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Hanford Tank Farms Vadose Zone

Addendum to the BX Tank Farm Report

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Executive Summary

In 1994, the U.S. Department of Energy (DOE) Richland Operations Office (DOE-RL) requested the DOE Grand Junction Office (GJO), Grand Junction, Colorado, to perform a baseline characterization of gamma-emitting radionuclides in the vadose zone beneath and around the single-shell tanks (SSTs) at the Hanford Site. The BX Tank Farm Report, which was prepared as part of this characterization project, was issued as document GJO-98-40-TAR, GJO-HAN-19 in August 1998. That document reported the results of the spectral gamma logging characterizations at the BX Tank Farm that were originally reported in Tank Summary Data Reports for each individual tank. The BX Tank Farm Report provided background information, a history of the farm, geology and hydrology reviews, and a description and review of adjacent waste sites. Data derived from logging existing boreholes in the BX Tank Farm were used to develop a three-dimensional model of the distribution of the contamination in the vadose zone in the immediate vicinity of the BX Tank Farm.

Since the original BX Tank Farm Report was issued, additional data have been collected, new analysis techniques developed, and additional insights into the nature and distribution of contamination have been gained. The purpose of this addendum is to present these additional data and to provide revised visualizations of the subsurface contaminant distribution in the BX Tank Farm.

A high rate logging system was developed and deployed in the BX Tank Farm to measure cesium-137 (^{137}Cs) concentration levels in high gamma flux zones where the spectral gamma logging system was unable to collect usable data because of high dead times and detector saturation. This new system has enabled measurement of ^{137}Cs concentrations up to about 100 million picocuries per gram.

Other data collected since the BX Farm Report was issued include repeat logging measurements acquired approximately 2 years after the initial baseline data were collected. In some boreholes these measurements have indicated concentration increases that are attributed to migration of contaminants through the vadose zone. Analysis of historical gross gamma logging data by Randall and Price (1999) indicates gamma count rate increases between 1975 and 1994 in some boreholes. Analysis of repeat logging data suggests that this contaminant migration may be continuing. However, the repeat logging was limited in scope and the gross gamma logging program was discontinued in 1994; no comprehensive vadose zone monitoring program currently exists.

The interpreted data set presented in the BX Tank Farm Report was revised to incorporate the high rate data and to remove contaminants linked to borehole effects. The decision to remove additional contamination from boreholes was based on the results of the previous shape factor analysis, the Randall and Price (1999) data, and the judgment of the analysts. These new data sets were used to create the three-dimensional visualizations of subsurface contamination for the BX Tank Farm. As a result, the plumes depicted in the visualizations are more realistic and have

been used to provide an estimate of contaminant inventories. The visualizations will also prove useful in directing future characterization work in the BX Tank Farm.

This addendum completes the baseline characterization of the BX Tank Farm. The purpose of the characterization was to identify the nature and extent of contamination associated with gamma-emitting radionuclides in the BX Tank Farm using data collected from existing boreholes. This work serves as a baseline against which future measurements can be compared to identify changes in the vadose zone, to track gamma-emitting radionuclide contaminant movement, and to identify or verify future tank leaks.

1.0 Introduction

The BX Tank Farm is located in the north-central portion of the 200 East Area of the Hanford Site (Figure 1). This tank farm consists of 12 single-shell tanks (SSTs), each with an individual capacity of 530,000 gallons (gal). These tanks currently store high-level nuclear waste that was primarily generated at B Plant. Five of the 12 tanks are listed in Hanlon (2000) as "assumed leakers" and are estimated to have leaked approximately 96,500 gal of high-level radioactive liquid to the vadose zone.

In 1994, the U.S. Department of Energy (DOE) Richland Operations Office (DOE-RL) requested the DOE Grand Junction Office (GJO), Grand Junction, Colorado, to perform a baseline characterization of gamma-emitting radionuclides in the vadose zone at all Hanford SST farms using high resolution spectral gamma-ray logging methods in existing boreholes surrounding the tanks. The DOE-GJO deployed the Spectral Gamma Logging System (SGLS), which consists of a downhole sonde and surface support system (cable, winch, and electronic systems mounted in a custom-built truck). The downhole sonde contains an n-type high purity germanium (HPGe) semiconductor detector with approximately 35 percent efficiency. The baseline BX Tank Farm geophysical logging was completed in 1997, and the results of the radionuclide concentration logs for individual boreholes were compiled and presented in 12 individual Tank Summary Data Reports (DOE 1997a, 1998a, 1998b, 1998c, 1998d, 1998e, 1998f, 1998g, 1998h, 1998i, 1998j, and 1998k).

The BX Tank Farm Report was completed by the Hanford Tank Farms Vadose Zone Project in August 1998. Since it was completed, additional work has been performed, and modifications to the original report are warranted. This document will discuss those modifications and serves as an addendum to the original report. The original report was issued as document GJO-98-40-TAR, GJO-HAN-19.

1.1 Background

A compilation of all borehole data collected for the baseline characterization was presented in the original BX Tank Farm Report. Included within that report were three-dimensional visualizations of contaminant distribution in the vadose zone around the BX Tank Farm.

In June 1996, a Phase I groundwater quality assessment for the B-BX-BY Waste Management Area (WMA) was initiated in response to a directive from the Washington State Department of Ecology. This action was triggered by increases in specific conductivity in downgradient monitoring wells. Results of the Phase 1 assessment (Narbutovskih 1998) indicated that the B-BX-BY WMA had contributed to the groundwater contamination and that remobilized single-shell tanks waste, either from past tank-related spills or leaks in the BX Tank Farm, was identified as the likely source of the groundwater contamination. This work was carried out independently of the work reported in the BX Tank Farm Report.

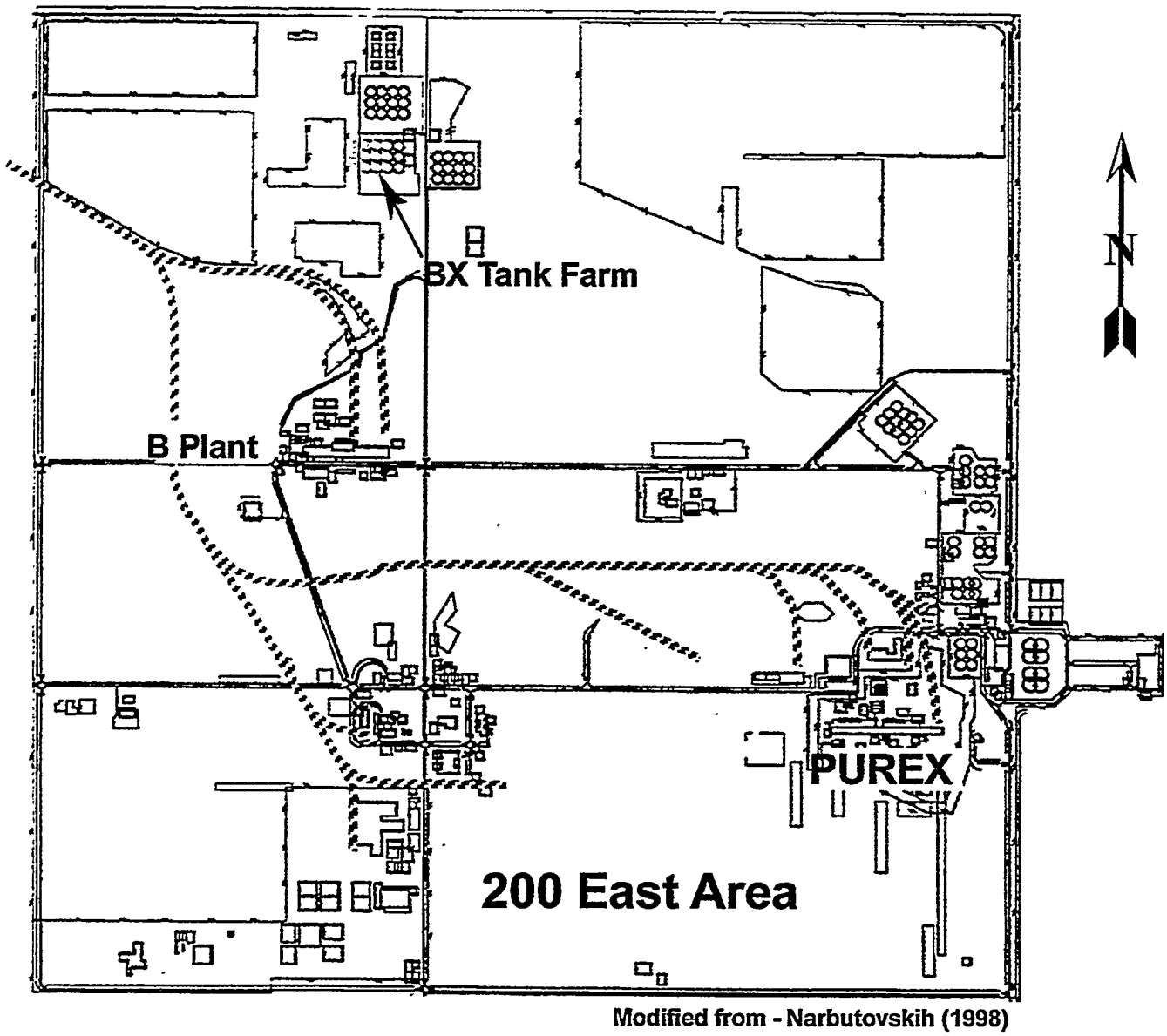

Figure 1. Map of the 200 East Area Showing the Location of the BX Tank Farm

Since the original BX Tank Farm Report was issued in 1998, additional data have been obtained and enhancements have been made in the data evaluation process. Shape factor analysis had been applied to the original baseline spectral data prior to issuing the BX Tank Farm Report; however, experience in the interpretation of these data has led to a more liberal approach when removing data suspected of being attributed to borehole effects. Other data have been acquired by repeat logging of selected borehole intervals. Finally, a high rate logging tool has been deployed to investigate intervals of very high gamma flux where the SGLS was unable to collect usable spectral data.

1.2 Purpose and Scope

The purpose of this addendum is to present additional data relevant to the BX Tank Farm, and to provide revised visualizations of subsurface contamination that are based on re-evaluation of the original data, as well as incorporation of high rate log data. Tank farm conditions, operational history, current status, and geologic conditions are discussed in the original BX Tank Farm Report and in relevant Tank Summary Data Reports (DOE 1997a, 1998a, 1998b, 1998c, 1998d, 1998e, 1998f, 1998g, 1998h, 1998i, 1998j, and 1998k), and will not be restated in this report. The reader is referred to those documents for detailed information.

Results of repeat logging and high rate logging are summarized in tables included in appendices to this report. Log plots for both the repeat and High Rate Logging System (HRLS) are also included in the appendices.

In general, only the high rate data have been incorporated into the interpreted data set used to create the visualizations. Repeat logging data are generally not incorporated into the interpreted data set, unless the data clarify ambiguities in the original log data. The primary justification for excluding repeat data is that only a small fraction of the total logging footage was re-logged. To routinely insert these data would thus distort the original baseline. Discrepancies between repeat logging and the original logs are discussed in the text, and areas where potential contaminant movement is evident are identified, but the contaminant plumes shown in the visualizations are based on the original data, as modified by professional judgment, with HRLS results included in intervals where the SGLS was saturated.

Although areas of potential contaminant movement are identified on the basis of comparison of repeat logging data and original baseline data, as well as analysis of gross gamma data collected between 1975 and 1994, it is difficult to draw firm conclusions regarding recent contaminant movement because routine borehole monitoring was discontinued in 1994.

2.0 Summary of Additional Data

Additional data presented in this addendum include data from high rate logging and repeat logging. Improvements in data analysis and interpretation methods are applied to all borehole data where appropriate. Also referenced in this addendum is work performed by Randall and

Price (1999), which summarizes an analysis of historical gross gamma logging data for the BX Tank Farm. This analysis by Randall and Price in addition to SGLS repeat logging identifies areas of possible contaminant movement within the BX Tank Farm vadose zone.

2.1 High Rate Logging

During SGLS logging operations in the BX Tank Farm in 1997, it soon became apparent that many subsurface intervals exhibited very high gamma-ray fluxes, such that the SGLS detectors became saturated, yielding no usable data.

On the basis of this experience and in response to recommendations from the Expert Panel (a panel of experts appointed by DOE to provide independent oversight of vadose zone technical investigations [DOE 1997b]), DOE-GJO designed a sonde capable of recording gamma-ray spectra while operating in intense gamma-ray fluxes. The detector is a low-efficiency, 6-millimeter (mm) by 8-mm n-type HPGe detector. The sonde containing the detector is operated by either of the SGLSs. This system is referred to as the High Rate Logging System (HRLS). Information regarding this system and its calibrations are described in a base calibration report (DOE 1999).

The HRLS operates normally in gamma-ray fluxes intense enough to "saturate" the SGLSs. Saturation refers to the circumstance when the detector records spectra in which the peaks (full energy peaks) are tiny or even absent. This situation is an extreme manifestation of "pileup," of which two types contribute to degradation of spectra (Knoll 1989). "Pulse pileup" occurs when the photon flux at the detector is so great that the probability is high that two or more photons will deposit their energies in the detector within a time interval that is short compared to the time resolution of the system. The electrical charge liberated by the several photons is then processed as if just one photon were involved. Pulse pileup events give output pulses with variable amplitudes because the amplitude of each output pulse depends on the total energy of the several captured photons that contribute to the pulse. The pulses with variable amplitudes add counts to the spectral background continuum, and the photons that participate in pileup are lost, in the sense that they contribute to the spectral background instead of a peak. Consequently, as pileup events increase in frequency, the spectral peaks become more and more obscure. Because peak counts are lost, the peak intensities are no longer proportional to the source concentrations.

Like the SGLSs, the HRLS is essentially nonparalyzable. "Nonparalyzable" and "paralyzable" describe system behavior during "dead periods" of data acquisition (Knoll 1989). In nonparalyzable systems, the deposition of photon energy in the detector is followed by a brief time interval, or dead period, of fixed duration, during which the output electrical pulse is being processed. The system is unresponsive to any additional photons that enter the detector during the dead period. If the gamma-ray flux is intense, a significant number of photons enter the detector during dead periods, and are uncounted. Thus, the count rate rises as the gamma flux increases, but the count rate does not rise as rapidly as the flux. The count rate is non-linear in relation to flux, but linearity is imposed by applying the dead time correction to the recorded count rates (DOE 1995).

In a paralyzable system, of which certain of the old Hanford Geiger-Mueller-based monitoring systems are examples, the deposition of photon energy in the detector is followed by a dead period, but the duration of this period is lengthened if additional photons enter the detector during the dead period. Thus, on average, the dead periods grow longer as the gamma flux increases. A consequence is that as the gamma flux on the detector increases, the output count rate rises, but the count rate eventually reaches a maximum, then the rate decreases if the gamma flux continues to climb. Data from paralyzable systems may be ambiguous in high gamma-ray fluxes and may significantly underestimate contaminant concentrations.

Two tungsten shields that can be used individually or in combination are available to extend the range of the high rate detector. One is a 0.31-inch (in.).-thick tungsten pipe sleeve, designated as the external shield, that fits over the sonde housing. The other is a 0.7-in.-thick tungsten "cup," designated as the internal shield, that fits over the high rate detector, filling the excess space inside the sonde normally occupied by the SGLS detector. By using the shields individually or in combination, the measurement range of the high rate detector can be extended from several thousand picocuries per gram without shielding to about 100 million pCi/g using maximum shielding.

The HRLS presented a particularly difficult calibration challenge. Construction of test zones with uniformly distributed gamma-emitting radionuclides at high activity levels is not practical, for reasons of personnel exposure, cost, long-term surveillance requirements, and disposal. Hence, the calibration had to be carried out using existing calibration models. As a result, the relative degree of uncertainty for measurements made with the high rate tool is significantly higher than the uncertainty in the SGLS data. DOE (1999) describes the calibration in detail.

For the SGLS, dead time, casing, and water corrections are computed by the analytical software and the output values are concentrations in picocuries per gram. However, it was not practical to collect data for determination of casing and water correction factors for the HRLS. Only a dead time correction is applied to high rate data by the analysis software. Depending on the borehole configuration and whether or not shields were used, it may be necessary to apply correction factors to the data after processing is completed.

Calibration measurements for the HRLS were made with a 0.28-in. steel sleeve in place over the sonde to simulate the effects of 6-in. schedule-40 casing, which is the most common borehole casing used in Hanford tank farm boreholes. HRLS data accurately reflect contaminant concentrations in unsaturated intervals with 6-in. schedule-40 casing. When other casing configurations are present, a correction factor must be applied. The correction factor is determined by calculating the attenuation for the assumed casing thickness relative to attenuation associated with a 0.28-in. thickness of steel. No water correction factor is available.

When shields are used, an additional correction factor must be applied. Factors were determined for all three shield configurations (internal shield, external shield, and both shields) from field measurements of ^{137}Cs activity at 662 kilo-electron volts (keV). Shield correction factors for other energy levels can be determined by extrapolation of relative attenuation calculations.

^{137}Cs was the only radionuclide detected with the HRLS in the BX Tank Farm. All boreholes logged in the BX Tank Farm appear to have had 6-in. schedule-40 casing, with the exception of borehole 21-02-04, which had both 4-in. and 6-in. schedule-40 casings. This borehole was also reported to have cement grout in the annulus between the two casing strings. There are currently no correction factors for cement grout. High rate data correction factors for ^{137}Cs (662 keV) are provided in the following table:

6-in. Casing	4-in. & 6-in. Casing	Internal Shield	External Shield	Both Shields
1.000	1.41	27.42	3.758	96.40

2.2 Repeat Logging

Repeat logging using the SGLS is useful to evaluate possible contaminant movement over time by comparing concentration data. Analysis of historical gross gamma logging by Randall and Price (1999) has also proved useful for determining potential movement, particularly in zones of high gamma flux. A sufficient amount of time has not passed since the implementation of the HRLS to collect repeat data that would provide meaningful comparisons.

2.2.1 Spectral Gamma Logging System

Repeat logging was performed for selected borehole intervals in the BX Tank Farm using the SGLS. These boreholes were selected for repeat logging primarily because of zones that exhibited elevated total gamma count rates in the absence of identifiable radionuclides. Other reasons for repeat logging included the possibility of recent contaminant movement around a borehole and questionable data. The repeat logging typically was performed with longer counting times over limited depth intervals. Plots of repeat logging data are included in Appendix B. To provide for proper comparison of log data between the original baseline and the repeat logging, the shorter lived isotopes (^{60}Co and ^{125}Sb) were corrected for decay. No repeat logging data were included in the development of the BX Tank Farm contaminant visualizations.

2.2.2 Historical Gross Gamma Logging

In 1998, Randall and Price (1999) conducted an analysis of historical gross gamma-ray log data collected in the BX Tank Farm between 1975 and 1994. All historical log surveys for individual drywells (boreholes) were evaluated for each interval with elevated gross gamma count rates, allowing observations to be made regarding the stability of any contaminant interval over time. Conclusions from this analysis are presented in this addendum to identify areas in the vadose zone where contaminant movement may have occurred and to support conclusions drawn from comparisons of the repeat logs with the original baseline data.

3.0 Discussion of Results

3.1 High Rate Logging

Logging was conducted using the HRLS in all borehole intervals where the original SGLS logs indicated zones of detector saturation resulting from very high gamma fluxes. The SGLS provides reliable results from background levels up to several thousand picocuries per gram when an external shield is used. However, zones of more intense radiation were encountered around a number of boreholes in which dead times became excessive or the detector became saturated. The HRLS detected ^{137}Cs as the primary radionuclide in all but one of these intervals. The one interval where no ^{137}Cs peaks were identified in the spectra was probably due to an intense gamma-ray source remote from the borehole.

Table A-1 (Appendix A) summarizes borehole information where high rate logging was conducted in the BX Tank Farm. Included in the table are the depth intervals of each log run. A log run refers to a single sequential set of log data collected during a borehole logging event. Multiple log runs may occur, for example, when using different shield configurations or when logging is terminated at the end of a day. Depth overlaps (1 ft) typically occur between two log runs. The shield configuration and the corresponding correction factors for each log run are also listed on the table. The comments column of the table generally includes a brief description of the maximum concentration detected and an assessment of relative stability by Randall and Price (1999). A list of the specific HRLS data points used to create the interpreted HRLS data set is also included in these comments. The interpreted HRLS data set is the high rate data that is added to the baseline SGLS data.

^{137}Cs concentration values calculated from the high-rate data are presented on plots for each borehole (Appendix A). None of the HRLS ^{137}Cs concentration values have been corrected for decay. The high rate logging was performed approximately 2 years after the SGLS baseline data were collected. The reduction in ^{137}Cs due to decay is insignificant in this case. Each of these figures includes two graphs. The graph on the left plots the baseline SGLS data with the interpreted HRLS data to produce a composite baseline. Intervals of contamination that were removed from the interpreted data set are noted on this graph. Creation of the interpreted data set will be discussed in more detail in Section 4.1. The graph on the right plots all the baseline SGLS and HRLS data collected near the interval logged with the high rate tool. The scale has been expanded to allow the reader to compare the data. The legend separates the data by borehole logging event. Borehole logging events are designated sequentially as A, B, C, etc. This designation describes separate episodes of data collection from a borehole. Thus, Event A is the initial logging event and referred to as the SGLS baseline, while Events B or C are subsequent events that could refer to either repeat or HRLS logging.

3.2 Repeat Logging

Repeat logging was performed for selected depth intervals in 13 boreholes in the BX Tank Farm. Data were collected approximately 2 years after the original baseline data were collected in 1997.

Table B-1 (Appendix B) lists all the repeat logging performed in the BX Tank Farm using the SGLS and indicates the zones of investigation in each borehole, the reason for repeat logging, and an evaluation of the results. Appendix B also includes comparison log plots for the repeat logging events.

Log results for borehole 21-27-08 are included in Figure B-11 (Appendix B) to illustrate the usefulness of repeat logging. These logs appear to indicate an increase in $^{235}U/^{238}U$ concentrations between 110 and 148.5 ft. They also appear to indicate an increase in ^{60}Co between 135 and 140 ft. However, the gross gamma log analysis by Randall and Price (1999) suggests that the zones from 92 to 116 ft and from 130 to 146 ft have both been stable from 1979 to 1993, indicating there may have been an influx of contaminants into this zone between 1997 and 1999. However, routine drywell monitoring was discontinued in 1994, and only two data points are available in the period from 1994 to the present. Additional spectral gamma measurements and neutron moisture logging will be required to properly assess the probability of contaminant movement in this interval.

The remaining borehole logs included in Appendix B are self-explanatory. The log profiles in boreholes 21-02-03, 21-03-03, 21-27-01, and 21-27-11 may indicate possible contaminant increases since 1997. However, interpretation is not considered definitive because in most cases the observed changes in concentrations are within the error bars of the respective measurements. The Randall and Price (1999) assessment of historical gross gamma data does not support these findings. However, this assessment is based on the 1975-1994 time period while the SGLS and repeat data were collected in 1997 and 1999. Beginning in February 1996, increases in specific conductivity have been observed in groundwater monitoring wells associated with the B/BX/BY WMA (Narbutovskih 1998). Subsequent investigation has observed rapid increases and fluctuations in conductivity, nitrate, uranium, and ^{99}Tc concentration in groundwater monitoring wells in and around the B/BX/BY WMA. Several scenarios that could explain the observed groundwater contaminant behavior are presented in the Phase 1 assessment (Narbutovskih 1998). A common factor in each scenario is remobilization of contaminants associated with an existing vadose zone plume. Taken together, the groundwater data and the repeat logging data strongly suggest that contaminant movement may be continuing within BX Tank Farm. Additional periodic spectral gamma logging and neutron moisture logging will be required to investigate this issue. Figure B-1 is a map of the BX Tank Farm showing the location of each drywell and indicating those suspected of contaminant movement based on the SGLS repeat logging measurements and Randall and Price (1999) data.

3.3 Changes to the Interpreted Data Set

The original interpreted data set presented in the BX Tank Farm Report was updated by adding the high rate data to zones of SGLS detector saturation. The results of shape factor analysis were used to identify and eliminate most intervals where contamination is attributable to borehole effects from the data set used to create the original visualizations. Only minor additional modifications were made. Intervals eliminated from the data set used to create the original visualizations are indicated in black and intervals removed to create the revised data set are indicated in red.

Table C-1 (Appendix C) includes the rationale for removing specific depth intervals from the interpreted data set used to create the three-dimensional visualizations. Correlation plots of boreholes surrounding each tank are also included in Appendix C to provide a visual representation of the contaminated intervals. The table and correlation plots constitute the interpreted data set (Section 4.1).

4.0 Three-Dimensional Visualizations

An objective of this addendum is to create revised three-dimensional visualizations of the major contamination plumes within the vadose zone in the vicinity of the BX Tank Farm. ^{137}Cs, ^{60}Co, ^{125}Sb, ^{154}Eu, ^{152}Eu, ^{235}U, and ^{238}U were all detected in the BX Tank Farm. Visualizations were created for each of these radionuclides except ^{152}Eu, which only occurs in association with ^{154}Eu. The development of the geostatistical models and the resulting visualizations are described in the BX Tank Farm Report. The software package from C Tech Development Corporation called "Environmental Visualization System" (EVS) was used to create the visualizations in both the original BX Tank Farm Report and in this addendum. Improvements to the data input and calculation parameters implemented since the original report are described in the following sections.

4.1 Interpreted Data Set

The first step in the visualization process is to create an interpreted data set that represents the input to the kriging process. This data set consists of the original interpreted data set presented in the BX Tank Farm Report with the HRLS data added in intervals of SGLS detector saturation and contamination intervals judged to be not representative of the subsurface contamination removed.

Contamination values in the interpreted data set have not been corrected for decay and are thus representative of conditions in 1997 when the baseline data were collected.

Construction of the interpreted data set begins by creating a text file that contains all individual measurements from the SGLS data. The data set includes the horizontal coordinates and depth of each data point and the concentration value at that point. The data set is manually edited to

remove borehole intervals identified as non-representative, and to add HRLS data to zones of SGLS detector saturation.

4.2 Development of Three-Dimensional Visualizations

The total data domain for the calculations included all vadose zone monitoring boreholes within the BX Tank Farm. The domain was extended in the north-south and east-west directions to include the maximum and minimum borehole coordinate values. Borehole depths were converted to elevations, and the vertical extent of the domain was set to include the highest and lowest sample points.

The original visualizations utilized an adaptive gridding option that produces a model that contains estimated values everywhere inside a rectangular domain. A convex hull boundary option was selected to produce the visualizations shown in this addendum. This option produces an irregular boundary that is defined by the distribution of measured data points, and restricts the extrapolation of concentration values to that volume in the immediate vicinity of the data points.

The interpreted data set consists of measurement data at 0.5-ft intervals in vertical boreholes with a lateral separation generally on the order of tens of feet, resulting in a much greater data density in the vertical direction compared to the horizontal direction. To minimize processing time, search routines in the kriging algorithm utilize a limited number of data points closest to the calculation point, creating a situation in which a contaminated interval in a borehole tends to have an undue effect on nearby points. Because adjacent points in a single borehole are closer than points from another borehole, the data search routine is truncated after collecting all data points from a single borehole. To offset this effect, data points in individual boreholes were averaged over 5-ft intervals, significantly reducing the size of the input data set and the processing time. More importantly, it "forced" the search algorithm to bring in data from multiple boreholes at most calculation points, resulting in a more realistic extrapolation of concentration values into the region between boreholes. To maintain fidelity to the original data, sphere plots and other representations of measurement data are based on the interpreted data set, which contains actual values at 0.5-ft vertical increments.

4.2.1 Geostatistical Model

The EVS software determines geostatistical structure by calculating three-dimensional variograms that are plots of the variance of the data as a function of the distance between data points. The variogram is described by two parameters, the range and sill. The range is the distance beyond which the data points are no longer correlated (i.e., they are independent of one another), and the sill is the variance of all the data.

For the BX Tank Farm, the data did not show any significant decrease in variance as the data point-spacing decreased, implying that spatial correlation is poor and that more closely spaced data points are required to assess spatial variability. As a result, the geostatistical model takes on the form of the simple global variance value.

4.2.2 Three-Dimensional Plume Calculation and Visualizations

Kriging was used to estimate the contaminant concentration at points on a three-dimensional grid. Once this concentration grid was developed, visualizations of the estimated concentration of each radionuclide could be produced in the form of a solid surface model. The visualization can be moved, rotated, and viewed from any angle or direction; color printouts can also be produced.

The kriging process calculates the average radionuclide concentrations of a volume of sediment by using the information from nearby sample points. The influence of each sample point is determined by proximity, and weighting factors are based on the geostatistical structure.

The kriging software applies a horizontal-to-vertical anisotropy ratio that allows the user to influence the "fabric" of the data set. The anisotropy ratio applies a biased weighting to data points in horizontal and vertical directions from a given data node. The program default is 10, which means that data points a given distance in the horizontal direction from a node will have an influence 10 times greater than data points at the same distance in a vertical direction. Analyses were performed at several anisotropy values and the value that yielded results that appeared to best represent the measured distributions of each radionuclide was determined through trial and error. An anisotropy value of 4 was selected for the ^{137}Cs, ^{60}Co, ^{125}Sb, and ^{154}Eu plume calculations, and an anisotropy value of 2 was selected for the ^{235}U and ^{238}U plume calculations.

The MDLs for ^{137}Cs, ^{60}Co, ^{125}Sb, and ^{154}Eu were generally between 0.1 and 1.0 pCi/g. In the preprocessing module, a value of 0.01 pCi/g was substituted for non-detects for each radionuclide in the data file. This allowed the presence of non-detects in the data set to have an impact on computation of nodal values during the kriging process. During post-processing, values less than 0.1 pCi/g for ^{137}Cs, ^{60}Co, ^{125}Sb, and ^{154}Eu were ignored. The MDL for ^{235}U was generally greater than 1 pCi/g, so values less than 1 pCi/g were ignored during post-processing. The MDL for ^{238}U is generally about 10 pCi/g, so values less than 10 pCi/g were ignored during post-processing. Note that this is the MDL for "processed" ^{238}U, which is based on a different spectral peak, and is about two orders of magnitude greater than the MDL for "natural" ^{238}U.

During the kriging process, grids are constructed to encompass all data points in three-dimensional space. The horizontal extent of the grid is governed by the positions of the boreholes. The model does not extrapolate beyond the extent of either the range value or the kriging limit. As a result, both the grid and the associated visualizations can extend only to the maximum depth of the boreholes and the extent of the range.

In the visualization process, solid surfaces are created by connecting the three-dimensional points in space that have equal concentrations. The outermost solid surface of the plume is defined by a user-selected contamination threshold value or isolevel. To view an inner surface, a cut section is inserted through the solid surface plume. As the isolevel is increased, progressively higher radionuclide concentration surfaces can be visualized. Where a low concentration volume

surrounds a zone of higher concentration, a cut surface is helpful in visualizing the variation in concentration.

Tanks were portrayed by creating solid three-dimensional surfaces at the location of the tank centers. In regions occupied by tanks, the model does not insert a contamination barrier so that contamination in a borehole can have some influence on concentrations on the opposite side of the tank. In a geostatistical estimation calculation, the closest boreholes will have the greatest influence and the model will be close to the actual distribution, except for areas where there are few or no boreholes.

4.3 Potential Uncertainties and Inaccuracies

The visualizations presented in this report are based on estimated radionuclide values as determined by geostatistical estimation (kriging) procedures applied to an interpreted data set that has been averaged over 5-ft depth intervals. In addition to the uncertainties associated with geostatistical estimation applied to an interpreted and averaged data set, there are other sources of uncertainty that must be considered. These include uncertainties in the assay calculation process as well as counting error. The uncertainty in assay calculation is discussed in the base calibration report (DOE 1995) and subsequent recalibration reports. It is estimated by combining errors associated with the calibration efficiency determination, counting statistics of the calibration measurements, and uncertainties in the model concentration values. The counting error is associated with the random nature of the radioactive decay process.

Potential model inaccuracies may also result from zones of high ^{137}Cs concentrations (and resultant detector saturation). Where SGLS detector saturation occurred in the original baseline, no concentration values could be calculated, or they were highly suspect. Therefore, a value of 8,000 pCi/g was placed in the database for kriging operations. In this addendum, concentration values computed from high rate log data were substituted in the previously saturated intervals. However, other radionuclides may not have been detected in zones of detector saturation, and may thus be under-represented in the interpreted data set and the visualizations if they are not present in sufficient concentrations to be detected by the HRLS.

The calibration of the logging system assumes contamination uniformly distributed in a homogeneous medium that is effectively infinite in extent relative to the detector in both horizontal and vertical directions. This assumption is valid for most situations except at the very top and the bottom of the boreholes or where the concentration changes rapidly with depth or distance from the borehole. The data acquisition interval used to log the BX Tank Farm boreholes (0.5 ft) provides adequate spatial resolution to characterize the situations where the contamination is not homogeneous in the vertical dimension.

Most inaccuracies or errors in the visualizations are insignificant compared to the inaccuracy caused by the introduction of contamination along the borehole and the generation of so-called false plumes. However, the potential for the generation of a false plume from contaminated boreholes is considered during the interpretation process. Specific borehole intervals suspected

to be primarily borehole contamination have been removed from the interpreted data set as discussed previously.

The visualizations are intended to provide the reader with an understanding of how gamma-emitting contaminants that have leaked from the tanks may be distributed in the vadose zone sediments. A valuable attribute of the visualizations is that they can be utilized to define areas of concern in which to focus future characterization and monitoring efforts.

The radionuclide contamination plumes presented in the visualizations were evaluated by comparing the visualizations with the spectral gamma-ray log data from the individual monitoring boreholes surrounding the tanks. The interpretation of each plume or group of plumes is discussed in Section 4.4.

4.4 Discussion of Visualizations

The following section presents a discussion of the visualizations created with the interpreted data set as discussed previously. The visualizations are provided in Appendix D in the order in which they are discussed.

Appendix Figure D-1 illustrates the ^{137}Cs contamination derived from the interpreted data set for all boreholes logged in the BX Tank Farm. This figure portrays the data values at 0.5-ft intervals as spheres that are colored and sized to show the relative radionuclide concentration. The concentrations are presented with logarithmic color scales that range from 0.1 to as high as 100 million pCi/g. The borehole numbers are indicated to facilitate correlation of the three-dimensional representation of the data in the remaining figures with the plan plot and the correlation plots presented in Appendix C.

Figures D-2 through D-7 are similar to Figure D-1 except they portray ^{60}Co, ^{154}Eu, ^{152}Eu, ^{125}Sb, ^{235}U, and ^{238}U, respectively. The logarithmic color scales have also been changed to reflect the concentration range of each radionuclide.

Figures D-8 through D-15 show horizontal planar slices at various depths in the BX Tank Farm. The slices illustrate the distribution of contaminants that occur at concentrations greater than the isolevels listed on each figure. The depths of these slices were selected to indicate a balance of concentration and areal extent of plumes.

The slice at 6 ft provides the best representation of near-surface contamination. The next slice at 13 ft, which lies just below the top of the tanks, shows fairly widespread ^{137}Cs contamination. The slice at 24 ft, near the depth of the transfer lines, shows the tops of several plumes. The ^{137}Cs plume between tanks BX-107 and -110 is thought to originate from a surface spill and/or transfer line leak. A transfer line, which runs west from the 241-BX-153 Diversion Box, turns north between tanks BX-107 and BX-110 and connects to tank BY-108 in the BY Tank Farm (Figure A-2, Wood et al. 2000), is one possible source of this contamination. This plume

appears to extend to at least the 105-ft depth, and may be spreading to the south, although there is little horizontal control in that direction.

The plume on the northeast side of tank BX-101 is thought to originate from the sluice pit on top of the tank. A portion of this plume may have originated from a leak in the tank itself as stated in the BX Tank Farm Report. This plume consists of ^{137}Cs, ^{60}Co, ^{125}Sb, ^{152}Eu, and ^{154}Eu and shows very little evidence of lateral spreading, but may extend to a depth of at least 80 ft as shown by the ^{60}Co in Figure D-13.

The BX-102 plume is thought to originate from a spare inlet nozzle as a result of overfilling in 1951. Because of this suspected leak, the tank was placed on limited service. The contents were reduced to a level of about 22 inches. This incident is estimated to have released approximately 91,600 gal of metal waste to the vadose zone (Wood et al. 2000). This inlet nozzle is located on the southeast side of tank BX-102 near borehole 21-02-04. The major constituent of metal waste was 22.5 tons of processed uranium (^{235}U and ^{238}U). The processed uranium appears to be fairly mobile. It is first observed in the slice from 80 ft, and becomes more laterally extensive in each of the next two slices from 104 and 126 ft. Available data indicate that the plume extends eastward and deeper than the volume investigated by the vadose zone boreholes discussed in this addendum. Furthermore, analysis of historical gross gamma logs and SGLS repeat log data strongly suggests that contaminant movement may be continuing.

Plumes from tanks BX-108, BX-110, and BX-111, all assumed leakers, are most evident on the slice from 43 ft. These plumes appear to have commingled. The plumes from tank BX-108 and BX-111 do not extend below 65 ft, and the tank BX-110 plume does not extend below 80 ft.

The last plume of any consequence appears only in the slice from 43 ft on the southeast side of tank BX-106. This tank is not listed as a leaker and the contamination may be due to overfilling or a possible transfer line leak that ran down the side of the tank and spread laterally at the base of the tank farm excavation. Historical gross gamma data and SGLS repeat logging data do not provide any indication of continuing movement.

Figures D-16 through D-21 (Appendix D) are three-dimensional visualizations that illustrate contamination plumes for each major radionuclide within the vadose zone at the BX Tank Farm. The figures show the plumes created with the EVS software superimposed over the SGLS and HRLS data from the interpreted data set. In these figures, the plumes are presented with a degree of transparency to view the data that define the plume. Each figure is viewed looking down at the tanks from the southeast. Only three selected radionuclides were presented on each figure so the extent of each plume can more easily be viewed.

Figures D-22 through D-24 (Appendix D) are visualizations of plumes in the vicinity of tanks BX-101 and BX-102. The figures show the plumes created with the EVS software superimposed over the SGLS and HRLS data from the interpreted data set. In these figures, the plumes are presented with a degree of transparency to view the data that define the plume. Each figure is viewed looking up at the tanks from the southeast. Only three selected radionuclides were

presented on each figure so the extent of each plume can more easily be viewed. Figure D-22 shows the ^{60}Co plume associated with tank BX-101 separate from the ^{137}Cs and ^{125}Sb plumes associated with tank BX-102. The next figure (D-23) shows both the ^{60}Co and the ^{154}Eu plumes from tank BX-101 and the ^{137}Cs from tank BX-102. Figure D-24 shows the separate plumes of ^{125}Sb for both tanks. This figure also shows the ^{137}Cs and the ^{238}U associated with tank BX-102.

Figure D-25 (Appendix D) shows a view from the southeast of the plumes associated with tanks BX-101 and BX-102. These plumes are cut by a southwest-northeast-trending vertical plane that passes through tank BX-101 and southeast of tank BX-102. This cut exposes the interior of the plumes showing the highest concentrations. This view indicates that there may be little commingling between the plumes from tanks BX-101 and BX-102.

Figure D-26 (Appendix D) shows a view from the south of the ^{137}Cs plumes at the BX Tank Farm. ^{137}Cs data from borehole 21-02-04 have been superimposed.

Figure D-27 (Appendix D) shows a view from the south of the ^{238}U plumes at the BX Tank Farm. Intervals of elevated gross-gamma activity that were encountered during the drilling of borehole 22-02-04 have been superimposed.

4.5 Contaminated Volume and Total Activity Estimate

With completion of the revised visualizations, it became possible to calculate a rough estimate of the volume of contaminated soil and total activity inventory as a function of contaminant threshold level within the plumes shown in the BX Tank Farm visualizations. Volume estimates are prepared by numerically integrating the volume within the specified isosurface. Contaminant inventories (in Curies) are calculated by numerically integrating the total mass within the isosurface. The total activity for each volumetric element is determined by multiplying the specific activity (concentration) in picocuries per gram by the mass per volume (density) for each element. A density of 1.8 g/cm^3 was assumed in the volume calculation.

These estimates are based on the kriged values extrapolated from the interpreted data set, where concentration values have been averaged over 5-ft intervals. They represent the volumes of the contaminated formation and total radioactivity for ^{137}Cs, ^{60}Co, ^{154}Eu, ^{125}Sb, ^{235}U, and ^{238}U. The total activity represents values at the time of the baseline logging in 1997. The activities have not been corrected for decay. These estimates are based entirely on the data from the baseline spectral gamma characterization program (SGLS), with HRLS data included in zones of detector saturation. The data sets used for the volume and total activity inventory estimates did not include any data from historical gross gamma logs, or any soil sample data.

The contribution from ^{60}Co, ^{154}Eu, ^{125}Sb, ^{235}U, and ^{238}U may be slightly underestimated because these data are not always measured accurately in zones of high gamma flux by the HRLS. A further limitation of this inventory is that no data are available from directly under the tanks where presumably the highest concentrations of radionuclides would exist.

The table below lists the threshold levels, the contaminated soil volume, and total activity that occurs at or above each level for ^{60}Co, ^{154}Eu, ^{125}Sb, ^{235}U, and ^{238}U.

Contaminant	Contaminant Threshold (pCi/g)	Contaminated Volume (Cubic Meters)	Total Activity (Curies)
^{137}Cs	0.5	85,830	967
	5	36,800	966
	50	20,650	965
	500	12,580	956
	5,000	5,960	913
	50,000	1,889	710
	5×10^5	212	286
	1×10^6	98.6	187
^{60}Co	0.1	14,500	1.05×10^{-2}
	0.5	2,347	6.7×10^{-3}
	1	1,207	5.2×10^{-3}
	5	164	1.7×10^{-3}
^{154}Eu	0.5	1,610	0.019
	5	477	0.015
	10	289	0.012
	40	59.2	4.36×10^{-3}
^{125}Sb	0.1	10,720	7.24×10^{-3}
	0.5	2,137	4.3×10^{-3}
	1	1,078	2.9×10^{-3}
	2	321	1.2×10^{-3}
^{235}U	2	11,070	0.120
	5	4,667	0.082
	10	1,799	0.046
	20	429	0.016
^{238}U	20	14,550	1.93
	50	7,220	1.49
	100	3,345	0.98
	200	1,039	0.45

5.0 Conclusions

The purpose of this addendum is to provide an update to the original BX Tank Farm Report that was issued 2 years ago. The essential interpretations in the original report are consistent with those cited in this addendum. However, since the original report was issued, knowledge has been gained that provides a more complete framework by which the contaminant distribution can be viewed. In addition, enhancements to the data collection and analysis process have been made since the BX Tank Farm Report was issued. Some of the more important improvements in the understanding of the log data have resulted from the following:

- Although revaluation of shape factor results and other data provided justification for eliminating many borehole contamination intervals from the interpreted data set, most intervals of significant contamination remain and only relatively low-concentration "ghost" plumes were eliminated from the visualizations.

- Contamination associated with gamma-emitting radionuclides does exist in the formation at significant depth (at least 150 ft).

- Analysis of historical gross gamma logging data provides a qualitative identification of contaminant movement. In addition, repeat logging using the SGLS has allowed for quantitative determination of concentration increases.

- High rate geophysical logging has allowed determination of maximum concentrations in contamination plumes, providing an improved basis to estimate the volume of contaminated soil and contaminant inventory within the volume of the vadose zone investigated by the tank farm boreholes. It also provides a method for future quantitative comparisons to detect contaminant movement in high gamma flux zones.

Re-evaluation of existing data, integration of the high rate data, and re-calculation of the spatial distribution based on the revised interpreted data set have resulted in an improved visualization of subsurface contaminant distribution in the BX Tank Farm. Conclusions stated in the original BX Tank Farm Report remain appropriate and will not be entirely reiterated. However, one finding of major significance is that evaluation of repeat logging data and independent assessment of historical gross gamma data indicate that ^{60}Co and $^{235}U/^{238}U$ movement through the vadose zone has occurred in the past and appears to be continuing. For the purpose of illustrating this contaminant movement, a plan map of the BX Tank Farm (Figure B-1) is included in Appendix B showing boreholes where contaminant movement has occurred in the past and may be continuing. This information is based on work performed by Randall and Price (1999) and the SGLS repeat logging. However, routine gross gamma logging was discontinued in 1994, and there has been no comprehensive monitoring effort since that time. Hence, evidence of continued movement since 1995 is based on very limited data.

Log data from borehole 21-02-04 exhibit anomalously high concentrations of ^{137}Cs over the entire length of the borehole to a maximum depth of 231 ft. Intervals of SGLS detector

saturation occur between 5 and 12 ft, 30 to 101 ft, and 125.5 to 231 ft. HRLS data indicate ^{137}Cs concentrations of 10^6 to more than 10^7 pCi/g from 31 to 84 ft, decreasing gradually to between 10^3 and 10^5 pCi/g from 102 to 125 ft. At about 125 ft, there is an abrupt increase to about 10^6 pCi/g, and levels remain relatively constant between 10^5 and 10^6 pCi/g over the remainder of the borehole. This borehole has double casing with annular grout. The double casing and high count rates preclude the use of shape factor analysis to assess the distribution of contamination with respect to the borehole. An investigation into the BX-102 leak (Womack and Larkin 1971) reported that all contaminants found from approximately 120 ft to groundwater while drilling borehole 21-02-04 were attributed to dragdown. However, radiation levels as high as 10,000 counts per minute were recorded on samples from depths below 200 ft as the borehole was drilled in 1970. In 1976, the original casing was perforated from 236 to 90 ft and from 20 ft to the ground surface, and a 4-in. casing was installed to 240 ft and grouted into place. Evaluation of historical gross gamma data by Randall and Price (1999) indicates that contaminated intervals appear to be stable, with decreases consistent with decay of ^{137}Cs, but no data are available below 150 ft. ^{137}Cs contamination below 83.5 ft is attributed primarily to borehole effects and has been removed from the interpreted data set. However, concentration levels of 10^5 to 10^6 pCi/g are much higher than those typically associated with dragdown effects. Three explanations are offered for the observed contaminant profile in 21-02-04:

- Borehole contamination and/or contaminated annular grout between casings. (This may be masking zones of subsurface contamination.)

- Subsurface contamination in the formation. This is not considered likely because experience with ^{137}Cs at other locations suggests it has a very high sorptive capability and does not generally migrate to such depths. The presence of an interval of continuous ^{137}Cs contamination in excess of 10^5 pCi/g more than 100 ft thick at this depth would be considered very unusual.

- Contaminant migration along the casing. The possibility exists that the borehole itself is serving as a contaminant migration pathway and contamination is moving along the outside of the well casing.

The data available at present are not sufficient to explain the observed radionuclide distribution. Womack and Larkin (1971) note that ^{137}Cs was detected in soil samples to at least 120 ft, and that ^{137}Cs was detected in a groundwater sample. They attribute the presence of ^{137}Cs in the groundwater to "the spread of minor contamination during the drilling of the well." However, the fact that contamination was encountered at depth when the borehole was drilled strongly suggests the borehole encountered pre-existing contamination. If so, this would indicate that subsurface contamination may extend to significantly greater depth than indicated on the visualizations. Figure D-26 (Appendix D) shows the location of the contaminated interval in borehole 21-02-04 relative to the ^{137}Cs plume shown in the visualizations.

The contamination encountered at depth in 21-02-04 may be associated with the uranium plume originating from the 1951 leak of metals waste from tank BX-102. Wood et al. (2000) cite a

1951 production report that mentions overfilling tank BX-102 with metals waste with an estimated loss of 91,600 gal containing 20,412 kilograms of uranium. This report was declassified in 1992, and it is not known if Womack and Larkin were aware that metals waste had been sent to tank BX-102. It does not appear that any analysis was made for uranium in either soil or water samples from borehole 21-02-04. Figure D-27 (Appendix D) shows the location of contamination detected during the drilling of borehole 27-02-04 relative to the uranium plume shown in the visualizations.

The contaminated interval in the lower portion of borehole 21-02-04 is highly unusual. Although levels are relatively high, it appears likely that most of the observed contamination is due to borehole contamination effects. Borehole 21-02-04 is significantly deeper than other boreholes in the BX Tank Farm and there are no other data points to provide horizontal corroboration at depth. Therefore, the contamination below 120 ft has been removed from the data set used to create the visualizations. However, if any of the observed contamination is legitimate, then the plumes shown in the visualizations would be significantly enlarged and would extend much deeper than currently shown.

Boreholes 21-27-07, 21-27-09, and 21-27-10 also exhibit increases in ^{137}Cs activity from less than 1 to about 10 pCi/g at approximately 115 to 120 ft. These intervals were tentatively identified as dragdown and removed from the interpreted data set. This decision is supported by the lack of ^{137}Cs at that depth interval in borehole 21-27-08, which lies between these three boreholes and 21-02-04.

Another area of concern is the ^{137}Cs plume between tanks BX-107 and BX-110. High rate logging was used to determine the ^{137}Cs concentration profiles in zones of SGLS detector saturation in boreholes 21-07-06, 21-10-03, and 21-10-05. The source or sources of these plumes are still ambiguous. The sources are probably from a combination of BX-107 and BX-110 tank leaks and/or leaks from transfer lines. Tank BX-107 is currently designated as sound (Hanlon 2000).

^{235}U originally detected in borehole 21-10-05 has been removed from the baseline because reevaluation of the spectra suggests it was the result of an analytical error.

A zone of SGLS detector saturation between 21 and 25 ft in borehole 21-03-12 was logged with the high rate tool. Because the spectra had no photopeaks, no ^{137}Cs was detected in this zone with the HRLS. However, SGLS logs show ^{137}Cs present above and below the zone that can be attributed to a remote zone of high gamma activity such as a transfer line. The high activity detected with the SGLS was probably the cascade line connecting tanks BX-103 and BY-101 (BY Tank Farm).

$^{235}U/^{238}U$ were detected in borehole 21-03-03 at a depth of 84.5 ft during the repeat logging. Processed uranium was not detected in this borehole during the baseline logging, which could indicate a plume of processed uranium that is moving laterally into this zone. Randall and Price

(1999) indicate an increase in total gamma activity in this borehole between 60 and 80 ft from 1975 to 1976, which, on the basis of decay behavior, they attribute to ^{106}Ru.

6.0 Recommendations

Recommendations included in the original BX Tank Farm Report have not substantially changed. Areas where recommendations have been implemented have resulted in improvements in the understanding of the nature and extent of vadose zone contamination in the BX Tank Farm. Three areas have been particularly useful in providing the updates in this addendum: the introduction of high rate logging, repeat SGLS logging, and independent analysis of historical gross gamma log data.

The baseline data reported in the BX Farm Report and in this addendum have provided an indication of the nature and extent of contamination migration associated with gamma-emitting radionuclides. Evaluation of historical data and relogging of selected holes have indicated that contaminant migration is continuing. However, the gross gamma logging program was terminated in 1994, and little new data are available to assess continuing migration. Therefore, it is imperative that a routine monitoring program be reinstated within the BX Tank Farm as soon as possible. It is not necessary to monitor all boreholes; the BX baseline data clearly indicate where monitoring data are required and provide guidance as to measurement frequency. The monitoring program should be based on the use of calibrated detectors with continuing verification measurements to assure detector stability. Both the SGLS and HRLS are complex and relatively slow. A faster logging system capable of routine operation by tank farms personnel should be deployed. Preliminary work has been completed on such a system, known as the Radioelement Assessment System (RAS). Priority should be given to completion of the RAS, and a monitoring plan should be developed. The SGLS and HRLS should remain available for follow-up investigation of anomalies.

It is particularly important that a borehole be drilled to groundwater near the southeast quadrant of tank BX-102 to investigate the anomaly observed in borehole 21-02-04. Results from this borehole were discussed previously. Although the contaminated intervals at depth have been attributed to borehole effects and were not included in the interpreted data set used to create the visualizations, the supporting data for this determination are equivocal and the evaluation discussed above is partly speculative. Deep migration of ^{137}Cs and possibly also $^{235/238}U$ remains a possibility, and should be investigated with a new borehole at the earliest opportunity.

Additional boreholes should be drilled and samples collected to further investigate contaminant plumes identified by the baseline study. This is particularly important for the area immediately north and east of tank BX-102, where it appears that $^{235}U/^{238}U$ have migrated to significant depths in the vadose zone and may have reached groundwater near well 299-E33-41 (Narbutovskih 1998). This may be accomplished by simply deepening some of the existing 27 series boreholes.

Results of Phase I Groundwater Quality Assessment for Single-Shell Tank Waste Management Areas B-BX-BY at the Hanford Site (Narbutovskih 1998) indicated several driving forces that may be contributing to the remobilization of contaminants in the BX Tank Farm. Moisture logging in boreholes in the vicinity would provide valuable data regarding the presence of moisture in the vadose zone that may be a controlling factor for contaminant migration. Womack and Larkin (1971) cite moisture logs run in borehole 21-02-04, and note that peaks observed in the moisture data appeared to be associated with peaks in the gross gamma data.

7.0 References

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Appendix A
Summary of High Rate Logging Results for the BX Tank Farm

Table A-1. Summary of High Rate Logging Results for the BX Tank Farm

Borehole Number	Log Run Depth Interval (ft)	Shield/ Correction Factor[a]	Comments
21-02-04	0.0 - 9.0	NS/1.00	^{137}Cs was identified throughout the entire borehole. This borehole was double cased with 4-in. and 6-in. casings from 0.0 to 240.0 ft. A casing correction factor of 1.41 was applied to all HRLS data. The highest concentration (10^7 pCi/g) occurs at 39.5 ft. R/P[b] indicate all contaminants from 0 to 148 ft have been stable from 1980 to 1994. The HRLS ^{137}Cs data added to the baseline data: 2.5 - 19.5 ft HRLS ^{137}Cs (w/no shield) 29.0 - 30.0 ft HRLS ^{137}Cs (w/no shield) 30.5 - 83.0 ft HRLS ^{137}Cs (w/internal shield) 83.5 - 231.0 ft HRLS ^{137}Cs (w/no shield)
	8.0 - 30.5	NS/1.00	
	30.0 - 60.5	IS/27.42	
	30.0 - 67.0	NS/1.00	
	59.5 - 83.0	IS/27.42	
	66.0 - 84.0	NS/1.00	
	83.0 - 125.0	NS/1.00	
	124.0 - 164.0	NS/1.00	
	163.0 - 190.0	NS/1.00	
	189.0 - 231.0	NS/1.00	
21-03-12	21.0 - 26.0	NS/1.00	No man-made radionuclides were identified in the high rate spectra. Possible remote source such as a pipeline. A rerun from 26.0 - 21.0 ft was logged to check the repeatability of the HRLS. R/P indicate the ^{137}Cs from 15 to 35 ft has been stable from 1983 to 1993.
	21.0 - 26.0 (rerun)		
21-07-06	23.0 - 43.0	NS/1.00	^{137}Cs was identified throughout the interval. The highest concentration (10^6 pCi/g) occurs at 44.0 ft. R/P indicate the ^{137}Cs from 20 to 99 ft has been stable from 1980 to 1994. The HRLS ^{137}Cs data added to the baseline data: 24.5 - 39.0 ft HRLS ^{137}Cs (w/no shield) 39.5 - 47.0 ft HRLS ^{137}Cs (w/external shield) 47.5 - 52.0 ft HRLS ^{137}Cs (w/no shield) 58.0 - 95.0 ft HRLS ^{137}Cs (w/no shield)
	39.0 - 47.0	ES/3.758	
	42.0 - 45.0	NS/1.00	
	44.0 - 53.0	NS/1.00	
	52.0 - 74.0	NS/1.00	
	73.0 - 95.0	NS/1.00	

[a] Shield configuration options: NS - No shield; ES - External shield; IS - Internal shield; BS - Both shields.
[b] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

Table A-1 (con't.). Summary of High Rate Logging Results for the BX Tank Farm

Borehole Number	Log Run Depth Interval (ft)	Shield/ Correction Factor[a]	Comments
21-08-07	10.0 - 4.0	NS/1.00	^{137}Cs was identified between 5.0 and 5.5 ft and between 7.5 and 9.0 ft. The highest concentration (10^3 pCi/g) occurs at 8.5 ft. R/P indicate the ^{137}Cs and ^{60}Co from 30 to 54 ft have been stable from 1975 to 1994. The HRLS ^{137}Cs data added to the baseline data: 5.0 - 5.5 ft HRLS ^{137}Cs (w/no shield) 7.5 - 9.0 ft HRLS ^{137}Cs (w/no shield)
21-10-03	0.0 - 9.0	NS/1.00	^{137}Cs was identified throughout all intervals. The highest concentration (10^7 pCi/g) occurs at 11.5 ft. R/P indicate the ^{137}Cs from 0 to 96 ft has been stable from 1980 to 1994. The HRLS ^{137}Cs data added to the baseline data: 2.5 - 7.5 ft HRLS ^{137}Cs (w/no shield) 8.0 - 18.0 ft HRLS ^{137}Cs (w/internal shield) 18.5 - 24.0 ft HRLS ^{137}Cs (w/external shield) 24.5 - 39.5 ft HRLS ^{137}Cs (w/no shield) 45.5 - 55.0 HRLS ^{137}Cs (w/no shield) 77.0 - 87.0 HRLS ^{137}Cs (w/no shield)
	8.0 - 18.0	ES/3.758	
	8.0 - 18.0	IS/27.42	
	8.0 - 24.0	NS/1.00	
	17.0 - 24.0	ES/3.758	
	23.0 - 41.0	NS/1.00	
	40.0 - 55.0	NS/1.00	
	76.0 - 87.0	NS/1.00	
21-10-05	34.0 - 63.0	NS/1.00	^{137}Cs was identified from 35.0 to 63.0 ft. The highest concentration (10^5 pCi/g) occurs at 39.0 ft. R/P indicate the ^{137}Cs from 31 to 62 ft and from 74 to 85 ft has been stable from 1980 to 1989. The HRLS ^{137}Cs data added to the baseline data: 35.0 - 63.0 ft HRLS ^{137}Cs (w/no shield)

[a] Shield configuration options: NS - No shield; ES - External shield; IS - Internal shield; BS - Both shields.
[b] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

Table A-1 (con't.). Summary of High Rate Logging Results for the BX Tank Farm

Borehole Number	Log Run Depth Interval (ft)	Shield/ Correction Factor[a]	Comments
21-11-03	45.0 - 39.0	NS/1.00	^{137}Cs was identified from 40.0 to 44.0 ft and at 45.0 ft. The highest concentration (10^4 pCi/g) occurs at 42.0 ft. R/P indicate the ^{137}Cs from 0 to 10 ft and from 34 to 44 ft is undetermined. The ^{137}Cs from 44 to 94 ft has been stable from 1980 to 1989. The HRLS ^{137}Cs data added to the baseline data: 40.5 - 43.5 ft HRLS ^{137}Cs (w/no shield)
21-11-04	37.0 - 43.0	NS/1.00	^{137}Cs was identified from 38.0 to 41.5 ft. The highest concentration (10^4 pCi/g) occurs at 40.0 ft. A rerun from 26.0 - 21.0 ft was logged to check the repeatability of the HRLS. R/P indicate the ^{137}Cs from 35 to 46 ft has been stable from 1980 to 1989. The HRLS ^{137}Cs data added to the baseline data: 39.0 - 41.0 ft HRLS ^{137}Cs (w/no shield)
	37.0 - 43.0 (rerun)		

[a] Shield configuration options: NS - No shield; ES - External shield; IS - Internal shield; BS - Both shields.
[b] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

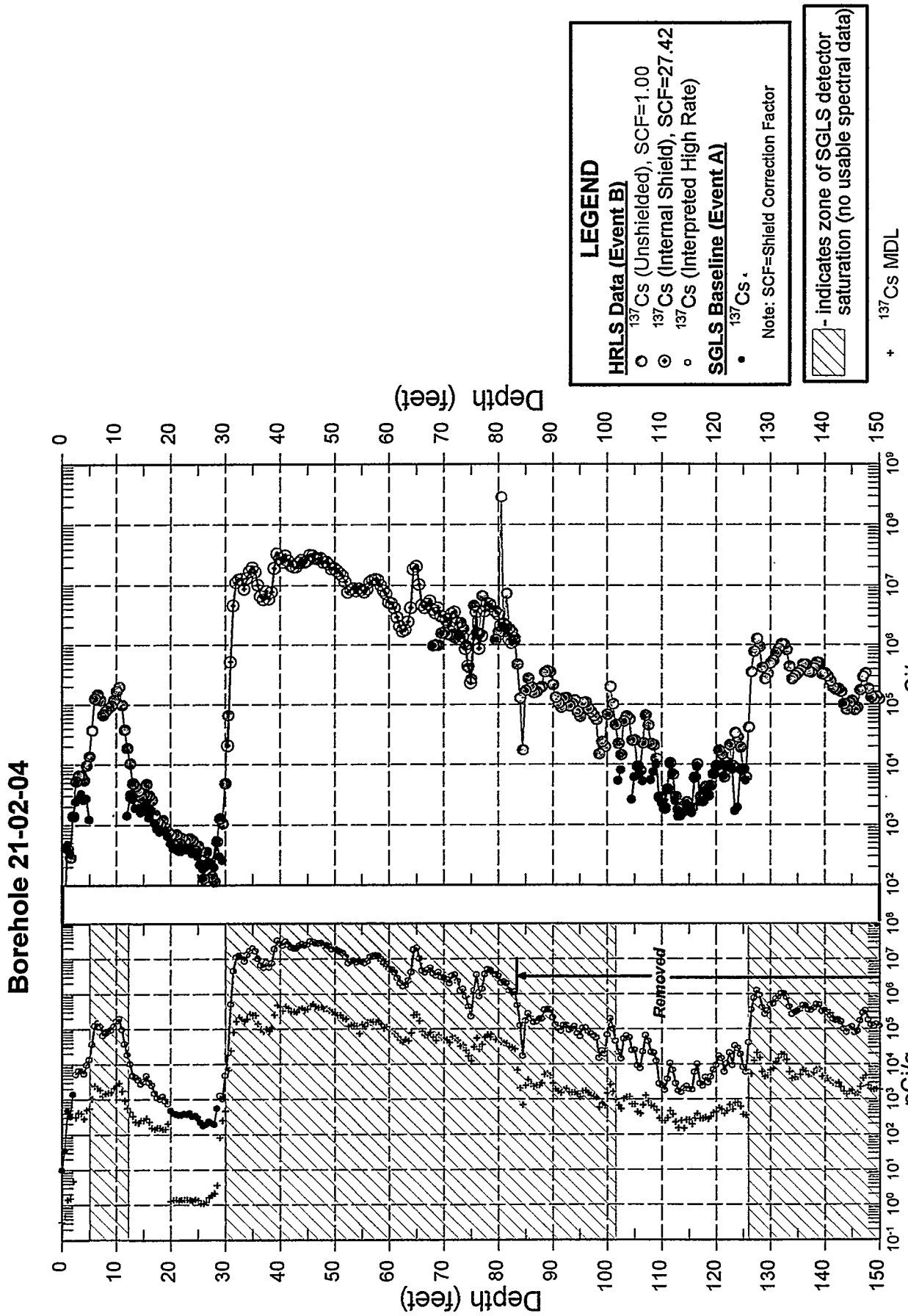

Figure A-1. Summary of High Rate Logging Results for the BX Tank Farm

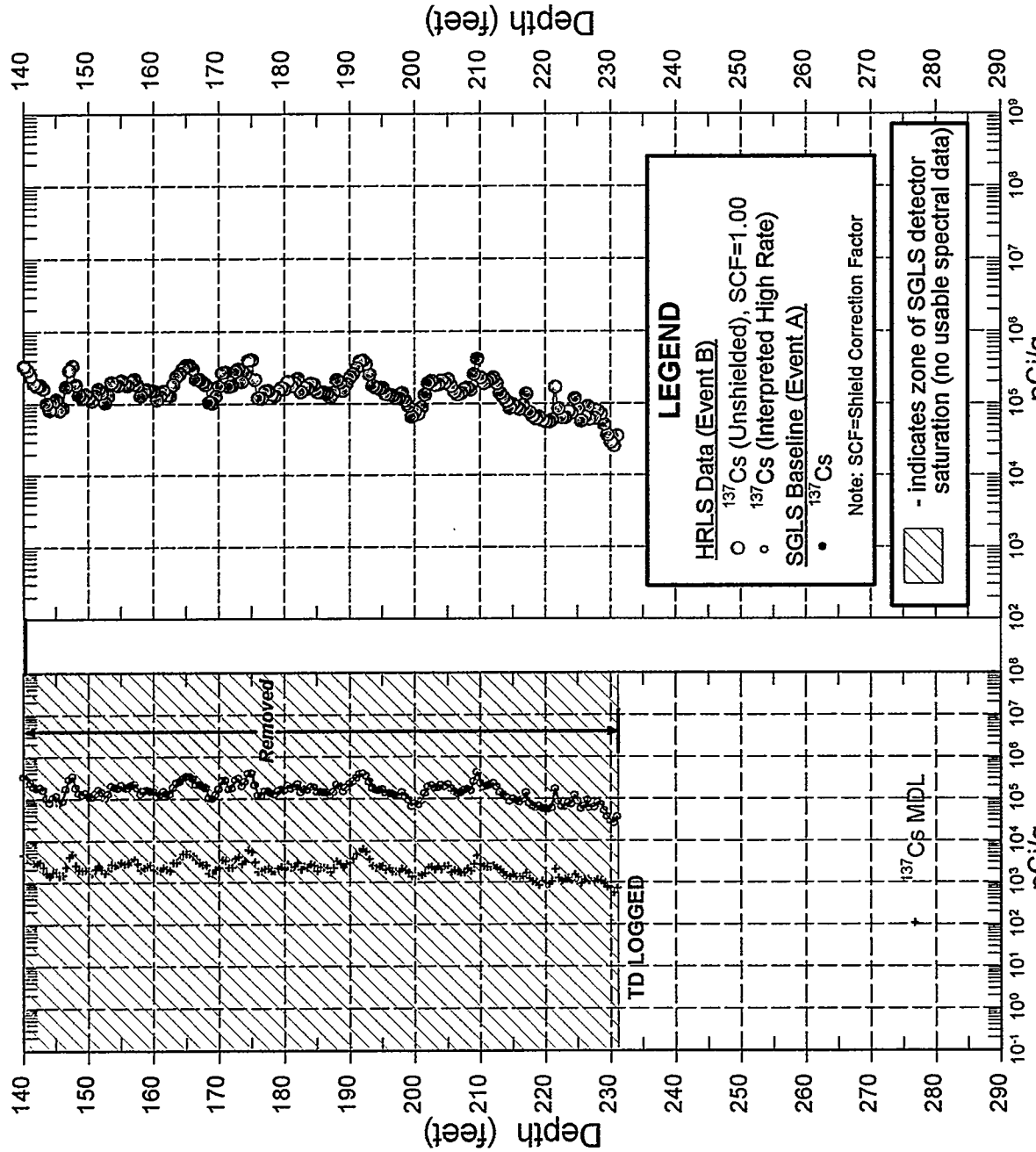

Figure A-2. Summary of High Rate Logging Results for the BX Tank Farm

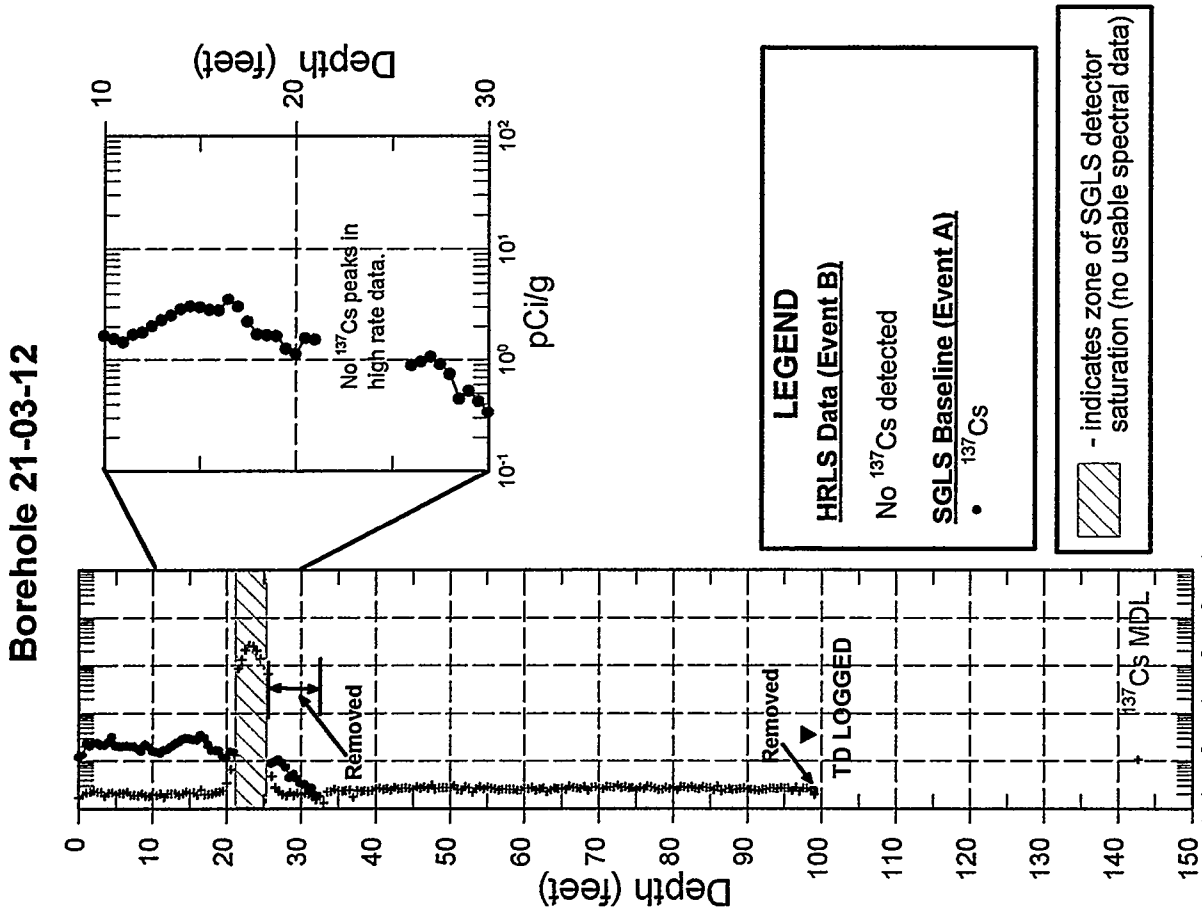

Figure A-3. Summary of High Rate Logging Results for the BX Tank Farm

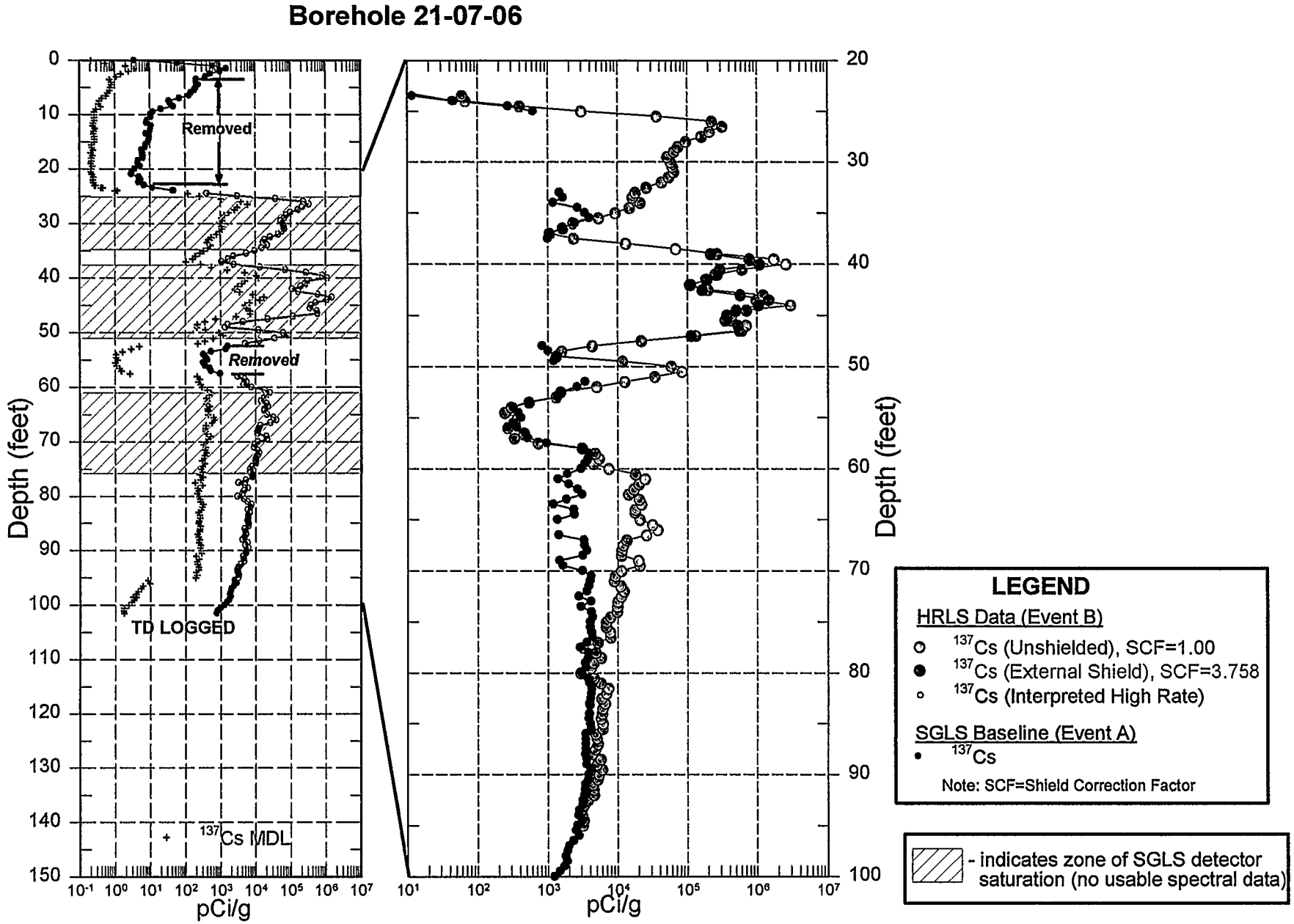

Figure A-4. Summary of High Rate Logging Results for the BX Tank Farm

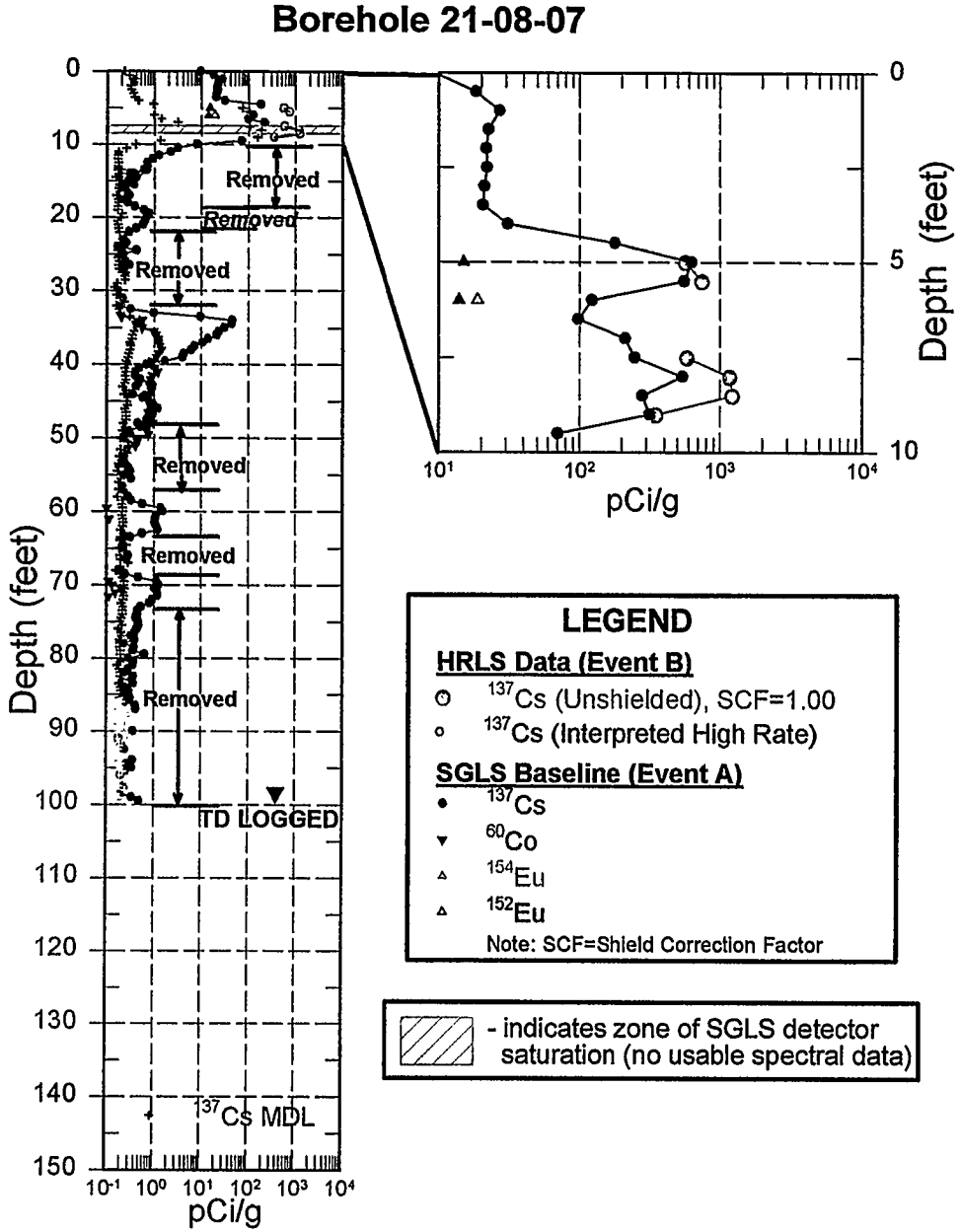

Figure A-5. Summary of High Rate Logging Results for the BX Tank Farm

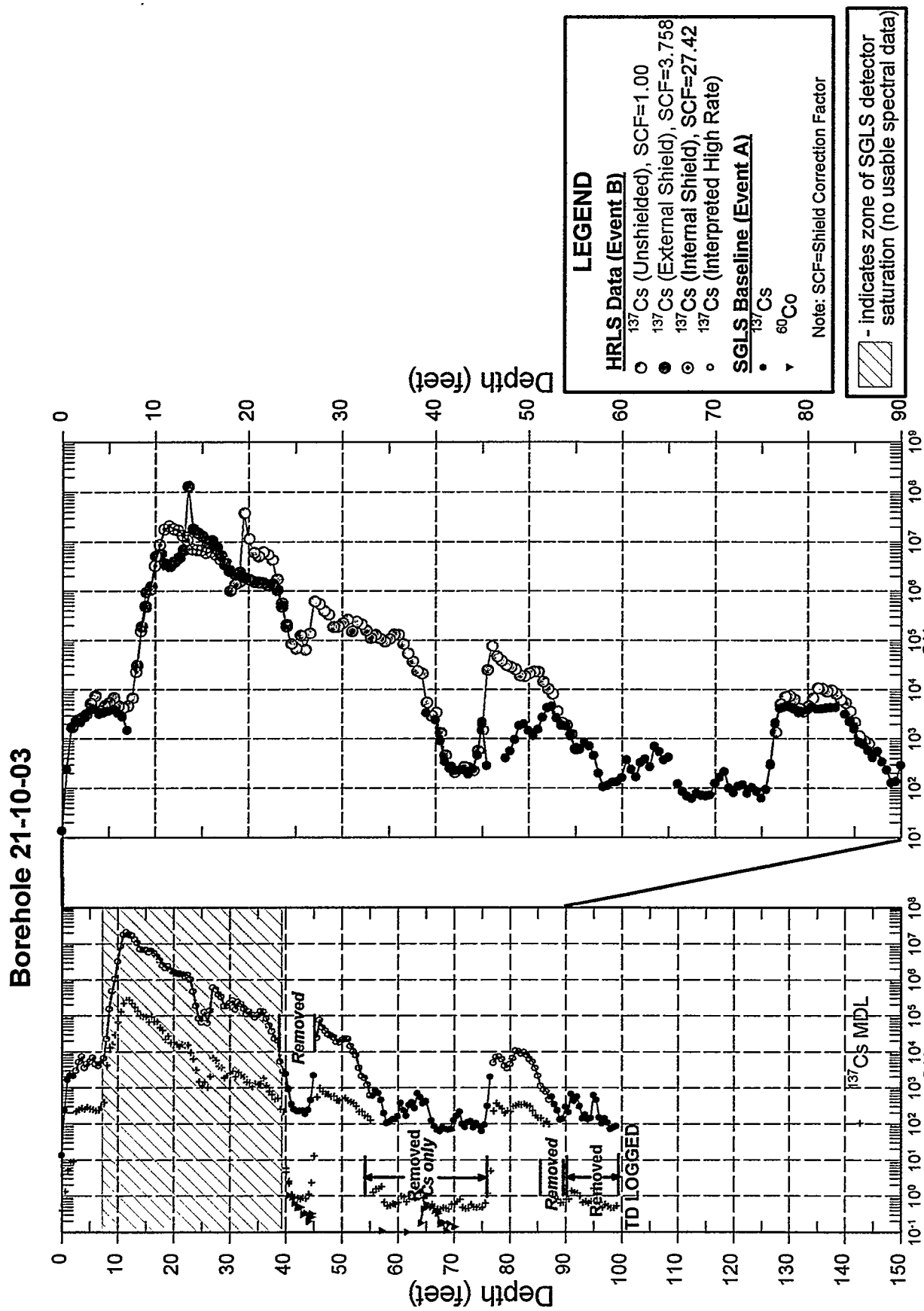

Figure A-6. Summary of High Rate Logging Results for the BX Tank Farm

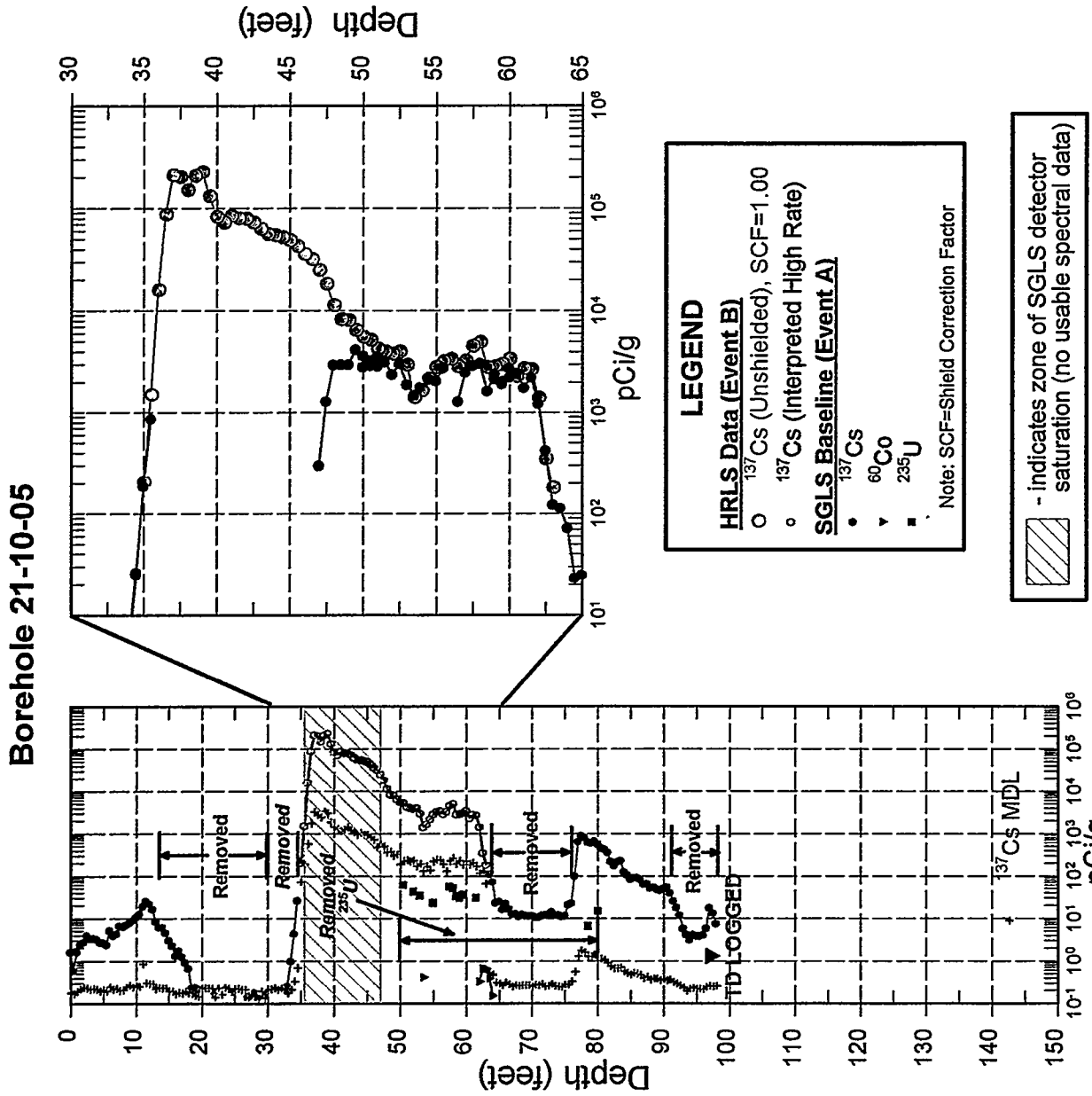

Figure A-7. Summary of High Rate Logging Results for the BX Tank Farm

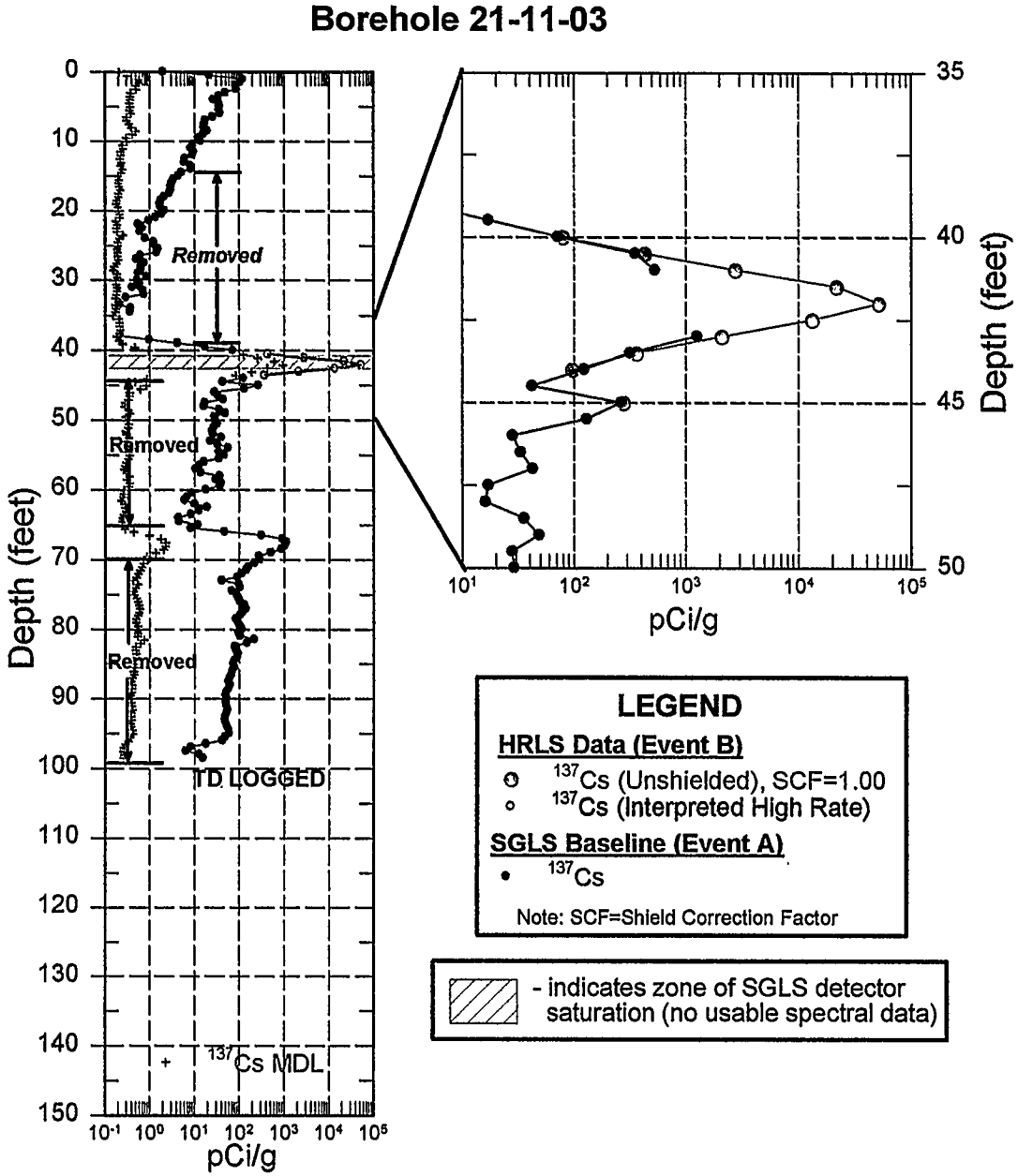

Figure A-8. Summary of High Rate Logging Results for the BX Tank Farm

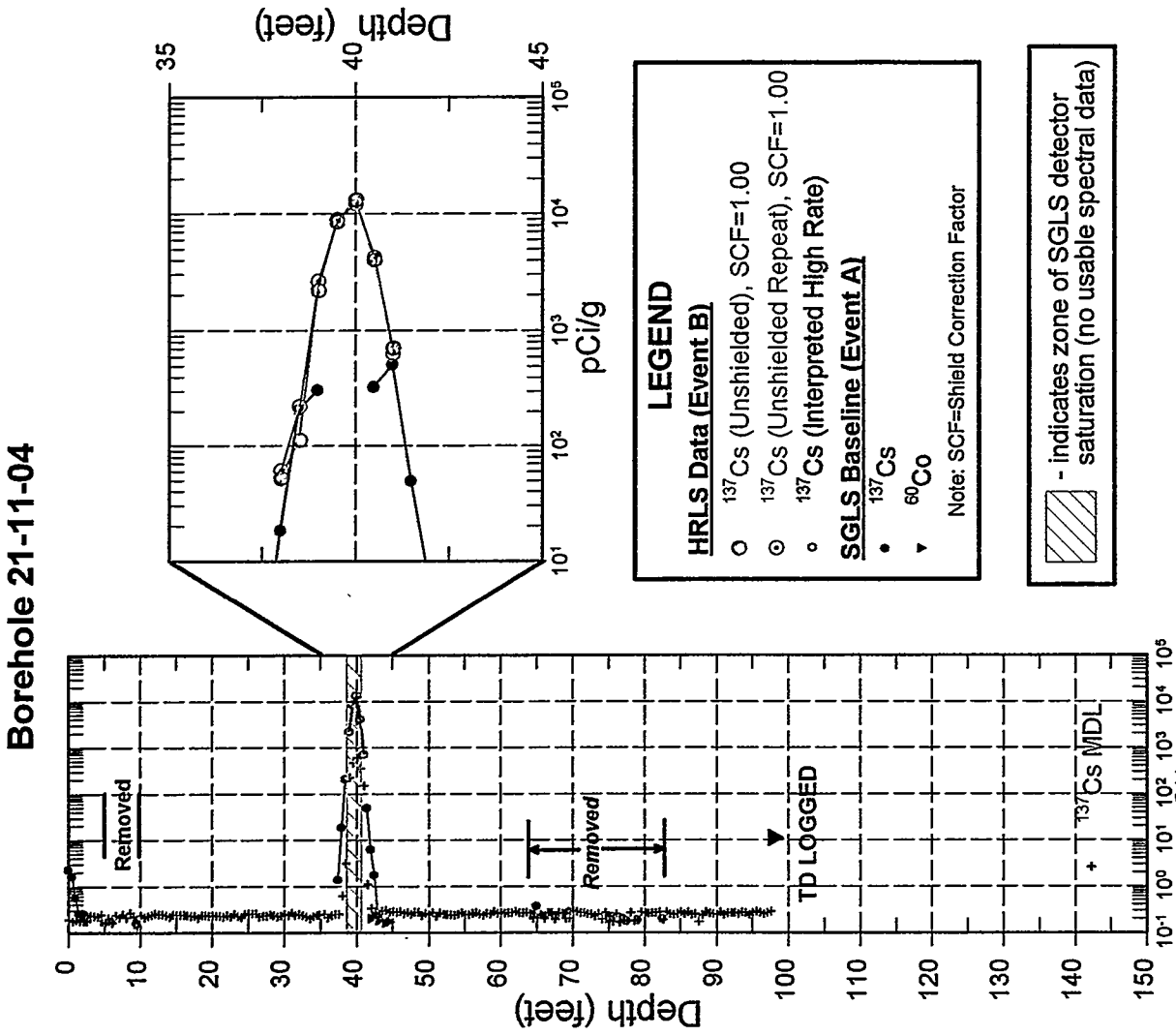

Figure A-9. Summary of High Rate Logging Results for the BX Tank Farm

Appendix B
Summary of Repeat Logging Results for the BX Tank Farm

Table B-1. Summary of Repeat Logging Results for the BX Tank Farm

Borehole Number	Depth Range (ft)	Reason for Repeat	Logging Unit & (count time)		Evaluation
			Baseline	Repeat	
21-01-02	75.0 - 98.0	CM[a]	G1B (100 s)	G2B (100 s)	No change in contaminant concentration or distribution. R/P[c] suggest increasing ^{60}Co from 72 - 78 ft between 1980 and 1985, but stable thereafter.
21-02-03	70.0 - 99.0	CM	G2A (100 s)	G2B (100 s)	There appears to be a slight increase in $^{235/238}U$ concentration throughout the depth interval. R/P suggest contaminants are stable.
21-02-06	35.0 - 50.0	CM	G2A (100 s)	G2B (100 s)	No change in ^{60}Co or $^{235/238}U$ concentration or distribution. ^{154}Eu was present in the relog interval at 42 ft. R/P suggest ^{60}Co movement between 34 - 46 ft starting in 1975, but stable after 1984.
21-03-03	80.0 - 85.0	TGA[b]	G1B (100 s)	G2B (200 s)	Found $^{235/238}U$ at depth of anomaly. $^{235/238}U$ was not present in baseline.
21-06-05	35.0 - 60.0	CM	G1B (100 s)	G2B (100 s)	No change in contaminant concentration or distribution. ^{125}Sb was not identified in the relog. R/P suggest contaminants are stable.
21-09-12	20.0 - 25.0	TGA	G2A (100 s)	G2B (200 s)	The gamma anomaly appears to be due to ^{137}Cs (possibly remote).
21-27-01	70.0 - 99.0	CM	G2A (100 s)	G2B (100 s)	There appears to be a slight increase in $^{235/238}U$ concentration throughout the depth interval. R/P suggest contaminants are stable.

[a] CM - Suspected contaminant movement.
[b] TGA - Total gamma anomaly.
[c] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

Table B-1 (con't.). Summary of Repeat Logging Results for the BX Tank Farm

Borehole Number	Depth Range (ft)	Reason for Repeat	Logging Unit & (count time)		Evaluation
			Baseline	Repeat	
21-27-02	70.0 - 80.0	CM	G2A (100 s)	G2B (100 s)	No change in contaminant concentration or distribution. R/P suggest contaminants are stable.
21-27-07	70.0 - 138.5	CM	G1B (100 s)	G2B (100 s)	No change in contaminant concentration or distribution. R/P suggest contaminants are stable.
21-27-08	40.0 - 148.5	CM	G2A (100 s)	G2B (100 s)	There is an increase in $^{235/238}U$ concentration between 110-148.5 ft. There is an increase in ^{60}Co concentration between 135 - 140 ft. R/P suggest contaminants are stable.
21-27-09	70.0 - 135.0	CM	G1B (100 s)	G2B (100 s)	No change in contaminant concentration or distribution. R/P suggest contaminants are stable.
21-27-10	80.0 - 140.0	CM	G1B (100 s)	G2B (100 s)	No change in contaminant concentration or distribution. R/P suggest contaminants are stable.
21-27-11	70.0 - 137.5	CM	G2A (100 s)	G2B (100 s)	There appears to be downward movement of ^{60}Co from 116-119 ft. R/P suggest contaminants from 66 - 110 ft are stable, but movement of contaminants below 110 ft is undetermined.

[a] CM - Suspected contaminant movement.
[b] TGA - Total gamma anomaly.
[c] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

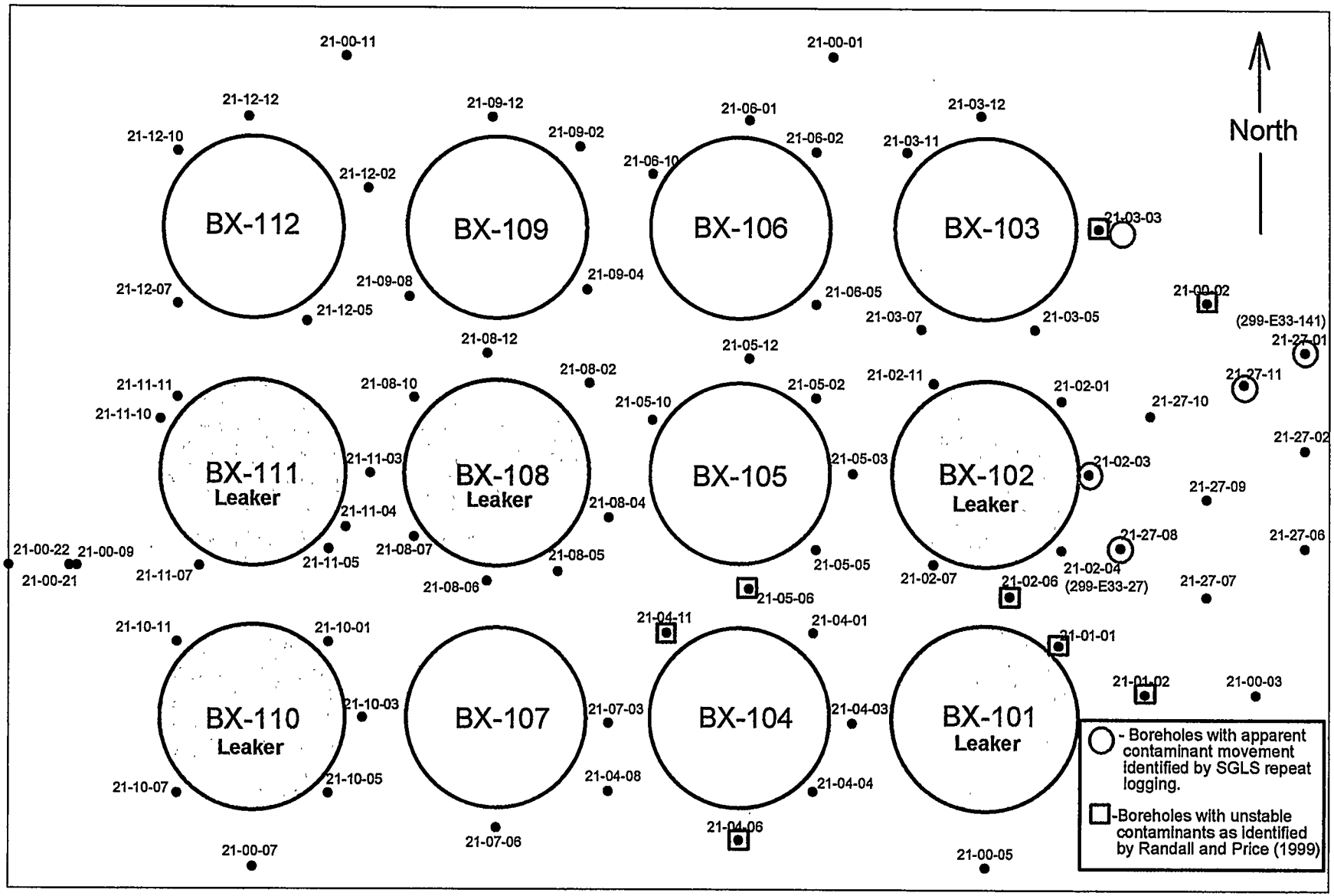

Figure B-1. Summary of Repeat Logging Results for the BX Tank Farm

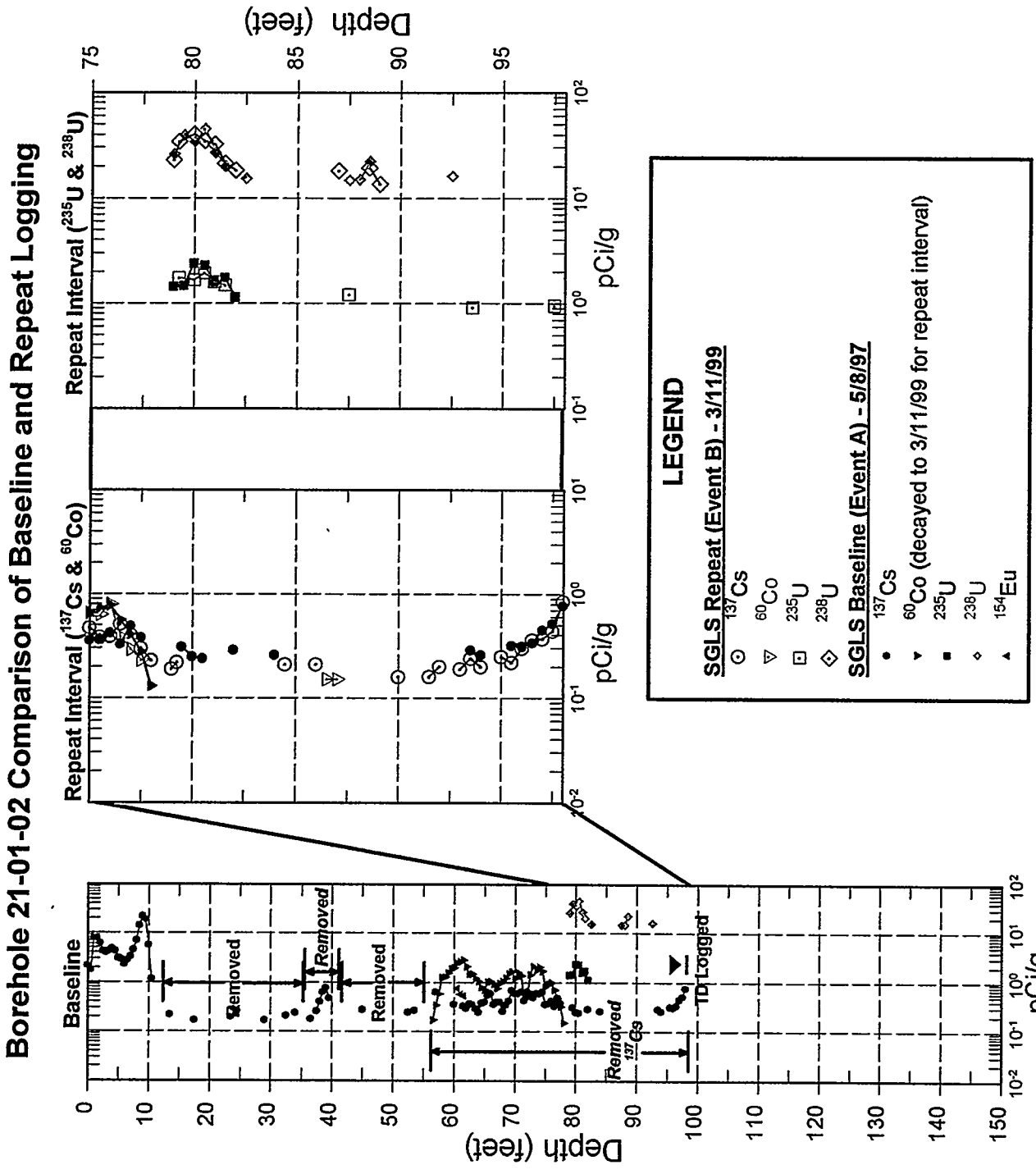

Figure B-2. Summary of Repeat Logging Results for the BX Tank Farm

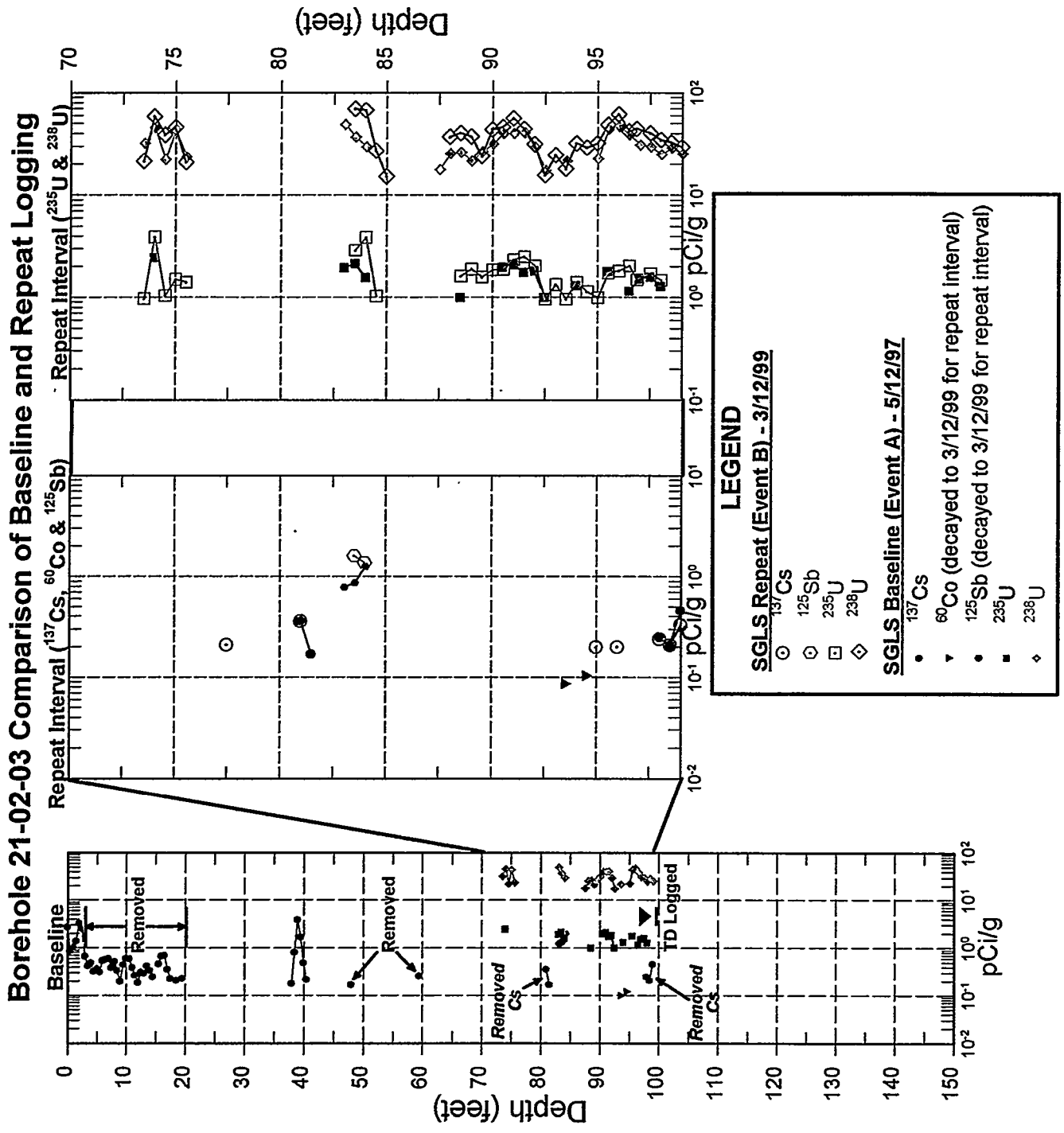

Figure B-3. Summary of Repeat Logging Results for the BX Tank Farm

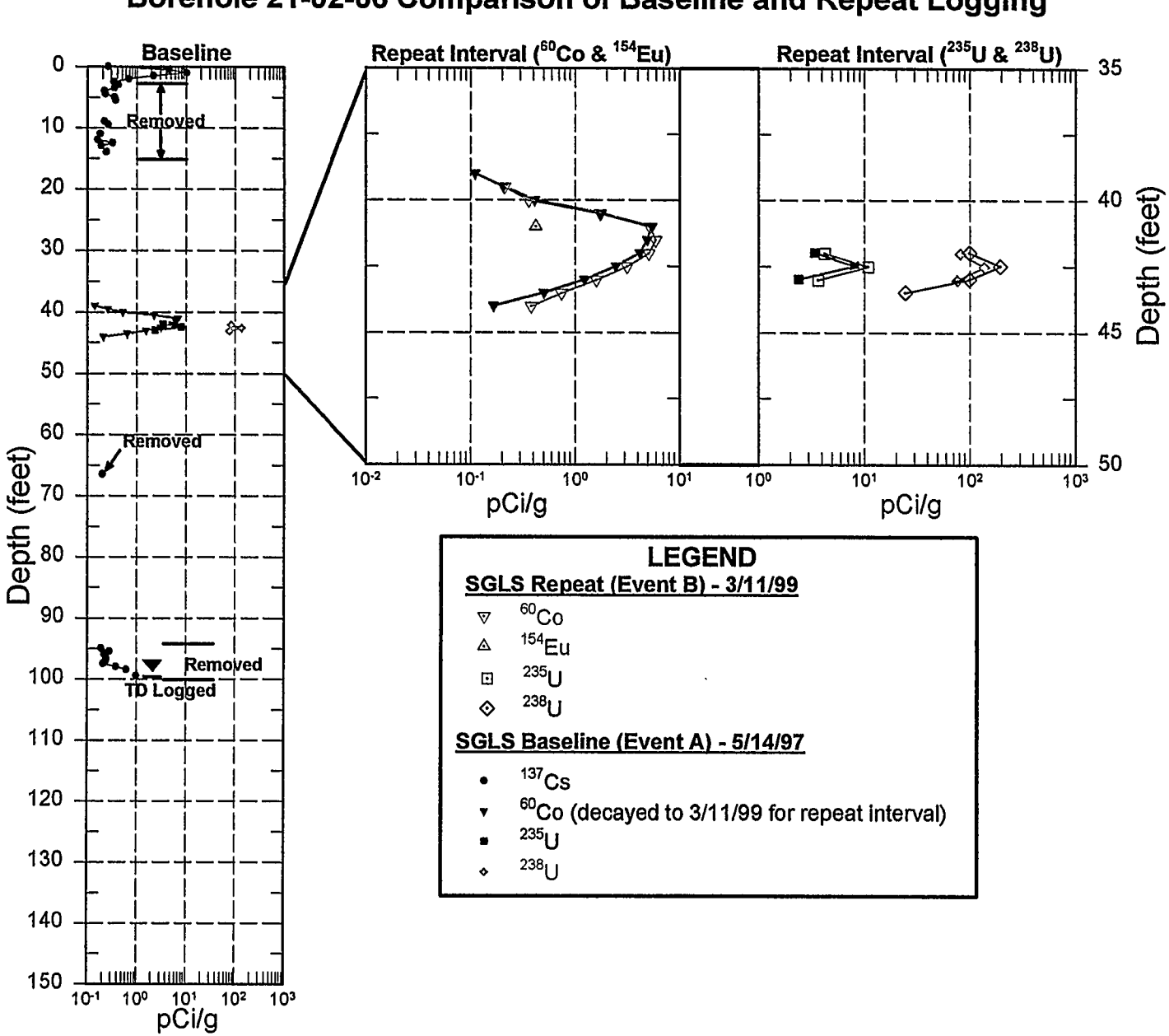

Figure B-4. Summary of Repeat Logging Results for the BX Tank Farm

Borehole 21-03-03 Comparison of Baseline and Repeat Logging

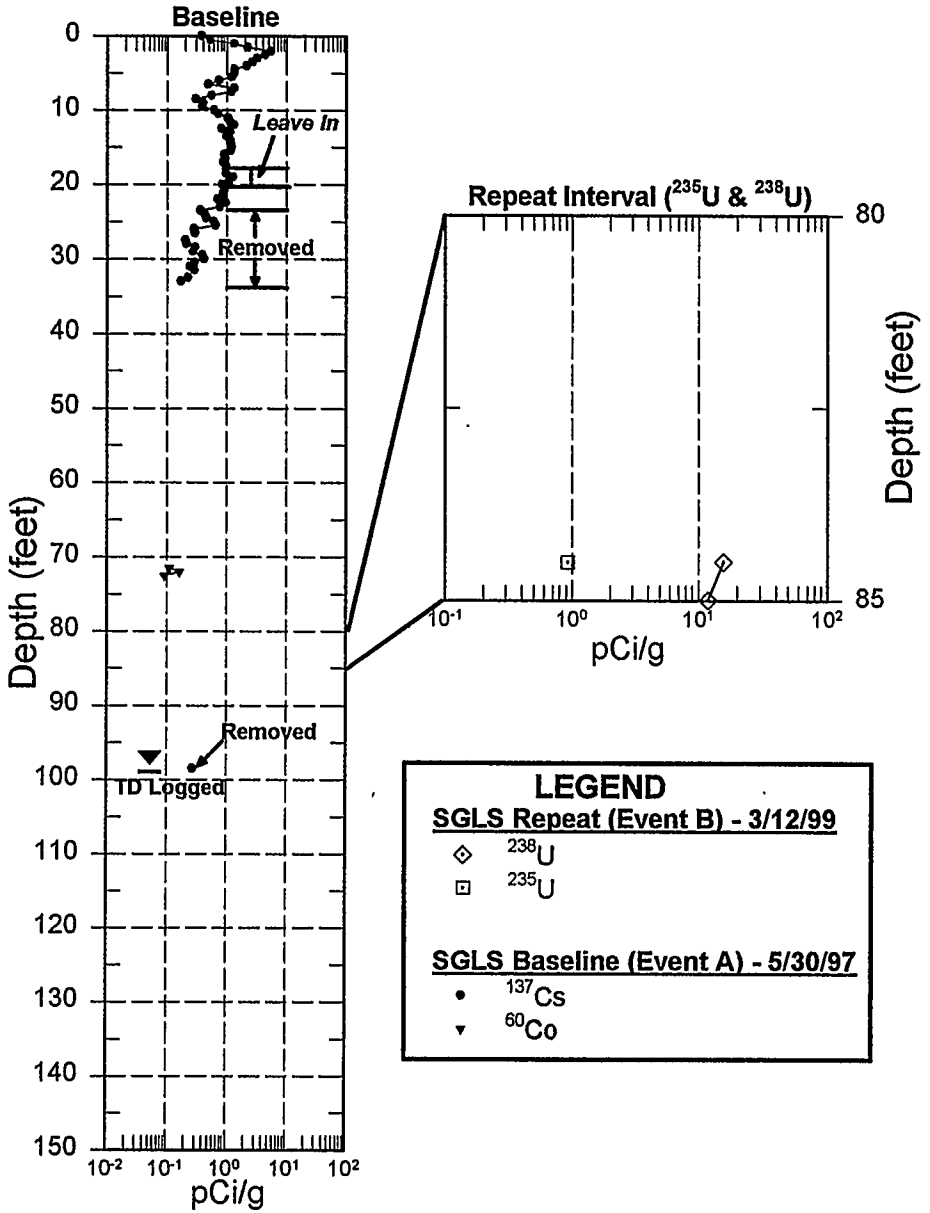

Figure B-5. Summary of Repeat Logging Results for the BX Tank Farm

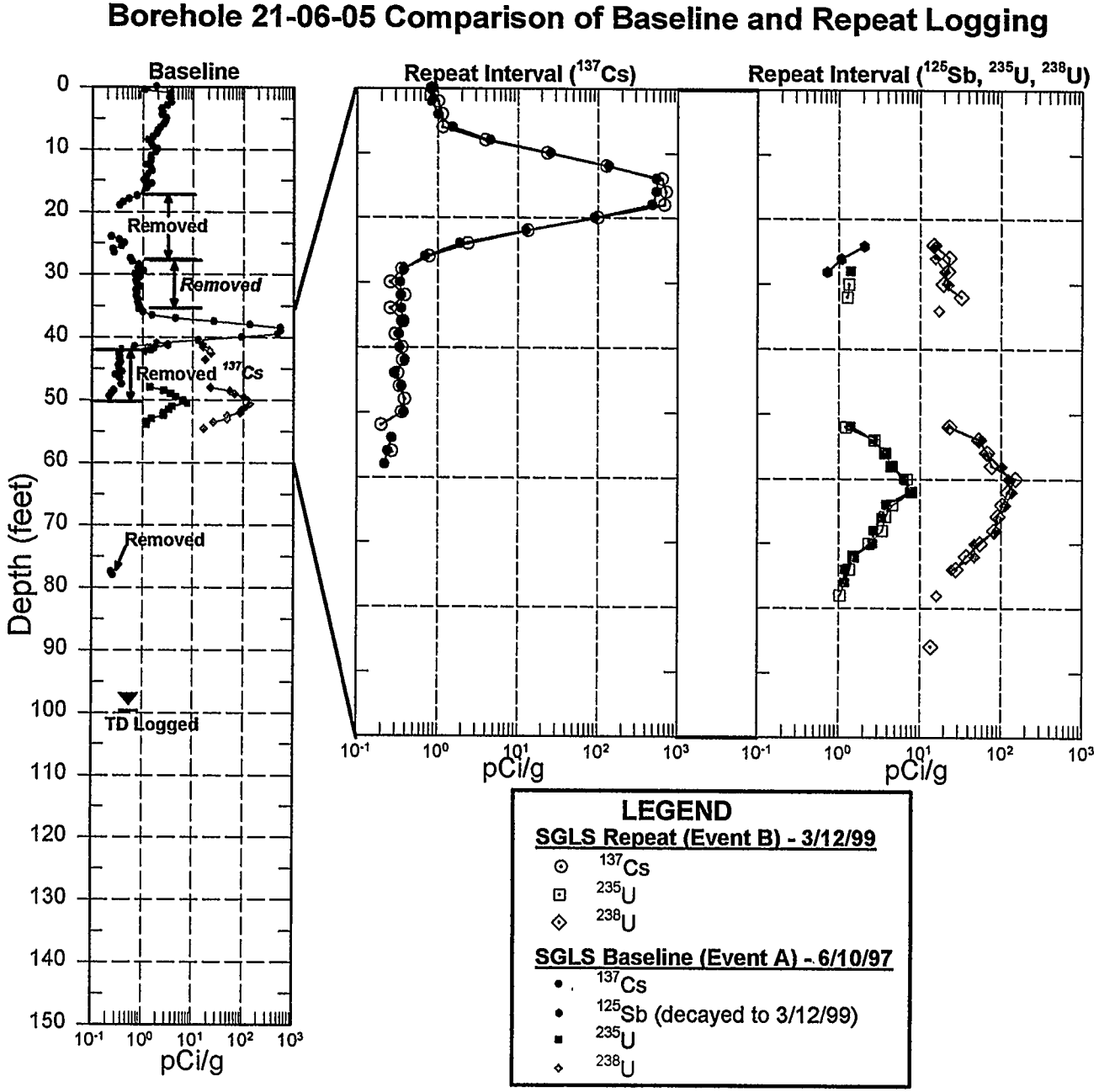

Figure B-6. Summary of Repeat Logging Results for the BX Tank Farm

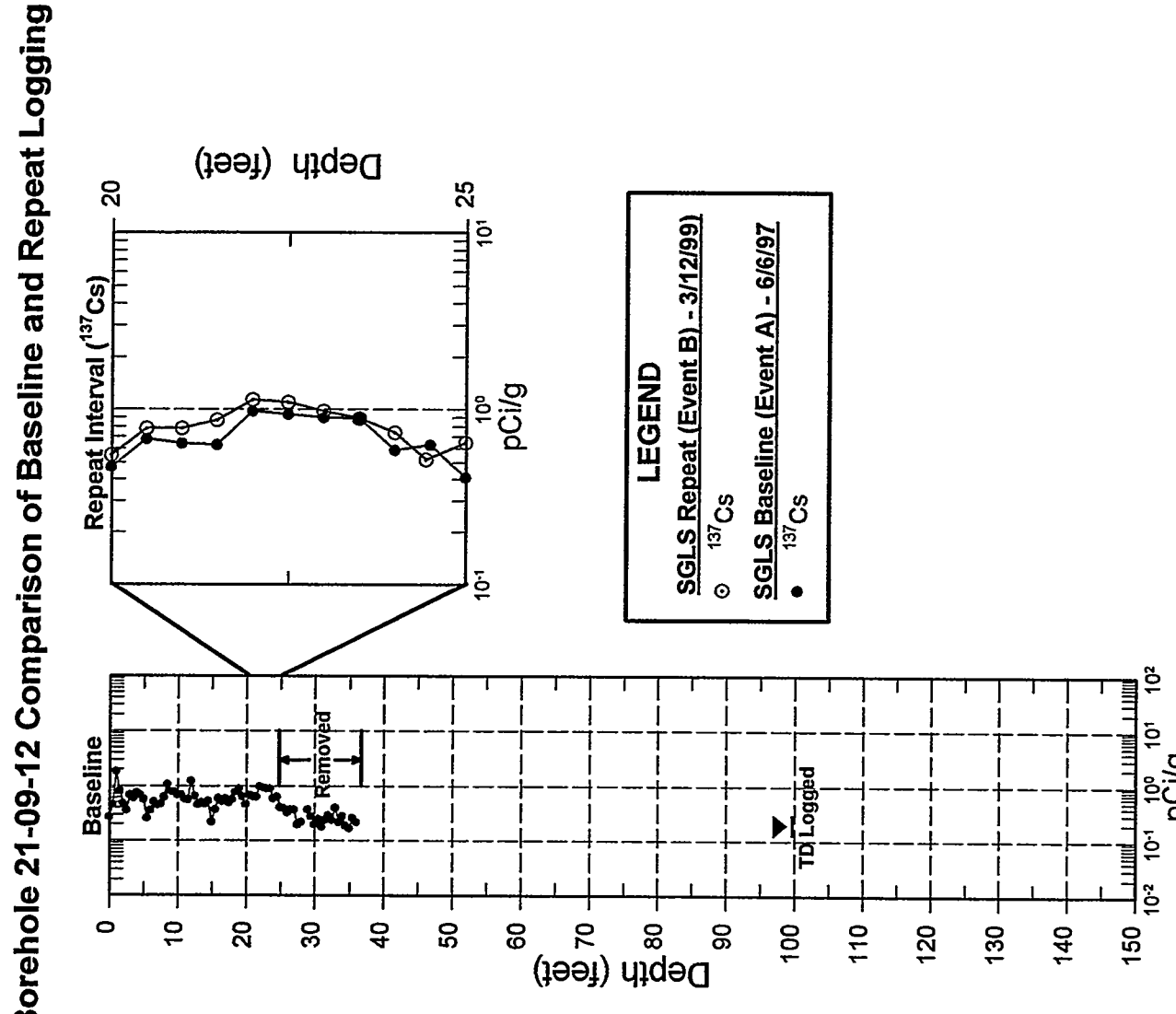

Figure B-7. Summary of Repeat Logging Results for the BX Tank Farm

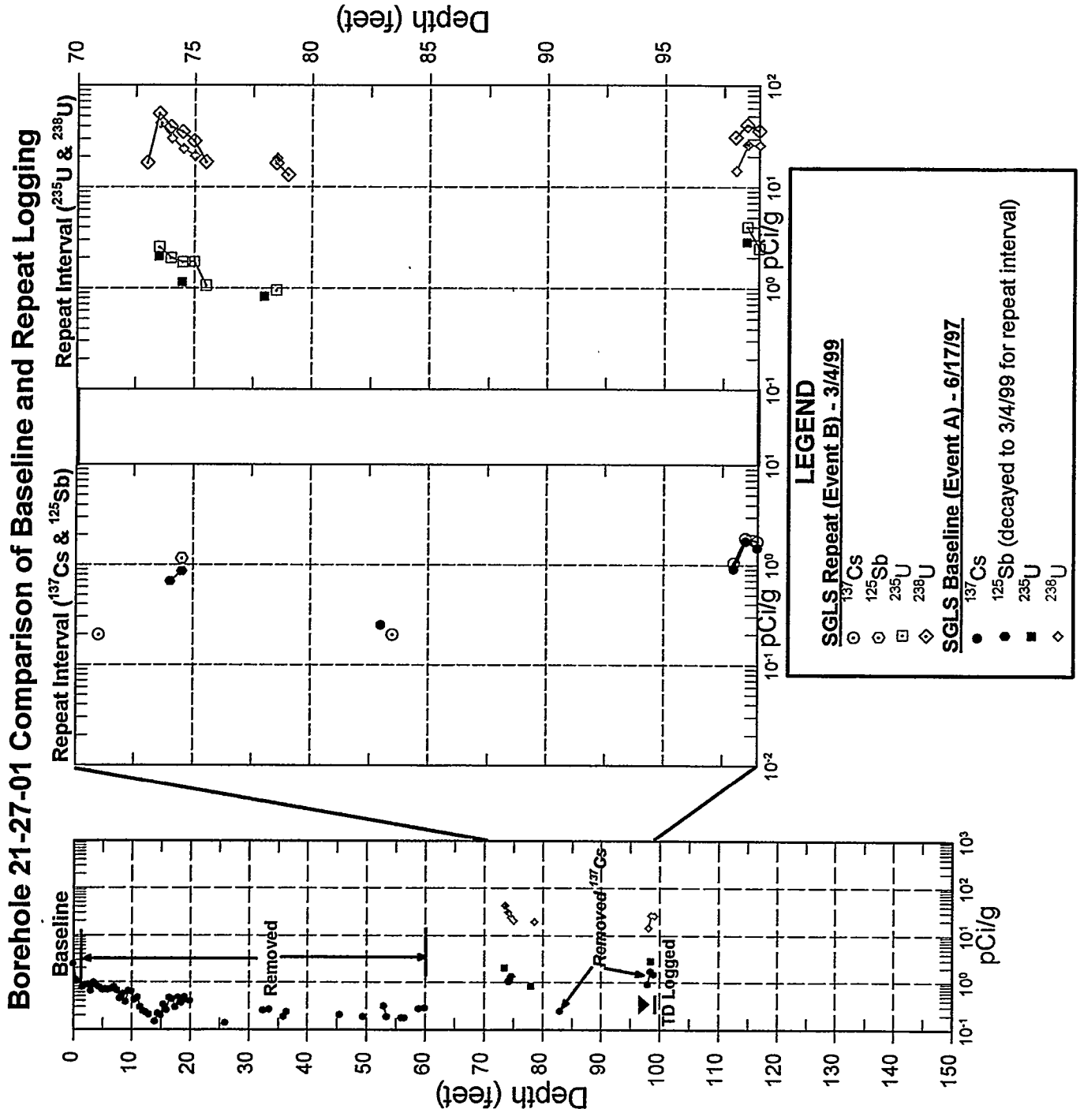

Figure B-8. Summary of Repeat Logging Results for the BX Tank Farm

Borehole 21-27-02 Comparison of Baseline and Repeat Logging

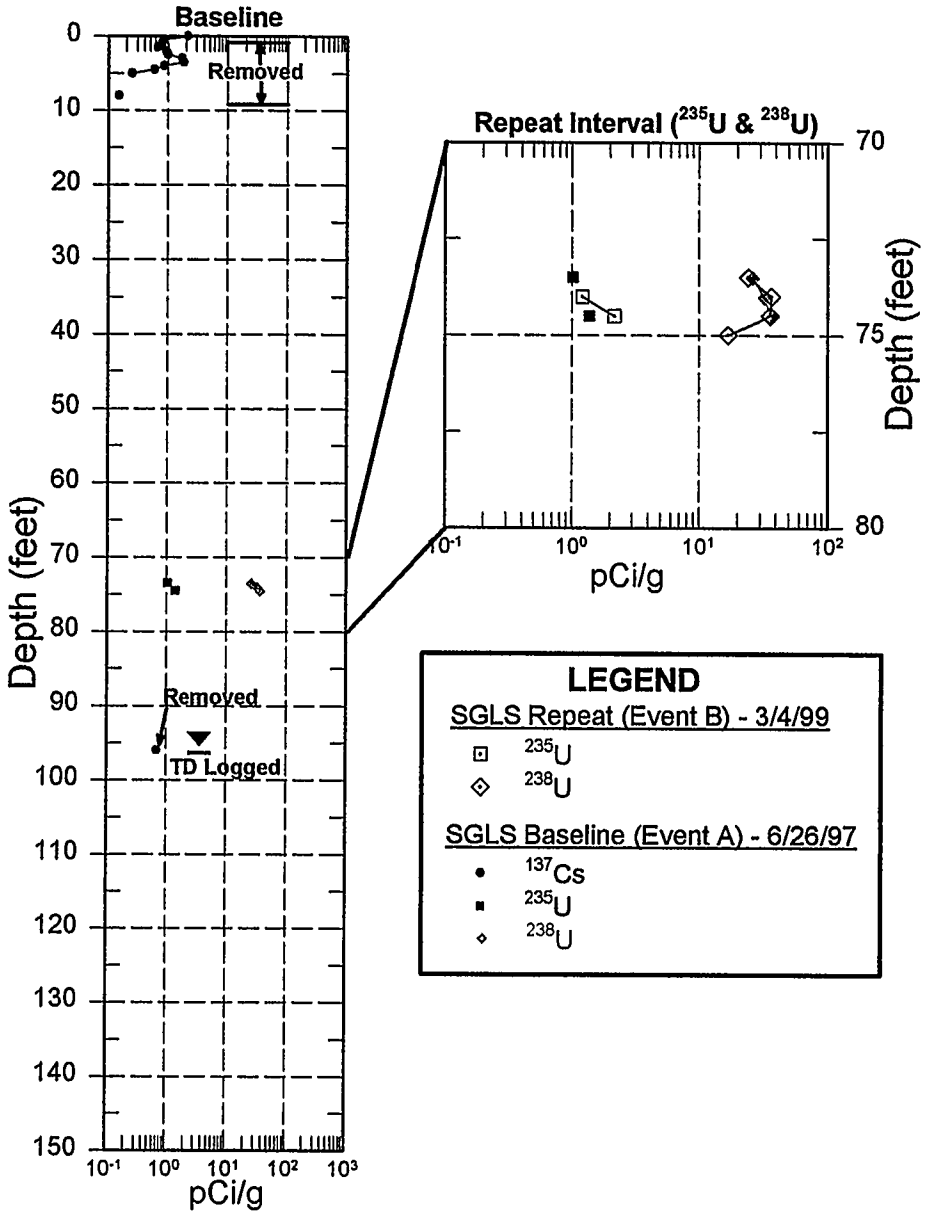

Figure B-9. Summary of Repeat Logging Results for the BX Tank Farm

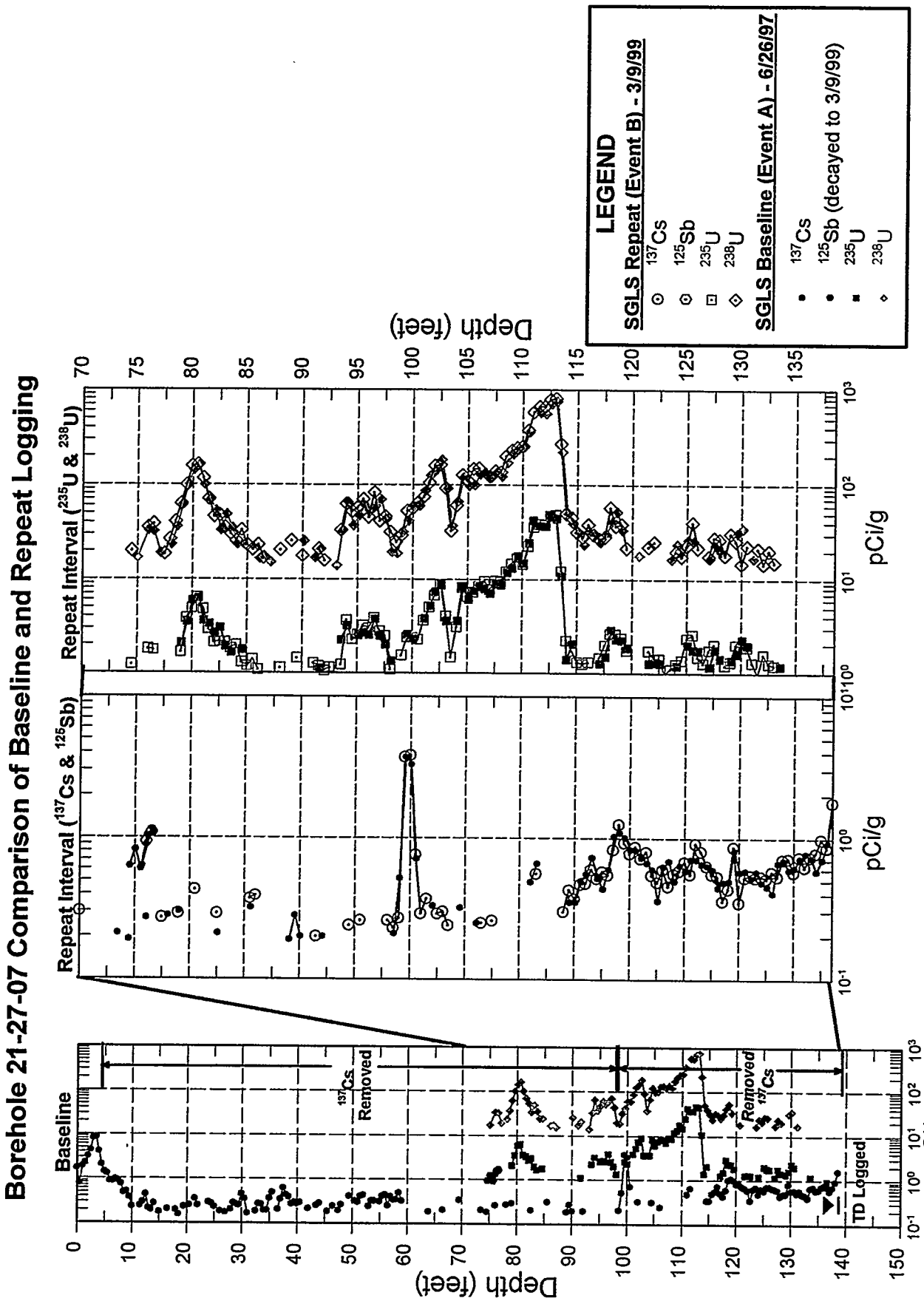

Figure B-10. Summary of Repeat Logging Results for the BX Tank Farm

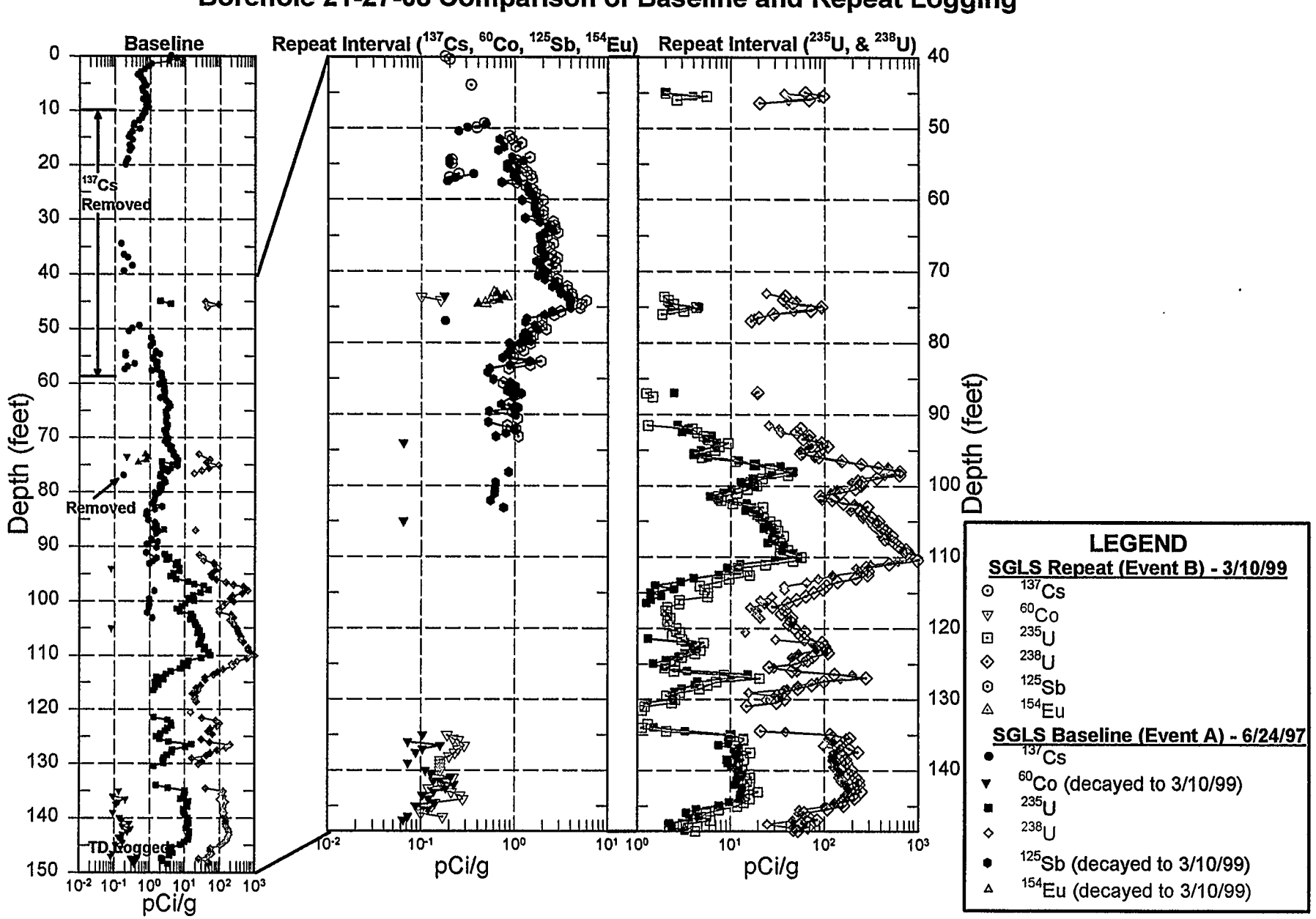

Figure B-11. Summary of Repeat Logging Results for the BX Tank Farm

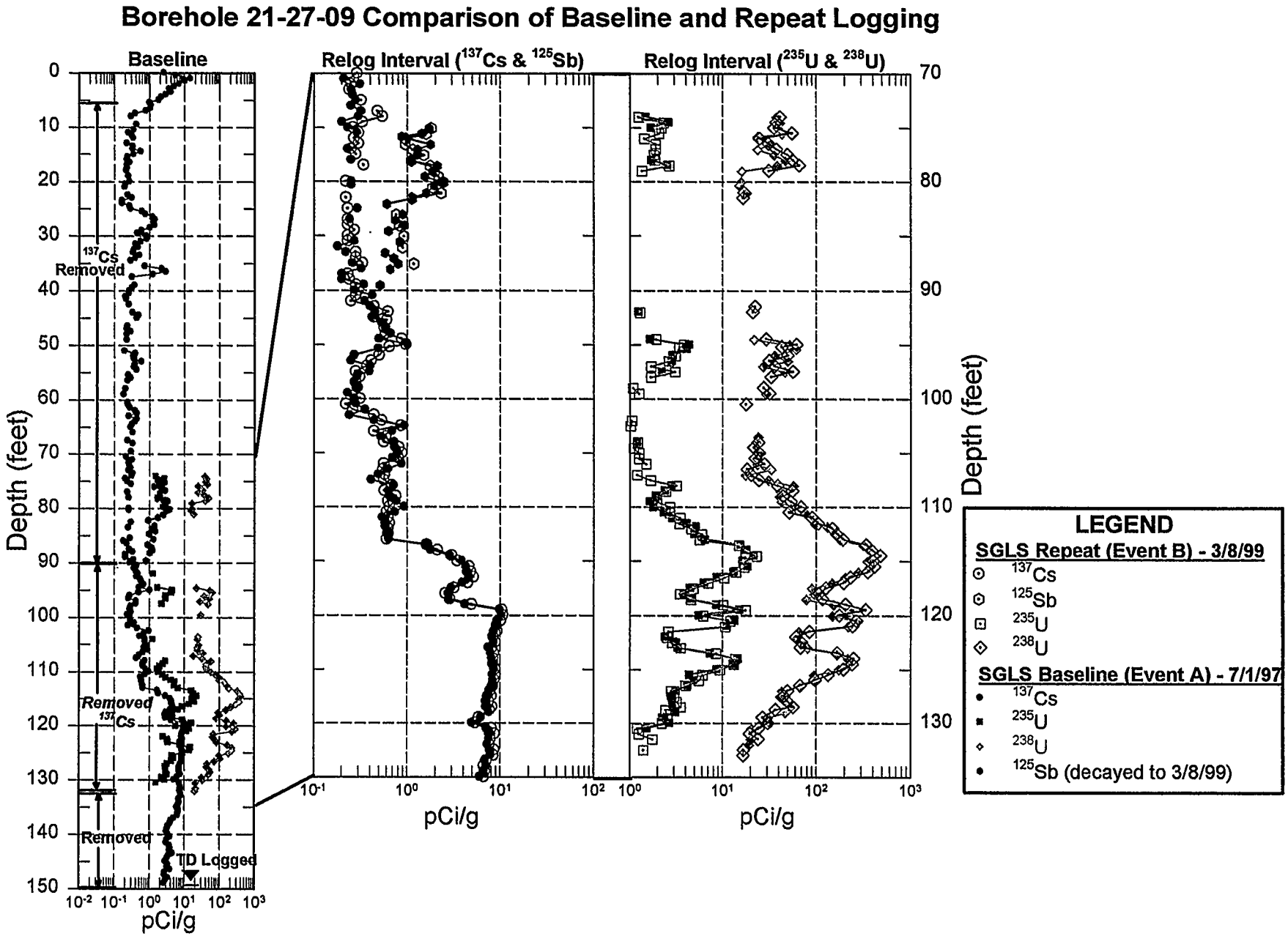

Figure B-12. Summary of Repeat Logging Results for the BX Tank Farm

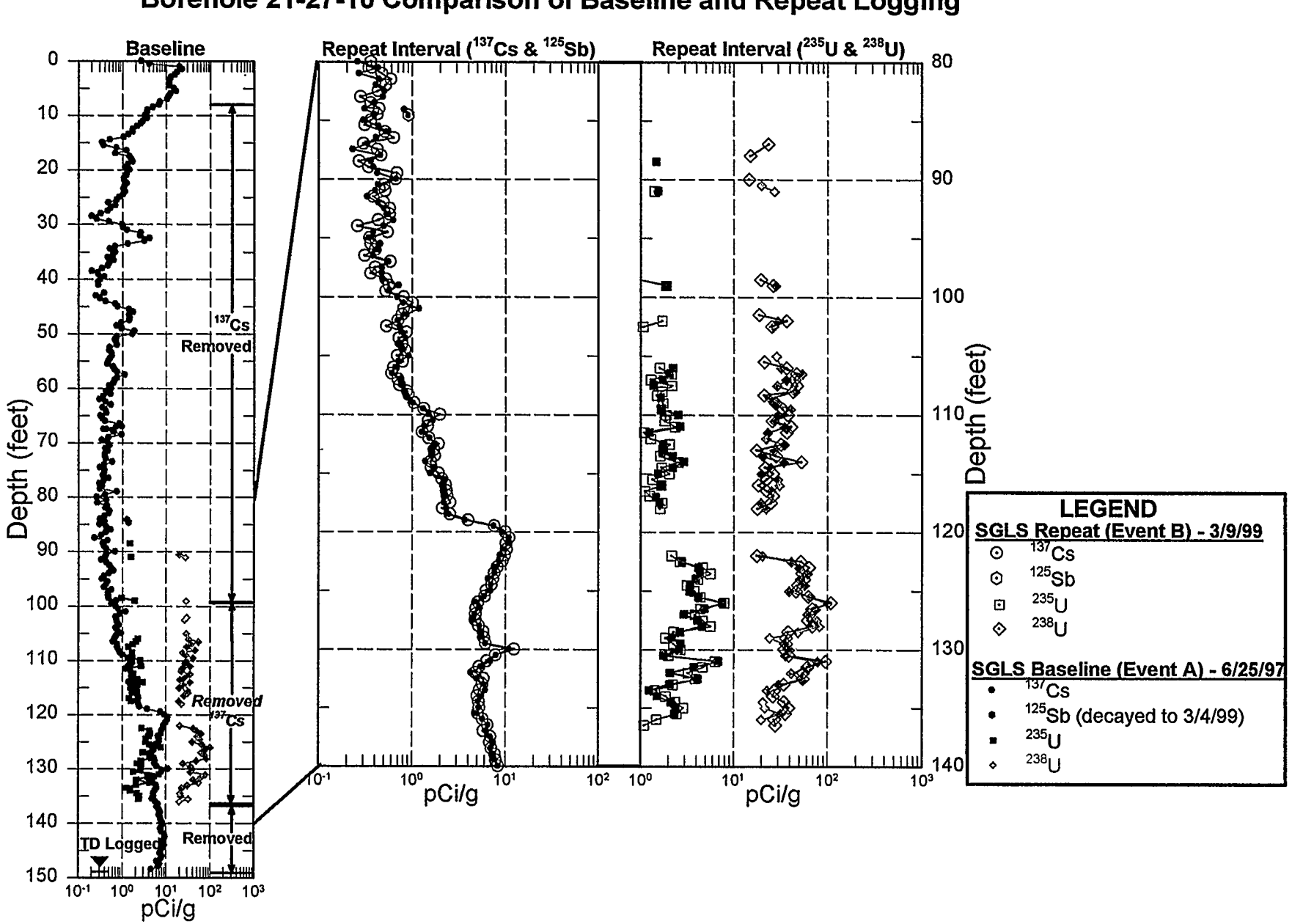

Figure B-13. Summary of Repeat Logging Results for the BX Tank Farm

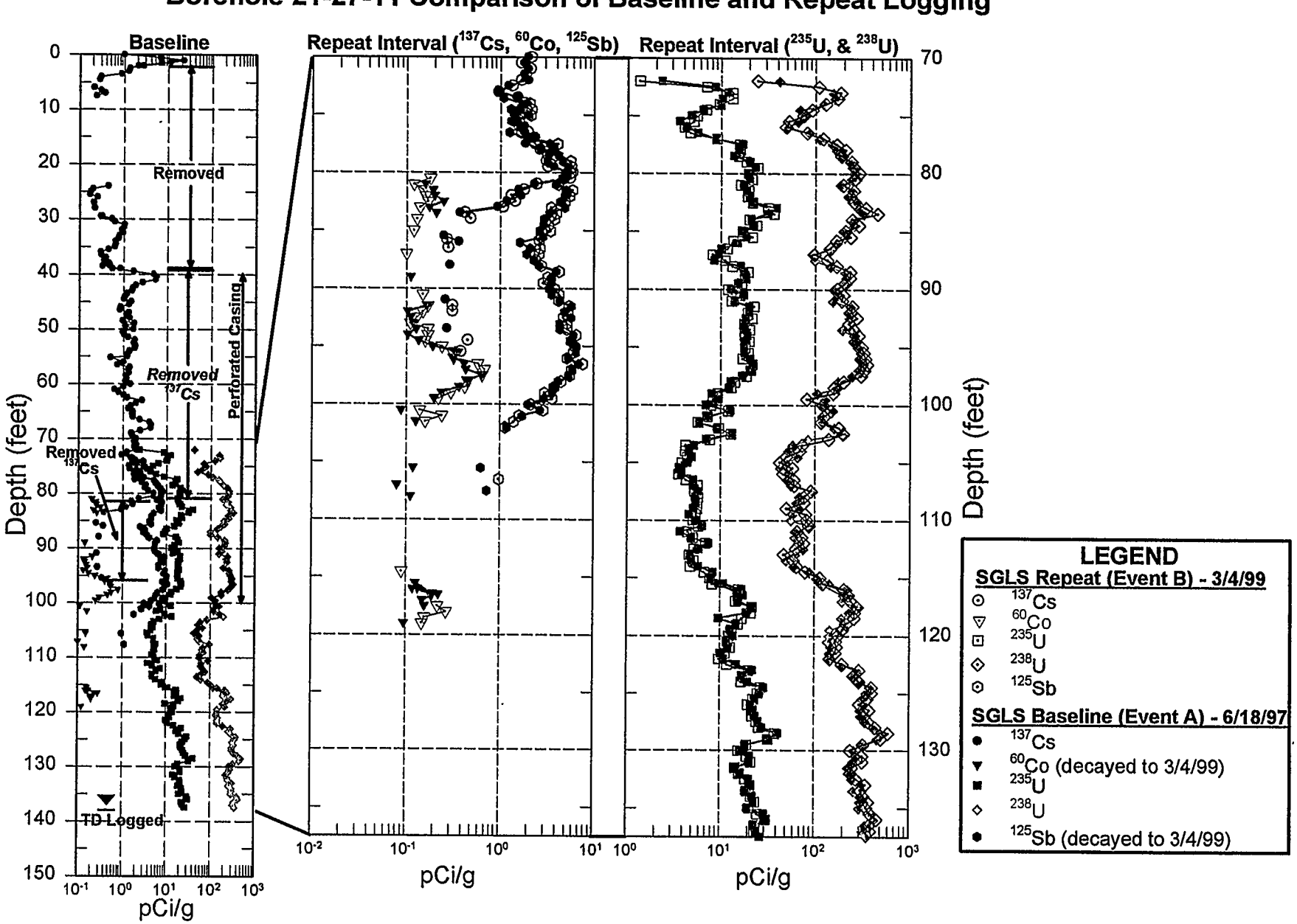

Figure B-14. Summary of Repeat Logging Results for the BX Tank Farm

Appendix C
Summary of the Interpreted Data Set for the BX Tank Farm

Table C-1. Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-01-01	0.0 - 15.0	SS[b]	D[f]	Included ^{137}Cs; surface spill or possibly 241-BXR-01C Sluice Pit leak.
	15.5 - 19.5	P[d]	R[i]	Included ^{137}Cs; 241-BXR-01C Sluice Pit leak. R/P[k] indicate 13 - 23 ft showed an inconsistent decrease from 1975 to 1977.
	20.0 - 50.5	P	Ina.[j]	Included ^{137}Cs, ^{60}Co, ^{125}Sb, ^{154}Eu, ^{152}Eu; 241-BXR-01C Sluice Pit leak or tank leak. R/P indicate 49 - 53 ft showed an inconsistent decrease from 1975 to 1985.
	51.0 - 58.0	P	D (^{60}Co)	Included ^{60}Co; 241-BXR-01C Sluice Pit leak or tank leak. Removed ^{137}Cs; probable dragdown.* R/P indicate 53 - 60 ft showed increases from 1975 to 1976 and from 1979 to 1980.
	58.5 - 99.0	P	Ina.	Included ^{60}Co; 241-BXR-01C Sluice Pit leak or tank leak. Included ^{235}U and ^{238}U; BX-102 tank leak. Removed ^{137}Cs; probable dragdown.*
21-01-02	0.0 - 10.5	SS	D	Included ^{137}Cs; surface spill. R/P indicate 5 - 12 ft showed an increase from 1975 to 1978 followed by an inconsistent decrease until 1985.
	11.0 - 35.0	BE[c]	Ina.	Removed ^{137}Cs; appears to be dragdown.
	35.5 - 40.0	BE	Ina.	Removed ^{137}Cs; levels are too low for SFA, appears to be dragdown.*
	40.5 - 55.0	BE	Ina.	Removed ^{137}Cs; levels are too low for SFA, appears to be dragdown.

[a] Source of contamination in judgment of analyst.
[b] SS- surface spill
[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

* Interpretation has changed from the original interpretation presented in the BX Tank Farm Report.

Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-01-02 (con't.)	55.5 - 98.0	P	Ina.	Included ^{60}Co and ^{154}Eu; 241-BXR-01C Sluice Pit leak or tank leak. Included ^{235}U and ^{238}U; BX-102 tank leak. Removed ^{137}Cs; levels are too low for SFA, appears to be dragdown.* R/P indicate 54 - 64 ft showed an inconsistent decrease from 1975 to 1977; 64 - 72 ft showed an increase from 1975 to 1976 followed by an inconsistent decrease until mid-1976; 72 - 78 ft showed an inconsistent flat decay rate from 1975 to 1980 followed by an increase until 1985.
21-00-05	0.0 - 4.0	SS	D	Included ^{137}Cs.
	4.5 - 40.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	41.0 - 48.0	P	Inc.	Included ^{137}Cs; possible BX-101 tank leak.
	48.5 - 61.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown, perforated casing.
	62.0 - 82.0	BE	Ina.	Removed ^{137}Cs and ^{60}Co; appears to be dragdown, perforated casing.*
	82.5 - 110.0	BE	Ina.	Removed ^{137}Cs and ^{60}Co; appears to be dragdown, perforated casing.
	110.0- 120.5	None	Ina.	No man-made contaminants detected.
	121.0- 121.5	BE	Ina.	Removed ^{60}Co; appears to be dragdown.*
	122.0- 133.5	None	Ina.	No man-made contaminants detected.

[a] Source of contamination in judgment of analyst.
[b] SS- surface spill
[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

* Interpretation has changed from the original interpretation presented in the BX Tank Farm Report.

Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-02-01	0.0 - 9.5	SS	D	Included ^{137}Cs.
	10.0 - 20.0	BE	Local	Removed ^{137}Cs; appears to be dragdown.*
	20.5 - 100.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
21-02-03	0.0 - 3.5	SS	D	Included ^{137}Cs.
	4.0 - 19.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	20.0 - 37.5	None	Ina.	No man-made contaminants detected.
	38.0 - 40.5	P	D	Included ^{137}Cs; BX-102 tank leak.
	41.0 - 73.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	73.5 - 99.0	P	Ina.	Included ^{235}U, ^{238}U, ^{60}Co, and ^{125}Sb; BX-102 tank leak. Removed ^{137}Cs; appears to be dragdown.*
21-02-04	0.0 - 2.0	SS	Ina.	Included ^{137}Cs.
	2.5 - 19.5	SS	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs.*
	20.0 - 28.5	SS	Ina.	Included ^{137}Cs.
	29.0 - 30.0	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs; BX-102 tank leak.*
	30.5 - 83.0	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/internal shield) ^{137}Cs; BX-102 tank leak.*
	83.5 - 231.0	BE	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Removed ^{137}Cs; this is probably borehole effects. See discussion in text.*

[a] Source of contamination in judgment of analyst.
[b] SS- surface spill
[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

* Interpretation has changed from the original interpretation presented in the BX Tank Farm Report.

Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-02-06	0.0 - 2.5	SS	D	Included ^{137}Cs.
	3.0 - 14.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	14.5 - 38.5	None	Ina.	No man-made contaminants detected.
	39.0 - 44.0	P	Ina.	Included ^{235}U, ^{238}U, and ^{60}Co; BX-102 tank leak. R/P indicate 34 - 46 ft showed an increase in 1975 and inconsistent decrease until 1979.
	44.5 - 66.0	None	Ina.	No man-made contaminants detected.
	66.5	BE	Ina.	Removed ^{137}Cs, appears to be dragdown.
	67.0 - 94.5	None	Ina.	No man-made contaminants detected.
	95.0 - 99.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-02-07	0.0 - 6.5	SS	D	Included ^{137}Cs.
	7.0 - 12.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	12.5 - 40.0	None	Ina.	No man-made contaminants detected.
	40.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	41.0 - 97.0	None	Ina.	No man-made contaminants detected.
	97.5 - 98.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-02-11	0.0 - 2.0	SS	D	Included ^{137}Cs.
	2.5 - 44.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	44.5 - 96.5	None	Ina.	No man-made contaminants detected.

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[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-02-11 (con't.)	97.0	BE	Ina.	Removed ^{137}Cs; fallen in from the ground surface.
21-27-01	0.0 - 2.0	SS	D	Included ^{137}Cs.
	2.5 - 60.0	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	60.5 - 72.5	None	Ina.	No man-made contaminants detected.
	73.0 - 99.0	P & BE	Ina.	Included ^{125}Sb, ^{235}U, and ^{238}U; possible BX-102 tank leak. Removed ^{137}Cs; probable dragdown.*
21-27-02	0.0 - 1.0	SS	D	Included ^{137}Cs.
	1.5 - 8.0	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	8.5 - 73.0	None	Ina.	No man-made contaminants detected.
	73.5 - 74.5	P	Ina.	Included ^{235}U and ^{238}U; possible BX-102 tank leak.
	75.0 - 95.5	None	Ina.	No man-made contaminants detected.
	96.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-27-06	0.0 - 1.0	SS	Ina.	Included ^{137}Cs.
	1.5 - 7.0	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	7.5 - 99.5	None	Ina.	No man-made contaminants detected.
21-27-07	0.0 - 5.0	SS	D	Included ^{137}Cs.
	5.5 - 74.0	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	74.5 - 98.5	P & BE	Ina.	Included ^{125}Sb, ^{235}U, and ^{238}U; possible BX-102 tank leak. Removed ^{137}Cs; probable dragdown.

[a] Source of contamination in judgment of analyst.
[b] SS- surface spill
[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-27-07 (con't.)	99.0 - 138.5	P & BE	Ina.	Included ^{235}U and ^{238}U; possible BX-102 tank leak. Removed ^{137}Cs; probable dragdown.*
21-27-08	0.0 - 10.0	SS	D	Included ^{137}Cs.
	10.5 - 44.5	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	45.0 - 148.5	P & BE	Ina.	Included ^{125}Sb, ^{235}U, ^{238}U, ^{154}Eu, and ^{60}Co; possible BX-102 tank leak.* Removed ^{137}Cs; probable dragdown.
21-27-09	0.0 - 5.0	SS	D	Included ^{137}Cs.
	5.5 - 73.5	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	74.0 - 89.5	P & BE	Ina.	Included ^{125}Sb, ^{235}U, and ^{238}U; possible BX-102 tank leak. Removed ^{137}Cs; probable dragdown.
	90.0 - 132.0	P & BE	Ina.	Included ^{235}U and ^{238}U; possible BX-102 tank leak. Removed ^{137}Cs; probable dragdown.*
	132.5- 149.0	BE	Local	Removed ^{137}Cs; probable dragdown.
21-27-10	0.0 - 7.0	SS	D	Included ^{137}Cs.
	7.5 - 83.5	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	84.0 -	P & BE	Ina.	Included ^{125}Sb, ^{235}U, and ^{238}U; possible BX-102 tank.
	137.0- 148.5	BE	Local	Removed ^{137}Cs; probable dragdown.

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[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-27-11	0.0 - 2.0	SS	D	Included ^{137}Cs.
	2.5 - 38.5	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	39.0 - 71.0	BE	Inc.	Removed ^{137}Cs; probable dragdown, perforated casing.*
	71.5 - 81.0	P & BE	Ina.	Included ^{125}Sb, ^{235}U, and ^{238}U; possible BX-102 tank leak. Removed ^{137}Cs; probable dragdown.*
	81.5 - 95.5	P & BE	Ina.	Included ^{60}Co, ^{125}Sb, ^{235}U, and ^{238}U; possible BX-102 tank leak. Removed ^{137}Cs; probable dragdown.
	97.0	BE	Ina.	Removed ^{137}Cs; fallen in from the ground surface.
21-03-03	0.0 - 18.0	SS	D	Included ^{137}Cs.
	18.5 - 20.5	SS	Local	^{137}Cs included; appears continuous w/above.*
	21.0 - 23.5	SS	D	Included ^{137}Cs.
	24.0 - 33.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	33.5 - 71.0	None	Ina.	No man-made contaminants detected.
	71.5 - 72.5	P	Ina.	Included ^{60}Co; possible tank leak. R/P indicate 60 - 80 ft showed an increase from 1975 to 1976.
	73.0 - 98.0	None	Ina.	No man-made contaminants detected.
	98.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.

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[d] P - plume of contamination
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[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
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[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-00-02	0.0 - 8.5	SS	Inc.	Included ^{137}Cs.
	9.0 - 15.0	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.*
	15.5 - 97.5	BE & P	Ina.	Removed ^{137}Cs; appears to be dragdown. Included ^{60}Co; possible tank leak.
21-03-05	0.0 - 16.0	SS	D	Included ^{137}Cs.
	16.5 - 44.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	44.5 - 63.5	None	Ina.	No man-made contaminants detected.
	64.0 - 73.5	P	Ina.	Included ^{60}Co; possible tank leak.
	74.0 - 98.5	None	Ina.	No man-made contaminants detected.
	99.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-03-07	0.0 - 4.5	SS	D	Included ^{137}Cs.
	5.0 - 8.0	SS	R	Included ^{137}Cs and ^{154}Eu; possible surface spill or transfer line leak.
	8.5 - 76.5	P	Ina.	Included ^{238}U; possible tank leak, although no ^{235}U.
	77.0 - 96.0	None	Ina.	No man-made contaminants detected.
21-03-11	0.0 - 7.0	SS	D	Included ^{137}Cs.
	7.5 - 11.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	12.0 - 39.5	None	Ina.	No man-made contaminants detected.
	40.0	P	Ina.	Included ^{60}Co; possible tank leak.

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[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
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[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-03-11 (con't.)	40.5 - 98.5	None	Ina.	No man-made contaminants detected.
21-03-12	0.0 - 21.0	SS	D	Included ^{137}Cs.
	21.5 - 25.0	Pipe	Ina.	SGLS was saturated and no ^{137}Cs peaks were detected with the HRLS, suggesting a remote transfer line.
	25.5 - 31.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	32.0 - 98.5	None	Ina.	No man-made contaminants detected.
	99.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-04-01	0.0 - 17.0	SS	D	Included ^{137}Cs.
	17.5 - 32.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	33.0 - 98.0	None	Ina.	No man-made contaminants detected.
	98.5 - 99.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-04-03	0.0 - 3.0	SS	D	Included ^{137}Cs.
	3.5 - 10.0	Pipe	R	Included ^{137}Cs, ^{60}Co, and ^{154}Eu; possible transfer line leak.
	10.5 - 22.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	22.5 - 99.0	None	Ina.	No man-made contaminants detected.
21-04-04	0.0 - 39.0	SS	D	Included ^{137}Cs; correlates with 21-04-06.
	39.5 - 96.0	None	Ina.	No man-made contaminants detected.

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[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-04-06	0.0 - 5.0	SS	R	Included ^{137}Cs and ^{154}Eu; possible transfer line leak or surface spill.
	5.5 - 38.5	SS	D & Ina.	Included ^{137}Cs; correlates with 21-04-04. R/P indicate 8 - 20 ft showed an inconsistent decrease from 1975 to 1985.
	39.0 - 101.5	None	Ina.	No man-made contaminants detected.
21-04-08	0.0 - 10.5	SS	D	Included ^{137}Cs.
	11.0 - 36.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	37.0 - 65.5	None	Ina.	No man-made contaminants detected.
	66.0 - 66.5	P	Ina.	Included ^{60}Co; possible tank leak, correlates with other boreholes.
	67.0 - 87.0	None	Ina.	No man-made contaminants detected.
	87.5 - 100.0	P	Ina.	Included ^{60}Co; possible tank leak, correlates with other boreholes. Removed ^{137}Cs at 100.0 ft; probably has fallen in from the ground surface.*
21-04-11	0.0 - 14.5	SS	D	Included ^{137}Cs. R/P indicate 2 - 17 ft showed an inconsistent decrease from 1977 to 1984.
	15.0 - 24.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	24.5 - 65.5	None	Ina.	No man-made contaminants detected.
	66.0 - 66.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	67.0 - 97.5	P	Ina.	Included ^{60}Co; possible tank leak, correlates with other boreholes.

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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-05-02	0.0 - 17.5	SS	D	Included ^{137}Cs.
	18.0 - 26.0	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.*
	26.5 - 100.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
21-05-03	0.0 - 9.5	SS	D	Included ^{137}Cs.
	10.0 - 13.5	BE	Local	Removed ^{137}Cs; appears to be dragdown.
	14.0 - 99.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
21-05-05	0.0 - 5.5	SS	D	Included ^{137}Cs.
	6.0 - 14.5	BE	Local	Removed ^{137}Cs; appears to be dragdown.
	15.0 - 19.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.*
	19.5 - 54.0	BE	Ina.	Removed ^{137}Cs and ^{152}Eu; appears to be dragdown.
	54.5 - 70.0	None	Ina.	No man-made contaminants detected.
	70.5 - 88.0	P	Ina.	Included ^{60}Co; possible tank leak, correlates with 21-05-06.
	88.5 - 96.5	None	Ina.	No man-made contaminants detected.
	97.0 - 99.0	BE	Ina.	Removed ^{137}Cs; fallen in from the ground surface.
21-05-06	0.0 - 9.5	SS	D	Included ^{137}Cs. R/P indicate 2 - 15 ft showed an inconsistent decrease from 1975 to 1984.
	10.0 - 17.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	18.0 - 20.5	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.*

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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-05-06 (con't.)	21.0 - 99.5	BE & P	Ina.	Removed ^{137}Cs; appears to be dragdown. Included ^{60}Co; possible tank leak.
21-05-10	0.0 - 3.5	SS	D	Included ^{137}Cs.
	4.0 - 10.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	11.0 - 19.5	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.*
	20.0 - 58.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	58.5 - 97.0	None	Ina.	No man-made contaminants detected.
	97.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-05-12	0.0 - 5.5	SS	D	Included ^{137}Cs.
	6.0 - 12.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	13.0 - 98.5	None	Ina.	No man-made contaminants detected.
	99.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-06-01	0.0 - 3.0	SS	Ina.	Included ^{137}Cs.
	3.5 - 15.5	None	Ina.	No man-made contaminants detected.
	16.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	16.5 - 99.0	None	Ina.	No man-made contaminants detected.
21-00-01	0.0 - 6.5	SS	Inc.	Included ^{137}Cs.
	7.0 - 12.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.

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[b] SS- surface spill
[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-00-01 (con't.)	12.5 - 65.0	None	Ina.	No man-made contaminants detected.
	65.5 - 143.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown, perforated casing.
21-06-02	0.0 - 6.5	SS	D	Included ^{137}Cs.
	7.0 - 32.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	32.5 - 99.0	None	Ina.	No man-made contaminants detected.
	99.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-06-05	0.0 - 17.5	SS	D	Included ^{137}Cs.
	18.0 - 27.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	28.0 - 35.0	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.*
	35.5 - 41.0	P	R	Included ^{137}Cs; possible BX-106 tank leak.
	41.5 - 55.0	P & BE	Ina.	Included ^{125}Sb, ^{235}U, and ^{238}U; possible BX-106 tank leak. Removed ^{137}Cs; appears to be dragdown.*
	55.5 - 72.0	None	Ina.	No man-made contaminants detected.
	72.4 - 73.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	73.5 - 99.5	None	Ina.	No man-made contaminants detected.
21-06-10	0.0 - 19.5	SS	D	Included ^{137}Cs.
	20.0 - 31.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	31.5 - 102.5	None	Ina.	No man-made contaminants detected.

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[b] SS- surface spill
[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-07-03	0.0 - 12.5	SS	Inc.	Included ^{137}Cs.
	13.0 - 22.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	22.5 - 66.5	None	Ina.	No man-made contaminants detected.
	67.0 - 68.0	P	Ina.	Included ^{60}Co; possible tank leak, correlates w/21-04-08.
	68.5 - 88.5	None	Ina.	No man-made contaminants detected.
	89.0 - 100.0	P	Ina.	Included ^{60}Co; possible tank leak, correlates w/21-04-08.
21-07-06	0.0 - 4.5	SS	Inc.	Included ^{137}Cs.
	5.0 - 23.0	BE	Local	Removed ^{137}Cs; appears to be dragdown.
	23.5 - 24.0	P	Ina.	Included ^{137}Cs; possible transfer line leak.
	24.5 - 39.0	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible transfer line leak.*
	39.5 - 47.0	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/external shield) ^{137}Cs. Included ^{137}Cs; possible transfer line and/or tank leak.*
	47.5 - 52.0	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible transfer line and/or tank leak.*
	52.5 - 57.5	BE	Local	Removed ^{137}Cs; appears to be dragdown.*
	58.0 - 95.0	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible transfer line and/or tank leak.*

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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-07-06 (con't.)	95.5 - 101.5	P	Inc.	Included ^{137}Cs; possible transfer line/tank leak.
21-08-02	0.0 - 6.0	SS	D	Included ^{137}Cs.
	6.5 - 11.0	SS	R	Included ^{137}Cs; possible transfer line leak.
	11.5 - 40.0	None	Ina.	No man-made contaminants detected.
	40.5 - 99.5	BE	Ina.	Removed ^{137}Cs; perforated casing.
	100.0- 129.0	None	Ina.	No man-made contaminants detected.
21-08-04	0.0 - 3.5	SS	D	Included ^{137}Cs.
	4.0 - 9.0	SS	R	Included ^{137}Cs and ^{154}Eu; possible transfer line leak.
	9.5 - 24.0	SS	D	Included ^{137}Cs; possible transfer line leak.
	24.4 - 39.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	39.5 - 99.5	None	Ina.	No man-made contaminants detected.
21-08-05	0.0 - 30.0	SS	D	Included ^{137}Cs.
	30.5 - 41.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	42.0 - 51.5	None	Ina.	No man-made contaminants detected.
	52.0 - 62.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.*
	62.5 - 67.0	None	Ina.	No man-made contaminants detected.
	67.5 - 77.5	P	Ina.	Included ^{60}Co; correlates w/21-08-06, possible tank leak.

[a] Source of contamination in judgment of analyst.
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[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-08-05 (con't.)	78.0 - 98.5	None	Ina.	No man-made contaminants detected.
21-08-06	0.0 - 9.5	SS	Ina.	Included ^{137}Cs.
	10.0 - 19.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	20.0 - 66.0	None	Ina.	No man-made contaminants detected.
	66.5	P	Ina.	Included ^{60}Co; possible tank leak.
	67.0 - 99.0	None	Ina.	No man-made contaminants detected.
21-08-07	0.0 - 4.5	SS	D	Included ^{137}Cs.
	5.0 - 5.5	SS	R	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs and ^{154}Eu; possible transfer line leak.*
	6.0 - 7.0	SS	R	Included ^{137}Cs, ^{152}Eu, and ^{154}Eu; possible transfer line leak.
	7.5 - 9.0	SS	R	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible transfer line leak.*
	9.5 - 10.0	SS	R	Included ^{137}Cs; possible transfer line leak.
	10.5 - 17.5	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.
	18.0 - 23.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.*
	23.5 - 32.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	32.5 - 47.5	P	D	Included ^{137}Cs and ^{60}Co; possible BX-108 tank leak.
	48.0 - 59.0	BE	Ina.	Removed ^{137}Cs and ^{60}Co; appear to be dragdown.
	59.5 - 62.5	P	D	Included ^{137}Cs and ^{60}Co; possible BX-108 tank leak.

[a] Source of contamination in judgment of analyst.
[b] SS- surface spill
[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-08-07 (con't.)	63.0 - 68.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	68.5 - 73.5	P	D	Included ^{137}Cs and ^{60}Co; possible BX-108 tank leak.
	74.0 - 99.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
21-08-10	0.0 - 33.5	SS	Inc.	Included ^{137}Cs.
	34.0 - 38.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	38.5 - 95.5	None	Ina.	No man-made contaminants detected.
	96.0 - 100.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-08-12	0.0 - 7.0	SS	Ina.	Included ^{137}Cs.
	7.5 - 23.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	23.5 - 49.0	None	Ina.	No man-made contaminants detected.
	49.5 - 71.0	P	Ina.	Included ^{60}Co; possible BX-108 tank leak.
	71.5 - 103.0	None	Ina.	No man-made contaminants detected.
21-09-02	0.0 - 22.5	SS	Inc.	Included ^{137}Cs.
	23.0 - 28.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	28.5 - 97.5	None	Ina.	No man-made contaminants detected.
21-09-04	0.0 - 6.0	SS	D	Included ^{137}Cs.
	6.5 - 10.0	SS	R	Included ^{137}Cs; possible transfer line leak.
	10.5 - 28.5	SS	D	Included ^{137}Cs.

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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-09-04 (con't.)	29.0 - 31.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	32.0 - 99.5	None	Ina.	No man-made contaminants detected.
	100.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-09-08	0.0 - 15.5	SS	D	Included ^{137}Cs.
	16.0 - 97.5	None	Ina.	No man-made contaminants detected.
21-09-12	0.0 - 24.5	SS	Inc.	Included ^{137}Cs.
	25.0 - 36.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	36.5 - 97.5	None	Ina.	No man-made contaminants detected.
21-10-01	0.0 - 5.0	SS	D	Included ^{137}Cs.
	5.5 - 30.5	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.
	31.0 - 37.5	None	Ina.	No man-made contaminants detected.
	38.0 - 42.5	P	D	Included ^{137}Cs and ^{60}Co; possible BX-110 tank leak.
	43.0 - 91.5	BE	Ina.	Removed ^{137}Cs and ^{60}Co; appears to be dragdown.
	92.0 - 98.5	None	Ina.	No man-made contaminants detected.

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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-10-03	0.0 - 2.0	SS	D	Included ^{137}Cs.
	2.5 - 7.5	SS	D	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs.*
	8.0 - 18.0	SS	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/internal shield) ^{137}Cs. Included ^{137}Cs; transfer line leak.*
	18.5 - 24.0	SS	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/external shield) ^{137}Cs. Included ^{137}Cs; possible transfer line leak.*
	24.5 - 39.0	SS	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible transfer line leak.*
	39.5 - 45.5	BE & P	Local	Removed ^{137}Cs, probable dragdown. Included ^{60}Co; correlates w/21-10-05; possible transfer line or tank leak.
	45.5 - 54.0	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible BX-110 tank leak.*
	54.5 - 75.0	BE	Local	Removed ^{137}Cs; probable dragdown. Included ^{60}Co; correlates w/ 21-10-05, possible BX-110 tank leak.*
	75.5 - 76.5	P	D	Included ^{137}Cs; possible BX-110 tank leak.
	77.0 - 84.5	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible BX-110 tank leak.*
	85.0 - 99.0	BE	Local	Removed ^{137}Cs; probable dragdown.

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[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-10-05	0.0 - 13.0	SS	D	Included ^{137}Cs.
	13.5 - 29.5	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	30.0 - 34.5	BE	Ina.	Removed ^{137}Cs; probable dragdown.*
	35.0 - 63.0	P	Ina. & D	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs and ^{60}Co; possible BX-110 tank leak. Removed ^{235}U; analytical error.
	63.5 - 75.5	BE	Inc.	Removed ^{137}Cs; probable dragdown.
	76.0 - 91.0	P	Inc.	Included ^{137}Cs; possible BX-110 tank leak. Removed ^{235}U; analytical error.
	91.5 - 98.0	BE	Local	Removed ^{137}Cs; probable dragdown.
21-00-07	0.0 - 3.5	SS	D	Included ^{137}Cs.
	4.0 - 39.0	None	Ina.	No man-made contaminants detected.
	39.5 - 71.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown, perforated casing.
	72.0 - 87.5	None	Ina.	No man-made contaminants detected.
21-10-07	0.0 - 3.0	SS	Ina.	Included ^{137}Cs.
	3.5 - 25.0	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	25.5 - 98.0	None	Ina.	No man-made contaminants detected.
	98.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.

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[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-10-11	0.0 - 7.0	SS	Ina.	Included ^{137}Cs.
	7.5 - 34.0	BE	Ina.	Removed ^{137}Cs; probable dragdown.
	34.5 - 99.0	None	Ina.	No man-made contaminants detected.
21-11-03	0.0 - 14.0	SS	D	Included ^{137}Cs.
	14.5 - 39.0	BE	Inc.	Removed ^{137}Cs; appears to be dragdown.*
	44.0 - 45.0	P	Inc.	Included ^{137}Cs; possible BX-111 tank leak.
	45.5 - 65.0	BE	Local	Removed ^{137}Cs; appears to be dragdown.
	65.5 - 69.5	P	D	Included ^{137}Cs; possible BX-111 tank leak.
	70.0 - 98.5	BE	Local	Removed ^{137}Cs; appears to be dragdown.
21-11-04	0.0 - 2.5	SS	Ina.	Included ^{137}Cs.
	3.0 - 9.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	10.0 - 37.0	None	Ina.	No man-made contaminants detected.
	37.5 - 38.5	P	Ina.	Included ^{137}Cs; possible BX-111 tank leak.
	39.0 - 41.5	P	Ina.	Replaced SGLS ^{137}Cs with HRLS (w/no shield) ^{137}Cs. Included ^{137}Cs; possible BX-111 tank leak.*
	42.0 - 44.5	P	Ina.	Included ^{137}Cs and ^{60}Co; possible BX-111 tank leak.
	45.0 - 64.0	None	Ina.	No man-made contaminants detected.
	64.5 - 82.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.*
	83.0 - 97.5	None	Ina.	No man-made contaminants detected.

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[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-11-05	0.0 - 1.5	SS	Ina.	Included ^{137}Cs.
	2.0 - 7.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	7.5 - 41.5	None	Ina.	No man-made contaminants detected.
	42.0 - 44.0	P	Inc.	Included ^{137}Cs; correlates w/21-11-04, possible BX-111 tank leak.
	44.5 - 64.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.*
	65.0 - 98.0	None	Ina.	No man-made contaminants detected.
21-11-07	0.0 - 4.0	SS	Ina.	Included ^{137}Cs.
	4.5 - 11.0	None	Ina.	No man-made contaminants detected.
	11.5 - 13.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	13.5 - 38.0	None	Ina.	No man-made contaminants detected.
	38.5 - 45.0	P	Ina.	Included ^{137}Cs and ^{60}Co; correlates w/21-11-05, possible BX-111 tank leak.
	45.5 - 98.0	None	Ina.	No man-made contaminants detected.
	98.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-11-10	0.0 - 1.5	SS	Ina.	Included ^{137}Cs.
	2.0 - 99.5	None	Ina.	No man-made contaminants detected.
21-11-11	0.0 - 2.0	SS	Ina.	Included ^{137}Cs.
	2.5 - 4.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.

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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-11-11 (con't.)	4.5 - 100.5	None	Ina.	No man-made contaminants detected.
21-00-09	0.0 - 1.5	SS	D	Included ^{137}Cs.
	2.0 - 21.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	21.5 - 48.5	None	Ina.	No man-made contaminants detected.
	49.0	P	Ina.	Included ^{60}Co; correlates w/21-00-21, possible transfer line leak.
	49.5 - 73.0	None	Ina.	No man-made contaminants detected.
	73.5 - 74.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-00-21	0.0 - 2.0	SS	D	Included ^{137}Cs.
	2.5 - 42.0	None	Ina.	No man-made contaminants detected.
	42.5 - 49.5	P	Ina.	Included ^{137}Cs; possible transfer line leak.
	50.0 - 74.5	BE & P	D (^{60}Co)	Included ^{60}Co; correlates w/ 21-00-09, possible transfer line leak.* Removed ^{137}Cs; appears to be dragdown, perforated casing.*
	75.0 - 98.5	BE	Ina.	Removed ^{137}Cs; probable dragdown, perforated casing.
	99.0 - 143.5	None	Ina.	No man-made contaminants detected.
	144.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.

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[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-00-22	0.0 - 1.0	SS	D	Included ^{137}Cs.
	1.5 - 72.5	BE & P	Ina.	Included ^{60}Co; possible transfer line leak.* Removed ^{137}Cs; appears to be dragdown.
	96.0 - 137.5	P	Ina.	Included ^{60}Co, ^{125}Sb, ^{235}U, and ^{238}U; possible BX-102 tank leak.
21-00-11	0.0 - 1.5	SS	D	Included ^{137}Cs.
	2.0 - 7.0	BE	Ina.	Removed ^{137}Cs, appears to be dragdown.
	7.5 - 38.5	None	Ina.	No man-made contaminants detected.
	39.0 - 75.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown, perforated casing.
	75.5 - 132.0	None	Ina.	No man-made contaminants detected.
21-12-02	0.0 - 17.5	SS	D	Include ^{137}Cs.
	18.0 - 29.0	BE	Ina.	Remove ^{137}Cs; appears to be dragdown.
	29.5 - 40.5	None	Ina.	No man-made contaminants detected.
	41.0 - 44.5	P	D	Include ^{137}Cs and ^{60}Co; possible tank leak.
	45.0 - 99.0	None	Ina.	No man-made contaminants detected.
21-12-05	0.0 - 1.0	SS	Ina.	Included ^{137}Cs.
	1.5 - 3.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	4.0 - 96.0	None	Ina.	No man-made contaminants detected.

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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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Table C-1 (con't.). Summary of Interpreted Data Set for the BX Tank Farm

Borehole Number	Depth Range (ft)	Source[a]	SFA[e]	Disposition/Comments
21-12-07	0.0 - 1.5	SS	Ina.	Included ^{137}Cs.
	2.0 - 38.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	38.5 - 95.5	None	Ina.	No man-made contaminants detected.
	96.0 - 99.0	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-12-10	0.0 - 4.5	SS	Inc.	Included ^{137}Cs.
	5.0 - 19.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	19.5 - 22.5	SS	D	Included ^{137}Cs; possible transfer line leak.
	23.0 - 26.0	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	26.5 - 99.0	None	Ina.	No man-made contaminants detected.
	99.5	BE	Ina.	Removed ^{137}Cs; appears to have fallen in from the ground surface.
21-12-12	0.0 - 24.0	SS	D	Included ^{137}Cs.
	24.5 - 33.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	34.0 - 79.0	None	Ina.	No man-made contaminants detected.
	79.5 - 83.5	BE	Ina.	Removed ^{137}Cs; appears to be dragdown.
	84.0 - 99.0	None	Ina.	No man-made contaminants detected.

[a] Source of contamination in judgment of analyst.
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[c] BE - borehole effects (e.g., dragdown, inside/outside casing contamination)
[d] P - plume of contamination
[e] SFA - shape factor analysis
[f] D - Contamination distributed in formation.
[g] Inc. - Inconclusive, generally due to low or rapidly changing concentrations.
[h] Local - Contamination is confined to the vicinity of the borehole casing.
[i] R - Contamination is remote from the borehole.
[j] Ina. - Inapplicable to apply SFA in this instance.
[k] R/P - *Analysis of Historical Gross Gamma Logging Data from BX Tank Farm* (Randall and Price 1999).

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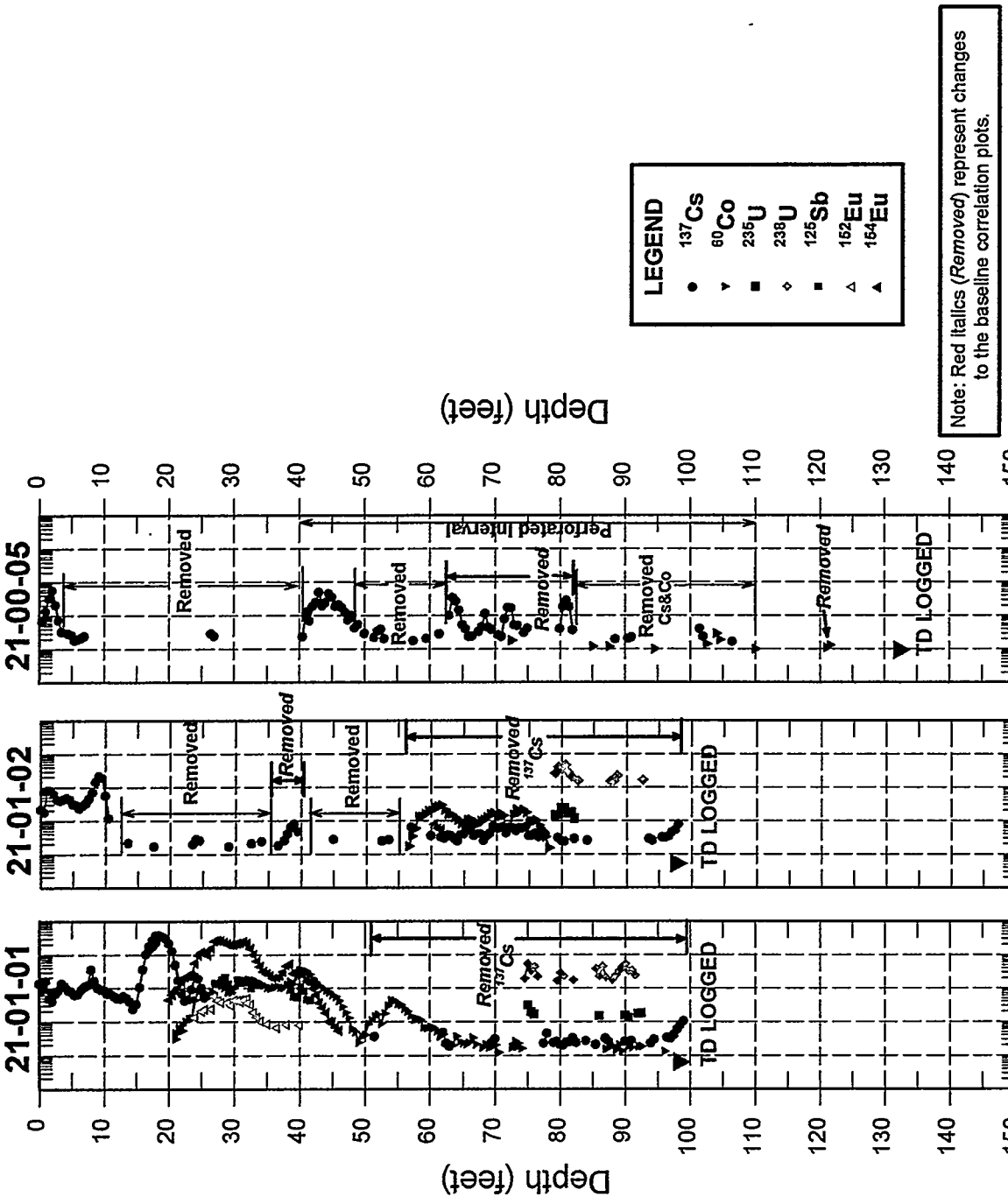

Figure C-1. Summary of Interpreted Data Set for the BX Tank Farm

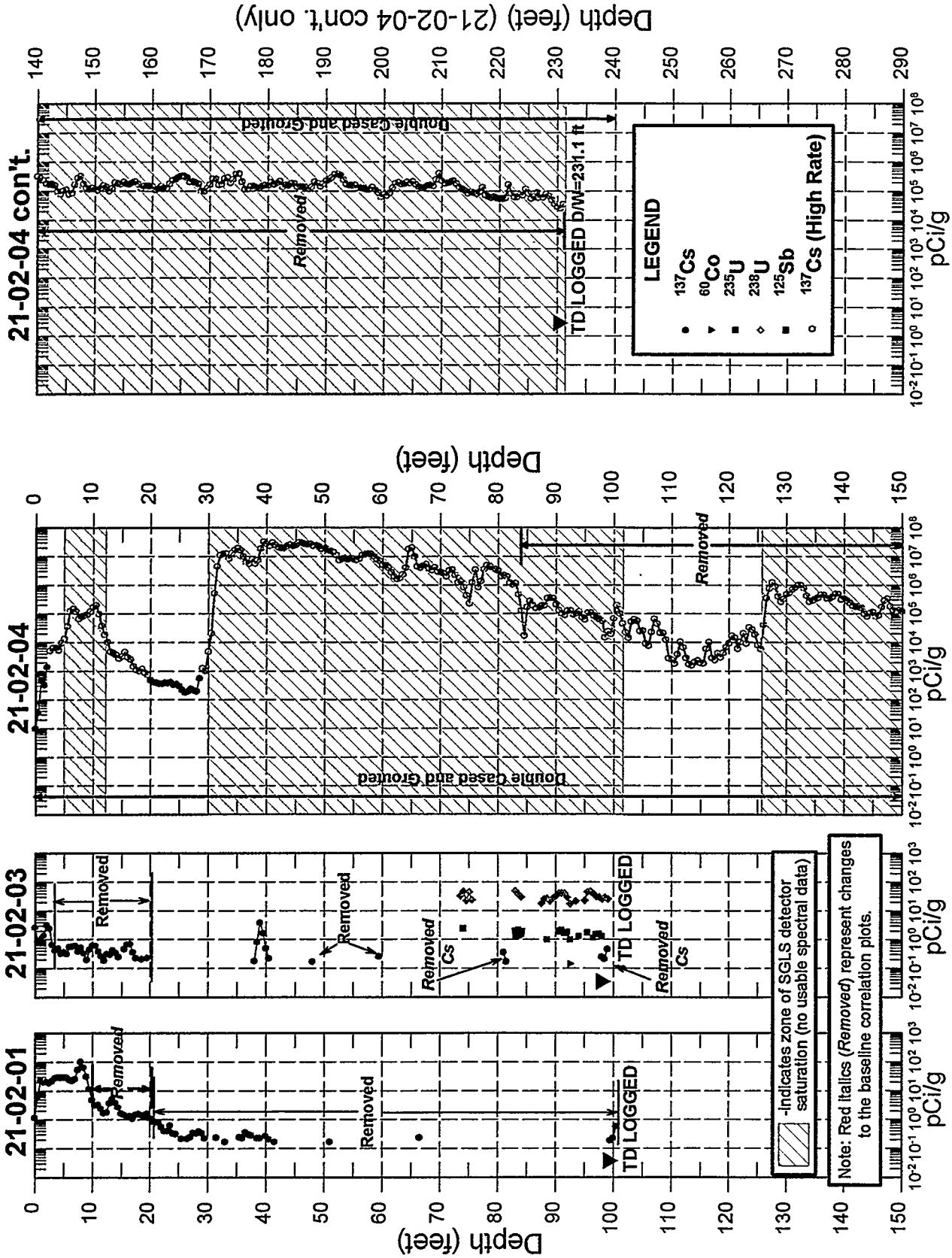

Figure C-2. Summary of Interpreted Data Set for the BX Tank Farm

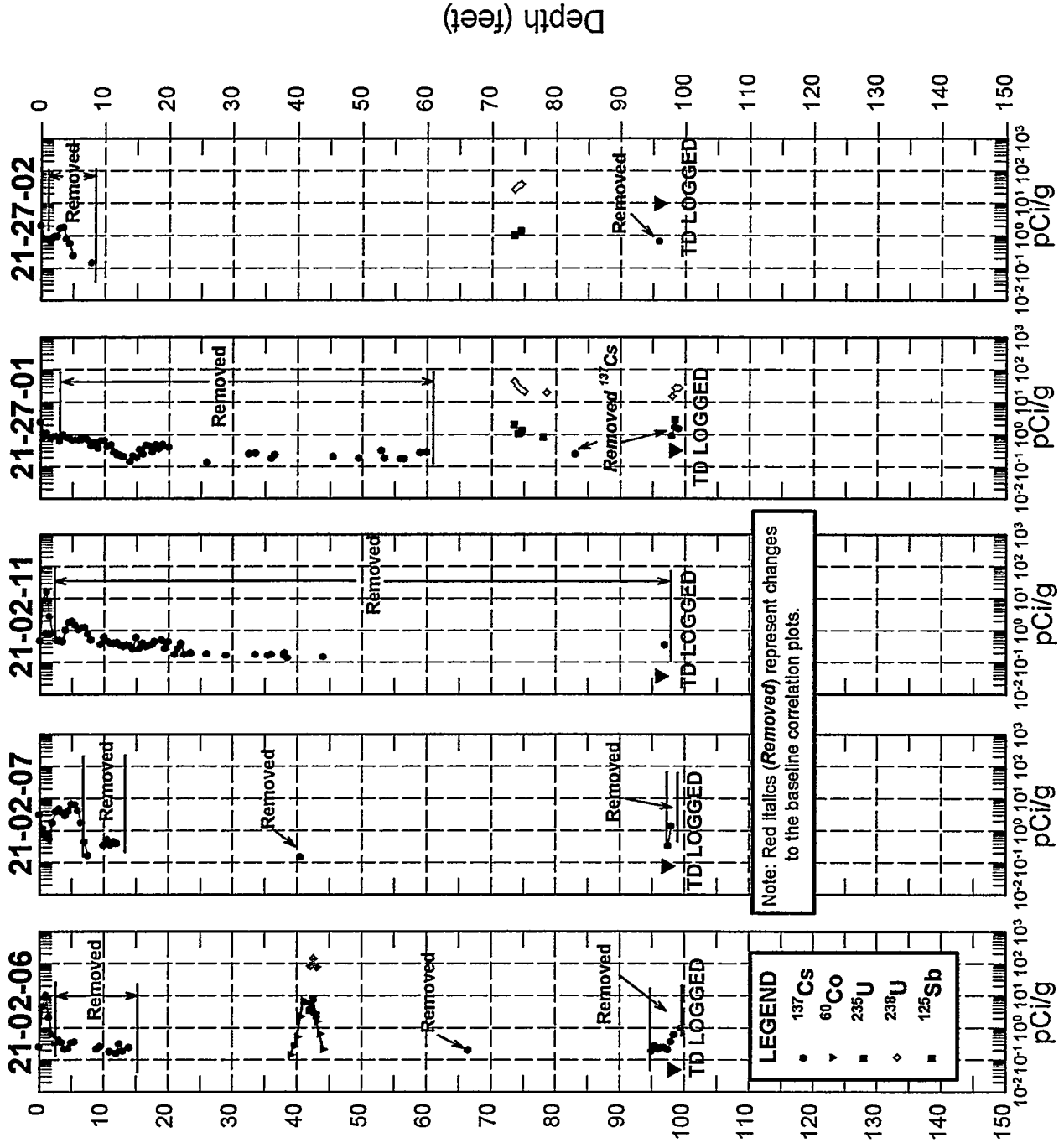

Figure C-3. Summary of Interpreted Data Set for the BX Tank Farm

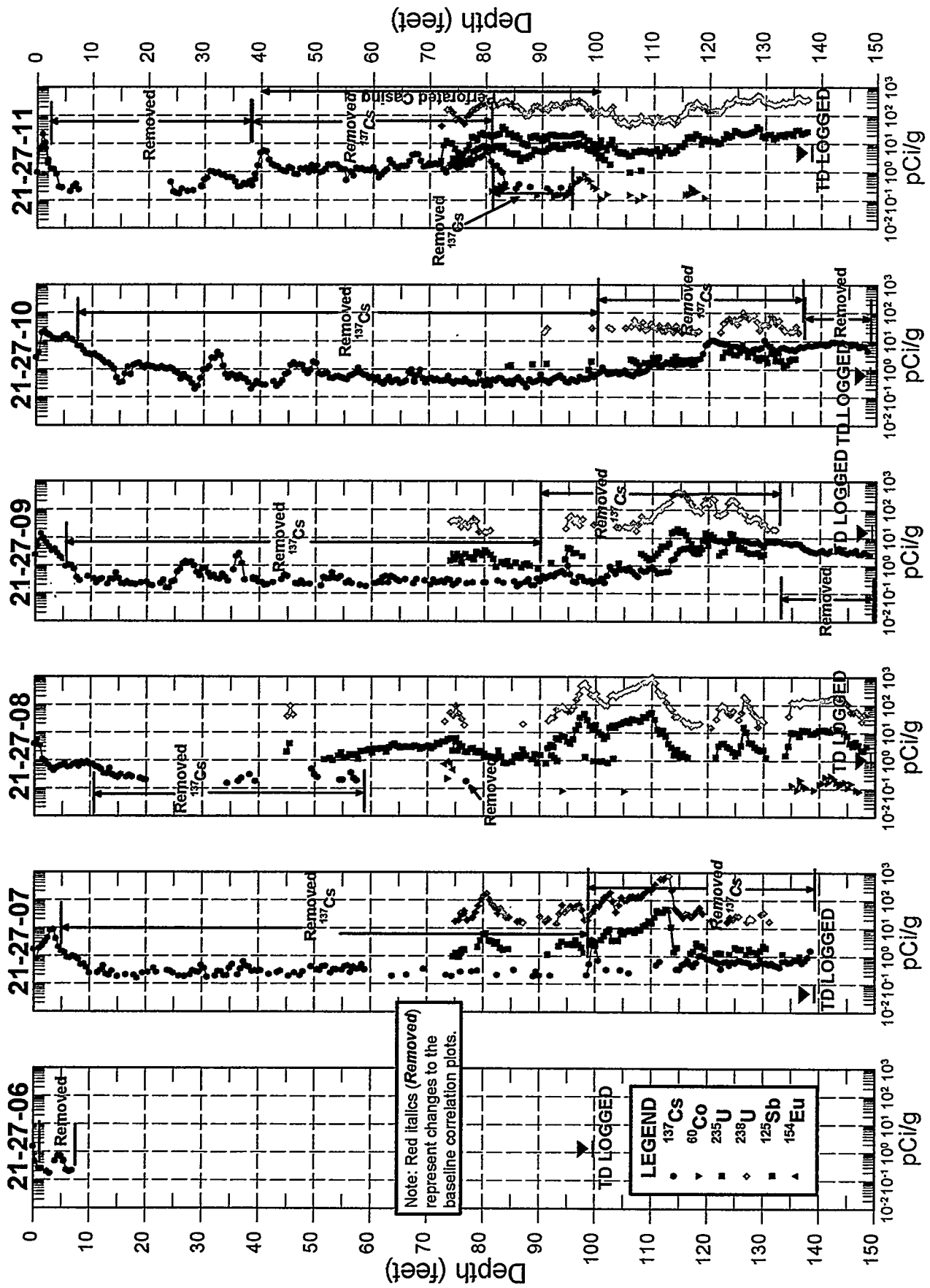

Figure C-4. Summary of Interpreted Data Set for the BX Tank Farm

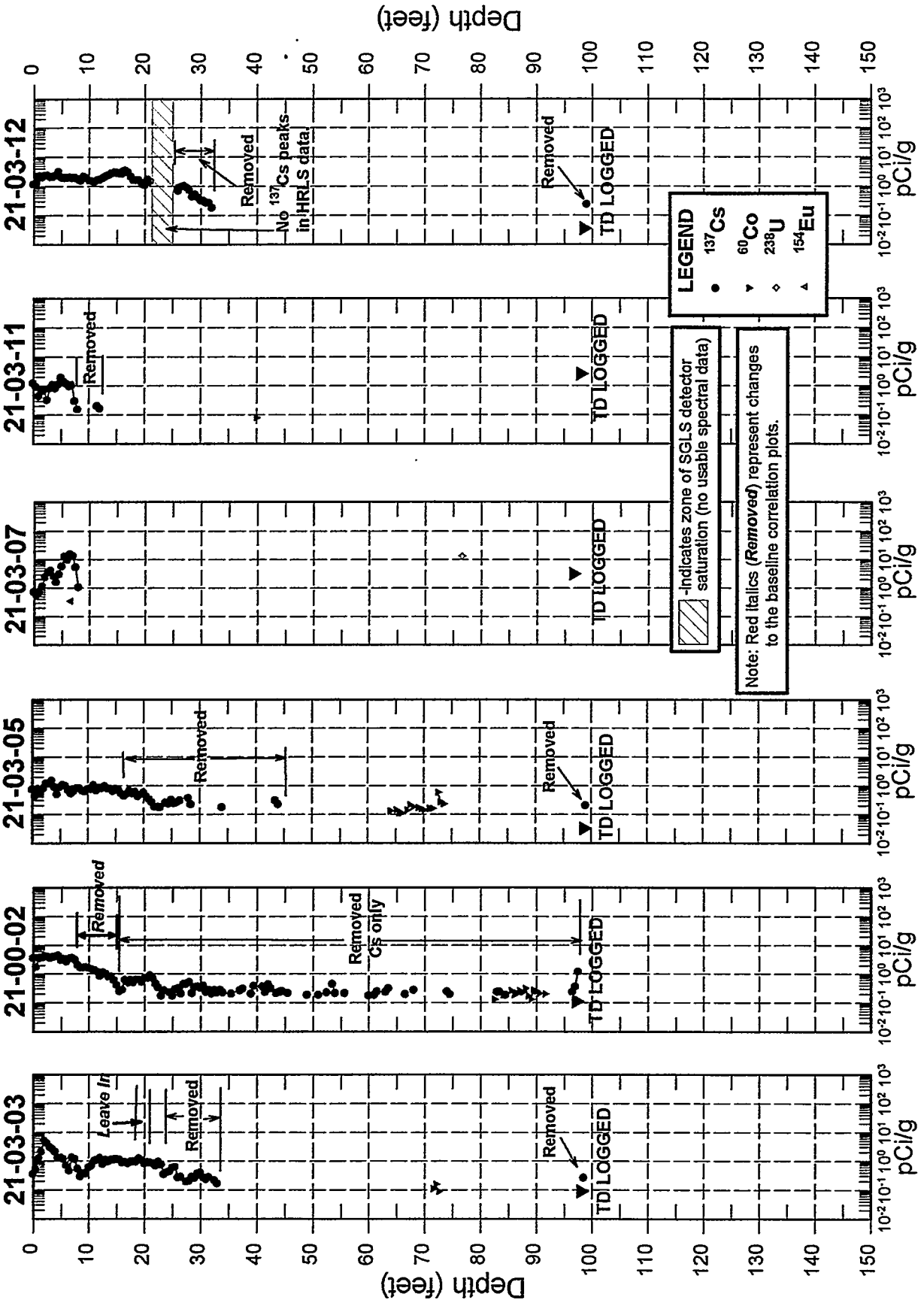

Figure C-5. Summary of Interpreted Data Set for the BX Tank Farm

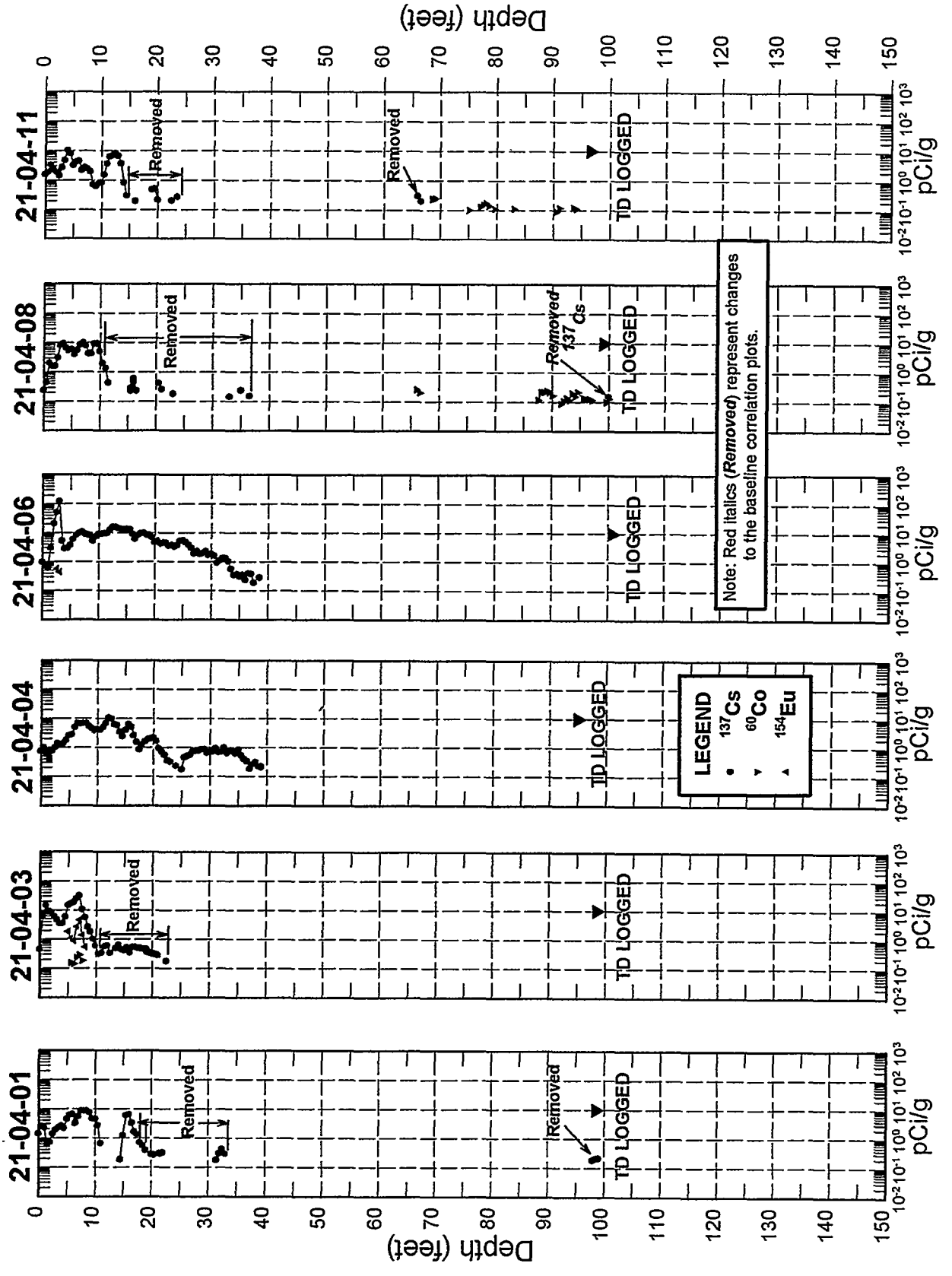

Figure C-6. Summary of Interpreted Data Set for the BX Tank Farm

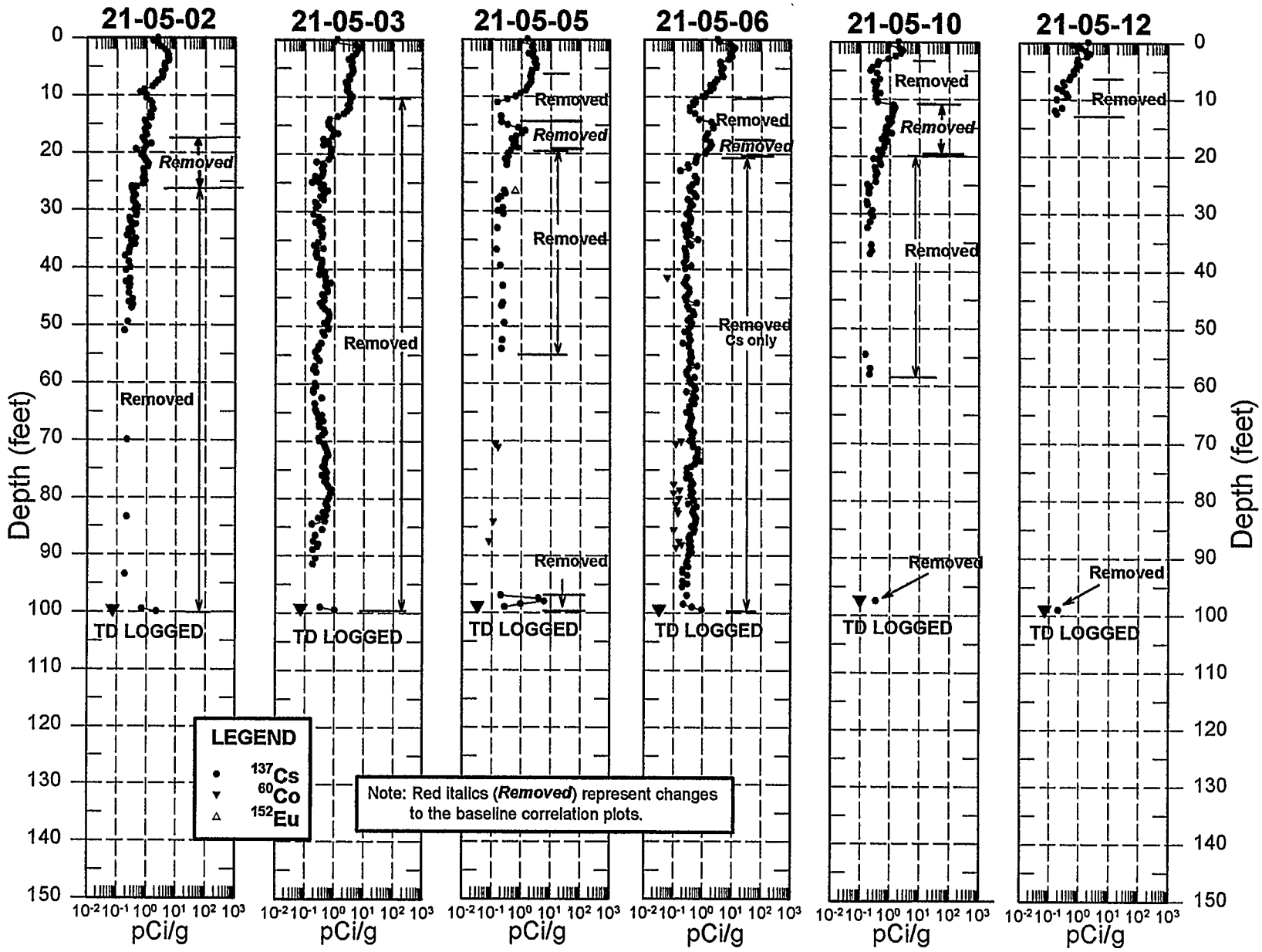

Figure C-7. Summary of Interpreted Data Set for the BX Tank Farm

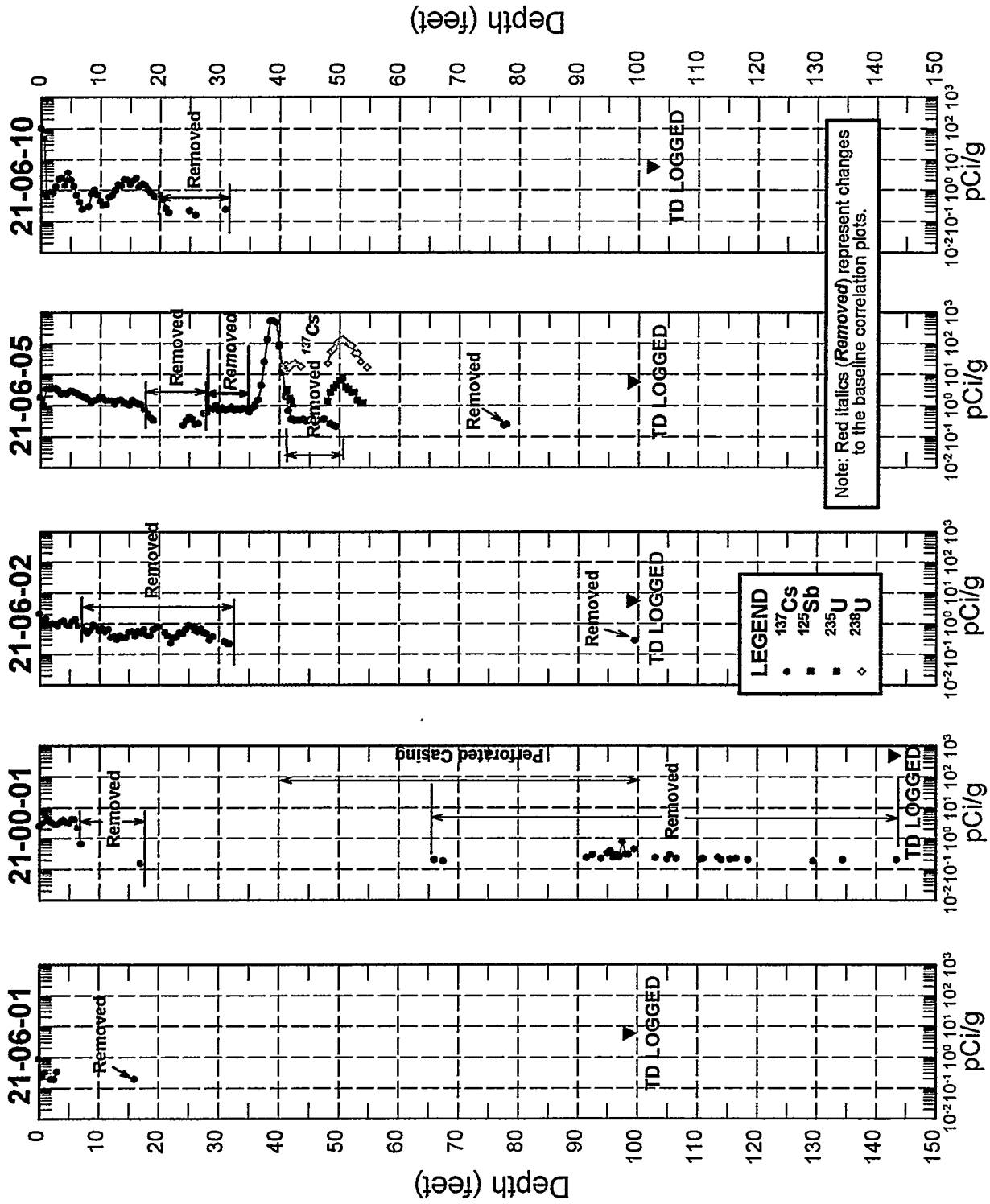

Figure C-8. Summary of Interpreted Data Set for the BX Tank Farm

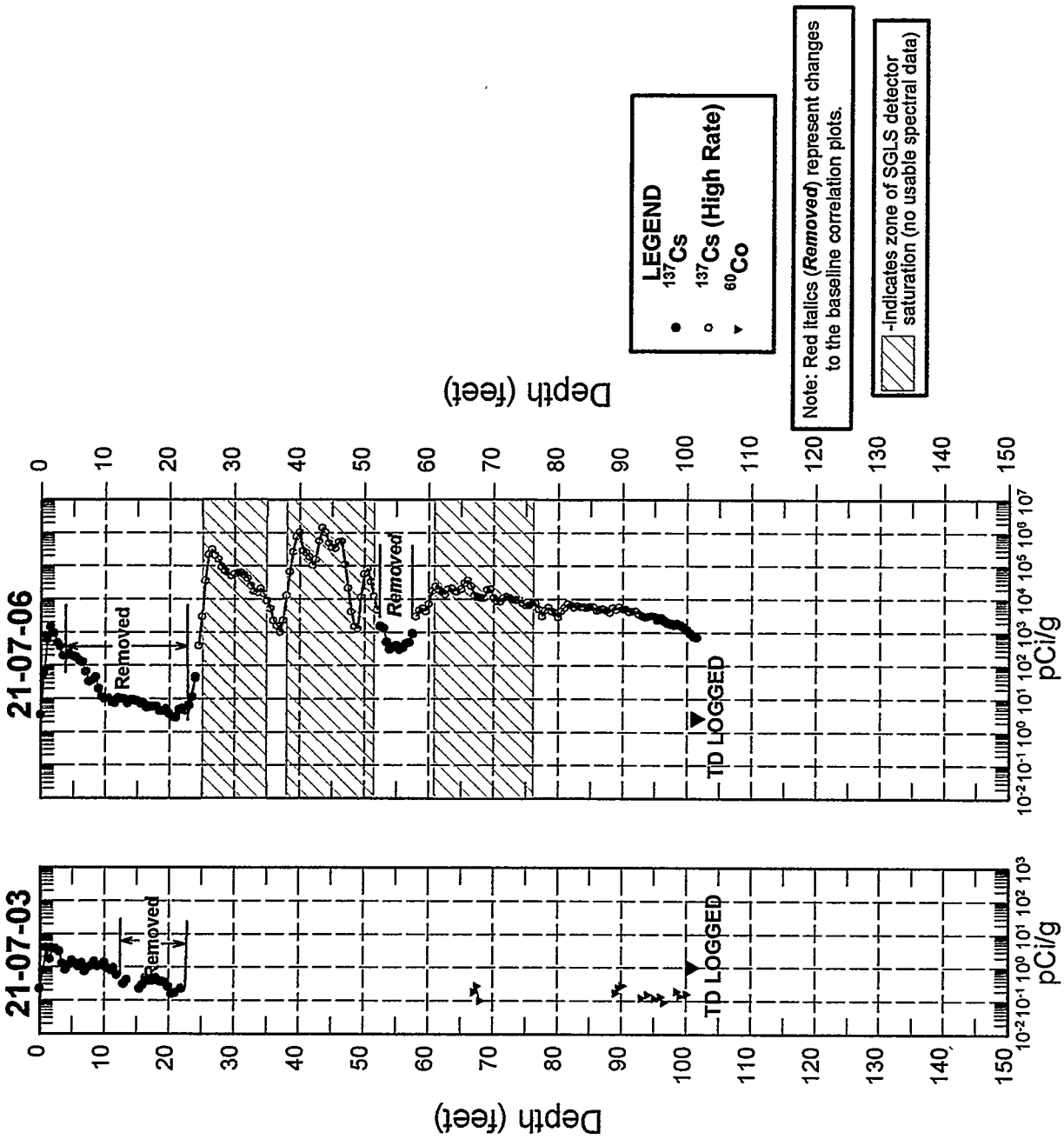

Figure C-9. Summary of Interpreted Data Set for the BX Tank Farm

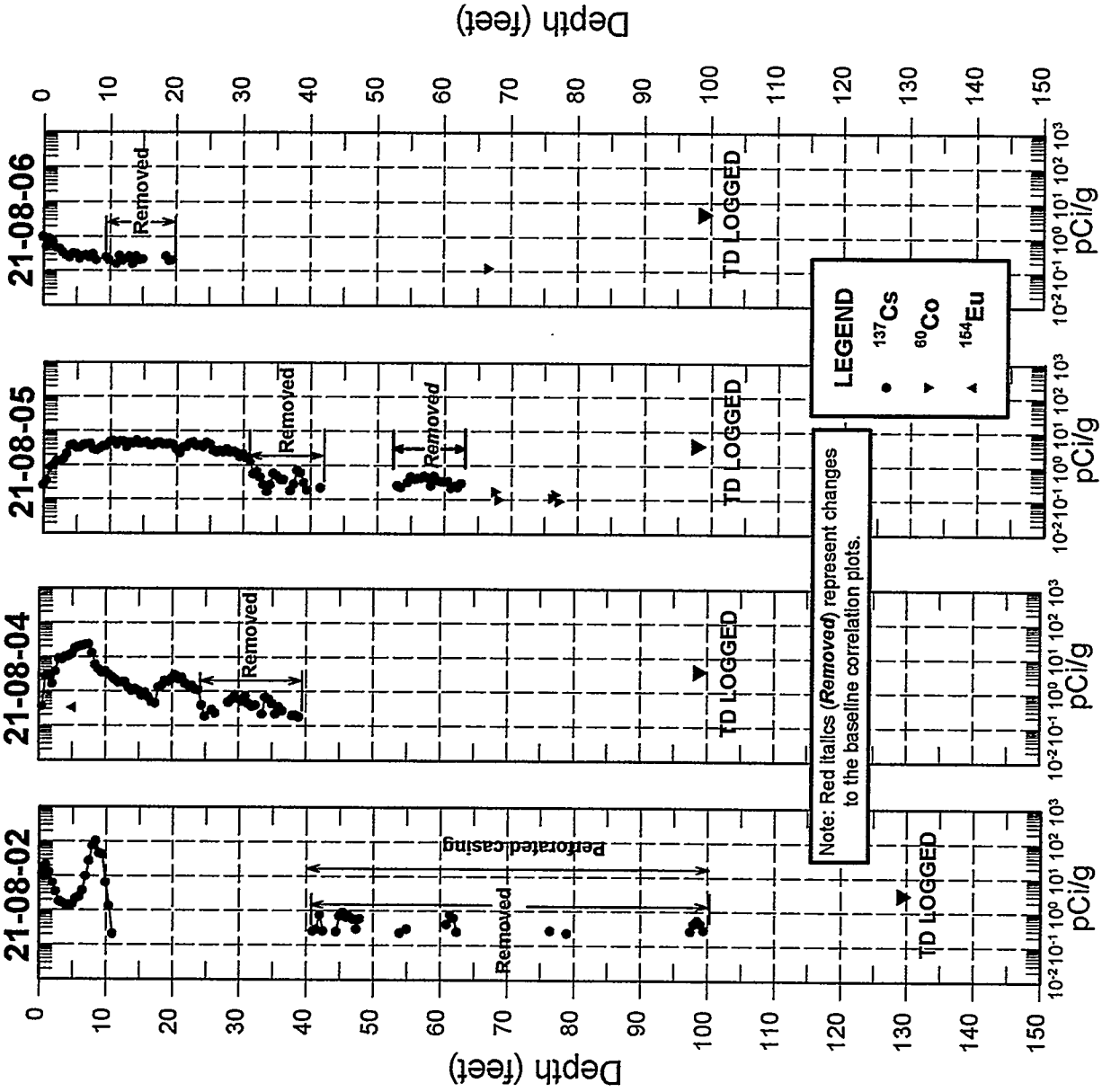

Figure C-10. Summary of Interpreted Data Set for the BX Tank Farm

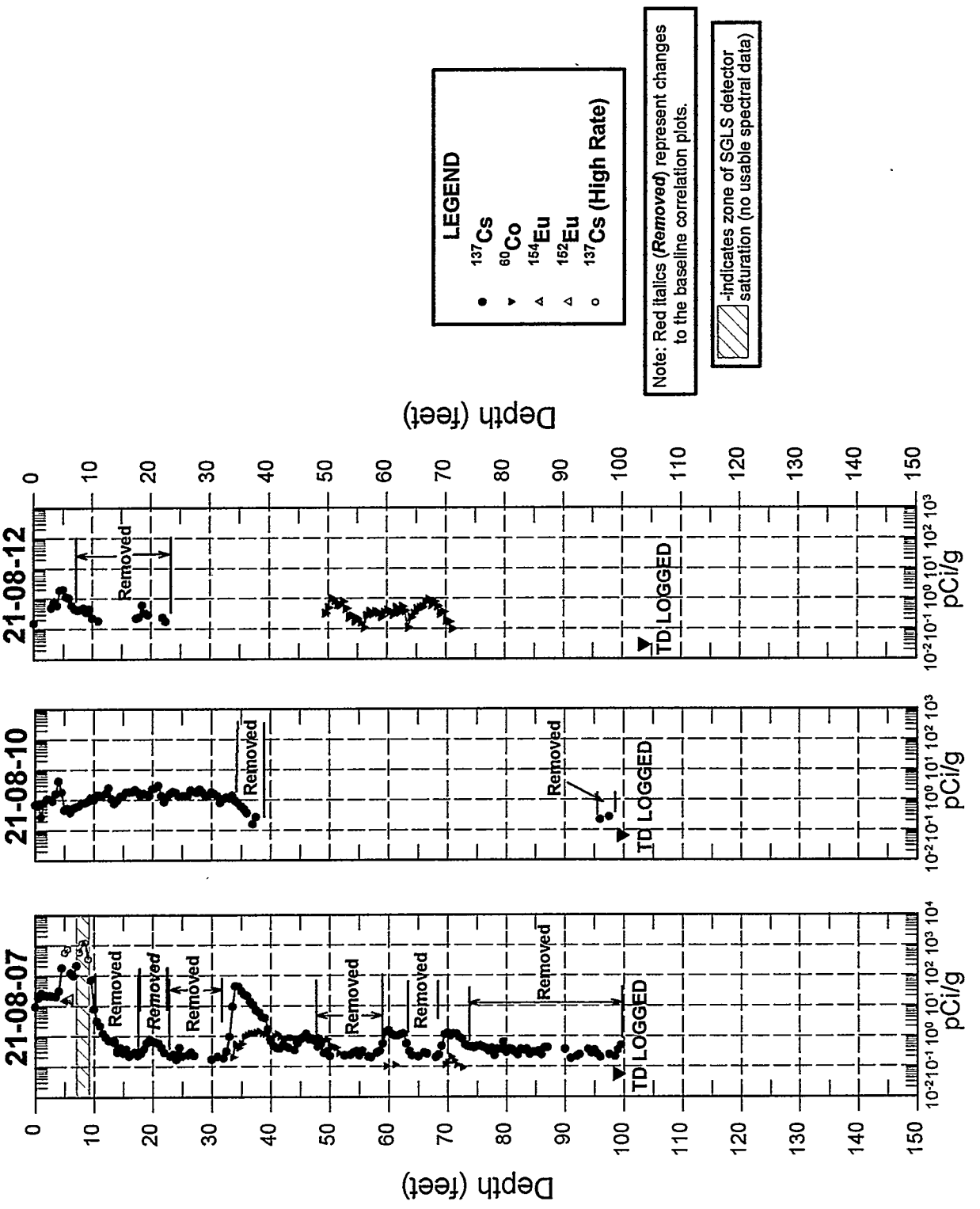

Figure C-11. Summary of Interpreted Data Set for the BX Tank Farm

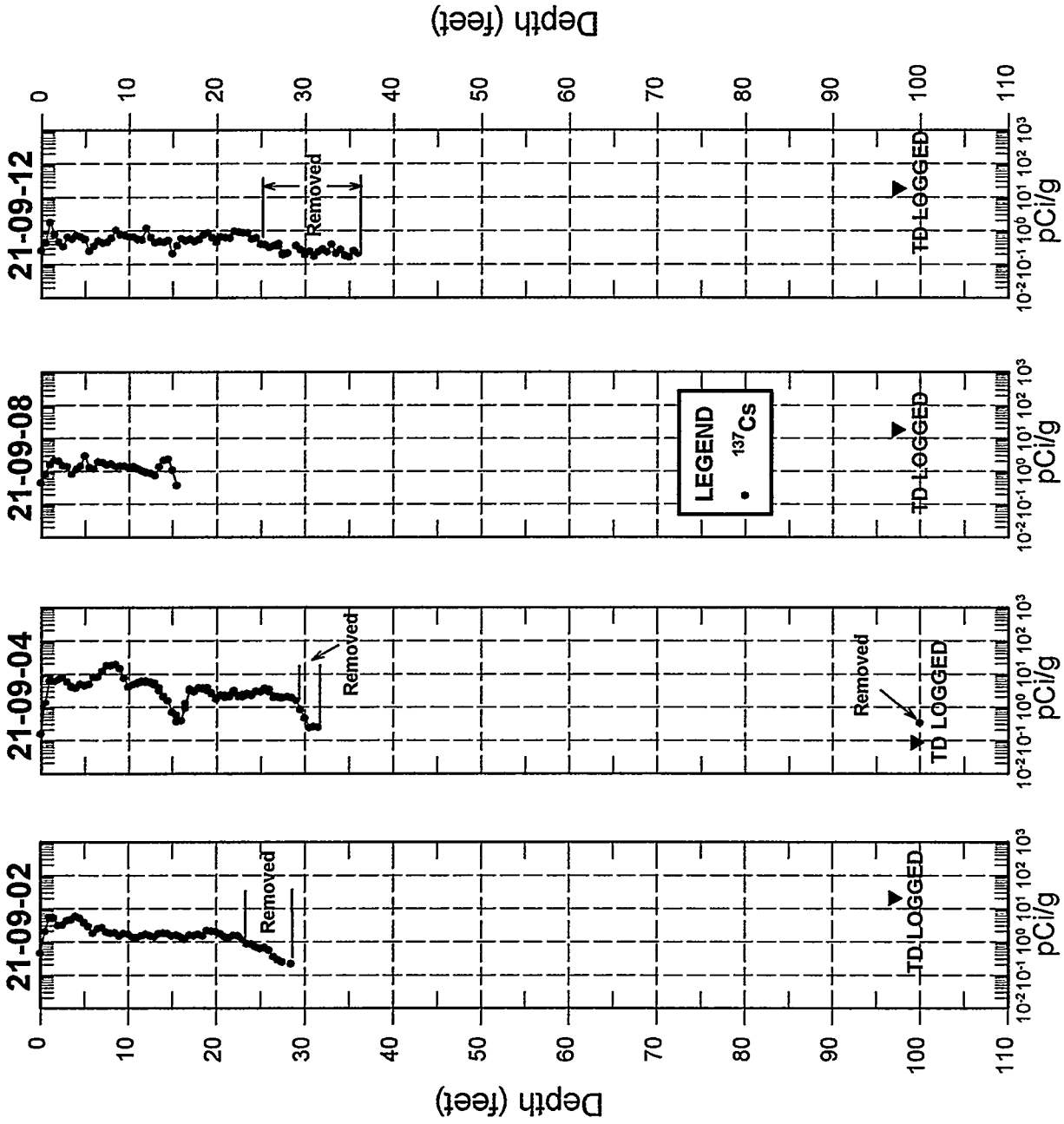

Figure C-12. Summary of Interpreted Data Set for the BX Tank Farm

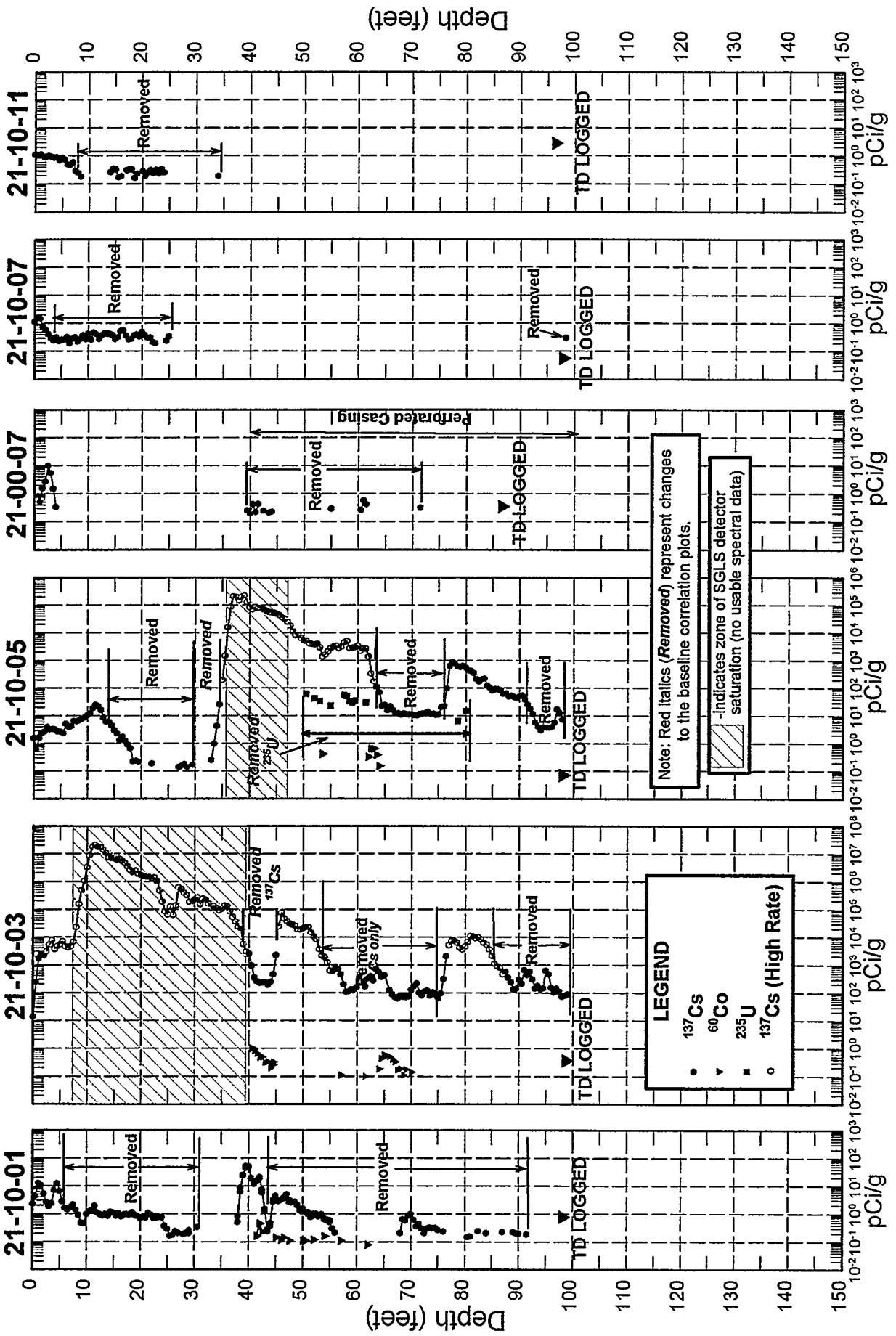

Figure C-13. Summary of Interpreted Data Set for the BX Tank Farm

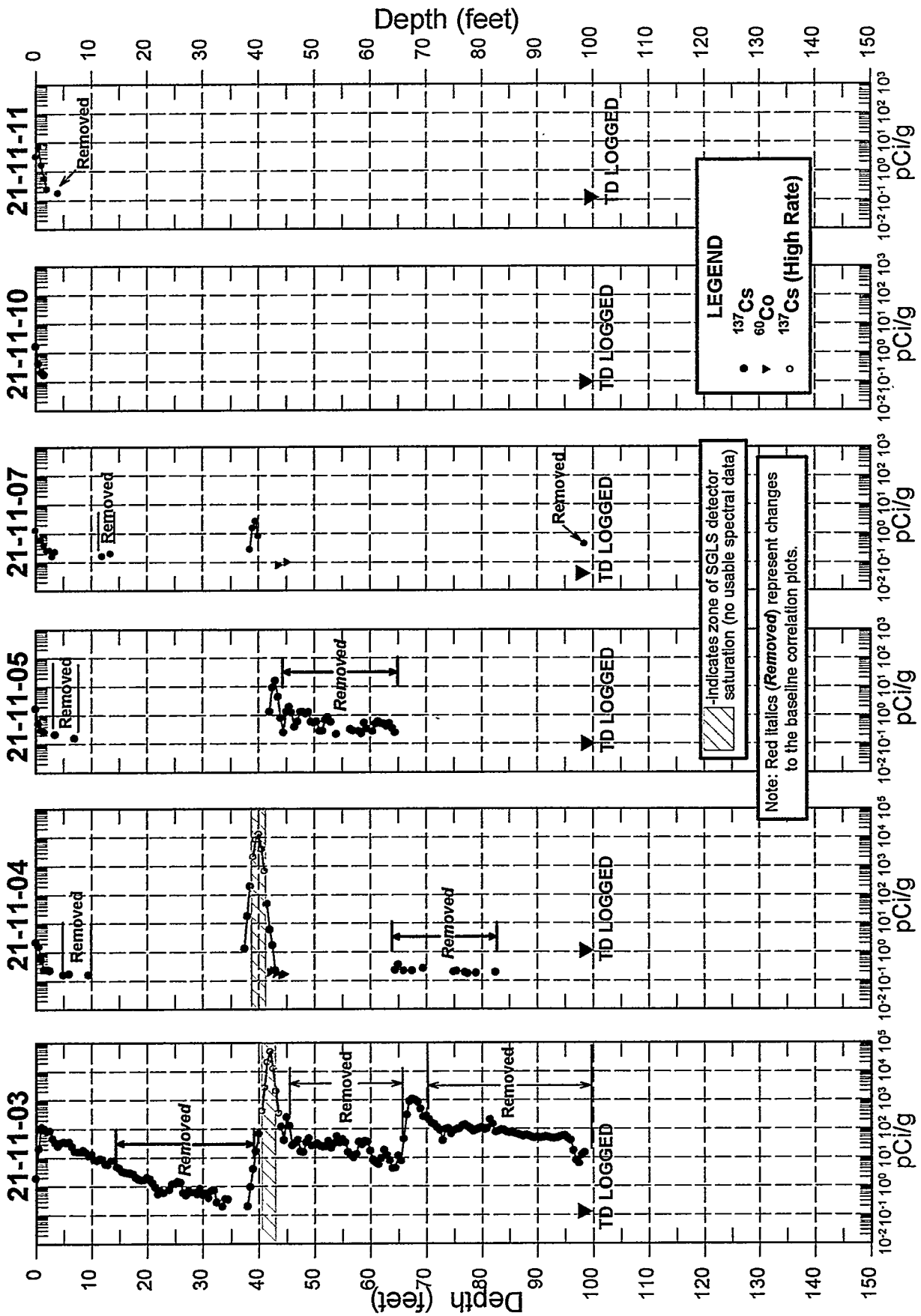

Figure C-14. Summary of Interpreted Data Set for the BX Tank Farm

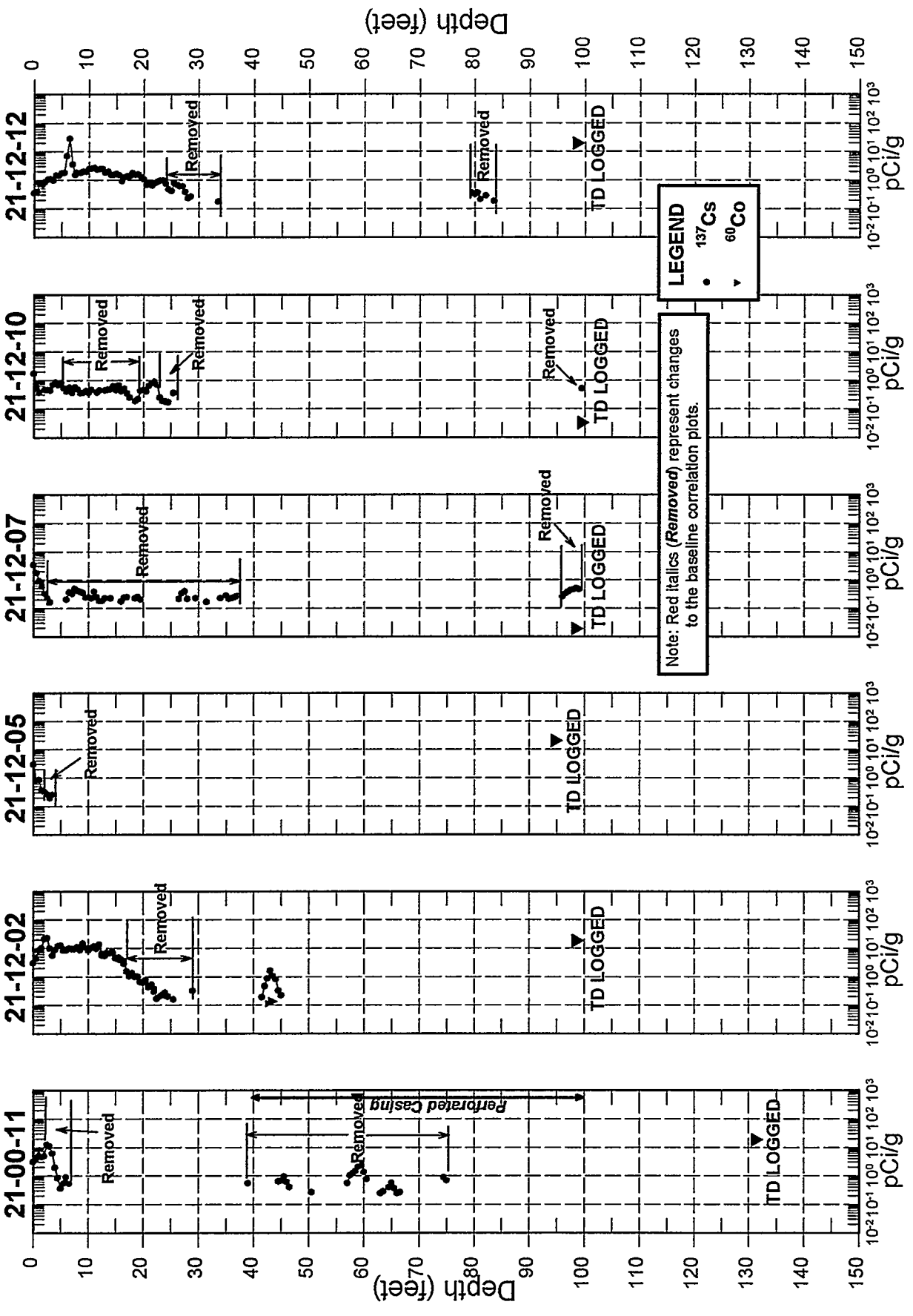

Figure C-15. Summary of Interpreted Data Set for the BX Tank Farm

Appendix D
BX Tank Farm Visualizations

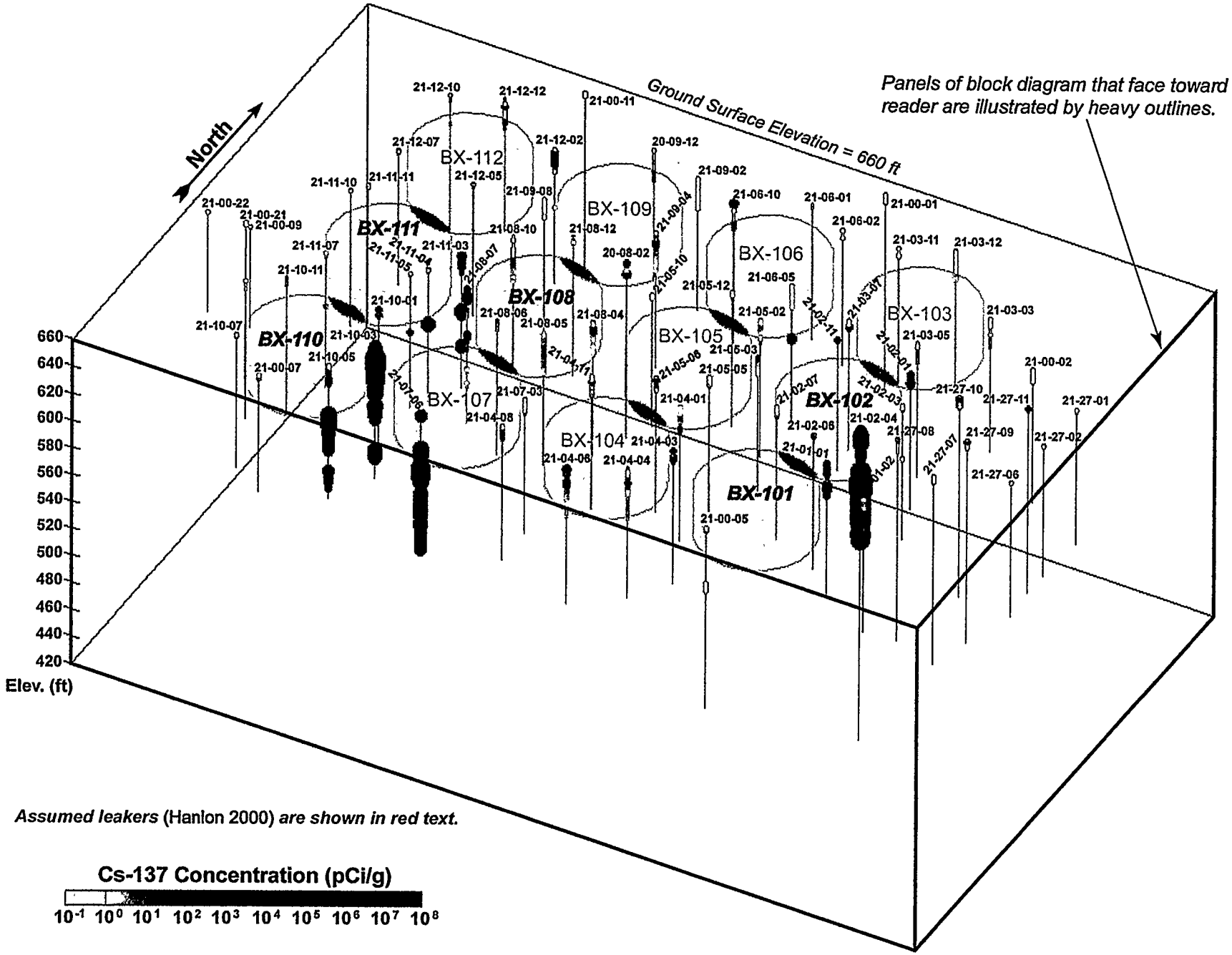

Figure D-1. BX Tank Farm Visualization

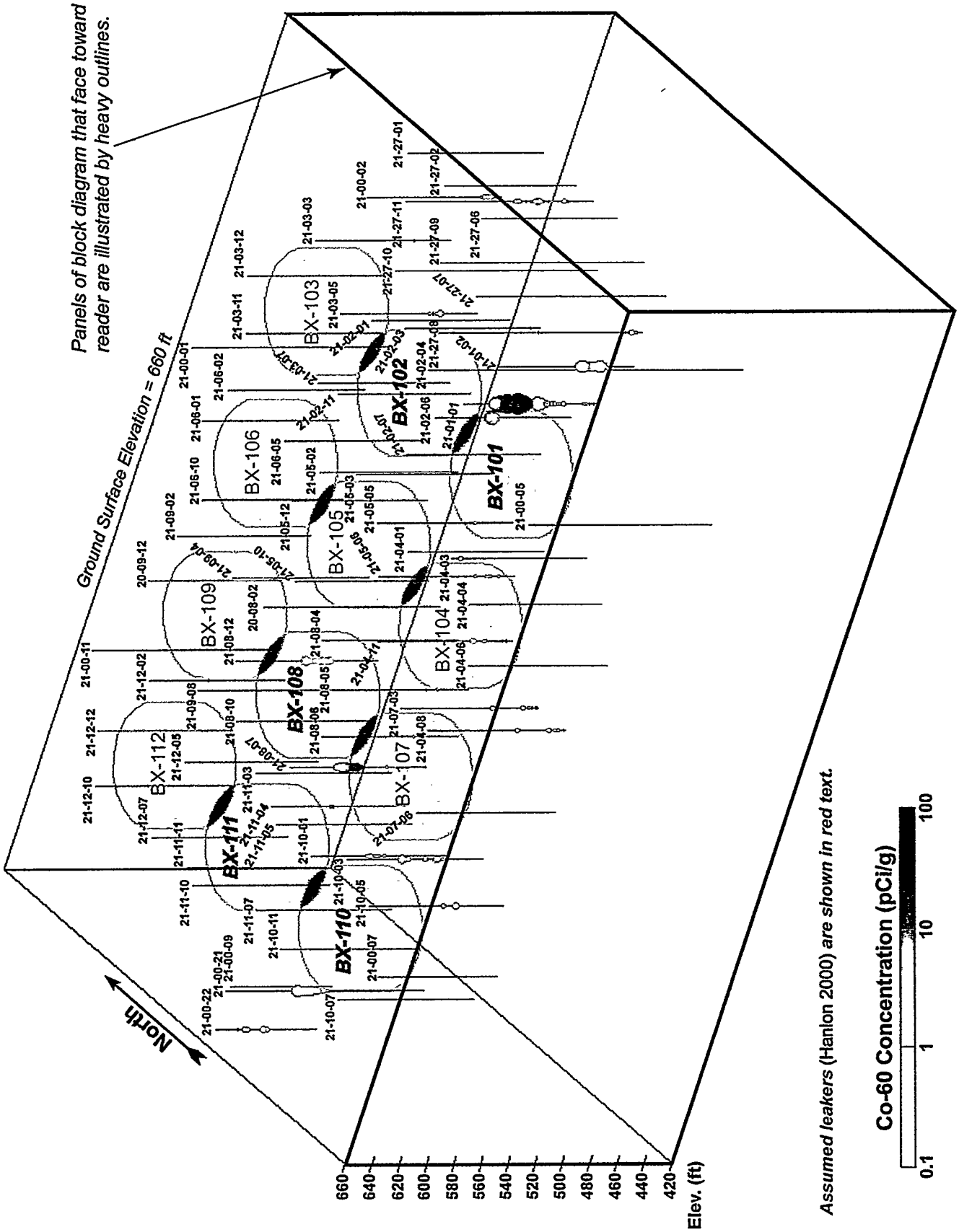

Figure D-2. BX Tank Farm Visualization

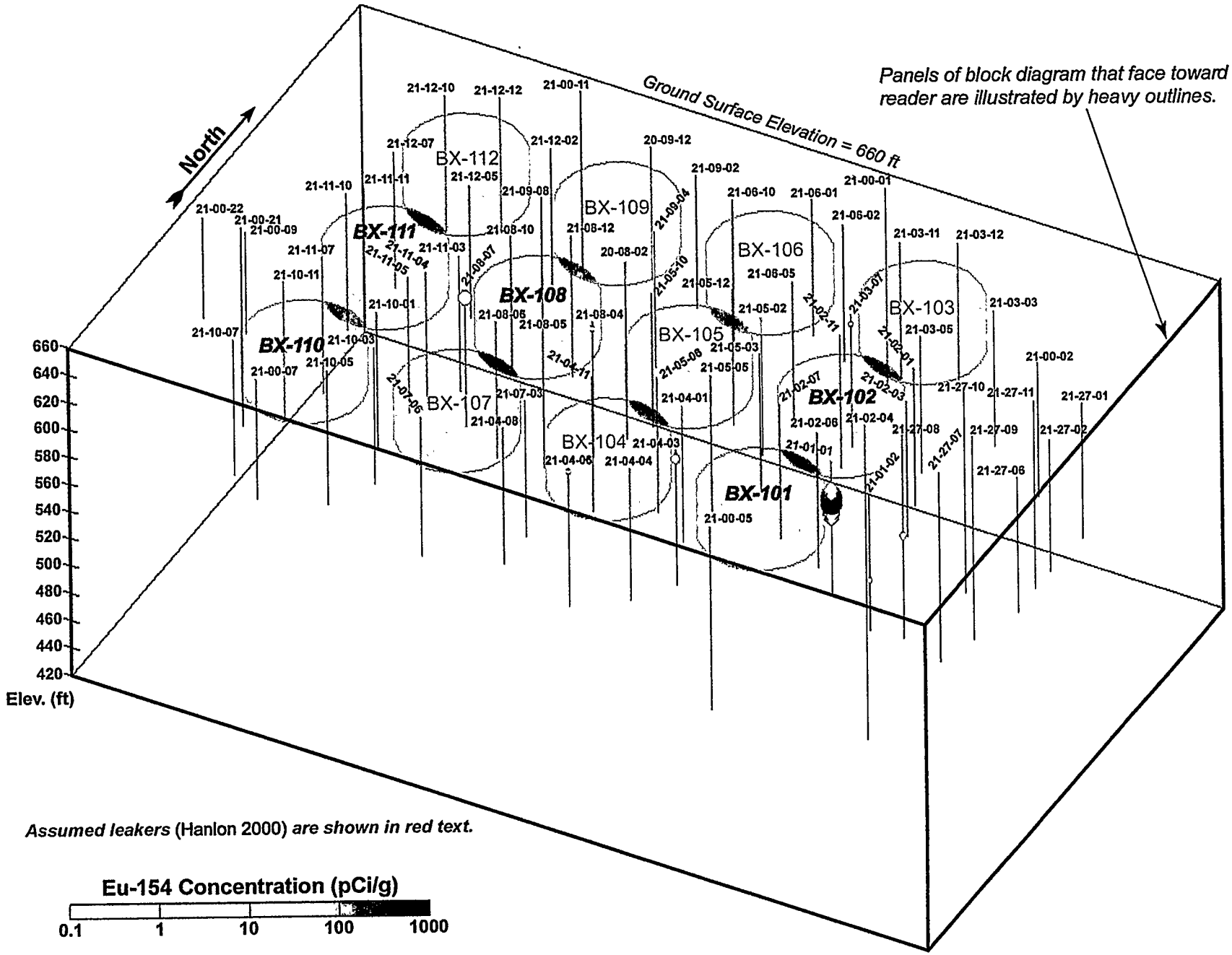

Figure D-3. BX Tank Farm Visualization

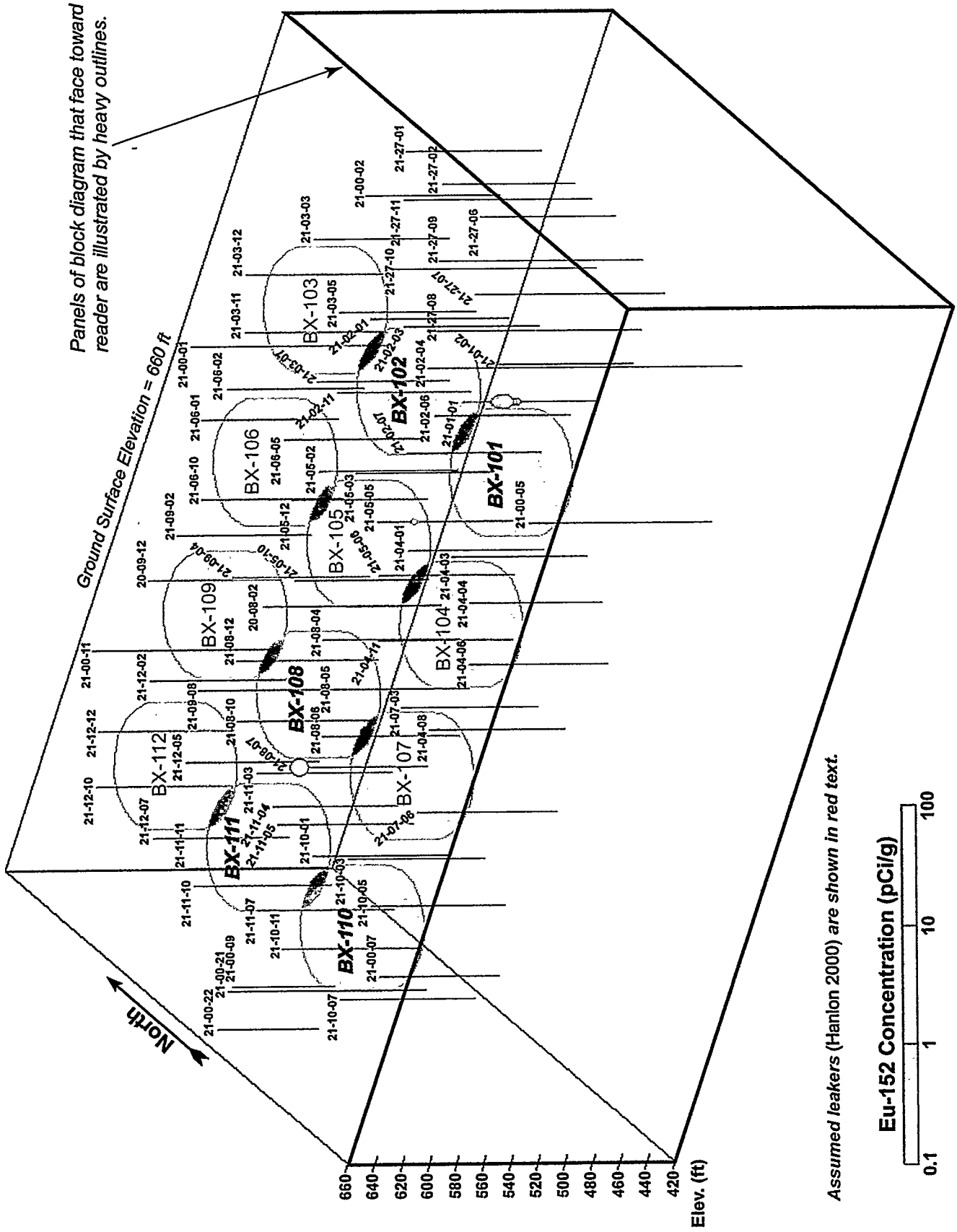

Figure D-4. BX Tank Farm Visualization

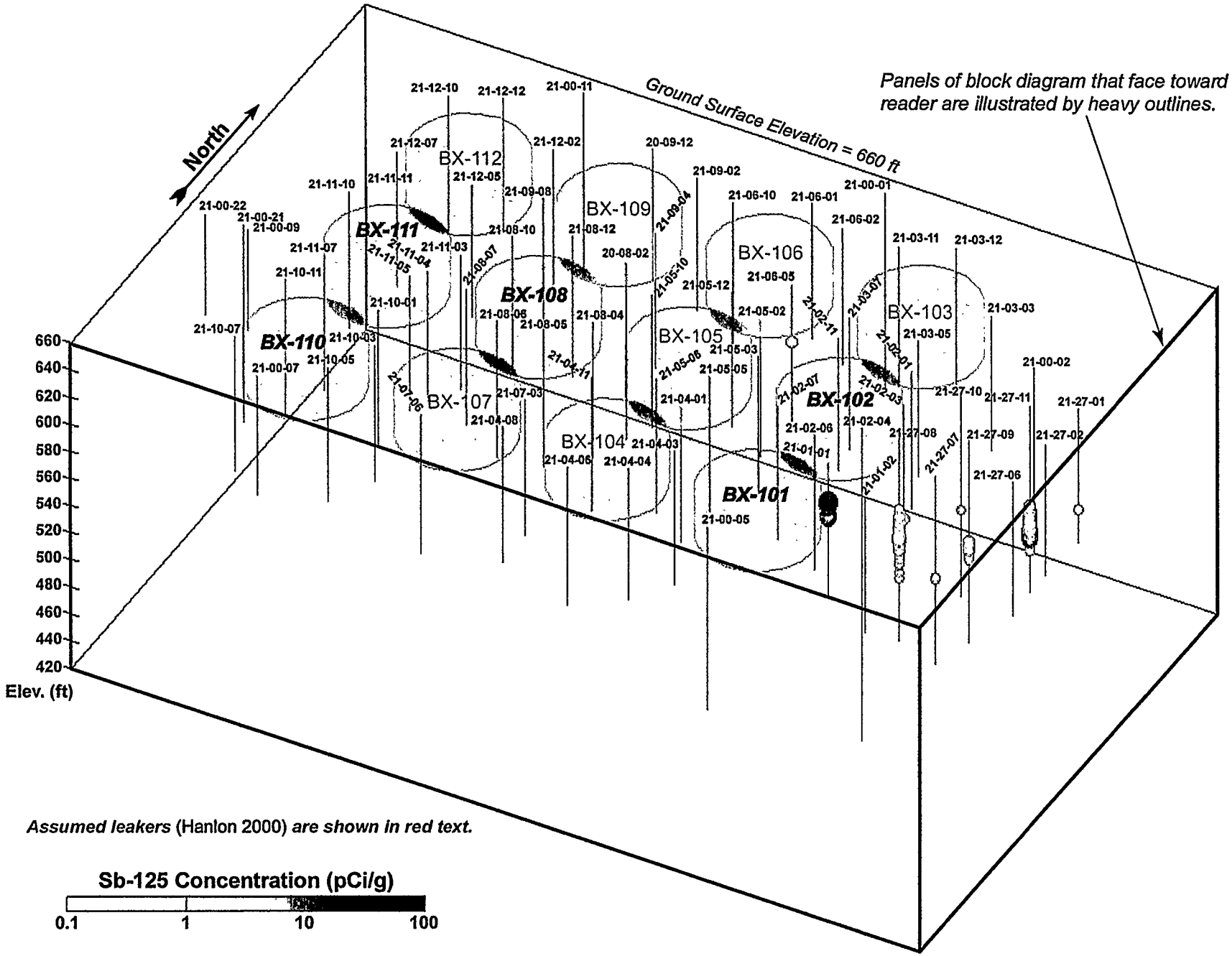

Figure D-5. BX Tank Farm Visualization

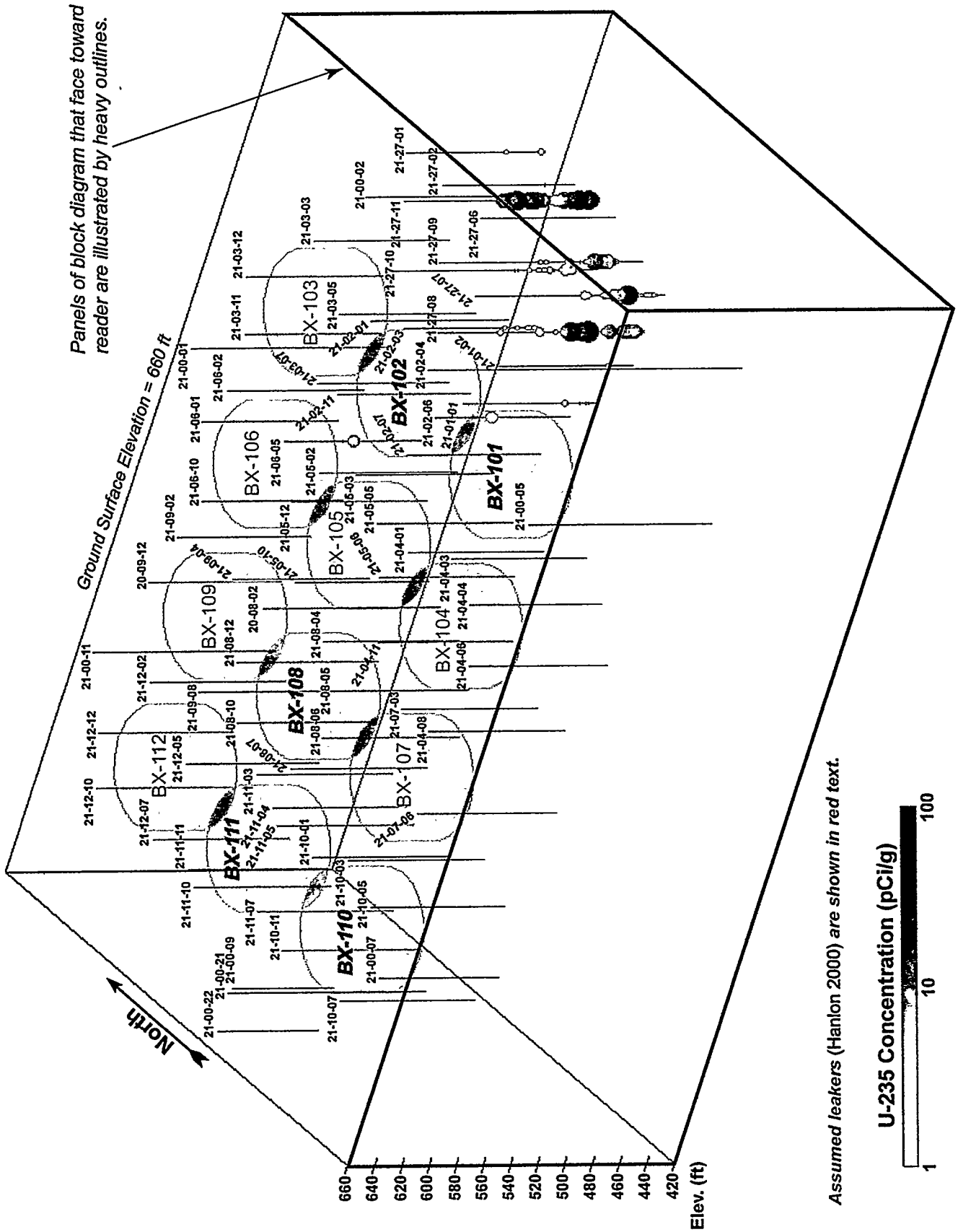

Figure D-6. BX Tank Farm Visualization

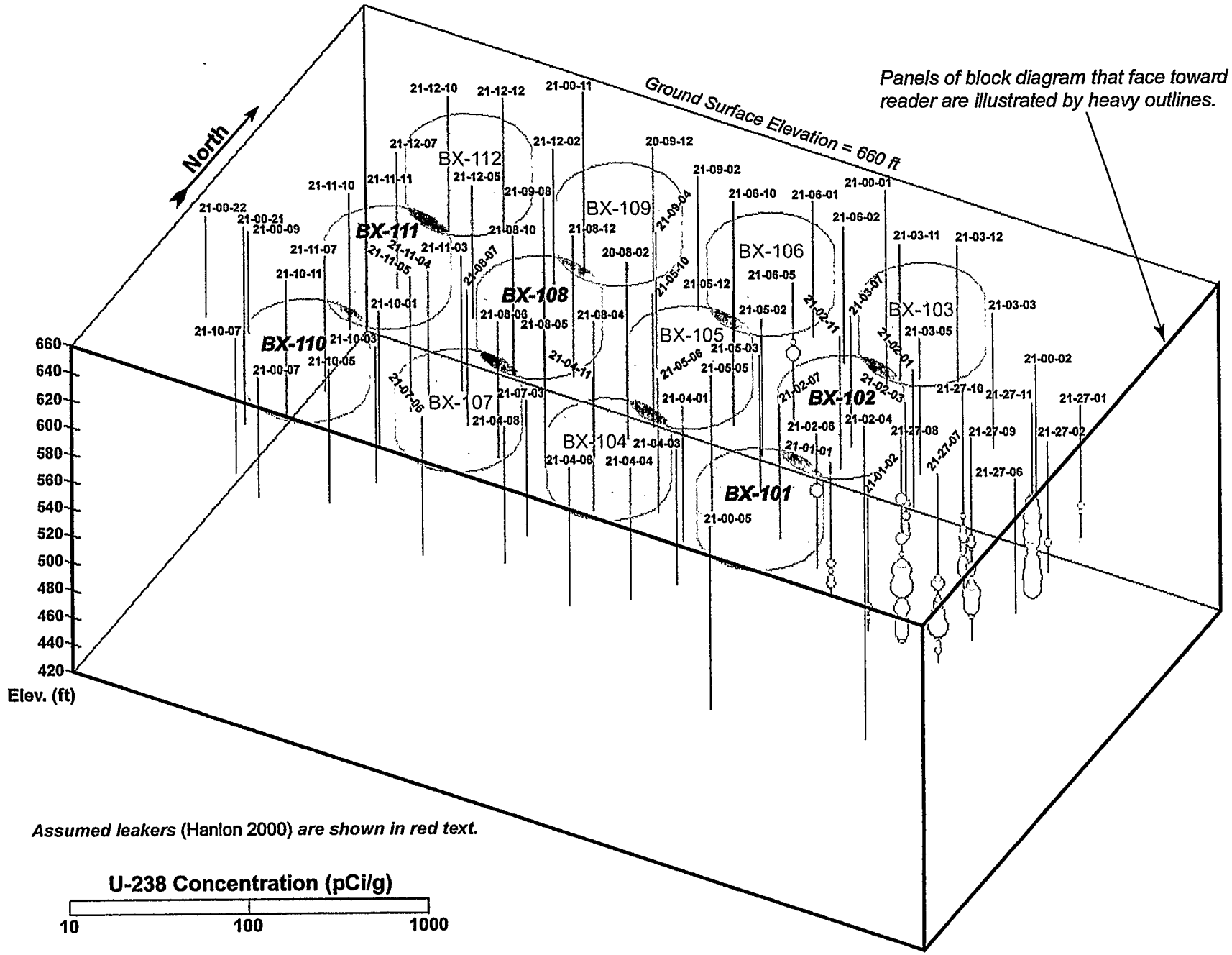

Figure D-7. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

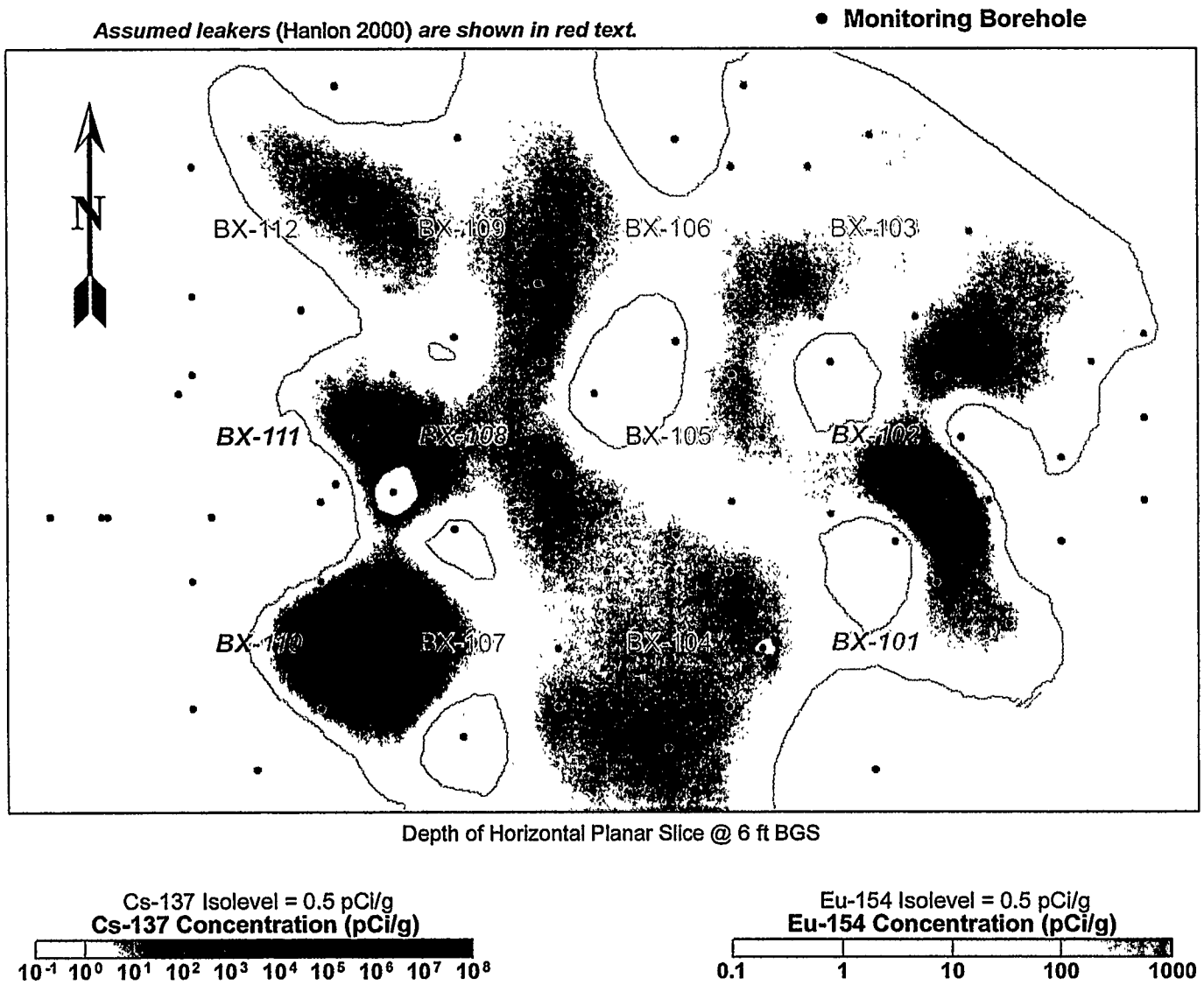

Figure D-8. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

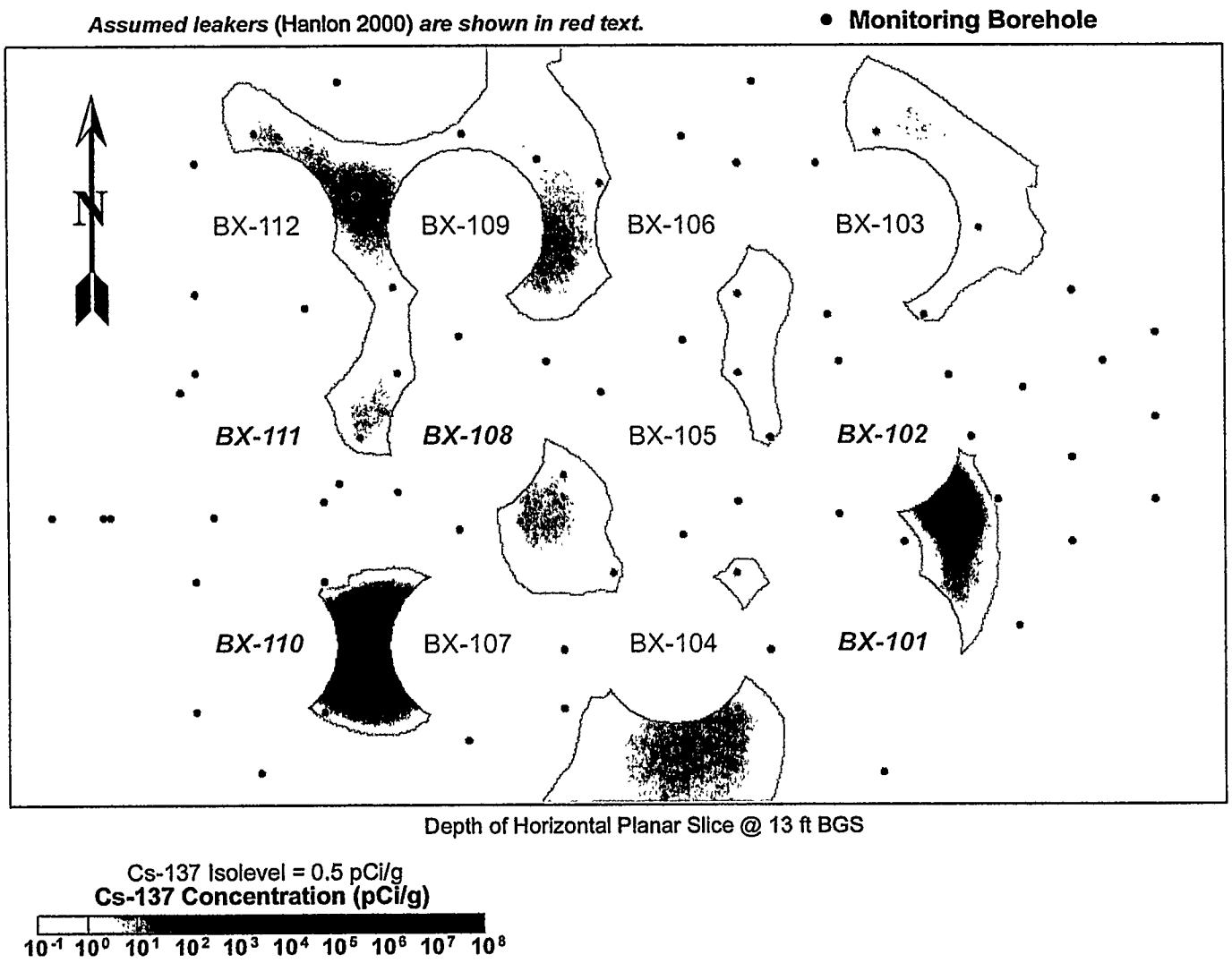

Figure D-9. BX Tank Farm Visualization

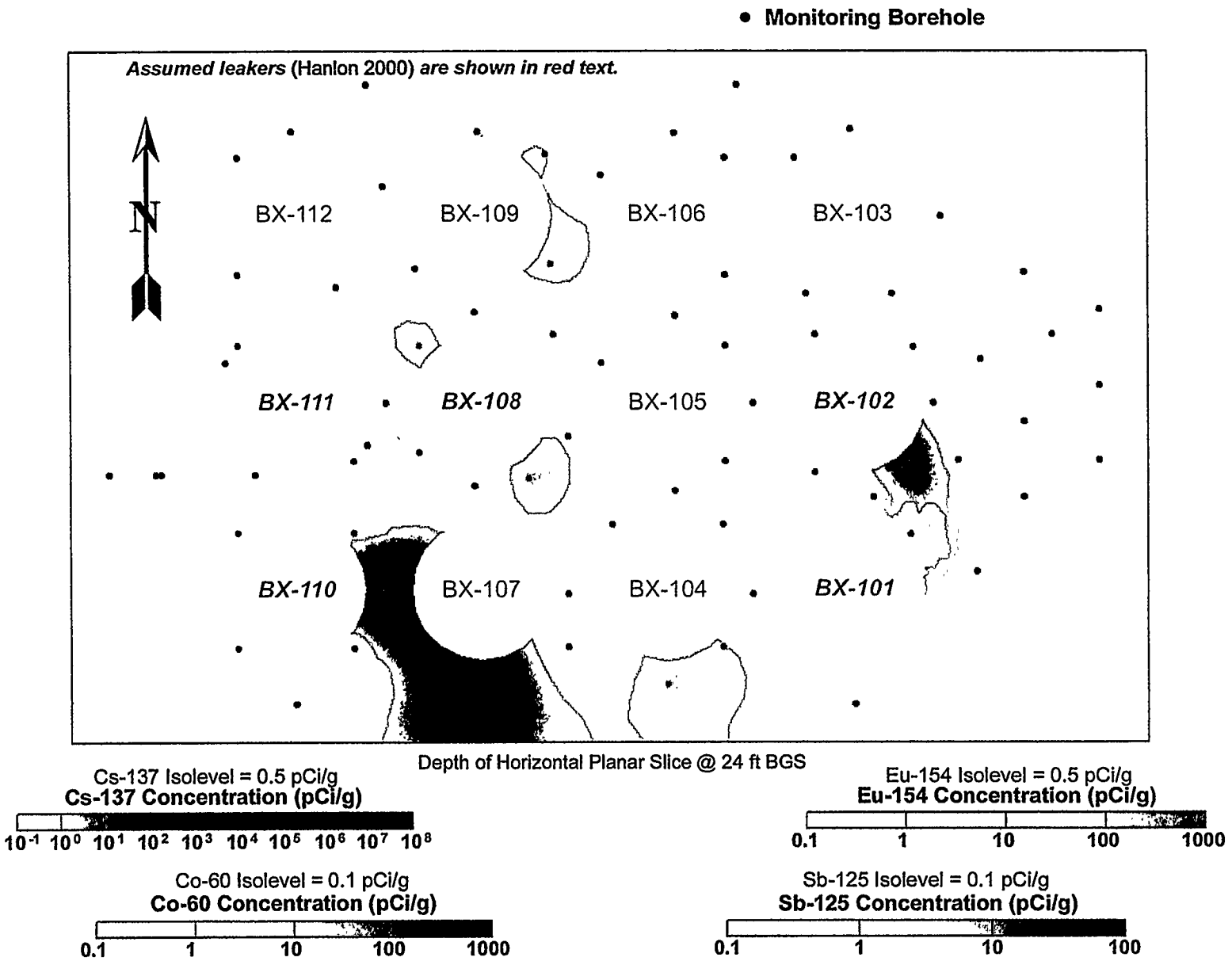

Figure D-10. BX Tank Farm Visualization

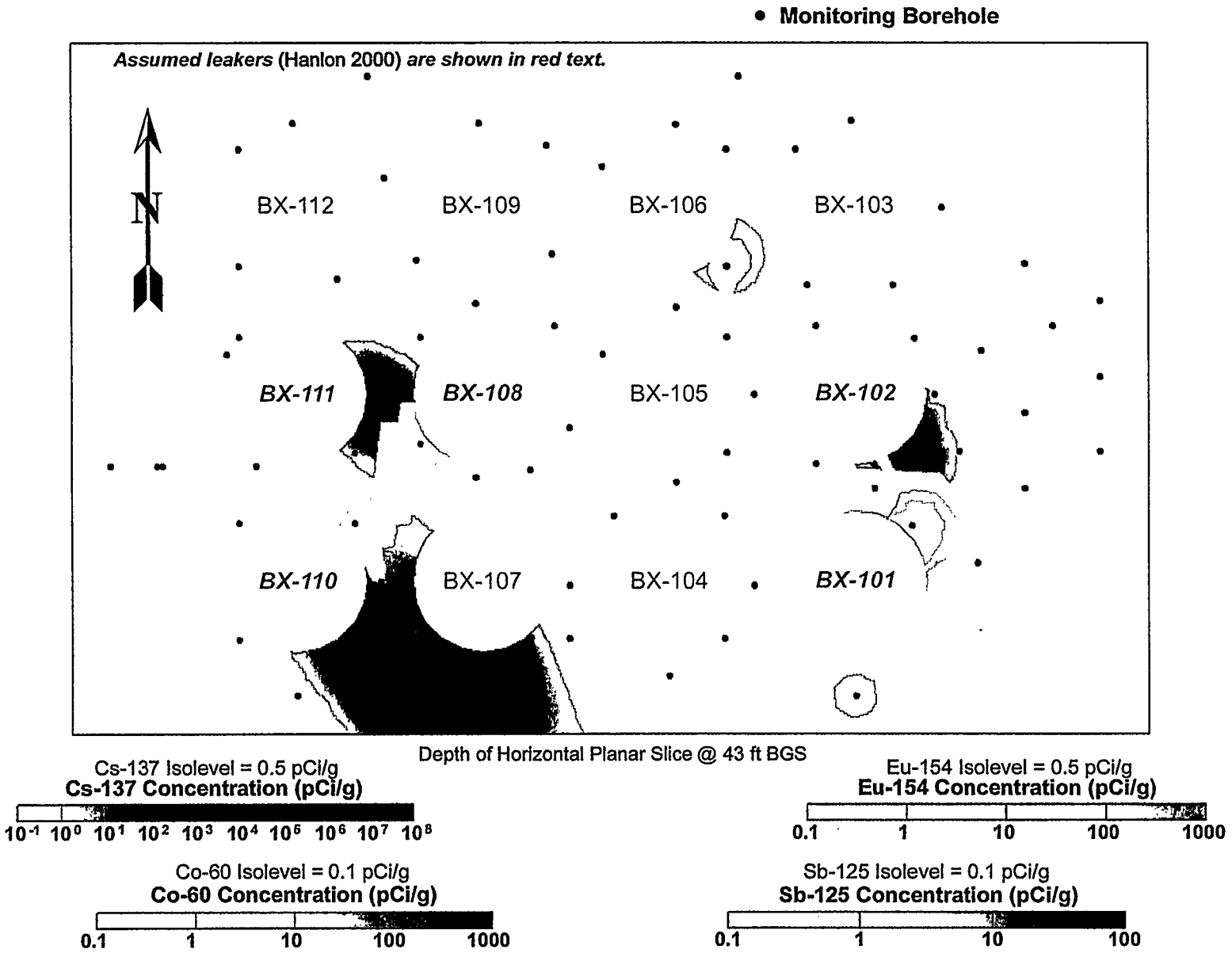

Figure D-11. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

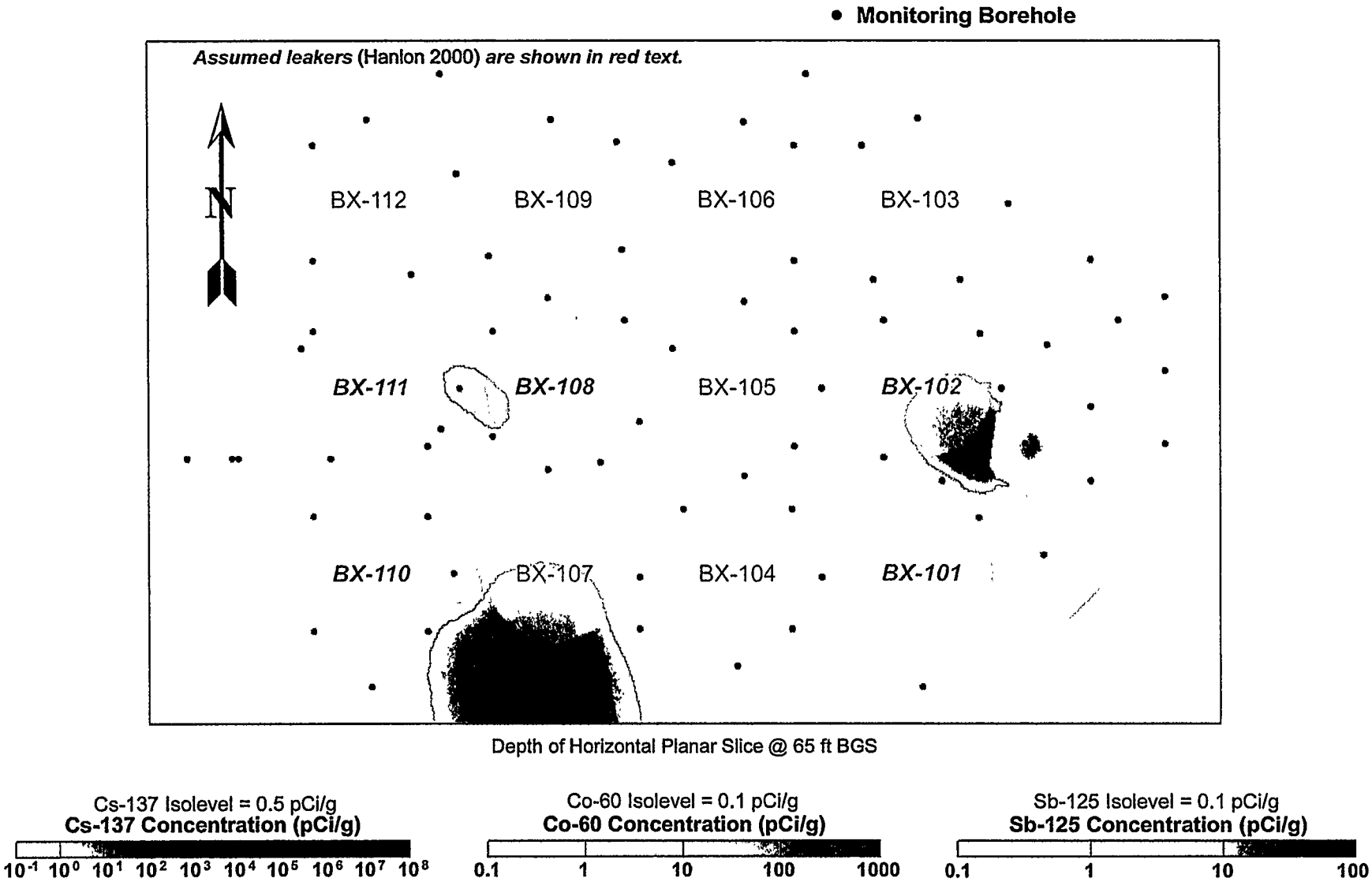

Figure D-12. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

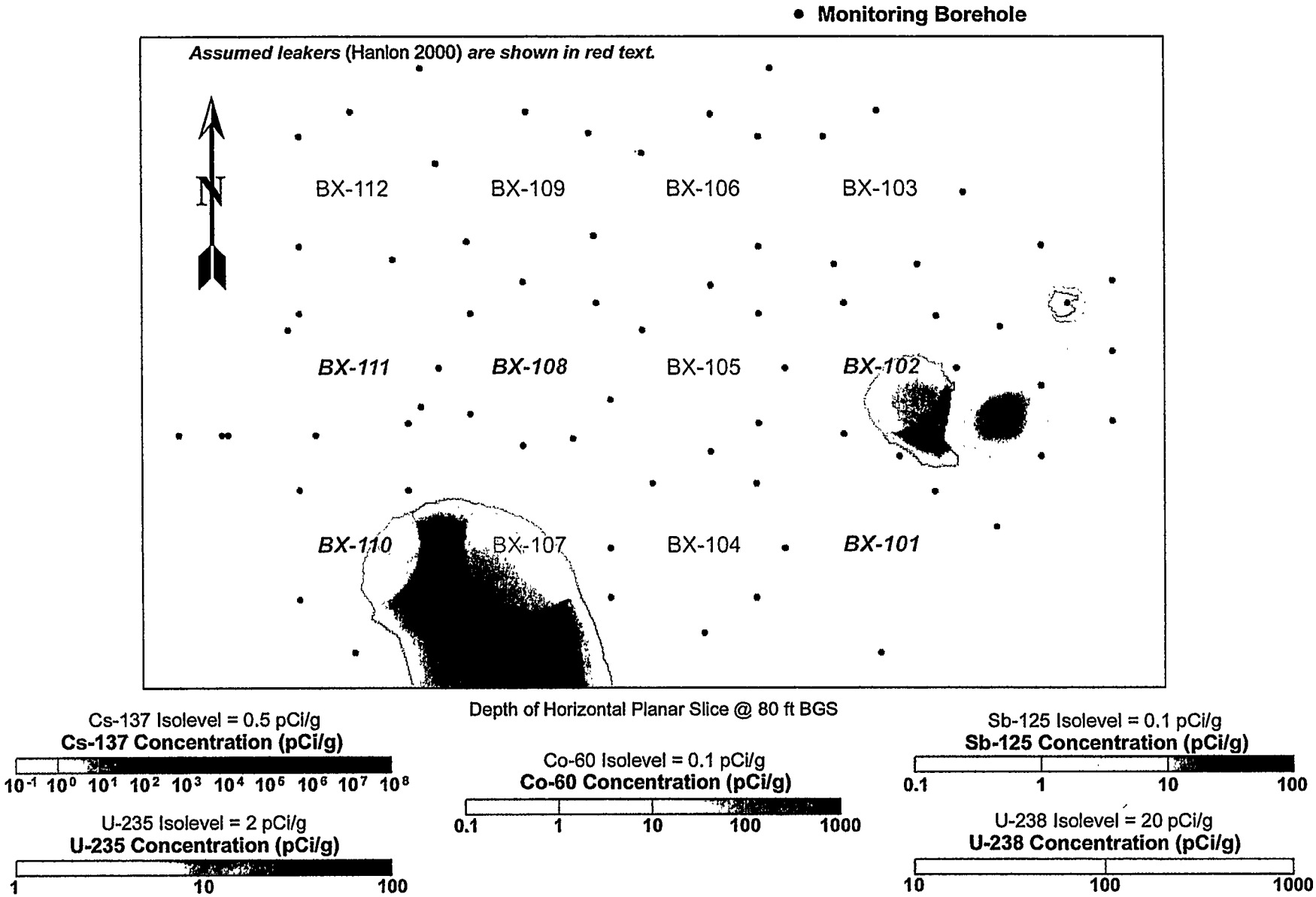

Figure D-13. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

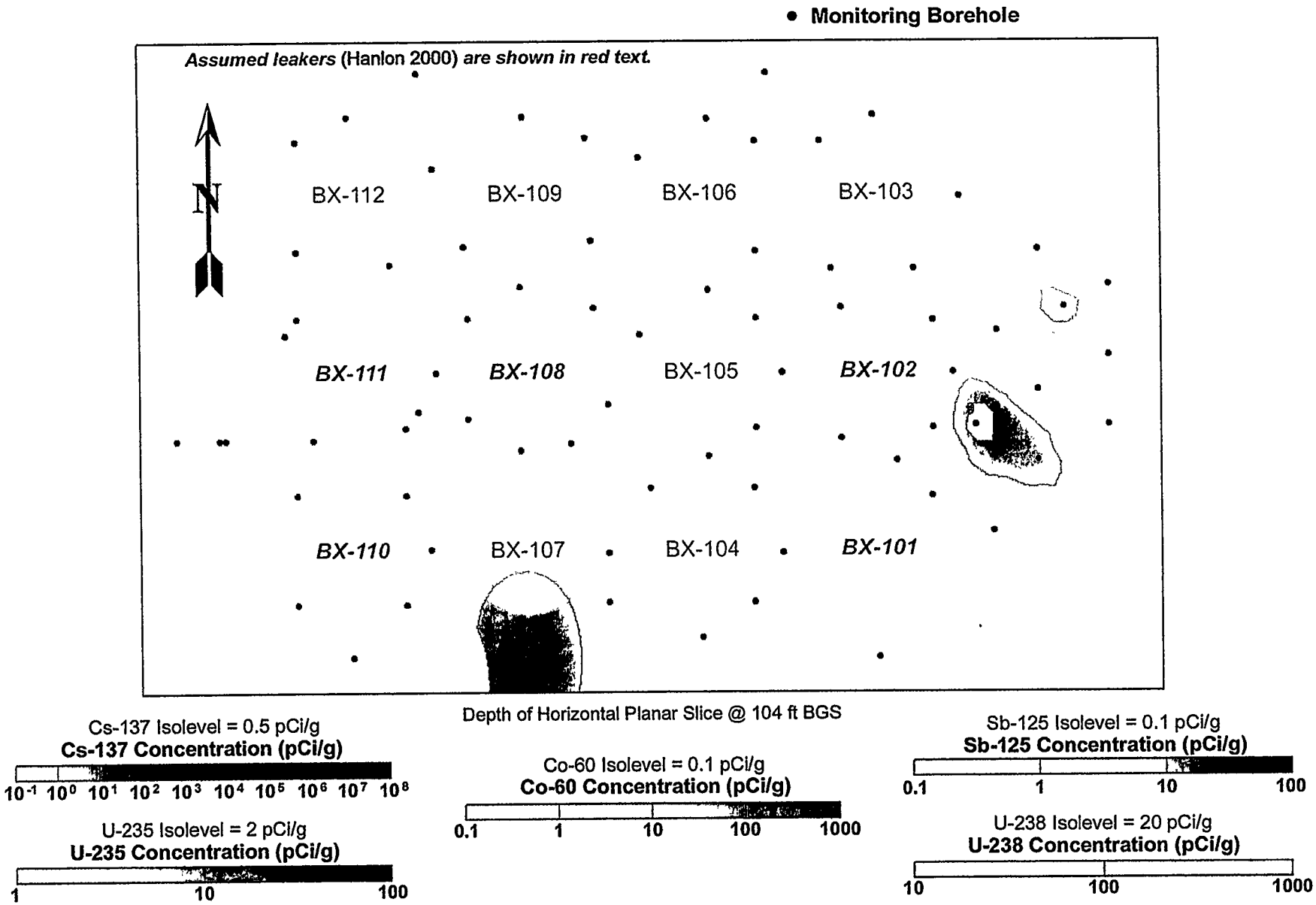

Figure D-14. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

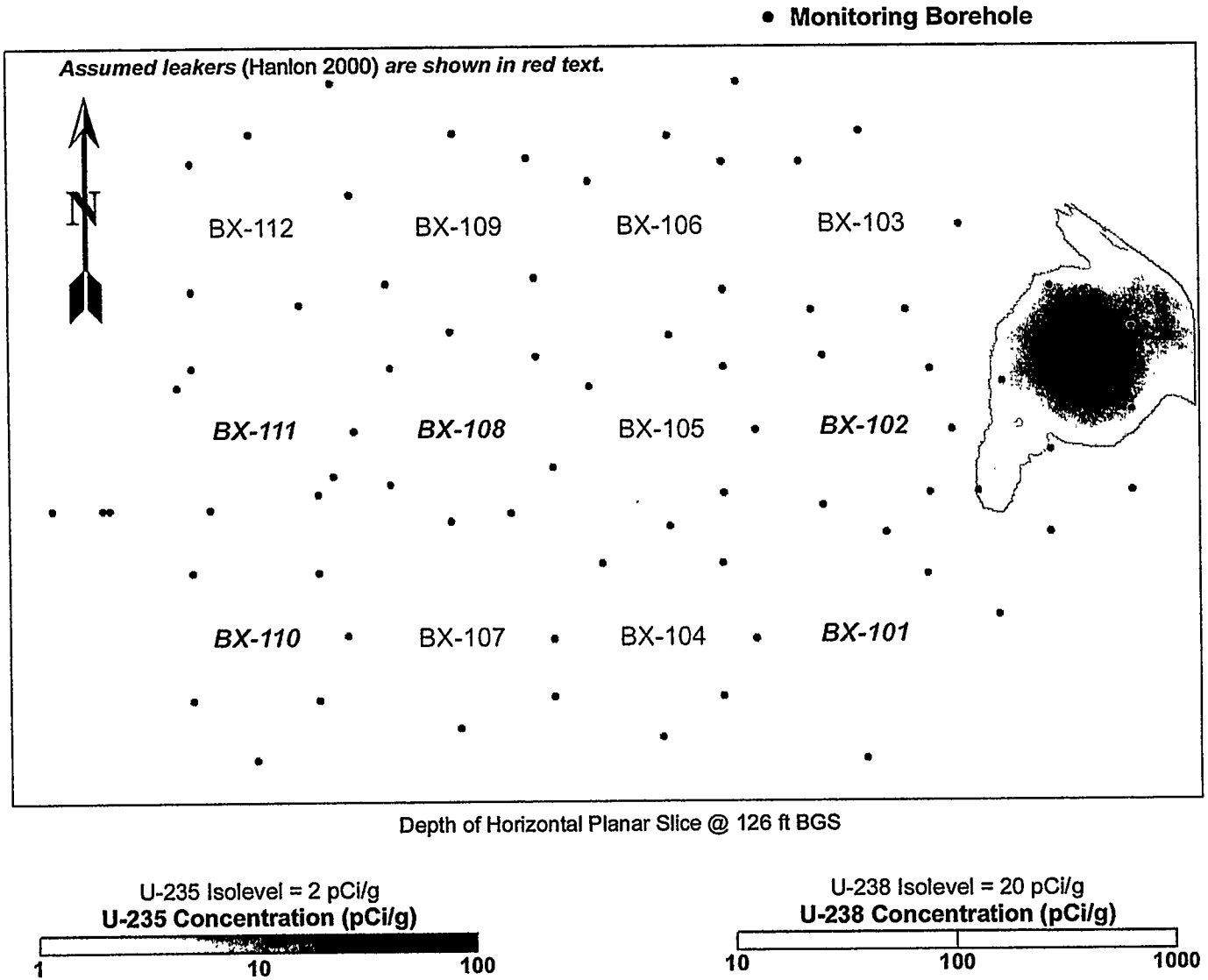

Figure D-15. BX Tank Farm Visualization

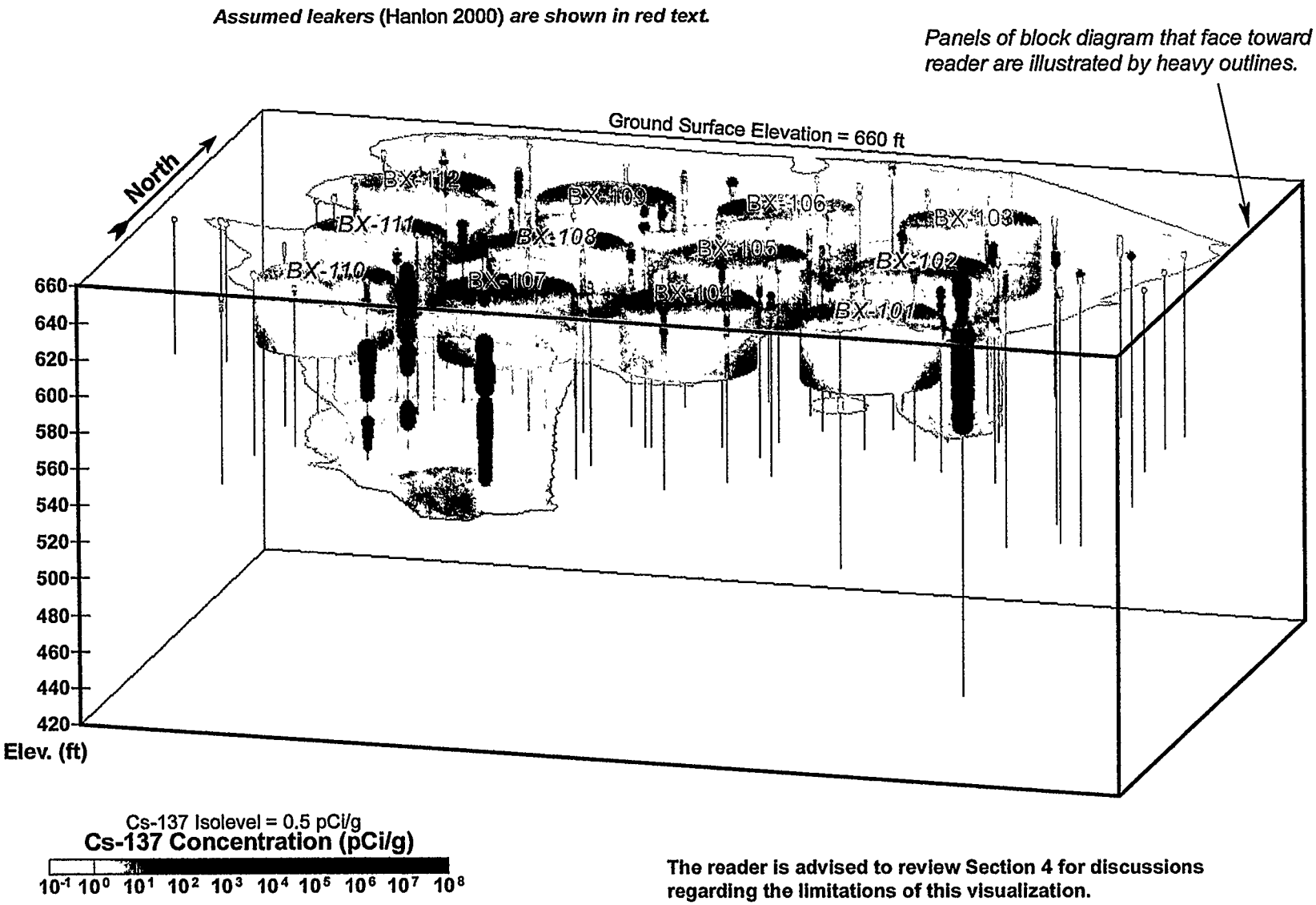

Figure D-16. BX Tank Farm Visualization

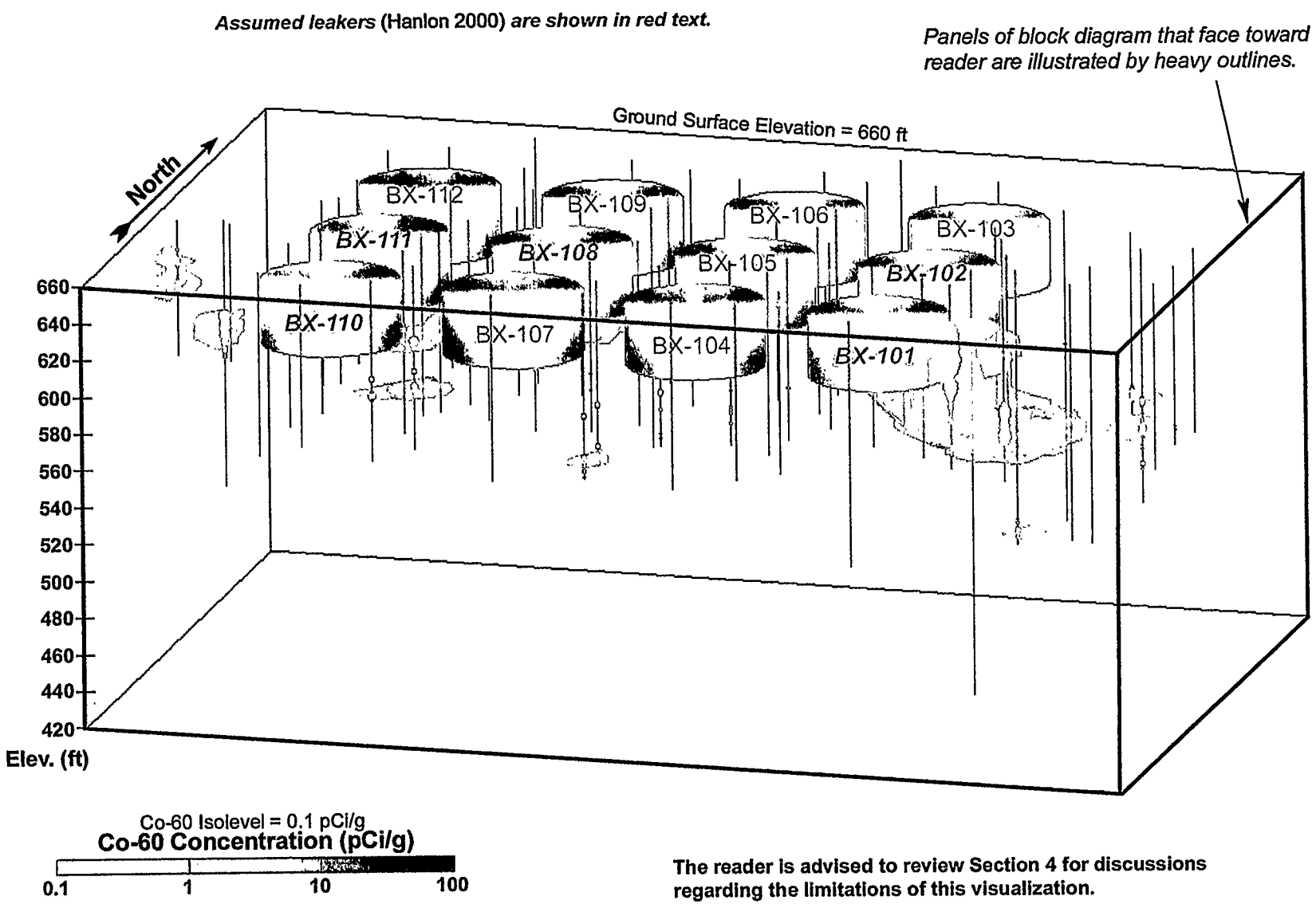

Figure D-17. BX Tank Farm Visualization

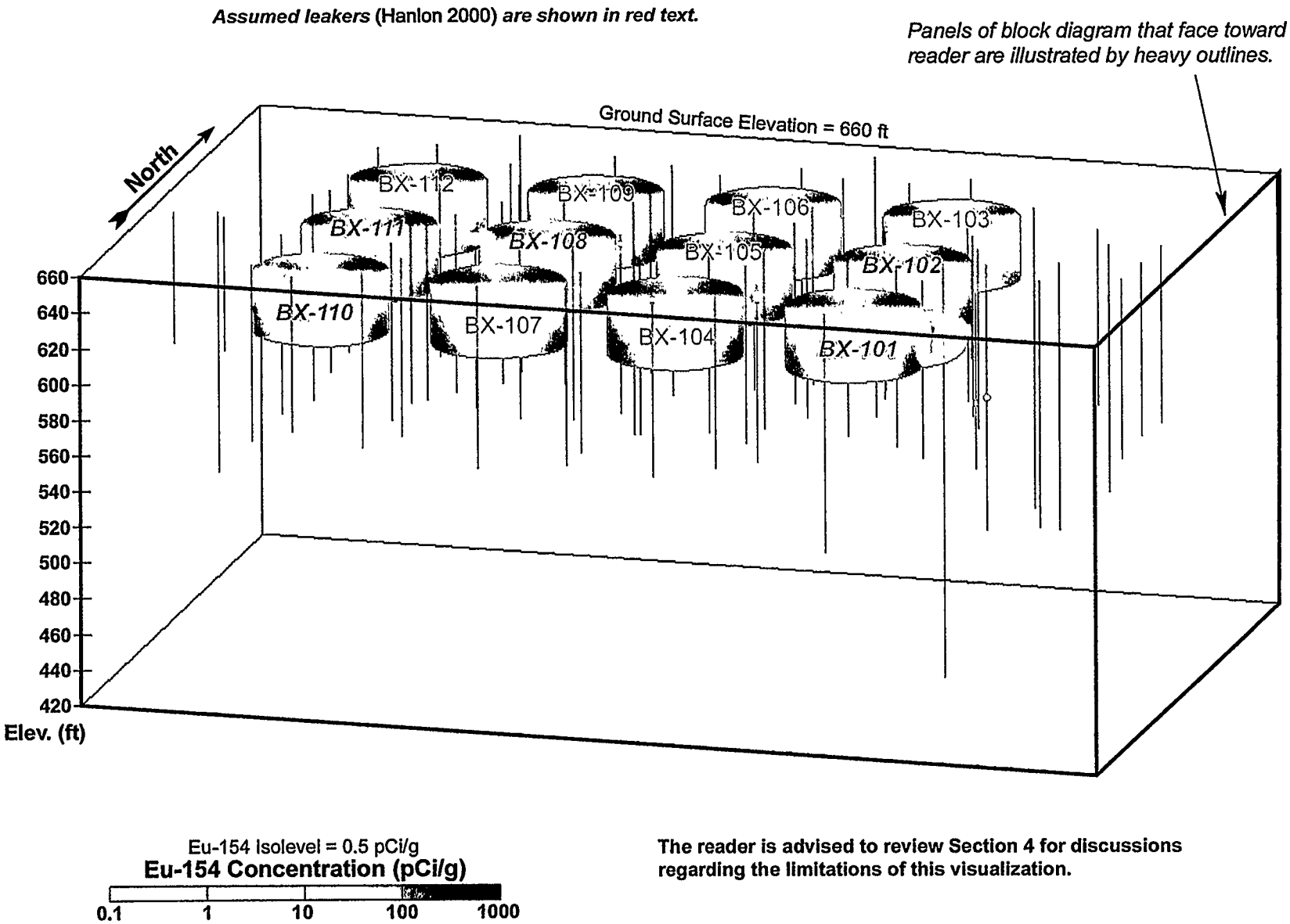

Figure D-18. BX Tank Farm Visualization

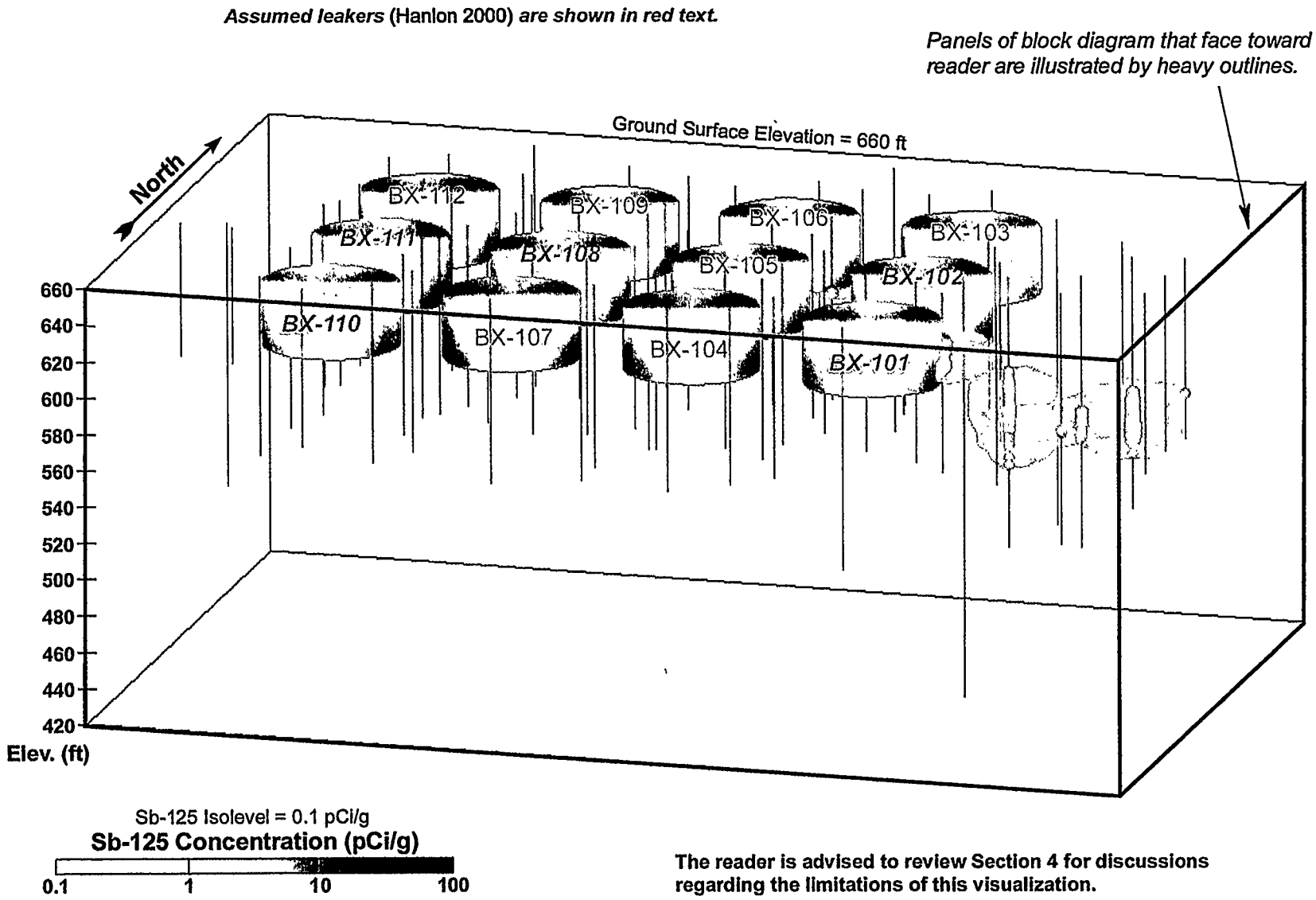

Figure D-19. BX Tank Farm Visualization

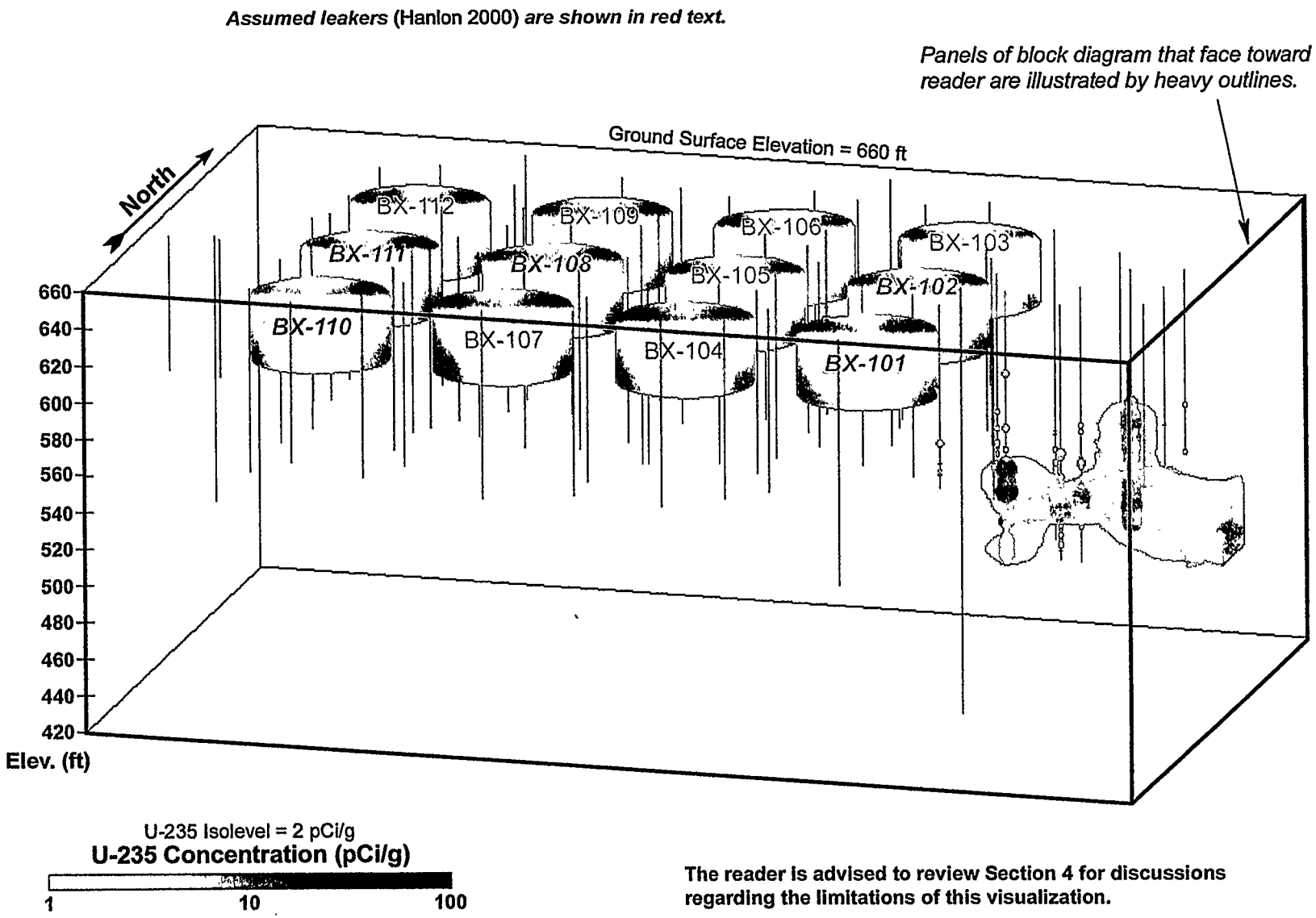

Figure D-20. BX Tank Farm Visualization

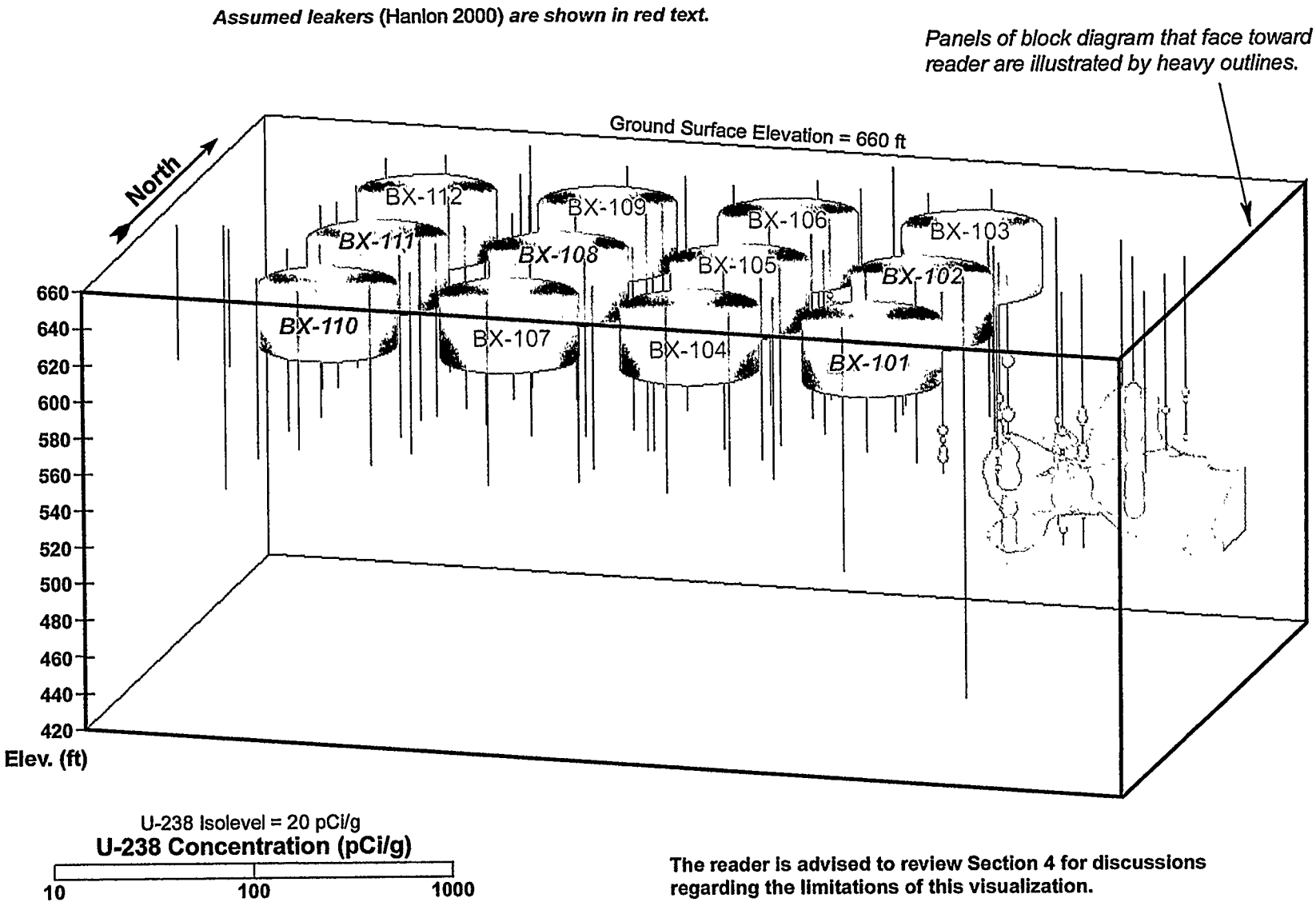

Figure D-21. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

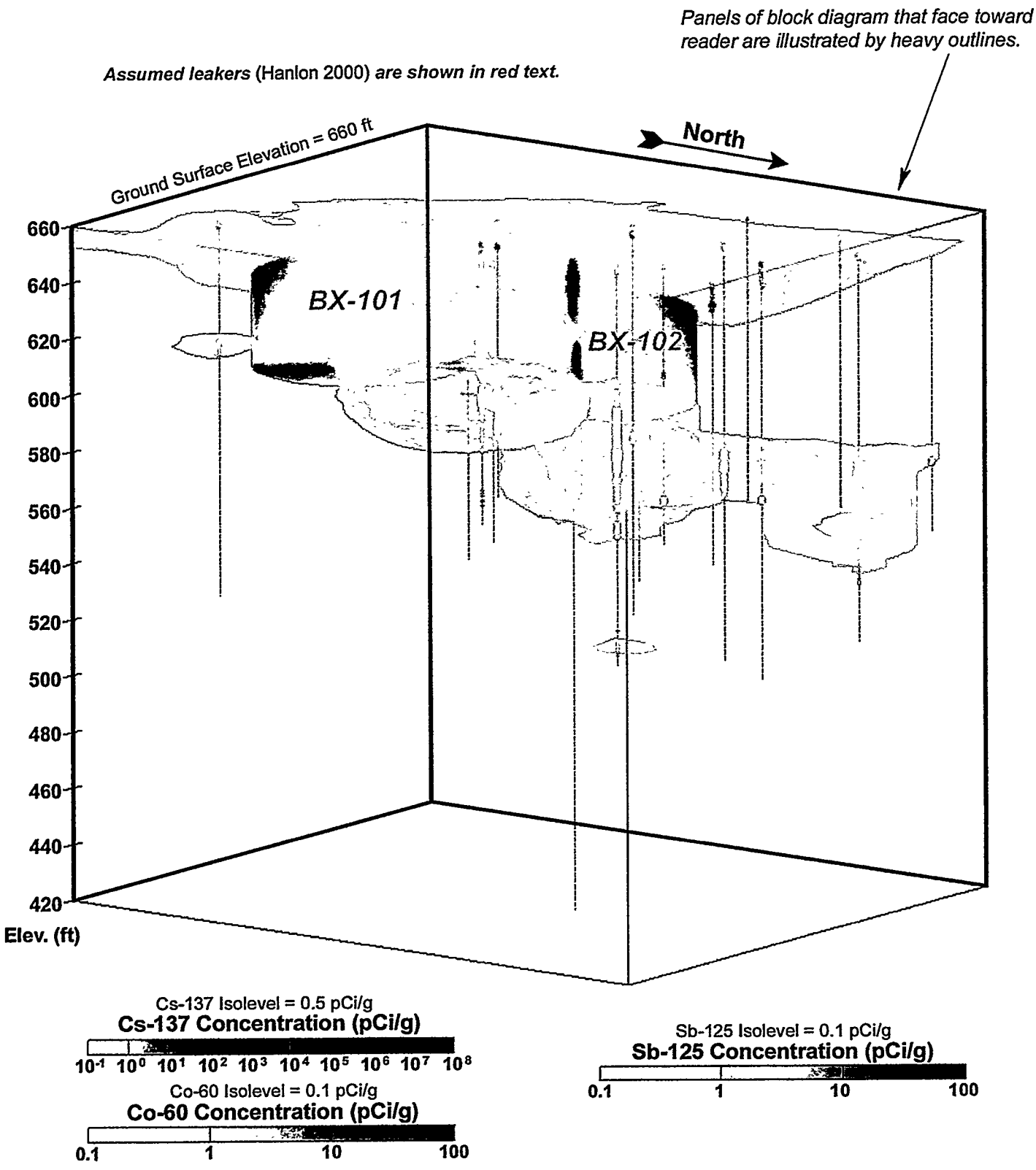

Figure D-22. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

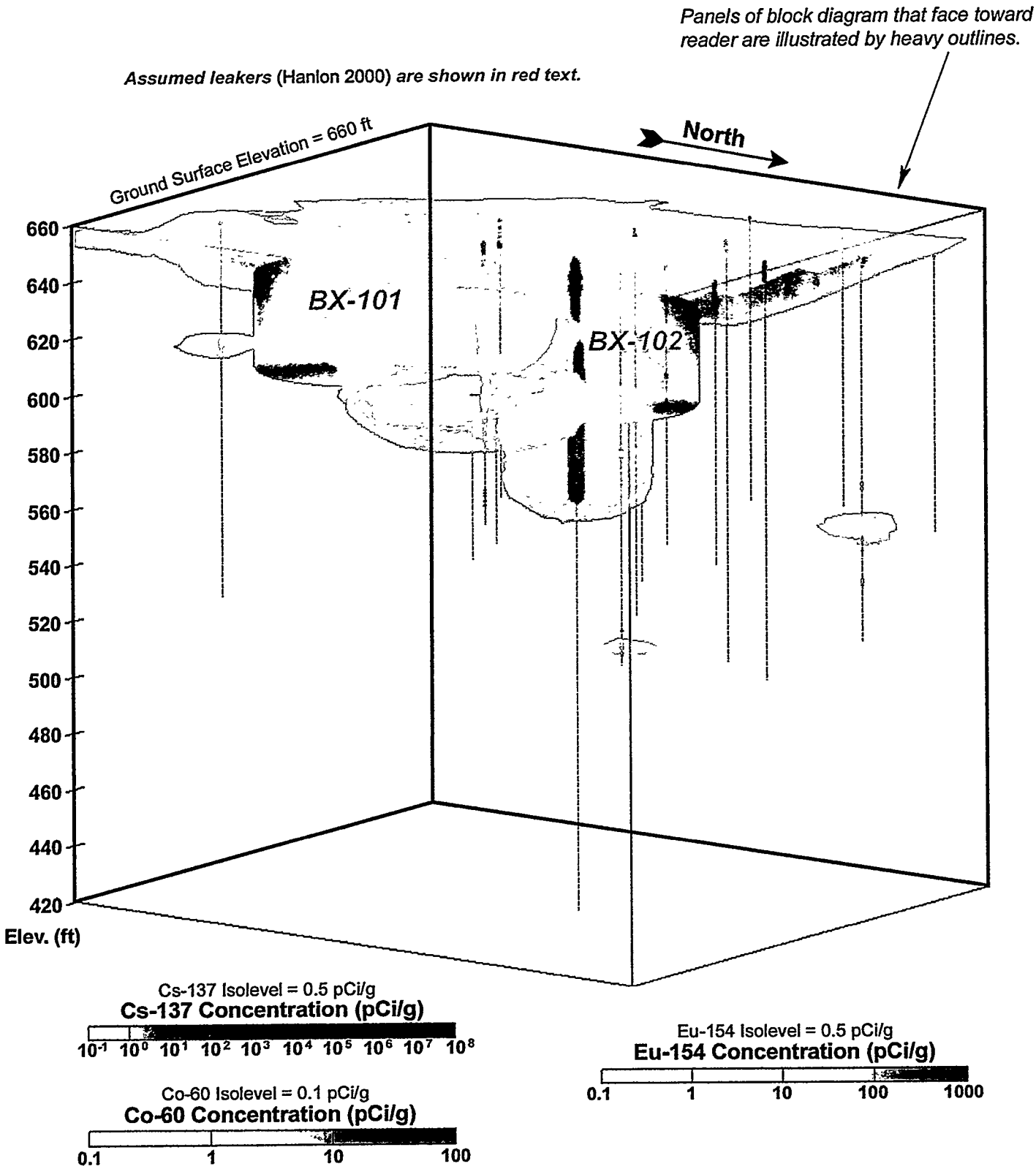

Figure D-23. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

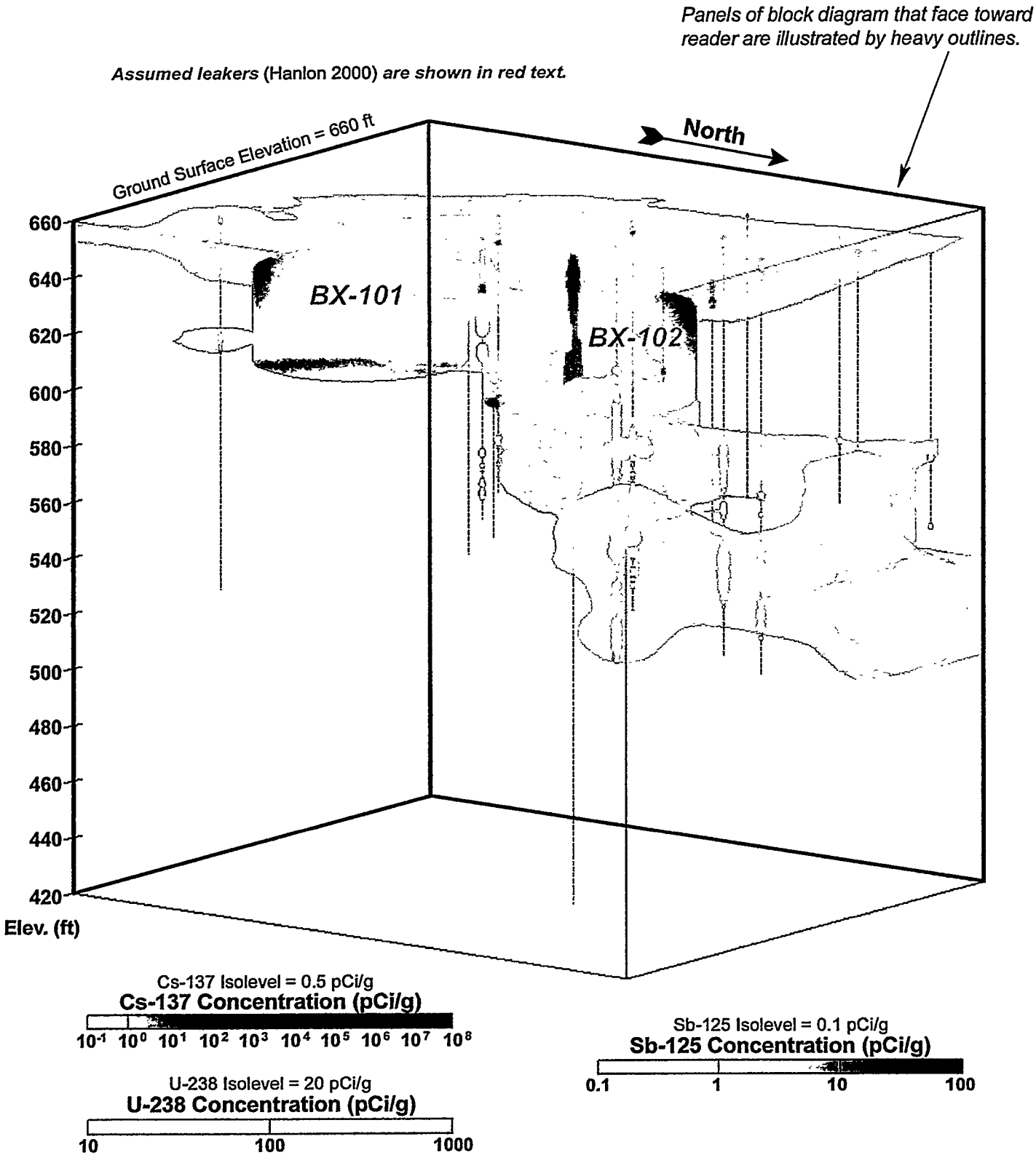

Figure D-24. BX Tank Farm Visualization

Assumed leakers (Hanlon 2000) *are shown in red text.*

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

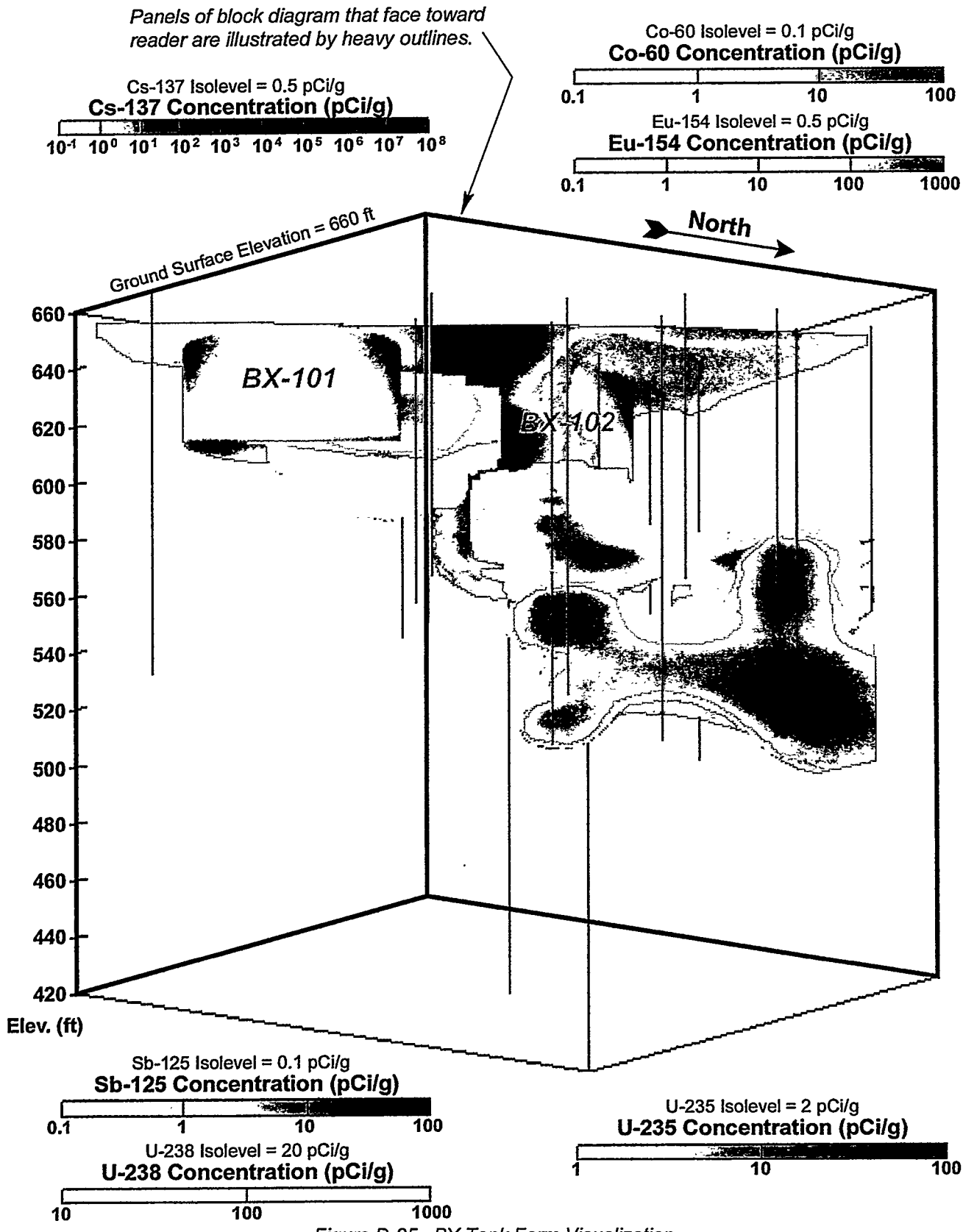

Figure D-25. BX Tank Farm Visualization

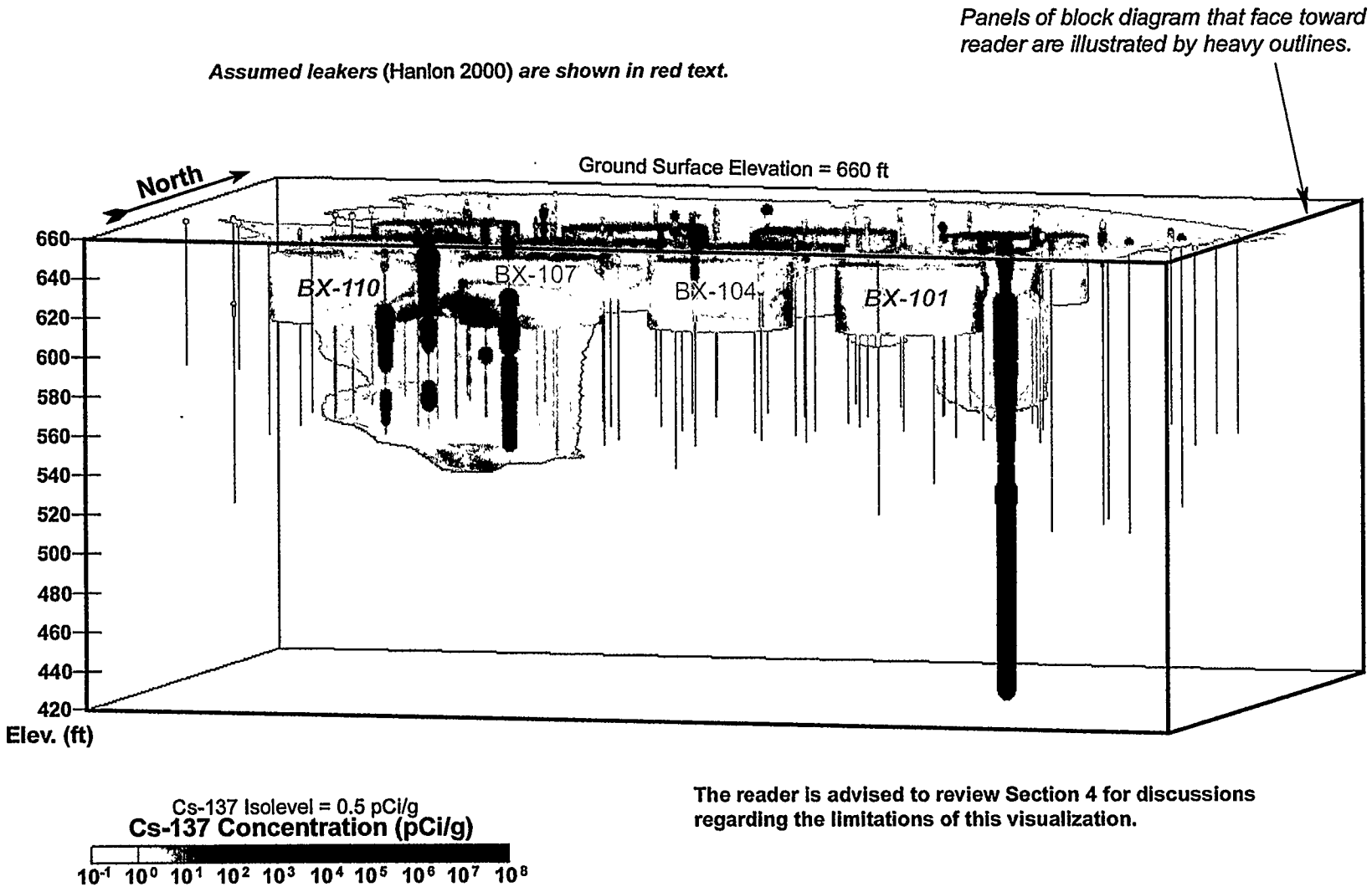

Figure D-26. BX Tank Farm Visualization

The reader is advised to review Section 4 for discussions regarding the limitations of this visualization.

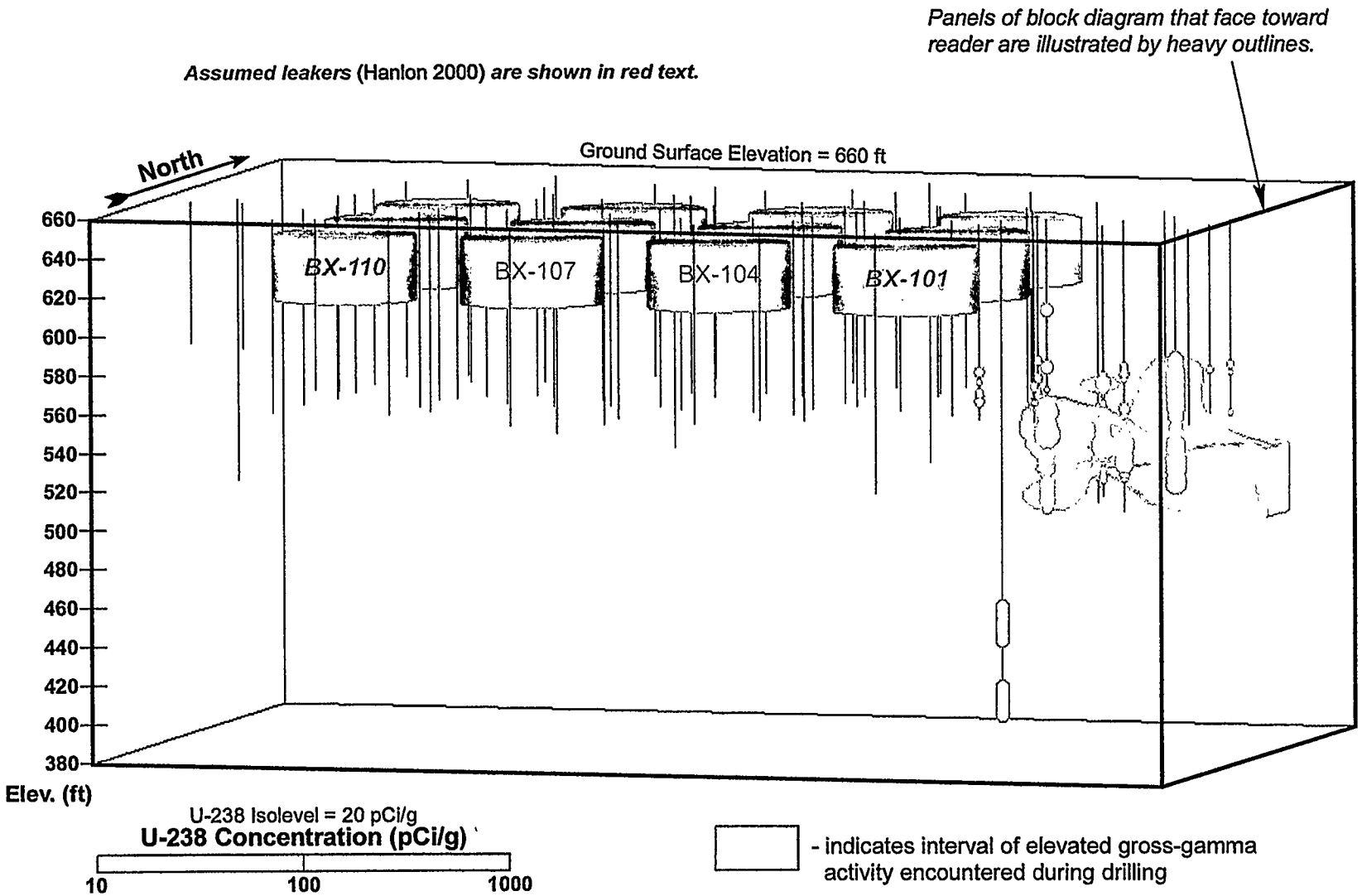

Figure D-27. BX Tank Farm Visualization