutral species, and bases	2.2	2.2
Total Phosphorus	$H_2PO_4^-$	—	2.1

— not applicable

[a] List of relevant analytes is based on background concentrations, source characterization, and groundwater monitoring conducted since the early 1960s.

[b] Representative speciation of groundwater from the regional aquifer, calculated using MINTEQA2 (Allison et al. 1991, 49930) and assuming 25°C, and median background concentrations (Table 4.2-4e in LANL 2005).

[c] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier 2.1 in section 4.4.2 and Table 4-5, and for Tier 2.2 in section 4.5.2 and Table 4-9.

Table A-2
Metal Analytes Relevant to this Assessment[a]

Analyte	Dominant Species in Regional Aquifer[b]	Tier Criterion[c]	Tier Flag[c]
Antimony	$Sb(OH)_6^-$, $Sb(OH)_5^0$ [ATSDR 1992c, 90533]	—	2.1, 2.2
Arsenic	$[HAsO_4]^{2-}$, $H_2AsO_4^-$	—	2.1, 2.2
Barium	Ba^{+2}	—	2.1, 2.2
Beryllium	Be^{2+} [ATSDR 2002, 90555]	—	2.1, 2.2
Boron	$[B(OH)_3]^0$	2.1	2.1, 2.2
Cadmium	Cd^{+2}	—	2.1, 2.2
Cesium	Cs^+	—	2.1, 2.2
Chromium	CrO_4^{2-}, $Cr(OH)_3$ aq, $Cr(OH)_2^+$	—	2.1, 2.2
Cobalt	Co^{2+}	—	2.1, 2.2
Copper	Cu^{2+}	—	2.1, 2.2
Iron	Fe^{2+}, $[Fe(OH)_2]^0$, $FeOH^+$, $Fe(OH)_3^-$	2.2	2.1, 2.2
Lead	Pb^{2+}	—	2.1, 2.2
Manganese	Mn^{2+}	2.2	2.1, 2.2
Mercury	Hg^{2+}	—	2.1, 2.2
Molybdenum	MoO_4^-	—	2.1, 2.2
Nickel	$NiCO_3$ aq	—	2.1, 2.2
Selenium	SeO_3^{2-}, SeO_4^{2-}, $HSeO_3^-$	—	2.1, 2.2
Silver	Ag^+	—	2.1, 2.2
Strontium	Sr^{2+}, $SrHCO_3^+$	2.1	2.1
Thallium	Tl^+ [ATSDR TP-54, p. 54]	—	2.1, 2.2
Uranium	$[UO_2(CO_3)_2]^{2-}$, $[UO_2(CO_3)_3]^{4-}$, $UO_2CO_3^0$	2.1	2.1, 2.2
Vanadium	$H_2VO_4^-$, HVO_4^{2-} [ATSDR 1992b, 90556]	—	2.1, 2.2
Zinc	Zn^{2+}	2.1	2.1, 2.2

— not applicable

[a] List of relevant analytes is based on background concentrations, source characterization, and groundwater monitoring conducted since the early 1960s. Most of the listed metals, including antimony, beryllium, cesium, cobalt, silver, thallium, vanadium and zinc, generally are not detected in the native regional aquifer and only are included for purposes of speciation calculations.

[b] Representative speciation of groundwater from the regional aquifer, calculated using MINTEQA2 (Allison et al. 1991, 49930) and assuming 25°C, and median background concentrations (Table 4.2-4e in LANL 2005).

[c] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier-2.1 in section 4.4.2 and Table 4-5, and for Tier 2.2 in section 4.5.2 and Table 4-9.

Table A-3
Radionuclides Relevant to this Assessment[a]

Analyte	Dominant Species in Regional Aquifer[b]	Tier Flag
Americium-241	$AmCO_3^+$, $Am(CO_3)^{2-}$, $Am(OH)^{2+}$	2.1, 2.2
Cerium-139, 141, 144	$CeCO_3^+$	2.1, 2.2
Cesium-137	Cs^+	2.1, 2.2
Cobalt-60	$Co_2(OH)_3^+$	2.1, 2.2
Europium-152, 154, 155	$EuCO_3^+$	2.1, 2.2
Lanthanum-140	$LaCO_3^+$	2.1, 2.2
Neodymium-147	$NdCO_3^+$	2.1, 2.2
Plutonium-238, 239, 240	PuO_2^+, PuO_2CO_3 aq, $Pu(CO_3)_3^{2-}$	2.1, 2.2
Radium-226, 228	Ra^{2+}	2.1, 2.2
Strontium-90	Sr^{2+}, $SrHCO_3^+$	2.1, 2.2
Technetium-99	TcO_4^-	2.2
Tritium	HTO^0	—
Uranium-234	$[UO_2(CO_3)_2]^{2-}$, $[UO_2(CO_3)_3]^{4-}$, $UO_2CO_3^0$	2.1, 2.2
Uranium-235/236	$[UO_2(CO_3)_2]^{2-}$, $[UO_2(CO_3)_3]^{4-}$, $UO_2CO_3^0$	2.1, 2.2
Uranium-238	$[UO_2(CO_3)_2]^{2-}$, $[UO_2(CO_3)_3]^{4-}$, $UO_2CO_3^0$	2.1, 2.2

— not applicable

[a] List of relevant analytes is based on background concentrations, source characterization, and groundwater monitoring conducted since the early 1960s. Isotopes of americium, plutonium, cesium, cobalt, iodine, technetium, strontium, and lanthanides generally are not detected in the native regional aquifer and only are included for purposes of speciation calculations.

[b] Representative speciation of groundwater from the regional aquifer, calculated using MINTEQA2 (Allison et al. 1991, 49930) and assuming 25°C, 4.8 mg/L dissolved oxygen, $10^{-2.57}$ atm CO_2, and median background concentrations (Table 4.2-4e in LANL 2005).

[c] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier 2.1 in section 4.4.2 and Table 4-5, and for Tier 2.2 in section 4.5.2 and Table 4-9.

Table A-4
High Explosive Analytes and Degradation Products Relevant to this Assessment[a]

Analyte in the HEXP Analytical Suite	Stoichiometric Formula	CAS RN	K_{oc} [b]	K_d (mL/g) [b]	Tier Flag[c]
Amino-2,6-dinitrotoluene[4-] *Syn*: 4-ADNT	C7 H7 N3 O4	19406-51-0	—	< 0.1 [based on data for 2-ADNT]	2.2
Amino-4,6-dinitrotoluene[2-] *Syn*: 2-ADNT	C7 H7 N3 O4	35572-78-2	—	< 0.1[d] [WE99]	2.2
Dinitrobenzene[1,2-] (ortho) *Syn*: 1,2-DNB	C6 H4 N2 O4	528-29-0	30 [VE01]	< 0.1 [based on K_{oc}][e]	2.2
[f]Dinitrobenzene[1,3-] (meta) *Syn*: 1,3-DNB	C6 H4 N2 O4	99-65-0	106 [SRC] 150 [HA96]	< 0.1[d] [WE99] 0.2[g] [HA96] 0.1 [FE98]	2.2
Dinitrobenzene[1,4-] (para) *Syn*: 1,4-DNB	C6 H4 N2 O4	100-25-4	150 [HSDB]	< 0.2 [based on K_{oc}]	2.2
[f]Dinitrotoluene[2,4-] *Syn*: 2,4-DNT	C7 H6 N2 O4	121-14-2	251 [VE01]	0.3 [based on K_{oc}]	2.2
[f]Dinitrotoluene[2,6-] *Syn*: 2,6-DNT	C7 H6 N2 O4	606-20-2	78 [VE01]	0.1 [based on K_{oc}]	2.2
Dinitrotoluene[3,4-] *Syn*: 3,4-DNT	C7 H6 N2 O4	610-39-9	413 [SRC]	0.4 [based on K_{oc}]	2.2
DNX *Syn*: Hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine	C3 H6 N6 O4	—	—	—	2.1, 2.2
HMX *Syn*: Octogen; Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine; cyclotetramethylene tetranitramine	C4 H8 N8 O8	2691-41-0	3.5 [AT97]	< 0.1 [based on K_{oc}] 0.7[h] [MO03] 8.0[i] [MO03]	2.1, 2.2
MNX *Syn*: Hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine	C3 H6 N6 O5	—	—	—	2.1, 2.2
[f]Nitrobenzene	C6 H5 N O2	98-95-3	1 to 103 [VE01, SE86, HSDB] 229 [SRC]	0.2 [based on K_{oc}]	2.2
Nitrotoluene[4-] (para) *Syn*: 4-Methylnitrobenzene; 4-nitrobenzene	C7 H7 N O2	99-99-0	460 [HSDB]	0.5 [based on K_{oc}]	2.2
Nitroglycerine Syn: 1,2,3-Propanetriol trinitrate	C3 H5 N3 O9	55-63-0	468 [SRC] 180 [HSDB]	0.5 [based on K_{oc}]	2.2
Nitrotoluene[2-] (ortho)	C7 H7 N O2	88-72-2	420 [HSDB]	0.4 [based on K_{oc}]	2.2
Nitrotoluene[3-] (meta)	C7 H7 N O2	99-08-1	510 [HSDB]	0.5 [based on K_{oc}]	2.2
PETN Syn: Pentaerythritol tetranitrate	C5 H8 N4 O12	78-11-5	179 to 1720 [HSDB]	0.2 to 2 [based on K_{oc}]	2.1, 2.2
RDX Syn: Cyclonite; hexahydro-1,3,5-trinitro-1,3,5-triazine; cyclotrimethylenetrinitramine	C3 H6 N6 O6	121-82-4	63 to 270 [AT95a] 42 to 167 [HSDB]	<0.3 [based on K_{oc}] < 1 [AT95a] 0.8 [SH01] 0.3 to 1.9[h] [MO03]	2.2

				6.6[i] [MO03]	

Table A-4 (continued)

Analyte in the HEXP Analytical Suite	Stoichiometric Formula	CAS RN	K_{oc} [b]	K_d (mL/g) [b]	Tier Flag[c]
Tetryl *Syn*: Nitramine; 2,4,6-trinitrophenylmethylnitramine; N,2,4,6-tetranitro-N-methylaniline	C7 H5 N5 O8	479-45-8	2100 [HSDB] 1300 to 3000 [AT95b]	1.3 to 3 [based on K_{oc}] 5.8 [HA96]	2.1, 2.2
TNX *Syn*: Hexahydro-1,3,5-trinitroso-1,3,5-triazine	C3 H6 N6 O3	13980-04-6	—	—	2.1, 2.2
[f]Trinitrobenzene[1,3,5-]	C6 H3 N3 O6	99-35-4	104 to 178 [HSDB] 20 [VE01]	< 0.2 [based on K_{oc}]	2.2
Trinitrotoluene[2,4,6-] *Syn*: alpha-TNT	C7 H5 N3 O6	118-96-7	300 to 1100 [AT95c] 1100 to 1900 [HSDB] 308 [SRC] 524 to 1584 [VE01]	< 0.1[d] [WE99] 1.7[g] [HA96] 35 to 84 [HSDB] 131[i] [MO03] 4 to 167[h] [MO03] 416[j] [MO03] 0.3 to 1.9 [based on K_{oc}]	2.1, 2.2

— data are not available

CAS RN—Chemical Abstract Service registry number, K_d—distribution coefficient, K_{OC}—Organic-carbon normalized partition coefficient, HSDB—Hazardous Substances Data Bank

[a] List of relevant organic analytes is based on source characterization and groundwater monitoring conducted since the early 1960s.

[b] References for parameter values are indicated in square brackets following the value, as follows: AT95a: ATSDR 1995a, 90534; AT95b: ATSDR 1995b, 90558; AT95c: ATSDR 1995c, 90559; AT97: ATSDR 1997, 90557; FE98: Fesch and Haderlein 1998, 90576; HA96: Haderlein et al. 1996, 90572; HSDB: National Library of Medicine 2005, 90524; MO03: Monteil-Rivera et al. 2003, 90570; SE86: Seip et al. 1986, 90568; SH99: Sheremata et al 1999, 90566; SH01: Sheremata et al 2001, 90567; SRC: Syracuse Research Corporation 2005, 90573; VE01: Verschueren 2001, 90563; WE99: Weissmahr et al. 1999, 90561.

[c] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier 2.1 in section 4.4.2 and Table 4-5, and for Tier 2.2 in section 4.5.2 and Table 4-9.

[d] Sorption coefficient was measured on Na-kaolinite with and without adsorbed natural organic matter [Weissmahr et al. 1999, p. 2596, 90561].

[e] K_d is estimated as 0.1% K_{OC}, where 0.1% is the assumed organic-carbon content of the residual bentonite drilling mud in the screen interval (section 3.0).

[f] This analyte is also included in the SVOA analytical suite.

[g] Sorption coefficient was measured on Ca-montmorillonite (Haderlein et al. 1996, p. 616, 90572).

[h] Sorption coefficient was measured on soils with total organic carbon ranging from 0.08 to 0.33%, and clay fractions ranging from 6 to 32% (Monteil-Rivera et al. 2003, Tables 1, 3, and 4, 90570).

[i] Sorption coefficient was measured on Aqua-Gel (Monteil-Rivera et al. 2003, Table 4, 90570).

[j] Sorption coefficient was measured on montmorillonite (Monteil-Rivera et al. 2003, Table 4, 90570).

Table A-5
Dioxins, Furans, Pesticides and PCBs Relevant to This Assessment[a]

Analyte (and Selected Synonyms)	Stoichiometric Formula	CAS RN	K_{OC} [b]	K_d (mL/g) [based on K_{OC}][c]	Tier Flag[d]
Dioxin/Furan (DIOX/FUR) Analytical Suite					
[e]1,2,3,4,6,7,8-HpCDD Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	C12 H Cl7 O2	35822-46-9	3×10^5 to 6×10^7 [MA92]	300 to 60,000	2.1, 2.2
[e]1,2,3,4,6,7,8-HpCDF Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	C12 H Cl7 O	67562-39-4	1×10^6 to 8×10^7 [MA92]	1000 to 80,000	2.1, 2.2
[e]1,2,3,4,7,8-HxCDD Hexachlorodibenzodioxin[1,2,3,4,7,8-]	C12 H2 Cl6 O2	39227-28-6	1×10^5 to 1×10^7 [MA92]	100 to 10,000	2.1, 2.2
[e]1,2,3,4,7,8-HxCDF Hexachlorodibenzofuran[1,2,3,4,7,8-]	C12 H2 Cl6 O	70648-26-9	3×10^7 [MA92]	30,000	2.1, 2.2
[e]1,2,3,7,8-PCDD Pentachlorodibenzodioxin[1,2,3,7,8-]	C12 H3 Cl5 O2	40321-76-4	82,000 [HSDB] 7×10^4 to 2×10^6 [f] [MA92]	82 70 to 2000	2.1, 2.2
[e]1,2,3,7,8-PCDF Pentachlorodibenzofuran[1,2,3,7,8-]	C12 H3 Cl5 O	57117-41-6	4×10^5 to 3×10^7 [g] [MA92]	400 to 30,000	2.1, 2.2
[e]2,3,7,8-TCDD Tetrachlorodibenzodioxin[2,3,7,8-]	C12 H4 Cl4 O2	1746-01-6	5×10^5 to 4×10^7 [MA92]	500 to 40,000	2.1, 2.2
[e]2,3,7,8-TCDF Tetrachlorodibenzofuran[2,3,7,8-]	C12 H4 Cl4 O	51207-31-9	2×10^5 to 3×10^7 [MA92]	200 to 30,000	2.1, 2.2
[e]OCDD Octachlorodibenzodioxin	C12 Cl8 O2	3268-87-9	8×10^5 to 8×10^7 [MA92]	800 to 80,000	2.1, 2.2
[e]OCDF Octachlorodibenzofuran	C12 Cl8 O	39001-02-0	1×10^6 to 3×10^7 [MA92]	1000 to 30,000	2.1, 2.2
[h]Heptachlorodibenzodioxins (total)	C12 H Cl7 O2	37871-00-4	3×10^5 to 6×10^7 [assumed same as 1,2,3,4,6,7,8-HpCDD]	300 to 60,000	2.1, 2.2
[h]Hexachlorodibenzodioxins (total)	C12 H2 Cl6 O2	34465-46-8	1×10^5 to 1×10^7 [assumed same as 1,2,3,4,7,8-HxCDD]	100 to 10,000	2.1, 2.2
[h]Pentachlorodibenzodioxins (total)	C12 H3 Cl5 O2	36088-22-9	7×10^4 to 2×10^6 [assumed same as 1,2,3,4,7-PCDD]	70 to 2000	2.1, 2.2
[h]Pentachlorodibenzofurans (total)	C12 H3 Cl5 O	30402-15-4	4×10^5 to 3×10^7 [assumed same as 2,3,4,7,8-PCDF]	400 to 30,000	2.1, 2.2

Table A-5 (continued)

Analyte (and Selected Synonyms)	Stoichiometric Formula	CAS RN	Koc[b]	K_d (mL/g) [based on K_{oc}][c]	Tier Flag[d]
Pesticide/PCB (PEST/PCB) Analytical Suite (excluding analytes that have already been listed in the DIOX/FUR or PEST/PCB analytical suites)					
[a]Aldrin	C12 H8 Cl6	309-00-2	400 to 28,000 [HSDB] 410 [KE80]	0.4 to 28	2.1, 2.2
Aroclor-1016 (approximate chlorine content of 42%; approximate distribution of chlorinated biphenyls in Aroclor 1016 are as follows: <1.0% mono-, 21.2% di-, 51.5% tri-, 27.3% tetra-, <0.6% pentachlorobiphenyl; biogrades slowly [HSDB])	Tri- and tetra-chlorobiphenyl	12674-11-2	17,000 to 46,000 [HSDB]	17 to 46	2.1, 2.2
Aroclor-1221 (biphenyl, 12.7%; 2-chlorobiphenyl, 28.4%; 4-chlorobiphenyl, 18.7%; 2,2'-dichlorobiphenyl, 9.2%; 2,4-dichlorobiphenyl, 3.5%; 2,4'-dichlorobiphenyl, 13.6%; 4,4'-dichlorobiphenyl, 6.2%; biodegrades relatively rapidly [HSDB])	Dichlorobiphenyl	11104-28-2	6300 to 16,000 [HSDB]	6 to 16	2.1, 2.2
Aroclor-1232 (biodegrades relatively rapidly)	Mono, di- and tri-chlorobiphenyl	11141-16-5	11,000 to 180,000 [HSDB]	11 to 180	2.1, 2.2
Aroclor-1242 (composed of 3% mono-, 13% di-, 38% tri-, 30% tetra-, 22% penta-, and 4% hexachlorobiphenyls; biogrades slowly)	Tri- and tetra-chlorobiphenyl	53469-21-9	10,000 to 126,000 [HSDB]	10 to 126	2.1, 2.2
Aroclor-1248 (polychlorobiphenyl containing 48% chlorine. It is comprised of 2% di-, 18% tri-, 40% tetra-, 36% penta-, and 4% hexa-chlorobiphenyls; biogrades slowly [HSDB, VE01])	Tetrachlorinated biphenyl	12672-29-6	25,000 to 79,000 [HSDB]	25 to 79	2.1, 2.2
Aroclor-1254 (polychlorobiphenyl containing 54% chlorine. It is comprised of 11% tetra-, 49% penta-, 34% hexa-, and 6% hepta- chlorobiphenyls; resistant to biodegradation [HSDB, VE01])	Pentachlorinated biphenyl	11097-69-1	42,500 [HSDB, KE80]	43	2.1, 2.2
Aroclor-1260 (polychlorobiphenyl mixture containing 60% chlorine. It is composed of 12% penta-, 38% hexa-, 41% hepta-, 8% octa-, and 1% nona-chlorobiphenyls; resistant to biodegradation [HSDB])	Heptachlorinated biphenyl	11096-82-5	63,000 to 1.6×10^6 [HSDB]	63 to 1600	2.1, 2.2
Aroclor-1262	—	37324-23-5	—	—	2.1, 2.2
[a]BHC[alpha-] *Syn*: alpha-hexachlorocylohexane; alpha-HCH	C6 H6 Cl6	319-84-6	2000 [HSDB]	2 to 14 [HSDB]	2.1, 2.2

Table A-5 (continued)

Analyte (and Selected Synonyms)	Stoichiometric Formula	CAS RN	Koc[b]	K_d (mL/g) [based on K_{oc}][c]	Tier Flag[d]
[e]BHC[beta-] *Syn*: beta-hexachlorocylohexane; beta-HCH	C6 H6 Cl6	319-85-7	2500 to 13,000 [HSDB]	2.5 to 13	2.1, 2.2
[e]BHC[delta-] *Syn*: delta-hexachlorocylohexane; delta-HCH	C6 H6 Cl6	319-86-8	700 to 2700 [HSDB] 4260	0.7 to 4	2.1, 2.2
[e]BHC[gamma-] *Syn*: 1,2,3,4,5,6-Hexachlorocyclohexane (Lindane)	C6 H6 Cl6	58-89-9	200 to 4800 [HSDB] 911 [KE80]	0.2 to 5	2.1, 2.2
Chlordane[alpha-] *Syn*: trans-chlordane	C10 H6 Cl8	5103-71-9	20,000 to 76,000 [HSDB]	20 to 76	2.1, 2.2
Chlordane[gamma-] *Syn*: cis-chlordane	C10 H6 Cl8	5103-74-2	251,000	251	2.1, 2.2
[e]DDD[4,4'-] *Syn*: Dichlorodiphenyl dichloroethane	C14 H10 Cl4	72-54-8	16200 80,500 [KE80]	80	2.1, 2.2
[e]DDE[4,4'-] *Syn*: Dichlorodiphenyl dichloroethylene	C14 H8 Cl4	72-55-9	50,100 55,000 [KE80]	55	2.1, 2.2
[e]DDT[4,4'-]	C14 H9 Cl5	50-29-3	151,000 238,000 [KE80]	238	2.1, 2.2
[e]Dieldrin	C12 H8 Cl6 O	60-57-1	2000 to 23,000 [HSDB] 35,600 [KE80]	2 to 23	2.1, 2.2
[e]Endosulfan I (alpha)	C9 H6 Cl6 O3 S	959-98-8	2000 to 20,000 [HSDB]	2 to 20	2.1, 2.2
[e]Endosulfan II (beta)	C9 H6 Cl6 O3 S	33213-65-9	2000 to 20,000 [HSDB]	2 to 20	2.1, 2.2
[e]Endosulfan Sulfate	C9 H6 Cl6 O4 S	1031-07-8	32,000 [HSDB]	32	2.1, 2.2
[e]Endrin	C12 H8 Cl6 O	72-20-8	11,420 [HSDB] 34,000 [KE80]	11	2.1, 2.2
[e]Endrin Aldehyde	C12 H8 Cl6 O	7421-93-4	4300 [HSDB]	4.3	2.1, 2.2
Endrin Ketone	C12 H8 Cl6 O	53494-70-5	4300 [HSDB]	4.3	2.1, 2.2
[e]Heptachlor *Syn*: heptachlorodicyclopentadiene	C10 H5 Cl7	76-44-8	13,000 to 661,000 [HSDB] 30,000 [KE80]	13 to 661	2.1, 2.2
[e]Heptachlor Epoxide	C10 H5 Cl7 O	1024-57-3	100 [HSDB, VE01] 7800 [HSDB]	0.1 to 8	2.1, 2.2
[e]Methoxychlor[4,4'-]	C16 H15 Cl3 O2	72-43-5	80,000 [HSDB, KE80]	80	2.1, 2.2

Table A-5 (continued)

Analyte (and Selected Synonyms)	Stoichiometric Formula	CAS RN	K_{OC} [b]	K_d (mL/g) [based on K_{OC}][c]	Tier Flag[d]
Tetrachlorodibenzodioxins (total)	C12 H4 Cl4 O2	41903-57-5	150,000 [HSDB]	150	2.1, 2.2
Tetrachlorodibenzofurans (totals)	C12 H4 Cl4 O	55722-27-5	2×10^5 to 3×10^7 [assumed same as 2,3,7,8-TCDF above]	200 to 30,000	2.1, 2.2
Toxaphene (technical grade) (very complex but reproducible mixture of at least 175 C10 polychloro-derivatives, having an approximate overall empirical formula of C10H10Cl8; each congener has its own K_{oc} value [HSDB])	C10 H10 Cl8	8001-35-2	7200 [KE80] 210,000 to 1×10^6 [HSDB]	7 to 1000	2.1, 2.2

— data are not available

CAS RN—Chemical Abstract Service registry number, K_d—distribution coefficient, K_{OC}—Organic-carbon normalized partition coefficient, HSDB—Hazardous Substances Data Bank

[a] List of relevant organic analytes is based on source characterization and groundwater monitoring conducted since the early 1960s.

[b] References for parameter values are indicated in square brackets following the value, as follows: HSDB: National Library of Medicine 2005, 90524; KE80: Kenaga 1980, 90571; MA92: Mackay et al. 1992, 90575, Table A-5; ST82: Strek and Weber 1982, 90577; VE01: Verschueren 2001, 90563

[c] K_d is estimated as 0.1% K_{OC}, where 0.1% is the assumed organic-carbon content of the residual bentonite drilling mud in the screen interval (section 3.0).

[d] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier 2.1 in section 4.4.2 and Table 4-5, and for Tier 2.2 in section 4.5.2 and Table 4-9.

[e] This analyte is also part of the SVOA analytical suite.

[f] K_{OC} determined for 1,2,3,4,7-PCDD

[g] K_{OC} determined for 2,3,4,7,8-PCDF

[h] This analyte is also part of the PEST/PCB analytical suite.

Table A-6
Herbicides and Diesel Range Organics Relevant to This Assessment[a]

Analyte (and Selected Synonyms)	Stoichiometric Formula	CAS RN	Koc[b]	K_d (mL/g)[b]	Tier Flag[c]
Herbicide (HERB) Analytical Suite					
Alachlor *Syn*: 2-chloro-2';6';-diethyl-N-(methoxymethyl)acetanilide	C14 H20 Cl N O2	15972-60-8	160 [VE01] 190 [KE80] 170 [DI95, EXT]	0.2	2.1, 2.2
Atrazine *Syn*: 2-chloro-2';6';-diethyl-N-(methoxymethyl)acetanilide	C14 H20 Cl N O2	1912-24-9	149 [KE80] 53 [SI90] 45 to 100 [VE01] 100 [DI95, EXT]	0.1	2.1, 2.2
Chloro-o-tolyloxyacetic[4-] Acid *Syn*: MCPA; 2-methyl-4-chlorophenoxyacetic acid	C9 H9 Cl O3	94-74-6	100 [EXT]	0.1	2.1, 2.2
[g]D[2,4-] *Syn*: 2,4-dichlorophenoxyacetic acid	C8 H6 Cl2 O3	94-75-7	109 [SRC] 20 [EXT, KE80]	0.1	2.1, 2.2
[g]Dalapon *Syn*: 2,2-dichloropropionic acid	C3 H4 Cl2 O2	75-99-0	1 [EXT] 3 [KE80] 2.3 [SRC]	< 0.1	2.1, 2.2
[g]DB[2,4-] *Syn*: 4-(2,4-dichlorophenoxy)butanoic acid; 2,4-dichlorophenoxybutyric acid	C10 H10 Cl2 O3	94-82-6	530 [KE80, SRC] 20 [EXT] 20 to 100 [KE80]	0.5	2.1, 2.2
[h]Dibromo-3-chloropropane[1,2-] *Syn*: DBCP	C3 H5 Br2 Cl	96-12-8	129 [KE80]	0.1	2.1, 2.2
[g]Dicamba *Syn*: 2-methoxy-3,6-dichlorobenzoic acid	C8 H6 Cl2 O3	1918-00-9	2 [EXT] 0.4 [KE80] 0 to 115 [SRC]	< 0.1	2.1, 2.2
[g]Dichloroprop *Syn*: 2,4-dichlorophenoxy-a-propionic acid	C9 H8 Cl2 O3	120-36-5	< 50 for pH greater than 6 [HSDB]	< 0.1	2.1, 2.2
[e,g]Dinoseb *Syn*: DNBP; 2,4-dinitro-6-sec-butylphenol (DNBP)	C10 H12 N2 O5	88-85-7	30 [EXT] 124 [KE80, SRC]	0.1	2.1, 2.2

Table A-6 (continued)

Analyte (and Selected Synonyms)	Stoichiometric Formula	CAS RN	Koc[b]	Kd (mL/g)[b]	Tier Flag[c]
Herbicide (HERB) Analytical Suite (continued)					
Diquat Syn: 1-1'-ethylene-2,2'-bipyridinium-dibromide; Diquat dibromide Note: Diquat is generally present as a bivalent cation that adsorbs by ion-exchange [HSDB].	C12 H12 Br2 N2	231-36-7 85-00-7 (cation)	2000 [HSDB]	2	2.1, 2.2
Endothall *Syn*: aquathol K; 7-oxabicyclo(2,2,1)heptane-2,3-dicarboxylic acid	C8 H10 O5	145-73-3	8 [HSDB, KE80]	< 0.1	2.1, 2.2
Glyphosate *Syn*: N-(phosphonomethyl)glycine; glyphosate acid Note: adsorption mechanism to clays is H-bonding and ion exchange, not hydrophobic partitioning [HSDB, VE01]]	C3 H8 N O5 P	1071-83-6	2600 to 4900 [HSDB] 2640 [KE80]	8 to 138 [VE01]	2.1, 2.2
MCPP *Syn*: Mecoprop; 2-(4-chloro-2-methylphenoxy) propionic acid	C10 H11 Cl O3	93-65-2	5 to 13 [HSDB]	< 0.1	2.1, 2.2
Picloram *Syn*: 4-amino-3,5,6-trichloropicolinic acid	C7 H3 Cl3 N2 O2	1918-02-1	0.03 to 26 [HSDB] 17 [KE80]	< 0.1	2.1, 2.2
[g]T[2,4,5-] *Syn*: 2,4,5-trichlorophenoxyacetic acid	C8 H5 Cl3 O3	93-76-5	80 [SRC] 53 [KE80]	0.1	2.1, 2.2
[g]TP[2,4,5-] *Syn*: 2-(2,4,5-trichlorophenoxy)propionic acid; Silvex	C9 H7 Cl3 O3	93-72-1	2600 [HSDB, SRC, KE80]	2.6	2.1, 2.2
Simazine *Syn*: 2-chloro-4,6-bis(ethylamino)-s-triazine	C7 H12 Cl N5	122-34-9	140 [HSDB] 135 [KE80]	< 0.2	2.1, 2.2
Diesel Range Organics (DRO) (excluding analytes that have already been listed as part of the HERB analytical suite)					
Diesel Range Organics	na	68334-30-6	1000 to 10^9 [AT99]	> 1	2.1, 2.2
MCPA *Syn*: MCPA methyl ester; Methyl (4-chloro-2methylphenoxy) acetate; 2-methyl-4-chlorophenoxyacetic acid	C10 H11 Cl O3 C9 H9 Cl O3	2436-73-9 94-74-6	50 to 60 [HSDB]	< 1	2.1, 2.2
Total Petroleum Hydrocarbons Diesel Range Organics (TPH-DRO)	na	na	1000 to 10^9 [AT99]	> 1	2.1, 2.2

Table A-6 (continued)

CAS RN—Chemical Abstract Service registry number, K_d—distribution coefficient, K_{OC}—Organic-carbon normalized partition coefficient, HSDB—Hazardous Substances Data Bank

[a] List of relevant organic analytes is based on source characterization and groundwater monitoring conducted since the early 1960s.

[b] References for parameter values are indicated in square brackets following the value, as follows: AT99: ATSDR 1999, 90528; DI95: Diaz Diaz et al. 1995, 90549; EXT: Oregon State University 2005, 90526; EXTOXNET database; HSDB: National Library of Medicine 2005, 90524; JA90: Jafvert 1990, 90547; KE80: Kenaga 1980, 90571; SE86: Seip et al. 1986, 90568; SI90: Singh et al. 1990, 90578; SRC: Syracuse Research Corporation 2005, 90573; VE01: Verschueren 2001, 90563

[c] K_d is estimated as 0.1% K_{OC}, where 0.1% is the assumed organic-carbon content of the residual bentonite drilling mud in the screen interval (section 3.0).

[d] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier 2.1 in section 4.4.2 and Table 4-5, and for Tier 2.2 in section 4.5.2 and Table 4-9.

[e] This analyte is also part of the SVOA analytical suite.

[f] This analyte is also part of the PEST/PCB analytical suite.

[g] This analyte is also part of the DRO analytical suite.

[h] This analyte is also part of the VOA analytical suite.

Table A-7
Polynuclear Aromatic Hydrocarbons (PAHs) Relevant to this Assessment[a]

Analyte in the SVOA Analytical Suite	Stoichiometric Formula	CAS RN	K_{oc}[b]	K_d (mL/g)[b]	Tier Flag[c]
Acenaphthene	C12 H10	83-32-9	3890 [SRC, SZ90]	3.9	2.1, 2.2
Acenaphthylene	C12 H8	208-96-8	5620 [SRC, SZ90]	5.6	2.1, 2.2
Acetylaminofluorene[2-] *Syn*: N-2-Fluorenylacetamide	C15 H13 N O	53-96-3	1380 [SRC]	1.4	2.1, 2.2
Anthracene	C14 H10	120-12-7	15,800 [SRC, KA81]	16	2.1, 2.2
Benz(a)anthracene	C18 H12	56-55-3	200,000 [SRC]	200	2.1, 2.2
Benzo(a)pyrene	C20 H12	50-32-8	5×10^6 [SRC]	5000	2.1, 2.2
Benzo(b)fluoranthene	C20 H12	205-99-2	156,000 [SRC]	156	2.1, 2.2
Benzo(g,h,i)perylene	C22 H12	191-24-2	406,000 [SRC]	406	2.1, 2.2
Benzo(k)fluoranthene	C20 H12	207-08-9	22,000 [SRC]	22	2.1, 2.2
Chrysene	C18 H12	218-01-9	133,000 [SRC]	133	2.1, 2.2
Dibenz(a,h)anthracene	C22 H14	53-70-3	2×10^6 [SRC, ME80]	2000	2.1, 2.2
Dimethylbenz(a)anthracene[7,12]	C20 H16	57-97-6	225,308 [SRC, ME80]	225	2.1, 2.2
Fluoranthene	C16 H10	206-44-0	30,000 to 300,000 [HSDB] 41,400 [SRC]	30 to 300	2.1, 2.2
Fluorene	C13 H10	86-73-7	2830 [SRC]	2.8	2.1, 2.2
Indeno(1,2,3-cd)pyrene	C22 H12	193-39-5	1.6×10^6 [SRC]	1600	2.1, 2.2
Methylcholanthrene[3-]	C21 H16	56-49-5	2.0×10^6 [SRC, ME80]	2000	2.1, 2.2
Methylnaphthalene[1-]	C11 H10	90-12-0	730 [SRC] 2291 [VO87]	2.3	2.1, 2.2
Methylnaphthalene[2-]	C11 H10	91-57-6	8500 [SRC, KE80]	8.5	2.1, 2.2
Naphthalene	C10 H8	91-20-3	400 to 1000 [VE01] 871 [SRC] 1300 [KE80]	1.0	2.1, 2.2
Phenanthrene	C14 H10	85-01-8	18,800 [SRC, VO87] 23,000 [KE80]	19	2.1, 2.2
Pyrene	C16 H10	129-00-0	62,700 [SRC, ME80] 84,000 [KE80]	63 to 84 [based on K_{OC}] 5400 [VO87]	2.1, 2.2

CAS RN—Chemical Abstract Service registry number, K_d—distribution coefficient, K_{OC}—Organic-carbon normalized partition coefficient, HSDB—Hazardous Substances Data Bank

[a] List of relevant organic analytes is based on source characterization and groundwater monitoring conducted since the early 1960s.

[b] References for parameter values are indicated in square brackets following the value, as follows: HSDB: National Library of Medicine 2005, 90524; KA81: Karickhoff 1981, 90546; KE80: Kenaga 1980, 90571; ME80: Means et al. 1980, 90527; SRC: Syracuse Research Corporation 2005, 90573; SZ90: Szabo et al. 1990, 90564; VE01: Verschueren 2001, 90563; VO87: Vowles and Mantoura 1987, 90562)

[c] K_d is estimated as 0.1% K_{OC}, where 0.1% is the assumed organic-carbon content of the residual bentonite drilling mud in the screen interval (section 3.0).

[d] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier-2.1 in section 4.4.2 and Table 4-5, and for Tier-2.2 in section 4.5.2 and Table 4-8.

Table A-8
Semi-volatile and Volatile Organic Analytes Relevant to This Assessment[a]

Analyte in the SVOA or VOA Analytical Suite	Stoichiometric Formula	CAS RN	Koc[b]	Kd (mL/g)[b]	Tier Flag[c]
Acetone	C3 H6 O	67-64-1	18 [SRC]	0.02	2.2[b]
Benzene	C6 H6	71-43-2	49 [SRC] 83 [KE80] 60 [KA81] 38 to 53 [VE01, SE86]	< 0.1	2.2
Benzidine	C12 H12 N2	92-87-5	462 to 4900 [HSDB]	4.9	
Benzoic Acid	C7 H6 O2	65-85-0	"Low" [HSDB] (biodegrades)	< 1	
Benzyl Alcohol	C7 H8 O	100-51-6	< 5 to 15 [HSDB]	< 0.1	
Bis(2-ethylhexyl)phthalate *Syn*: DEHP	C24 H38 O4	117-81-7	87,420 to 352,000 [HSDB]	352	
Bromodichloromethane	C H Br Cl2	75-27-4	35 to 251 [HSDB]	0.3	
Bromoform *Syn*: tribromomethane	C H Br3	75-25-2	35 [HSDB]	< 0.1	
Bromomethane *Syn:* methyl bromide	C H3 Br	74-83-9	9 to 22 [HSDB]	< 0.1	
Butanone[2-] (MEK; methyl ethyl ketone)	C4 H8 O	78-93-3	5.2 [SRC]	< 0.1	2.2
Butylbenzylphthalate	C19 H20 O4	85-68-7	2000 to 50,000 [HSDB]	50	
Carbazole	C12 H9 N	86-74-8	114 to 12500 [HSDB]	13	
Carbon Disulfide	C S2	75-15-0	89 [SRC]	< 0.1	2.2
Carbon tetrachloride	C Cl4	56-23-5	224 [SRC] 110 [KE80]	0.2	2.2
Chloro-3-methylphenol[4-] Syn: 3-methyl-4-chlorophenol; p-chloro-m-cresol	C7 H7 Cl O	59-50-7	490 [HSDB]	0.5	
Chlorobenzene	C6 H5 Cl	108-90-7	275 [SRC] 400 [VE01, DA91]	0.4	2.2
Chloroethane	C2 H5 Cl	75-00-3	38 [SRC]	< 0.1	2.2
Chloroform	C H Cl3	67-66-3	40 [SRC]	< 0.1	2.2
Chloromethane Syn: methyl chloride	C H3 Cl	74-87-3	14 [HSDB]	< 0.1	
Chloronaphthalene[2-]	C10 H7 Cl	91-58-7	3000 [HSDB]	3	
Chlorophenol[2-]	C6 H5 Cl O	95-57-8	51 to 5012 [HSDB]	5	
Dibenzofuran	C12 H8 O	132-64-9	4200 [HSDB]	4	
Dibromochloromethane	C H Br2 Cl	124-48-1	35 [HSDB]	< 0.1	

Table A-8 (continued)

Analyte in the SVOA or VOA Analytical Suite	Stoichiometric Formula	CAS RN	Koc	K_d (mL/g)	Tier Flag
Dichlorobenzene[1,2-] (ortho)	C6 H4 Cl2	95-50-1	280 [SRC] 830 [VE01, DA91]	0.8	2.2
Dichlorobenzene[1,3-] (meta)	C6 H4 Cl2	541-73-1	293 [SRC] 1700 [VE01, DA91]	1.7	2.2
Dichlorobenzene[1,4-] (para)	C6 H4 Cl2	106-46-7	390 [KE80] 600 [SRC] 1660 [VE01]	1.7	2.2
Dichloroethane[1,1-]	C2 H4 Cl2	75-34-3	40 [SRC]	< 0.1	2.2
Dichloroethane[1,2-]	C2 H4 Cl2	107-06-2	32 [SRC]	< 0.1	2.2
Dichloroethene[cis-1,2-]	C2 H2 Cl2	540-59-0	35 to 50 [SRC]	< 0.1	2.2
Dichloroethylene[1,1-]	C2 H2 Cl2	75-35-4	343 [SRC]	0.3	2.2
Dichloroethylene[trans-1,2-]	C2 H2 Cl2	156-60-5	35 [SRC]	< 0.1	2.2
Diethyl phthalate	C12 H14 O4	84-66-2	69 to 704 [HSDB]	0.7	
Dimethyl phthalate	C10 H10 O4	131-11-3	80 to 10^5 [HSDB]	100	
Di-n-butyl phthalate *Syn*: DBP	C16 H22 O4	84-74-2	1100 to 1400 [HSDB]	1.4	
Di-n-octyl phthalate *Syn:* DNOP	C24 H38 O4	117-84-0	6.1×10^5 [HSDB]	610	
Diphenylhydrazine[1,2-]	C12 H12 N2	122-66-7	950 [HSDB]	1	
Ethylbenzene	C8 H10	100-41-4	250 [SRC]	0.3	2.2
Hexachlorobutadiene	C4 Cl6	87-68-3	5020 to 275,000 [HSDB]	275	
Isopropyltoluene[4-] *Syn:* p-cymene	C10 H14	99-87-6	4050 [HSDB]	4	
Methyl tert-Butyl Ether (MTBE)	C5 H12 O	1634-04-4	11 [SRC, VE01]	< 0.1	2.2
Methyl-2-pentanone[4-] Syn: methyl isobutyl ketone, MIBK	C6 H12 O	108-10-1	123 [HSDB]	0.1	
Methylene chloride	C H2 Cl2	75-09-2	28 [SRC]	< 0.1	2.2
Methylphenol[4-] *Syn:* p-cresol, 1-hydroxy-4-methylbenzene	C7 H8 O	106-44-5	49 to 646 [HSDB]	0.6	
Nitrophenol[2-]	C6 H5 N O3	88-75-5	32 to 266 [HSDB]	0.3	
Pentachlorophenol	C6 H Cl5 O	87-86-5	1000 to 4000 [HSDB]	4	
Phenol	C6 H6 O	108-95-2	16 to 91 [HSDB] 27 [KE80]	< 0.1	
Pyridine	C5 H5 N	110-86-1	50 [HSDB]	< 0.1	
Tetrachloroethane[1,1,1,2-]	C2 H2 Cl4	630-20-6	93 [SRC] 99 [VE01]	0.1	2.2
Tetrachloroethane[1,1,2,2-]	C2 H2 Cl4	79-34-5	79 [SRC, VE01]	0.1	2.2

Table A-8 (continued)

Analyte in the SVOA or VOA Analytical Suite	Stoichiometric Formula	CAS RN	K_{OC}	K_d (mL/g)	Tier Flag
Tetrachloroethylene	C2 Cl4	127-18-4	363 [SRC, KA81] 177 to 350 [HSDB, SE86]	0.4	2.2
Toluene	C7 H8	108-88-3	38 to 302 [SRC, HSDB, SE86]	0.3	2.2
Trichlorobenzene[1,2,3-]	C6 H3 Cl3	87-61-6	4030 [SRC] 7413 [VE01, DA91]	7.4	2.1, 2.2
Trichlorobenzene[1,2,4-]	C6 H3 Cl3	120-82-1	885 to 2100 [VE01] 1430 [SRC] 6760 [DA91]	6.8	2.1, 2.2
Trichloroethane[1,1,1-]	C3 H3 Cl3	71-55-6	179 [SRC]	0.2	2.2
Trichloroethane[1,1,2-]	C3 H3 Cl3	79-00-5	79 [SRC] 60 to 108 [HSDB, SE86]	0.1	2.2
Trichloroethene	C2 H Cl3	79-01-6	104 [SRC] 70 to 140 [HSDB, SE86]	0.1	2.2
Trichlorofluoromethane [CFC-11]	C Cl3 F	75-69-4	93 [SRC]	0.1	2.2
Trimethylbenzene[1,2,4-] (pseudocumene)	C9 H12	95-63-6	720 [HSDB]	0.7	
Vinyl chloride	C2 H3 Cl	75-01-4	30 [SRC]	< 0.1	2.2
Xylene (Total)	C8 H10	1330-20-7	129 to 289	0.3	2.1, 2.2
Xylene[1,2-] [ortho]	C8 H10	95-47-6	129 [SRC]	0.1	2.2
Xylene[1,3-] [meta]	C8 H10	108-38-3	190 [SRC] 129 to 289 [SE86]	0.3	2.1, 2.2

CAS RN—Chemical Abstract Service registry number, K_d—distribution coefficient, K_{OC}—Organic-carbon normalized partition coefficient, HSDB—Hazardous Substances Data Bank.

[a] List of relevant organic analytes is based on source characterization and groundwater monitoring conducted since the early 1960s.

[b] References for parameter values are indicated in square brackets following the value, as follows: DA91: Dannenfelser et al 1991, 90522; HSDB: National Library of Medicine 2005, 90524; KA81: Karickhoff 1981, 90546; KE80: Kenaga 1980, 90571; ME80: Means et al. 1980, 90527; SE86: Seip et al. 1986, 90568; SRC: Syracuse Research Corporation 2005, 90573; VE01: Verschueren 2001, 90563.

[c] K_d is estimated as 0.1% K_{OC}, where 0.1% is the assumed organic-carbon content of the residual bentonite drilling mud in the screen interval (section 3.0).

[d] Tier criteria, and the applicability of tier flags to analytes if the specified criteria are not met, are defined for Tier-2.1 in section 4.4.2 and Table 4-5, and for Tier-2.2 in section 4.5.2 and Table 4-8.

Table A-9
Mineralogical Composition and Other Physico-Chemical Characteristics of Wyoming Bentonite

Mineral Composition [MU83]			
Montmorillonite	%	75	
Kaolinite	%	< 1	
Mica	%	< 1	
Quartz	%	15.2	
Feldspar	%	5 to 8	
Pyrite	%	0.3	
Calcite	%	1.4	
Others	%	2	
Organic carbon	%	0.4	
Other constituents [WA96]			
Sodium chloride (NaCl)	wt %	0.007	
Calcium sulfate ($CaSO_4$)	wt %	0.34	
Physical characteristics [LA95]			
Specific weight	g/cm^3	2.70	
Specific area	m^2/g	562	
Exchangeable cations		**[LA95]**	**[MU83]**
Total CEC	meq/100g	79	78
Na^+	meq/100g	56.0	62.4
Ca^{2+}	meq/100g	30.1*	7.4*
Mg^{2+}	meq/100g	15.6	3.0
K^+	meq/100g	2.3	0.2

MU83: Müller-Vonmoos and Kahr 1983, as cited by Bradbury and Baeyens 2002 (90607)

LA95: Lajudie et al. 1995 (90542)

WA96: Wanner et al. 1996 (90529)

* The concentration of exchangeble calcium reported by Müller-Vonmoos and Kahr 1983 is lower than that reported by Lajudie et al. 1995 because the former authors subtracted the contribution of calcium derived from dissolution of calcium sulfate in the bentonite.

Table A-10
Inorganic Analytes Leached from Bentonite Drilling Mud Using Deionized Water

Analyte	Measured Concentration in Leach Solution[a] (mg/L)	Calculated Leachable Concentration in Drilling Mud[b] (mg/kg dry wt)	Calculated Concentration in Drilling Mud Slurry[c] (µg/L)	Mean Concentration in Regional Aquifer[d] (µg/L)	Concentration Ratio (Slurry/Mean Background Groundwater)
Analytes detected in the leach solution					
Bromide	0.27	2.2	67	44	1.5
Calcium	9.98	81	2400	16000	0.2
Chloride	116	950	28000	3200	9
Fluoride	7.24	59	1800	430	4
Magnesium	1.28	10	310	2700	0.1
Nitrate	197	1600	48000	210	230
Oxalate	4.85	40	1200	9.4	130
Phosphate	6.50	53	1600	79	20
Potassium	6.05	49	1500	2400	0.6
Silica	204	1700	50000	58,000	0.9
Sodium	1347	11000	330,000	18100	18
Sulfate	1008	8200	250,000	4700	53
Aluminum	0.23	1.9	56	20	3
Antimony	0.056	0.46	14	0.50	27
Arsenic	1.37	11	340	2.2	150
Barium	0.018	0.15	4.5	37	0.12
Boron	1.01	8.2	250	23	11
Chromium	0.082	0.67	20	4.1	5
Copper	0.062	0.51	15	1.6	9
Lithium	0.25	2.0	60	30	2.0
Manganese	0.016	0.13	3.8	4.7	0.8
Mercury	0.0022	0.018	0.54	0.031	17
Molybdenum	2.47	20	600	1.3	450
Nickel	0.016	0.13	3.8	1.4	2.7
Rubidium	0.011	0.090	2.7	3.4	0.8
Selenium	0.092	0.75	22	0.71	32
Strontium	0.030	0.25	7.4	190	0.04
Uranium	0.070	0.57	17	0.88	19
Vanadium	0.13	1.0	31	10	3.0

Table A-10 (continued)

Analyte	Analyte	Measured Concentration in Leach Solution[a] (mg/L)	Calculated Leachable Concentration in Drilling Mud[b] (mg/kg dry wt)	Calculated Concentration in Drilling Mud Slurry[c] (µg/L)	Mean Concentration in Regional Aquifer[d] (µg/L)
Analytes not detected in the leach solution					
Beryllium	<0.009	< 0.07	< 2.2	0.6	< 4
Cadmium	<0.009	< 0.07	< 2.2	0.35	< 7
Cesium	<0.009	< 0.07	< 2.2	0.9	< 3
Cobalt	<0.009	< 0.07	< 2.2	0.7	< 4
Iron	<0.09	< 0.7	< 22	27	< 1
Lead	<0.0009	< 0.007	< 0.22	0.7	< 0.3
Silver	<0.009	< 0.07	< 2.2	0.5	< 5
Thallium	<0.009	< 0.07	< 2.2	1.1	< 2
Thorium	<0.009	< 0.07	< 2.2	0.5	< 5
Tin	<0.009	< 0.07	< 2.2	2.9	< 0.8
Titanium	<0.009	< 0.07	< 2.2	1.4	< 2
Zinc	<0.009	< 0.07	< 2.2	13	< 0.2

[a] A leachate sample was prepared by leaching 12.5 g (dry weight) bentonite drilling mud with 102 mL deionized water. The filtered leachate solution was analyzed October 2003 by D. Counce (EES-6 GGRL).

[b] The leachable concentration is calculated by multiplying the measured leachate concentration by the mass of water added (102 g), divided by the dry mass of bentonite mud that was leached (12.5 g).

[c] Assumes the drilling mud slurry is prepared in the proportion of 25 pounds of dry bentonite mud per 100 gal. of injection water

[d] Table 4.2-4E in LANL 2005

Table A-11
Clay Soil Adsorption Coefficients (K_ds)

Element	Number of observations	Adsorption Coefficient K_d (mL/g)		
		Mean[a]	Minimum[b]	Maximum[b]
Elements that adsorb weakly (K_d < 80 mL/g)				
Technetium	4	1	1.16	1.32
Iodine	8	1	0.2	29
Phosphorus	1	35	—	—
Calcium	1	50	—	—
Neptunium	4	55	0.4	2575
Bromide	1	75	—	—
Potassium	1	75	—	—
Elements that adsorb moderately (K_d between 80 and 500 mL/g)				
Molybdenum	7	90	13	400
Strontium	24	110	3.6	32,000
Iron	7	165	15	2121
Manganese	23	180	24	48,945
Silica	1	180	—	—
Silver	5	180	100	300
Antimony	1	250	—	—
Rubidium	1	270	—	—
Elements that adsorb strongly (K_d between 500 and 5000 mL/g)				
Cobalt	15	550	20	14,000
Lead	1	550	—	—
Cadmium	10	560	112	2450
Nickel	10	650	305	2467
Tin	1	670	—	—
Selenium	1	740	—	—
Beryllium	1	1300	—	—
Chromium	1	1500	—	—
Uranium	7	1600	46	395,000
Cesium	28	1900	37	31,500
Zinc	23	2400	200	100,000
Zirconium	1	3300	—	—
Elements that adsorb very strongly (K_d > 5000 mL/g)				
Plutonium	18	5100	316	190,000
Thorium	5	5800	244	160,000
Americium	11	8400	25	400,000
Radium	8	9100	696	56,000
Cerium	4	20,000	12,000	31,623

[a] Mean of the natural logarithms of the observed values.

[b] The wide range of values most likely reflects the varied geochemical conditions under which these coefficients were obtained.

Source: Sheppard and Thibault 1990, Table A-3, 90541

Table A-12
Sodium-Bentonite Clay Adsorption Coefficients

Element	K_d (mL/g)*	Reference
Americium	20 to 200	Shibutani et al. 1994, 90540
	1400	Westsik et al. 1982, 90544
Cesium	309	Wanner et al. 1996, 90529
	480	Jurček and Jedináková-Křižová 1998, 90554
	1000	Westsik et al. 1982, 90544
	1400	Torstenfelt 1986b, 90530
	32,000	Missana et al. 2004, 90538
Iodine	1	Torstenfelt 1986, 90530
Mercury	152 to 427	Akçay et al. 1996, 90531
Neptunium	29	Westsik et al. 1982, 90544
Nickel	300 to 3200	Grauer 1994, 90543
Plutonium	900 to 30,000	Shibutani et al. 1994, 90540
Strontium	53	Wang et al. 2004, 90535
	96	Wang et al. 2004, 90535
	155	Jurček and Jedináková-Křižová 1998, 90554
	2900	Torstenfelt 1986b, 90530
	6800	Westsik et al. 1982, 90544
Technetium	< 50 (no Fe) 50 (0.5% Fe)	Torstenfelt 1986b, 90530
Uranium	2.7 to 6.4	Akçay et al. 1996, 90531
	8	Westsik et al. 1982, 90544
	93	Torstenfelt 1986a, 90539
	1000	Missana et al 2004, 90538

* The wide range of K_d values reflects the varied geochemical conditions under which these coefficients were obtained, and emphasizes the importance of obtaining site-specific adsorption data for realistic evaluations of the distribution of these elements in groundwater. Nonetheless, this compilation serves the purpose of this report by permitting a qualitative ranking of the elements by adsorption potential (i.e., weak, moderate, strong, very strong).

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Appendix B

Drilling Methods and Dates,
Screen Descriptions, and Sampling Events

APPENDIX B. DRILLING METHODS AND DATES, SCREEN DESCRIPTIONS, AND SAMPLING EVENTS

Table B-1
Well Drilling, Construction, and Development Histories

Well	Well Drilling Completed	Well Construction Completed	Well Development Completed	Total Volume Purged (gal.)	Volume Removed During Hydrologic Testing (gal.)	Westbay Installation Completed	Total Depth (ft bgs)	Water Table Depth (ft)	Screen Type	# Screens*
CdV-16-1(i)	6-Nov-03	12-Nov-03	17-Dec-03	5468	2526	n/a	683	564	Single	1
CdV-R-15-3	27-Apr-00	20-Jun-00	1-Sep-00	39770	na	19-Sep-00	1722	1245	Multi	6
CdV-R-37-2	5-Aug-01	17-Aug-01	21-Sep-01	27340	na	8-Oct-01	1664	1197	Multi	4
MCOBT-4.4	14-Jun-01	1-Jul-01	13-Feb-02	1895	na	n/a	767	n/a	Single	1
R-1	8-Nov-03	14-Nov-03	25-Nov-03	9760	8912	n/a	1165	1003	Single	1
R-2	17-Oct-02	22-Oct-03	11-Dec-03	11895	4976	n/a	944	892.5	Single	1
R-4	26-Sep-03	3-Oct-03	10-Oct-03	14150	42197	n/a	843	732	Single	1
R-5	20-May-01	31-May-01	21-Jun-01	14230	na	19-Jul-01	902	685	Multi	4
R-6	11-Nov-04	4-Dec-04	5-Jan-05	19263	11001	n/a	1303	1158	Single	1
R-6i	9-Dec-04	20-Dec-04	14-Feb-05	1031	3975	n/a	660	n/a	Single	1
R-7	12-Jan-01	31-Jan-01	8-Feb-01	3000	na	26-Feb-01	1097	903	Multi	3
R-8	27-Jan-02	1-Feb-02	14-Feb-02	19740	2250	24-Feb-02	880	709	Multi	2
R-9	1-Oct-99	1-Oct-99	13-Feb-00	3000	26700	n/a	771	688	Single	1
R-9i	9-Mar-00	11-Mar-00	7-Apr-00	4465	na	15-Apr-00	322	na	Multi	2
R-11	2-Oct-04	8-Oct-04	21-Oct-04	na	85,976	n/a	926.5	835.5	Single	1
R-12	10-Jan-00	21-Jan-00	6-Feb-00	1613	na	1-Mar-00	886	805	Multi	3
R-13	20-Sep-01	6-Oct-01	30-Oct-01	24710	na	n/a	1133	834	Single	1
R-14	2-Jul-02	11-Jul-02	18-Nov-02	205010	4750	25-Nov-02	1327	1182	Multi	2
R-15	31-Aug-99	7-Sep-99	20-Feb-00	657	41130	n/a	1107	964	Single	1
R-16	29-Aug-02	7-Sep-02	4-Dec-02	76850	22800	10-Dec-02	1287	642	Multi	4
R-18	2-Dec-04	14-Dec-04	24-Jan-05	18870	12933	n/a	1440	1288	Single	1
R-19	13-Mar-00	1-Apr-00	24-Jun-00	50000	na	11-Sep-00	1903	1178	Multi	7
R-20	6-Sep-02	15-Sep-02	22-Dec-02	87008	8840	18-Jan-03	1365	837	Multi	3

Table B-1 (continued)

Well	Well Drilling Completed	Well Construction Completed	Well Development Completed	Total Volume Purged (gal.)	Volume Removed During Hydrologic Testing (gal.)	Westbay Installation Completed	Total Depth (ft bgs)	Water Table Depth (ft)	Screen Type	# Screens
R-21	17-Nov-02	20-Nov-02	5-Dec-02	3205	13337	n/a	995	803	Single	1
R-22	11-Oct-00	19-Oct-00	19-Nov-00	38877	na	8-Dec-00	1489	890	Multi	5
R-23	27-Sep-02	2-Oct-02	20-Feb-03	31870	na	n/a	935	829	Single	1
R-25	24-Feb-99	5-Mar-99	13-Sep-00	192000	na	2-Oct-00	1942	1286	Multi	9
R-26	17-Oct-03	21-Oct-03	16-Nov-03	41069	14225	16-Jan-04	1491	604	Multi	2
R-28	9-Dec-03	17-Dec-03	13-Jan-04	15250	10059	n/a	1005	888.8	Single	1
R-31	8-Feb-00	19-Feb-00	27-Mar-00	14930	na	6-Apr-00	1103	522	Multi	5
R-32	7-Aug-02	12-Aug-02	10-Nov-02	114970	28920	17-Nov-02	1008	783.4	Multi	3
R-33	3-Oct-04	13-Oct-04	22-Nov-04	122180	26418	3-Dec-04	1140	979	Multi	2
R-34	9-Aug-04	20-Aug-04	2-Sep-04	34120	16852	n/a	1065	796	Single	1

na – not available

n/a – not applicable

Source: Compiled from well completion reports listed at the end of this appendix.

* This screen count (total, 82 screens) includes several screens that are dry, plugged, or otherwise not suitable or capable for providing water-quality samples. Table B-4 indicates which screens provide samples, and which ones do not.

Table B-2
Drilling Methods and Materials Used in Each Well

Well	Drilling Method	EZ-MUD	QUIK-FOAM	Bentonite Mud	Other Drilling Additives
CdV-16-1(i)	Fluid-assisted air rotary. Screen interval drilled using QUIK-FOAM and EZ-MUD; no bentonite mud	x	x		Well-Guard drilling thread; potassium bromide (KBr) added as tracer
CdV-R-15-3	Open-hole fluid-assisted air-rotary; no bentonite mud but screens 3 and 5 partially obscured with bentonite-rich annular fill	x	x	x	None noted
CdV-R-37-2	Fluid-assisted air-rotary reverse-circulation (open hole to 794'; casing advance to 1208'); no bentonite mud	x	x		None noted
MCOBT-4.4	Fluid-assisted air-rotary; no bentonite mud	x	x		None noted
R-1	Fluid-assisted air rotary (140' – 1165'); no bentonite mud	x	x		Potassium bromide tracer, Well-Guard drilling thread
R-2	Fluid-assisted air rotary (143'–403'); mud rotary (403'–944') with Aqua-Gel bentonite	x	x	x	PAC-L, soda ash, potassium bromide tracer, Well-Guard drilling thread
R-4	Open-hole air rotary with foam (40'–266'); mud rotary (266'–843') with Aqua-Gel bentonite	x	x	x	PAC-L, soda ash, Well-Guard drilling thread
R-5	Open-hole down-the-hole hammer bit (130'–828'), casing advance (570–850'); air-rotary, at times fluid-assisted with polymer additives; no bentonite mud	x	x		None noted
R-6	Air rotary (to 945'), mud rotary (945'–1303')	x	x	x	Max-Gel, N-Seal, PAC-L, soda ash
R-6i	Air rotary; fluid-assisted air-rotary; no bentonite mud		x		None noted
R-7	Fluid-assisted air-rotary, reverse circulation; advanced casing (to 290'); no bentonite mud	x	x		None noted
R-8	DTH: casing advance (to 706'); open-hole (684'–862'); casing-advance through slough (to 809'); open-hole (809'–880'); no bentonite mud	x			None noted
R-9	Air-rotary (to 771'); with casing advance at times; no bentonite mud	x	x		None noted
R-9i	Open-hole rotary methods; no bentonite mud				None noted
R-11	Fluid-assisted open-hole air-rotary; no bentonite mud				None noted
R-12	Open-hole, air-rotary with casing advance; no bentonite mud	x	x		Tork-Ease
R-13	Fluid-assisted open-hole air-rotary; no bentonite mud but bentonite fell into the well during backfilling operations & was difficult to remove		x	x	Lost hydraulic fluid (165 gal. at 800–832 ft bgs)
R-14	Fluid-assisted air-rotary; mud rotary (1225'–1285')		x	x	Liqui-Trol, Magma Fiber, N-Seal, PAC-L, soda ash

Table B-2 (continued)

Well	Drilling Method	EZ-MUD	QUIK-FOAM	Bentonite Mud	Other Drilling Additives
R-15	Casing advance, fluid-assisted air-rotary	x			Tork-ease
R-16	Fluid-assisted air-rotary (to 867'); mud rotary (867'–1287')	x		x	Liqui-Trol, Magma Fiber, N-Seal, PAC-L, soda ash
R-18	Air-rotary (to 771'); fluid-assisted air-rotary; no bentonite mud	x	x		None noted
R-19	Air-rotary (dry to 143'; with lubrication slurry for 143'–1902.5'); no bentonite mud	x	x		Tork-Ease
R-20	Conventional mud rotary using QUIK-GEL (bentonite), fluid-assisted air-rotary with casing-advance, and air-rotary core with wireline retrieval		x	x	Liqui-Trol, Magma Fiber, N-Seal, soda ash
R-21	Air-rotary; no bentonite mud	x	x		None noted
R-22	Fluid-assisted reverse-circulation air-rotary drilling with casing advance; no bentonite mud	x	x		None noted
R-23	Fluid-assisted air-rotary; used QUIK-GEL (bentonite) only to stiffen QUIK-FOAM		x		Liqui-Trol, Magma Fiber, N-Seal, PAC-L, soda ash
R-25	Air-rotary with casing advance; fluid assist with QUIK-FOAM and EZ-MUD (588'-1427', 1507'-1547'); no bentonite mud	x	x		Magma Fiber, MF-1 flocculant, Tork-Ease, SAPP
R-26	Air-rotary, fluid-assisted air-rotary (from 205 to 1000 ft bgs; QUIK-FOAM and EZ-MUD), mud-rotary (1000 ft to TD; Aqua-Gel bentonite, soda ash & Pac-L)	x	x	x	PAC-L, soda ash
R-28	Air-rotary (to 325'), fluid-assisted air-rotary (QUIK-FOAM and EZ-MUD); no bentonite mud	x	x		Potassium bromide tracer, Well-Guard drilling thread
R-31	Air-rotary (to 345'), air-rotary with lubricating slurry containing TORKease and EZ-MUD (345'–1103'); no bentonite mud	x	x		Tork-Ease
R-32	Fluid-assisted air-rotary with soda ash, QUIK-GEL, Liqui-Trol, and QUIK-FOAM (to 908'); mud rotary using QUIK-GEL (bentonite) and Liqui-Trol (908'–1008')	x	x	x	Liqui-Trol, Magma Fiber, N-Seal, PAC-L, soda ash
R-33	Air-rotary, fluid-assisted air-rotary with QUIK-FOAM and EZ-MUD; no bentonite mud	x	x		None noted
R-34	Air-rotary, fluid-assisted air-rotary with QUIK-FOAM and EZ-MUD; no bentonite mud	x	x		Well-Guard drilling thread; KBr added as tracer

Source: Compiled from well completion reports listed at the end of this appendix.

Table B-3
Descriptions of Drilling Fluid Products Used in Wells

Product name	Description	Typical Amount Added per 100 gal. of Injection Water	Use
Aqua-Clear MGA	Dry blend of granular acid and additives used in the removal of iron, manganese and carbonate scale. pH (10% solution) 0.9	See entry under N-Seal.	Acid for cleaning well: Removes scale and incrustation from the water well screen, casing, gravel pack and pumping equipment
Aqua-Gel	Sodium bentonite (primarily montmorillonite) from Wyoming	na	Drilling mud
EZ-MUD	Liquid polymer emulsion containing partially hydrolyzed polyacrylamide/polyacrylate (PHPA) copolymer, is used primarily as a borehole stabilizer to prevent reactive shale and clay from swelling and sloughing. EZ-MUD is also added to low-solids drilling fluids to increase lubricity, fluid viscosity, and to improve carrying capacity of air/foam injection fluids.	0.5 to 2 quarts	Drilling fluid additive, to stabilize borehole, provide lubricity, and improve foam performance
Liqui-Trol	Free-flowing, liquid suspension of a modified natural cellulosic polymer, in an ultra-clean oil. LIQUI-TROL, when added to a QUIK-GEL® or BORE-GEL™ slurry, yields a drilling mud system suitable for drilling in water sensitive formations.	1 to 6 quarts	Drilling fluid additive, to stabilize formation, improve drilling mud suspension and stabilization properties, and improve foam performance and hole cleaning by improving cuttings transport.
Magma Fiber	Mineral fiber	na	
N-Seal	95% acid-soluble lost-circulation material; specially formulated extrusion spun mineral fiber. Due to its solubility in weak acids, N-SEAL is easily removed from production zones.	5 to 20 lb Note: 1 lb of N-Seal is dissolved in 1 to 2 lb Aqua-Clear MGA or 0.5 to 1 gal. of 10% HCl/5% acetic acid blend	Lost circulation material
PAC-L	Modified natural cellulosic polymer (fiber), provides filtration control in most water-based drilling fluids without substantially increasing viscosity. PAC-L, when added to a QUIK-GEL® or BORE-GEL™ slurry, yields a drilling mud system suitable for drilling in sandy formation.	0.5 to 7 lb	Provide filtration control in fresh or brackish water-based drilling fluids Reduce fluid loss without significantly increasing fluid viscosity Encapsulate shale to prevent swelling and disintegration Promote borehole stability in water sensitive formations Minimize rod chatter, rotational torque and circulating pressure Improve hole cleaning and core recovery

Table B-3 (continued)

Product name	Description	Typical Amount Added per 100 gal. of Injection Water	Use
QUIK-FOAM	Proprietary blend of alcohol ethoxy sulfates (AES) which are biodegradable, is an effective foaming agent. QUIK-FOAM can be added to fresh, brine, or brackish water for air/foam, air/gel-foam, or mist drilling applications.	Dry-air drilling (as a dust suppressant): drilling conditions: 0.5–1 pint Mud-mist drilling in sticky clays: 1–2 quarts Foam and gel-foam drilling: 0.5–2 gal.	Foaming agent: enhances the rate of cuttings removal Increase the ability of lifting large volumes of water Improve hole-cleaning capability of the airstream Reduce the sticking tendencies of wet clays, thereby eliminating mud rings and wall packing Reduce erosion of poorly consolidated formations Provide a technique for drilling in zones with lost circulation Increase borehole stability Reduce air-volume requirement Suppress dust during air drilling operation
QUIK-GEL	Finely ground (200-mesh), premium-grade, high-yielding Wyoming sodium bentonite. QUIK-GEL imparts viscosity, fluid loss control and gelling characteristics to freshwater-based drilling fluids.	Normal drilling conditions: 15–25 lb Unconsolidated formations: 35–50 lb Gel/foam drilling system: 12–15 lb	Viscosifier: Mix with fresh water to form a low-solids drilling fluid for general drilling applications Viscosify water-based drilling fluids Reduce filtration by forming a thin filter cake with low permeability Improve hole-cleaning capability of drilling fluids Mix with foaming agents to make "gel/foam" drilling fluids for air/foam drilling applications
SAPP	Sodium acid pyrophosphate		
Soda Ash	Anhydrous sodium carbonate (Na_2CO_3)		Alkalinity control. Used to precipitate soluble calcium in drilling muds
TORKease	Emulsion of complex stearates		Mud additive used to reduce friction

Source: Product information from various drilling supply companies.

Table B-4
Well Screen Characteristics

Screen ID	Well	Screen #	Saturated Zone	Lithologic Unit	Water Production Status of Aug 05*	Casing ID (in.)	Screen depth (ft)			Screen Type
							Nominal	Top	Bottom	
1	CdV-16-1(i)	1	Intermediate	Otowi Member of Bandelier Tuff	Functional	4.5	624	624	634	Rod 0.02 in.
2	CdV-R-15-3	1	Intermediate	Otowi Member of Bandelier Tuff	Dry	4.5	621	617.7	624.5	Pipe 0.01 in.
3	CdV-R-15-3	2	Intermediate	Contact: Guaje Pumice Bed/Puye Formation	Dry	4.5	804	800.8	807.8	Pipe 0.01 in.
4	CdV-R-15-3	3	Intermediate	Cerros del Rio basalt	Dry	4.5	973	964.8	980.9	Pipe 0.01 in.
5	CdV-R-15-3	4	Regional water table	Puye Formation	Functional	4.5	1254	1235	1279	Pipe 0.01 in.
6	CdV-R-15-3	5	Regional aquifer	Puye Formation	Functional	4.5	1350	1348	1355	Pipe 0.01 in.
7	CdV-R-15-3	6	Regional aquifer	Puye Formation	Functional	4.5	1640	1638	1645	Pipe 0.01 in.
8	CdV-R-37-2	1	Intermediate	Puye fanglomerate	Dry	4.5	935	914.4	939.5	Pipe 0.01 in.
9	CdV-R-37-2	2	Regional water table	Tschicoma Formation Dacitic Lavas	Functional	4.5	1200	1189	1214	Pipe 0.01 in.
10	CdV-R-37-2	3	Regional aquifer	Tschicoma Formation Dacitic Lavas	Functional	4.5	1359	1354	1377	Pipe 0.01 in.
11	CdV-R-37-2	4	Regional aquifer	Tschicoma Formation Dacitic Lavas	Functional	4.5	1551	1549	1556	Pipe 0.01 in.
12	MCOBT-4.4	1	Intermediate	Puye fanglomerate	Functional (dry after 6–8 gal.)	4.5	505	482.1	524.0	Pipe 0.01 in.
13	R-1	1	Regional water table	Lower Puye Fanglomerates	Functional	4.5	1044	1030	1057	Rod 0.02 in.
14	R-2	1	Regional water table	Unassigned fanglomerates	Functional	4.5	918	906.5	929.6	Rod 0.02 in.

Table B-4 (continued)

Screen ID	Well	Screen #	Saturated Zone	Lithologic Unit	Water Production Status of Aug 05	Casing ID (in.)	Screen depth (ft)			Screen Type
15	R-4	1	Regional water table	Unassigned fanglomerates	Functional	4.5	804.5	792.9	816	Rod 0.02 in.
16	R-5	1	Intermediate	Puye Formation	Dry	4.5	329	326.4	331.5	Pipe 0.01 in.
17	R-5	2	Intermediate	Puye Formation	Functional	4.5	383.9	372.8	388.8	Pipe 0.01 in.
18	R-5	3	Regional water table	Santa Fe Group basalt	Functional (port 3B)	4.5	718.6	676.9	720.3	Pipe 0.01 in.
19	R-5	4	Regional aquifer	Santa Fe Group basalt	Functional	4.5	860.9	858.7	863.7	Pipe 0.01 in.
20	R-6	1	Regional water table	Unassigned fanglomerates	Functional	4.5	1217	1205	1228	Rod 0.02 in.
21	R-6i	1	Intermediate	Puye Formation	Functional	4.5	607	602	612	Rod 0.02 in.
22	R-7	1	Intermediate	Upper Puye Formation	Dry	4.5	378	363.2	379.2	Pipe 0.01 in.
23	R-7	2	Intermediate	Puye Formation, pumiceous	Dry	4.5	738.4	730.4	746.4	Pipe 0.01 in.
24	R-7	3	Regional water table	Puye Formation pumiceous	Functional	4.5	915.1	895.5	937.4	Pipe 0.01 in.
25	R-8	1	Regional water table	Puye Formation	Functional	4.5	711.1	705.3	755.7	Pipe 0.01 in.
26	R-8	2	Regional aquifer	Puye Formation	Functional	4.5	825	821.3	828	Pipe 0.01 in.
27	R-9	1	Regional water table	Santa Fe Group sediments	Functional	4.5	684	684	704	Rod 0.01 in.
28	R-9i	1	Upper Intermediate	Cerros del Rio basalt (fractured)	Functional (slow fill)	4.5	198.8	189.1	199.5	Rod 0.01 in.
29	R-9i	2	Lower Intermediate	Cerros del Rio basalt (fractured)	Functional	4.5	278.8	269.6	280.3	Rod 0.01 in.

Table B-4 (continued)

Screen ID	Well	Screen #	Saturated Zone	Lithologic Unit	Water Production Status of Aug 05	Casing ID (in.)	Screen depth (ft)			Screen Type
30	R-11	1	Regional water table	Lower Puye Formation	Functional	4.5	855	855	877.9	Rod 0.02 in.
31	R-12	1	Intermediate	Cerros del Rio basalt	Functional	4.5	468.1	459	467.5	Rod 0.01 in
32	R-12	2	Intermediate	Older alluvium	Dry	4.5	507	504.5	508	Rod 0.005 in
33	R-12	3	Regional water table	Santa Fe Group basalt	Functional (slow fill)	4.5	810.8	801	839	Rod 0.01 in
34	R-13	1	Regional water table	Puye fanglomerate/pumiceous units	Functional	4.5	958.3	958.3	1019	Pipe 0.01 in.
35	R-14	1	Regional water table	Puye Formation	Functional	4.5	1205	1201	1233	Pipe 0.01 in.
36	R-14	2	Regional aquifer	Puye Formation	Functional	4.5	1289	1287	1293	Pipe 0.01 in.
37	R-15	1	Regional water table	Puye Formation	Functional	4.5	958.6	958.6	1020	Pipe 0.01 in.
38	R-16	1	Intermediate	Puye Formation	Cased off during construction	4.5	644.8	641	648.6	Pipe 0.01 in.
39	R-16	2	Regional water table	Santa Fe Group sediments	Functional	4.5	866.1	863.4	870.9	Pipe 0.01 in.
40	R-16	3	Regional aquifer	Santa Fe Group sediments	Functional	4.5	1018	1015	1022	Pipe 0.01 in.
41	R-16	4	Regional aquifer	Santa Fe Group sediments	Functional	4.5	1238	1237	1245	Pipe 0.01 in.
42	R-18	1	Regional water table	Puye Formation	Functional	4.5	1375	1358	1381	Rod 0.02 in.
43	R-19	1	Intermediate	Guaje Pumice Bed	Dry	4.5	835.4	827.2	843.6	Pipe 0.01 in.
44	R-19	2	Intermediate	Puye Formation	Functional (low pressure)	4.5	909.3	893.3	909.6	Pipe 0.01 in.

Table B-4 (continued)

Screen ID	Well	Screen #	Saturated Zone	Lithologic Unit	Water Production Status of Aug 05	Casing ID (in.)	Screen depth (ft)			Screen Type
45	R-19	3	Regional water table	Puye Formation (fanglomerate facies)	Functional (slow fill)	4.5	1191	1171	1215	Pipe 0.01 in.
46	R-19	4	Regional aquifer	Puye Formation (fanglomerate facies)	Functional	4.5	1413	1410	1417	Pipe 0.01 in.
47	R-19	5	Regional aquifer	Puye Formation (fanglomerate facies)	Functional	4.5	1586	1583	1590	Pipe 0.01 in.
48	R-19	6	Regional aquifer	Puye Formation (fanglomerate facies)	Functional	4.5	1730	1727	1734	Pipe 0.01 in.
49	R-19	7	Regional aquifer	Puye Formation (fanglomerate facies)	Functional	4.5	1835	1832	1840	Pipe 0.01 in.
50	R-20	1	Regional water table	Puye Formation	Functional	4.5	907	904.6	912.2	Pipe 0.01 in.
51	R-20	2	Regional aquifer	Pumiceous fanglomerates	Functional	4.5	1150	1147	1155	Pipe 0.01 in.
52	R-20	3	Regional aquifer	Santa Fe Group sediments	Functional	4.5	1330	1329	1337	Pipe 0.01 in.
53	R-21	1	Regional water table	Puye Formation	Functional	6	888.8	887.8	907.8	Rod 0.02 in.
54	R-22	1	Regional water table	Cerros del Rio basalt	Functional	4.5	907.1	872.3	914.2	Pipe 0.01 in.
55	R-22	2	Regional aquifer	Cerros del Rio basalt	Functional	4.5	962.8	947	988.9	Pipe 0.01 in.
56	R-22	3	Regional aquifer	Upper Puye Fanglomerateas	Functional	4.5	1274	1272	1279	Pipe 0.01 in.
57	R-22	4	Regional aquifer	Older basalt (clay-altered)	Functional	4.5	1378	1378	1385	Pipe 0.01 in.
58	R-22	5	Regional aquifer	Lower Puye Fanglomerates	Functional	4.5	1448	1447	1452	Pipe 0.01 in.
59	R-23	1	Regional water table	Santa Fe Group sediments	Functional	4.5	816	816	873.2	Pipe 0.01 in.

Table B-4 (continued)

Screen ID	Well	Screen #	Saturated Zone	Lithologic Unit	Water Production Status of Aug 05	Casing ID (in.)	Screen depth (ft)			Screen Type
60	R-25	1	Intermediate	Otowi Member of Bandelier Tuff	Functional	5.17	754.8	737.6	758.4	Rod 0.01 in.
61	R-25	2	Intermediate	Puye Formation (fanglomerate facies)	Functional	5.17	891.8	882.6	893.4	Rod 0.01 in.
62	R-25	3	Intermediate	Puye Formation (fanglomerate facies)	Dry	5.17	1063	1055	1065	Rod 0.01 in.
63	R-25	4	Intermediate	Puye Formation (fanglomerate facies)	Functional	5.17	1192	1185	1195	Rod 0.01 in.
64	R-25	5	Regional water table	Puye Formation (fanglomerate facies)	Functional (very slow fill)	5.17	1303	1295	1305	Rod 0.01 in.
65	R-25	6	Regional aquifer	Puye Formation (fanglomerate facies)	Functional	5.17	1406	1405	1415	Rod 0.01 in.
66	R-25	7	Regional aquifer	Puye Formation (fanglomerate facies)	Functional	5.17	1606	1605	1615	Rod 0.01 in.
67	R-25	8	Regional aquifer	Puye Formation (fanglomerate facies)	Functional	5.17	1796	1795	1805	Rod 0.01 in.
68	R-25	9	Regional aquifer	Puye Formation (fanglomerate facies)	Plugged off during well construction	5.17	na	1895	1905	Rod 0.01 in.
69	R-26	1	Intermediate	Cerro Toledo interval	Functional	4.5	659.3	651.8	669.9	Rod 0.02 in.
70	R-26	2	Regional aquifer	Puye Formation	Screen clogged	4.5	1433	1422	1445	Pipe 0.01 in.
71	R-28	1	Regional water table	Puye Formation	Functional	4.5	946.2	934.3	958.1	Rod 0.02 in.
72	R-31	1	Intermediate	Cerros del Rio basalt	Dry	4.5	446.8	439.1	454.4	Rod 0.01 in.
73	R-31	2	Regional water table	Cerros del Rio basalt	Functional (port 2B; slow fill)	4.5	532.2	515	545.7	Rod 0.01 in.

Table B-4 (continued)

Screen ID	Well	Screen #	Saturated Zone	Lithologic Unit	Water Production Status of Aug 05	Casing ID (in.)	Screen depth (ft)			Screen Type
74	R-31	3	Regional aquifer	Cerros del Rio basalt	Unreliable pressures	4.5	670	666.3	676.3	Rod 0.01 in.
75	R-31	4	Regional aquifer	Totavi Lentil	Unreliable pressures	4.5	830	826.6	836.6	Rod 0.01 in.
76	R-31	5	Regional aquifer	Puye fanglomerates and river gravels	Unreliable pressures	4.5	1011	1007	1017	Rod 0.01 in.
77	R-32	1	Regional water table	Cerros del Rio basalt and river gravels	Functional	4.5	870.9	867.5	875.2	Pipe 0.01 in.
78	R-32	2	Regional aquifer	Puye Formation	Only used for pressure readings	4.5	933.4	931.8	934.8	Pipe 0.01 in.
79	R-32	3	Regional aquifer	Puye Formation	Functional	4.5	976	927.9	980.6	Pipe 0.01 in.
80	R-33	1	Regional water table	Pumiceous Unit (unassigned)	Functional	4.5	995.5	995.5	1018.5	Rod 0.02 in.
81	R-33	2	Regional aquifer	Pumiceous Unit (unassigned)	Functional	4.5	1112.4	1112.4	1122.3	Rod 0.02 in.
82	R-34	1	Regional water table	Puye Formation	Functional	4.5	895.2	883.7	906.6	Rod 0.02 in.

Source: Compiled from well completion reports listed at the end of this Appendix.

* Water production comments are provided by A. Banar (ENV-WQH), on 15-Aug-05 and 24-Aug-05. "Functional" indicates that the screen interval produces an adequate volume of groundwater for chemical analysis.

Table B-5
Inventory of Post-development Sampling Events and Availability of Water-Quality Data

Note: Samples used for the Tier 2 screen assessment in this report are indicated by an asterisk (*) in the column labeled "Sampling Phase."

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase[a]	Sample Collection Date[b]	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data[c]	General Inorganics	Metals	Radionucides[d]	Low-Detection Limit Tritium	HEXP[e]	SVOA[e]	VOA[e]	Pesticides/PCBs[e]	Geochemistry Report[f]	Field Data[c,g]	ER Database[g]
1	CdV-16-1(i)	1	624.0	*Characterization 1	1-Jun-05	—	x	x	—	x	x	x	x	—	—	x	—
1	CdV-16-1(i)	1	624.0	*Characterization 2	29-Aug-05	x	x	x	—	—	—	—	x	—	—	—	—
5	CdV-R-15-3	4	1254.4	Characterization 1	3-Jan-01	—	—	—	—	—	—	—	—	—	—	x	x
5	CdV-R-15-3	4	1254.4	Characterization 2	23-Apr-01	—	—	—	—	—	—	—	—	—	—	x	x
5	CdV-R-15-3	4	1254.4	Characterization 3	18-Jul-01	—	—	—	—	—	—	—	—	—	—	x	x
5	CdV-R-15-3	4	1254.4	Characterization 4	9-Oct-01	—	x	x	x	x	x	x	x	x	—	x	—
5	CdV-R-15-3	4	1254.4	Surveillance	4-Jan-02	—	x	x	x	x	x	x	x	x	—	—	—
5	CdV-R-15-3	4	1254.4	Surveillance	15-Apr-02	—	x	x	—	x	x	—	—	—	—	x	—
5	CdV-R-15-3	4	1254.4	Surveillance	16-Jul-02	—	x	x	—	x	x	—	—	—	—	x	—
5	CdV-R-15-3	4	1254.4	Investigation	16-Sep-02	—	—	—	—	—	—	—	—	—	—	x	x
5	CdV-R-15-3	4	1254.4	Investigation	14-Jan-03	—	—	—	—	—	—	—	—	—	—	x	x
5	CdV-R-15-3	4	1254.4	Investigation	1-May-03	—	—	—	—	—	—	—	—	—	—	x	x
5	CdV-R-15-3	4	1254.4	Investigation	30-Jul-03	—	—	—	—	—	—	—	—	—	—	x	x
5	CdV-R-15-3	4	1254.4	Surveillance	6-Jan-04	—	x	x	—	x	x	x	x	—	—	x	—
5	CdV-R-15-3	4	1254.4	Surveillance	20-Apr-04	—	x	x	—	x	x	—	—	—	—	x	—
5	CdV-R-15-3	4	1254.4	Surveillance	6-Jul-04	—	x	x	—	x	x	—	—	—	—	x	—
5	CdV-R-15-3	4	1254.4	*Surveillance	19-Oct-04	—	x	x	—	x	x	—	—	—	—	x	—
5	CdV-R-15-3	4	1254.4	*Surveillance	4-Apr-05	—	x	x	—	x	x	x	x	—	—	x	—
5	CdV-R-15-3	4	1254.4	*Surveillance	12-Jul-05	x	x	x	—	x	x	—	x	—	—	—	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionuclides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
6	CdV-R-15-3	5	1350.1	Characterization 1	4-Jan-01	—	—	—	—	—	—	—	—	—	—	x	x
6	CdV-R-15-3	5	1350.1	Characterization 2	25-Apr-01	—	—	—	—	—	—	—	—	—	—	x	x
6	CdV-R-15-3	5	1350.1	Characterization 3	19-Jul-01	—	—	—	—	—	—	—	—	—	—	x	x
6	CdV-R-15-3	5	1350.1	Characterization 4	11-Oct-01	—	x	x	x	x	x	x	x	x	—	x	—
6	CdV-R-15-3	5	1350.1	Surveillance	15-Jan-02	—	x	x	x	x	x	x	x	x	—	x	—
6	CdV-R-15-3	5	1350.1	Surveillance	15-Apr-02	—	x	x	—	x	x	—	—	—	—	x	—
6	CdV-R-15-3	5	1350.1	Surveillance	16-Jul-02	—	x	x	—	x	x	—	—	—	—	x	—
6	CdV-R-15-3	5	1350.1	Investigation	17-Sep-02	—	—	—	—	—	—	—	—	—	—	x	x
6	CdV-R-15-3	5	1350.1	Investigation	15-Jan-03	—	—	—	—	—	—	—	—	—	—	x	x
6	CdV-R-15-3	5	1350.1	Investigation	2-May-03	—	—	—	—	—	—	—	—	—	—	x	x
6	CdV-R-15-3	5	1350.1	Investigation	31-Jul-03	—	—	—	—	—	—	—	—	—	—	x	x
6	CdV-R-15-3	5	1350.1	Investigation	7-Jan-04	—	x	x	—	x	x	x	x	—	—	x	—
6	CdV-R-15-3	5	1350.1	Surveillance	21-Apr-04	—	x	x	—	x	x	—	—	—	—	x	—
6	CdV-R-15-3	5	1350.1	Surveillance	7-Jul-04	—	x	x	—	x	x	—	—	—	—	x	—
6	CdV-R-15-3	5	1350.1	*Surveillance	20-Oct-04	—	x	x	—	x	x	—	—	—	—	x	—
6	CdV-R-15-3	5	1350.1	*Surveillance	5-Apr-05	—	x	x	—	x	x	x	x	—	—	x	—
6	CdV-R-15-3	5	1350.1	*Surveillance	12-Jul-05	x	x	x	—	x	x	—	x	—	—	—	—
7	CdV-R-15-3	6	1640.1	Characterization 1	4-Jan-01	—	—	—	—	—	—	—	—	—	—	x	x
7	CdV-R-15-3	6	1640.1	Characterization 2	25-Apr-01	—	—	—	—	—	—	—	—	—	—	x	x
7	CdV-R-15-3	6	1640.1	Characterization 3	20-Jul-01	—	—	—	—	—	—	—	—	—	—	x	x
7	CdV-R-15-3	6	1640.1	Characterization 4	12-Oct-01	—	x	x	x	—	—	—	—	—	—	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
7	CdV-R-15-3	6	1640.1	Surveillance	15-Jan-02	—	x	x	x	x	x	x	x	x	—	x	—
7	CdV-R-15-3	6	1640.1	Investigation	16-Apr-02	—	x	x	—	x	x	—	—	—	—	x	—
7	CdV-R-15-3	6	1640.1	Investigation	17-Jul-02	—	x	x	—	x	x	—	—	—	—	x	—
7	CdV-R-15-3	6	1640.1	Surveillance	18-Sep-02	—	—	—	—	—	—	—	—	—	—	x	x
7	CdV-R-15-3	6	1640.1	Surveillance	12-Oct-02	—	x	x	x	x	x	x	x	x	—	—	—
7	CdV-R-15-3	6	1640.1	Surveillance	16-Jan-03	—	—	—	—	—	—	—	—	—	—	x	x
7	CdV-R-15-3	6	1640.1	Surveillance	5-May-03	—	—	—	—	—	—	—	—	—	—	x	x
7	CdV-R-15-3	6	1640.1	Surveillance	31-Jul-03	—	—	—	—	—	—	—	—	—	—	x	x
7	CdV-R-15-3	6	1640.1	Surveillance	8-Jan-04	—	x	x	—	x	x	x	x	—	—	x	—
7	CdV-R-15-3	6	1640.1	Surveillance	21-Apr-04	—	x	x	—	x	x	—	—	—	—	x	—
7	CdV-R-15-3	6	1640.1	Surveillance	8-Jul-04	—	x	x	—	x	x	—	—	—	—	x	—
7	CdV-R-15-3	6	1640.1	*Surveillance	21-Oct-04	—	x	x	—	x	x	—	—	—	—	x	—
7	CdV-R-15-3	6	1640.1	*Surveillance	6-Apr-05	—	x	x	—	x	x	x	x	—	—	x	—
7	CdV-R-15-3	6	1640.1	*Surveillance	13-Jul-05	x	x	x	—	x	x	—	x	—	—	—	—
9	CdV-R-37-2	2	1200.3	Characterization 1	28-Jan-02	—	x	x	—	x	x	x	x	—	—	x	x
9	CdV-R-37-2	2	1200.3	Characterization 2	23-Apr-02	—	x	x	—	x	x	—	—	—	—	x	—
9	CdV-R-37-2	2	1200.3	Characterization 3	18-Jul-02	—	—	—	—	—	—	—	—	—	—	x	x
9	CdV-R-37-2	2	1200.3	Characterization 4	18-Sep-02	—	—	—	—	—	—	—	—	—	—	x	x
9	CdV-R-37-2	2	1200.3	Surveillance	21-Jan-03	—	—	—	—	—	—	—	—	—	—	x	x
9	CdV-R-37-2	2	1200.3	Surveillance	6-May-03	—	—	—	—	—	—	—	—	—	—	x	x
9	CdV-R-37-2	2	1200.3	Surveillance	5-Aug-03	—	—	—	—	—	—	—	—	—	—	x	x

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
9	CdV-R-37-2	2	1200.3	Surveillance	2-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
9	CdV-R-37-2	2	1200.3	Surveillance	13-Apr-04	—	x	x	—	x	x	—	—	—	—	x	—
9	CdV-R-37-2	2	1200.3	*Surveillance	26-Oct-04	—	x	x	—	x	x	—	—	—	—	x	—
9	CdV-R-37-2	2	1200.3	*Surveillance	29-Mar-05	—	x	x	—	x	x	x	x	—	—	x	—
9	CdV-R-37-2	2	1200.3	*Surveillance	6-Jul-05	x	x	x	—	x	x		x	—	—	—	—
10	CdV-R-37-2	3	1359.3	Characterization 1	29-Jan-02	—	x	x	—	x	x	x	x	—	—	x	x
10	CdV-R-37-2	3	1359.3	Characterization 2	24-Apr-02	—	x	x	—	x	x	—	—	—	—	x	—
10	CdV-R-37-2	3	1359.3	Characterization 3	19-Jul-02	—	—	—	—	—	—	—	—	—	—	x	x
10	CdV-R-37-2	3	1359.3	Characterization 4	24-Sep-02	—	—	—	—	—	—	—	—	—	—	x	x
10	CdV-R-37-2	3	1359.3	Surveillance	22-Jan-03	—	—	—	—	—	—	—	—	—	—	x	x
10	CdV-R-37-2	3	1359.3	Surveillance	7-May-03	—	—	—	—	—	—	—	—	—	—	x	x
10	CdV-R-37-2	3	1359.3	Surveillance	6-Aug-03	—	—	—	—	—	—	—	—	—	—	x	x
10	CdV-R-37-2	3	1359.3	Surveillance	3-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
10	CdV-R-37-2	3	1359.3	Surveillance	13-Apr-04	—	x	x	—	x	x	—	—	—	—	x	—
10	CdV-R-37-2	3	1359.3	Surveillance	27-Oct-04	—	x	x	—	x	x	—	—	—	—	x	—
10	CdV-R-37-2	3	1359.3	Surveillance	30-Mar-05	—	x	x	—	x	x	x	x	—	—	x	—
10	CdV-R-37-2	3	1359.3	Surveillance	7-Jul-05	x	x	x	—	x	x	—	x	—	—	—	—
11	CdV-R-37-2	4	1550.6	Characterization 1	30-Jan-02	—	x	x	—	x	x	x	x	—	—	x	—
11	CdV-R-37-2	4	1550.6	Characterization 2	25-Apr-02	—	x	x	—	x	x	—	—	—	—	x	—
11	CdV-R-37-2	4	1550.6	Characterization 3	22-Jul-02	—	—	—	—	—	—	—	—	—	—	x	x
11	CdV-R-37-2	4	1550.6	Characterization 4	26-Sep-02	—	—	—	—	—	—	—	—	—	—	x	x

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
11	CdV-R-37-2	4	1550.6	Surveillance	23-Jan-03	—	—	—	—	—	—	—	—	—	—	x	x
11	CdV-R-37-2	4	1550.6	Surveillance	8-May-03	—	—	—	—	—	—	—	—	—	—	x	x
11	CdV-R-37-2	4	1550.6	Surveillance	6-Aug-03	—	—	—	—	—	—	—	—	—	—	x	x
11	CdV-R-37-2	4	1550.6	Surveillance	3-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
11	CdV-R-37-2	4	1550.6	Surveillance	15-Apr-04	—	x	x	—	x	x	—	—	—	—	x	—
11	CdV-R-37-2	4	1550.6	*Surveillance	27-Oct-04	—	x	x	—	x	x	—	—	—	—	x	—
11	CdV-R-37-2	4	1550.6	*Surveillance	31-Mar-05	—	x	x	—	x	x	x	x	—	—	x	—
11	CdV-R-37-2	4	1550.6	*Surveillance	8-Jul-05	x	x	x	—	x	x	—	x	—	—	—	—
12	MCOBT-4.4	1	504.7	Characterization ?	22-Apr-02	—	—	—	—	—	—	—	—	—	—	—	x
12	MCOBT-4.4	1	504.7	Characterization ?	28-Jun-02	—	—	—	—	—	—	—	—	—	—	—	x
12	MCOBT-4.4	1	504.7	Characterization ?	30-Sep-02	—	—	—	—	—	—	—	—	—	—	—	x
12	MCOBT-4.4	1	504.7	Characterization ?	28-Jan-03	—	x	x	—	—	—	—	x	—	—	—	x
12	MCOBT-4.4	1	504.7	Characterization ?	21-May-03	—	—	—	—	—	—	—	—	—	—	—	x
12	MCOBT-4.4	1	504.7	*Surveillance	14-Oct-04	—	x	x	—	—	—	—	x	—	—	—	x
12	MCOBT-4.4	1	504.7	*Surveillance	29-Mar-05	x	—	—	—	—	—	—	—	—	—	—	—
12	MCOBT-4.4	1	504.7	*Surveillance	8-Jun-05	x	x	—	x	—	—	—	—	—	—	—	—
13	R-1	1	1031.1	*Characterization 1	19-May-05	x	x	x	x	—	x	x	x	x	—	x	—
14	R-2	1	918.0	Investigation	13-Jan-04	—	—	—	x	x	—	—	—	—	—	—	x
14	R-2	1	918.0	*Characterization 1	26-Apr-05	x	x	x	x	x	x	x	x	x	—	x	—
14	R-2	1	918.0	*Characterization 2	9-Aug-05	x	x	x	—	—	—	—	x	—	—	—	—
15	R-4	1	804.45	Investigation	9-Sep-03	—	—	—	—	x	—	—	—	—	—	—	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
15	R-4	1	804.45	Investigation	10-Oct-03	—	—	—	x	—	—	—	—	—	—	—	—
15	R-4	1	804.45	*Characterization 1	27-Apr-05	x	x	x	x	x	x	x	x	x	—	x	—
15	R-4	1	804.45	*Characterization 2	8-Aug-05	x	x	x	x	—	x	x	x	x	—	—	—
17	R-5	2	383.9	Characterization 1	23-Feb-04	—	x	x	x	x	x	x	x	x	—	x	—
17	R-5	2	383.9	*Characterization 2	28-Apr-04	x	x	x	x	x	x	x	x	x	—	x	—
17	R-5	2	383.9	*Characterization 3	27-Sep-04	—	x	x	x	x	x	x	x	x	—	x	—
17	R-5	2	383.9	*Characterization 4	2-May-05	x	x	x	x	x	—	—	x	x	—	—	—
18	R-5	3	718.6	Characterization 1a	26-Feb-04	—	x	x	—	—	—	—	—	—	—	x	—
18	R-5	3	718.6	Characterization 1b	2-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
18	R-5	3	718.6	*Characterization 2	30-Apr-04	—	x	x	x	x	x	x	x	x	—	x	—
18	R-5	3	718.6	*Characterization 3	28-Sep-04	—	x	x	x	x	x	x	x	x	—	x	—
18	R-5	3	718.6	*Characterization 4	3-May-05	x	x	x	x	x	—	—	x	x	—	—	—
19	R-5	4	860.9	Characterization 1	19-Feb-04	—	x	x	x	x	x	x	x	x	—	x	—
19	R-5	4	860.9	*Characterization 2	3-May-04	—	x	x	x	x	x	x	x	x	—	x	—
19	R-5	4	860.9	*Characterization 3	30-Sep-04	—	x	x	x	x	x	x	x	x	—	x	—
19	R-5	4	860.9	*Characterization 4	4-May-05	x	x	x	x	x	—	—	x	x	—	—	—
20	R-6	1	1217	*Characterization 1	23-Aug-05	x	x	x	—	—	—	—	x	—	—	—	—
21	R-6(i)	1	607	*Characterization 1	24-Aug-05	x	x	x	—	—	—	—	x	—	—	—	—
24	R-7	3	915.1	Characterization 1	30-May-01	—	x	x	x	x	x	x	x	x	x	x	—
24	R-7	3	915.1	Characterization 2	9-Aug-01	—	x	x	x	—	x	x	x	x	x	x	—
24	R-7	3	915.1	Characterization 3	20-Nov-01	—	x	x	x	x	x	x	x	x	x	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
24	R-7	3	915.1	Characterization 4	20-Feb-02	—	x	x	x	x	x	x	x	x	x	x	—
24	R-7	3	915.1	Surveillance	6-Aug-02	x	x	x	x	x	—	x	x	—	—	x	—
24	R-7	3	915.1	*Surveillance	18-Dec-03	—	x	x	x	x	—	x	x	—	—	x	—
24	R-7	3	915.1	*Surveillance	26-May-04	—	x	x	x	x	—	—	x	—	—	x	—
24	R-7	3	915.1	Investigation	12-Oct-04	—	—	—	—	—	—	—	—	—	—	x	—
24	R-7	3	915.1	*Surveillance	26-Apr-05	x	x	x	x	x	—	—	x	x	—	—	—
25	R-8	1	711.1	Characterization 1	25-Feb-04	—	x	x	x	x	x	x	x	x	—	x	—
25	R-8	1	711.1	Characterization 2	21-Apr-04	—	—	—	—	x	—	—	—	—	—	—	—
25	R-8	1	711.1	Characterization 2	26-Apr-04	—	x	x	x	—	x	x	x	x	—	x	—
25	R-8	1	711.1	*Characterization 3	24-Aug-04	—	x	x	x	x	x	x	x	x	—	x	—
25	R-8	1	711.1	*Characterization 4	8-Dec-04	—	x	x	x	x	x	x	x	x	—	x	—
25	R-8	1	711.1	*Surveillance	27-Apr-05	x	—	x	x	x	—	—	x	x	—	—	—
26	R-8	2	825.0	Characterization 1	20-Feb-04	—	x	x	x	x	—	x	x	x	—	—	—
26	R-8	2	825.0	Characterization 1	23-Feb-04	—	—	—	—	—	x	—	—	—	—	x	—
26	R-8	2	825.0	Characterization 2	27-Apr-04	—	x	x	x	x	x	x	x	x	—	x	—
26	R-8	2	825.0	*Characterization 3	25-Aug-04	—	x	x	x	x	x	x	x	x	—	x	—
26	R-8	2	825.0	*Characterization 4	9-Dec-04	—	x	x	x	x	x	x	x	x	—	x	—
26	R-8	2	825.0	*Surveillance	28-Apr-05	x	x	x	x	x	—	—	x	x	—	—	—
27	R-9	1	684.0	Characterization 1	28-Feb-00	—	x	x	x	—	x	x	x	—	x	—	—
27	R-9	1	684.0	Characterization 2	29-Sep-00	—	x	x	x	—	x	x	x	—	x	—	—
27	R-9	1	684.0	Characterization 3	13-Feb-01	—	x	x	x	x	x	—	x	—	x	—	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
27	R-9	1	684.0	Characterization 4	15-May-01	—	x	x	x	x	x	—	x	—	x	—	x
27	R-9	1	684.0	*Surveillance	12-Dec-03	x	x	x	x	x	—	—	—	—	—	—	—
27	R-9	1	684.0	*Surveillance	27-May-04	—	x	x	x	x	—	—	x	—	—	x	—
27	R-9	1	684.0	Investigation	8-Oct-04	—	—	—	—	—	—	—	—	—	—	x	—
27	R-9	1	684.0	Investigation	19-Mar-05	x	—	—	—	—	—	—	—	—	—	x	—
27	R-9	1	684.0	Investigation	6-Apr-05	x	—	—	—	x	—	—	—	—	—	x	—
27	R-9	1	684.0	*Surveillance	28-Apr-05	x	x	x	x	x	—	—	x	x	—	—	—
28	R-9i	1	198.8	Characterization 1	14-Sep-00	—	x	x	x	—	x	x	x	—	x	x	—
28	R-9i	1	198.8	Characterization 2a	2-Feb-01	—	—	x	—	x	x	—	—	—	—	—	—
28	R-9i	1	198.8	Characterization 2b	20-Feb-01	—	x	x	x	—	—	—	—	—	x	x	—
28	R-9i	1	198.8	Characterization 3	11-Jun-01	—	x	x	x	x	x	—	—	—	x	x	—
28	R-9i	1	198.8	Characterization 4	5-Sep-01	—	x	x	x	x	x	x	x	—	x	x	—
28	R-9i	1	198.8	Surveillance	26-Jul-02	x	x	x	x	x	—	—	—	—	—	x	—
28	R-9i	1	198.8	Surveillance	2-Aug-02	—	—	—	x	—	—	—	—	—	—	x	—
28	R-9i	1	198.8	Surveillance	16-Aug-02	—	—	—	—	—	—	—	—	—	—	x	—
28	R-9i	1	198.8	*Surveillance	6-Feb-04	—	x	x	x	x	—	—	—	—	—	—	—
28	R-9i	1	198.8	*Surveillance	2-Jun-04	—	x	x	x	x	—	—	x	—	—	x	—
28	R-9i	1	198.8	*Surveillance	20-Apr-05	x	x	x	x	x	—	—	x	x	—	—	—
29	R-9i	2	278.8	Characterization 1	15-Sep-00	—	x	x	x	—	x	x	x	—	x	x	—
29	R-9i	2	278.8	Characterization 2	21-Feb-01	—	x	x	x	x	x	—	—	—	x	x	—
29	R-9i	2	278.8	Characterization 3	12-Jun-01	—	x	x	x	x	x	—	—	—	x	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
29	R-9i	2	278.8	*Characterization 4	6-Sep-01	—	x	x	x	x	—	—	x	—	x	x	—
29	R-9i	2	278.8	*Surveillance	29-Jul-02	x	x	x	x	x	—	—	—	—	—	x	—
29	R-9i	2	278.8	*Surveillance	6-Feb-04	—	x	x	x	x	—	—	—	—	—	—	—
30	R-11	1	855.0	*Characterization 1	17-May-05	x	x	x	x	x	x	x	x	x	—	x	—
30	R-11	1	855.0	*Characterization 2	3-Aug-05	—	x	x	x	x	x	x	x	x	—	—	—
31	R-12	1	468.1	Characterization 1	18-Sep-00	—	x	x	x	x	x	x	x	—	x	x	—
31	R-12	1	468.1	Characterization 2	14-Mar-01	—	x	x	x	—	x	—	—	—	x	x	—
31	R-12	1	468.1	Characterization 3	13-Jun-01	—	x	x	x	x	x	—	—	—	x	x	—
31	R-12	1	468.1	Characterization 4	7-Sep-01	—	x	x	—	x	—	—	x	—	x	x	—
31	R-12	1	468.1	Surveillance	31-Jul-02	x	x	x	x	x	—	—	—	—	—	x	—
31	R-12	1	468.1	*Surveillance	2-Feb-04	—	x	x	x	x	—	—	—	—	—	—	—
31	R-12	1	468.1	*Surveillance	2-Jun-04	—	x	x	x	—	x	x	x	x	—	x	—
31	R-12	1	468.1	*Surveillance	16-Jun-05	x	x	x	x	x	x	x	x	x	—	—	—
31	R-12	1	468.1	*Surveillance	30-Jun-05	x	—	—	x	—	—	—	—	—	—	—	—
33	R-12	3	810.8	Characterization 1	20-Sep-00	—	x	x	x	—	x	x	x	—	x	x	—
33	R-12	3	810.8	Characterization 2	15-Mar-01	—	x	x	x	—	x	—	—	—	x	x	—
33	R-12	3	810.8	Characterization 3	14-Jun-01	—	x	x	x	x	x	—	—	—	x	x	—
33	R-12	3	810.8	Characterization 4	11-Sep-01	—	x	x	x	x	x	x	x	—	x	x	—
33	R-12	3	810.8	Surveillance	1-Aug-02	x	x	x	x	x	—	—	—	—	—	x	—
33	R-12	3	810.8	*Surveillance	27-Jan-04	—	x	x	x	x	—	—	—	—	—	—	—
33	R-12	3	810.8	*Surveillance	3-Jun-04	—	x	x	x	—	x	x	x	x	—	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
33	R-12	3	810.8	*Surveillance	20-Jun-05	x	x	x	x	—	x	x	x	x	—	—	—
34	R-13	1	958.3	Characterization ?	18-Apr-02	—	—	—	—	—	—	—	—	—	—	—	x
34	R-13	1	958.3	Characterization ?	3-Jul-02	—	—	—	—	—	—	—	—	—	—	—	x
34	R-13	1	958.3	Characterization ?	28-Oct-02	—	—	—	—	—	—	—	—	—	—	—	x
34	R-13	1	958.3	Characterization ?	27-Jan-03	—	—	—	—	—	—	—	—	—	—	—	x
34	R-13	1	958.3	Characterization ?	22-May-03	—	—	—	—	—	—	—	—	—	—	—	x
34	R-13	1	958.3	*Surveillance	9-Dec-03	x	x	x	x	x	—	—	—	—	—	—	—
34	R-13	1	958.3	*Surveillance	11-Jun-04	x	x	x	x	x	x	x	x	x	—	—	—
34	R-13	1	958.3	Investigation	10-Mar-05	x	—	—	—	—	—	—	—	—	—	x	—
34	R-13	1	958.3	Investigation	26-May-05	x	x	—	—	x	—	—	—	—	—	x	—
34	R-13	1	958.3	Surveillance	1-Sep-05	x	—	—	—	—	—	—	—	—	—	—	—
35	R-14	1	1204.5	Characterization 1	9-Feb-04	—	x	x	x	x	x	x	x	x	—	—	—
35	R-14	1	1204.5	*Characterization 2	12-Jul-04	—	x	x	x	x	x	x	x	x	—	x	—
35	R-14	1	1204.5	*Characterization 3	28-Oct-04	—	x	x	x	x	x	x	x	x	—	x	—
35	R-14	1	1204.5	*Characterization 4	10-May-05	x	x	x	x	x	x	x	x	x	—	x	—
36	R-14	2	1288.5	Post-development	11-Feb-04	—	x	x	x	x	—	—	x	—	—	—	—
36	R-14	2	1288.5	Post-development	14-Feb-04	—	—	—	—	—	—	—	—	—	—	—	—
36	R-14	2	1288.5	Characterization 1	17-Feb-04	—	x	x	—	—	x	x	x	x	—	—	—
36	R-14	2	1288.5	*Characterization 2	14-Jul-04	—	x	x	x	x	x	x	x	x	—	x	—
36	R-14	2	1288.5	*Characterization 3	3-Nov-04	—	x	x	x	x	x	x	x	x	—	x	—
36	R-14	2	1288.5	*Characterization 4	12-May-05	x	x	x	x	x	x	x	x	x	—	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
37	R-15	1	958.6	Characterization 1	24-Feb-00	—	x	x	x	x	x	x	x	—	x	—	—
37	R-15	1	958.6	Characterization 2	10-Oct-00	—	x	x	x	—	x	x	x	—	x	—	—
37	R-15	1	958.6	Characterization 3	15-Feb-01	—	x	x	x	x	—	—	x	—	x	—	x
37	R-15	1	958.6	Characterization 4	22-May-01	—	x	x	x	x	—	—	x	—	x	—	—
37	R-15	1	958.6	Investigation	18-Sep-02	—	—	—	—	—	—	—	—	—	—	—	—
37	R-15	1	958.6	Investigation	5-May-03	—	—	—	—	—	—	—	—	—	—	—	—
37	R-15	1	958.6	*Surveillance	15-Dec-03	x	x	x	x	x	—	—	—	—	—	x	—
37	R-15	1	958.6	*Surveillance	10-Jun-04	x	x	x	x	x	x	x	x	x	—	—	—
37	R-15	1	958.6	Investigation	19-Nov-04	—	—	—	—	x	—	—	—	—	—	x	—
37	R-15	1	958.6	Investigation	9-Mar-05	x	—	—	—	—	—	—	—	—	—	x	—
37	R-15	1	958.6	*Surveillance	25-May-05	x	x	x	x	x	x	x	x	—	—	x	—
37	R-15	1	958.6	*Surveillance	31-Aug-05	x	x	x	—	—	—	—	x	—	—	—	—
39	R-16	2	866.1	Characterization 1	16-Mar-04	—	x	—	x	x	x	x	x	x	—	x	—
39	R-16	2	866.1	Characterization 2a	12-May-04	x	—	x	x	x	—	—	—	—	—	x	—
39	R-16	2	866.1	Characterization 2b	18-May-04	—	x	—	—	—	x	x	x	x	—	x	—
39	R-16	2	866.1	*Characterization 3	13-Oct-04	—	x	x	x	x	x	x	x	x	—	—	—
39	R-16	2	866.1	*Characterization 4	2-Dec-04	—	x	x	x	x	x	x	x	x	—	x	—
39	R-16	2	866.1	*Surveillance	13-Jun-05	x	x	x	x	—	—	x	x	—	—	—	—
40	R-16	3	1018.4	Characterization 1	16-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
40	R-16	3	1018.4	Characterization 2	16-May-04	x	x	x	x	x	x	x	x	x	—	x	—
40	R-16	3	1018.4	Characterization 3	14-Oct-04	—	x	x	x	x	x	x	x	x	—	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
40	R-16	3	1018.4	*Characterization 4a	3-Dec-04	—	x	x	x	x	—	x	x	x	—	—	—
40	R-16	3	1018.4	*Characterization 4b	6-Dec-04	—	—	—	—	—	x	—	—	—	—	x	—
40	R-16	3	1018.4	*Surveillance	13-Jun-05	—	x	x	x	—	—	x	x	—	—	—	—
41	R-16	4	1238.0	Characterization 1	18-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
41	R-16	4	1238.0	Characterization 2	13-May-04	x	x	x	x	x	x	x	x	x	—	x	—
41	R-16	4	1238.0	Characterization 3	15-Oct-04	—	x	x	x	—	x	x	x	x	—	—	—
41	R-16	4	1238.0	*Characterization 3	18-Oct-04	—	—	—	—	x	—	—	—	—	—	x	—
41	R-16	4	1238.0	*Characterization 4	7-Dec-04	—	x	x	x	x	x	x	x	x	—	x	—
41	R-16	4	1238.0	*Surveillance	14-Jun-05	x	x	x	x	—	—	x	x	—	—	—	—
42	R-18	1	1358.0	*Characterization 1	25-Aug-05	x	x	x	—	—	—	—	x	—	—	—	—
44	R-19	2	909.3	Characterization 1a	22-Sep-00	—	x	x	—	—	x	x	x	—	x	x	x
44	R-19	2	909.3	Characterization 1b	25-Sep-00	—	—	x	x	—	—	—	—	—	—	x	x
44	R-19	2	909.3	Characterization 2	10-Apr-01	—	x	x	x	—	x	x	x	—	x	x	x
44	R-19	2	909.3	Characterization 3	5-Jul-01	—	x	x	x	x	x	x	x	—	x	x	x
44	R-19	2	909.3	Characterization 4	13-Sep-01	—	x	x	x	x	x	x	x	—	x	x	x
44	R-19	2	909.3	Surveillance	20-Aug-02	x	x	x	—	x	—	x	x	—	—	x	x
44	R-19	2	909.3	*Surveillance	15-Dec-03	—	x	x	—	x	x	—	—	—	—	x	—
44	R-19	2	909.3	*Surveillance	10-Jun-04	—	x	x	x	—	x	—	—	—	—	x	—
44	R-19	2	909.3	*Surveillance	21-Jul-05	x	x	x	x	—	x	—	—	—	—	—	—
45	R-19	3	1190.7	Characterization 1	26-Sep-00	—	x	x	x	—	x	x	x	—	x	x	x
45	R-19	3	1190.7	Characterization 2	9-Apr-01	—	x	x	x	—	x	x	x	—	x	x	x

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
45	R-19	3	1190.7	Characterization 3	10-Jul-01	—	x	x	x	x	x	x	x	—	x	x	x
45	R-19	3	1190.7	Characterization 4	18-Sep-01	—	x	x	x	x	x	x	x	—	x	x	x
45	R-19	3	1190.7	Surveillance	22-Aug-02	x	x	x	—	x		x	x	—	—	x	x
45	R-19	3	1190.7	*Surveillance	15-Dec-03	—	x	x	—	x	x	—	—	—	—	x	—
45	R-19	3	1190.7	*Surveillance	14-Jun-04	—	x	x	x	—	x	x	x	x	—	x	—
45	R-19	3	1190.7	*Surveillance	21-Jul-05	x	x	x	x	—	x	x	x	x	—	—	—
46	R-19	4	1412.9	Characterization 2a	6-Apr-01	—	x	x	x	—	x	x	x	—	x	x	x
46	R-19	4	1412.9	Characterization 2b	9-Apr-01	—	x	x	x	—	—	x	x	—	—	x	x
46	R-19	4	1412.9	Characterization 3	11-Jul-01	—	x	x	x	x	x	x	x	—	x	x	x
46	R-19	4	1412.9	Characterization 4	19-Sep-01	—	—	—	—	—	—	—	—	—	x	x	—
46	R-19	4	1412.9	Characterization	20-Sep-01	—	—	—	—	—	—	—	—	—	—	x	—
46	R-19	4	1412.9	Surveillance	26-Aug-02	x	x	x	—	x	—	x	x	—	—	x	x
46	R-19	4	1412.9	*Surveillance	16-Dec-03	—	x	x	x	—	x	—	—	—	—	x	—
46	R-19	4	1412.9	*Surveillance	15-Jun-04	—	x	x	x	—	x	x	x	—	—	x	—
46	R-19	4	1412.9	*Surveillance	28-Jul-05	x	x	x	x	—	x	x	x	—	—	—	—
47	R-19	5	1586.1	Characterization 1	10-Oct-00	—	—	—	x	—	x	—	—	—	x	x	x
47	R-19	5	1586.1	Characterization 2	4-Apr-01	—	x	x	x	—	x	x	x	—	x	x	x
47	R-19	5	1586.1	Characterization 3	12-Jul-01	—	x	x	x	x	x	x	x	—	x	x	x
47	R-19	5	1586.1	*Characterization 4	20-Sep-01	—	x	x	x	x	x	x	x	—	x	x	x
47	R-19	5	1586.1	*Surveillance	23-Aug-02	x	x	x	—	x	—	x	x	—	—	x	x
47	R-19	5	1586.1	*Surveillance	16-Dec-03	—	x	x	—	x	x	—	—	—	—	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
48	R-19	6	1730.1	Characterization 1	4-Oct-00	—	x	x	x	—	x	x	x	—	x	x	x
48	R-19	6	1730.1	Characterization 2	2-Apr-01	—	x	x	x	—	x	x	x	—	x	x	x
48	R-19	6	1730.1	Characterization 3	16-Jul-01	—	x	x	x	x	x	x	x	—	x	x	x
48	R-19	6	1730.1	Characterization 4	21-Sep-01	—	x	x	x	x	x	x	x	—	x	x	x
48	R-19	6	1730.1	*Surveillance	27-Aug-02	x	x	x	—	x	—	x	x	—	—	x	x
48	R-19	6	1730.1	*Surveillance	16-Dec-03	—	x	x	—	x	x	—	—	—	—	x	—
48	R-19	6	1730.1	*Surveillance	22-Dec-03	—	—	—	—	—	x	—	—	—	—	x	—
49	R-19	7	1834.7	Characterization 1	3-Oct-00	—	x	x	x	—	—	—	—	—	x	x	x
49	R-19	7	1834.7	Characterization 2	29-Mar-01	—	x	x	x	—	x	x	x	—	x	x	x
49	R-19	7	1834.7	Characterization 3	17-Jul-01	—	x	x	—	x	x	x	x	—	x	x	x
49	R-19	7	1834.7	Characterization 4	24-Sep-01	—	x	x	—	x	x	x	x	—	x	x	x
49	R-19	7	1834.7	*Surveillance	26-Aug-02	x	x	x	—	x	—	x	x	—	—	x	x
49	R-19	7	1834.7	*Surveillance	17-Dec-03	—	x	x	—	x	x	—	—	—	—	—	—
49	R-19	7	1834.7	*Surveillance	16-Jun-04	—	x	x	x	—	x	x	x	—	—	x	—
49	R-19	7	1834.7	*Surveillance	28-Jul-05	x	x	x	—	—	—	x	x	—	—	—	—
50	R-20	1	907.0	Characterization 1a	11-Mar-04	—	x	x	—	x	—	—	x	—	—	—	—
50	R-20	1	907.0	Characterization 1b	15-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
50	R-20	1	907.0	*Characterization 2	10-May-04	—	x	x	x	x	x	x	x	x	—	x	—
50	R-20	1	907.0	*Characterization 3	20-Sep-04	—	x	x	x	x	x	x	x	x	—	x	—
50	R-20	1	907.0	*Characterization 4	4-Nov-04	—	x	x	x	x	x	x	x	x	—	x	—
50	R-20	1	907.0	*Surveillance	20-Jul-05	x	x	x	x	—	—	x	x	x	—	—	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
51	R-20	2	1149.7	Characterization 1	10-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
51	R-20	2	1149.7	*Characterization 2	5-May-04	—	x	x	x	x	x	x	x	x	—	x	—
51	R-20	2	1149.7	*Characterization 3a	3-Sep-04	—	—	x	x	x	—	—	x	—	—	—	—
51	R-20	2	1149.7	*Characterization 3b	7-Sep-04	—	x	x	—	—	x	x	x	x	—	x	—
51	R-20	2	1149.7	*Characterization 4	8-Nov-04	—	x	x	x	x	x	x	x	—	—	x	—
51	R-20	2	1149.7	*Surveillance	19-Jul-05	x	x	x	x	—	—	x	x	x	—	—	—
52	R-20	3	1330	Characterization 1	9-Mar-04	x	x	x	x	x	x	x	x	x	—	x	—
52	R-20	3	1330	Characterization 2	5-May-04	—	x	x	x	x	x	x	x	x	—	x	—
52	R-20	3	1330	*Characterization 3	7-Sep-04	x	x	x	x	x	x	x	x	x	—	x	—
52	R-20	3	1330	*Characterization 4	9-Nov-04	—	x	x	x	x	x	x	x	x	—	x	—
52	R-20	3	1330	*Surveillance	18-Jul-05	x	x	x	x	—	—	x	x	x	—	—	—
53	R-21	1	888.8	Characterization 1	31-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
53	R-21	1	888.8	Characterization 2	30-Jun-04	—	x	x	x	x	x	x	x	x	—	—	—
53	R-21	1	888.8	*Characterization 3	23-Sep-04	—	x	x	x	x	x	x	x	x	—	x	—
53	R-21	1	888.8	*Characterization 4	14-Dec-04	—	x	x	x	x	x	x	x	x	—	x	—
53	R-21	1	888.8	*Surveillance	6-Jun-05	x	x	x	x	—	—	x	x	—	—	—	—
54	R-22	1	907.1	Characterization 1	13-Mar-01	—	—	—	—	—	—	—	—	—	x	x	x
54	R-22	1	907.1	Characterization 2	19-Jun-01	—	—	—	—	—	—	—	—	—	x	x	x
54	R-22	1	907.1	Characterization 3	30-Nov-01	—	—	—	—	—	—	—	—	—	x	x	x
54	R-22	1	907.1	Characterization 4	27-Feb-02	—	—	—	—	—	—	—	—	—	x	x	x
54	R-22	1	907.1	*Surveillance	8-Jul-02	x	x	x	x	x	—	x	x	—	—	—	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
54	R-22	1	907.1	*Surveillance	18-Nov-03	—	x	x	x	x	x	x	x	—	—	—	—
54	R-22	1	907.1	*Surveillance	21-Jun-04	—	—	x	x	x	—	x	x	x	—	x	—
54	R-22	1	907.1	*Surveillance	27-Jun-05	x	x	x	x	x	—	x	x	x	—	—	—
55	R-22	2	962.8	Characterization 1	12-Mar-01	—	—	—	—	—	—	—	—	—	x	x	x
55	R-22	2	962.8	Characterization 2	20-Jun-01	—	—	—	—	—	—	—	—	—	x	x	x
55	R-22	2	962.8	Characterization 3	3-Dec-01	—	—	—	—	—	—	—	—	—	x	x	x
55	R-22	2	962.8	Characterization 4	28-Feb-02	—	—	—	—	—	—	—	—	—	x	x	x
55	R-22	2	962.8	*Surveillance	11-Jul-02	x	x	x	x	x	—	x	x	—	—	—	—
55	R-22	2	962.8	*Surveillance	19-Nov-03	—	x	x	x	x	x	x	x	—	—	—	—
55	R-22	2	962.8	*Surveillance	22-Jun-04	—	x	x	x	x	—	x	x	x	—	x	—
55	R-22	2	962.8	*Surveillance	28-Jun-05	x	x	x	x	x	—	x	x	x	—	—	—
56	R-22	3	1273.5	Characterization 1	8-Mar-01	—	—	—	—	—	—	—	—	—	x	x	x
56	R-22	3	1273.5	Characterization 2	21-Jun-01	—	—	—	—	—	—	—	—	—	x	x	x
56	R-22	3	1273.5	Characterization 3	4-Dec-01	—	—	—	—	—	—	—	—	—	x	x	x
56	R-22	3	1273.5	Characterization 4	4-Mar-02	—	—	—	—	—	—	—	—	—	x	x	x
56	R-22	3	1273.5	Surveillance	9-Jul-02	x	x	x	x	x	—	x	x	—	—	—	—
56	R-22	3	1273.5	*Surveillance	20-Nov-03	—	x	x	x	x	x	x	x	—	—	—	—
56	R-22	3	1273.5	*Surveillance	23-Jun-04	—	x	x	x	x	—	x	x	x	—	x	—
56	R-22	3	1273.5	*Surveillance	30-Jun-04	—	—	—	—	—	—	—	x	—	—	x	—
56	R-22	3	1273.5	*Surveillance	29-Jun-05	x	x	x	x	x		x	x	x	—	—	—
57	R-22	4	1378.0	Characterization 1	7-Mar-01	—	—	—	—	—	—	—	—	—	x	x	x

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
57	R-22	4	1378.0	Characterization 2	25-Jun-01	—	—	—	—	—	—	—	—	—	x	x	x
57	R-22	4	1378.0	Characterization 3	5-Dec-01	—	—	—	—	—	—	—	—	—	x	x	x
57	R-22	4	1378.0	Characterization 4	5-Mar-02	—	—	—	—	—	—	—	—	—	x	x	x
57	R-22	4	1378.0	Surveillance	11-Jul-02	x	x	x	x	x	—	x	x	—	—	—	—
57	R-22	4	1378.0	*Surveillance	20-Nov-03	—	x	x	x	x	x	x	x	—	—	—	—
57	R-22	4	1378.0	*Surveillance	23-Jun-04	—	x	x	x	x		x	x	x	—	x	—
57	R-22	4	1378.0	*Surveillance	30-Jun-04	—	—	—	—	—	—	—	x	—	—	x	—
57	R-22	4	1378.0	Investigation	12-Oct-04	—	—	—	—	—	—	—	—	—	—	x	—
57	R-22	4	1378.0	*Surveillance	1-Jul-05	x	x	x	x	x	—	x	x	x	—	—	—
58	R-22	5	1448.2	Characterization 1	6-Mar-01	—	—	—	—	—	—	—	—	—	x	x	x
58	R-22	5	1448.2	Characterization 2	26-Jun-01	—	—	—	—	—	—	—	—	—	x	x	x
58	R-22	5	1448.2	Characterization 3	7-Dec-01	—	—	—	—	—	—	—	—	—	x	x	x
58	R-22	5	1448.2	Characterization 4	7-Mar-02	—	—	—	—	—	—	—	—	—	x	x	x
58	R-22	5	1448.2	Investigation	8-May-02	—	—	—	—	—	—	—	—	—	—	—	x
58	R-22	5	1448.2	*Surveillance	10-Jul-02	x	x	x	x	x	—	x	x	—	—	—	—
58	R-22	5	1448.2	*Surveillance	21-Nov-03	—	x	x	x	x	x	x	x	—	—	—	—
58	R-22	5	1448.2	*Surveillance	5-Jul-05	x	x	x	x	x	—	x	x	x	—	—	—
59	R-23	1	816.0	Characterization 1	17-Dec-03	x	x	x	x	x	x	x	x	x	—	—	—
59	R-23	1	816.0	Characterization 2	23-Mar-04	x	x	x	x	x	x	x	x	x	—	x	—
59	R-23	1	816.0	*Characterization 3	29-Jun-04	—	x	x	x	x	x	x	x	x	—	x	—
59	R-23	1	816.0	*Characterization 4	24-Sep-04	x	x	x	x	x	x	x	x	x	—	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
59	R-23	1	816.0	*Surveillance	14-Jul-05	x	x	x	x	x	—	x	x	x	—	—	—
60	R-25	1	754.8	Characterization 1	14-Nov-00	—	x	x	x	—	x	—	x	—	x	x	—
60	R-25	1	754.8	Characterization 2	3-May-01	—	x	x	—	x	x	—	x	—	x	x	—
60	R-25	1	754.8	Characterization 3	13-Aug-01	—	x	x	x	—	x	—	x	—	x	x	—
60	R-25	1	754.8	Characterization 4	4-Feb-02	—	x	x	x	x	x	—	x	—	x	x	—
60	R-25	1	754.8	Surveillance	7-Aug-02	x	x	x	x	x	x	x	x	—	—	—	—
60	R-25	1	754.8	*Surveillance	11-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
60	R-25	1	754.8	*Surveillance	1-Sep-04	—	x	x	x	x	x	x	x	—	—	x	—
60	R-25	1	754.8	*Surveillance	2-Aug-05	x	x	x	x	x	x	x	x	—	—	—	—
61	R-25	2	891.8	Characterization 1	15-Nov-00	—	x	x	x	—	x	—	x	—	x	x	—
61	R-25	2	891.8	Characterization 2	4-May-01	—	x	x	—	x	x	—	x	—	x	x	—
61	R-25	2	891.8	Characterization 3	14-Aug-01	—	x	x	x	—	x	—	x	—	x	x	—
61	R-25	2	891.8	Characterization 4	5-Feb-02	—	x	x	x	x	x	—	x	—	x	x	—
61	R-25	2	891.8	*Surveillance	8-Aug-02	x	x	x	—	x	x	x	x	—	—	—	—
61	R-25	2	891.8	*Surveillance	10-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
61	R-25	2	891.8	*Surveillance	3-Aug-05	x	x	x	—	—	—	—	x	—	—	x	—
63	R-25	4	1192.4	Characterization 1	4-Dec-00	—	x	x	x	—	x	—	x	—	x	x	—
63	R-25	4	1192.4	Characterization 2	7-May-01	—	x	x	—	x	x	—	x	—	x	x	—
63	R-25	4	1192.4	Characterization 3	14-Aug-01	—	x	x	x	—	x	—	x	—	x	x	—
63	R-25	4	1192.4	Characterization 4	6-Feb-02	—	x	x	—	x	x	—	x	—	x	x	—
63	R-25	4	1192.4	*Surveillance	8-Aug-02	x	x	x	—	x	x	x	x	—	—	—	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
63	R-25	4	1192.4	*Surveillance	10-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
63	R-25	4	1192.4	*Surveillance	4-Aug-05	x	x	x	x	—	x	x	x	—	—	x	—
64	R-25	5	1303.4	Characterization 1	7-Dec-00	—	x	x	x	—	x	—	x	—	x	x	—
64	R-25	5	1303.4	Characterization 2	8-May-01	—	x	x	—	x	x	—	x	—	x	x	—
64	R-25	5	1303.4	Characterization 3	15-Aug-01	—	x	x	—	—	x	—	x	—	x	x	—
64	R-25	5	1303.4	Characterization 4	7-Feb-02	—	x	x	—	x	x	—	x	—	x	x	—
64	R-25	5	1303.4	*Surveillance	9-Aug-02	x	x	x	—	x	x	x	x	—	—	—	—
64	R-25	5	1303.4	*Surveillance	9-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
64	R-25	5	1303.4	*Surveillance	31-Aug-04	—	x	x	x	x	x	x	x	—	—	x	—
64	R-25	5	1303.4	*Surveillance	9-Aug-05	x	x	x	—	—	—	—	x	—	—	—	—
65	R-25	6	1406.3	Characterization 1	8-Dec-00	—	x	x	x	—	x	—	x	—	x	x	x
65	R-25	6	1406.3	Characterization 2	9-May-01	—	x	x	—	x	x	—	x	—	x	x	—
65	R-25	6	1406.3	Characterization 3	16-Aug-01	—	x	x	—	x	—	—		—	x	x	x
65	R-25	6	1406.3	*Characterization 4	8-Feb-02	—	x	x	—	x	x	—	x	—	x	x	x
65	R-25	6	1406.3	*Surveillance	12-Aug-02	x	x	x	—	x	x	x	x	—	—	—	—
65	R-25	6	1406.3	*Surveillance	9-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
66	R-25	7	1606.0	Characterization 1	11-Dec-00	—	x	x	x	—	x	—	x	—	x	x	—
66	R-25	7	1606.0	Characterization 2a	11-May-01	—	x	x	—	x	—	—		—		x	—
66	R-25	7	1606.0	Characterization 2b	14-May-01	—	—	x	—	x	x	—	x	—	x	x	—
66	R-25	7	1606.0	Characterization 3	17-Aug-01	—	x	x	x	—	x	—	x	—	x	x	—
66	R-25	7	1606.0	*Characterization 4	11-Feb-02	—	x	x	—	x	x	—	x	—	x	x	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
66	R-25	7	1606.0	*Surveillance	12-Aug-02	x	x	x	—	x	x	x	x	—	—	—	—
66	R-25	7	1606.0	*Surveillance	8-Dec-03	—	x	x	—	x	x	x	x	—	—	x	—
67	R-25	8	1796.0	Characterization 1	12-Dec-00	—	x	x	x	—	x	—	x	—	x	x	—
67	R-25	8	1796.0	Characterization 2	14-May-01	—	x	x	—	x	x	—	x	—	x	x	—
67	R-25	8	1796.0	Characterization 3	20-Aug-01	—	x	x	x	—	x	—	x	—	x	x	—
67	R-25	8	1796.0	*Characterization 4	12-Feb-02	—	x	x	—	x	x	—	x	—	x	x	—
67	R-25	8	1796.0	*Surveillance	14-Aug-02	x	x	x	—	x	x	x	x	—	—	—	—
67	R-25	8	1796.0	Surveillance	4-Dec-03	—	—	—	—	x	x	x	x	—	—	x	—
67	R-25	8	1796.0	*Surveillance	10-Aug-05	x	x	x	—	x	—	x	x	—	—	x	—
69	R-26	1	659.3	*Characterization 1	13-Apr-05	—	x	x	x	x	x	x	x	x	—	x	—
69	R-26	1	659.3	*Characterization 2	27-Jul-05	x	x	x	x	x	x	x	x	x	—	—	—
71	R-28	1	946.2	*Characterization 1	20-May-05	x	x	x	x	—	x	x	x	x	—	x	—
71	R-28	1	946.2	Characterization 2	1-Sep-05	x	—	x	—	—	—	—	—	—	—	—	—
73	R-31	2	532.2	Characterization 2	26-Sep-01	—	—	—	—	—	—	—	—	—	—	x	—
73	R-31	2	532.2	*Surveillance	18-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
73	R-31	2	532.2	Surveillance	17-Aug-05	x	—	—	—	—	—	—	—	—	—	—	—
77	R-32	1	870.9	Characterization 1	1-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
77	R-32	1	870.9	Characterization 2	5-May-04	—	x	x	x	x	x	x	x	x	—	x	—
77	R-32	1	870.9	*Characterization 3	21-Sep-04	—	x	x	x	x	x	x	x	x	—	x	—
77	R-32	1	870.9	*Characterization 4	15-Nov-04	—	x	x	x	x	x	x	x	x	—	x	—
77	R-32	1	870.9	*Surveillance	22-Jun-05	x	x	x	x	—	—	x	x	x	—	—	—

Table B-5 (continued)

Screen ID	Well Screen		Screen Depth (ft)	Sampling Phase	Sample Collection Date	WQDB (Data Availability by Analytical Suite)									Other Data Sources		
						Field Data	General Inorganics	Metals	Radionucides	Low-Detection Limit Tritium	HEXP	SVOA	VOA	Pesticides/PCBs	Geochemistry Report	Field Data	ER Database
79	R-32	3	976.0	Characterization 1	3-Mar-04	—	x	x	x	x	x	x	x	x	—	x	—
79	R-32	3	976.0	Characterization 2a	6-May-04	—	x	x	x	x	x	x	—	x	—	—	—
79	R-32	3	976.0	Characterization 2b	10-May-04	—	x	x	—	—	—	—	x	—	—	x	—
79	R-32	3	976.0	*Characterization 3	22-Sep-04	—	x	x	x	x	x	x	x	x	—	x	—
79	R-32	3	976.0	*Characterization 4	16-Nov-04	—	x	x	x	x	x	x	x	x	—	x	—
79	R-32	3	976.0	*Surveillance	24-Jun-05	x	x	x	x	—	—	x	x	x	—	—	—
80	R-33	1	995.5	*Characterization 1	27-Jun-05	x	x	x	x	x	—	x	x	—	—	—	—
81	R-33	2	1112.4	*Characterization 1	24-Jun-05	x	x	x	x	x	—	x	x	—	—	—	—
82	R-34	1	895.15	*Characterization 1	7-Jun-05	x	x	x	x	x	x	x	x	x	—	—	—
82	R-34	1	895.15	Characterization 2	7-Sep-05	x	—	—	—	—	—	—	—	—	—	—	—

[a] Sampling Phase is not indicated in the WQDN but has been inferred from the sampling date, analytical suites, and source organizations for each sample event.

[b] Sample collection date—start date for a sampling event that produced sufficient water to submit for at least one analytical suite. The sampling event may continue for more than one day, but subsequent days have not been listed separately in this table unless more than two days elapsed between the two dates.

[c] Field data—entries in this column are limited to the availability of parameters that are relevant to the screen assessment: field pH, field alkalinity, dissolved oxygen, and turbidity.

[d] Radionuclides—entries in this column exclude analyses of low-detection-limit tritium (which has been tabulated separately in this table), or of stable isotopes of hydrogen, oxygen and nitrogen.

[e] Note that the various organic analytical suites overlap considerably. Thus, pesticide data may be available as part of the VOA analytical suite, even a sample has not been submitted for the pesticide analytical suite.

[f] Geochemistry reports containing characterization data are available for R-7 (Longmire and Goff 2002, 75905), R9 and R-9i (Longmire 2002, 72713), R-12 (Longmire 2002, 72800), R-15 (Longmire 2002, 72614), R-19 (Longmire 2002, 73282), R-22 (Longmire 2002, 73676), and R-25 (Longmire 2005, 88510).

[g] The availability of field data and data in the ER database is indicated only for those cases in which some or all of the data are not already available in the WQDB or in a published geochemistry report.

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Appendix C

Water-Quality Data Used for Screen Assessments

Table C-1a
Laboratory Qualifier Codes used in this Appendix

Lab Qual Code	Laboratory Qualifier Code Description
*	(Inorganic)- Duplicate analysis not within control limits. (Organic) - Spike recovery is equal to or outside the control criteria used.
B	(Inorganic) - reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but greater than or equal to the Instrument Detection Limit (IDL). (Organic) - Analyte present in the blank and the sample.
E	(Inorganic) Paragon- Reported value is estimated because of the presence of interference. GEL- Percent difference between the parent sample and its serial dilution's concentration exceeds 10%. (Organic) - Analyte concentration exceeded the upper level of
EN	(Inorganic) - The qualifier that is used when the percent difference between the parent sample and its serial dilution's concentration exceeds 10%. The sample's concentration must be greater than 50 times the IDL/MDL for ICP or 100 times the absolute value of the preparation blank's concentration for ICP-MS. However, if analyzing ILMO 4.0 (ICP-MS), the parent sample's concentration must be 20 times the CRDL before the "E" flag is applied. This qualifier is used to indicate that the matrix or pre-digested spike sample recovery for an analyte is not within the specified control limit.
H	Holding time exceeded
J	(Inorganic) -The associated numerical value is an estimated quantity. (Organic) - The associated numerical value is an estimated quantity.
J*	(Inorganic) -The associated numerical value is an estimated quantity. Duplicate analysis not within control limits.
N	(Inorganic) - Spiked sample recovery not within control limits. (Organic) -Presumptive evidence based on a mass spectral library search to make a tentative identification of the analyte.
NQ	No validation qualifier flag is associated with this result, and the analyte is classified as detected.
U	(Inorganic) -The material was analyzed for, but was not detected above the level of the associated numeric value. The associated numerical value is either the sample quantitation limit or the sample detection limit. (Organic) –The material was analyzed.
U*	(Inorganic) - Compound was analyzed for, but was not detected. Duplicate analysis not within control limits.

Table C-1b
Validation Flag Codes used in this Appendix

Valid Flag Code	Validation Flag Description
J	The analyte is classified as detected but the reported concentration value is expected to be more uncertain than usual.
J-	The analyte is classified as detected but the reported concentration value is expected to be more uncertain than usual with a potential negative bias.
J+	The analyte is classified as detected but the reported concentration value is expected to be more uncertain than usual with a potential positive bias.
JN-	Presumptive evidence of the presence of the material at an estimated quantity with a suspected negative bias.
NQ	No validation qualifier flag is associated with this result, and the analyte is classified as detected.
R	The reported sample result is classified as rejected due to serious noncompliances regarding quality control acceptance criteria. The presence or absence of the analyte cannot be verified based on routine validation alone.
U	The analyte is classified as not detected.
UJ	The analyte is classified as not detected, with an expectation that the reported result is more uncertain than usual.

Table C-2
Identifiers of Samples Used for Tier-2.1 Assessments (Bentonite Mud)

Screen ID[b]	Well Screen		Port Depth (ft)	Collection Date	Field Prep.[c]	Sample ID	Preliminary Flag[d]
14	R-2	1	918.0	26-Apr-05	F	GF05040G02R01	N
				9-Aug-05	F	GF05080G02R01	N
15	R-4	1	804.5	27-Apr-05	F	GF05040G04R01	N
				8-Aug-05	F	GF05080G04R01	Y
20	R-6	1	1205.0	23-Aug-05	F	GF0508G06R01	Y
36	R-14	2	1288.5	14-Jul-04	F	GF0407G14R201	N
				3-Nov-04	F	GF0411G14R201	N
				12-May-05	F	GF0505G14R201	N
39	R-16	2	866.1	13-Oct-04	F	GF0409G16R201	N
				2-Dec-04	F	GF0411G16R201	N
				13-Jun-05	F	GF0506G16R201	N
40	R-16	3	1018.4	14-Oct-04	F	GF0410G16R301	N
				3-Dec-04	F	GF0411G16R301	N
				13-Jun-05	F	GF0506G16R301	N
41	R-16	4	1238.0	15-Oct-04	F	GF0410G16R401	N
				7-Dec-04	F	GF0411G16R401	N
				14-Jun-05	F	GF0506G16R401	N

Table C-2 (continued)

Screen ID	Well Screen		Port Depth (ft)	Collection Date	Field Prep	Sample ID	Preliminary Flag
50	R-20	1	907.0	20-Sep-04	F	GF0409G20R101	N
				4-Nov-04	F	GF0411G20R101	N
				20-Jul-05	F	GF0507G20R101	Y
51	R-20	2	1149.7	7-Sep-04	F	GF0409G20R201-1	N
				8-Nov-04	F	GF0411G20R201	N
				19-Jul-05	F	GF0507G20R201	Y
52	R-20	3	1330.0	9-Nov-04	F	GF0411G20R301	N
				18-Jul-05	F	GF0507G20R301	N
				18-Jul-05	F	GF0507G20R301	Y
77	R-32	1	870.9	15-Nov-04	F	GF0411G32R101	N
				21-Sep-04	F	GF0409G32R101	N
				22-Jun-05	F	GF0506G32R101	N
79	R-32	3	976.0	16-Nov-04	F	GF0411G32R301	N
				22-Sep-04	F	GF0409G32R301	N
				24-Jun-05	F	GF0506G32R301	N

Data Source: WQDB

[a] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information

[b] Field prep—field preparation; F—filtered; UF—not filtered

[c] Prel flag—Preliminary flag. This table contains chemical data that are in various stages of review. The data are assigned preliminary and provisional flags in the WQDB to indicate their current status. The preliminary flag indicates whether a result has been through a level 4 validation. All data from analytical laboratories that have the capability to provide level 4 data packages are validated. The provisional flag indicates when a result is final.

Table C-3
Water-Quality Data Used for Tier 2.1 Assessments (Residual Bentonite Drilling Mud)[a]

Screen ID[b]	Well Screen		Port Depth (ft)	Collection Date	Boron µg/L	Codes[c] L	Codes[c] V	Sodium mg/L	Codes L	Codes V	Strontium µg/L	Codes L	Codes V	Sulfate mg/L	Codes L	Codes V	Uranium µg/L	Codes L	Codes V	Zinc µg/L	Codes L	Codes V
14	R-2	1	918.0	26-Apr-05	24	J		22			42			3.4			0.7			10		
	Single screen			9-Aug-05	17	J		19	N		46			2.4			0.45			7	J	
15	R-4	1	804.5	27-Apr-05	31	J		13			87			4.7			0.8			8	J	
	Single screen			8-Aug-05	25	J		12			82			4.3			0.7			< 4	J	U
20	R-6	1	1205.0	23-Aug-05	24	J		15			59			3.2			0.6			9	J	
	Single screen																					
36	R-14	2	1288.5	14-Jul-04	18	B		15			68			1.4			0.04	B		6		
				3-Nov-04	19	J		14			98			0.4	J		< 0.02	U		4	J	
				12-May-05	21	J		14			80			1.0			0.05	J		5	J	
39	R-16	2	866.1	13-Oct-04	14	J		12			56			2.9			0.2			< 3	J	U
				2-Dec-04	< 22	J	U	20			189			2.8			0.4			< 1	U	
				13-Jun-05	21	J		22		J	179			2.5			0.4			6	J	
40	R-16	3	1018.4	14-Oct-04	20	J		18			316			7.5			3.1			12		
				3-Dec-04	24	J		19			316			6.7			3.6	E	J	11		
				13-Jun-05	25	J		17			277			4.9			2.5			12		
41	R-16	4	1238.0	15-Oct-04	29	J		30			570			48.9			0.2	J	J-	2	J*	
				7-Dec-04	< 39	J	U	28			599			40.2			0.2			8		
				14-Jun-05	28	J		27			475			28.8			0.2	J		< 6	J	U
50	R-20	1	907.0	20-Sep-04	39	J		52			39			3.8			0.2	J		< 5	J	U
				4-Nov-04	27	J		48			38			3.7			0.1	J	J-	< 3	J	U
				20-Jul-05	36	J		51			41			0.1			0.2	J		6	J	
51	R-20	2	1149.7	7-Sep-04	91			94			1950			< 0.4		U	0.06	J		< 1	U	R
				8-Nov-04	91			84			2010			< 0.2	U		< 0.02	U		< 9		U
				19-Jul-05	92			84			2070			< 0.1	U		0.11	J		5	J	

Table C-3 (continued)

Screen ID[b]	Well Screen		Port Depth (ft)	Collection Date	Boron µg/L	Codes[c] L	Codes[c] V	Sodium mg/L	Codes L	Codes V	Strontium µg/L	Codes L	Codes V	Sulfate mg/L	Codes L	Codes V	Uranium µg/L	Codes L	Codes V	Zinc µg/L	Codes L	Codes V
52	R-20	3	1330.0	7-Sep-04	32	J		21			117			< 0.2	U		< 0.02	U		3	J	JN-
				9-Nov-04	32	J		20			109			< 0.2	U		< 0.02	U		< 7		U
				18-Jul-05	38	J	J+	20			105			< 0.1	U		< 0.05	U		12		
77	R-32	1	870.9	21-Sep-04	< 13	J	U	11			85			5.7			1.1			< 11		U
				15-Nov-04	14	J		11			86			5.7			1.0			7		J-
				22-Jun-05	13[e]	J		11			82			5.7			1.0			< 10		U
79	R-32	3	976.0	22-Sep-04	16	J		11			103			1.5			0.04	J		< 6		U
				16-Nov-04	16	J		10			105			1.9			0.04	J		1	J	JN-
				24-Jun-05	16	J		10			98			1.5		J	0.06	J		< 6	J	U

Data source: WQDB

[a] Notes: (1) This table includes some data that have not been released to the public. Usually, these data have not been released because they were collected at a facility or on property that is not controlled or owned by LANL, and an external entity must approve the data for general release. (2) Sample identifiers are listed in Table C-2. (3) Results are reported for filtered samples unless noted otherwise. (4) Data are plotted for comparison against Tier 2.2-1 criteria on Figure D-1. (5) Yellow highlighting indicates data that fail at least one tier criterion.

[b] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information

[c] Codes: L—Laboratory Qualifier Code (assigned by the analytical laboratory); V—Validation Flag Code (assigned by LANL). These codes are defined in Tables C-1a and C-1b.

[d] Analysis of nonfiltered sample; no filtered sample data were available.

[e] Used data reported for the duplicate sample.

Table C-4
Field Data Used for Tier 2.2 Assessments

Screen ID[a]	Well Screen		Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
1	CdV-16-1(i)	1	624	1-Jun-05	GU0505GC16i01	WQDB	5.2	63	67	8.0	5.8	0.057
				29-Aug-05	FU0508GC16i01	WQDB	6.8	49	149	4.8	4.9	0.006
5	CdV-R-15-3	4	1254.4	19-Oct-04	—	FN[d]	9.0	57	—	7.6	0.4	0.001
				4-Apr-05	GU0503G153401	FN	8.2	47	-10	1.2	0.2	0.000
				20-Apr-05	GU0404G153401	FN	8.6	54	37	6.6	0.3	0.000
				12-Jul-05	FU0506G153401	WQDB	8.5	57 L	208	4.5	0.3	—
6	CdV-R-15-3	5	1350.1	20-Oct-04	—	FN	7.8	75	—	13	0.3	0.232
				5-Apr-05	GU0503G153501	FN	7.2	76	-99	7.4	0.2	0.290
				20-Apr-05	GU0404G153501	FN	7.7	71	—	6.1	0.3	0.118
				12-Jul-05	FU0506G153501	WQDB	7.3	67 L	-59	4.2	0.2	—
7	CdV-R-15-3	6	1640.1	21-Oct-04	—	FN	7.9	51	—	13	1.1	0.005
				6-Apr-05	GU0503G153601	FN	7.1	60	-85	11	0.7	0.014
				21-Apr-05	GU0404G153601	FN	7.6	47	-44	14	0.8	0.007
				13-Jul-05	FU0506G153601	WQDB	7.4	59 L	28	5.9	1.2	—
9	CdV-R-37-2	2	1200.3	26-Oct-04	—	FN	7.2	133	—	6.1	12	0.001
				29-Mar-05	—	FN	6.8	199	—	8.4	12	0.004
				6-Jul-05	FU0506G37R201	WQDB	6.8	106 L	-70	3.1	36	—
10	CdV-R-37-2	3	1359.3	25-Oct-04	—	FN	8.0	50	—	9.1	0.6	0.010
				28-Mar-05	WQDB	FN	8.2	59	—	12	0.2	0.000
				7-Jul-05	FU0506G37R301	WQDB	7.9	57 L	264	11	0.3	—
11	CdV-R-37-2	4	1550.6	27-Oct-04	—		7.0	60	—	13	1.1	0.002
				31-Mar-05	—		7.2	50	—	13	1.0	0.006
				8-Jul-05	FU0506G37R401		6.9	55 L	16	8.8	1.1	—

Table C-4 (continued)

Screen ID[a]	Well Screen		Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
12	MCOBT-4.4	1	504.7	28-Jan-03	GWM03-50311	ERDB	7.2	45	—	—	0.2	—
				21-May-03	GWM03-51697	ERDB	7.5	46[L]	—	—	0.3	—
				14-Oct-04	GWM4-05-56041	EES	7.1	36	—	—	—	—
				29-Mar-05	FU05030G44M01	WQDB	7.5	41[EES]	—	6.3	0.6[EES]	—
				8-Jun-05	FU05050G44M01	WQDB	7.4	—	54	7.2	0.6	—
13	R-1	1	1031.1	19-May-05	FU05050G01R01	WQDB	7.6	50[FN]	29	4.5	0.4	0.003[FN]
14	R-2	1	918	26-Apr-05	FN05040G02R01	WQDB	7.0	69[EES]	0.1	4.9	12	—
				9-Aug-05	FU05080G02R01	WQDB	7.4	61	65	4.8	12	0.028
15	R-4	1	804.45	27-Apr-05	FN05040G04R01	WQDB	7.7	68[EES]	131	6.3	0.0	—
				8-Aug-05	FU05080G04R02	WQDB	8.0	52	43	3.6	0.2	0.000
17	R-5	2	383.9	28-Apr-04	GU0404G05R201	FN	8.0	92	46	7.2	0.1	0.001
				27-Sep-04	GU0409G05R201	WQDB	8.3	89	88	9.7	0.2	0.000
				2-May-05	FU0504G05R201	WQDB	7.7	120[L]	127[FN]	5.2	0.1	—
18	R-5	3	718.6	30-Apr-04	GU0404G05R301	WQDB	8.1	89	165	5.6	0.2	-0.001
				28-Sep-04	GU0409G05R301	WQDB	8.2	77[FN]	59	6.9[FN]	0.2	0.001[FN]
				3-May-05	FU0504G05R301	WQDB	7.9	95[L]	203[FN]	5.0	0.2	—
19	R-5	4	860.9	3-May-04	GU0404G05R401-A	WQDB	7.6	105	21	10.5	2.0	0.017
				30-Sep-04	GU0409G05R401	WQDB	7.8	102	85	9.0	1.7	0.005
				5-May-05	FU0504G05R401	WQDB	7.7	129[L]	65	6.6	0.5	—
20	R-6	1	1205	23-Aug-05	FU05080G06R01	WQDB	8.2	68	140	3.4	1.6	0.012
21	R-6i	1	602	24-Aug-05	FU05080G6IR01	WQDB	7.3	75	116	6.1	2.8	0.011

Table C-4 (continued)

Screen ID[a]	Well Screen	Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
24	R-7 3	915.1	18-Dec-03	GU0311G07R301	WQDB	8.0	39[L]	—	—	1.6	—
			26-May-04	GU0405G07R301	WQDB	6.8	38[L]	—	—	1.3	—
			26-Apr-05	FU0504G07R301	WQDB	7.1	46[L]	-26[FN]	5.3	1.2	—
25	R-8 1	711.1	24-Aug-04	GU0407G08R101	WQDB	8.5	58	110	11	0.1	0.000
			8-Dec-04	—	FN	7.9	62	—	9.1	0.1	0.000
			27-Apr-05	FU0504G08R101	WQDB	8.3	60[L]	125	7.5	0.1	—
26	R-8 2	825	25-Aug-04	GU0407G08R201	WQDB	9.5	65	217	6.5	1.9	0.001
			9-Dec-04	—	FN	9.2	95	—	9.9	1.3	0.002
			28-Apr-05	FU0504G08R201	WQDB	9.3	76[L]	-22	8.7	0.8	—
27	R-9 1	684	12-Dec-03	GU03120G09R01	WQDB	8.0	107[FN]	—	—	1.1	—
			27-May-04	GU04050G09R01	WQDB	8.0	100[FN]	—	—	0.4	—
			19-Mar-05	FU05030G09R01	WQDB	8.3	115[EES]	133[FN]	4.2	0.3	—
			6-Apr-05	FU05040G09R01	WQDB	8.2	115[EES]	—	4.2	0.6[EES]	—
			28-Apr-05	FU05040G09R02	WQDB	7.8	104[EES]	—	6.2	3.6	—
28	R-9i 1	198.8	2-Aug-02	GU0208G9iR101	WQDB	7.4	—	-63	3.7	1.2	—
			16-Aug-02	—	FN	7.0	69	—	—	0.6	—
			6-Feb-04	GU0311G9iR101	WQDB	7.3[L]	68[L]	—	—	—	—
			2-Jun-04	GU0405G9iR101	WQDB	7.4	78[L]	—	—	0.3	—
			20-Apr-05	FU0504G9iR101	WQDB	8.0	64[L]	126	8.2	0.8	—
29	R-9i 2	278.8	6-Sep-01	GW9I-01-0011	WQDB	7.2	35	—	—	0.1	—
			29-Jul-02	FU0207G9iR201	WQDB	7.1	52	-96	2.3	0.9	—
			6-Feb-04	GU0311G9iR201	WQDB	7.4	56[L]	—	—	0.8	—
30	R-11 1	855	17-May-05	FU05050G11R01	WQDB	8.0	61[FN]	153	6.2	0.4	0.001[FN]
			3-Aug-05	FU05080G11R01	FN	8.1	72[EES]	99	0.8	1.1	0.000

Table C-4 (continued)

Screen ID[a]	Well Screen		Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
31	R-12	1	468.1	2-Feb-04	GU0311G12R101	WQDB	9.2	46[L]	—	—	1.8	—
				2-Jun-04	GU0405G12R101	WQDB	8.8	34[L]	—	—	1.6	—
				16-Jun-05	FU0506G12R101	WQDB	8.9	43[L]	88[FN]	4.8	1.2[FN]	—
				30-Jun-05	FU0506G12R102	WQDB	8.3	—	—	—	34	—
33	R-12	3	810.8	27-Jan-04	GU0311G12R301	WQDB	8.2	141[L]	—	—	1.4	—
				3-Jun-04	GU0405G12R301	WQDB	8.4	168[L]	—	—	0.9	—
				20-Jun-05	FU0506G12R301	WQDB	8.2	144[L]	180[FN]	3.7	0.6	—
34	R-13	1	958.3	9-Dec-03	GU03120G31R01	WQDB	8.2	61[L]	—	—	0.2	—
				11-Jun-04	FU04060G31R01	WQDB	8.2	59[L]	—	—	0.4	—
				10-Mar-05	FU05030G31R01	WQDB	8.3	62[EES]	—	4.5	0.2[FN]	—
				26-May-05	FU05050G13R01	WQDB	9.0	58[L]	123[FN]	6.0	0.2	—
35	R-14	1	1204.5	12-Jul-04	GU0407G14R101	WQDB	7.8	80[EES]	205	3.5[FN]	2.0	0.001[FN]
				28-Oct-04	—	FN	8.5	63	—	5.8	0.9	0.001
				11-May-05	FU0505G14R101	WQDB	8.3	60[FN]	10[FN]	5.7	0.6	0.001[FN]
36	R-14	2	1288.5	14-Jul-04	GU0407G14R201	WQDB	7.0	63	-42	5.1	2.2	0.016
				3-Nov-04	GU0411G14R201	WQDB	7.4	73	—	7.2	2.8	0.030
				12-May-05	FU0505G14R201	WQDB	7.2	55[FN]	-71[FN]	3.9	4.2	—

Table C-4 (continued)

Screen ID[a]	Well Screen	Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
37	R-15 1	958.6	15-Dec-03	GU03120G15R01	WQDB	8.4	51[EES]	—	—	0.5	—
			10-Jun-04	FU04050G15R01	WQDB	8.3	—	—	—	2.3	—
			19-Nov-04	UU04110G15R01	WQDB	8.2	48	146	6.2	1.8	—
			9-Mar-05	FU05030G15R01	WQDB	8.4	55[EES]		5.8	1.8[FN]	—
			25-May-05	FU05050G15R01	WQDB	8.0	42[FN]	78[FN]	7.2	0.6	—
			31-Aug-05	FU05080G15R02	WQDB	8.2	55[EES]	78	5.5	7.5	—
39	R-16 2	866.1	18-May-04	GU0405G16R202	WQDB	8.8	93	-65	9.9	0.5	0.473
			13-Oct-04	GU0409G16R201	WQDB	9.4	85	—	13	0.4	0.567
			2-Dec-04	GU0411G16R201	WQDB	9.3	88	—	13	0.4	0.564
			13-Jun-05	FU0506G16R201	WQDB	9.3	86[L]	-75[FN]	5.3	—	—
40	R-16 3	1018.4	14-Oct-04	GU0410G16R301	WQDB	8.2	101	—	11	0.1	0.005
			3-Dec-04	GU0411G16R301	WQDB	7.8	113	—	12	0.4	0.007
			13-Jun-05	GF0506G16R301	WQDB	8.1	103[L]	-6[FN]	—	—	—
41	R-16 4	1238	15-Oct-04	GU0410G16R401	WQDB	9.6	117	—	8.4	0.4	> 0.6
			7-Dec-04	GU0411G16R401	WQDB	9.4	149	—	10	0.4	> 0.6
			14-Jun-05	FU0506G16R401	WQDB	9.5	131	-160[FN]	5.0	0.6	—
42	R-18 1	1358	25-Aug-05	FU05080G18R01	WQDB	7.6	46	156	4.6	0.5	0.005
44	R-19 2	909.3	20-Aug-02	FU0208G19R201	WQDB	9.1	78	166	4.6	0.7	—
			15-Dec-03	GU0312G19R201	WQDB	8.8	71[L]	—	—	0.2	—
			10-Jun-04	GU0406G19R201	WQDB	8.9	68[L]	—	—	0.2	—
			21-Jul-05	FU0507G19R201	WQDB	8.4	71[L]	236[FN]	—	0.4	—
45	R-19 3	1190.7	22-Aug-02	FU0208G19R301	WQDB	8.2	61	163	5.7	0.7	—
			15-Dec-03	GU0312G19R301	WQDB	7.8	57[L]	—	—	0.4	—
			14-Jun-04	GU0406G19R301	WQDB	8.2	53[L]	—	—	0.2	—
			21-Jul-05	FU0507G19R301	WQDB	7.8	57[L]	190[FN]	—	0.6	—

Table C-4 (continued)

Screen ID[a]	Well Screen		Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
46	R-19	4	1412.9	26-Aug-02	FU0208G19R401	WQDB	7.7	50	154	8.6	0.5	—
				16-Dec-03	GU0312G19R401	WQDB	8.0	48[L]	—	—	0.4	—
				15-Jun-04	GU0406G19R401	WQDB	8.1	47[L]	—	—	0.2	—
				28-Jul-05	FU0507G19R401	WQDB	7.7	49[L]	267[FN]	—	0.4	—
47	R-19	5	1586.1	20-Sep-01	GW19-01-0039	WQDB	7.3	96[GR]	—	—	6.5	—
				23-Aug-02	GU0208G19R501	WQDB	6.9	124	-114	3.0	4.0	—
				16-Dec-03	GU0312G19R501	WQDB	6.9	125[L]	—	—	0.4	—
48	R-19	6	1730.1	24-Sep-01	GW19-01-0040	WQDB	7.2	27	—	—	1.1	—
				27-Aug-02	GU0208G19R601	WQDB	7.1	50	-76	6.2	0.6	—
				16-Dec-03	GU0312G19R601	WQDB	6.9	41[L]	—	—	0.3	—
				22-Dec-03	—	FN	6.6	—	—	—	0.1	—
49	R-19	7	1834.7	26-Aug-02	GU0208G19R701	WQDB	7.3	192	-2	6.6	10	—
				17-Dec-03	GU0312G19R701	WQDB	7.6	150[L]	—	—	41	—
				16-Jun-04	GU0406G19R701	WQDB	7.8	133[L]	—	—	33	—
				28-Jul-05	FU0507G19R701	WQDB	7.6	126[L]	159[FN]	3.5[FN]	73	—
50	R-20	1	907	20-Sep-04	GU0409G20R101	WQDB	9.3	110	-21	8.0	0.9	> 0.6
				4-Nov-04	GU0411G20R101	WQDB	9.3	106	—	3.3	1.0	> 0.6
				20-Jul-05	FU0507G20R101	WQDB	9.0	103[L]	-211[FN]	5.0[FN]	0.7	—
51	R-20	2	1149.7	7-Sep-04	GU0409G20R201-1	WQDB	7.5	214	27	3.9	1.6	0.092
				8-Nov-04	GU0411G20R201	WQDB	8.0	220	—	12	1.2	0.036
				19-Jul-05	FU0507G20R201	WQDB	7.8	275	40[FN]	—	1.1	—
52	R-20	3	1330	7-Sep-04	GU0409G20R301	WQDB	7.2	77	8	11	4.7	0.034
				9-Nov-04	GU0411G20R301	WQDB	7.5	77	—	13	3.1	0.007
				18-Jul-05	FU0507G20R301	WQDB	7.3	77[FN]	—	—	4.3	—

Table C-4 (continued)

Screen ID[a]	Well Screen		Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
53	R-21	1	888.8	23-Sep-04	GU04090G21R01	WQDB	8.1	49[FN]	—	5.2[FN]	0.6	0.003
				14-Dec-04	GU04120G21R90	WQDB	8.1	67[FN]	29	4.8	0.3	0.000
				6-Jun-05	FU05060G21R01	WQDB	8.1	58[FN]	585[FN]	4.3	0.2	—
54	R-22	1	907.1	8-Jul-02	GU0207G22R101	WQDB	6.9	294	—	3.1	26	—
				18-Nov-03	GU0311G22R101	WQDB	6.8	127[L]	—	—	25	—
				21-Jun-04	GU0406G22R101	WQDB	7.2	156[L]	—	—	20	—
				27-Jun-05	FU0506G22R101	WQDB	6.9	342[FN]	-91[FN]	3.4	—	—
55	R-22	2	962.8	11-Jul-02	GU0207G22R201	WQDB	8.2	67	—	5.7	0.3	—
				19-Nov-03	GU0311G22R201	WQDB	8.1	59[L]	—	—	0.2	—
				22-Jun-04	GU0406G22R201	WQDB	8.5	76[L]	—	—	0.2	—
				28-Jun-05	FU0506G22R201	WQDB	8.0	66[FN]	220[FN]	7.3	0.2	—
56	R-22	3	1273.5	9-Jul-02	GU0207G22R301	WQDB	8.6	106	—	3.5	0.9	—
				20-Nov-03	GU0311G22R301	WQDB	8.9	280[L]	—	—	0.5	—
				23-Jun-04	GU0406G22R301	WQDB	9.1	79[L]	—	—	0.5	—
				30-Jun-04	GU0406G22R302	WQDB	9.0	—	—	—	0.9	—
				29-Jun-05	FU0506G22R301	WQDB	8.5	—	177[FN]	6.6	—	—
57	R-22	4	1378	11-Jul-02	GU0207G22R401	WQDB	7.2	245	—	3.9	17	—
				20-Nov-03	GU0311G22R401	WQDB	7.3	217[L]	—	—	6.4	—
				23-Jun-04	GU0406G22R401	WQDB	7.5	236[L]	—	—	4.4	—
				30-Jun-04	GU0406G22R402	WQDB	7.8	—	—	—	2.8	—
				1-Jul-05	FU0506G22R401	WQDB	7.2	216[FN]	17[FN]	4.0	—	—
58	R-22	5	1448.2	10-Jul-02	GU0207G22R501	WQDB	7.2	132	—	3.4	0.9	—
				21-Nov-03	GU0311G22R501	WQDB	7.4	147[L]	—	—	0.7	—
				5-Jul-05	FU0506G22R501	WQDB	7.2	171[FN]	34[FN]	5.1	—	—

Table C-4 (continued)

Screen ID[a]	Well Screen	Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
59	R-23 1	816	29-Jun-04	GU04060GR2301	WQDB	8.0	71[EES]		3.9	3.7	0.001[FN]
			24-Sep-04	GU04090GR2301	WQDB	7.6	52	152	4.3	1.1	0.272
			14-Jul-05	FU05070GR2301	WQDB	7.7	67[FN]	2[FN]	3.6	2.2	—
60	R-25 1	754.8	7-Aug-02	GU0207G25R101	WQDB	7.3	74	165	5.0	11	—
			12-Dec-03	GU0312G25R101	WQDB	6.9	64[L]	—	—	10	—
			1-Sep-04	GU0408G25R101	WQDB	6.8	49[L]	—	—	22	—
			2-Aug-05	FU0508G25R101	WQDB	6.8	59[L]	255	5.2	9.1	—
61	R-25 2	891.8	8-Aug-02	GU0207G25R201	WQDB	8.2	202	131	4.5	12	—
			10-Dec-03	GU0312G25R201	WQDB	7.7	146[L]	—	—	17	—
			3-Aug-05	FU0508G25R201	WQDB	7.0	86[L]	-9	4.0	12	—
63	R-25 4	1192.4	8-Aug-02	GU0208G25R401	WQDB	7.2	52	-52	5.7	3.7	—
			10-Dec-03	GU0312G25R401	WQDB	6.9	75[L]	—	—	1.1	—
			4-Aug-05	FU0508G25R401	WQDB	7.2	66[L]	320	4.6	7.6	—
64	R-25 5	1303.4	9-Aug-02	GU0208G25R501	WQDB	7.5	102[EES]	76	4.1	4.8	—
			9-Dec-03	GU0312G25R501	WQDB	7.4	92[L]	—	—	1.4	—
			31-Aug-04	GU0408G25R501	WQDB	7.0	—	—	—	5.0	—
			9-Aug-05	FU0508G25R501	WQDB	7.2	—	—	2.8	3.6	—
65	R-25 6	1406.3	8-Feb-02	GW25-02-0009	WQDB	7.8	90	—	6.5	0.4	—
			12-Aug-02	GU0208G25R601	WQDB	7.8	74	233	6.3	0.5	—
			9-Dec-03	GU0312G25R601	WQDB	7.9	67[L]	—	—	0.4	—
66	R-25 7	1606	11-Feb-02	GW25-02-0011	WQDB	7.8	65	—	8.1	2.6[FN]	—
			12-Aug-02	GU0208G25R701	WQDB	8.1	46	206	6.3	1.8	—
			8-Dec-03	GU0312G25R701	WQDB	8.0	51[L]	—	—	1.4	—
67	R-25 8	1796	14-Aug-02	GU0208G25R801	WQDB	8.4	61[FN]	170	8.5	4.4	—
			4-Dec-03	GU0312G25R801	WQDB	8.6	54[L]	—	—	3.6	—
			10-Aug-05	FU0508G25R801	WQDB	8.5	61[L]	—	6.6	5.1	—

Table C-4 (continued)

Screen ID[a]	Well Screen		Screen Depth (ft)	Collection Date	Sample ID	Data Source[b]	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Total Sulfide (mg/L)
69	R-26	1	659.3	13-Apr-05	—	FN	7.8	36	8	8.9	0.1	0.001
				27-Jul-05	FU0507G26R101	WQDB	7.8	39[FN]	173	5.7	0.1	—
71	R-28	1	946.2	20-May-05	FU05050G28R01	WQDB	7.7	51	58	6.1	39	0.005
73	R-31	2	532.2	18-Mar-04	GU0403G31R201	WQDB	7.5	264	-92	10	7.4	0.004
				17-Aug-05	FU0508G31R201	WQDB	7.6	268	—	4.8	6.3	0.0001
77	R-32	1	870.9	21-Sep-04	GU0409G32R101	WQDB	8.4	64	169	7.2	0.2	0.005
				15-Nov-04	GU0411G32R101	WQDB	8.7	64	0	8.6	0.2	0.000
				22-Jun-05	FU0506G32R101	WQDB	8.1	79[FN]	252[FN]	4.0	—	—
79	R-32	3	976	22-Sep-04	GU0409G32R301	WQDB	7.4	60	-52	4.7	0.6	0.072
				16-Nov-04	GU0411G32R301	WQDB	7.5	57	—	10	0.5	0.132
				24-Jun-05	FU0506G32R301	WQDB	7.1	60[FN]	-50	4.4	0.5	—
80	R-33	1	995.5	27-Jun-05	FU0506G33R101	WQDB	8.0	66	-20	—	1.6	—
81	R-33	2	1112.4	24-Jun-05	FU0506G33R201	WQDB	7.5	67[FN]	176	5.8	1.0	—
82	R-34	1	895.15	7-Jun-05	FU05060G34R01	WQDB	8.1	59	-60	2.8	11	0.031

NTU—Nephelometric turbidity units.

[a] Yellow highlighting indicates data that fail at least one tier criterion.

[a] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.

[b] Field data have been extracted from the WQDB unless otherwise noted by one of the following codes: EES—measurement by theEES-6 analytical laboratory, usually within a few hours of sample collection and therefore considered as reliable as field pH and alkalinity measurements for water-quality conditions in the screen interval.; FN—obtained from field notes; GR—published in geochemistry report; see section 6.3 for reference list.

Table C-5
Identifiers of Samples Used for Tier-2.2 Assessments (Residual Organic Drilling Fluids)[a]

Screen ID[b]	Well Screen	Port Depth (ft)	Sample Collection Date	Filtered Sample ID	Preliminary Flag[c]	Nonfiltered Sample ID	Preliminary Flag[d]
1	CdV-16-1(i) 1	624.0	1-Jun-05	GF0505GC16i01	N	GU0505GC16i01	N
			29-Aug-05	GF0508GC16i01	Y	GU0508GC16i01	Y
5	CdV-R-15-3 4	1254.4	19-Oct-04	GF0410G153401	N	GU0410G153401	N
			4-Apr-05	GF0503G153401	N	GU0503G153401	N
			12-Jul-05	GF0506G153401	N	GU0506G153401	N
6	CdV-R-15-3 5	1350.1	20-Oct-04	GF0410G153501	N	GU0410G153501	N
			5-Apr-05	GF0503G153501	N	GU0503G153501	N
			12-Jul-05	GF0506G153501	N	GU0506G153501	N
7	CdV-R-15-3 6	1640.1	21-Oct-04	GF0410G153601	N	GU0410G153601	N
			6-Apr-05	GF0503G153601	N	GU0503G153601	N
			13-Jul-05	GF0506G153601	N	GU0506G153601	N
9	CdV-R-37-2 2	1200.3	26-Oct-04	GF0410G37R201	N	GU0410G37R201	N
			29-Mar-05	GF0503G37R201	N	GU0503G37R201	N
			6-Jul-05	GF0506G37R201	N	GU0506G37R201	N
10	CdV-R-37-2 3	1359.3	27-Oct-04	GF0410G37R301	N	GU0410G37R301	N
			30-Mar-05	GF0503G37R301	N	GU0503G37R301	N
			7-Jul-05	GF0506G37R301	N	GU0506G37R301	N
11	CdV-R-37-2 4	1550.6	27-Oct-04	GF0410G37R401	N	GU0410G37R401	N
			31-Mar-05	GF0503G37R401	N	GU0503G37R401	N
			8-Jul-05	GF0506G37R401	N	GU0506G37R401	N
12	MCOBT-4.4 1	485.4	28-Jan-03	GWM4-03-50311	ERDB/EES	GWM4-03-50310	ERDB
			21-May-03	GW05-03-51697	ERDB	GWM05-03-51696	ERDB
			14-Oct-04	GWM4-05-56041	ERDB/EES	GWM4-05-56041	ERDB
			8-Jun-05	GF05050G44M01	N	GU05050G44M01	N
13	R-1 1	1031.1	19-May-05	GF05050G01R01	N	GU05050G01R01	N
14	R-2 1	918.0	26-Apr-05	GF05040G02R01	N	GU05040G02R01	N
			9-Aug-05	GF05080G02R01	Y	GU05080G02R01	Y

Table C-5 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Filtered Sample ID	Preliminary Flag	Nonfiltered Sample ID	Preliminary Flag
15	R-4	1	804.5	27-Apr-05	GF05040G04R01	N	GU05040G04R01	N
				8-Aug-05	GF05080G04R01	N	GU05080G04R01	N
17	R-5	2	383.9	28-Apr-04	GF0404G05R201	N	GU0404G05R201	N
				27-Sep-04	GF0409G05R201	N	GU0409G05R201	N
				2-May-05	—	—	GU0504G05R201	N
18	R-5	3	718.6	30-Apr-04	GF0404G05R301	N	GU0404G05R301	N
				28-Sep-04	GF0409G05R301	N	GU0409G05R301	N
				3-May-05	—	—	GU0504G05R301	N
19	R-5	4	860.9	3-May-04	GF0404G05R401	N	GU0404G05R401	N
				30-Sep-04	GF0409G05R401	N	GU0409G05R401	N
				4-May-05	—	—	GU0504G05R401	N
20	R-6	1	1205.0	23-Aug-05	GF0508G06R01	Y	GU0508G06R01	Y
21	R-6i	1	602.0	24-Aug-05	GF0508G06IR01	Y	GU0508G06IR01	Y
24	R-7	3	915.1	18-Dec-03	—	—	GU0311G07R301	N
				26-May-04	—	—	GU0405G07R301	N
				26-Apr-05	—	—	GU0504G07R301	N
25	R-8	1	711.1	24-Aug-04	GF0407G08R101	N	GU0407G08R101	N
				8-Dec-04	GF0411G08R101	N	GU0411G08R101	N
				27-Apr-05	—	—	GU0504G08R101	N
26	R-8	2	825.0	25-Aug-04	GF0407G08R201	N	GU0407G08R201	N
				9-Dec-04	GF0411G08R201	N	GU0411G08R201	N
				28-Apr-05	—	—	GU0504G08R201	N
27	R-9	1	684.0	12-Dec-03	—	—	GU03120G09R01	N
				27-May-04	—	—	GU04050G09R01	N
				28-Apr-05	—	—	GU05040G09R01	N

Table C-5 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Filtered Sample ID	Preliminary Flag	Nonfiltered Sample ID	Preliminary Flag
28	R-9i	1	198.8	6-Feb-04	—	—	GU0311G9iR101	N
				2-Jun-04	—	—	GU0405G9iR101	N
				20-Apr-05	—	—	GU0504G9iR101	N
29	R-9i	2	278.8	6-Sep-01	GW9I-01-0012	N	GW9I-01-0011	N
				29-Jul-02	—	—	GU0207G9iR201	N
				6-Feb-04	—	—	GU0311G9iR201	N
30	R-11	1	855.0	17-May-05	GF05050G11R01	N	GU05050G11R01	N
				3-Aug-05	GF05080G11R01	N	GU05080G11R01	N
31	R-12	1	468.1	2-Feb-04	—	—	GU0311G12R101	N
				2-Jun-04	—	—	GU0405G12R101	N
				16-Jun-05	GF0506G12R101	N	GU0506G12R101	N
33	R-12	3	810.8	27-Jan-04	—	—	GU0311G12R301	N
				3-Jun-04	—	—	GU0405G12R301	N
				20-Jun-05	GF0506G12R301	N	GU0506G12R301	N
34	R-13	1	958.3	9-Dec-03	—	—	GU03120G31R01	N
				11-Jun-04	—	—	GU04060G31R01	N
				26-May-05	—	—	GU05050G13R01	N
35	R-14	1	1204.5	12-Jul-04	GF0407G14R101	N	GU0407G14R101	N
				28-Oct-04	GF0410G14R101	N	GU0410G14R101	N
				11-May-05	GF0505G14R101	N	GU0505G14R101	N
36	R-14	2	1288.5	14-Jul-04	GF0407G14R201	N	GU0407G14R201	N
				3-Nov-04	GF0411G14R201	N	GU0411G14R201	N
				12-May-05	GF0505G14R201	N	GU0505G14R201	N
37	R-15	1	958.6	15-Dec-03	—	—	GU03120G15R01	N
				10-Jun-04	—	—	GU04050G15R01	N
				25-May-05	GF05050G15R01	N	GU05050G15R01	N
				31-Aug-05	GF05080G15R01	Y	GU05080G15R01	Y

Table C-5 (continued)

Screen ID	Well Screen	Port Depth (ft)	Sample Collection Date	Filtered Sample ID	Preliminary Flag	Nonfiltered Sample ID	Preliminary Flag
39	R-16 2	866.1	13-Oct-04	GF0409G16R201	N	GU0409G16R201	N
			2-Dec-04	GF0411G16R201	N	GU0411G16R201	N
			13-Jun-05	GF0506G16R201	N	GU0506G16R201	N
40	R-16 3	1018.4	14-Oct-04	GF0410G16R301	N	GU0410G16R301	N
			3-Dec-04	GF0411G16R301	N	GU0412G16R301	N
			13-Jun-05	GF0506G16R301	N	GU0506G16R301	N
41	R-16 4	1238.0	15-Oct-04	GF0410G16R401	N	GU0410G16R401	N
			7-Dec-04	GF0411G16R401	N	GU0411G16R401	N
			14-Jun-05	GF0506G16R401	N	GU0506G16R401	N
42	R-18 1	1358.0	25-Aug-05	GF0508G18R01	Y	GU0508G18R01	Y
44	R-19 2	909.3	13-Sep-01	GW19-01-0033	N	GW19-01-0032	N
			20-Aug-02	—	—	GU0208G19R201	N
			15-Dec-03	—	—	GU0312G19R201	N
			21-Jul-05	GF0507G19R201	Y	GU0507G19R201	Y
45	R-19 3	1190.7	19-Sep-01	GW19-01-0037	N	GW19-01-0036	N
			22-Aug-02	—	—	GU0208G19R301	N
			15-Dec-03	—	—	GU0312G19R301	N
			14-Jun-04	—	—	GU0406G19R301	N
			21-Jul-05	GF0507G19R301	Y	GU0507G19R301	Y
46	R-19 4	1412.9	26-Aug-02	—	—	GU0208G19R401	N
			16-Dec-03	—	—	GU0312G19R401	N
			15-Jun-04	—	—	GU0406G19R401	N
			28-Jul-05	GF0507G19R401	Y	GU0507G19R401	Y
47	R-19 5	1586.1	20-Sep-01	GW19-01-0039	N	GW19-01-0038	N
			23-Aug-02	—	—	GU0208G19R501	N
			16-Dec-03	—	—	GU0312G19R501	N

Table C-5 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Filtered Sample ID	Preliminary Flag	Nonfiltered Sample ID	Preliminary Flag
48	R-19	6	1730.1	21-Sep-01	GW19-01-0041	N	GW19-01-0040	N
				27-Aug-02	—	—	GU0208G19R601	N
				16-Dec-03	—	—	GU0312G19R601	N
49	R-19	7	1834.7	24-Sep-01	GW19-01-0043	N	GW19-01-0042	N
				26-Aug-02	—	—	GU0208G19R701	N
				17-Dec-03	—	—	GU0312G19R701	N
				16-Jun-04	—	—	GU0406G19R701	N
				28-Jul-05	GF0507G19R701	Y	GU0507G19R701	Y
50	R-20	1	907.0	20-Sep-04	GF0409G20R101	N	GU0409G20R101	N
				4-Nov-04	GF0411G20R101	N	GU0411G20R101	N
				20-Jul-05	GF0507G20R101	Y	GU0507G20R101	Y
51	R-20	2	1149.7	7-Sep-04	GF0409G20R201-1	N	GU0409G20R201-1	N
				8-Nov-04	GF0411G20R201	N	GU0411G20R201	N
				19-Jul-05	GF0507G20R201	Y	GU0507G20R201	Y
52	R-20	3	1330.0	7-Sep-04	GF0409G20R301	N	GU0409G20R301	N
				9-Nov-04	GF0411G20R301	N	GU0411G20R301	N
				18-Jul-05	GF0507G20R301	N	GU0507G20R301	N
53	R-21	1	888.8	23-Sep-04	GF04090G21R01	N	GU04090G21R01	N
				14-Dec-04	GF04120G21R01	N	GU04120G21R01	N
				6-Jun-05	GF05060G21R01	N	GU05060G21R01	N
54	R-22	1	907.1	18-Nov-03	—	—	GU0311G22R101	N
				21-Jun-04	—	—	GU0406G22R101	N
				27-Jun-05	GF0506G22R101	N	GU0506G22R101	N
55	R-22	2	962.8	19-Nov-03	—	—	GU0311G22R201	N
				22-Jun-04	—	—	GU0406G22R201	N
				28-Jun-05	GF0506G22R201	N	GU0506G22R201	N

Table C-5 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Filtered Sample ID	Preliminary Flag	Nonfiltered Sample ID	Preliminary Flag
56	R-22	3	1273.5	20-Nov-03	—	—	GU0311G22R301	N
				30-Jun-04	—	—	GU0406G22R302	N
				29-Jun-05	GF0506G22R301	N	GU0506G22R301	N
57	R-22	4	1378.0	20-Nov-03	—	—	GU0311G22R401	N
				30-Jun-04	—	—	GU0406G22R402	N
				1-Jul-05	GF0506G22R401	N	GU0506G22R401	N
58	R-22	5	1448.2	10-Jul-02	—	—	GU0207G22R501	N
				21-Nov-03	—	—	GU0311G22R501	N
				5-Jul-05	GF0506G22R501	N	GU0506G22R501	N
59	R-23	1	816.0	29-Jun-04	GF04060GR2301	N	GU04060GR2301	N
				24-Sep-04	GF04090GR2301	N	GU04090GR2301	N
				14-Jul-05	GF05070GR2301	N	GU05070GR2301	N
60	R-25	1	754.8	11-Dec-03	—	—	GU0312G25R101	N
				1-Sep-04	—	—	GU0408G25R101	N
				2-Aug-05	GF0508G25R101	N	GU0508G25R101	N
61	R-25	2	891.8	5-Feb-02	GW25-02-0004	N	GW25-02-0004	N
				8-Aug-02	—	—	GU0207G25R201	N
				10-Dec-03	—	—	GU0312G25R201	N
				3-Aug-05	GF0508G25R201	N	GU0508G25R201	N
63	R-25	4	1192.4	8-Aug-02	—	—	GU0208G25R401	N
				10-Dec-03	—	—	GU0312G25R401	N
				4-Aug-05	GF0508G25R401	Y	GU0508G25R401	Y
64	R-25	5	1303.4	9-Dec-03	—	—	GU0312G25R501	N
				31-Aug-04	—	—	GU0408G25R501	N
				9-Aug-05	GF0508G25R501	Y	GU0508G25R501	Y

Table C-5 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Filtered Sample ID	Preliminary Flag	Nonfiltered Sample ID	Preliminary Flag
65	R-25	6	1406.3	8-Feb-02	GW25-02-0010	N	GW25-02-0009	N
				12-Aug-02	—	—	GU0208G25R601	N
				9-Dec-03	—	—	GU0312G25R601	N
66	R-25	7	1606.0	11-Feb-02	GW25-02-0012	N	GW25-02-0011	N
				12-Aug-02	—	—	GU0208G25R701	N
				8-Dec-03	—	—	GU0312G25R701	N
67	R-25	8	1796.0	14-Aug-02	—	—	GU0208G25R801	N
				4-Dec-03	—	—	GU0312G25R801	N
				10-Aug-05	GF0508G25R801	Y	GU0508G25R801	Y
69	R-26	1	659.3	13-Apr-05	GF0501G26R101	N	GU0501G26R101	N
				27-Jul-05	GF0507G26R101	Y	GU0507G26R101	Y
71	R-28	1	946.2	20-May-05	GF05050G28R01	N	GU05050G28R01	N
73	R-31	2	532.2	18-Mar-04	GF0403G31R201	N	GU0403G31R201	N
				17-Aug-05	GF0408G31R201	N	GU0408G31R201	N
77	R-32	1	870.9	21-Sep-04	GF0409G32R101	N	GU0409G32R101	N
				15-Nov-04	GF0411G32R101	N	GU0411G32R101	N
				22-Jun-05	GF0506G32R101	N	GU0506G32R101	N
79	R-32	3	976.0	22-Sep-04	GF0409G32R301	N	GU0409G32R301	N
				16-Nov-04	GF0411G32R301	N	GU0411G32R301	N
				24-Jun-05	GF0506G32R301	N	GU0506G32R301	N
80	R-33	1	995.5	27-Jun-05	GF0506G33R101	N	GU0506G33R101	N
81	R-33	2	1112.4	24-Jun-05	GF0506G33R201	N	GU0506G33R201	N
82	R-34	1	895.15	7-Jun-05	GF05060G34R01	N	GU05060G34R01	N

— Sample does not exist or was not needed for this assessment.
[a] Data for these samples reside in the WQDB unless otherwise noted.
[b] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.
[d] Preliminary flag — This table contains chemical data that are in various stages of review. The data are assigned preliminary and provisional flags in the WQDB to indicate their current status. The preliminary flag indicates whether a result has been through a level 4 validation. All data from analytical laboratories that have the capability to provide level 4 data packages are validated. The provisional flag indicates when a result is final.

Table C-6
Water-Quality Data Used for Tier 2.2-1 Assessments (Indicators of Residual Drilling Fluids)[a]

Screen ID[b]	Well Screen		Port Depth (ft)	Date		Acetone[c] µg/L	Codes[d]			Ammonia[e] as N (mg/L)	Codes			TKN[e] µg/L	Codes			TOC[c] (mg/L)	Codes	
							L	V			L	V			L	V			L	V
1	CdV-16-1(i)	1	624.0	1-Jun-05	<	64		U	<	0.01	U	R	<	0.01	U			1.3		J
				29-Aug-05		3	J		<	0.04	U			0.44				0.8	J	
5	CdV-R-15-3	4	1254.4	19-Oct-04		—			<	0.02	U	UJ		0.07	J		<	0.3		U
				4-Apr-05	<	5	U		<	0.01	U	R	<	0.12		U		0.4		J-
				12-Jul-05	<	5	U		<	0.01	U	UJ		0.06	J		<	0.3		J-
6	CdV-R-15-3	5	1350.1	20-Oct-04		—				0.12				0.27				4.4		
				5-Apr-05		16				0.12				0.30				4.9		
				12-Jul-05		6				0.14				0.29		J		1.4		
7	CdV-R-15-3	6	1640.1	21-Oct-04		—			<	0.02	U	UJ		0.14		J	<	0.5		U
				6-Apr-05	<	5	U		<	0.01	U	R		0.14				0.6		
				13-Jul-05	<	5	U		<	0.01	U	UJ		0.06	J	J		—		
9	CdV-R-37-2	2	1200.3	26-Oct-04		—				0.54				0.59				4.6		
				29-Mar-05	<	5	U			0.39				0.48		JN-		5.7		
				6-Jul-05	<	5	U			0.29				0.48				4.7		
10	CdV-R-37-2	3	1359.3	27-Oct-04		—			<	0.02	U	UJ	<	0.04	U	UJ	<	0.3		U
				30-Mar-05	<	5	U		<	0.01	U	R	<	0.08	J	U	<	0.5		U
				7-Jul-05	<	5	U		<	0.01	U		<	0.01	U	UJ		0.2		JN-
11	CdV-R-37-2	4	1550.6	27-Oct-04		—				0.09				0.10	J	JN-		0.8		
				31-Mar-05	<	5	U			0.08		J-		0.33				1.4		
				8-Jul-05	<	5	U			0.08				0.18				0.8		J-
12	MCOBT-4.4	1	485.4	28-Jan-03	<	5			<	0.05				0.23				0.8		
				28-Oct-04	<	5														
				8-Jun-05		—				—			<	0.01	U			1.0		
13	R-1	1	1031.1	19-May-05	<	1	J	U	<	0.01	U	R	<	0.01	U	UJ		0.2		UJ
14	R-2	1	918.0	26-Apr-05	<	5	J	U	<	0.01	J	U	<	0.01	U			1.7		
				9-Aug-05		2	J		<	0.01	U			0.16				1.0		

Table C-6 (continued)

Screen ID	Well Screen		Port Depth (ft)	Date	Acetone µg/L	Codes L	Codes V	Ammonia[a] as N (mg/L)	Codes L	Codes V	TKN µg/L	Codes L	Codes V	TOC (mg/L)	Codes L	Codes V
15	R-4	1	804.5	27-Apr-05	< 5	U		< 0.01	U		< 0.01	U	R	0.5		J-
				8-Aug-05	< 5	U		< 0.01	U	UJ	0.15			0.3		J-, JN-
17	R-5	2	383.9	28-Apr-04	< 5	U		< 0.02	U	R	0.07	J		0.3		J-
				27-Sep-04	< 5	U		< 0.02	U	R	0.12		JN-	< 0.3		U
				2-May-05	< 5	U		—			< 0.01	U	R	0.5		J-
18	R-5	3	718.6	30-Apr-04	< 5	U		< 0.02	U	UJ	0.08	J		0.3		J-
				28-Sep-04	< 5	U		< 0.02	U	R	0.07	J		< 0.3		U
				3-May-05	< 5	U		—			< 0.01	U	UJ	0.4		J-
19	R-5	4	860.9	3-May-04	< 5	U		< 0.02	U	R	0.30			0.9		J-
				30-Sep-04	< 5	U		< 0.02	U	R	0.07	J		0.8		J-
				4-May-05	< 5	U		—			< 0.01	U	UJ	0.8		J-
20	R-6	1	1205.0	23-Aug-05	< 5	U		< 0.04	U		< 0.02	U		1.4		
21	R-6i	1	602.0	24-Aug-05	1	J		< 0.04	U		0.14	J		4.4		
24	R-7	3	915.1	18-Dec-03	< 5	U		< 0.02	U	R	—			1.2		
				26-May-04	< 5	U		—			—			—		
				26-Apr-05	< 5	U		—			0.22		JN-	1.3		
25	R-8	1	711.1	24-Aug-04	< 5	U		< 0.02	U	UJ	0.07	U		0.1		J-
				8-Dec-04	< 5	U		< 0.02	U	UJ	< 0.04	U		< 0.2		UJ
				27-Apr-05	< 5	U		—			< 0.01	U	R	0.3		J-
26	R-8	2	825.0	25-Aug-04	< 5	U		< 0.02	U	UJ	0.08	J		0.6		J-
				9-Dec-04	< 5	U		< 0.02	U	UJ	< 0.04	U		< 0.5		UJ
				28-Apr-05	—			—			< 0.01	U	UJ	0.6		J-
27	R-9	1	684.0	12-Dec-03	—			< 0.02	U		—			0.4		J-
				27-May-04	< 5	U		—			—			—		
				28-Apr-05	< 5	U		—			< 0.01	U	UJ	0.5		J-
28	R-9i	1	198.8	6-Feb-04	—			< 0.02	U		—			3.2		
				2-Jun-04	< 5	U		—			—			—		
				20-Apr-05	< 5	U		—			0.23		JN-	3.4		

Table C-6 (continued)

Screen ID	Well Screen	Port Depth (ft)	Date	Acetone µg/L	Codes L	Codes V	Ammonia[a] as N (mg/L)	Codes L	Codes V	TKN µg/L	Codes L	Codes V	TOC (mg/L)	Codes L	Codes V
29	R-9i 2	278.8	6-Sep-01	< 6	B	U	< 0.02	U	U	0.2		NQ	2.6		NQ
			29-Jul-02	—			< 0.02	U	R	—			1.8		
			6-Feb-04	—			< 0.02	U		—			1.4		J-
30	R-11 1	855.0	17-May-05	< 2	J	U	< 0.01	U	R	< 0.01	U	R	< 0.3		UJ
			3-Aug-05	< 5	U		0.02	J	J-	< 0.01	U	UJ	< 0.5		J
31	R-12 1	468.1	2-Feb-04	—			1.66			—			5.3		
			2-Jun-04	< 5	U		—			—			—		
			16-Jun-05	< 5	U		1.40			1.54			—		
33	R-12 3	810.8	27-Jan-04	—			< 0.02	U		—			1.0		
			3-Jun-04	< 5	U		—			—			—		
			20-Jun-05	—			< 0.01	U	UJ	< 0.01	U	R	—		
34	R-13 1	958.3	9-Dec-03	—			< 0.02	U		—			0.2		J-
			11-Jun-04	< 5	U		—			—			—		
			26-May-05	—			—			< 0.01	U	UJ	0.2		J-
35	R-14 1	1204.5	12-Jul-04	< 5	U		< 0.02	U	UJ	< 0.04	U		< 0.5		UJ
			28-Oct-04	< 5	U		< 0.02	U	UJ	< 0.04	U		0.4		J-
			11-May-05	3	J		< 0.01	U	R	0.03	J	JN-	< 0.5		UJ
36	R-14 2	1288.5	14-Jul-04	< 5	U		0.06		JN-	0.07	J		1.9		
			3-Nov-04	< 5	U		0.08			0.07	J		2.2		
			12-May-05	4	J		0.08		J-	0.11		JN+	2.1		
37	R-15 1	958.6	15-Dec-03	< 5	U		< 0.02	U		—			0.3		
			10-Jun-04	< 5	U		—			—			—		
			25-May-05	< 5	U		—			< 0.01	U	UJ	0.4		
			31-Aug-05	< 5	U		—			< 0.01	U		0.2	J	
39	R-16 2	866.1	13-Oct-04	< 5	U		0.02	J		0.11			< 1.5		U
			2-Dec-04	< 5	U		0.02	J	JN-	0.06	J		1.8		
			13-Jun-05	< 5	U		< 0.01	U		0.05	J	U	—		

Table C-6 (continued)

Screen ID	Well Screen		Port Depth (ft)	Date	Acetone µg/L	Codes L	Codes V	Ammonia[e] as N (mg/L)	Codes L	Codes V	TKN µg/L	Codes L	Codes V	TOC (mg/L)	Codes L	Codes V
40	R-16	3	1018.4	14-Oct-04	< 5	U		0.58			1.30			0.8		J-
				3-Dec-04	< 5	U		0.39			1.10			0.8		R
				13-Jun-05	< 5	U	R	0.04	J	JN-	0.31			—		
41	R-16	4	1238.0	15-Oct-04	< 5	U		0.84			0.68			1.7		
				7-Dec-04	< 5	U		0.84			0.92			< 3.1		U
				14-Jun-05	< 5	U	R	0.95			1.10			—		
42	R-18	1	1358.0	25-Aug-05	< 5	U		< 0.04	U		< 0.02	U		0.6	J	
44	R-19	2	909.3	13-Sep-01	—			—			0.17		NQ	0.7		NQ
				20-Aug-02	< 5	U		< 0.02	U		—			0.2		
				15-Dec-03	—			< 0.02	U		—			0.3		
				21-Jul-05	—			< 0.01	U		0.32			—		
45	R-19	3	1190.7	19-Sep-01	—			—			0.08	J	J	0.5		NQ
				22-Aug-02	< 5	U		< 0.02	U		—			0.1	J	
				15-Dec-03	—			< 0.02	U	R	—			0.2		J-
				14-Jun-04	< 5	U		—			—			—		
				21-Jul-05	< 5	U		< 0.01	U		22.9			—		
46	R-19	4	1412.9	26-Aug-02	< 5	U		< 0.02	U	R	—			0.2		
				16-Dec-03	—			< 0.02	U	R	—			0.2	J	J-
				15-Jun-04	< 5	U		—			—			—		
				28-Jul-05	< 5	U		0.05			0.02	J		—		
47	R-19	5	1586.1	20-Sep-01	—			—			0.96		NQ	6.4		NQ
				23-Aug-02	< 5	U		0.88		J-	—			7.6		
				16-Dec-03	—			0.76		J-	—			6.4		
48	R-19	6	1730.1	21-Sep-01	—			—			0.92		NQ	3.0		NQ
				27-Aug-02	< 5	U		0.31		J-	—			1.4		
				16-Dec-03	—			0.37		J-	—			0.6		J-

Table C-6 (continued)

Screen ID	Well Screen	Port Depth (ft)	Date	Acetone µg/L	Codes		Ammonia[e] as N (mg/L)	Codes		TKN µg/L	Codes		TOC (mg/L)	Codes	
					L	V		L	V		L	V		L	V
49	R-19 7	1834.7	24-Sep-01	—			—			0.57		NQ	4.1		NQ
			26-Aug-02	< 5	U		0.37		J-	—			3.6		
			17-Dec-03	—			0.23		J-	—			2.3		
			16-Jun-04	< 5	U		—			—			—		
			28-Jul-05	< 5	U		0.33			0.60			—		
50	R-20 1	907.0	20-Sep-04	164			0.36		J-	0.53			17.1		
			4-Nov-04	55			0.28			0.34		J+	12.3		
			20-Jul-05	12			0.26			0.41			—		
51	R-20 2	1149.7	7-Sep-04	< 5	U		0.68			0.89	H	J	38.3		
			8-Nov-04	< 5	U		0.57			0.84			35.2		
			19-Jul-05	< 5	U		0.51			0.83			—		
52	R-20 3	1330.0	7-Sep-04	< 5	U		0.32			0.46	H	J	2.9		
			9-Nov-04	< 5	U		0.31			0.41			2.4		
			18-Jul-05	< 5	U		0.29			0.37			—		
53	R-21 1	888.8	23-Sep-04	< 5	U		< 0.02	U	R	0.05	J		< 0.4		UJ
			14-Dec-04	< 5	U		< 0.02	U	UJ	< 0.04	U		< 0.4		U
			6-Jun-05	3	J		< 0.01	U	R	< 0.01	U		—		
54	R-22 1	907.1	18-Nov-03	< 5	U		0.82			—			6.4		
			21-Jun-04	< 5	U		—			—			—		
			27-Jun-05	1	J		0.53		J+	0.81			—		
55	R-22 2	962.8	19-Nov-03	< 5	U		< 0.02	U	UJ	—			0.2	J	J-
			22-Jun-04	< 5	U		—			—			—		
			28-Jun-05	< 5	U	R	< 0.01	U	UJ	< 0.01	U	UJ	—		
56	R-22 3	1273.5	20-Nov-03	< 5	U		< 0.02	U	UJ	—			1.3		
			30-Jun-04	< 5	U		—			—			—		
			29-Jun-05	< 5	U		< 0.01	U	R	0.29			—		

Table C-6 (continued)

Screen ID	Well Screen		Port Depth (ft)	Date	Acetone µg/L	Codes L	Codes V	Ammonia[e] as N (mg/L)	Codes L	Codes V	TKN µg/L	Codes L	Codes V	TOC (mg/L)	Codes L	Codes V
57	R-22	4	1378.0	20-Nov-03	< 5	U		0.40		J	—			16.7		
				30-Jun-04	< 5	U		—			—			—		
				1-Jul-05	< 5	U		0.28			< 0.06	J	UJ	—		
58	R-22	5	1448.2	10-Jul-02	< 5	U		0.54			—			4.0		
				21-Nov-03	< 5	U		0.35			—			2.6		
				5-Jul-05	< 5	U	R	0.23			0.36			—		
59	R-23	1	816.0	29-Jun-04	< 5	U		< 0.02	U		< 0.04	U		< 0.6		U
				24-Sep-04	< 5	U		< 0.02	U	R	0.22			0.7		J-
				14-Jul-05	< 5	U		< 0.01	U	UJ	0.02	J	JN-	—		
60	R-25	1	754.8	11-Dec-03	< 5	U		< 0.02	U		—			0.9		J-
				1-Sep-04	< 5	U		—			—			—		
				2-Aug-05	1	J		< 0.04	J	JN-	< 0.01	U	UJ	—		
61	R-25	2	891.8	5-Feb-02	3	J	J	< 0.05	U	U	0.24		NQ	2.9		NQ
				8-Aug-02	< 5	U		< 0.02	U		—			2.7		
				10-Dec-03	< 5	U		0.05			—			2.4		
				3-Aug-05	< 5	U		0.15			0.23			—		
63	R-25	4	1192.4	8-Aug-02	< 5	U		< 0.02	U		0.29		NQ	1.6		
				10-Dec-03	< 5	U		0.56			—			1.0		J-
				4-Aug-05	< 5	U		< 0.01	U	UJ	0.17			—		
64	R-25	5	1303.4	9-Dec-03	< 5	U		0.08			—			10.3		
				31-Aug-04	< 5	U		—			—			—		
				9-Aug-05	< 5	U		—			—			—		
65	R-25	6	1406.3	8-Feb-02	< 5	U	U	< 0.05	U	U	< 0.1	U	U	0.7		NQ
				12-Aug-02	< 5	U		< 0.02	U	R	—			< 0.5		U
				9-Dec-03	< 5	U		< 0.02	U		—			0.3		J-
66	R-25	7	1606.0	11-Feb-02	< 5	U	U	< 0.05	U	U	< 0.1	U	U	0.3		NQ
				12-Aug-02	< 5	U		< 0.02	U	R	—			0.3		R
				8-Dec-03	< 5	U		< 0.02	U		—			0.2		J-

Table C-6 (continued)

Screen ID	Well Screen		Port Depth (ft)	Date	Acetone µg/L	Codes L	Codes V	Ammonia[e] as N (mg/L)	Codes L	Codes V	TKN µg/L	Codes L	Codes V	TOC (mg/L)	Codes L	Codes V
67	R-25	8	1796.0	14-Aug-02	< 5	U		< 0.02	U	R	—			0.3		R
				4-Dec-03	< 5	U		< 0.03	J	U	—			< 0.5		U
				10-Aug-05	< 5	U		< 0.01	U		0.23			—		
69	R-26	1	659.3	13-Apr-05	< 5	U		< 0.01	U	R	< 0.01	U	UJ	< 0.2		U
				27-Jul-05	< 5	U		0.04	J		0.04	J		0.2		
71	R-28	1	946.2	20-May-05	< 5	U		< 0.01	U	R	0.19			0.5		J-
73	R-31	2	532.2	18-Mar-04	< 5	U		0.42			1.28			6.2		
				17-Aug-05	< 5	U		1.21			0.31			—		
77	R-32	1	870.9	21-Sep-04	< 5	U		0.08			0.08	J		< 0.4		U
				15-Nov-04	< 5	U		< 0.02	U		< 0.04	U		0.4		J-
				22-Jun-05	< 5	U		< 0.01	U	R	< 0.01	U	R	—		
79	R-32	3	976.0	22-Sep-04	< 5	U		0.22			0.40			0.7		J-
				16-Nov-04	< 5	U		0.19			0.41			0.6		J-
				24-Jun-05	< 5	U		0.18			0.26			—		
80	R-33	1	995.50	27-Jun-05	< 5	U		—			< 0.01	U	UJ	0.3		JN-
81	R-33	2	1112.40	24-Jun-05	< 5	U		—			< 0.01	U	UJ	0.3		J-
82	R-34	1	895.15	7-Jun-05	< 2.5	J	U	< 0.01	U		< 0.01	U		< 0.5		U

TKN—Total Kjeldahl Nitrogen (organic nitrogen); TOC—Total Organic Carbon

[a] Notes: (1) Data for these samples reside in the WQDB unless otherwise noted. (2) This table includes some data that have not been released to the public. Usually, these data have not been released because they were collected at a facility or on property that is not controlled or owned by LANL, and an external entity must approve the data for general release. (3) Yellow highlighting indicates data that fail at least one tier criterion.

[b] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.

[c] Analysis for this parameter is conducted on nonfiltered samples.

[d] Codes: L—Laboratory Qualifier Code (assigned by the analytical laboratory); V—Validation Flag Code (assigned by LANL). These codes are defined in Table C-1.

[d] Analysis for this parameter is conducted on filtered samples.

Table C-7
Water-Quality Data Used for Tier 2.2-2 Assessments (Indicators of Redox Conditions)a

Screen ID[b]	Well Screen	Port Depth (ft)	Sample Collection Date	Sulfate (mg/L)	Codes[c] L	Codes[c] V	Iron µg/L	Codes L	Codes V	Manganese µg/L	Codes L	Codes V	Nitrate (as N) mg/L	Codes L	Codes V
1	CdV-16-1(i) 1	624.0	1-Jun-05	10.3			29	J		6			0.6		
			29-Aug-05	12.5			42	J		11			0.6		
5	CdV-R-15-3 4	1254.4	19-Oct-04	1.3			< 13	U		2	J		0.2		
			4-Apr-05	1.3			< 18	U		2	J		0.2		J-
			12-Jul-05	1.2			< 18	U		3	J		0.2		J-
6	CdV-R-15-3 5	1350.1	20-Oct-04	0.3	J		146			187			< 0.003	U	R
			5-Apr-05	1.0			145			141			< 0.003	U	R
			12-Jul-05	7.8			123			214	E	J	< 0.02	U	UJ
7	CdV-R-15-3 6	1640.1	21-Oct-04	1.1			17	J		26			< 0.003	U	UJ
			6-Apr-05	1.0			178			151			< 0.003	U	R
			13-Jul-05	1.0			157			137	E	J	0.04	J	J-
9	CdV-R-37-2 2	1200.3	26-Oct-04	0.5			7910	EN	J+	2930			< 0.003	U	
			29-Mar-05	< 0.2	J	U	13400			2290		J	< 0.003	U	
			6-Jul-05	0.4	J	J+	15800			2200		J-	< 0.02	U	
10	CdV-R-37-2 3	1359.3	27-Oct-04	2.0			< 13	U		5	J		0.4		
			30-Mar-05	< 1.4		U	< 18	U		3	J	J	0.2		
			7-Jul-05	1.4			< 18	U		3	J		0.3	J	
11	CdV-R-37-2 4	1550.6	27-Oct-04	2.0			2070			71			< 0.003	U	R
			31-Mar-05	1.8			1740			61			< 0.003	U	R
			8-Jul-05	1.5			1450			56			0.02	J	J-
12	MCOBT-4.4 1	485.4	28-Jan-03	26			< 100	U		< 5	U		14.8		
			14-Oct-04	27			85			< 1			19.1		
			8-Jun-05	—			—			—			15.5		
13	R-1 1	1031.1	19-May-05	3.6			79	J		< 1	U		0.2		

Table C-7 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Sulfate (mg/L)	Codes L	Codes V	Iron µg/L	Codes L	Codes V	Manganese µg/L	Codes L	Codes V	Nitrate (as N) mg/L	Codes L	Codes V
14	R-2	1	918.0	26-Apr-05	3.4			60	J		35			0.3		
				9-Aug-05	2.4			< 18	U*		23			0.3		
15	R-4	1	804.5	27-Apr-05	4.7			< 18	U		< 1	U		1.6		
				8-Aug-05	4.3			< 18	U		< 1	U		1.8		
17	R-5	2	383.9	28-Apr-04	8.0			< 13	U		6			2.3		
				27-Sep-04	8.8			< 13	U		7			3.3		
				2-May-05	8.2			< 18	U		1	J	J	2.7		
18	R-5	3	718.6	30-Apr-04	16.0			< 13	U		6			1.8		
				28-Sep-04	17.2			< 13	U		5	J		2.4		
				3-May-05	16.1			24[d]	J		1	J		2.1		
19	R-5	4	860.9	3-May-04	4.4			383			442			< 0.01	U	R
				30-Sep-04	4.8			158			382			< 0.02	U	R
				4-May-05	4.2			202[d]			110[d]			0.1		J-
20	R-6	1	1205.0	23-Aug-05	3.2			< 18	U		60			0.27		
21	R-6i	1	602.0	24-Aug-05	13.2			34	J		6			3.5		
24	R-7	3	915.1	18-Dec-03	0.7		J	2360[d]			637[d]			< 0.01	U	
				26-May-04	1.0			2200[d]			587[d]			< 0.01	U	R
				26-Apr-05	0.6			2120[d]			504[d]	E	J	< 0.02	J	U
25	R-8	1	711.1	24-Aug-04	—			< 13	U		< 2	U		0.4	H	J
				8-Dec-04	2.2			< 13	U	UJ	3	J		0.4		
				27-Apr-05	2.0			20[d]	J		2[d]	J		—		
26	R-8	2	825.0	25-Aug-04	3.3			18	B		< 2	U		0.3	H	J
				9-Dec-04	3.4			< 13	U	UJ	< 2	U		0.3		
				28-Apr-05	3.2			26	J		3[d]	J		0.2		
27	R-9	1	684.0	12-Dec-03	6.0			< 62	B	U	84[d]			0.8		
				27-May-04	6.4			255[d]			113[d]			0.7		
				28-Apr-05	5.8			< 18[d]	U		54[d]			0.6		

Table C-7 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Sulfate (mg/L)	Codes L	Codes V	Iron µg/L	Codes L	Codes V	Manganese µg/L	Codes L	Codes V	Nitrate (as N) mg/L	Codes L	Codes V
28	R-9i	1	198.8	6-Feb-04	17.4			672[d]			767[d]			< 0.01	U	
				2-Jun-04	20.6		J	453[d]			663[d]			< 0.01	U	UJ
				20-Apr-05	17.1			55[d]			284[d]		J	0.07		
29	R-9i	2	278.8	6-Sep-01	7.3		NQ	703		NQ	487		NQ	0.02	J	J
				29-Jul-02	8.9			429[d]			382[d]			< 0.01	U	
				6-Feb-04	9.2			< 180[d]		U	222[d]			< 0.01	U	
30	R-11	1	855.0	17-May-05	6.0			29	J		< 1	U		3.7		
				3-Aug-05	6.3			< 18	U		< 1	U		3.4		
31	R-12	1	468.1	2-Feb-04	0.4	J		209[d]			95[d]			< 0.01	U	
				2-Jun-04	< 0.2	U	J	205[d]			68[d]			< 0.01	U	UJ
				16-Jun-05	1.3			113	*	J	54			< 0.003	U	R
33	R-12	3	810.8	27-Jan-04	8.4			406[d]			283[d]			< 0.01	U	
				3-Jun-04	9.2		J	316[d]			201[d]			< 0.01	U	UJ
				20-Jun-05	8.9			147			119			< 0.02	U	R
34	R-13	1	958.3	9-Dec-03	2.8			< 13[d]	U		< 2[d]	B	U	0.8		
				11-Jun-04	3.4			32[d]	B		< 1[d]	B	U	0.8		
				26-May-05	3.1			—			—			0.6		
35	R-14	1	1204.5	12-Jul-04	1.8			105			78			< 0.03	J	U
				28-Oct-04	1.9			83			80			0.07		
				11-May-05	1.4			64			44			0.06		
36	R-14	2	1288.5	14-Jul-04	1.4			2640			354			< 0.01	U	
				3-Nov-04	0.4	J		2780			393	E	J	< 0.007	J	UJ
				12-May-05	1.0			2330	E		350		J	< 0.003	U	R
37	R-15	1	958.6	15-Dec-03	6.6			276[d]			4[d]	B		2.5		
				10-Jun-04	6.9			200[d]			3[d]	B		2.2		
				25-May-05	6.4			< 18	U		< 1	U		2.3		
				31-Aug-05	6.4			39	J		< 2	U		2.4		

Table C-7 (continued)

Screen ID	Well Screen	Port Depth (ft)	Sample Collection Date	Sulfate (mg/L)	Codes L	Codes V	Iron µg/L	Codes L	Codes V	Manganese µg/L	Codes L	Codes V	Nitrate (as N) mg/L	Codes L	Codes V
39	R-16 2	866.1	13-Oct-04	2.9			75	J		146			0.004	J	JN-
			2-Dec-04	2.8			< 13	U		25			< 0.02	J	U
			13-Jun-05	—			< 18	U		19			< 0.02	U	R
40	R-16 3	1018.4	14-Oct-04	7.5			247			68			0.09		J-
			3-Dec-04	6.7			< 13	U		66			0.2		
			13-Jun-05	4.9			< 18	U		19			0.2		
41	R-16 4	1238.0	15-Oct-04	48.9			14	J		9			< 0.009	J	UJ
			7-Dec-04	40.2			< 13	U	UJ	13			< 0.003	U	R
			14-Jun-05	28.8			< 18	U		5	J		< 0.02	U	
42	R-18 1	1358.0	25-Aug-05	1.7			< 18	U		< 1	U		0.4		
44	R-19 2	909.30	15-Dec-03	3.1			< 52[d]	B	U	2[d]	B	U	0.4		
			10-Jun-04	3.3			< 13[d]	U		1[d]	B	U	0.4		
			21-Jul-05	2.6			26	J		2	U		0.7		
45	R-19 3	1190.70	15-Dec-03	1.9		J	< 17	B	U	4[d]	B		0.3		J
			14-Jun-04	2.1			39[d]	B		3[d]	B		0.2		J
			21-Jul-05	0.06			< 18	U		9	J		0.2		
46	R-19 4	1412.90	16-Dec-03	1.5		J	< 35[d]	B	U	1[d]	B		0.4		J
			15-Jun-04	1.2			88[d]	B		2[d]	B		0.3		
			28-Jul-05	1.4			< 18	U		4	J		0.2		
47	R-19 5	1586.10	20-Sep-01												
			23-Aug-02	< 0.2	U		5840[d]			1050[d]			< 0.01	U	
			16-Dec-03	0.4	J	J	992[d]			1020[d]			< 0.01	U	UJ
48	R-19 6	1730.10	21-Sep-01												
			27-Aug-02	< 0.2	U		3430[d]			421[d]			< 0.01	U	
			16-Dec-03	0.8		J	1140[d]			303[d]			< 0.01	J	U

Table C-7 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Sulfate (mg/L)	Codes L	Codes V	Iron µg/L	Codes L	Codes V	Manganese µg/L	Codes L	Codes V	Nitrate (as N) mg/L	Codes L	Codes V
49	R-19	7	1834.70	17-Dec-03	38.8		J	1680[d]			99[d]			0.02	J	J
				16-Jun-04	34.1			413[d]			96[d]			0.03	J	
				28-Jul-05	23.4			44	J		61			0.03	J	
50	R-20	1	907.0	20-Sep-04	3.8			123			16			< 0.003	U	R
				4-Nov-04	3.7			95	J		28			< 0.003	U	R
				20-Jul-05	0.06			123			14			< 0.02	U	
51	R-20	2	1149.7	7-Sep-04	< 0.4		U	246			346			< 0.01	J	U
				8-Nov-04	< 0.2	U		187			332	E	J	< 0.003	U	R
				19-Jul-05	< 0.06	U		141			368			< 0.02	U	
52	R-20	3	1330.0	7-Sep-04	< 0.2	U		7750[d]			680			< 0.003	U	R
				9-Nov-04	< 0.2	U		7170[d]			587	E	J	< 0.003	U	R
				18-Jul-05	< 0.06	U		6060			645			< 0.02	U	UJ
53	R-21	1	888.8	23-Sep-04	2.0			< 22	J	U	8	E	J	0.4		J+
				14-Dec-04	2.3			< 13	U	UJ	8			0.3		
				6-Jun-05	2.0			25	J		11			0.2		
54	R-22	1	907.1	18-Nov-03	0.4			21100[d]			3740[d]			< 0.01	U	
				21-Jun-04	0.4	J		18400[d]			3530[d]			< 0.01	U	
				27-Jun-05	0.4	J		11200			3160			< 0.02	U	
55	R-22	2	962.8	19-Nov-03	3.4			< 13	U		3[d]	B		0.6		
				22-Jun-04	3.2			< 13	U		1[d]	B		0.6		
				28-Jun-05	3.5			< 18	U		< 2	U		0.6		
56	R-22	3	1273.5	20-Nov-03	6.0			93	B		7[d]	B		0.3		
				23-Jun-04	6.0			13	B		3[d]	B		0.4		J+
				29-Jun-05	9.1			27	J		< 2	U		0.4		
57	R-22	4	1378.0	20-Nov-03	1.7			3860[d]			847[d]			< 0.01	U	R
				23-Jun-04	1.2			2940[d]			703[d]			< 0.02	J	U
				1-Jul-05	2.0			927			642			0.02	J	

Table C-7 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Sulfate (mg/L)	Codes		Iron µg/L	Codes		Manganese µg/L	Codes		Nitrate (as N) mg/L	Codes	
						L	V		L	V		L	V		L	V
58	R-22	5	1448.2	10-Jul-02	0.7			1350[d]			469[d]			< 0.02	J	U
				21-Nov-03	0.5			1170[d]			483[d]			< 0.01	U	R
				5-Jul-05	0.7			73	J		439			< 0.02	U	
59	R-23	1	816.0	29-Jun-04	6.1			< 13	U		10			0.9		
				24-Sep-04	5.6			< 13	U		8	E	J	1.4		
				14-Jul-05	5.4			< 18	U		3	J*		1.0		
60	R-25	1	754.8	11-Dec-03	8.3			1080[d]			237[d]			1.2		
				1-Sep-04	10.7			4410[d]			409[d]			1.1		
				2-Aug-05	8.5			192			183			1.0		J
61	R-25	2	891.8	5-Feb-02	11.6			117		NQ	19		NQ	< 0.05	U	U
				8-Aug-02	9.6			635[d]			32[d]			< 0.03	J	U
				10-Dec-03	8.9			1570[d]			48[d]			< 0.01	U	
				3-Aug-05	7.8			2310			150			0.08		
63	R-25	4	1192.4	8-Aug-02	27.2			444[d]			28[d]			0.8		
				10-Dec-03	11.8			210[d]			8[d]	B		< 0.01	U	
				4-Aug-05	207			< 18	U		8	J		0.7		
64	R-25	5	1303.4	9-Dec-03	10.0			2780[d]			177[d]			0.01	J	
				31-Aug-04	—			2030[d]			204[d]			< 0.02	J	UJ
				9-Aug-05	—			664			125			—		
65	R-25	6	1406.3	8-Feb-02	3.9		NQ	< 50	U	U	< 1	B		0.3		NQ
				12-Aug-02	3.3			184[d]			6[d]	B		0.3		
				9-Dec-03	2.9			< 62	B	U	< 2	B	U	0.3		
66	R-25	7	1606.0	11-Feb-02	2.2		NQ	< 23	B	J	< 2	B	J	0.3		NQ
				12-Aug-02	1.9			145[d]			3[d]	B		0.3		
				8-Dec-03	1.8			127[d]			< 2	B	U	0.3		

Table C-7 (continued)

Screen ID	Well Screen		Port Depth (ft)	Sample Collection Date	Sulfate (mg/L)	Codes L	Codes V	Iron µg/L	Codes L	Codes V	Manganese µg/L	Codes L	Codes V	Nitrate (as N) mg/L	Codes L	Codes V
67	R-25	8	1796.0	14-Aug-02	2.2			307[d]			3[d]	B		0.3		
				4-Dec-03	1.9			204[d]		J	< 2	B	U	0.3		
				10-Aug-05	1.8			24	J		12			0.2		
69	R-26	1	659.3	13-Apr-05	1.1			< 18	U		< 1	U		0.3		
				27-Jul-05	0.8			< 18	U		2	J		0.3		
71	R-28	1	946.2	20-May-05	38.1		J	< 18	U		4	J		3.1		
73	R-31	2	532.2	18-Mar-04	< 0.2	U		746			1760	E	J	< 0.01	U	
				17-Aug-05	0.3	J		628			1610			< 0.02	U	
77	R-32	1	870.9	21-Sep-04	5.7			< 13	U		11			0.8		J+
				15-Nov-04	5.7			< 13	U		6			0.9		
				22-Jun-05	5.7			< 18	U		3	J		0.7		
79	R-32	3	976.0	22-Sep-04	1.5			748			1610	E	J	< 0.004	J	UJ
				16-Nov-04	1.9			813			2000			< 0.003	U	R
				24-Jun-05	1.5		J	701			2060		J	< 0.02	U	
80	R-33	1	995.5	27-Jun-05	2.7			213			4	J		0.3		
81	R-33	2	1112.4	24-Jun-05	2.1		J	163			6			0.3		
82	R-34	1	895.15	7-Jun-05	2.5			< 18	U		43			0.3		

[a] Notes: (1) Data for these samples reside in the WQDB unless otherwise noted. (2) This table includes some data that have not been released to the public. Usually, these data have not been released because they were collected at a facility or on property that is not controlled or owned by LANL, and an external entity must approve the data for general release. (3) Yellow highlighting indicates data that fail at least one tier criterion.

[b] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.

[c] Codes: L—Laboratory Qualifier Code (assigned by the analytical laboratory); V—Validation Flag Code (assigned by LANL). These codes are defined in Table C-1.

[d] Analysis was conducted on a nonfiltered sample; no filtered sample data were available.

Appendix D

Comparison of Water-Quality Data against Tier 2 Criteria

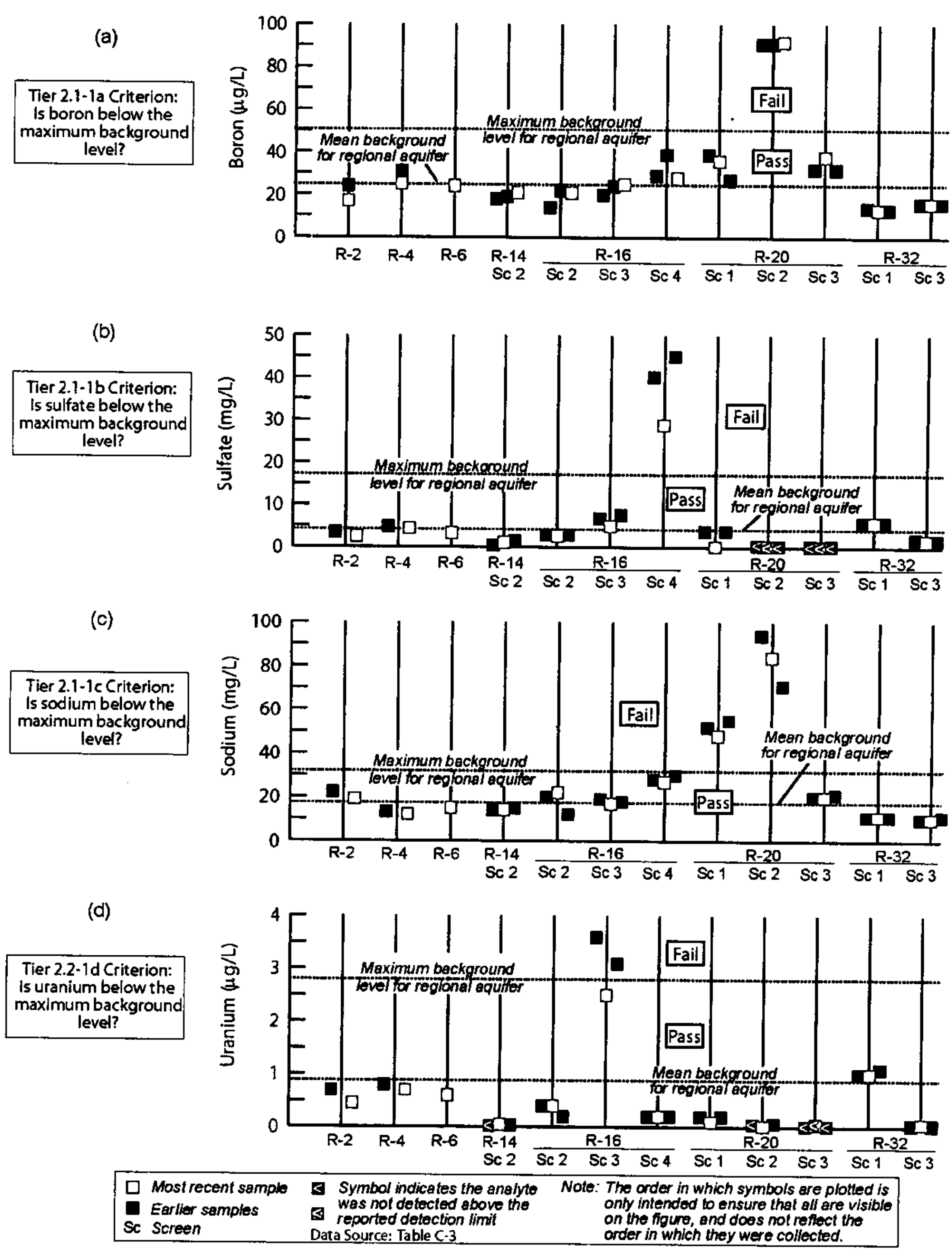


Figure D-1. **Comparison of water-quality data against tier criteria for removal of analytes leached from residual bentonite drilling mud: (a) Boron, (b) Sulfate, (c) Sodium, and (d) Uranium.**

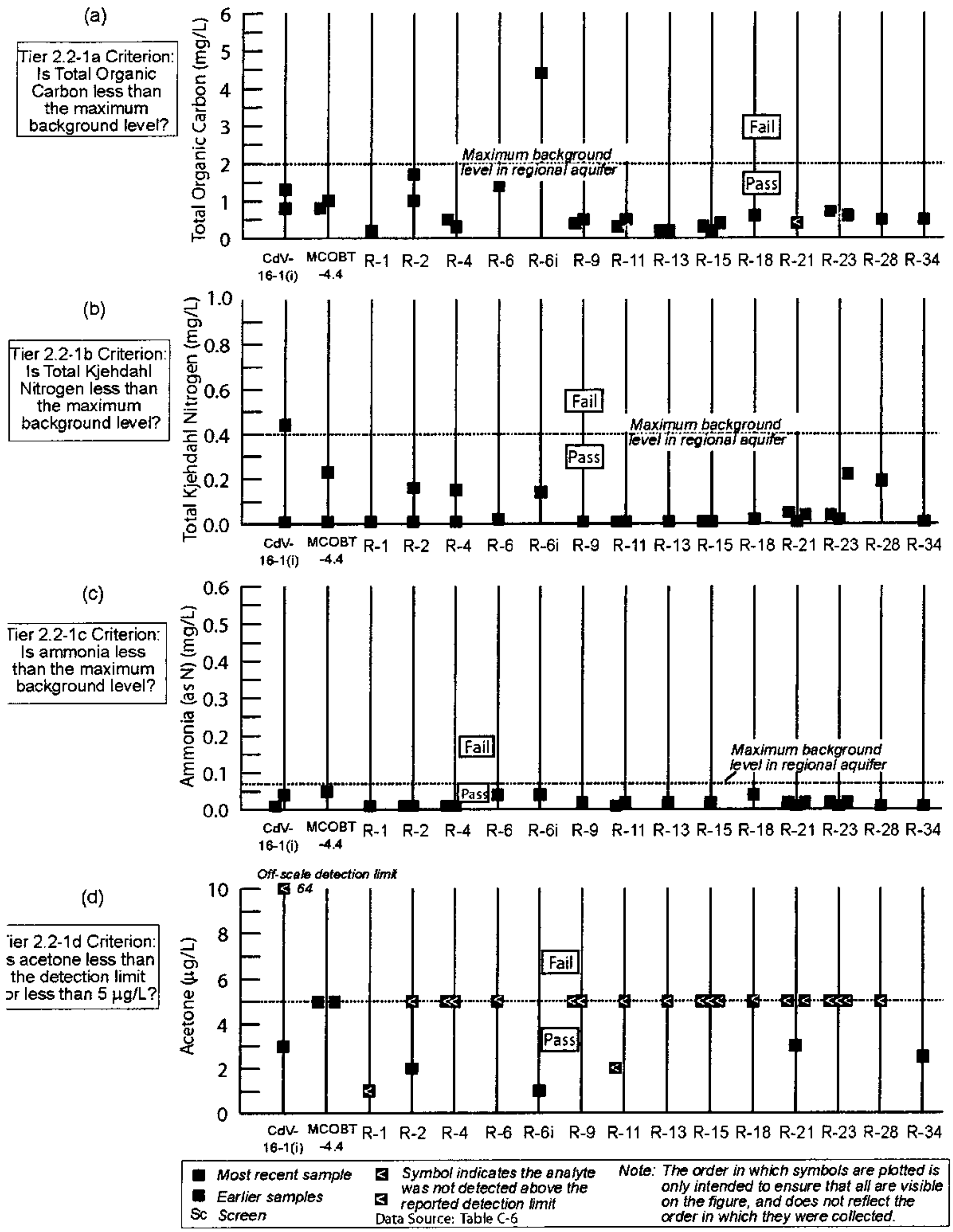


Figure D-2. Comparison of water-quality data against tier criteria for removal of residual organic drilling fluids in single-screen wells: (a) Total Organic Carbon, (b) Total Kjehdahl Nitrogen, (c) Ammonia, and (d) Acetone.

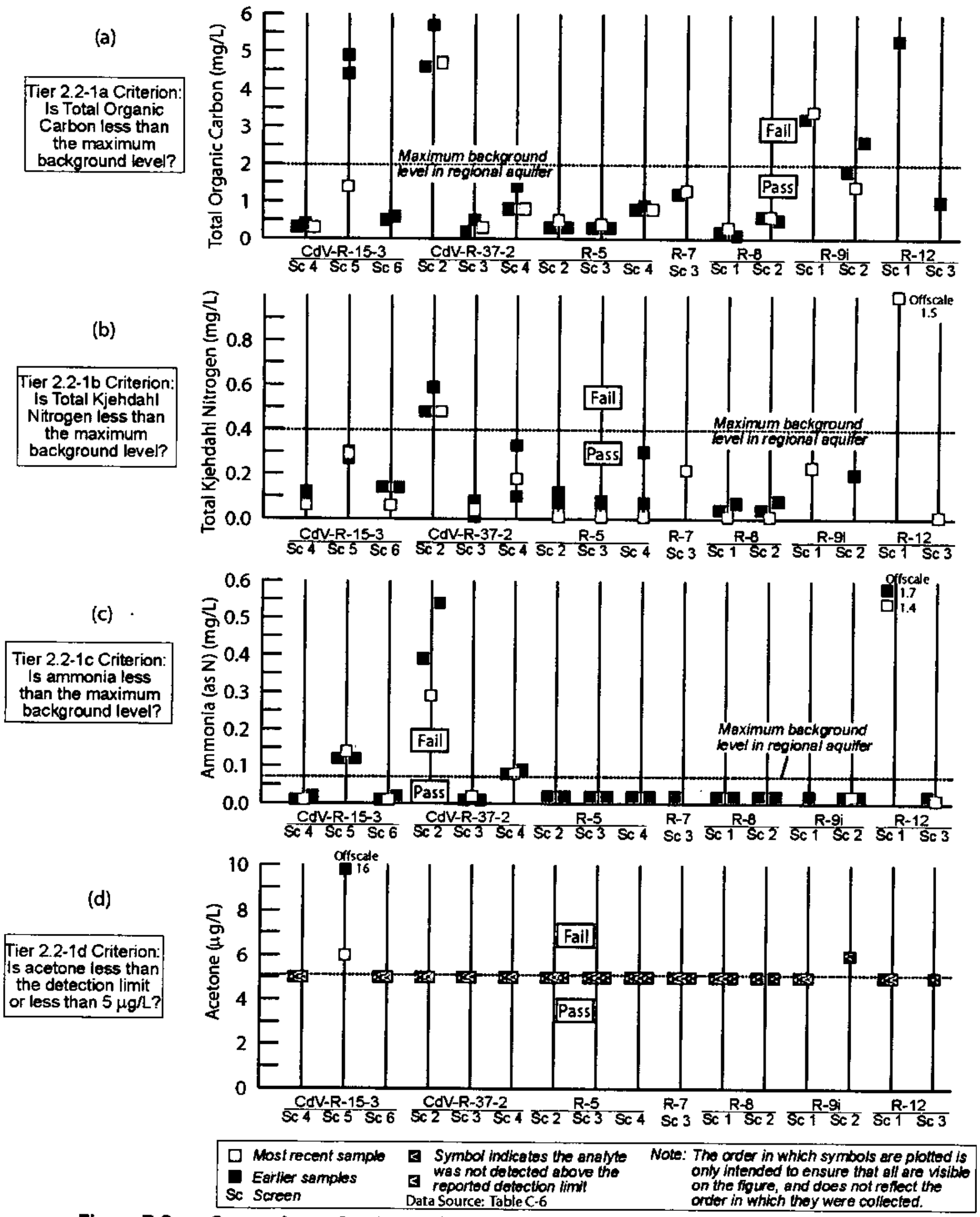


Figure D-3. **Comparison of water-quality data against tier criteria for removal of residual organic drilling fluids in multi-screen wells: (a) Total Organic Carbon, (b) Total Kjehdahl Nitrogen, (c) Ammonia, and (d) Acetone.**

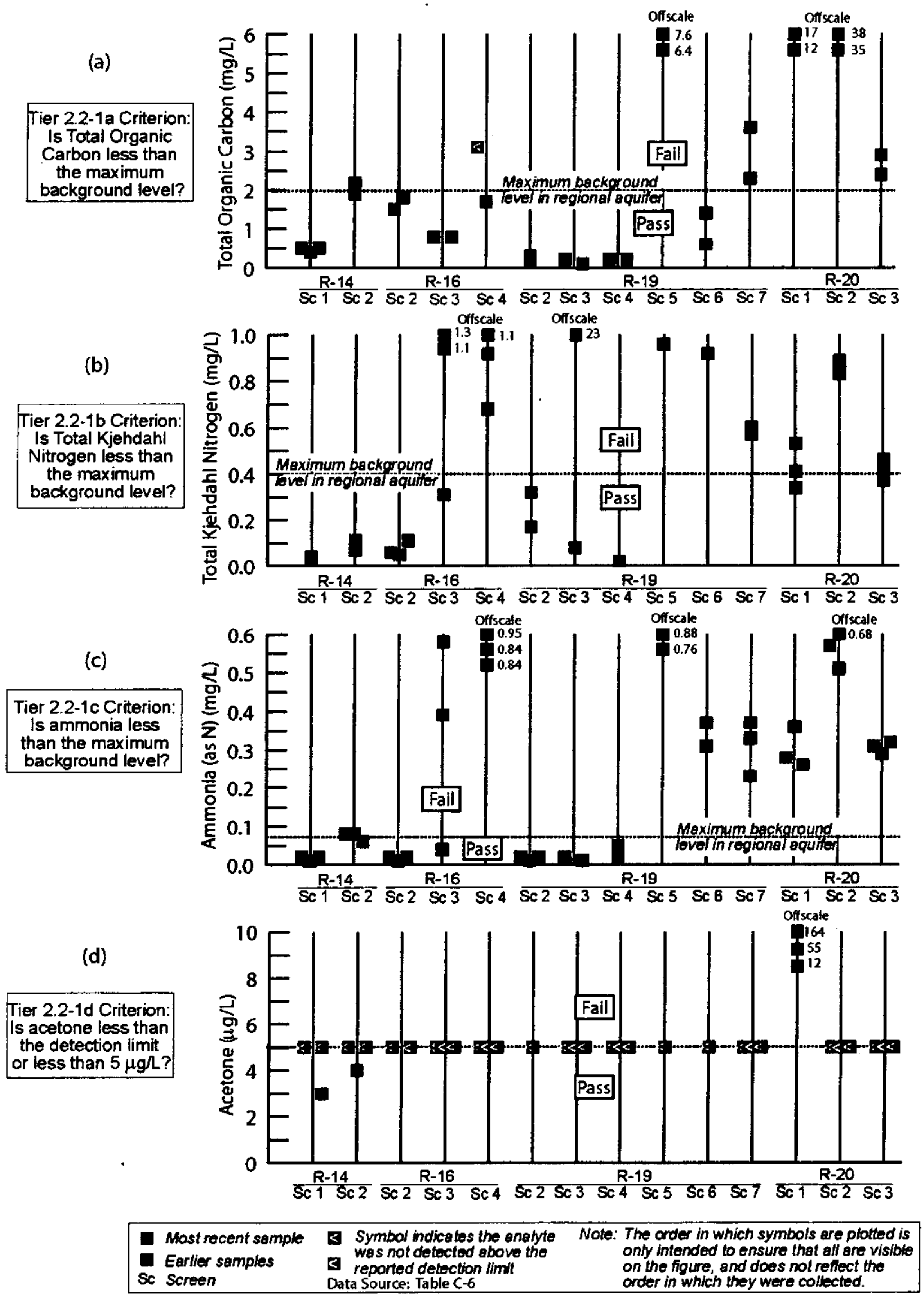


Figure D-3 (continued).

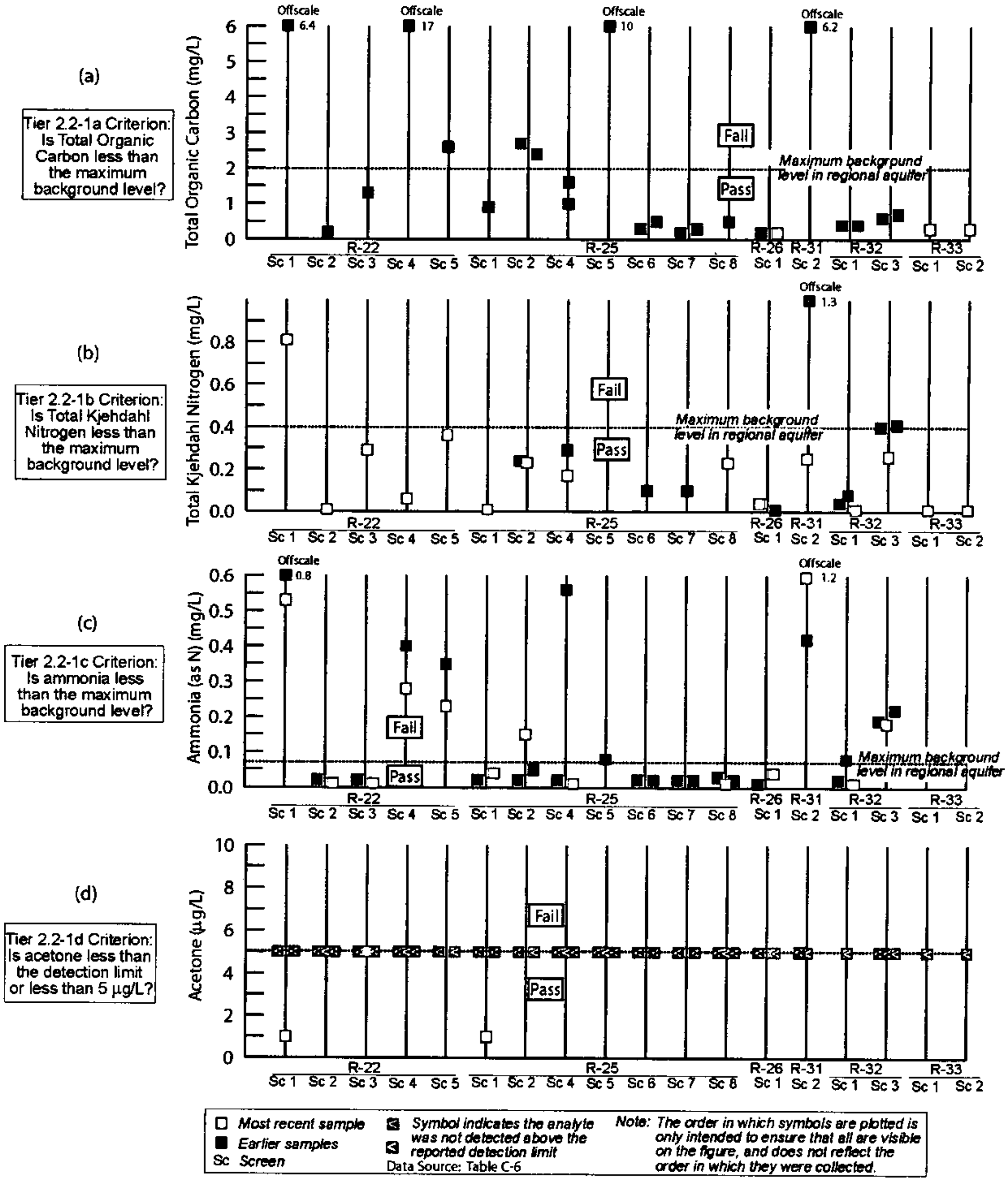


Figure D-3 (continued)

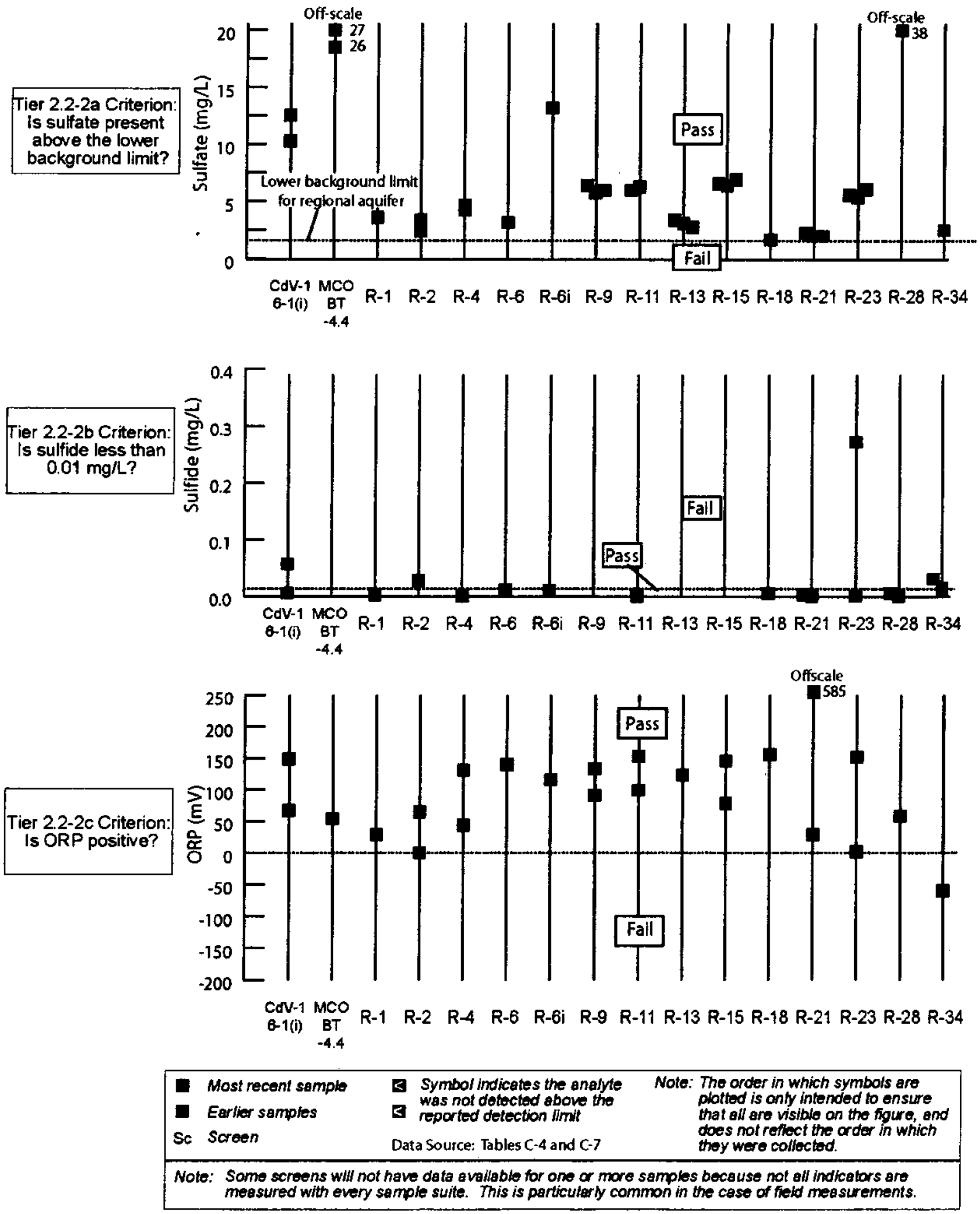


Figure D-4. Comparison of water-quality data against tier criteria for absence of sulfate-reducing conditions in single-screen wells: (a) Sulfate, (b) Sulfide, and (c) Oxygen Reduction Potential (ORP).

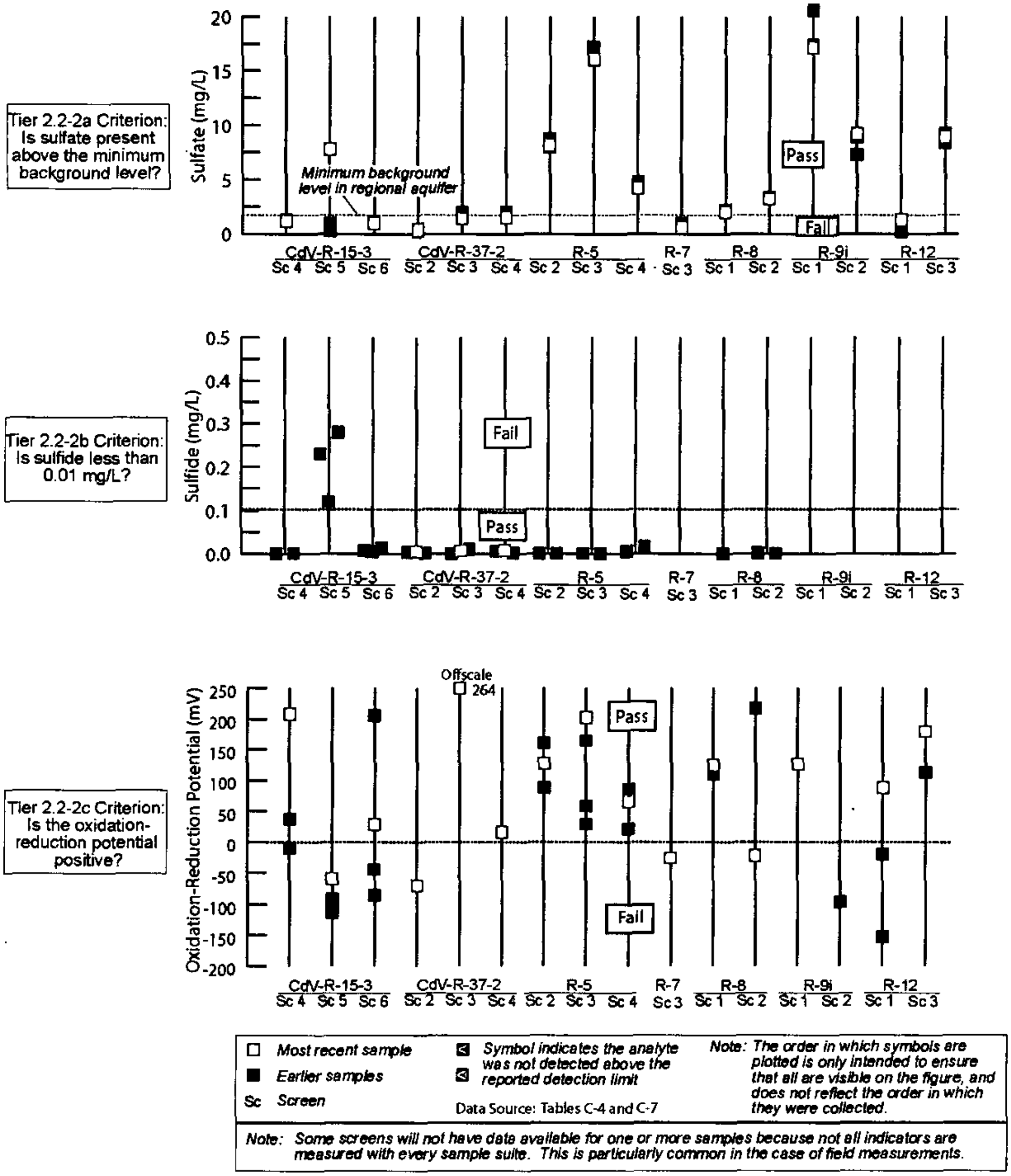


Figure D-6. Comparison of water-quality data against tier criteria for absence of sulfate-reducing conditions in multi-screen wells: (a) Sulfate, (b) Sulfide, and (c) Oxygen Reduction Potential.

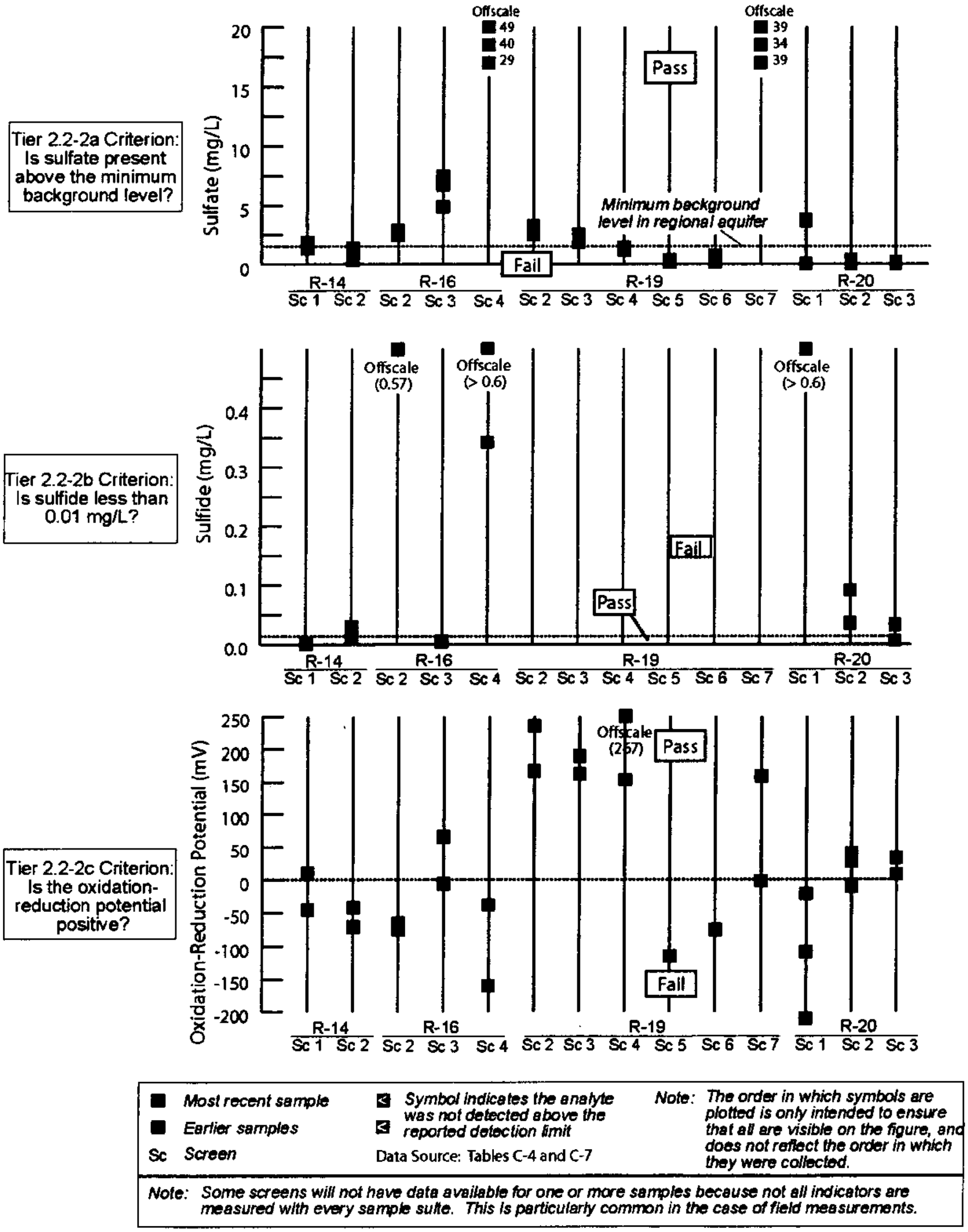
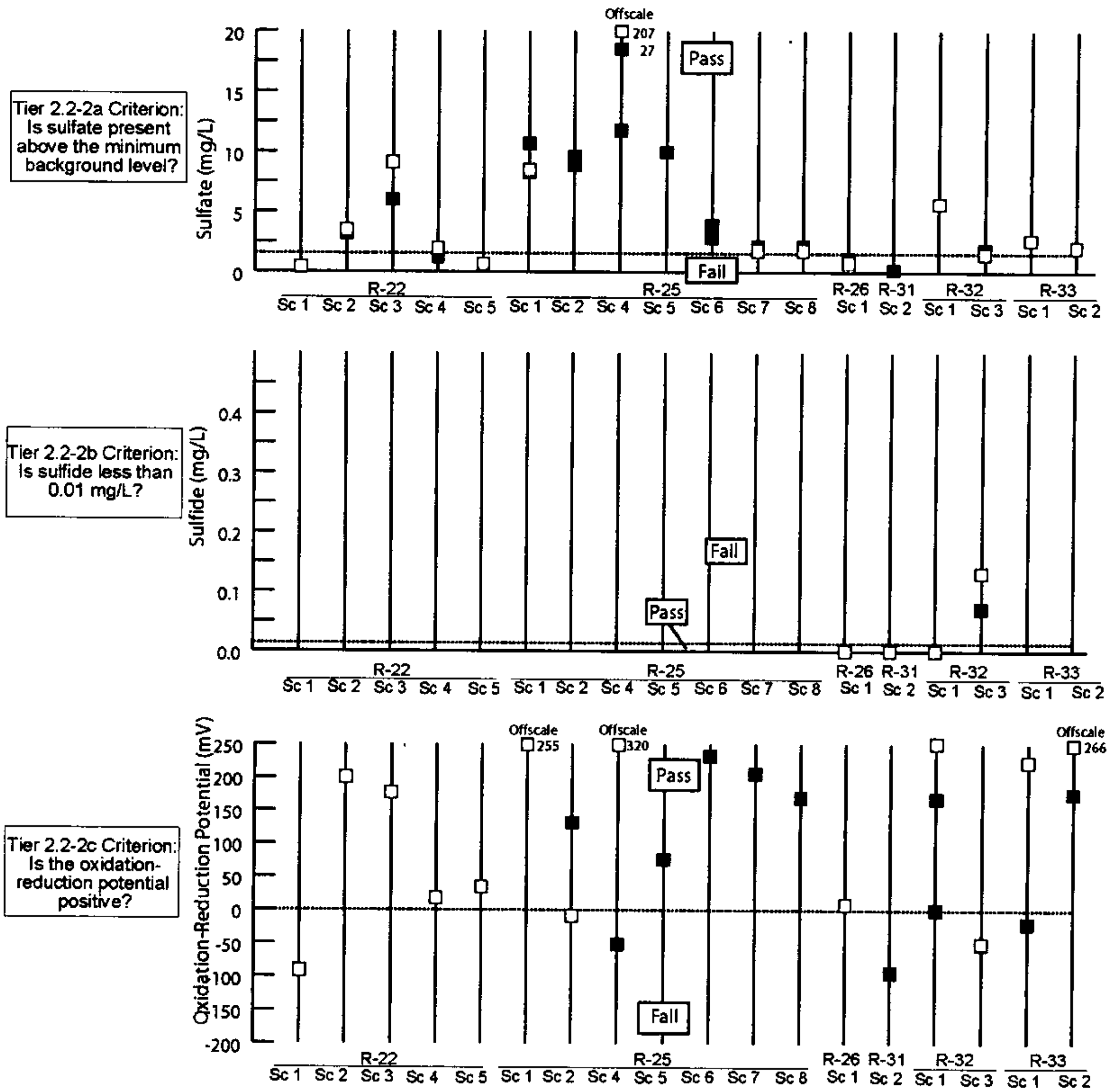


Figure D-5 (continued)



□ *Most recent sample* ■ *Earlier samples* Sc *Screen*	*Symbol indicates the analyte was not detected above the reported detection limit* Data Source: Tables C-4 and C-7	*Note: The order in which symbols are plotted is only intended to ensure that all are visible on the figure, and does not reflect the order in which they were collected.*

Note: Some screens will not have data available for one or more samples because not all indicators are measured with every sample suite. This is particularly common in the case of field measurements.

Figure D-5 (continued)

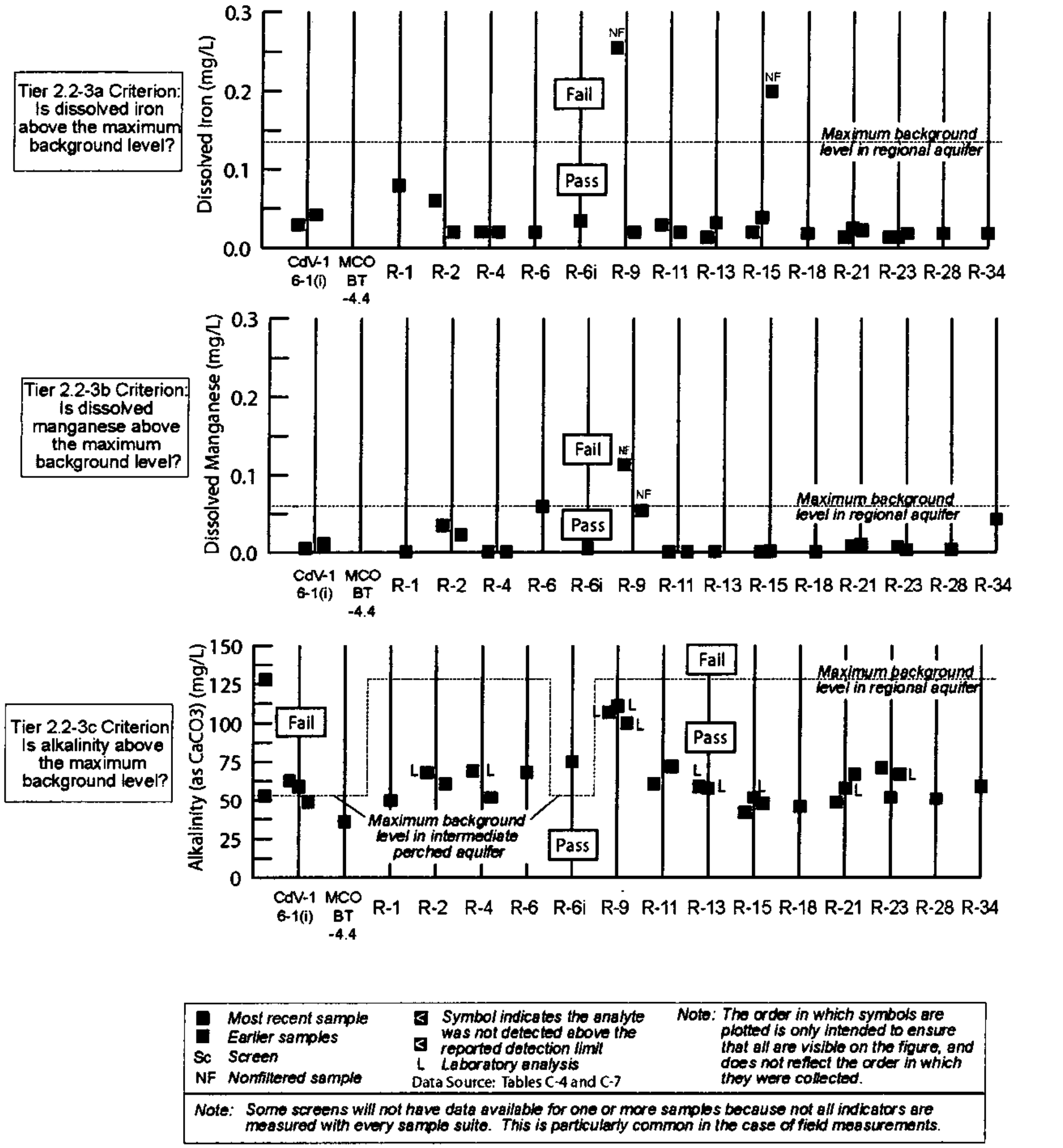


Figure D-6. Comparison of water-quality data against tier criteria for iron and manganese -reducing conditions in single-screen wells: (a) Iron, (b)Manganese, (c) Alkalinity, and (d) pH.

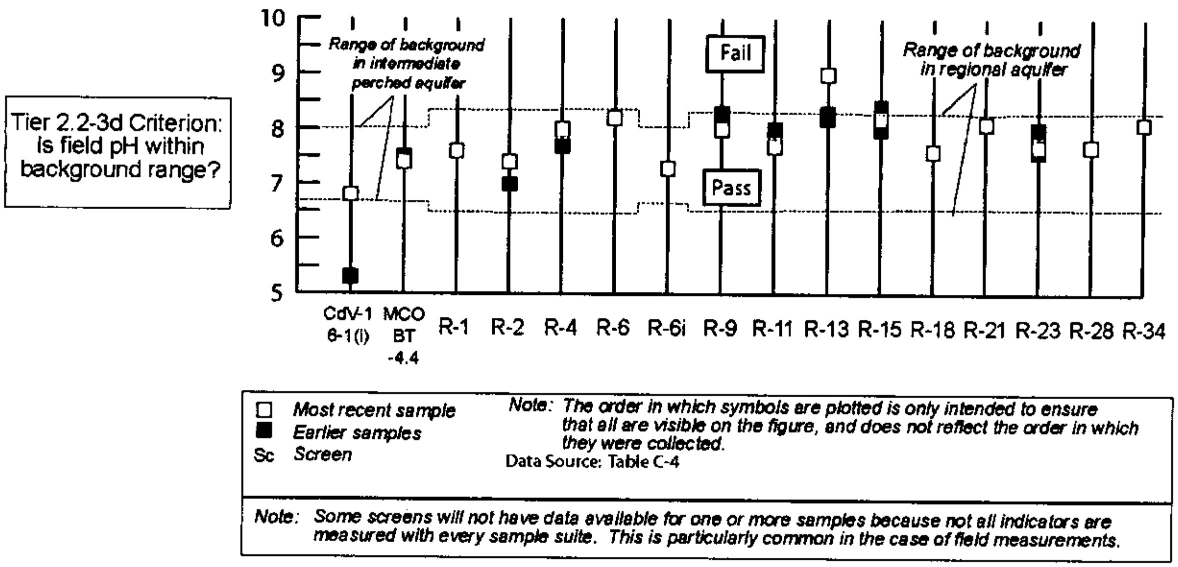


Figure D-6 (continued)

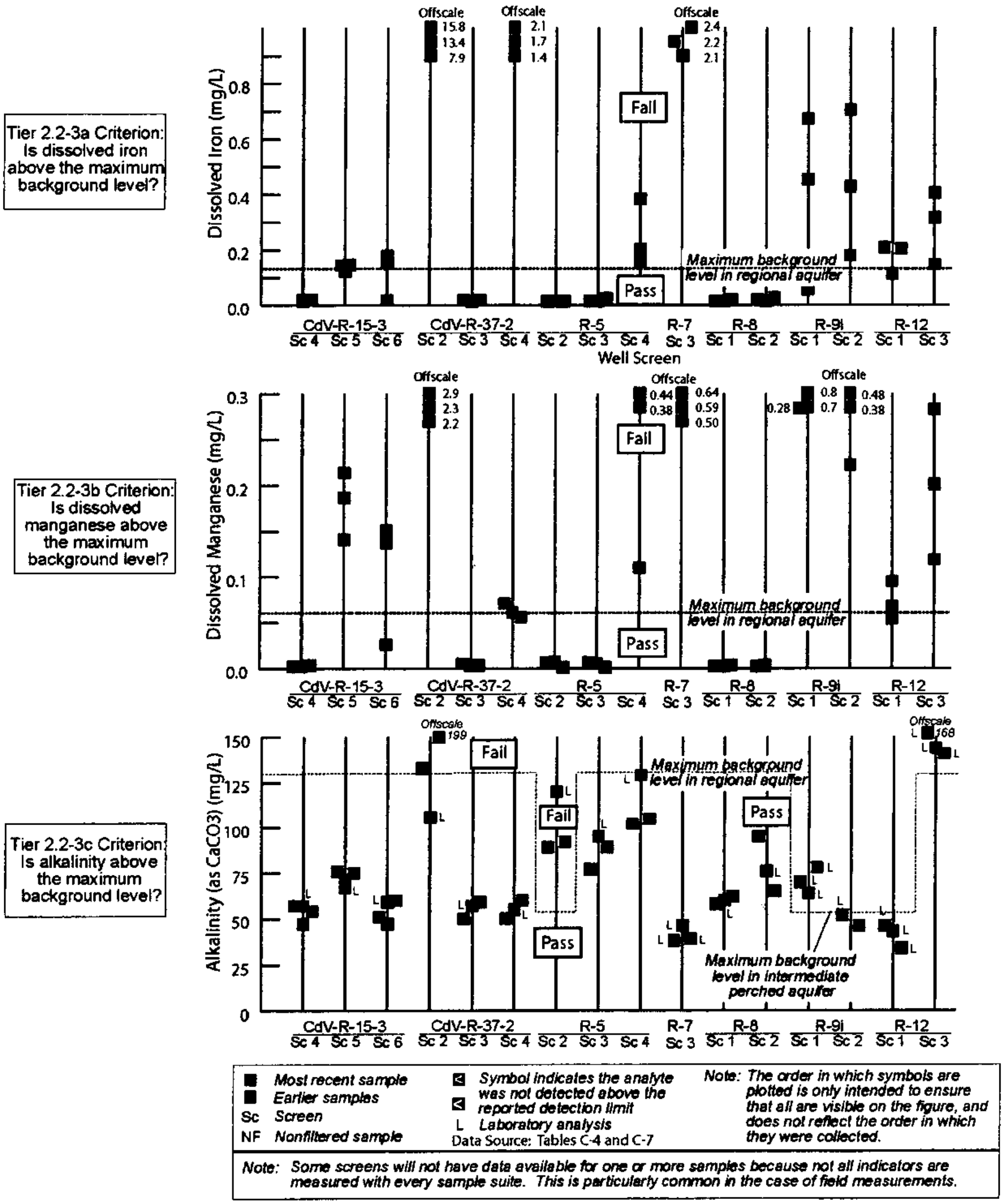


Figure D-7. Comparison of water-quality data against tier criteria for iron and manganese -reducing conditions in multi-screen wells: (a) Iron, (b)Manganese, (c) Alkalinity, and (d) pH.

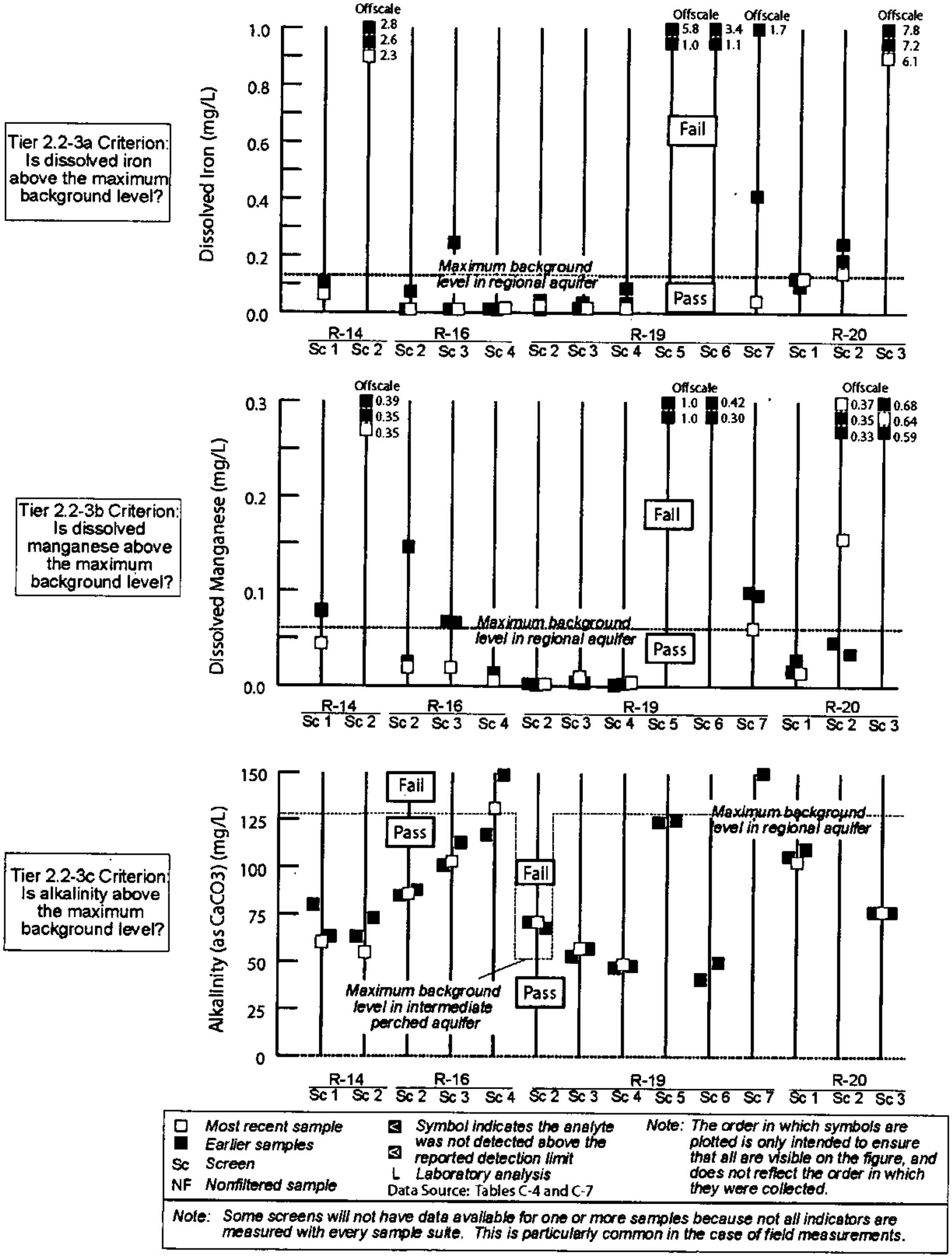


Figure D-7 (continued)

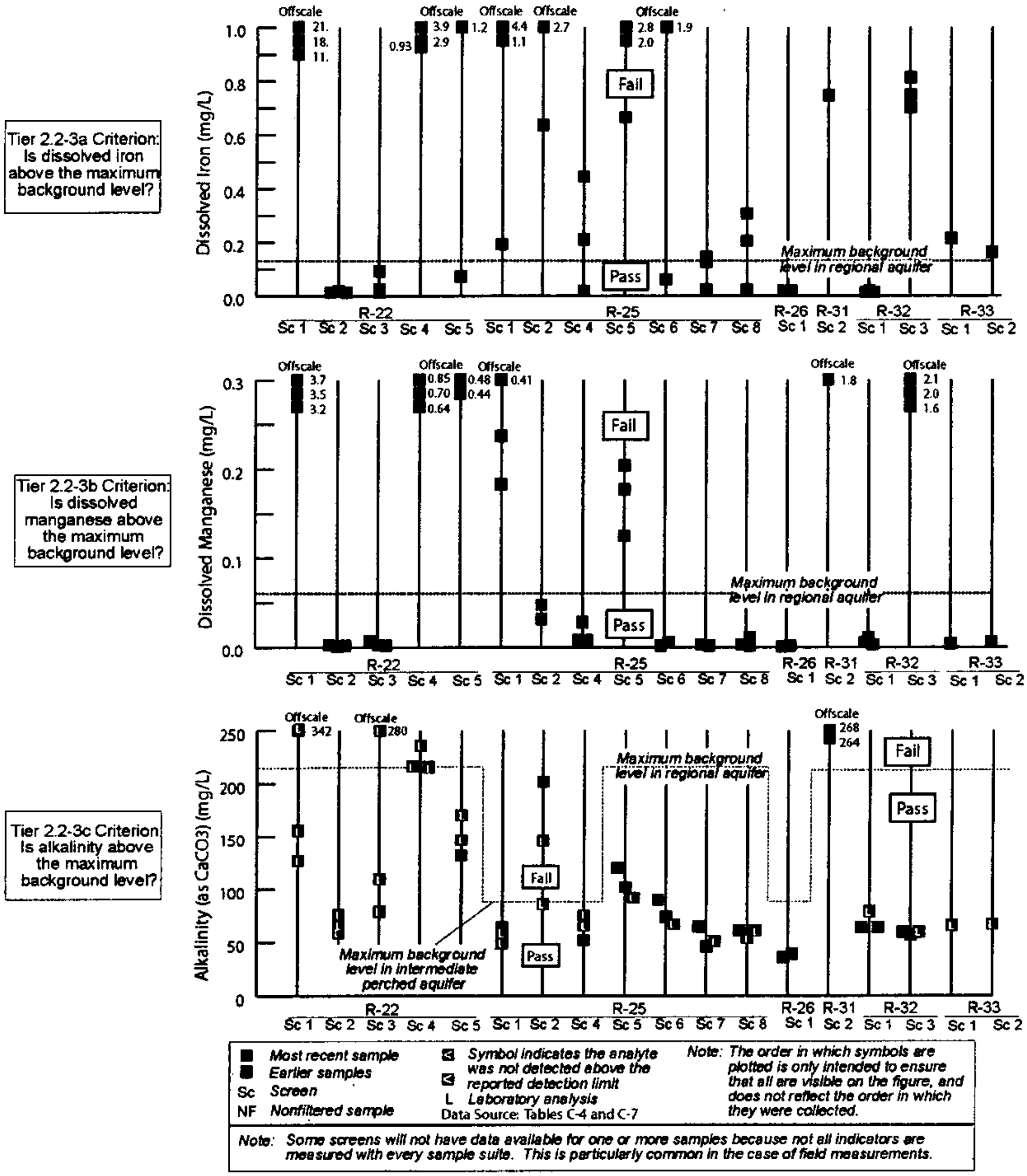


Figure D-7 (continued)

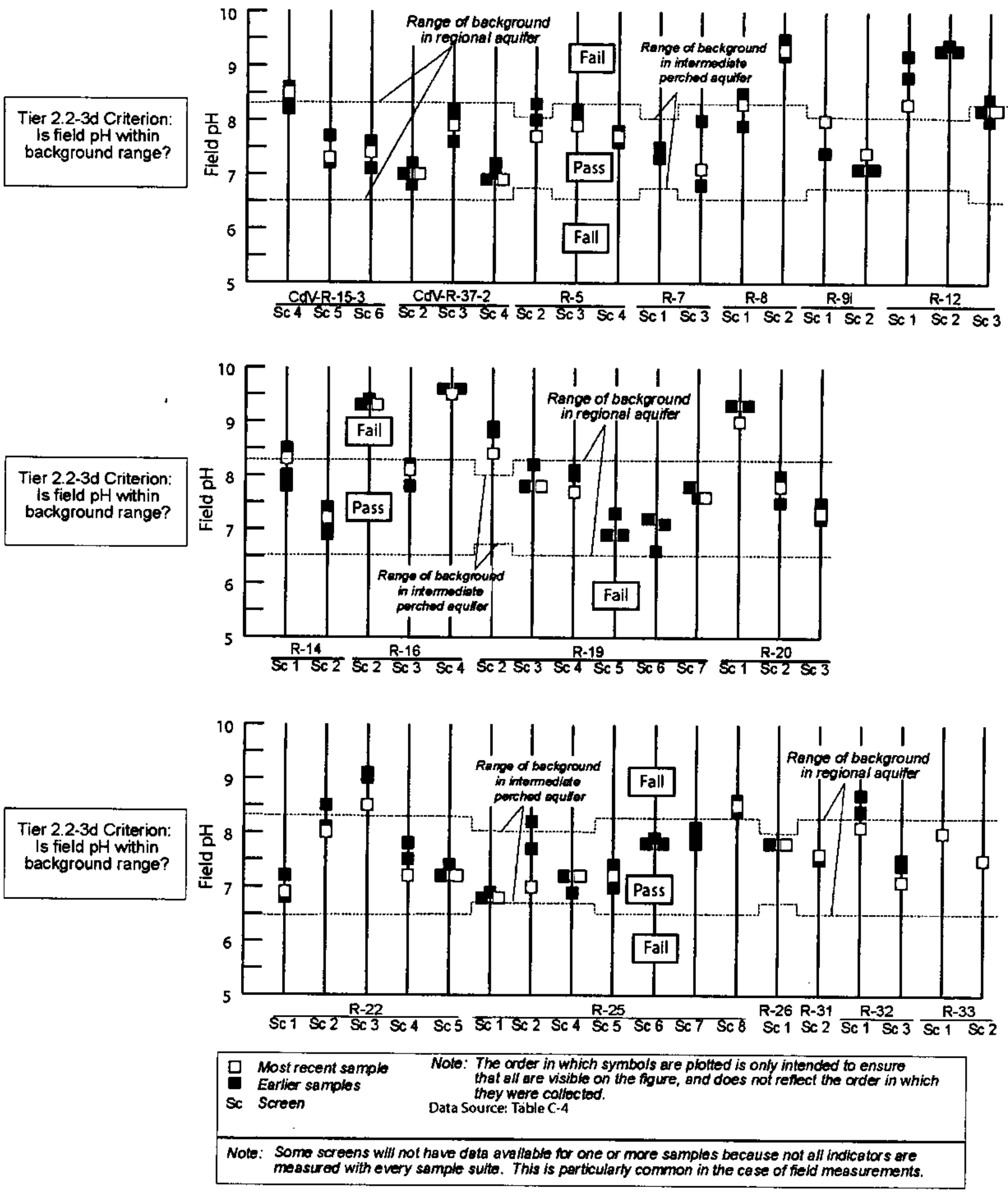


Figure D-7 (continued)

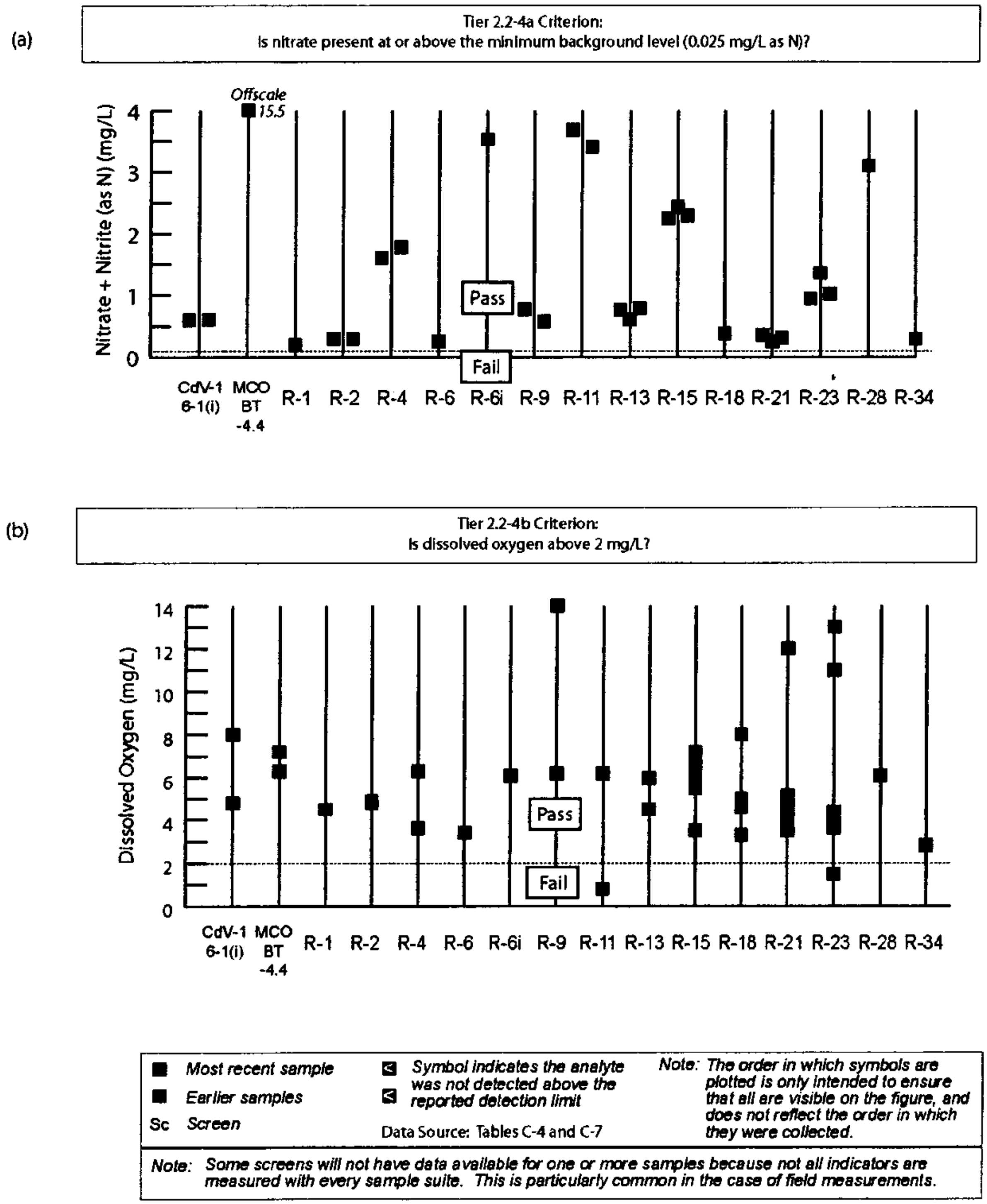


Figure D-8. **Comparison of water-quality data against tier criteria for nitrate-reducing conditions in single-screen wells: (a) Nitrate and (b) Dissolved Oxygen.**

(a)

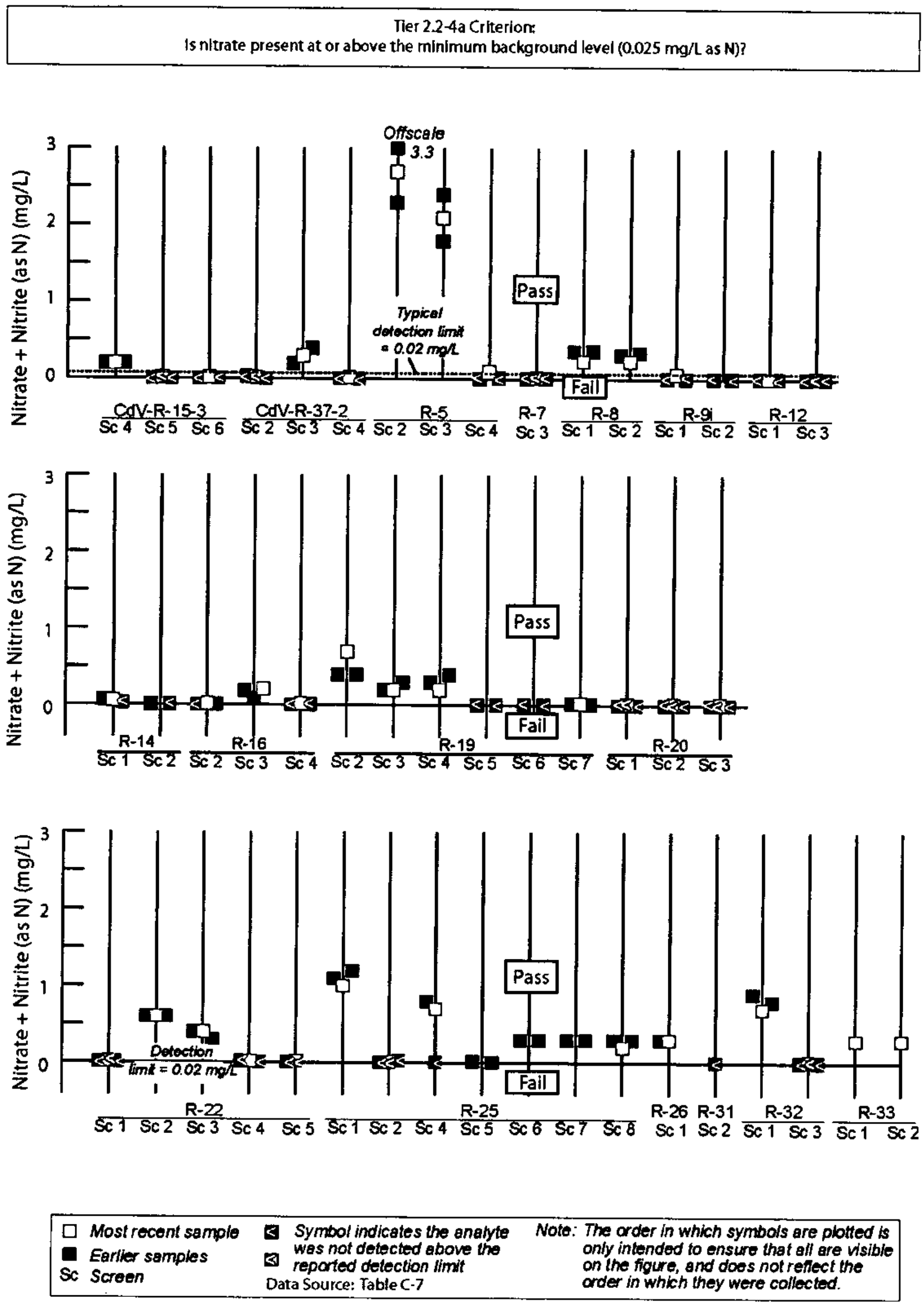


Figure D-9. Comparison of water-quality data against tier criteria for nitrate-reducing conditions in multi-screen wells: (a) Nitrate and (b) Dissolved Oxygen.

(b)

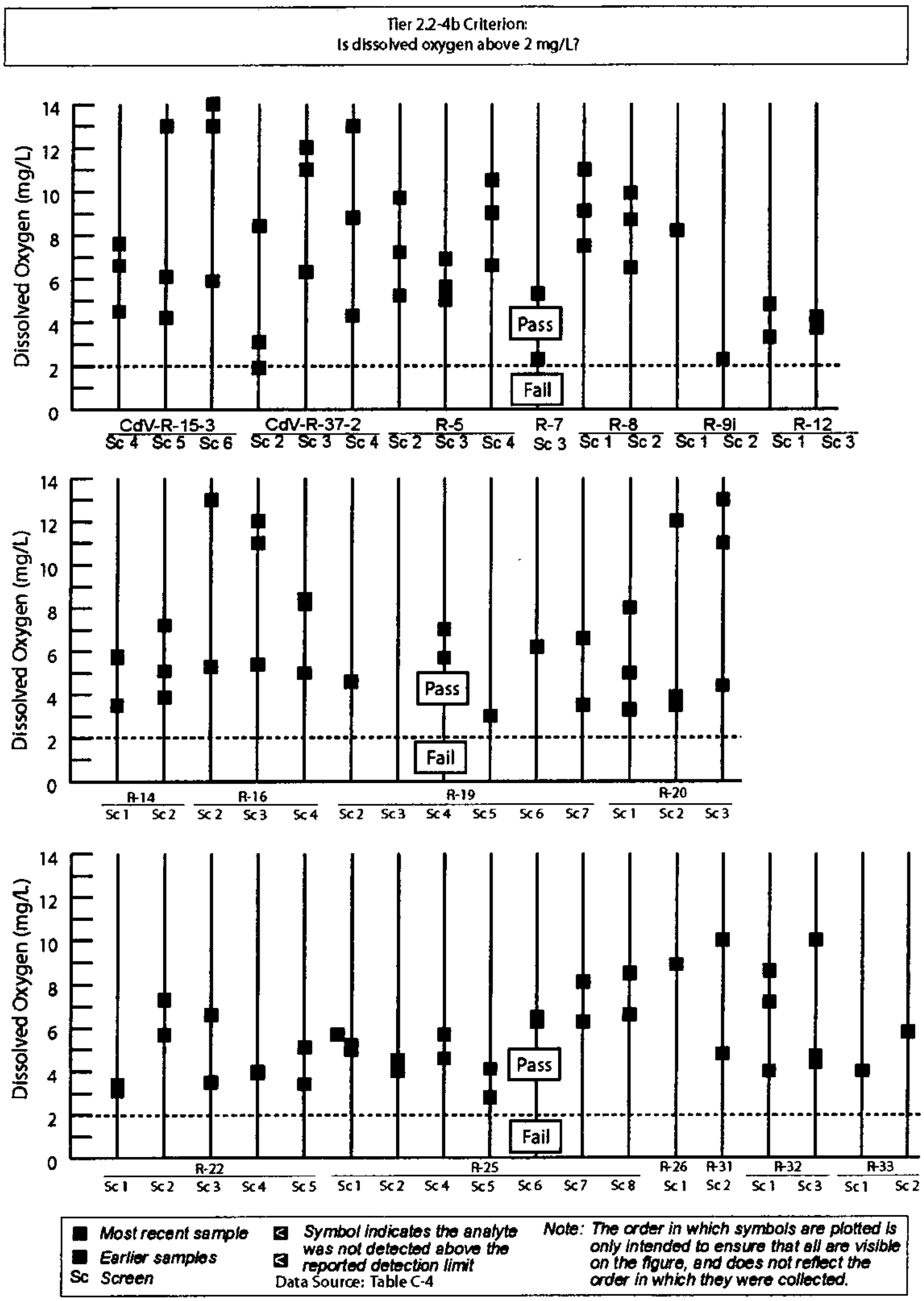


Figure D-9 (continued)

Appendix E

Screen Assessment Results

SCREEN ASSESSMENT RESULTS

Purpose of this Appendix

The tables in this appendix document the evaluation of water-quality data for each sampling event from each screen, against the applicable Tier 2 criteria. The final table (E-6) summarizes the detailed evaluation of each screen in terms of four ratings:

- an overall score expressing the percent of the applicable Tier 2 criteria which are met by the screen's water samples,
- classification of the screen with respect to its ability to provide reliable and representative water-quality samples (very good, good, fair, or poor),
- direction of trends in the screen's condition with respect to water-quality impacts of residual drilling fluids (stable, improving, worsening, variable, or indeterminate), and
- level of confidence in the outcome of the evaluation (high, moderate, or low).

Because each of the four rating is based on different considerations, any combination of them can occur. For example, one may have a high level of confidence concerning the poor condition of a screen, as well as a low level of confidence concerning the good condition of a screen. Conditions for each qualitative rating are defined explicitly under "Definitions of Qualitative Ratings" at the end of this section.

Overview of Contents

Tables E-1 to E-3 compare water-quality data against each of the applicable Tier 2 criteria. The outcome of the comparison determines which analytes in the screen's water samples are considered reliable and representative of groundwater conditions, and which analytes are flagged as potentially unreliable because of the effects of residual drilling fluids. The tables parallel the order in which the Tier 2 tests are applied, following the flow chart of the process in Figure 4-1: Table E-1 applies Tier 2.1 criteria for residual bentonite, Table E-2 applies Tier 2.2-1 criteria for the presence of residual organic drilling fluids, and Table E-3 applies Tier 2.2-2 criteria for indicators of oxidizing conditions.

Tables E-4 and E-5 express the outcome of the Tier 2 evaluation as an assessment score for each water-quality sample from each screen. The score is calculated as the percent of criteria met out of the total number of criteria tested for each sample. Criteria not met are listed for each sample. Table E-4 provides the scores for the 12 screen intervals drilled with bentonite mud (Tier 2.1), and Table E-5 provides the scores for the 64 screen intervals drilled with organic drilling fluids or additives (Tier 2.2).

Table E-6 summarizes the detailed evalution as described under "Purpose of this Appendix."

Data Sources

- Water-quality data are tabulated in Appendix C and plotted in Appendix D.
- Tier 2.1 criteria are presented in Table 4-5, and Tier 2.2 criteria are presented in Table 4-9.
- Tables 4-5 and 4-9 also indicate which analytes are considered as potentially not reliable, and are to be flagged, if a particular citerion is not met by a water sample.

Use of Output

These tables are the basis for the summary text and figures presented in the main report, particularly the following:

- Tier 2.1 outcomes in sections 4.4.3 and 6.2 and Figure 4-5;

- Tier 2.2 outcomes in section 4.5.3 and 6.2, and Figures 4-11 and 4-12; and
- overall Tier 2 outcomes in sections 5.6 and 6, Table 5-3, and Figures 6-1 through 6-5.

Definitions of Qualitative Ratings

Classification of the screen with respect to its ability to provide reliable and representative water-quality samples:

- Very good—more than 90% of the applicable criteria are met.
- Good—81 to 90% of the criteria are met.
- Fair—60 to 80% of the criteria are met.
- Poor—less than 60% of the criteria are met.

Characterization of the direction of water-quality trends in the screen's condition:

- Stable—water-quality impacts from residual drilling fluids neither diminish nor increase over the time spanned by the three sample events evaluated for the screen. The outcomes for each water-quality criterion do not vary significantly among the three events,
- Improving—impacts from residual drilling fluids have lessened over the period of time spanned by the three sample event. the outcome for the most recent sample event is significantly and consistently better than those for earlier events, for one or more criteria,
- worsening—water quality is degrading as the result of residual drillling fluids; the outcome for the most recent sample event is significantly and consistently worse than those for the earlier events, for one or more criteria,
- variable—comparison of the outcome of the evaluation for the most recent sample event to those for earlier events does not reveal a consistent trend, and
- indeterminate—the available data are inadequate for determining a trend.

Level of confidence in the outcome of the evaluation:

- High level of confidence—the outcome is based on three sample events that show consistent outcomes or trends, and for which the majority of data are available;
- Moderate level of confidence—one or more of the following conditions are present: (a) only two sample events are available, (b) the most recent sample was collected more than a year ago, (c) the reliability of the data for one criterion is in question, (d) field-based data provide the only indication of a worsening or improving trend, or (e) the outcomes of individual tests show minor inconsistencies with one another.
- Low level of confidence—only one sample event is available for evaluation, or several of the conditions listed above are present.

Table E-1
Summary of Tier 2.1 Assessment for Effects of Residual Bentonite Drilling Mud[a]

Screen ID	Well Screen	Port Depth (ft)	Tier 2.1-1 Indicators and Threshold Values[b]				Tier 2.1-2 Indicators and Threshold Values[b]			Overall Tier 2.1 Rating and (Level of Confidence)[c]	Applicable Validation Flag Codes[d] for Inorganic Analytes
			2.1-1a	2.1-1b	2.1-1c	2.1-1d	2.1-2a	2.1-2b	2.1-2c		
			B	SO_4	Na	U	Sr	U	Zn		
			< 51 µg/L	< 17 mg/L	< 31 mg/L	< 2.8 µg/L	> 42 µg/L	> 0.2 µg/L	> DL		
14	R-2 1	918	Y	Y	Y	Y	Y	Y	Y	Good (Moderate)	DB- for any nondetects of Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
15	R-4 1	804.5	Y	Y	Y	Y	Y	Y	Y	Good (Moderate)	DB- for any nondetects of Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
20	R-6 1	1217	Y	Y	Y	Y	Y	Y	Y	Good (Low)	DB- for any nondetects of Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
36	R-14 2	1289	Y	Y	Y	Y	Y	No[e]	Y	Good (High)	DB- for U, U-234/235/238 DB- for any nondetects of U-236, Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
39	R-16 2	866.1	Y	Y	Y	Y	Y	Y	No/Y	Good (High)	[f]DB- for Ag, Be, Cd, Cr, Cs, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Sb, Tl, Zn [f]DB- for Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147 DB- for any nondetects of Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
40	R-16 3	1018	Y	Y	Y	No/Y	Y	Y	Y	Good (High)	[f]DB+ for alkalinity, K, Mg, Na, Br, Cl, F, NO3, Total P, SO_4 [f]DB+ for As, Ba, B, Cr, Cu, Hg, Mn, Mo, Ni, Sb, Se, U, V, U-234/235/238 DB- for any nondetects of Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228

Table E-1 (continued)

Screen ID	Well Screen	Port Depth (ft)	Tier 2.1-1 Indicators and Threshold Values				Tier 2.1-2 Indicators and Threshold Values			Overall Tier 2.1 Rating and (Level of Confidence)	Applicable Validation Flag Codes for Inorganic Analytes
			2.1-1a	2.1-1b	2.1-1c	2.1-1d	2.1-2a	2.1-2b	2.1-2c		
			B	SO_4	Na	U	Sr	U	Zn		
			< 51 µg/L	< 17 mg/L	< 31 mg/L	< 2.8 µg/L	> 42 µg/L	> 0.2 µg/L	> DL		
41	R-16 4	1238	Y	No	Y	Y	Y	No[e]	No	Fair (High)	DB+ for detections of Alkalinity, K, Mg, Na, Br, Cl, F, NO_3, Total P, SO_4 DB+ for detections of As, Ba, B, Cr, Cu, Hg, Mn, Mo, Ni, Sb, Se, U, V DB- for Ag, Be, Cd, Cr, Cs, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Sb, Tl, Zn DB- for Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147 DB for U, U-234/235/238 DB- for nondetects of U-236, Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
50	R-20 1	907	Y	Y	No	Y	No	No[e]	No	Poor (Moderate)	DB+ for detections of Alkalinity, K, Mg, Na, Br, Cl, F, NO_3, Total P, SO4 DB+ for detections of As, Ba, B, Cr, Cu, Hg, Mn, Mo, Ni, Sb, Se, V DB for U, U-234/235/238 DB- for Ag, Be, Cd, Cr, Cs, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Sb, Tl, Zn DB- for Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147 DB- for Ca, Mo, V, Sr-90 DB- for nondetects of U-236, Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228

Table E-1 (continued)

Screen ID	Well Screen		Port Depth (ft)	Tier 2.1-1 Indicators and Threshold Values				Tier 2.1-2 Indicators and Threshold Values			Overall Tier 2.1 Rating and (Level of Confidence)	Applicable Validation Flag Codes for Inorganic Analytes
				2.1-1a	2.1-1b	2.1-1c	2.1-1d	2.1-2a	2.1-2b	2.1-2c		
				B	SO_4	Na	U	Sr	U	Zn		
				< 51 µg/L	< 17 mg/L	< 31 mg/L	< 2.8 µg/L	> 42 µg/L	> 0.2 µg/L	> DL		
51	R-20	2	1150	No	Y	No	Y	Y	No[e]	No	Poor (Moderate)	DB+ for detections of Alkalinity, K, Mg, Na, Br, Cl, F, NO_3, Total P, SO_4 DB+ for detections of As, Ba, B, Cr, Cu, Hg, Mn, Mo, Ni, Sb, Se, V DB for U, U-234/235/238 DB- for Ag, Be, Cd, Cr, Cs, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Sb, Tl, Zn DB- for Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147 DB- for any nondetects of U-236, Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
52	R-20	3	1330	Y	Y	Y	Y	Y	No[e]	No/Y	Fair (Moderate)	[f]DB- for Ag, Be, Cd, Cr, Cs, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Sb, Tl, Zn [f]DB- for Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147 DB- for U, U-234/235/238 DB- for any nondetects of U-236, Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
77	R-32	1	870.9	Y	Y	Y	Y	Y	Y	No/Y	Good (High)	[f]DB- for Ag, Be, Cd, Cr, Cs, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Sb, Tl, Zn [f]DB- for Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147 DB- for any nondetects of Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228
79	R-32	3	976	Y	Y	Y	Y	Y	No[e]	No/Y	Fair (High)	[f]DB- for Ag, Be, Cd, Cr, Cs, Co, Cu, Fe, Pb, Hg, Mn, Mo, Ni, Sb, Tl, Zn [f]DB- for Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147 DB- for U, U-234/235/238 DB- for any nondetects of U-236, Am-241, Ce-139/141/144, Pu-238/239/240, Ra-226/228

na = not available

n/a = not applicable

Y = Yes, criterion is met;

No = No, criterion is not met

No/Y = The most recent sample meets the criterion, but at least one of the earlier samples does not

DL = detection limit

[a] This assessment is based on data in Appendix Table C-3 and plotted in Appendix Figure D-1.

[b] Threshold values are those for the regional aquifer, in which all of these well screens are located.

[c] The level of confidence in the rating is indicated as low or moderate for one or more of the following reasons: (a) less than 3 samples are available, (b) some required data are not available for the assessment, (c) the most recent sample was collected over a year ago, or (d) reducing conditions are present and may be affecting concentrations of SO_4, U and/or Zn.

[d] Validation flag codes are defined in Table 4-3. The DB- flag is also applicable to all of the screens listed in this table, for those organic analytes which have a partition coefficient (K_d) greater than 1 mL/g, as indicated in Table 4-4.

[e] Reducing conditions may account for the low uranium concentrations in this well screen; see Tier 2.2 assessment results.

[f] This flag is not applicable to the most recent sample because it passed the corresponding criterion although at least one of the earlier samples did not pass.

Table E-2
Summary of Tier 2.2-1 Assessment for Removal of Residual Organic Drilling Fluids

Screen ID[a]	Well Screen		Port depth (ft)	Tier 2.2-1 Indicators and Threshold Values[b,c] (Responses below based on 3 samples)				Tier 2.2-1 Outcome for Most Recent Sample[d]	
				TOC	TKN	NH_3-N	Acetone		
				< 2 mg/L	< 0.4 mg/L	< 0.07 mg/L	< DL or < 5 µg/L	Pass/Fail	Applicable DO Validation Flag Codes[e]
1	CdV-16-1(i)	1	624	Y	N	Y	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
5	CdV-R-15-3	4	1254	Y	Y	Y	Y	Pass	—
6	CdV-R-15-3	5	1350	No/Y	Y	No	No	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
7	CdV-R-15-3	6	1640	Y	Y	Y	Y	Pass	—
9	CdV-R-37-2	2	1200	No	No	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
10	CdV-R-37-2	3	1359	Y	Y	Y	Y	Pass	—
11	CdV-R-37-2	4	1551	Y	Y	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
12	MCOBT-4.4	1	505	Y	Y	Y(P)	Y	Pass	Preliminary; no recent NH3-N data
13	R-1	1	1031	Y	Y	Y	Y	Pass	—
14	R-2	1	918	Y	Y	Y	Y	Pass	—
15	R-4	1	804.5	Y	Y	Y	Y	Pass	—
17	R-5	2	383.9	Y	Y	Y	Y	Pass	—
18	R-5	3	718.6	Y	Y	Y	Y	Pass	—
19	R-5	4	860.9	Y	Y	Y	Y	Pass	—
20	R-6	1	1217	Y	Y	Y	Y	Pass	Preliminary; only 1 sample
21	R-6i	1	607	Y(P)	Y	Y	Y	Pass	Preliminary; only 1 sample; high TOC due to contaminant plume
24	R-7	3	915.1	Y	Y(P)	Y	Y	Pass	—
25	R-8	1	711.1	Y	Y	Y	Y	Pass	—
26	R-8	2	825	Y	Y	Y	Y	Pass	—
27	R-9	1	684	Y	Y(P)	Y	Y(P)	Pass	—
28	R-9i	1	198.8	No	Y(P)	Y	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
29	R-9i	2	278.8	No/Y	Y	Y	Y	Pass	—
30	R-11	1	855	Y	Y	Y	Y	Pass	—
31	R-12	1	468.1	No	No	No	Y(P)	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone

Table E-2 (continued)

Screen ID	Well Screen		Port depth (ft)	Tier 2.2-1 Indicators and Threshold Values (Responses below based on 3 samples)				Tier 2.2-1 Outcome for Most Recent Sample	
				TOC	TKN	NH_3-N	Acetone		
				< 2 mg/L	< 0.4 mg/L	< 0.07 mg/L	< DL or < 5 µg/L	Pass/Fail	Applicable DO Validation Flag Codes
33	R-12	3	810.8	Y	Y(P)	Y	Y(P)	Pass	—
34	R-13	1	958.3	Y	Y(P)	Y	Y(P)	Pass	—
35	R-14	1	1205	Y	Y	Y	Y	Pass	—
36	R-14	2	1289	No	Y	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
37	R-15	1	958.6	Y	Y(P)	Y	Y	Pass	—
39	R-16	2	866.1	Y	Y	Y	Y(P)	Pass	Preliminary; no recent TOC data
40	R-16	3	1018	Y	No/Y	No/Y	Y	Pass	—
41	R-16	4	1238	Y(P)	No	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
42	R-18	1	1358	Y	Y	Y	Y	Pass	Preliminary: only 1 sample
44	R-19	2	909.3	Y	Y	Y	Y	Pass	—
45	R-19	3	1191	Y	No	Y	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
46	R-19	4	1413	Y	Y	Y	Y	Pass	—
47	R-19	5	1586	No	No	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
48	R-19	6	1730	No/Y	No	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
49	R-19	7	1835	No	No	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
50	R-20	1	907	No	No	No	No	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
51	R-20	2	1150	No	No	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
52	R-20	3	1330	No	No/Y	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
53	R-21	1	888.8	Y	Y	Y	Y	Pass	—
54	R-22	1	907.1	No	No	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
55	R-22	2	962.8	Y	Y(P)	Y	Y	Pass	—
56	R-22	3	1274	Y	Y(P)	Y	Y	Pass	—
57	R-22	4	1378	No	Y(P)	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
58	R-22	5	1448	No	Y(P)	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
59	R-23	1	816	Y	Y	Y	Y	Pass	—
60	R-25	1	754.8	Y	Y(P)	Y	Y	Pass	—
61	R-25	2	891.8	No	Y	No	No/Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone

Table E-2 (continued)

Screen ID	Well Screen		Port depth (ft)	Tier 2.2-1 Indicators and Threshold Values (Responses below based on 3 samples)				Tier 2.2-1 Outcome for Most Recent Sample	
				TOC	TKN	NH_3-N	Acetone		
				< 2 mg/L	< 0.4 mg/L	< 0.07 mg/L	< DL or < 5 µg/L	Pass/Fail	Applicable DO Validation Flag Codes
63	R-25	4	1192	Y	Y	No/Y	Y	Pass	—
64	R-25	5	1303	No	na	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone Preliminary; no recent TOC, TKN, NH4 data
65	R-25	6	1406	Y	Y	Y	Y	Pass	—
66	R-25	7	1606	Y	Y	Y	Y	Pass	—
67	R-25	8	1796	Y	Y(P)	Y	Y	Pass	—
69	R-26	1	659.3	Y	Y	Y	Y	Pass	—
71	R-28	1	946.2	Y	Y	Y	Y	Pass	—
73	R-31	2	532.2	No	No/Y	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
77	R-32	1	870.9	Y	Y	No/Y	Y	Pass	—
79	R-32	3	976	Y	No/Y	No	Y	Fail	DO+ for detected DOC, TOC, TKN, NH3-N, acetone
80	R-33	1	995.5	Y	Y	na	Y	Pass	Preliminary; only 1 sample; some data not available
81	R-33	2	1112.4	Y	Y	na	Y	Pass	Preliminary; only 1 sample; some data not available
82	R-34	1	895.2	Y	Y	Y	Y	Pass	Preliminary; only 1 sample available

na data not available; — no analyte flags are applicable

Y = Yes, criterion is met

Y(P) = Yes criterion is met but outcome is considered preliminary[d]

No = No, criterion is not met

No/Y = The most recent sample meets the criterion, but at least one of the earlier samples does not

DL = detection limit

DO+ = Flag indicating that some of the listed analyte concentrations may be elevated above that in predrilling groundwater due to presence of residual organic drilling fluids

[a] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.

[b] Assessment is based on data in Appendix Table C-6 and plotted in Appendix Figure D-2 and D-3

[c] The indicator species used for the Tier 2.2-1 assessment are often not analyzed for surveillance sampling rounds, particularly if no elevated levels have been detected in the well screen in an earlier round. These species generally decrease with time to background levels. Consequently, once a screen has passed a given criterion, it is assumed that it will continue to pass even though no data are available for the parameter for the most recent sample. [This assumption is not used for any other tier issues.]

[d] An outcome is considered preliminary for one or more of the following reasons: (a) less than 3 samples are available, (b) some required data are not available for the assessment, (c) the most recent sample was collected over a year ago and water-quality conditions may have changed since then, or (d) the data are inconsistent with other indicator species.

[e] DO—Flag indicating presence of residual organic drilling fluids. Validation flag codes are defined in Table 4-3.

Table E-3
Summary of Tier 2.2-2 to 2.2-4 Assessment of Redox Conditions

Screen ID[a]	Well Screen	Port Depth (ft)	Tier 2.2 Indicators and Threshold Values[b] (Responses below based on 3 samples): 2.2-2a SO_4 (SO_4>1.8 mg/L; S<0.01 mg/L; ORP >0)	2.2-3a pH (8.3>pH > 6.5)	2.2-3b Fe (<130 µg/L)	2.2-3c Mn (< 60 µg/L)	2.2-3d Alk as $CaCO_3$ (<128 mg/L)	2.2-4 NO_3 (NO_3 >0.025 mg/L; DO>2 mg/L)	Tier 2.2-2 to 2.2-4 Outcome for Most Recent Sample[c]: Pass/Fail and Redox Condition	DR Validation Flag Codes Applicable to Affected Analytes[d]
1	CdV-16-1(i) 1	624	No/Y	No/Y	Y	Y	No/Y [e]	Y	Pass / Oxidizing	Preliminary: only 2 samples DR flags are not applicable for oxidizing conditions
5	CdV-R-15-3 4	1254	No	No	Y	Y	Y	No/Y	Fail / Reducing low SO_4, high pH	DR for analytes affected by SO_4-reducing conditions Preliminary: may need to re-assess background range of indicator species
6	CdV-R-15-3 5	1350	No	Y	No/Y	No	Y	No	Fail / Reducing SO_4, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
7	CdV-R-15-3 6	1640	No/Y	Y	No	No	Y	No/Y	Fail / Reducing Fe, Mn	DR for analytes affected by Fe/Mn-reducing conditions
9	CdV-R-37-2 2	1200	No	Y	No	No	No/Y	No	Fail / Reducing SO_4, Fe, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
10	CdV-R-37-2 3	1359	No	Y	Y	Y	Y	Y	Fail / Reducing Low SO_4	DR for analytes affected by SO_4-reducing conditions Preliminary: may need to re-assess background range of indicator species
11	CdV-R-37-2 4	1551	No	Y	No	No/Y	Y	No	Fail / Reducing SO_4, Fe, NO_3	DR for analytes affected by SO_4-reducing conditions
12	MCOBT-4.4 1	505	Y(P)	Y	Y	Y	Y (P) [e]	Y	Pass/Oxidizing	DR flags are not applicable for oxidizing conditions Preliminary: only 2 samples
13	R-1 1	1031	Y	Y	Y	Y	Y	Y	Pass/Oxidizing	DR flags are not applicable for oxidizing conditions Preliminary: only 2 samples
14	R-2 1	918	No	Y	Y	Y	Y	Y	Fail / Reducing SO_4, pH	DR for analytes affected by SO_4-reducing conditions Preliminary: only 2 samples

Table E-3 (continued)

Screen ID	Well Screen	Port Depth (ft)	Tier 2.2 Indicators and Threshold Values (Responses below based on 3 samples)						Tier 2.2-2 to 2.2-4 Outcome for Most Recent Sample	
			2.2-2a SO_4	2.2-3a pH	2.2-3b Fe	2.2-3c Mn	2.2-3d Alk as $CaCO_3$	2.2-4 NO_3		
			SO_4>1.8 mg/L; S<0.01 mg/L; ORP >0	8.3>pH > 6.5	<130 µg/L	< 60 µg/L	<128 mg/L	NO_3 >0.025 mg/L; DO>2 mg/L	Pass/Fail	Applicable DR Validation Flag Codes
15	R-4 1	804.5	Y	Y	Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions Preliminary: only 2 samples
17	R-5 2	383.9	Y	No/Y	Y	Y	No	Y	Fail / Reducing Alk	DR for analytes affected by Fe/Mn-reducing conditions
18	R-5 3	718.6	Y	Y	Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
19	R-5 4	860.9	Y	Y	No (NF)	No (NF)	No[L]	No/Y	Fail / Reducing Fe, Mn, Alk	DR for analytes affected by Fe/Mn-reducing conditions Preliminary: nonfiltered samples and lab alkalinity
20	R-6 1	1217	No	Y	Y	No	Y(P)	Y	Fail / Reducing SO_4, Mn	DR for analytes affected by SO_4-reducing conditions Preliminary: only 1 sample
21	R-6i 1	607	No	Y	Y	Y	No	Y	Fail / Reducing SO_4, Alk	DR for analytes affected by SO_4-reducing conditions Preliminary: only 1 sample
24	R-7 3	915.1	No	Y	No	No (NF)	—	No	Fail / Reducing SO_4, Fe, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
25	R-8 1	711.1	Y	No/Y	Y	Y	Y(P)	Y(P)	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
26	R-8 2	825	No	No	Y	Y	Y(P)	Y	Fail / Reducing SO_4, pH	DR for analytes affected by SO_4-reducing conditions
27	R-9 1	684	Y	Y	No/Y	No/Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
28	R-9i 1	198.8	Y	Y(P)	No/Y	No (NF)	No	Y	Fail / Reducing Mn, Alk	DR for analytes affected by Fe/Mn-reducing conditions Preliminary: nonfiltered sample; no field alkalinity
29	R-9i 2	278.8	No/Y	Y(P)	No/Y (NF)	No (NF)	No[a,L]	No	Fail / Reducing Mn, Alk, NO_3	DR for analytes affected by Fe/Mn-reducing conditions Preliminary: nonfiltered sample; no recent field alkalinity

Table E-3 (continued)

Screen ID	Well Screen		Port Depth (ft)	Tier 2.2 Indicators and Threshold Values (Responses below based on 3 samples)						Tier 2.2-2 to 2.2-4 Outcome for Most Recent Sample	
				2.2-2a SO_4	2.2-3a pH	2.2-3b Fe	2.2-3c Mn	2.2-3d Alk as $CaCO_3$	2.2-4 NO_3		
				SO_4>1.8 mg/L; S<0.01 mg/L; ORP >0	8.3>pH > 6.5	<130 µg/L	< 60 µg/L	<128 mg/L	NO_3 >0.025 mg/L; DO>2 mg/L	Pass/Fail	Applicable DR Validation Flag Codes
30	R-11	1	855	Y	Y	Y	Y	Y	No	Fail / Reducing NO_3 (low DO)	DR for analytes affected by NO_3-reducing conditions Preliminary
31	R-12	1	468.1	No	No	No/Y	No/Y	Y	No	Fail / Reducing SO_4, pH, NO_3	DR for analytes affected by SO_4-reducing conditions
33	R-12	3	810.8	Y	No/Y	No	No	No	No	Fail / Reducing Fe, Mn, Alk, NO_3	DR for analytes affected by Fe/Mn-reducing conditions
34	R-13	1	958.3	Y	No	Y(P)	Y	na	Y	Fail / Reducing pH	DR for analytes affected by Fe/Mn-reducing conditions
35	R-14	1	1205	No	No/Y	Y	No/Y	Y	No/Y	Fail / Reducing SO_4	DR for analytes affected by SO_4-reducing conditions
36	R-14	2	1289	No	Y	No	No	Y	No	Fail / Reducing SO_4, Fe, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
37	R-15	1	958.6	Y	Y	No/Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
39	R-16	2	866.1	No	No	Y	No/Y	Y	No	Fail / Reducing pH, NO_3	DR for analytes affected by Fe/Mn-reducing conditions
40	R-16	3	1018	No	Y	No/Y	No/Y	Y	Y	Fail / Reducing SO_4	DR for analytes affected by SO_4-reducing conditions
41	R-16	4	1238	No	No	Y	Y	No	No	Fail / Reducing SO_4, pH, Alk, NO_3	DR for analytes affected by SO_4-reducing conditions
42	R-18	1	1358	Y	Y	Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
44	R-19	2	909.3	Y	No	Y	Y	No	Y	Fail / Reduced pH, Alk	DR for analytes affected by Fe/Mn-reducing conditions
45	R-19	3	1191	No	Y	Y	Y	Y	Y	Fail / Reducing SO_4	DR for analytes affected by SO_4-reducing conditions

Table E-3 (continued)

Screen ID	Well Screen	Port Depth (ft)	Tier 2.2 Indicators and Threshold Values (Responses below based on 3 samples)						Tier 2.2-2 to 2.2-4 Outcome for Most Recent Sample	
			2.2-2a SO_4	2.2-3a pH	2.2-3b Fe	2.2-3c Mn	2.2-3d Alk as $CaCO_3$	2.2-4 NO_3		
			SO_4>1.8 mg/L; S<0.01 mg/L; ORP >0	8.3>pH > 6.5	<130 µg/L	< 60 µg/L	<128 mg/L	NO_3 >0.025 mg/L; DO>2 mg/L	Pass/Fail	Applicable DR Validation Flag Codes
46	R-19 4	1413	No	Y	Y	Y	Y	Y	Fail / Reducing SO_4	DR for analytes affected by SO_4-reducing conditions
47	R-19 5	1586	No	Y	No (NF)	No (NF)	Y	No	Fail / Reducing SO_4, Fe, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
48	R-19 6	1730	No	Y	No (NF)	No (NF)	Y	No	Fail / Reducing SO_4, Fe, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
49	R-19 7	1835	Y(P)	Y	No/Y	No/Y	No/Y[L]	No/Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
50	R-20 1	907	No	No	Y	Y	Y	No	Fail / Reducing SO_4, pH, NO_3	DR for analytes affected by SO_4-reducing conditions
51	R-20 2	1150	No	Y	No	No	No	No	Fail / Reducing SO_4, Fe, Mn, Alk, NO_3	DR for analytes affected by SO_4-reducing conditions
52	R-20 3	1330	No	Y	No	No	Y	No	Fail / Reducing SO_4, Fe, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
53	R-21 1	888.8	Y	Y	Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
54	R-22 1	907.1	No	Y	No	No	No	No	Fail / Reducing SO_4, Fe, Mn, Alk, NO_3	DR for analytes affected by SO4-reducing conditions
55	R-22 2	962.8	Y	No/Y	Y	Y	Y	Y	Pass /Oxidizing	DR flags are not applicable for oxidizing conditions
56	R-22 3	1274	Y	No	Y	Y	No/Y	Y	Fail / Reducing pH, Alk	DR for analytes affected by Fe/Mn-reducing conditions

Table E-3 (continued)

Screen ID	Well Screen	Port Depth (ft)	Tier 2.2 Indicators and Threshold Values (Responses below based on 3 samples)						Tier 2.2-2 to 2.2-4 Outcome for Most Recent Sample	
			2.2-2a SO_4	2.2-3a pH	2.2-3b Fe	2.2-3c Mn	2.2-3d Alk as $CaCO_3$	2.2-4 NO_3		
			SO_4>1.8 mg/L; S<0.01 mg/L; ORP >0	8.3>pH > 6.5	<130 µg/L	< 60 µg/L	<128 mg/L	NO_3 >0.025 mg/L; DO>2 mg/L	Pass/Fail	Applicable DR Validation Flag Codes
57	R-22 4	1378	No/Y	Y	No	No	No	No	Fail / Reducing Fe, Mn, Alk, NO_3	DR for analytes affected by Fe/Mn-reducing conditions
58	R-22 5	1448	No	Y	No/Y	No	No	No	Fail / Reducing SO_4, Mn, Alk, NO_3	DR for analytes affected by SO_4-reducing conditions
59	R-23 1	816	No/Y	Y	Y	Y	Y(P)	Y	Pass /Oxidizing	DR flags are not applicable for oxidizing conditions
60	R-25 1	754.8	Y	Y	No	No	No	Y	Fail / Reducing Fe, Mn, Alk	DR for analytes affected by Fe/Mn-reducing conditions
61	R-25 2	891.8	No	Y	No	No	No/Y	No/Y	Fail / Reducing SO_4, Fe, Mn	DR for analytes affected by SO_4-reducing conditions
63	R-25 4	1192	No/Y	Y	No/Y	Y	No	No/Y	Fail / Reducing Alk	DR for analytes affected by Fe/Mn-reducing conditions
64	R-25 5	1303	Y(P)	Y	No	No	Y(P)	No	Fail / Reducing Fe, Mn, NO_3	DR for analytes affected by Fe/Mn-reducing conditions
65	R-25 6	1406	Y	Y(P)	No/Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
66	R-25 7	1606	Y	Y(P)	No/Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
67	R-25 8	1796	Y	No	No/Y	Y	Y	Y	Fail / Reducing pH	DR for analytes affected by Fe/Mn-reducing conditions
69	R-26 1	659.3	No	Y	Y	Y	Y	Y	Fail / Reducing SO_4	DR for analytes affected by SO_4-reducing conditions Preliminary; only 2 samples
71	R-28 1	946.2	Y	Y	Y	Y	Y	Y	Pass / Oxidizing	Preliminary; only 1 sample DR flags are not applicable for oxidizing conditions

Table E-3 (continued)

Screen ID	Well Screen	Port Depth (ft)	Tier 2.2 Indicators and Threshold Values (Responses below based on 3 samples)						Tier 2.2-2 to 2.2-4 Outcome for Most Recent Sample	
			2.2-2a SO_4	2.2-3a pH	2.2-3b Fe	2.2-3c Mn	2.2-3d Alk as $CaCO_3$	2.2-4 NO_3		
			SO_4>1.8 mg/L; S<0.01 mg/L; ORP >0	8.3>pH > 6.5	<130 µg/L	< 60 µg/L	<128 mg/L	NO_3 >0.025 mg/L; DO>2 mg/L	Pass/Fail	Applicable DR Validation Flag Codes
73	R-31 2	532.2	No	Y	No	No	No	No	Fail / Reducing Fe, Mn, NO_3, pH, SO_4	DR for analytes affected by SO_4-reducing conditions Preliminary; only 2 samples
77	R-32 1	870.9	Y	No/Y	Y	Y	Y	Y	Pass / Oxidizing	DR flags are not applicable for oxidizing conditions
79	R-32 3	976	No	Y	No	No	Y	No	Fail / Reducing SO_4, Fe, Mn, NO_3	DR for analytes affected by SO_4-reducing conditions
80	R-33 1	995.5	No	Y	No	Y	Y	Y	Fail / Reducing SO_4, Fe	DR for analytes affected by SO_4-reducing conditions Preliminary: only 1 sample
81	R-33 2	1112.4	Y	Y	No	Y	Y	Y	Fail / Reducing Fe	DR for analytes affected by Fe/Mn-reducing conditions Preliminary: only 1 sample
82	R-34 1	895.2	No	Y	Y	Y	Y	Y	Fail / Reducing SO_4	DR for analytes affected by SO_4-reducing conditions Preliminary: only 1 sample

na data not available; — no analyte flags are applicable
Alk—carbonate alkalinity
Y = Yes, criterion is met
Y(P) = Yes criterion is met but outcome is considered preliminary (see footnote c below)
No = No, criterion is not met
No/Y = The most recent sample meets the criterion, but at least one of the earlier samples does not;
No[NF] = No, criterion is not met (for Fe or Mn) but this finding is based on data for a nonfiltered sample
No[L] = alkalinity criteria not met but based on laboratory analysis because field alkalinity data were not available
DL = detection limit
DR = Flag indicating that some of the listed analyte concentrations may be not be representative of those in predrilling groundwater due to the presence of reducing conditions

[a] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.

[b] Assessment is based on data in Appendix Tables C-4 (field data) and C-7 (major ion and metal data) and plotted in Appendix Figure D-4 through D-9.

[c] An outcome is considered preliminary for one or more of the following reasons: (a) less than 3 samples are available, (b) some required data are not available for the assessment, (c) the most recent sample was collected over a year ago and water-quality conditions may have changed since then, or (d) the data are inconsistent with other indicator species.

[d] DR—flag indicating the presence of reducing conditions. Analytes that.

- Analytes affected by SO4-reducing conditions: (a) General inorganics: alkalinity, Ca, Mg, NO3, ClO4, SO4, pH; (b) Metals: Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Mn, Hg, Mo, Ni, Se, Ag, Tl, U, V, Zn; (c) Radionuclides: Am-241, Ce-139/141/144, Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147, Pu-238/239/240, Ra-226/228, Tc-99, U-234/235/236/238; (d) All HE chemicals and their degradation products; (e) All organic species, including SVOCs, VOCs, PAHs, diesel range organics, herbicides, pesticides, PCBs, dioxins, and furans

- Analytes affected by Fe/Mn-reducing conditions: (a) General inorganics: alkalinity, Ca, Mg, NO3, pH; (b) Metals: Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Hg, Mn, Mo, Ni, Se, Ag, Tl, U, V, Zn; (c) Radionuclides: Am-241, Ce-139/141/144, Cs-137, Co-60, Eu-152/154/155, La-140, Nd-147, Pu-238/239/240, Ra-226/228, Tc-99, U-234/235/236/238; (d) All HE chemicals and their degradation products; (e) All organic species, including SVOCs, VOCs, PAHs, diesel range organics, herbicides, pesticides, PCBs, dioxins, and furans

- Analytes affected by NO3-reducing conditions: (a) General inorganics: alkalinity, Ca, Mg, NO3, pH; (b) All organic species, including SVOCs, VOCs, PAHs, diesel range organics, herbicides, pesticides, PCBs, dioxins, and furans

[e] This well screen is in a perched intermediate zone. For Tier 2.2-3d, the corresponding threshold value for alkalinity (as CaCO3) is 53 mg/L.

Table E-4
Tier 2.1 Assessment Scores for Individual Samples

Screen ID[b]	Well Screen		Port Depth (ft)	Collection Date	Tier 2.1-1 indicators (leaching)[a]				Tier 2.1-2 indicators (sorption)[a]				Overall outcome		
					Pass?	# tested	# failed	Criteria failed	Pass?	# tested	# failed[c]	Criteria failed	# tested	# passed	Rating
14	R-2	1	918.0	26-Apr-05	Yes	4	0	—	Yes	4	1	—	8	7	88
				9-Aug-05	Yes	4	0	—	Yes	4	1	—	8	7	88
15	R-4	1	804.5	27-Apr-05	Yes	4	0	—	Yes	4	1	—	8	7	88
				8-Aug-05	Yes	4	0	—	Yes	4	1	—	8	7	88
20	R-6	1	1205.0	23-Aug-05	Yes	4	0	—	Yes	4	1	—	8	7	88
36	R-14	2	1288.5	14-Jul-04	Yes	4	0	—	No	4	2	U	8	6	75
				3-Nov-04	Yes	4	0	—	No	4	2	U	8	6	75
				12-May-05	Yes	4	0	—	No	4	2	U	8	6	75
39	R-16	2	866.1	13-Oct-04	Yes	4	0	—	Yes	4	1	—	8	7	88
				2-Dec-04	Yes	4	0	—	No	4	2	Zn	8	6	75
				13-Jun-05	Yes	4	0	—	Yes	4	1	—	8	7	88
40	R-16	3	1018.4	14-Oct-04	No	4	1	U	Yes	4	1	—	8	6	75
				3-Dec-04	No	4	1	U	Yes	4	1	—	8	6	75
				13-Jun-05	Yes	4	0	—	Yes	4	1	—	8	7	88
41	R-16	4	1238.0	15-Oct-04	No	4	1	SO4	Yes	4	1	—	8	6	75
				7-Dec-04	No	4	1	SO4	Yes	4	1	—	8	6	75
				14-Jun-05	No	4	1	SO4	Yes	4	1	—	8	6	75
50	R-20	1	907.0	20-Sep-04	No	4	1	Na	No	4	2	Sr	8	5	63
				4-Nov-04	No	4	1	Na	No	4	3	Sr, U	8	4	50
				20-Jul-05	No	4	1	Na	No	4	2	Sr	8	5	63
51	R-20	2	1149.7	7-Sep-04	No	4	2	B, Na	No	4	3	U, Zn	8	3	38
				8-Nov-04	No	4	2	B, Na	No	4	2	U	8	4	50
				19-Jul-05	No	4	2	B, Na	No	4	2	U	8	4	50
52	R-20	3	1330.0	7-Sep-04	Yes	4	0	—	No	4	1	U	8	7	88
				9-Nov-04	Yes	4	0	—	No	4	1	U	8	7	88
				18-Jul-05	Yes	4	0	—	No	4	1	U	8	7	88
77	R-32	1	870.9	21-Sep-04	Yes	4	0	—	Yes	4	1	—	8	7	88
				15-Nov-04	Yes	4	0	—	Yes	4	1	—	8	7	88
				22-Jun-05	Yes	4	0	—	Yes	4	1	—	8	7	88
79	R-32	3	976.0	22-Sep-04	Yes	4	0	—	No	4	2	U	8	6	75
				16-Nov-04	Yes	4	0	—	No	4	2	U	8	6	75
				24-Jun-05	Yes	4	0	—	No	4	2	U	8	6	75

Data source: Table C-3, Figure D-1 (leaching indicators only)

[a] Assessment is based on data in Table C-3 (leaching indicators are also plotted in Figure D-1) evaluated against test criteria presented in Table 4-5.

[b] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.

[c] All samples are assumed to fail the criterion for reliable detection of very strongly sorbing analytesfor which no analog is available: Am-241, Ce-139, 141, 144, Pu-239, 239, 240, Ra-226, Ra-228

Table E-5
Tier 2.2 Assessment Scores for Individual Samples

Screen ID[c]	Well Screen		Port Depth (ft)	Collection Date	Indicators for absence of residual organics[a]				Indicators for oxidizing conditions[b]				Overall outcome		
					Pass ?	# tested	# failed	Criteria failed and complicating factors	Pass?	# tested	# failed	Criteria failed and complicating factors	# tested	# passed	Rating
1	CdV-16-1i	1	624	1-Jun-05	Yes	3	0	High DL for Ace	No	9	3	S, low pH, Alk	12	9	75
				29-Aug-05	No	4	1	TKN	Yes	9	0	high SO4	13	12	92
5	CdV-R-15-3	4	1254	19-Oct-04	Yes	3	0	—	No	8	2	SO4, high pH	11	9	82
				4-Apr-05	Yes	4	0	—	No	9	3	SO4, ORP, DO	13	10	77
				12-Jul-05	Yes	4	0	—	No	8	2	SO4, High pH,	12	10	83
6	CdV-R-15-3	5	1350	20-Oct-04	No	3	2	NH3, TOC	No	8	5	SO4, S, Fe, Mn, NO3	11	4	36
				5-Apr-05	No	4	3	Ace, NH3, TOC	No	9	6	SO4, ORP, S, Fe, Mn, NO3	13	4	31
				12-Jul-05	No	4	2	Ace, NH3	No	8	3	ORP, Mn, NO3	12	7	58
7	CdV-R-15-3	6	1640	21-Oct-04	Yes	3	0	—	No	8	2	SO4, NO3	11	9	82
				6-Apr-05	Yes	4	0	—	No	9	6	SO4, ORP, S, Fe, Mn, NO3	13	7	54
				13-Jul-05	Yes	3	0	—	No	8	3	SO4, Fe, Mn	11	8	73
9	CdV-R-37-2	2	1200	26-Oct-04	No	3	3	NH3, TKN, TOC	No	8	5	SO4, Fe, Mn, Alk, NO3	11	3	27
				29-Mar-05	No	4	3	NH3, TKN, TOC	No	8	5	SO4, Fe, Mn, Alk, NO3	12	4	33
				6-Jul-05	No	4	3	NH3, TKN, TOC	No	8	5	SO4, ORP, Fe, Mn, NO3	12	4	33
10	CdV-R-37-2	3	1359	25-Oct-04	Yes	3	0	—	No	8	1	S	11	10	91
				28-Mar-05	Yes	4	0	—	No	8	1	SO4	12	11	92
				7-Jul-05	Yes	4	0	—	No	8	1	SO4	12	11	92
11	CdV-R-37-2	4	1550	27-Oct-04	No	3	1	NH3	No	8	3	Fe, Mn, NO3	11	7	64
				31-Mar-05	No	4	1	NH3	No	8	3	Fe, Mn, NO3	12	8	67
				8-Jul-05	No	4	1	NH3	No	8	3	SO4, Fe, NO3	12	8	67
12	MCOBT-4.4	1	505	28-Jan-03	Yes	4	0	—	Yes	6	0	High SO4 + NO3	10	10	100
				14-Oct-04	Yes	1	0	—	Yes	6	0	High SO4, high NO3	7	7	100
				8-Jun-05	Yes	2	0	—	Yes	4	0	No SO4+Alk data, high NO3	6	6	100

Table E-5 (continued)

Screen ID[c]	Well Screen		Port Depth (ft)	Collection Date	Indicators for absence of residual organics				Indicators for oxidizing conditions				Overall outcome		
					Pass ?	# tested	# failed	Criteria failed and complicating factors	Pass?	# tested	# failed	Criteria failed and complicating factors	# tested	# passed	Rating
13	R-1	1	1031	19-May-05	Yes	4	0	—	Yes	9	0	—	13	13	100
14	R-2	1	918	26-Apr-05	Yes	4	0	—	Yes	8	0	—	12	12	100
				9-Aug-05	Yes	4	0	—	No	9	1	S	13	12	92
15	R-4	1	804	27-Apr-05	Yes	4	0	—	Yes	8	0	—	12	12	100
				8-Aug-05	Yes	4	0	—	Yes	9	0	—	13	13	100
17	R-5	2	384	28-Apr-04	Yes	4	0	—	No	8	1	Alk, high NO3	12	11	92
				27-Sep-04	Yes	4	0	—	No	9	2	High pH, Alk, high NO3	13	11	85
				2-May-05	Yes	3	0	—	No	8	1	Alk, high NO3	11	10	91
18	R-5	3	719	30-Apr-04	Yes	4	0	—	Yes	9	0	—	13	13	100
				28-Sep-04	Yes	4	0	—	Yes	9	0	—	13	13	100
				3-May-05	Yes	3	0	—	Yes	8	0	—	11	11	100
19	R-5	4	860	3-May-04	Yes	4	0	—	No	9	4	S, Fe, Mn, NO3	13	9	69
				30-Sep-04	Yes	4	0	—	No	9	3	Fe, Mn, NO3	13	10	77
				5-May-05	Yes	3	0	—	No	8	3	Fe, Mn (NF), Alk (lab)	11	8	73
20	R-6	1	1205	23-Aug-05	Yes	4	0	—	No	9	2	S, Mn	13	11	85
21	R-6i	1	602	24-Aug-05	No	4	0	TOC*	No	9	2	S, Alk, high NO3*	13	11	85
24	R-7	3	915	18-Dec-03	Yes	3	0	—	No	6	4	SO4, Fe, Mn (NF), NO3	9	5	56
				26-May-04	Yes	1	0	—	No	6	4	SO4, Fe, Mn (NF), NO3	7	3	43
				26-Apr-05	Yes	3	0	—	No	8	5	SO4, ORP, Fe, Mn (NF), NO3	11	6	55
25	R-8	1	711	24-Aug-04	Yes	4	0	—	No	8	1	High pH	12	11	92
				8-Dec-04	Yes	4	0	—	Yes	8	0	—	12	12	100
				27-Apr-05	Yes	3	0	—	Yes	7	0	No NO3 data	10	10	100
26	R-8	2	825	25-Aug-04	Yes	4	0	—	No	9	1	High pH	13	12	92

Table E-5 (continued)

Screen ID[c]	Well Screen		Port Depth (ft)	Collection Date	Indicators for absence of residual organics				Indicators for oxidizing conditions				Overall outcome		
					Pass ?	# tested	# failed	Criteria failed and complicating factors	Pass?	# tested	# failed	Criteria failed and complicating factors	# tested	# passed	Rating
				9-Dec-04	Yes	4	0	—	No	8	1	pH	12	11	92
				28-Apr-05	Yes	2	0	—	No	8	2	ORP, pH	10	8	80
27	R-9	1	684	12-Dec-03	Yes	2	0	—	No	6	1	Mn (NF)	8	7	88
				27-May-04	Yes	1	0	—	No	6	2	Fe, Mn (NF)	7	5	71
				28-Apr-05	Yes	3	0	—	Yes	7	0	No alk data	10	10	100
28	R-9i	1	199	6-Feb-04	No	2	1	TOC	No	6	4	High SO4, Fe, Mn(NF), Alk	8	3	38
				2-Jun-04	Yes	1	0	—	No	6	4	High SO4, Fe, Mn(NF), Alk	7	3	43
				20-Apr-05	No	3	1	TOC	No	8	2	High SO4, Mn(NF), Alk	11	8	73
29	R-9i	2	278	6-Sep-01	No	4	1	TOC	No	6	4	Fe, Mn, Alk, NO3	10	5	50
				29-Jul-02	Yes	2	0	—	No	8	4	ORP, Fe, Mn (NF), NO3	10	6	60
				6-Feb-04	Yes	2	0	—	No	6	3	Mn (NF), Alk, NO3	8	5	63
30	R-11	1	855	17-May-05	Yes	4	0	—	Yes	9	0	High NO3	13	13	100
				3-Aug-05	Yes	4	0	—	No	9	1	Low DO	13	12	92
31	R-12	1	468	2-Feb-04	No	2	2	NH3, TOC	No	6	5	SO4, Fe, Mn (NF), pH, NO3	8	1	13
				2-Jun-04	Yes	1	0	—	No	6	5	SO4, Fe, Mn (NF), pH, NO3	7	2	29
				16-Jun-05	No	3	2	NH3, TKN	No	8	3	SO4, pH, NO3	11	6	55
33	R-12	3	811	27-Jan-04	Yes	2	0	—	No	6	4	Fe, Mn (NF), Alk, NO3	8	4	50
				3-Jun-04	Yes	1	0	—	No	6	5	Fe, Mn (NF), pH, Alk, NO3	7	2	29
				20-Jun-05	Yes	2	0	—	No	8	4	Fe, Mn, Alk, NO3	10	6	60
34	R-13	1	958	9-Dec-03	Yes	2	0	—	Yes	6	0	—	8	8	100
				11-Jun-04	Yes	1	0	—	Yes	6	0	—	7	7	100
				26-May-05	Yes	2	0	—	No	6	1	pH	8	7	88
35	R-14	1	1204	12-Jul-04	Yes	4	0	—	No	9	2	Mn, NO3	13	11	85
				28-Oct-04	Yes	4	0	—	No	8	2	Mn, pH	12	10	83
				11-May-05	Yes	4	0	—	No	9	1	SO4	13	12	92

Table E-5 (continued)

Screen ID[c]	Well Screen		Port Depth (ft)	Collection Date	Indicators for absence of residual organics: Pass?	# tested	# failed	Criteria failed and complicating factors	Indicators for oxidizing conditions: Pass?	# tested	# failed	Criteria failed and complicating factors	Overall outcome: # tested	# passed	Rating
36	R-14	2	1288	14-Jul-04	Yes	4	0	—	No	9	6	SO4, ORP, S, Fe, Mn, NO3	13	7	54
				3-Nov-04	No	4	2	NH3, TOC	No	8	5	SO4, S, Fe, Mn, NO3	12	5	42
				12-May-05	No	4	2	NH3, TOC	No	8	5	SO4, ORP, Fe, Mn, NO3	12	5	42
37	R-15	1	958	10-Jun-04	Yes	1	0	—	No	5	1	Fe (NF)	6	5	83
				25-May-05	Yes	3	0	—	Yes	8	0	—	11	11	100
				31-Aug-05	Yes	3	0	—	Yes	8	0	—	11	11	100
39	R-16	2	866	13-Oct-04	Yes	4	0	—	No	8	4	S, Mn, pH, NO3	12	8	67
				2-Dec-04	Yes	4	0	—	No	8	3	S, pH, NO3	12	9	75
				13-Jun-05	Yes	3	0	—	No	8	3	ORP, pH, NO3	11	8	73
40	R-16	3	1018	14-Oct-04	No	4	2	NH3, TKN	No	8	2	Fe, Mn	12	8	67
				3-Dec-04	No	4	2	NH3, TKN	No	8	1	Mn	12	9	75
				13-Jun-05	Yes	3	0	—	No	7	1	ORP	10	9	90
41	R-16	4	1238	15-Oct-04	No	4	2	NH3, TKN	No	8	3	S, pH, NO3	12	7	58
				7-Dec-04	No	4	2	NH3, TKN	No	8	4	S, pH, Alk, NO3	12	6	50
				14-Jun-05	No	3	2	NH3, TKN	No	8	4	ORP, pH, Alk, NO3	11	5	45
42	R-18	1	1358	25-Aug-05	Yes	4	0	—	Yes	9	0	—	13	13	100
44	R-19	2	909	15-Dec-03	Yes	2	0	—	No	6	2	pH, Alk	8	6	75
				10-Jun-04	—	0	—	—	No	6	2	pH, Alk	6	4	67
				21-Jul-05	Yes	2	0	—	No	7	2	pH, Alk	9	7	78
45	R-19	3	1191	15-Dec-03	Yes	2	0	—	Yes	6	0	—	8	8	100
				14-Jun-04	Yes	1	0	—	Yes	6	0	—	7	7	100
				21-Jul-05	Yes	2	1	TKN	No	7	1	SO4	9	7	78
46	R-19	4	1413	16-Dec-03	Yes	2	0	—	No	6	1	SO4	8	7	88

Table E-5 (continued)

Screen ID[c]	Well Screen	Port Depth (ft)	Collection Date	Indicators for absence of residual organics: Pass ?	# tested	# failed	Criteria failed and complicating factors	Indicators for oxidizing conditions: Pass?	# tested	# failed	Criteria failed and complicating factors	Overall outcome: # tested	# passed	Rating
			15-Jun-04	Yes	1	0	—	No	6	1	SO4	7	6	86
			28-Jul-05	Yes	3	0	—	No	7	1	SO4	10	9	90
47	R-19 5	1586	20-Sep-01	No	2	2	TKN, TOC	Yes	2	0	—	4	2	50
			23-Aug-02	No	3	2	NH3, TOC	No	8	5	SO4, ORP, Fe, Mn (NF), NO3	11	4	36
			16-Dec-03	No	2	2	NH3, TOC	No	6	4	SO4, Fe, Mn (NF), NO3	8	2	25
48	R-19 6	1730	24-Sep-01	No	2	2	TKN, TOC	Yes	2	0	—	4	2	50
			27-Aug-02	No	3	1	NH3	No	8	5	SO4, ORP, Fe, Mn (NF), NO3	11	5	45
			16-Dec-03	No	2	1	NH3	No	6	4	SO4, Fe, Mn (NF), NO3	8	3	38
49	R-19 7	1835	17-Dec-03	No	2	2	NH3, TOC	No	6	4	Note high SO4, Fe, Mn (NF), Alk, NO3	8	2	25
			16-Jun-04	Yes	1	0	—	No	6	3	Note high SO4, Fe, Mn (NF), Alk	7	4	57
			28-Jul-05	No	3	2	NH3, TKN	Yes	8	0	—	11	9	82
50	R-20 1	907	20-Sep-04	No	4	4	Ace, NH3, TKN, TOC	No	9	4	ORP, S, High pH, NO3	13	5	38
			4-Nov-04	No	4	3	Ace, NH3, TOC	No	8	3	S, High pH, NO3	12	6	50
			20-Jul-05	No	3	3	Ace, NH3, TKN	No	8	4	SO4, ORP, High pH, NO3	11	4	36
51	R-20 2	1150	7-Sep-04	No	4	3	NH3, TKN, TOC	No	9	6	SO4, S, Fe, Mn, Alk, NO3	13	4	31
			8-Nov-04	No	4	3	NH3, TKN, TOC	No	8	6	SO4, S, Fe, Mn, Alk, NO3	12	3	25
			19-Jul-05	No	3	2	NH3, TKN	No	7	5	SO4, Fe, Mn, Alk, NO3	10	3	30
52	R-20 3	1330	7-Sep-04	No	4	3	NH3, TKN, TOC	No	9	5	SO4, S, Fe, Mn (NF), NO3	13	5	38
			9-Nov-04	No	4	3	NH3, TKN, TOC	No	8	4	SO4, Fe, Mn (NF), NO3	12	5	42
			18-Jul-05	No	3	1	NH3	No	6	4	SO4, Fe, Mn, NO3	9	4	44
53	R-21 1	888	23-Sep-04	Yes	4	0	—	Yes	8	0	—	12	12	100
			14-Dec-04	Yes	4	0	—	Yes	9	0	—	13	13	100

Table E-5 (continued)

Screen ID[c]	Well Screen		Port Depth (ft)	Collection Date	Indicators for absence of residual organics				Indicators for oxidizing conditions				Overall outcome		
					Pass ?	# tested	# failed	Criteria failed and complicating factors	Pass?	# tested	# failed	Criteria failed and complicating factors	# tested	# passed	Rating
				6-Jun-05	Yes	3	0	—	Yes	8	0	—	11	11	100
54	R-22	1	907	18-Nov-03	No	3	2	NH3, TOC	No	6	4	SO4, Fe, Mn (NF), NO3	9	3	33
				21-Jun-04	Yes	1	0	—	No	6	5	SO4, Fe, Mn (NF), Alk, NO3	7	2	29
				27-Jun-05	No	3	2	NH3, TKN	No	8	6	SO4, ORP, Fe, Mn, Alk, NO3	11	3	27
55	R-22	2	963	19-Nov-03	Yes	3	0	—	Yes	6	0	—	9	9	100
				22-Jun-04	Yes	1	0	—	No	6	1	High pH	7	6	86
				28-Jun-05	Yes	3	0	—	Yes	8	0	—	11	11	100
56	R-22	3	1274	20-Nov-03	Yes	3	0	—	No	6	2	High pH, Alk (lab)	9	7	78
				23/30-Jun-04	Yes	1	0	—	No	6	1	High pH	7	6	86
				29-Jun-05	Yes	3	0	—	No	7	1	High pH	10	9	90
57	R-22	4	1378	20-Nov-03	No	3	2	NH3, TOC	No	6	4	Fe, Mn (NF), Alk, NO3	9	3	33
				23-Jun-04	Yes	1	0	—	No	6	5	SO4, Fe, Mn (NF), Alk, NO3	7	2	29
				1-Jul-05	No	3	1	NH3	No	8	4	Fe, Mn, Alk, NO3	11	6	55
58	R-22	5	1448	10-Jul-02	No	3	2	NH3, TOC	No	6	5	SO4, Fe, Mn, Alk, NO3	9	2	22
				21-Nov-03	No	3	2	NH3, TOC	No	6	5	SO4, Fe, Mn (NF), Alk, NO3	9	2	22
				5-Jul-05	No	3	1	NH3	No	8	4	SO4, Mn, Alk, NO3	11	6	55
59	R-23	1	816	29-Jun-04	Yes	4	0	—	Yes	8	0	—	12	12	100
				24-Sep-04	Yes	4	0	—	No	9	1	S	13	12	92
				14-Jul-05	Yes	3	0	—	Yes	8	0	—	11	11	100
60	R-25	1	755	12-Dec-03	Yes	3	0	—	No	6	3	Fe, Mn (NF), Alk	9	6	67
				1-Sep-04	Yes	1	0	—	No	6	2	Fe, Mn (NF)	7	5	71
				2-Aug-05	Yes	3	0	—	No	8	3	Fe, Mn, Alk	11	8	73
61	R-25	2	891	8-Aug-02	No	3	1	TOC	No	8	3	Fe (NF), Alk, NO3	11	7	64
				10-Dec-03	No	3	1	TOC	No	6	3	Fe (NF), Alk, NO3	9	5	56
				3-Aug-05	No	3	1	NH3	No	8	3	Fe, Mn, ORP	11	7	64

Table E-5 (continued)

Screen ID[c]	Well Screen		Port Depth (ft)	Collection Date	Indicators for absence of residual organics				Indicators for oxidizing conditions				Overall outcome		
					Pass ?	# tested	# failed	Criteria failed and complicating factors	Pass?	# tested	# failed	Criteria failed and complicating factors	# tested	# passed	Rating
63	R-25	4	1192	8-Aug-02	Yes	4	0	—	No	8	1	Fe (NF), ORP	12	10	83
				10-Dec-03	No	2	1	NH_3	No	6	3	Fe (NF), Alk, NO_3	8	4	50
				4-Aug-05	Yes	3	0	—	No	8	1	Alk	11	10	91
64	R-25	5	1303	9-Dec-03	No	3	2	NH_3, TOC	No	6	3	Fe, Mn (NF), NO_3	9	4	44
				31-Aug-04	Yes	1	0	—	No	4	3	Fe, Mn (NF),NO_3	5	2	40
				9-Aug-05	Yes	1	0	—	No	4	2	Fe, Mn, No alk or NO_3 data	5	3	60
65	R-25	6	1406	8-Feb-02	Yes	4	0	—	Yes	7	0	—	11	11	100
				12-Aug-02	Yes	3	0	—	No	8	1	Fe (NF)	11	10	91
				9-Dec-03	Yes	3	0	—	Yes	6	0	—	9	9	100
66	R-25	7	1606	11-Feb-02	Yes	4	0	—	Yes	7	0	—	11	11	100
				12-Aug-02	Yes	3	0	—	No	8	1	Fe (NF)	11	10	91
				8-Dec-03	Yes	3	0	—	Yes	6	0	—	9	9	100
67	R-25	8	1796	14-Aug-02	Yes	3	0	—	No	8	2	Fe (NF), High pH	11	9	82
				4-Dec-03	Yes	3	0	—	No	6	2	Fe (NF), High pH	9	7	78
				10-Aug-05	Yes	3	0	—	No	7	1	High pH	10	9	90
69	R-26	1	659	13-Apr-05	Yes	4	0	—	No	9	1	SO_4	13	12	92
				27-Jul-05	Yes	4	0	—	No	6	1	SO_4	10	9	90
71	R-28	1	946	20-May-05	Yes	4	0	—	Yes	9	0	—	13	13	100
73	R-31	2	532	18-Mar-04	No	4	3	NH_3, TKN, TOC	No	9	6	SO_4, ORP, Fe, Mn, Alk, NO_3	13	4	31
				17-Aug-05	No	3	1	NH_3	No	8	5	SO_4, Fe, Mn, NO_3, Alk	11	5	45
77	R-32	1	871	21-Sep-04	No	4	1	NH_3	No	9	1	High pH	13	11	85
				15-Nov-04	Yes	4	0	—	No	9	1	High pH	13	12	92
				22-Jun-05	Yes	3	0	—	Yes	8	0	—	11	11	100
79	R-32	3	976	22-Sep-04	No	4	2	NH_3, TKN	No	9	6	SO_4, ORP, S, Fe, Mn, NO_3	13	5	38
				16-Nov-04	No	4	2	NH_3, TKN	No	8	4	S, Fe, Mn, NO_3	12	6	50

Table E-5 (continued)

Screen ID[c]	Well Screen		Port Depth (ft)	Collection Date	Indicators for absence of residual organics				Indicators for oxidizing conditions				Overall outcome		
					Pass ?	# tested	# failed	Criteria failed and complicating factors	Pass?	# tested	# failed	Criteria failed and complicating factors	# tested	# passed	Rating
				24-Jun-05	No	3	1	NH_3	No	8	5	SO_4, ORP, Fe, Mn, NO_3	11	5	45
80	R-33	1	995	27-Jun-05	Yes	3	0	—	No	7	2	ORP, Fe	10	8	80
81	R-33	2	1112	24-Jun-05	Yes	3	0	—	No	8	1	Fe	11	10	91
82	R-34	1	895	7-Jun-05	Yes	4	0	—	No	9	2	ORP, S	13	11	85

[a] Assessment is based on data in Table C-4 evaluated against test criteria presented in Table 4-8.

[b] Assessment is based on data in Tables C-6 and C-7 evaluated against test criteria presented in Table 4-8.

[c] Screen ID—unique identifier assigned to each screen addressed by this report in order to simplify management of information.

* from a groundwater contaminant plume

Table E-6. Comparison of Composite Tier 2 Outcome to Tier 2 Outcome for the Most Recent Sample from Each Screen

Screen ID[c]	Well screen		Tier 2 Composite Outcome[a] (includes all 3 sample events, if available): 2.1 Bentonite N_{max}=24		2.2-1 Organics N_{max}=12		2.2-2 Redox N_{max}=27		Tier 2 Overall N_{max}=63		Level of confidence[b]	Tier 2 Outcome for Most Recent Sample: 2.1 Bentonite N_{max}=8		2.2-1 Organics N_{max}=4		2.2-2 Redox N_{max}=9		Tier 2 Overall N_{max}=21		Level of confidence	General Condition for Most Recent Sample / Overall Trend
			# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		
1	CdV-16-1i	1	—		7	86%	18	83%	25	84%	Mod	—		4	75%	9	100%	13	92%	Mod	Very good / Indeter
5	CdV-R-15-3	4	—		11	100%	25	72%	36	81%	High	—		4	100%	8	75%	12	83%	High	Good / Stable
6	CdV-R-15-3	5	—		11	36%	25	44%	36	42%	Mod	—		4	50%	8	63%	12	58%	Mod	Poor / Improving
7	CdV-R-15-3	6	—		10	100%	25	56%	35	69%	High	—		3	100%	8	63%	11	73%	High	Fair / Variable
9	CdV-R-37-2	2	—		11	18%	24	38%	35	31%	High	—		4	25%	8	38%	12	33%	High	Poor / Stable
10	CdV-R-37-2	3	—		11	100%	24	88%	35	91%	High	—		4	100%	8	88%	12	92%	High	Very good / Stable
11	CdV-R-37-2	4	—		11	73%	24	63%	35	66%	High	—		4	75%	8	63%	12	67%	High	Fair / Stable
12	MCOBT-4.4	1	—		7	100%	16	100%	23	100%	Mod	—		2	100%	4	100%	6	100%	Low	Very good / Stable
13	R-1	1	Not applicable (only 1 sample event)									—		4	100%	9	100%	13	100%	Low	Very good / Indeter
14	R-2	1	16	88%	8	100%	17	94%	41	93%	Mod	8	88%	4	100%	9	89%	21	90%	Mod	Good / Indeter
15	R-4	1	16	88%	8	100%	13	100%	37	95%	Mod	8	88%	4	100%	9	100%	21	95%	Mod	Very good / Stable
17	R-5	2	—		11	100%	25	84%	36	89%	High	—		3	100%	8	88%	11	91%	High	Very good / Stable
18	R-5	3	—		11	100%	26	100%	37	100%	High	—		3	100%	8	100%	11	100%	High	Very good / Stable
19	R-5	4	—		11	100%	26	62%	37	73%	High	—		3	100%	8	63%	11	73%	Mod	Fair / Variable
20	R-6	1	Not applicable (only 1 sample event)									8	88%	4	100%	9	78%	21	86%	Low	Good / Indeter
21	R-6i	1	Not applicable (only 1 sample event)									—		4	100%	9	78%	13	85%	Low	Good / Indeter

Table E-6 (continued)

Screen ID	Well screen		Tier 2 Composite Outcome (includes all 3 sample events, if available): 2.1 Bentonite N_{max}=24		2.2-1 Organics N_{max}=12		2.2-2 Redox N_{max}=27		Tier 2 Overall N_{max}=63		Level of confidence	Outcome for Most Recent Sample: 2.1 Bentonite N_{max}=8		2.2-1 Organics N_{max}=4		2.2-2 Redox N_{max}=9		Tier 2 Overall N_{max}=21		Level of confidence	General Condition for Most Recent Sample / Overall Trend
			# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		
24	R-7	3	—		7	100%	20	35%	27	52%	High	—		3	100%	8	38%	11	55%	High	Poor / Stable
25	R-8	1	—		11	100%	23	96%	34	97%	High	—		3	100%	7	100%	10	100%	High	Very good/ Stable
26	R-8	2	—		10	100%	25	84%	35	89%	High	—		2	100%	8	75%	10	80%	Mod	Fair / Indeter
27	R-9	1	—		6	100%	19	84%	25	88%	High	—		3	100%	7	100%	10	100%	High	Very good / Stable
28	R-9i	1	—		6	67%	20	50%	26	54%	Mod	—		3	67%	8	75%	11	73%	Mod	Fair / Improving
29	R-9i	2	—		8	88%	20	45%	28	57%	Mod	—		2	100%	6	50%	8	63%	High	Fair / Improving
30	R-11	1	—		8	100%	18	94%	26	96%	Mod	—		4	100%	9	89%	13	92%	Mod	Very good / Indeter
31	R-12	1	—		6	33%	20	35%	26	35%	Mod	—		3	33%	8	63%	11	55%	Mod	Poor / Improving
33	R-12	3	—		5	100%	20	35%	25	48%	Mod	—		2	100%	8	50%	10	60%	Mod	Fair / Variable
34	R-13	1	—		5	100%	18	94%	23	96%	High	—		2	100%	6	83%	8	88%	High	Good / Improving
35	R-14	1	—		12	100%	26	81%	38	87%	Mod	—		4	100%	9	89%	13	92%	Mod	Very good/Improving
36	R-14	2	24	75%	12	67%	25	36%	61	57%	High	8	75%	4	50%	8	38%	20	55%	High	Poor / Worsening
37	R-15	1	—		7	100%	21	95%	28	96%	High	—		3	100%	8	100%	11	100%	High	Very good / Stable
39	R-16	2	24	83%	11	100%	24	58%	59	75%	High	8	88%	3	100%	8	63%	19	74%	High	Fair / Stable
40	R-16	3	24	79%	11	64%	23	83%	58	78%	High	8	88%	3	100%	7	86%	18	89%	High	Good / Improving
41	R-16	4	24	75%	11	45%	24	54%	59	61%	High	8	75%	3	33%	8	50%	19	58%	High	Poor / Stable
42	R-18	1	Not applicable (only 1 sample event)									—		4	100%	9	100%	13	100%	Low	Very good / Indeter
44	R-19	2	—		4	100%	19	68%	23	74%	High	—		2	100%	7	71%	9	78%	High	Fair / Stable
45	R-19	3	—		5	80%	19	95%	24	92%	High	—		2	50%	7	86%	9	78%	Low	Fair / Worsening
46	R-19	4	—		6	100%	19	84%	25	88%	High	—		3	100%	7	86%	10	90%	High	Good / Stable
47	R-19	5	—		7	14%	16	44%	23	35%	High	—		2	0%	6	33%	8	25%	Mod	Poor / Stable
48	R-19	6	—		7	43%	16	44%	23	43%	Mod	—		2	50%	6	33%	8	38%	Mod	Poor / Improving
49	R-19	7	—		6	33%	20	65%	26	58%	Mod	—		3	33%	8	100%	11	82%	Mod	Fair / Variable

Table E-6 (continued)

Screen ID	Well screen		Tier 2 Composite Outcome (includes all 3 sample events, if available): 2.1 Bentonite N_{max}=24		2.2-1 Organics N_{max}=12		2.2-2 Redox N_{max}=27		Tier 2 Overall N_{max}=63		Level of confidence	Outcome for Most Recent Sample: 2.1 Bentonite N_{max}=8		2.2-1 Organics N_{max}=4		2.2-2 Redox N_{max}=9		Tier 2 Overall N_{max}=21		Level of confidence	General Condition for Most Recent Sample / Overall Trend
			# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		
50	R-20	1	24	58%	11	9%	25	56%	60	48%	High	8	63%	3	0%	8	50%	19	47%	High	Poor / Variable
51	R-20	2	24	46%	11	27%	24	29%	59	36%	High	8	50%	3	33%	7	29%	18	39%	High	Poor / Variable
52	R-20	3	24	88%	11	36%	23	43%	58	60%	Mod	8	88%	3	67%	6	33%	17	65%	Mod	Fair / Stable
53	R-21	1	—		11	100%	25	100%	36	100%	High	—		3	100%	8	100%	11	100%	High	Very good / Stable
54	R-22	1	—		7	43%	20	25%	27	30%	High	—		3	33%	8	25%	11	27%	High	Poor / Stable
55	R-22	2	—		7	100%	20	95%	27	96%	High	—		3	100%	8	100%	11	100%	High	Very good / Stable
56	R-22	3	—		7	100%	19	79%	26	85%	High	—		3	100%	7	86%	10	90%	Mod	Good / Variable
57	R-22	4	—		7	57%	20	35%	27	41%	Mod	—		3	67%	8	50%	11	55%	High	Poor / Variable
58	R-22	5	—		9	44%	20	30%	29	34%	Mod	—		3	67%	8	50%	11	55%	High	Poor / Variable
59	R-23	1	—		11	100%	25	96%	36	97%	Mod	—		3	100%	8	100%	11	100%	Mod	Very good /Variable
60	R-25	1	—		7	100%	20	60%	27	70%	High	—		3	100%	8	63%	11	73%	High	Fair / Improving
61	R-25	2	—		9	67%	22	59%	31	61%	High	—		3	67%	8	63%	11	64%	High	Fair / Variable
63	R-25	4	—		9	89%	22	73%	31	77%	Mod	—		3	100%	8	75%	11	91%	Mod	Very good /Variable
64	R-25	5	—		5	60%	14	43%	19	47%	Mod	—		1	100%	4	50%	5	60%	Mod	Fair / Improving
65	R-25	6	—		10	100%	21	95%	31	97%	Mod	—		3	100%	6	100%	9	100%	Mod	Very good / Stable
66	R-25	7	—		10	100%	21	95%	31	97%	Mod	—		3	100%	6	100%	9	100%	Mod	Very good / Stable
67	R-25	8	—		9	100%	21	76%	30	83%	High	—		3	100%	7	86%	10	90%	High	Good / Improving
69	R-26	1	—		8	100%	15	87%	23	91%	Mod	—		4	100%	6	83%	10	90%	Mod	Good / Stable
71	R-28	1	Not applicable (only 1 sample event)									—		4	100%	9	100%	13	100%	Low	Very good / Indeter
73	R-31	2	—		7	43%	17	35%	24	38%	Mod	—		3	67%	8	38%	11	45%	Mod	Poor / Variable
77	R-32	1	24	88%	11	91%	26	92%	61	90%	High	8	88%	3	100%	8	100%	19	95%	High	Very good / Stable
79	R-32	3	24	75%	11	55%	25	40%	60	57%	High	8	75%	3	67%	8	38%	19	58%	High	Poor / Stable
80	R-33	1	Not applicable (only 1 sample event)									—		3	100%	7	71%	10	80%	Low	Fair / Indeter
81	R-33	2	Not applicable (only 1 sample event)									—		3	100%	8	88%	11	91%	Low	Very good / Indeter

Table E-6 (continued)

Screen ID	Well screen		Tier 2 Composite Outcome (includes all 3 sample events, if available)									Outcome for Most Recent Sample									General Condition for Most Recent Sample / Overall Trend
			2.1 Bentonite N_{max}=24		2.2-1 Organics N_{max}=12		2.2-2 Redox N_{max}=27		Tier 2 Overall N_{max}=63		Level of confidence	2.1 Bentonite N_{max}=8		2.2-1 Organics N_{max}=4		2.2-2 Redox N_{max}=9		Tier 2 Overall N_{max}=21		Level of confidence	
			# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		# of tests	% Pass	# of tests	% Pass	# of tests	% Pass	# of tests	% Pass		
82	R-34	1	Not applicable (only 1 sample event)									—		4	100%	9	78%	13	85%	Low	Good / Indeter

Indeter—Indeterminate

N_{max} = maximum number of tier tests possible, assuming data are avialble for all tier criteria.

[a] Summarized from results compiled in Tables E-4 (for Tier 2.1) and E-5 (for Tier 2.2-1 and Tier 2.2-2).

[b] These qualitative ratings are defined on page E-2.

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