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GJ-HAN-85
Tank C-101

Vadose Zone Characterization Project at the Hanford Tank Farms

Tank Summary Data Report for Tank C-101

September 1997

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U.S. Department of Energy

Work Performed Under DOE Contract No. DE-AC13-96GJ87335 for the U.S. Department of Energy

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September 1997

Prepared for
U.S. Department of Energy
Albuquerque Operations Office
Grand Junction Office
Grand Junction, Colorado

Prepared by
MACTEC-ERS
Grand Junction Office
Grand Junction, Colorado

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Work performed under DOE Contract No. DE–AC13–96GJ87335 for the U.S. Department of Energy.

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Prepared by:

D.L. Parker 9/3/97
Date

Approved by:

J.F. Bertsch, Hanford Project Manager 9-4-97
Date

J.R. Brodeur, Hanford Project Technical Lead 9-3-97
Date

1.0 Introduction

1.1 Background

The U.S. Department of Energy (DOE) Richland Operations Office tasked the DOE Grand Junction Office (GJO) with characterizing and establishing a baseline of man-made radionuclide concentrations in the vadose zone surrounding the single-shell tanks (SSTs) at the Hanford Site. These tasks are being accomplished using spectral gamma-ray borehole geophysical logging measurements made in the boreholes surrounding the tanks. The primary objective of this project is to provide data on the tanks for use by DOE organizations. These data may also be used to develop an SST Closure Plan in compliance with the Resource Conservation and Recovery Act and to prepare an Environmental Impact Statement for the Tank Waste Remediation Systems program.

1.2 Scope of Project

The scope of this project is to locate and identify the gamma-ray-emitting radionuclides and determine their concentrations in the vadose zone sediment by logging the monitoring boreholes around the SSTs with a Spectral Gamma Logging System (SGLS). Additional details regarding the scope and general approach to this characterization program are included in the project management plan (DOE 1995c) and baseline monitoring plan (DOE 1995d). This project may help to identify possible sources of any subsurface contamination encountered during the logging and to determine the implications of the contamination for Tank Farm operations. The acquired data will establish a contamination baseline that can be used for future data comparisons, for tank-leak verifications, and to help develop contaminant flow-and-transport models.

1.3 Purpose of Tank Summary Data Report

A Tank Summary Data Report (TSDR) will be prepared for each SST to document the results of the spectral gamma-ray logging in the boreholes around the tank. Each TSDR provides a brief review and a summary of existing information about a specific tank and an assessment of the implications of the spectral gamma-ray log information, including recommendations on future data needs or immediate corrective action, where appropriate. Appendix A of each TSDR presents logs of radionuclide concentrations versus depth for all boreholes around that specific tank. A comprehensive Tank Farm Report will be prepared for each tank farm after completion of characterization logging of all boreholes in the subject farm.

2.0 Spectral Gamma-Ray Log Measurements

2.1 Data Acquisition and Processing

The concentrations of individual gamma-ray-emitting radionuclides in the sediments surrounding a borehole can be calculated from the activities in the gamma-ray energy spectra measured in the borehole using calibrated instrumentation. Spectral gamma-ray logging is the process of collecting gamma-ray spectra at sequential depths in a borehole. Figure 1 shows a gamma-ray spectrum with peaks at energies, from 0 to 2,700 kilo-electron-volts (keV), that are characteristic of specific radionuclides. The spectrum includes peaks from naturally occurring radionuclides ^{40}K, ^{238}U, and ^{232}Th (KUT) and from man-made contaminants (e.g., ^{137}Cs and ^{60}Co). Gamma-ray source concentrations are cited in terms of picocuries per gram (pCi/g), even though this unit technically describes decay rate per unit mass of sample rather than concentration. The use of decay rate per unit mass is widespread in environmental work, where health and safety issues relate to the radioactivity, not the chemical concentration.

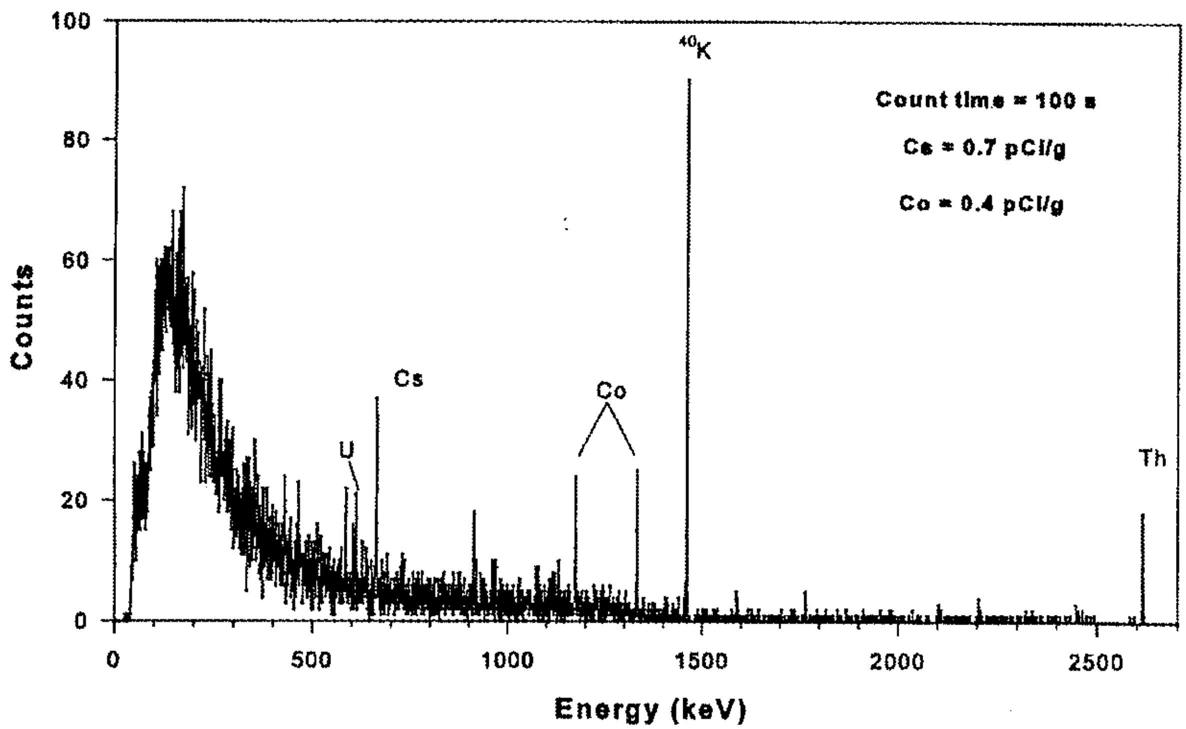

Figure 1. Gamma-Ray Spectrum

Data are acquired in boreholes near the tanks according to methods described in the logging procedures (DOE 1995b). Typical counting times at each measurement position are about 100 seconds (s), with a spectrum being collected every 0.5 foot (ft) along the length of the borehole.

Long data acquisition times can reduce the uncertainties in the calculated concentrations presented on the logs. However, economic and time constraints limit the amount of time available for data collection. The statistical uncertainty for gamma rays emitted from low-activity radionuclides such as ^{238}U and ^{232}Th can be high for this counting time, and the logs for these radionuclides will show high levels of statistical uncertainty, as evidenced on the logs by scatter in the plotted data and wide confidence intervals.

The minimum detection level (MDL) of a radionuclide represents the lowest concentration at which the positive identification of a gamma-ray peak for that radionuclide is statistically defensible. The spectrum analysis program calculates the MDL for a particular peak on the basis of a statistical analysis of the spectral background level in the vicinity of the peak. The same equations that translate peak intensities into decay rates per unit-sample mass also translate the MDLs from counts per second (cps) to picocuries per gram. A description of the MDL calculation is included in the data analysis manual (DOE 1996b).

The gamma-ray spectra measured in a borehole are processed using a variety of software programs to obtain the concentrations of individual gamma-ray-emitting radionuclides. All the algorithms used in the concentration calculations and their application is discussed in the data analysis manual (DOE 1996b). These calculated data, which are usually presented as vertical profiles, are used to make an interpretation of vadose zone contamination associated with each borehole. When data from all the boreholes associated with a specific tank have been processed and interpreted, a correlation interpretation is made of the vadose zone contamination surrounding each tank.

The initial SGLS calibration report (DOE 1995a) contains the results obtained from operating the logging tools in calibration models. The calibration report presents the mathematical functions used to convert the measured peak area count rates to radioelement concentration in picocuries per gram. The SGLS is routinely recalibrated (DOE 1996a) to ensure the accuracy of the calculated radionuclide concentrations. The calculated radionuclide concentrations derived with these conversion factors may be as much as 14 percent higher than the actual in situ concentrations because the concentrations of the calibration models are expressed in terms of gamma-ray activity per unit-sample mass of *dry* bulk material. However, the measurements made in the calibration models were in a water-saturated environment. The conversion factors in the calibration report (DOE 1995a) are strictly applicable only when the logged formation has the same water content as the calibration-model test zones. The vadose zone contains pore-space water in various percentages of saturation from near 0 percent to near 100 percent, and the boreholes are logged dry. Corrections for pore-space water cannot presently be applied to the vadose zone measurements because the in situ water content is not being measured.

The calibration data from which conversion factors were derived were recorded with a logging tool in a borehole drilled through a uniform homogeneous isotropic gamma-ray-source material. If the gamma-ray sources in the borehole being logged are not uniformly distributed in the sediments, the conversion factor produces apparent concentrations. The concentrations calculated for the top and bottom of a borehole are also apparent concentrations, because the source-to-detector geometries at these locations differ from the source-to-detector geometries during calibration.

When gamma-ray spectra are measured in cased boreholes, a casing correction must be applied to the peak count rates to compensate for gamma-ray attenuation by the casing. This correction function is described in the calibration report (DOE 1995a), and the data analysis manual (DOE 1996b) describes the application of the correction function in the data processing.

2.2 Log Data and Plots

The results of the processing and analysis of the log data presented in Appendix A, "Spectral Gamma-Ray Logs for Boreholes in the Vicinity of Tank C-101," are grouped into a set of data for each borehole. Each set includes a Log Data Report and log plots showing radionuclide concentration versus depth.

Log plots are presented that show the spatial distribution of the detected man-made radionuclides. Plots of the natural gamma-ray-emitting radionuclides, at the same vertical scale as the man-made contamination plots, allows for interpretation of geologic information and the correlation of these data with the man-made contamination. Rerun sections in selected boreholes are used to check the logging system for data acquisition repeatability.

The log plots show the concentrations of the individual radionuclides or the total gamma count rate in counts per second in each borehole. Where appropriate, log plots show the statistical uncertainties in the calculated concentrations at the 95-percent confidence level (±2 standard deviations).

A combination plot for each borehole shows the individual natural and man-made radionuclide concentrations, the total gamma log, and the Tank Farms gross gamma log. The total gamma log is a plot of the total number of gamma rays detected during each spectrum measurement. The combination plot provides information on the relative contributions of individual radionuclides to the total gamma-ray count. The total gamma log also provides a means for comparing the spectral data with the historical Tank Farms gross gamma log data.

The Tank Farms gross gamma log data were collected with a nonspectral logging system previously used by DOE contractors for leak-detection monitoring at the Hanford Tank Farms. This system does not identify specific radionuclides, but its logs provide an important historical record for the individual boreholes and offer a basis for temporal comparison. The gross gamma logs shown on the plots in Appendix A are the latest data available.

Rerun sections in selected boreholes are used to check the logging system for data acquisition repeatability. Radionuclide concentrations shown on these plots are calculated independently from the separate gamma-ray spectra provided by the original and repeated logging runs.

The Log Data Report provides borehole construction information, casing information, logging system identification, and data acquisition parameters used for each log run. A log run is a set of spatially sequential spectra that are recorded in the borehole with the same data acquisition parameters. A single borehole may have several log runs, often occurring on different days because of the length of time required to log the deeper boreholes. The Log Data Report also contains analysis information, including analysis notes and log plot notes.

3.0 Review of Tank History

3.1 C Tank Farm

3.1.1 Construction History

The C Tank Farm is located in the east portion of the 200 East Area, north of 7th Avenue and west of Canton Avenue. This farm was constructed during 1943 and 1944 to store high-level radioactive waste generated by chemical processing of irradiated uranium fuel from C Plant. The tank farm consists of four Type I and twelve Type II single-shell storage tanks. Vadose zone boreholes are located around the tanks for purposes of leak detection. Figure 2 shows the relative positions of the storage tanks and the vadose zone monitoring boreholes around them.

All 16 tanks in the C Tank Farm were constructed to the first-generation tank design and were designed for non-boiling waste with a temperature of less than 220 °F. The twelve Type II tanks are 75 ft in diameter and have capacities of 530,000 gallon (gal) each. The four Type I tanks are 20 ft in diameter and have capacities of 55,000 gal each. Other than diameter, the Types I and II tanks are of the same basic design (Brevick et al. 1994a and 1994b).

The Type II tanks are domed and steel-lined, with a maximum operating depth (cascade overflow level) of approximately 17 ft above the center of the dished tank base; the tank base is 1 ft lower at its center than at its edges. The storage portion of each tank is lined with a 0.25-in.-thick carbon-steel liner. The steel liners on the tank sides extend to 19 ft above the dished bottoms of the tank bases. The interiors of the concrete dome tops are not steel lined, but were treated with a magnesium zincfluosilicate wash. The tanks are entirely below the ground surface and are covered with approximately 7.25 ft of backfill material (Brevick et al. 1994a and 1994b).

The twelve type II tanks are connected in four three-tank cascade series. These cascade series consist of tanks C-101, -102, and -103, C-104, -105, and -106, C-107, -108, and -109, and C-110, -111, and -112. The tanks in the cascade series are arranged with each successive tank sited at an elevation 1 ft lower than the previous tank, creating a gradient allowing fluids to flow from one tank to another as they were filled. The four Type I tanks are connected with tie lines. The tie lines allow the tanks to overflow to other tanks in the series and equalize tank volumes (Brevick et al. 1994a and 1994b).

For primary internal leak detection, tanks C-103, -106, and -107 are each equipped with an ENRAF level detector and tank C-110 is equipped with a manual tape. Tanks C-101, -102, -104,

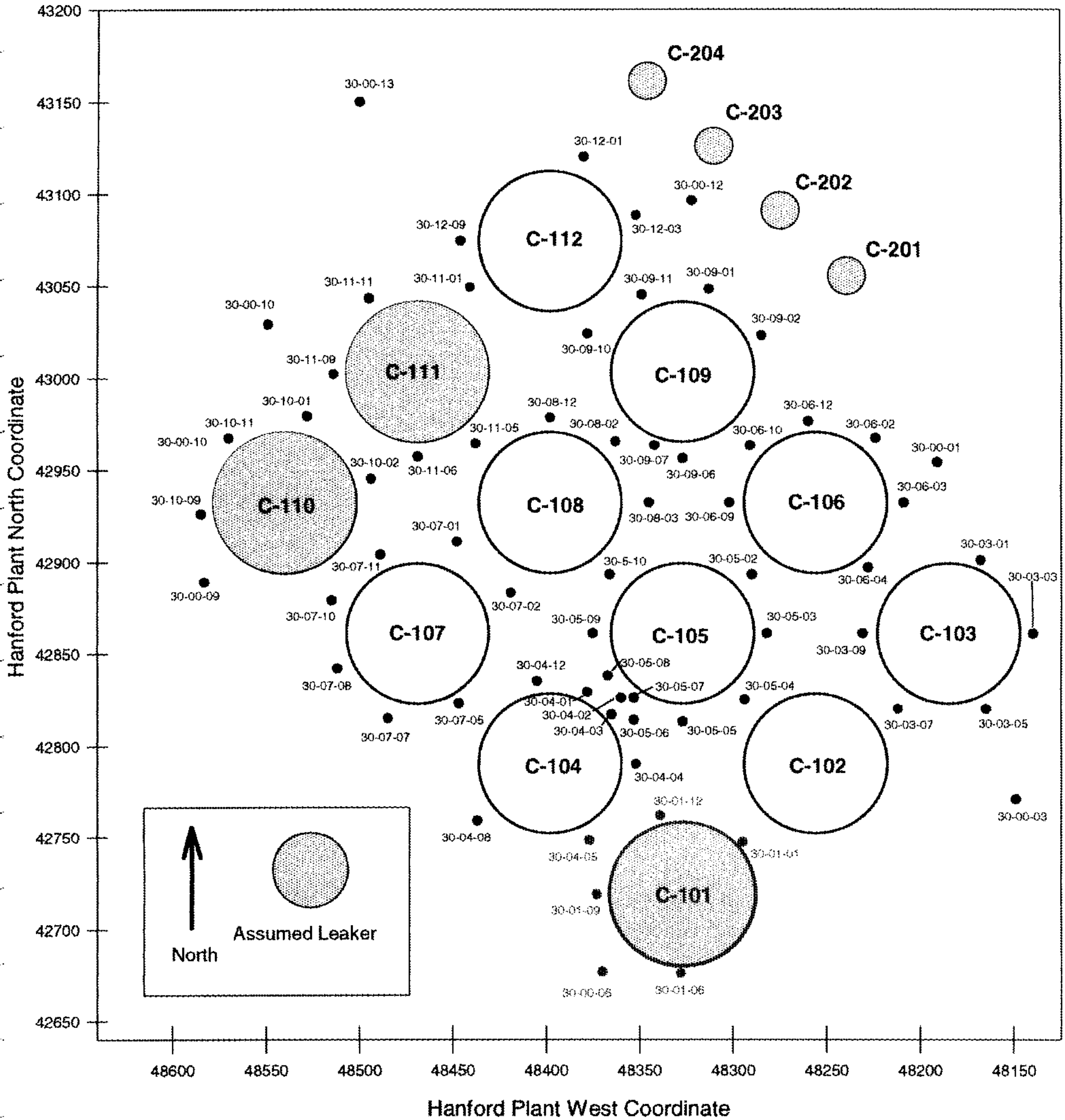

Figure 2. Plan View of Tanks and Boreholes in the C Tank Farm

-105, -108, -109, -111, -112, -201, -202, -203, and -204 are not equipped with primary leak-detection sources (Hanlon 1997).

3.1.2 Geologic and Hydrologic Setting

Excavation for the construction of the C Tank Farm occurred in glaciofluvial sediments of the Hanford formation. These sediments consist primarily of cobbles, pebbles, and coarse to medium sands with some silts. The excavated sediments were used as backfill around the completed tanks (Price and Fecht 1976).

Beneath the backfill material are the undisturbed sediments of the Hanford formation. The Hanford formation sediments consist of pebble to boulder gravel, fine- to coarse-grained sand, and silt. Three distinct facies were recognized by Lindsey (1992): gravel-dominated, sand-dominated, and silt-dominated (ordered from top to bottom of the formation). Baker et al. (1991) named these facies the coarse-grained deposits (generally referred to as the Pasco Gravels), the plane-laminated sand facies, and the rhythmite facies (commonly referred to as the Touchet Beds), respectively. The Hanford formation sediments extend to a depth of about 225 ft in the vicinity of the C Tank Farm (Lindsey 1993).

The distribution and similarities in lithologic succession of the facies types described above indicate the Hanford formation can be divided into three stratigraphic sequences across the 200 East Area. These sequences are designated: 1) upper gravel, 2) sandy, and 3) lower gravel. The sequences are composed mostly of the gravel-dominated and sand-dominated facies. The silt-dominated facies are relatively rare except in the southern part of the 200 East Area. Because of the variability of Hanford deposits, contacts between the sequences can be difficult to identify (DOE 1993).

In the vicinity of the C Tank Farm, the upper gravel sequence is dominated by deposits typical of the gravel-dominated facies of the Hanford formation. Lesser occurrences of the sand-dominated facies are encountered locally (DOE 1993). The upper gravel sequence consists of well-stratified gravels with lenticular sand and silt interbeds and extends to a depth of approximately 61 to 73 ft (23 to 35 ft below the base of the tank farm excavation). Strata within this interval generally dip to the east-southeast and thin to the south (Lindsey 1993). However, strata near the transition from the gravel-dominated to the sand-dominated facies locally dip to the north and east (Price and Fecht 1976).

The sandy sequence generally consists of deposits typical of the sand-dominated facies of the Hanford formation (DOE 1993). The sandy sequence is characterized by well-stratified coarse-to medium-grained sand with minor pebble and lenticular silt interbeds less than 1 ft thick. Localized silty intervals greater than 1 ft thick may be present and could potentially host perched water horizons that would probably not be laterally extensive because of pinchouts and clastic dikes. The sandy sequence extends to a depth of approximately 198 ft (Lindsey 1993).

The lower gravel sequence of the Hanford formation is dominated by deposits typical of the gravel-dominated facies. Local intercalated intervals of the sand-dominated facies are also found

(DOE 1993). This unit is composed of interbedded sands and gravels with few silt interbeds. Perched water is considered unlikely in this unit. The lower gravel sequence is about 27 ft thick and extends to a depth of approximately 225 ft (Lindsey 1993).

The Ringold Formation directly underlies the Hanford formation in the vicinity of the C Tank Farm. The Ringold Formation is approximately 70 ft thick and extends to a depth of 295 ft. A thin, discontinuous silt-rich layer that dips to the south and pinches out to the north and west is present in the southern portion of the tank farm. Perched water may occur at the top of this unit. A variably cemented pebble to cobble gravel with a sand matrix occurs stratigraphically below the silt-rich layer. This gravel may contain mud interbeds that could cause perched water to form if the mud is cemented or well enough developed (Lindsey 1993).

In the vicinity of the C Tank Farm, the uppermost aquifer occurs within the Ringold Lower Mud Unit at a depth of approximately 245 ft (Lindsey 1993; PNNL 1997). This uppermost aquifer is generally referred to as the unconfined aquifer, but includes locally confined to semi-confined areas DOE 1993).

The Ringold Formation is underlain by the Columbia River Basalt Group, which includes approximately 50 basalt flows. Sandwiched between the various basalt flows are sedimentary interbeds, collectively called the Ellensberg Formation. The Ellensberg Formation consists of mud, sand, and gravel deposited between volcanic eruptions. These sediments and porous flow tops and bottoms form confined aquifers that extend across the Pasco Basin (PNNL 1997).

At the Hanford Site, recharge of the unconfined aquifer by precipitation is highly variable depending on climate, vegetation, and soil texture. Recharge from precipitation is highest in coarse-textured soils with little or no vegetation (PNNL 1997). Fayer and Walters (1995) estimate that recharge to the unconfined aquifer in the area of the C Tank Farm is approximately 2 to 4 in. per year.

For more detailed information about the geology and hydrogeology below the C Tank Farm, the reader is referred to the following documents: Price and Fecht (1976), Caggiano and Goodwin (1991), Lindsey (1993), Lindsey (1995), and PNNL (1997).

3.1.3 Tank Contents

The C Tank Farm received a variety of waste types beginning in 1945. Initially, tanks C-101, -102, -103, -104, -105, and -106 received metal waste, and tanks C-107, -108, -109, -110, -111, and -112 received byproduct cake solution and waste solution from the first decontamination waste cycle (referred to collectively as first-cycle waste). Tanks C-201, -202, -203, and -204 were used to settle waste to allow the supernatant liquid to be sent to a crib (Brevick et al. 1994b). Over their operating life, the C Tank Farm tanks also received B-Plant decontamination waste, U Plant waste, cladding wastes, PUREX Plant fission product waste, waste water, and other waste types (Agnew 1997). A large amount of strontium from the PUREX Plant fission product waste remains in tank C-106 and has caused a high heat load in the tank (Brevick et al. 1994b).

The tanks in the C Tank Farm currently contain an estimated 1,976,000 gal of mixed wastes (Hanlon 1997) consisting primarily of various cladding wastes, tributyl phosphate and uranium recovery wastes, and sludge produced by in-tank scavenging (Agnew 1997). Detailed descriptions of the waste streams are presented in Anderson (1990) and Agnew (1995 and 1997). On the basis of information presented in Agnew (1997), some of the principal radionuclides in the tank wastes include ^{90}Sr, ^{137}Cs, ^{144}Ce, ^{151}Sm, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{63}Ni, ^{137m}Ba, ^{155}Eu, and ^{154}Eu.

The wastes currently contained in the C Tank Farm tanks are in the form of sludge, supernatant liquid, and interstitial liquid. Sludge is composed of a solid precipitate (hydrous metal oxides) that results from the neutralization of acid waste. The wastes were neutralized before being transferred to the tanks. Sludge forms the "solids" component of the tank waste. Liquids are present as supernatant and interstitial liquids. Supernatant liquid floats on the surface of the solid waste and interstitial liquid fills the interstitial voids within the solid waste. Interstitial liquid may be drainable if it is not held in the interstitial voids by capillary forces.

3.1.4 Tank Farm Status

All the tanks in the C Tank Farm were removed from service during the late 1970s and early 1980s (Brevick et al. 1994a). Nine tanks in the C Tank Farm are categorized as sound (C-102, -103, -104, -105, -106, -107, -108, -109, and -112), and seven are categorized as assumed leakers (C-101, -110, -111, -201, -202, -203, and -204) (Hanlon 1997). The tanks in the C Tank Farm that have been designated as "assumed leakers" are identified on Figure 2.

All the tanks in the C Tank Farm, except tanks C-103 and C-106, have been interim stabilized, and all the tanks, except tanks C-103, -105, and -106, have intrusion prevention completed. Tanks C-103, -105, and -106 have been partial interim isolated (Hanlon 1997).

Currently, tanks C-102 and C-103 are on the Organics Watch List and tank C-106 is on the High-Heat Load Watch List (Hanlon 1997). SSTs are added to a watch list because the waste in the tanks may be in a potentially unsafe condition and the handling of the waste material requires corrective action or special monitoring to reduce or eliminate the hazard. Resolution of the safety issues has been codified under Public Law 101-510 (generally known as the Wyden Amendment).

3.2 Tank C-101

Tank C-101 was constructed during 1943 and 1944 (Welty 1988) as the first tank in a three-tank cascade series; it was used to cascade waste to tanks C-102 and C-103 from 1946 until 1953. The overflow outlet to tank C-102 became partially plugged during the second quarter of 1954 (Brevick et al. 1994a).

The tank began receiving metal waste in March 1946 and was full by May 1946 (Agnew 1997). During the second quarter of 1952, the metal waste in the tank was sluiced to recover uranium. This tank received uranium recovery waste during 1953, PUREX cladding waste from the fourth quarter of 1960 to the second quarter of 1962, and decontamination waste during the second quarter of 1965 (Brevick et al. 1994a).

In the late 1960s, tank C-101 experienced a liquid-level decrease and was taken out of service (Brodeur 1993). No details concerning the tank leak or associated liquid-level decrease are available. The tank was pumped to a minimum heel in December 1969, and was categorized as "questionable integrity" in 1970 (Welty 1988).

A salt-well pump was installed in February 1976 and pumping was completed in April 1979. In January 1980, the tank was apparently reclassified as a "confirmed leaker" on the basis of vadose zone contamination. The tank was interim isolated in December 1982 and interim stabilized in November 1983 (Welty 1988).

The present inventory for tank C-101 includes 88,000 gal of sludge and 3,000 gal of drainable liquid classified as noncomplexed waste (Hanlon 1997). The waste level is approximately 27 in. above the dished bottom of the tank base; the waste level has remained constant since it was adjusted in November 1983 (Brevick et al. 1994b).

A primary method of leak detection for tank C-101 is not identified in Hanlon (1997). Welty (1988) states that the vadose zone boreholes are the only means of leak detection because of the tank solids.

4.0 Boreholes in the Vicinity of Tank C-101

Six vadose zone monitoring boreholes surround tank C-101. These boreholes are 30-01-01, 30-01-06, 30-00-06, 30-01-09, 30-04-05, and 30-01-12. Figure 2 shows the locations of these boreholes in red.

All the boreholes, except borehole 30-00-06, were completed with 6-in. steel casings. The surface exposures of most the borehole casings are flush with small-diameter concrete pads, making accurate measurements of the borehole casing wall thicknesses difficult. Because the calculations of radionuclide concentrations incorporate a correction factor based on casing thickness, correction factors appropriate to the casing thickness must be determined and applied in the development of the log data. The casing thickness for the 6-in. boreholes is assumed to be 0.280 in., on the basis of the published thickness for schedule-40, 6-in., carbon-steel casing, which was the typical casing used in tank farm borehole construction in the 1970s.

Borehole 30-00-06 was completed with 8-in. and 12-in. casings to a depth of 53.8 ft and with only 8-in. casing below this depth. No appropriate correction factor is available to account for the attenuation caused by the double casing and any grout, soil, or open space between the two casings; therefore, a correction factor for the 8-in. casing was applied to data acquired throughout the entire borehole. A correction for 0.330-in. casing was applied because it most closely matches the actual casing thickness of 0.313 in. The use of this correction factor will cause the calculated concentrations for radionuclides above 54 ft to be underestimated and below 54 ft to be slightly overestimated. Concentration values for the interval above 54 ft in borehole 30-00-06 are highly inaccurate and should be used only as qualitative indicators of contaminant presence, lithology changes, and casing locations.

Spectral gamma-ray data were acquired for each borehole. The spectral gamma-ray data were collected in the move/stop/acquire logging mode with a 100-s acquisition time at 0.5-ft depth intervals. All the boreholes were logged dry.

The pre- and post-survey field verification spectra were used to create the peak resolution and channel-to-energy parameters used in processing the spectra acquired during logging operations.

The following sections present results of the spectral gamma-ray log data collected from these boreholes. Appendix A contains the plots of the log data. The most recent historical gross gamma data are presented on the combination plots in Appendix A. These data, historical gross gamma logs from 1975 to 1994, and results from other investigations were used in the preparation of this report.

4.1 Borehole 30-01-01

Borehole 30-01-01 is located approximately 2 ft from the northeast side of tank C-101 and was given the Hanford Site designation 299-E27-60. This borehole was drilled in March 1970 and completed to a depth of 100 ft with 6-in. casing. The driller's log does not indicate that the casing was perforated or the borehole grouted. Total logging depth achieved by the SGLS was 98.0 ft.

The man-made radionuclides detected in this borehole were ^{137}Cs and ^{60}Co. ^{137}Cs contamination was detected continuously from the ground surface to 13 ft, almost continuously from 20.5 to 32 ft, and at the bottom of the logged interval from 97.5 to 98 ft. ^{137}Cs contamination was also detected at depths of 18, 41.5, and 43 ft. The maximum measured ^{137}Cs concentration was about 2 pCi/g at 29.5 ft. A higher concentration (28.5 pCi/g) was detected at the ground surface; however, as described in Section 2.1, this is not an accurate concentration value because the source-to-detector geometry at the top of the borehole differs from the source-to-detector geometry used in the calibration.

^{60}Co contamination was detected almost continuously from 37 to 41 ft. The maximum ^{60}Co concentration of 0.16 pCi/g was measured at 38 and 38.5 ft.

The KUT concentration plot shows an apparent decrease in ^{238}U concentrations below about 6 ft. This concentration decrease coincides with an overlap of two logging runs on two different days. The apparent change in ^{238}U concentrations is probably the result of radon venting up the borehole between log runs. The variability in the ^{238}U background is not related to changes in the efficiency of the logging system, but more likely to the weather conditions during a particular run. The 609-keV spectral peak used to calculate the ^{238}U concentration is actually emitted by ^{214}Bi, and the calculated ^{238}U concentration is only accurate if the ^{214}Bi and ^{238}U are in secular equilibrium. Because radon gas is an intermediate member of the ^{238}U decay chain, the equilibrium condition will be disturbed by changes in the weather conditions in the vicinity of the borehole. Wind, or the absence of it, affects the rate of radon venting from the borehole. The variations in the calculated ^{238}U background do not affect the determination of man-made gamma-ray-emitting nuclides from the SGLS data set.

^{40}K concentrations are slightly decreased from 32 to 37.5 ft. This concentration decrease coincides with an overlap of logging runs from two different days. This difference in measurement may be caused by drift in the logging system rather than changes in the backfill material. It should be noted that the ^{40}K measurements within the overlapping interval (31 to 32 ft) repeat within two standard deviations (95-percent confidence level), indicating the measurements are essentially equivalent within the stated accuracy for the system.

The ^{40}K concentrations increase from 38 to 40 ft. This concentration increase is caused by a change from backfill material to the undisturbed sediments of the Hanford formation at about this depth.

^{40}K concentrations decrease from about 14 to 12.5 pCi/g below 53.5 ft. ^{40}K concentrations are slightly decreased and variable from 53.5 to 69.5 ft. These decreased concentrations are probably caused by a decrease in the fraction of fine-grained sediments in this interval.

^{40}K concentrations increase gradually from 69.5 ft to the bottom of the logged interval, with ^{40}K concentrations relatively variable below about 72 ft. This gradual concentration increase probably represents a gradual increase in the fine-grained fraction of the sediments in this interval.

The SGLS total gamma-ray plot reflects the influence of the natural and man-made radionuclides. The ^{137}Cs concentrations from the ground surface to 13 ft and about 25 to 30 ft and the ^{60}Co concentrations from 37 to 41 ft are clearly reflected on the total gamma-ray plot.

The ^{137}Cs contamination from the ground surface to about 13 ft may be the result of a surface spill. Contamination probably migrated down into the backfill material or down the outside of the borehole casing to this depth. The ^{137}Cs contamination from 20.5 to 32 ft may be from a pipeline leak.

The ^{60}Co contamination from 37 to 41 ft is probably the result of a tank leak. The driller's log notes elevated gross gamma activity at this depth during borehole construction in March 1970. Count rates of 10,000 counts per minute (cpm) were recorded with an unknown radiation survey instrument for samples taken from depths of 38, 40, 41, 42, 43, and 44 ft. Count rates of 5,000 cpm were recorded for a sample from 39 ft, and 800 cpm were recorded for a sample from 45 ft.

Gross gamma logs from January 1975 through June 1994 were reviewed and a plot of representative gross gamma logs is included in Appendix A. Anomalous gamma-ray activity is present from about 35 to 52 ft in the earliest gross gamma logs available, indicating the contamination was present by January 1975 or earlier. In addition, Welty (1988) indicates that a zone of anomalous gamma-ray activity was present at 39 ft in July 1972.

The historical gamma logs indicate that the gamma-ray activity from about 35 to 52 ft decreased rapidly between 1975 and 1979. This could indicate that a short-lived radionuclide, such as ^{125}Sb, was responsible for some of the activity and then decayed away during this time interval. However, the historical gross gamma logs are not of sufficient quality to make such a determination.

The ^{137}Cs contamination at the bottom of the borehole may be from particles that were blown down into the borehole.

4.2 Borehole 30-01-06

Borehole 30-01-06 is located approximately 3 ft from the south side of tank C-101 and was given the Hanford Site designation 299-E27-59. This borehole was drilled in January 1970 and completed to a depth of 100 ft with 6-in. casing. The driller's log does not indicate that the borehole was perforated or grouted. The total logging depth achieved by the SGLS was 98.5 ft.

The man-made radionuclides detected in this borehole were ^{137}Cs and ^{60}Co. Continuous ^{137}Cs contamination was detected from the ground surface to 7.5 ft, 14 to 20 ft, 35 to 38.5 ft, and 97.5 ft to the bottom of the logged interval. Scattered occurrences of ^{137}Cs contamination were also detected from 21 to 30.5 ft and at 55.5 ft. The maximum measured ^{137}Cs concentration was 48.6 pCi/g at a depth of 37 ft. ^{60}Co contamination was detected only at 37 ft with a concentration of 0.1 pCi/g.

The ^{40}K concentrations increase from 38 to 40 ft. This concentration increase is caused by a change from backfill material to the undisturbed sediments of the Hanford formation at about this depth.

^{40}K concentrations were measured at approximately 14 pCi/g from 40.5 to 45 ft and then decrease to a background concentration of about 12.5 pCi/g from 45.5 to 57 ft. These decreased concentrations are probably from a decreased fraction of fine-grained sediments.

^{40}K concentrations increase gradually from 57 to 89 ft. This gradual concentration increase is probably caused by an increase in fine-grained sediments in this interval.

It was not possible to identify many of the 609-keV peaks used to derive the ^{238}U concentrations between 36.5 and 37.5 ft. This occurred because high gamma-ray activity associated with the nearby ^{137}Cs peak (661 keV) in this interval created an elevated Compton continuum extending to the 609-keV region, causing the MDL to exceed the measured ^{238}U concentration.

The interval between 28.5 and 45 ft was relogged as an additional quality check and to demonstrate the repeatability of the radionuclide concentration measurements made by the SGLS. A comparison of the measured concentrations of the naturally occurring and man-made radionuclides using the data sets provided by the original and repeated logging runs is included with Appendix A. The measurements generally repeat within two standard deviations (95-percent confidence level), indicating the excellent repeatability of the measured spectral gamma-ray intensities used to calculate the radionuclide assays.

Historical gross gamma logs from January 1975 through June 1994 were reviewed. A plot of representative gross gamma logs is included in Appendix A.

The ^{137}Cs contamination from the ground surface to about 20 ft may be the result of a surface spill. Contamination probably migrated down into the backfill material or down the outside of the borehole casing to this depth. It is also possible that a pipeline leak contributed to contamination at this depth.

The ^{137}Cs contamination from 35 to 38.5 ft probably migrated from a tank leak and accumulated at the base of the tank farm excavation. The driller's log notes that contamination was not detected during borehole drilling, but it is not clear what protocols were followed or what equipment was used to make that determination. The earliest historical gross gamma logs available (January 1975) indicate anomalously high gamma activity was present in this interval at that time.

Welty (1988) does not record the zone of anomalous gamma-ray activity at about 35 ft until May 1978, but indicates that a zone of anomalous gamma-ray activity was present at 78 ft by July 1972. It is not possible to determine when contamination first migrated to this depth because data are not available before July 1972. The activity at 78 ft decreased by about 50 percent from July 1972 to June 1973 (Welty 1988). This may indicate that a short-lived radionuclide, such as ^{125}Sb, was responsible for much of the activity and decayed away during this time interval. However, the historical gross gamma logs are not of sufficient quality to make such a determination. This zone of anomalous gamma-ray activity appears to have decayed away by late 1982.

The ^{137}Cs contamination at the bottom of the borehole may be from particles that were blown down into the borehole.

4.3 Borehole 30-00-06

Borehole 30-00-06 is located approximately 20 ft from the southwest side of tank C-101 and was given the Hanford Site designation 299-E27-55. This borehole was drilled in December 1944 and completed to a depth of 154 ft with 8-in. casing. The driller's log indicates that a string of 12-in.-diameter casing is also present to a depth of 53.8 ft. Data from above 54 ft are usable only for qualitative interpretations because of this double casing. The borehole was perforated from 53 to 153 ft with five cuts per foot. The driller's log indicates that the bottom of the 8-in. casing was grouted.

The depth of the borehole was measured with an electrical tape before borehole logging. The depth of the borehole was measured at 111 ft, rather than 154 ft as reported on the driller's log.

The reason the borehole is more shallow than reported in the driller's log is not known. Total logging depth achieved by the SGLS was 111.0 ft.

The zero reference for logging is the top of the 8-in. casing. The borehole is located in a hillside, and the top of the 8-in. casing is approximately 7 ft above the ground surface. The 12-in. casing is not visible at the ground surface; it is possible that an additional section of 8-in. casing was added to the top of the original borehole casing to extend the top of the borehole casing above the hill slope.

A 0.330-in. casing correction factor was used for the 8-in. casing rather than the actual casing thickness of 0.313 in. A casing correction factor for 0.313 in. is not available and the correction factor for 0.330-in. casing is the closest available. Use of the correction factor for 0.330-in. casing will cause calculated radionuclide concentrations to be slightly overestimated for the interval below about 54 ft.

The man-made radionuclides detected in this borehole were ^{137}Cs and ^{60}Co. ^{137}Cs concentrations were detected intermittently from the ground surface to 5 ft and intermittently from 57 ft to the bottom of the logged interval. ^{60}Co contamination was detected only at 77.5 ft. The maximum ^{137}Cs and ^{60}Co concentrations for this borehole could not be measured from the portion of the borehole with the double casing.

^{40}K and ^{232}Th concentrations decrease below a depth of 7 ft because the top of the 12-in. surface casing is probably located at this depth.

KUT concentrations decrease from 7 to 58.5 ft and increase below 58.5 ft. This concentration increase represents the change from the double-cased portion of the borehole to the single-cased portion. This indicates that the 12-in. casing was installed from 7 to 58.5 ft, rather than to 53.8 ft, as indicated in the driller's log. This difference in depth could be caused by a section of casing that was added to the top of the borehole, as noted previously. The decrease in the ^{40}K and ^{238}U concentrations and the total count plot from 56.5 to 58 ft indicates the presence of a casing shoe in this interval.

Historical gross gamma-ray logs from January 1975 through June 1993 were reviewed. No zones of anomalous gamma-ray activity were identified in logs for this time interval.

The near-surface ^{137}Cs contamination is probably from surface contamination that was detected through the casing above the ground surface.

The origin of the ^{137}Cs contamination detected below 56 ft is uncertain. Without information from higher in the borehole, it is not possible to determine whether this contamination migrated downward from higher in the borehole or laterally to this location. Downward contamination migration could be enhanced by the perforations below 56 ft, but the mechanism that promotes this activity is unknown. It is also possible that the calculated radionuclide concentrations below 56 ft are further overstated because of the casing perforations. The radionuclide concentrations are calculated on the basis of the thickness of steel casing, which acts as shielding to gamma rays. The perforations remove portions of this shielding.

4.4 Borehole 30-01-09

Borehole 30-01-09 is located approximately 5 ft from the west side of tank C-101 and was given the Hanford Site designation 299-E27-58. This borehole was drilled in April 1970 and completed to a depth of 100 ft with 6-in. casing. The driller's log does not indicate that the borehole was grouted or perforated. Total logging depth achieved by the SGLS was 97.5 ft.

The interval from 26.5 to 30 ft was logged using real time because the dead time exceeded 50 percent. Real time is a data acquisition method in which the data are gathered at each depth for a set period of time, in this case 100 s, and then the data are corrected for the dead time measured at each depth. This method allows useful data to be collected in relatively high activity zones, although the counting statistics are not as accurate as standard logging data collection. This results in larger measurement uncertainties as shown on the plots from this interval.

The man-made radionuclides detected in this borehole were ^{137}Cs, ^{60}Co, ^{154}Eu, and ^{152}Eu. Continuous ^{137}Cs contamination was detected from the ground surface to 6 ft, 24.5 to 32 ft, and 34.5 to 37 ft. ^{137}Cs contamination was also detected nearly continuously from 9 to 16.5 ft and at the bottom of the logged interval (97.5 ft). A maximum ^{137}Cs concentration of 568.4 pCi/g was measured at a depth of 28.5 ft. ^{60}Co contamination was detected at 39.5 and 40 ft. The maximum measured ^{60}Co concentration was 0.15 pCi/g at 40 ft. ^{152}Eu and ^{154}Eu were both detected at 27.5 ft at concentrations of 128.9 pCi/g and 106.7 pCi/g, respectively.

The ^{40}K concentrations are relatively elevated from 38 to 40.5 ft. This concentration increase probably represents the transition from the backfill material above this depth to the undisturbed Hanford formation below this depth.

^{40}K concentrations are slightly decreased and variable from 40.5 to about 59 ft. The ^{40}K background concentrations are approximately 14 pCi/g from 42.5 to 45 ft and then decrease to a background concentration of about 13 pCi/g from 45.5 to 59 ft. The decreases in ^{40}K concentrations probably reflect decreases in the amount of fine-grained sediments in these intervals.

^{40}K concentrations increase gradually from 59 ft to the bottom of the logged interval. This gradual concentration increase is probably from an increase in fine-grained sediments in this interval.

It was not possible to identify many of the 609-keV peaks used to derive the ^{238}U concentrations between 25 and about 32 ft. This occurred because high gamma-ray activity associated with the nearby ^{137}Cs peak (661 keV) created an elevated Compton continuum extending to the 609-keV region, causing the MDL to exceed the measured ^{238}U concentration. The 2614-keV peaks could not be identified at 28 and 28.5 ft because the relatively high 661-keV radiation associated with the ^{137}Cs contamination produced spectral distortions that caused the MDLs associated with the 2614-keV peaks to exceed the measured radionuclide concentrations.

The SGLS total gamma-ray plot reflects the influence of the natural and man-made radionuclides. Two distinct zones of ^{137}Cs contamination are clearly reflected on the total gamma-ray plot between 24 and 37 ft.

Historical gross gamma-ray logs from January 1975 through November 1994 were reviewed. A plot of representative gross gamma logs is included in Appendix A.

The ^{137}Cs contamination in the upper 16.5 ft of the borehole is probably the result of a surface spill that migrated into the backfill material around the borehole or down the inside or outside of the borehole casing. The upper portion of this contamination was present in the earliest gross gamma logs available (January 1975).

The ^{137}Cs contamination from 24.5 to 32 ft and the ^{152}Eu and ^{154}Eu contamination at 27.5 ft is probably the result of a tank leak at approximately this depth. The earliest historical gross gamma logs indicate that gamma activity was present at this depth at that time. In addition, Welty (1988) indicates that anomalously high gamma activity was present in this interval by at least July 1972.

The ^{137}Cs contamination from 34.5 to 37 ft and the ^{60}Co at 39 and 40 ft is probably the result of contamination from a tank leak collecting at the base of the tank farm excavation. The historical logs indicate that the activity in this interval decreased by about 50 percent from July 1972 to June 1973 (Welty 1988). This could indicate that a short-lived radionuclide, such as ^{125}Sb, was responsible for much of the activity and then decayed away during this time interval. However, the historical gross gamma logs are not of sufficient quality to make such a determination.

The ^{137}Cs contamination at the bottom of the borehole may be from particles that were blown down into the borehole.

4.5 Borehole 30-04-05

Borehole 30-04-05 is located approximately 17 ft from the northwest side of tank C-101 and was given the Hanford Site designation 299-E27-80. This borehole was drilled in July 1974 and completed to a depth of 100 ft with 6-in. casing. A driller's log was not available for this borehole; therefore, the information presented is from Chamness and Merz (1993). Total logging depth achieved by the SGLS was 98.5 ft.

The only man-made radionuclide detected in this borehole was ^{137}Cs. ^{137}Cs contamination was detected almost continuously from the ground surface to a depth of 57.5 ft, intermittently from 69.5 to 91.5 ft, and continuously from 94.5 ft to the bottom of the logged interval (98.5 ft). The contamination in these intervals seems to be located in six distinct zones: from the ground surface to 14 ft, 15 to 18.5 ft, 19.5 to 33.5 ft, 35 to 38 ft, 45 to 57.5 ft, and 94.5 ft to the bottom of the logged interval. A maximum ^{137}Cs concentration of 91.5 pCi/g was measured at 12.5 ft.

The KUT log plots show an increase in ^{40}K concentrations at 38 ft with a background concentration of about 15 pCi/g between 38 and 45 ft. This concentration increase may indicate the transition from backfill material to the undisturbed sediments of the Hanford formation.

^{40}K concentrations are slightly decreased and variable from 45.5 to about 59 ft. The concentration decrease probably reflects a decrease in the amount of fine-grained sediments in this interval.

^{40}K concentrations increase gradually from 59.5 to 89 ft. This gradual concentration increase is probably caused by a gradual increase in fine-grained sediments in this interval.

It was not possible to identify many of the 609-keV peaks used to derive the ^{238}U concentrations at the ground surface and about 14.5 ft. This occurred because high gamma-ray activity associated with the nearby ^{137}Cs peak (661 keV) created an elevated Compton continuum extending to the 609-keV region, causing the MDL to exceed the measured ^{238}U concentration.

The SGLS total gamma-ray plot reflects the influence of the natural and man-made radionuclides. The ^{137}Cs concentrations from the ground surface to about 54 ft are clearly reflected on the total gamma-ray plot.

Historical gross gamma-ray logs from January 1975 through July 1994 were reviewed. A plot of representative historical logs for this borehole is included in Appendix A. The ^{137}Cs contamination from 11 to 38 ft is probably the result of a surface spill that migrated into the backfill material around the borehole. This contamination may have migrated laterally along the surface of the tank dome and into the region of this borehole. The contamination in this interval was present in the earliest gross gamma log available (January 1975). In addition, Welty (1988) indicates that anomalously high gamma activity was present in this interval by at least September 1974, the earliest data provided for this borehole in Welty (1988).

The historical logs indicate that the gross gamma activity at 11.5 ft increased from about 444 to 9,000 cps from January 10, 1975 to March 7, 1975. However, activities in this interval fluctuate widely over the span of the historical logs available. A plot of historical gross gamma logs from January to March 1978 is included in Appendix A to illustrate these fluctuations. No conclusions were drawn from these changes in activity because of the questionable quality of these logs.

The ^{137}Cs contamination from 45 to 57.5 ft is probably from a tank leak that migrated into the Hanford formation sediments beneath the tank farm excavation. The ^{137}Cs contamination coincides with an interval of low ^{40}K concentrations. This zone of low ^{40}K concentrations may have acted as a preferential pathway for contaminants to migrate to this depth. The earliest historical gross gamma logs available indicate that gamma activity was present at this depth at that time.

The ^{137}Cs contamination at the bottom of the borehole may be from particles that have been blown down into the borehole or from contamination that has accumulated around the base of the borehole casing. The ^{137}Cs concentrations at this depth could also be from contamination present in the formation near the borehole at this depth.

4.6 Borehole 30-01-12

Borehole 30-01-12 is located approximately 4 ft from the north side of tank C-101 and was given the Hanford Site designation 299-E27-61. This borehole was drilled in March 1970 and completed to a depth of 100 ft with 6-in. casing. The driller's log does not indicate that the borehole was grouted or perforated. Total logging depth achieved by the SGLS was 99.5 ft.

The only man-made radionuclide detected in this borehole was ^{137}Cs. ^{137}Cs contamination was detected almost continuously from the ground surface to 40.5 ft. Isolated occurrences of ^{137}Cs were also detected at 45, 60, 66.5 ft, and at the bottom of the logged interval (99.5 ft). A maximum ^{137}Cs concentration of 85.2 pCi/g was detected at 4.5 ft. A higher concentration (95.8 pCi/g) was detected at the ground surface; however, the ^{137}Cs concentration calculated at the ground surface is not an accurate concentration because the source-to-detector geometry at the top of the borehole differs from the source-to-detector geometry used in the calibration.

The KUT log plots show an increase in ^{40}K concentrations at 38.5 ft with a background concentration of about 14 pCi/g between 38.5 and 50.5 ft. This concentration increase is caused by the transition from backfill material above this depth to the undisturbed sediments of the Hanford formation below.

^{40}K concentrations are slightly decreased from 51 to about 59 ft. These decreased concentrations probably reflect decreases in the amount of fine-grained sediments in these intervals.

^{40}K concentrations gradually increase from 59.5 to 92.5 ft. This concentration increase is probably from a gradual increase in the fine-grained sediments in this interval.

It was not possible to identify many of the 609-keV peaks used to derive the ^{238}U concentrations between the ground surface and 8 ft. This occurred because high gamma-ray activity associated with the nearby ^{137}Cs peak (661 keV) created an elevated Compton continuum extending to the 609-keV region, causing the MDL to exceed the measured ^{238}U concentration.

The SGLS total gamma-ray plot reflects the influence of the natural and man-made radionuclides. The ^{137}Cs contamination from the ground surface to about 20 ft is clearly reflected on the total gamma-ray plot.

Historical gross gamma logs from January 1975 through June 1994 were reviewed. A plot of representative historical logs for this borehole is included in Appendix A.

The ^{137}Cs contamination in the upper 10 ft of the borehole is probably the result of a surface spill that migrated into the backfill material around the borehole. The spill appears to have occurred between June 6 and June 13, 1975 based on a review of historical gross gamma logs.

Anomalously high gamma activity does not appear within this interval in the historical logs before June 13, 1975, but is very evident after June 26, 1975.

The ^{137}Cs contamination from 14 to 22.5 ft is probably from a surface spill or pipeline leak that migrated into the backfill material and Hanford formation sediments around this borehole. The earliest historical gross gamma logs available indicate that gamma activity was present at this depth at that time.

The ^{137}Cs contamination below 22.5 ft may be from contamination that has migrated down the outside or inside of the borehole casing or the contamination could have been carried down during drilling operations. This contamination could also be in the sediments around the borehole casing.

5.0 Discussion of Results

A plot of the man-made radionuclide concentration profiles for the six boreholes surrounding tank C-101 is presented in Figure 3. The plot shows widespread ^{137}Cs contamination, less extensive ^{60}Co contamination, and limited ^{152}Eu and ^{154}Eu contamination.

^{137}Cs contamination was detected in the upper 10 ft of all the boreholes surrounding tank C-101. This near-surface contamination is probably from surface spills that migrated into the backfill material around the tank. Because of the double casing in borehole 30-00-06, it is not possible to determine if contamination was not detected in the interval of 5 to 50 ft because it was not present, or if the radiation from the contamination was attenuated by the double casing so that the contamination could not be detected. Because the upper 7 ft of borehole 30-00-06 is located in a hillside, the contamination detected in the upper 5.5 ft of the borehole is probably caused by surface contamination detected through the casing. Data collected from boreholes 30-04-05 and 30-01-12 indicate a marked increase in the ^{137}Cs concentrations from about 11 to 12 ft, possibly indicating that contaminants from the surface spill spread along the upper surface of the domed top into the region of these two boreholes.

The ^{137}Cs contamination from 24.5 to 32 ft and the ^{152}Eu and ^{154}Eu contamination at 27.5 ft in borehole 30-01-09 are probably the result of a tank leak at approximately this depth near this borehole. The earliest historical gross gamma logs available indicate that gamma activity was present at this depth at that time. In addition, Welty (1988) indicates that anomalously high gamma activity was present in this interval by at least July 1972.

Boreholes 30-01-01, 30-01-06, and 30-01-09 show ^{60}Co contamination at about the depth of the base of the tank farm excavation. It is suspected that contaminants from a tank leak collected at the base of the tank farm excavation. Relative increases in ^{137}Cs concentrations at about this depth were detected in boreholes 30-01-06, 30-01-09, 30-04-05, and 30-01-12. The source of this contamination may be the tank leak near borehole 30-01-09, as noted previously.

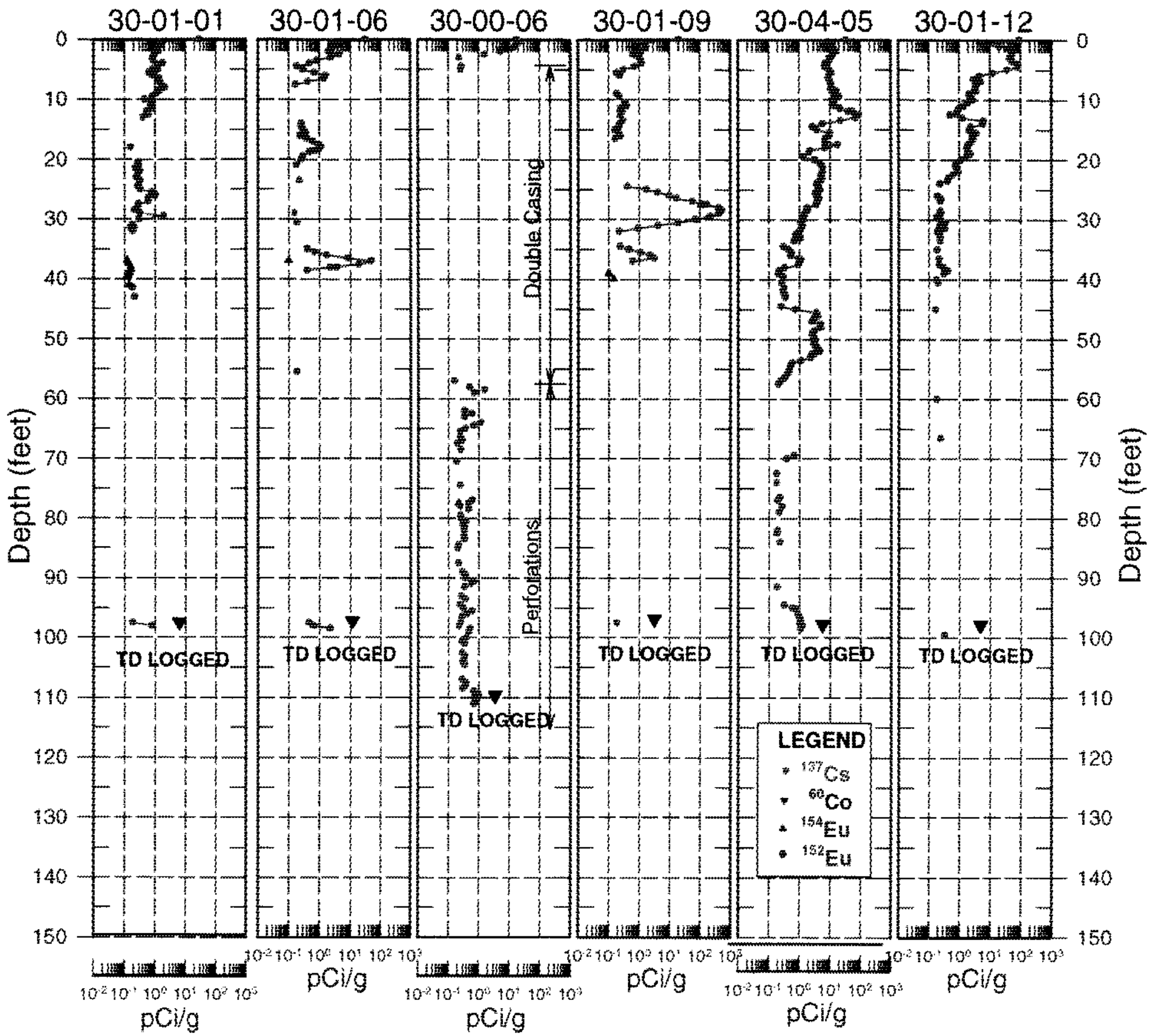

Figure 3. Correlation Plot of ^{137}Cs, ^{60}Co, ^{152}Eu, and ^{154}Eu Concentrations in Boreholes Surrounding Tank C-101

Borehole 30-04-05 shows an interval of elevated ^{137}Cs concentrations from 45 to 57.5 ft. This contamination is probably from a tank leak that migrated along a preferential pathway into the Hanford formation sediments beneath the tank farm excavation. The ^{137}Cs contamination in this interval coincides with an interval of low ^{40}K concentrations.

In borehole 30-00-06, the SGLS detected ^{137}Cs contamination from 57 ft to the bottom of the logged interval and ^{60}Co contamination at 77.5 ft. Downward migration of contamination in this borehole could be enhanced by the perforations from 54 ft to the bottom of the borehole. It is also possible that the calculated radionuclide concentrations in this depth interval are overstated because of the casing perforations. The radionuclide concentrations are calculated on the basis of the thickness of the steel casing, which acts as shielding to gamma rays; the perforations remove portions of this shielding.

6.0 Conclusions

The characterization of the gamma-ray-emitting contamination in the vadose zone surrounding tank C-101 was completed using the SGLS. Data obtained with the SGLS and geologic and historical information indicate that the source of the ^{137}Cs contamination around this tank is a combination of surface spills and pipeline and tank leaks. The source of the tank leaks is probably near borehole 30-01-09 on the west side of tank C-101.

7.0 Recommendations

Approximately 3,000 gal of drainable, interstitial liquid and 88,000 gal of sludge remains in tank C-101 (Hanlon 1997). It is recommended that logging of the boreholes surrounding this tank be continued to detect potential future leakage from the tank and associated tank facilities and to monitor the potential spread of contaminant plumes detected during this study. Changes in the contamination profiles would show contaminant migration.

It is further recommended that borehole 30-00-06 be replaced with a new, single-cased, nonperforated borehole. The perforations in borehole 30-00-06 are not needed and may enhance downward migration of contamination; the double casing makes the borehole practically unusable for vadose zone monitoring. A new monitoring borehole should be constructed in this general area to monitor possible contaminant migration.

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Appendix A
Spectral Gamma-Ray Logs for Boreholes in the Vicinity of Tank C-101

Log Event A

Borehole 30-01-01

Borehole Information

Farm : C   Tank : C-101   Site Number : 299-E27-60
N-Coord : 42,747   W-Coord : 48,295   TOC Elevation : 646.33
Water Level, ft : None   Date Drilled : 3/31/70

Casing Record

Type : Steel-welded   Thickness, in. : 0.280   ID, in. : 6
Top Depth, ft. : 0   Bottom Depth, ft. : 100

Borehole Notes:

This borehole was drilled in March 1970 and completed to a depth of 100 ft with 6-in. casing. The casing thickness is presumed to be 0.280 in., on the basis of the published thickness for schedule-40, 6-in. steel tubing. No information was available that indicated the borehole casing was perforated or the borehole grouted; therefore, it is assumed that the borehole was not perforated or grouted. The top of the casing, which is the zero reference for the SGLS, is even with the tank farm ground surface.

Equipment Information

Logging System : 2   Detector Type : HPGe   Detector Efficiency : 35.0 %
Calibration Date : 10/96   Calibration Reference : GJO-HAN-13   Logging Procedure : P-GJPO-1783

Log Run Information

Log Run Number : 1   Log Run Date : 3/26/97   Logging Engineer: Bob Spatz
Start Depth, ft.: 0.0   Counting Time, sec.: 100   L/R : L   Shield : N
Finish Depth, ft. : 6.0   MSA Interval, ft. : .5   Log Speed, ft/min.: n/a

Log Run Number : 2   Log Run Date : 3/27/97   Logging Engineer: Bob Spatz
Start Depth, ft.: 5.0   Counting Time, sec.: 100   L/R : L   Shield : N
Finish Depth, ft. : 13.0   MSA Interval, ft. : .5   Log Speed, ft/min.: n/a

Log Run Number : 3   Log Run Date : 3/27/97   Logging Engineer: Bob Spatz
Start Depth, ft.: 98.0   Counting Time, sec.: 100   L/R : L   Shield : N
Finish Depth, ft. : 31.0   MSA Interval, ft. : .5   Log Speed, ft/min.: n/a

Borehole 30-01-01

Log Event A

Log Run Number :	4	Log Run Date :	3/28/97	Logging Engineer:	Bob Spatz
Start Depth, ft.:	32.0	Counting Time, sec.:	100	L/R : L	Shield : N
Finish Depth, ft. :	12.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a

Analysis Information

Analyst :	D.L. Parker		
Data Processing Reference :	P-GJPO-1787	Analysis Date :	6/27/97

Analysis Notes :

This borehole was logged by the SGLS in four log runs. The pre- and post-survey field verification spectra met the acceptance criteria established for the peak shape and detector efficiency, confirming that the SGLS was operating within specifications. The energy calibration and peak-shape calibration from these spectra were used to establish the peak resolution and channel-to-energy parameters used in processing the spectra acquired during the logging operation. No fine gain adjustments were necessary during these log runs.

Casing correction factors for a 0.280-in.-thick steel casing were applied during analysis.

The man-made radionuclides Cs-137 and Co-60 were detected in this borehole. Cs-137 contamination was measured continuously from the ground surface to 13 ft, at 18 ft, almost continuously from 20.5 to 32 ft, at 41.5 ft, at 43 ft, and the bottom of the logged interval (97.5 and 98 ft). Co-60 contamination was detected almost continuously from 37 to 41 ft.

The U-238 concentrations decrease below 6 ft. The K-40 concentrations decrease slightly from 32 to 37.5 ft, increase from 38 to 39 ft, and decrease to a background concentration of about 14 pCi/g from 39.5 to 53 ft. K-40 concentrations are slightly decreased and variable from 53.5 to about 69.5 ft, increase gradually from 69.5 to 72 ft, and become variable below about 72 ft.

Additional information and interpretations of log data are included in the main body of the Tank Summary Data Reports for tanks C-101 and C-102.

Log Plot Notes:

Separate log plots show the man-made and the naturally occurring radionuclides. The natural radionuclides can be used for lithology interpretations. The headings of the plots identify the specific gamma rays used to calculate the concentrations. Uncertainty bars on the plots show the statistical uncertainties for the measurements as 95-percent confidence intervals. Open circles on the plots give the MDL. The MDL of a radionuclide represents the lowest concentration at which positive identification of a gamma-ray peak is statistically defensible.

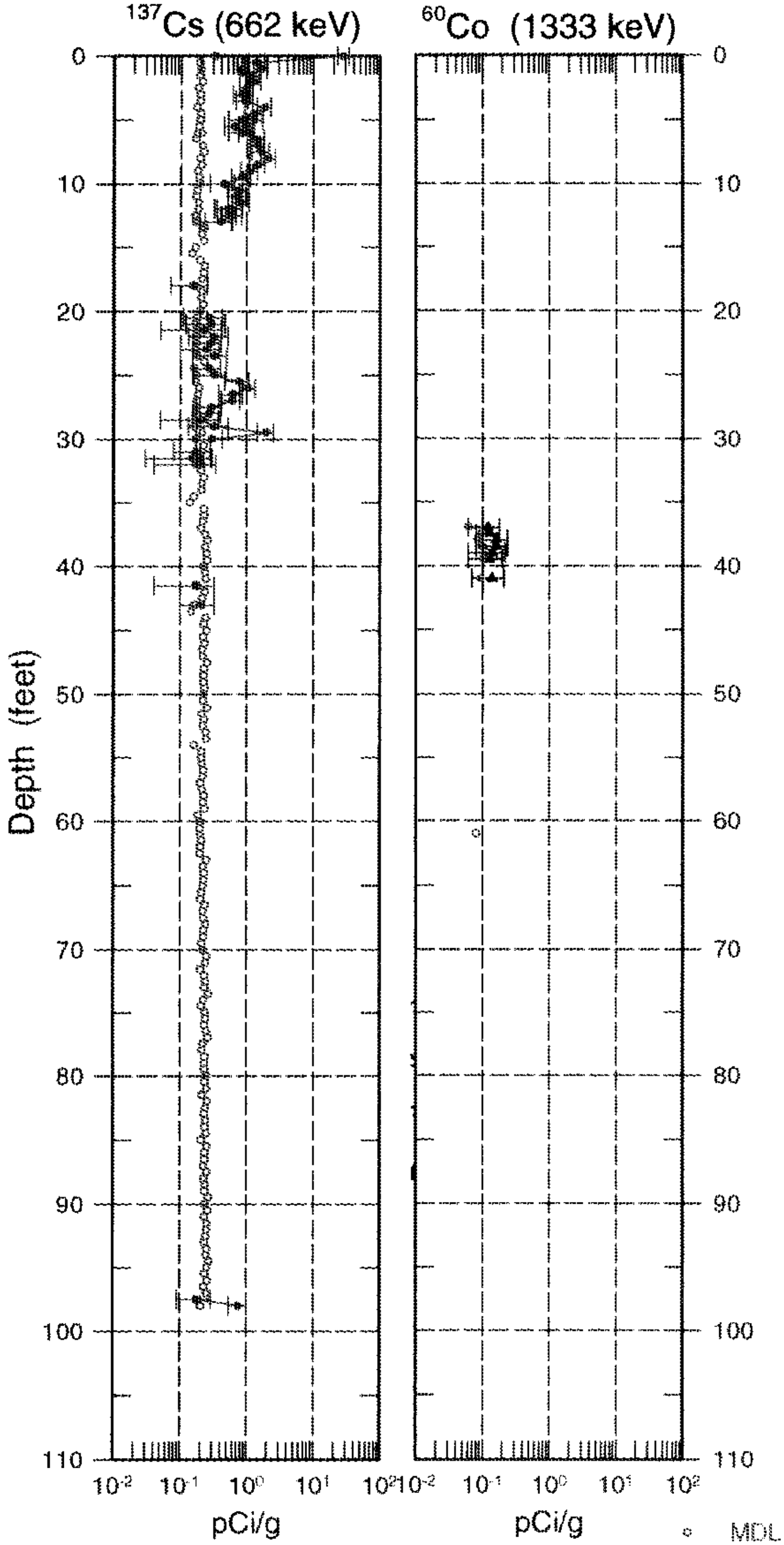
A combination plot includes the man-made and natural radionuclides, the total gamma derived from the spectral data, and the Tank Farms gross gamma log. The gross gamma plot displays the latest available digital data. No attempt has been made to adjust the depths of the gross gamma logs to coincide with the SGLS data.

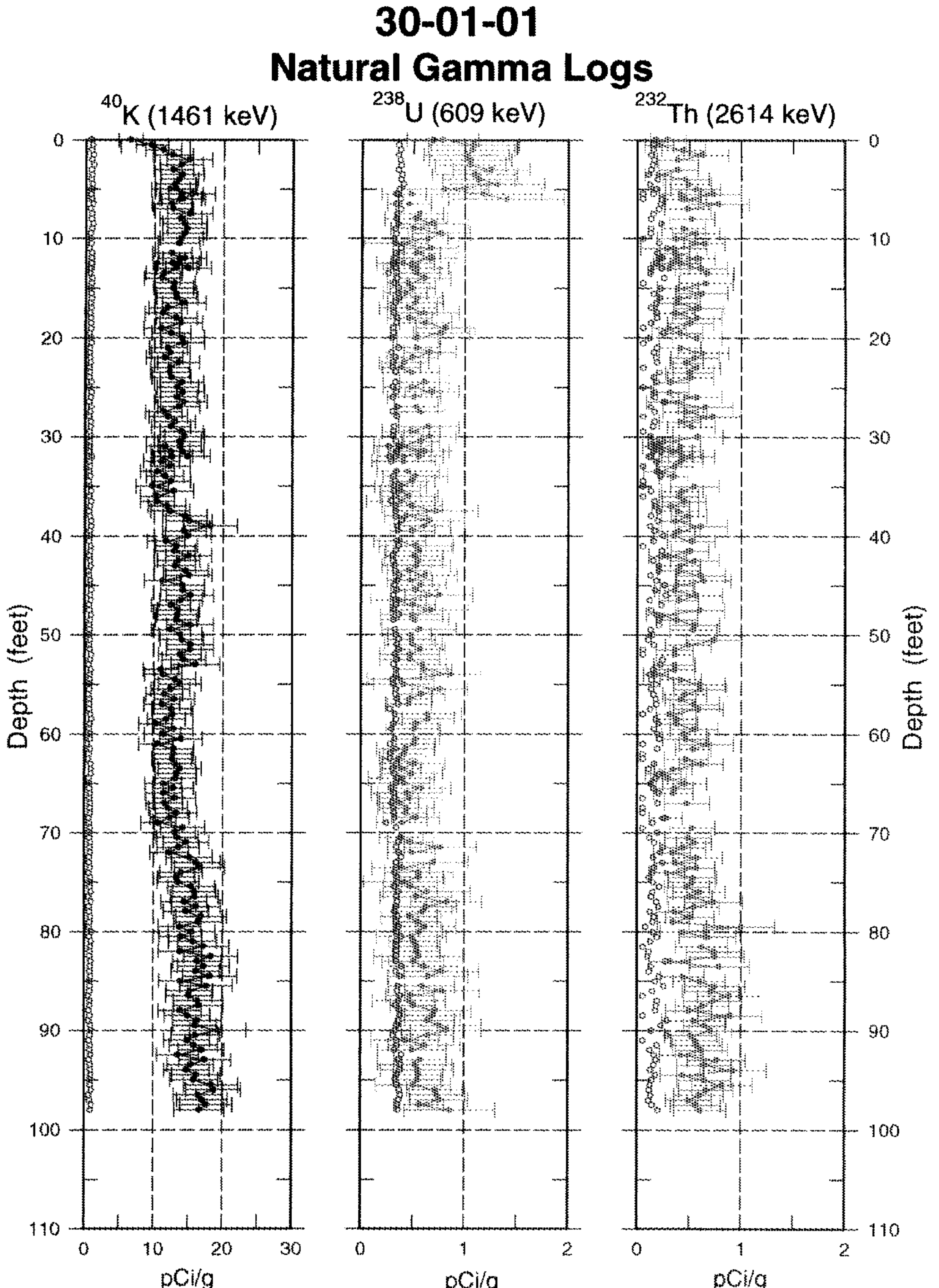
Log Event A

Borehole 30-01-01

A plot of representative historical gross gamma-ray logs from 1975 to 1992 is included. The headings of the plots identify the date on which the data in the plots were gathered.

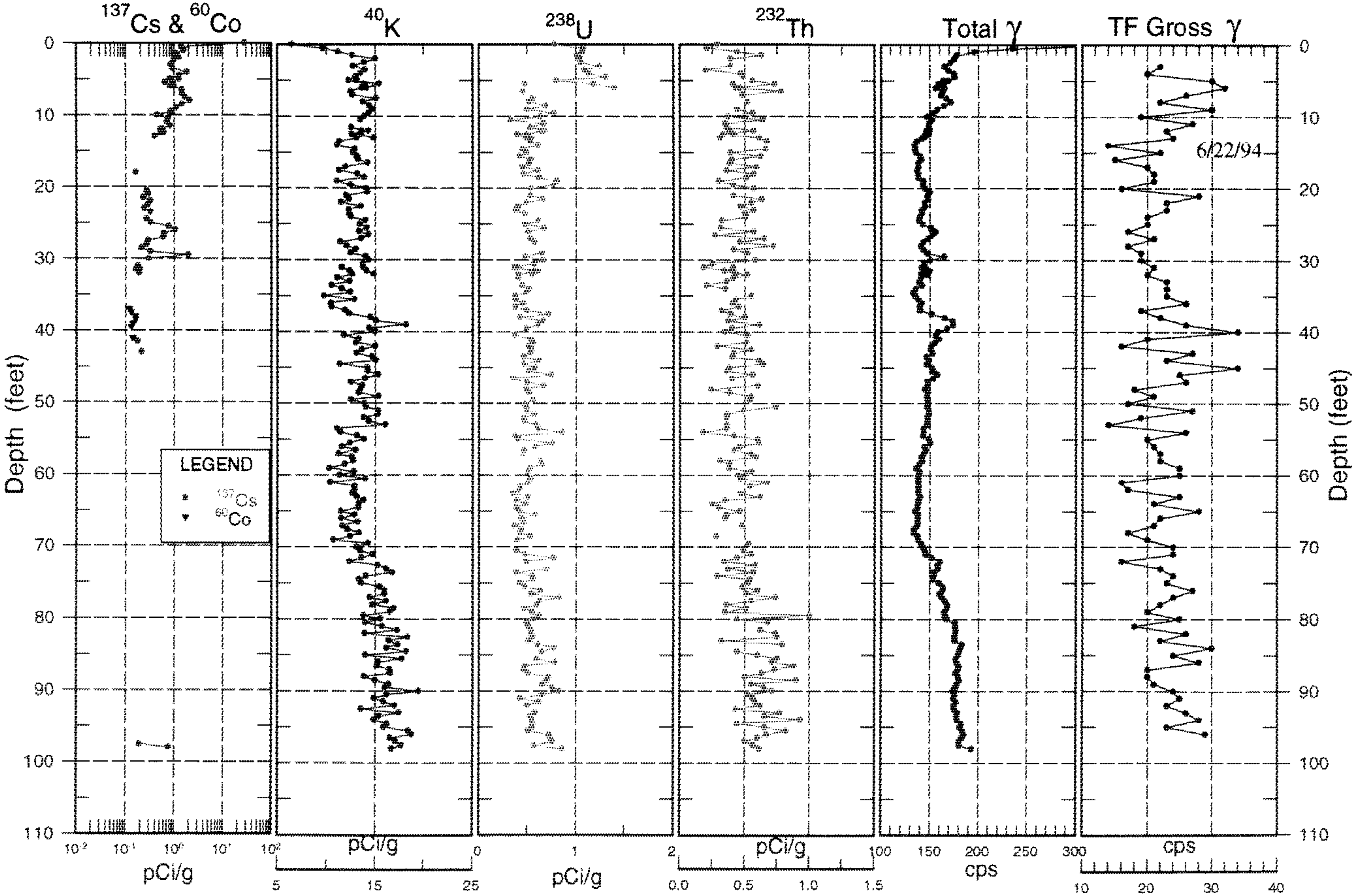
30-01-01
Man-Made Radionuclide Concentrations



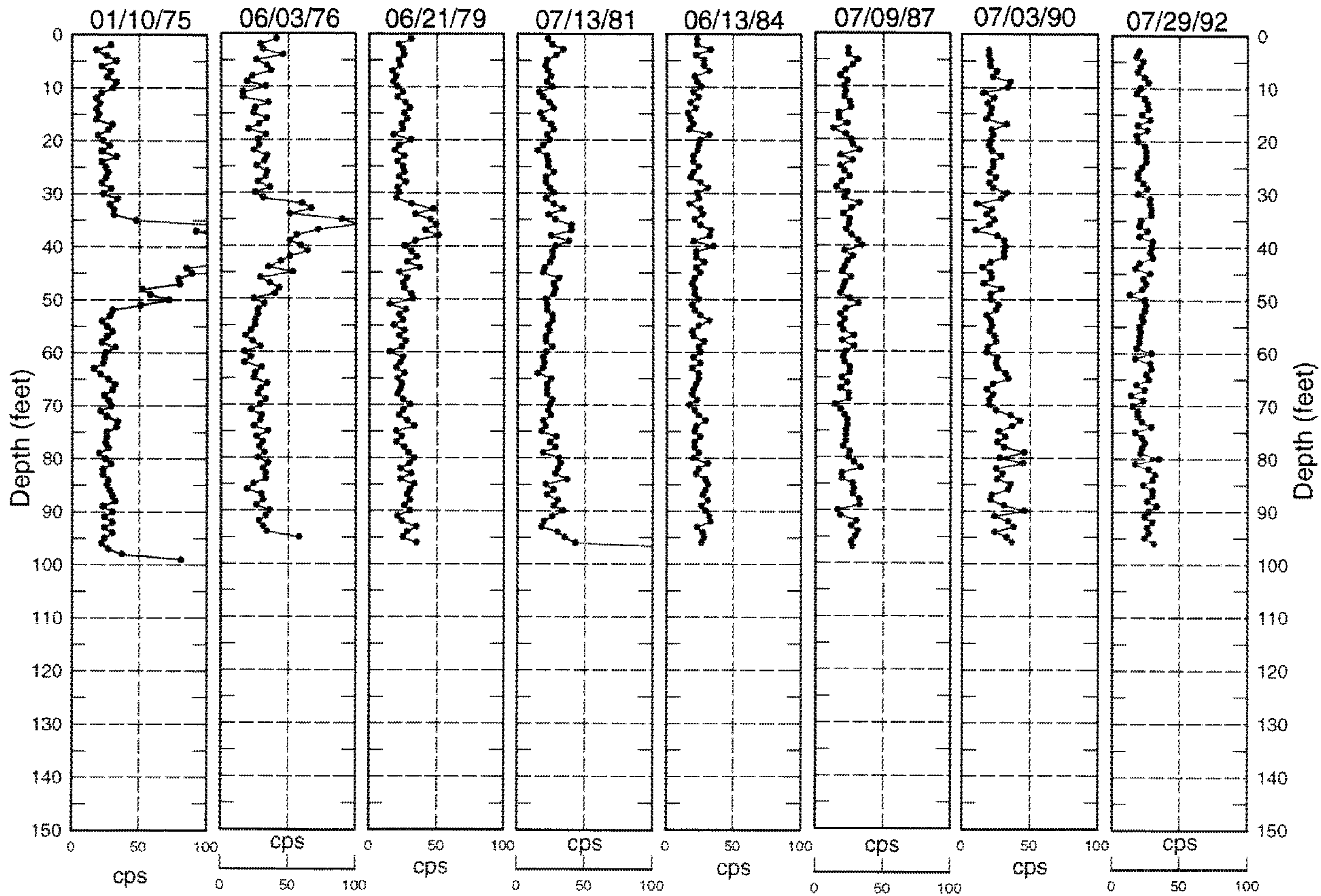


30-01-01
Natural Gamma Logs
40K (1461 keV)
238U (609 keV)
232Th (2614 keV)
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
0
10
20
30
pCi/g
0
1
2
pCi/g
0
1
2
pCi/g
MDL

30-01-01 Combination Plot



Historical Gross Gamma Logs for Borehole 30-01-01



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Spectral Gamma-Ray Borehole Log Data Report

Log Event A

Borehole 30-01-06

Borehole Information

Farm :	C	Tank :	C-101	Site Number :	299-E27-59
N-Coord :	42,676	W-Coord :	48,328	TOC Elevation :	647.59
Water Level, ft :	None	Date Drilled :	1/31/70		

Casing Record

Type :	Steel-welded	Thickness :	0.280	ID, in. :	6
Top Depth, ft. :	0	Bottom Depth, ft. :	100		

Borehole Notes:
This borehole was drilled in January 1970 and completed to a depth of 100 ft with 6-in. casing. The casing thickness is presumed to be 0.280 in., on the basis of the published thickness for schedule-40, 6-in. steel tubing. No information was available that indicated the borehole was perforated or grouted; therefore, it is assumed that the borehole was not perforated or grouted. The top of the casing, which is the zero reference for the SGLS, is even with the tank farm ground surface.

Equipment Information

Logging System :	2	Detector Type :	HPGe	Detector Efficiency :	35.0 %
Calibration Date :	10/96	Calibration Reference :	GJO-HAN-13	Logging Procedure :	P-GJPO-1783

Log Run Information

Log Run Number :	1	Log Run Date :	3/28/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	98.5	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	38.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Log Run Number :	2	Log Run Date :	3/31/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	39.0	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	0.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Log Run Number :	3	Log Run Date :	4/1/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	45.0	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	28.5	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Analysis Information

Analyst : D.L. Parker

Data Processing Reference : P-GJPO-1787 Analysis Date : 6/27/97

Analysis Notes :

This borehole was logged by the SGLS in two log runs, with a third log run performed as a rerun log to provide an additional quality check. The pre- and post-survey field verification spectra met the acceptance criteria established for the peak shape and detector efficiency, confirming that the SGLS was operating within specifications. The energy calibration and peak-shape calibration from these spectra were used to establish peak resolution and channel-to-energy parameters used in processing the spectra acquired during the logging operation. There was some gain drift during logging operations and it was necessary to adjust the established channel-to-energy parameters during processing of log data to maintain proper peak identification.

Casing correction factors for a 0.280-in.-thick steel casing were applied during analysis.

The man-made radionuclides detected in this borehole were Cs-137 and Co-60. Continuous Cs-137 contamination was detected from the ground surface to 7.5 ft, 14 to 20 ft, 35 to 38.5 ft, and 97.5 ft to the bottom of the logged interval. Scattered occurrences of Cs-137 were also detected between 21 and 30.5 ft and at 55.5 ft. Co-60 was detected only at 37 ft.

The K-40 concentrations increase from 38 to 40 ft and then maintain a background concentration of about 14 pCi/g to 45 ft. The K-40 concentrations are slightly lower from 45.5 to about 57 ft and then increase gradually from 57 to 89 ft.

Additional information and interpretations of log data are included in the main body of the Tank Summary Data Report for tank C-101.

Log Plot Notes:

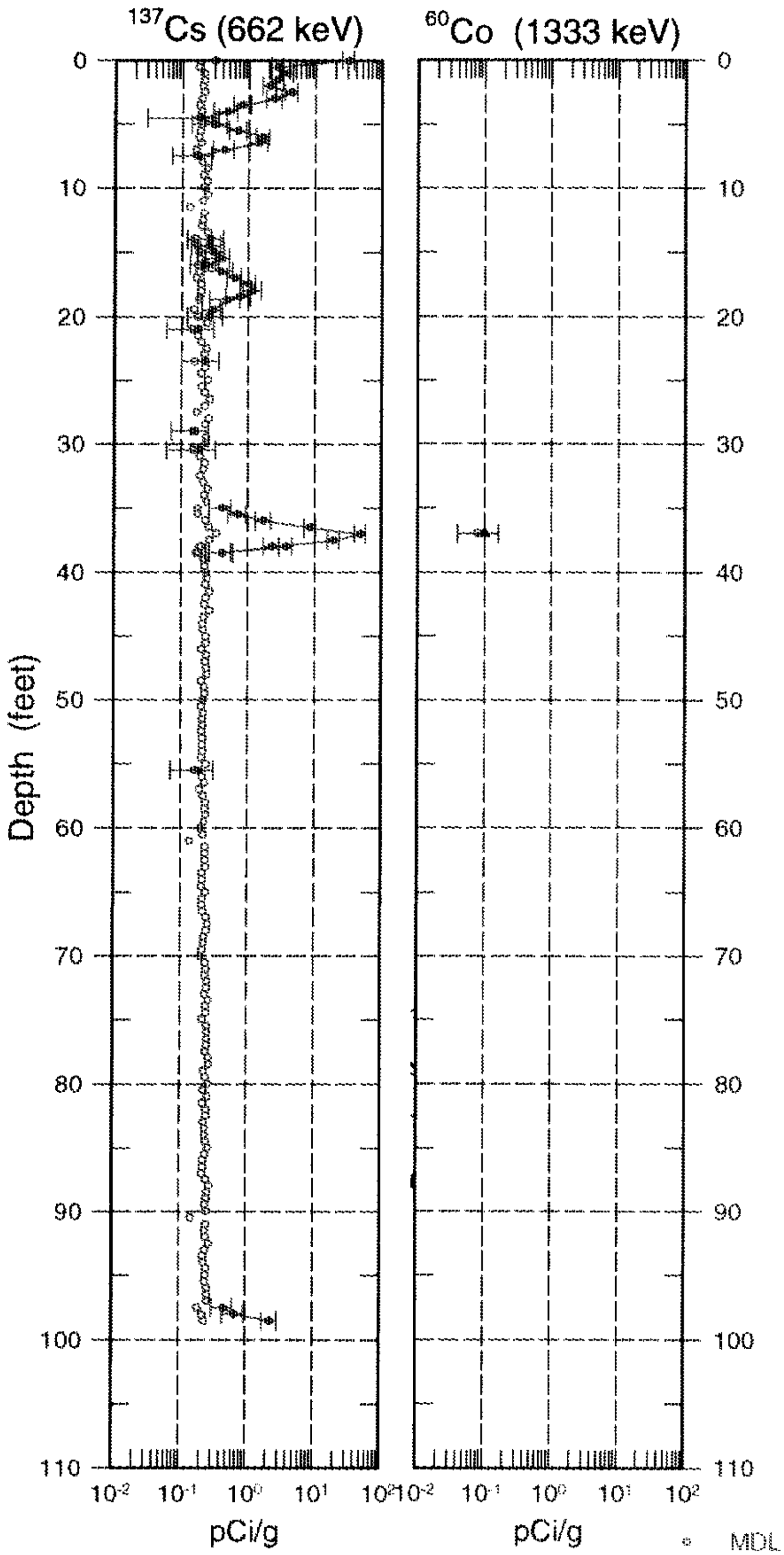
Separate log plots show the man-made and the naturally occurring radionuclides. The natural radionuclides can be used for lithology interpretations. The headings of the plots identify the specific gamma rays used to calculate the concentrations. Uncertainty bars on the plots show the statistical uncertainties for the measurements as 95-percent confidence intervals. Open circles on the plots give the MDL. The MDL of a radionuclide represents the lowest concentration at which positive identification of a gamma-ray peak is statistically defensible.

A combination plot includes the man-made and natural radionuclides, the total gamma derived from the spectral data, and the Tank Farms gross gamma log. The gross gamma plot displays the latest available digital data. No attempt has been made to adjust the depths of the gross gamma logs to coincide with the SGLS data.

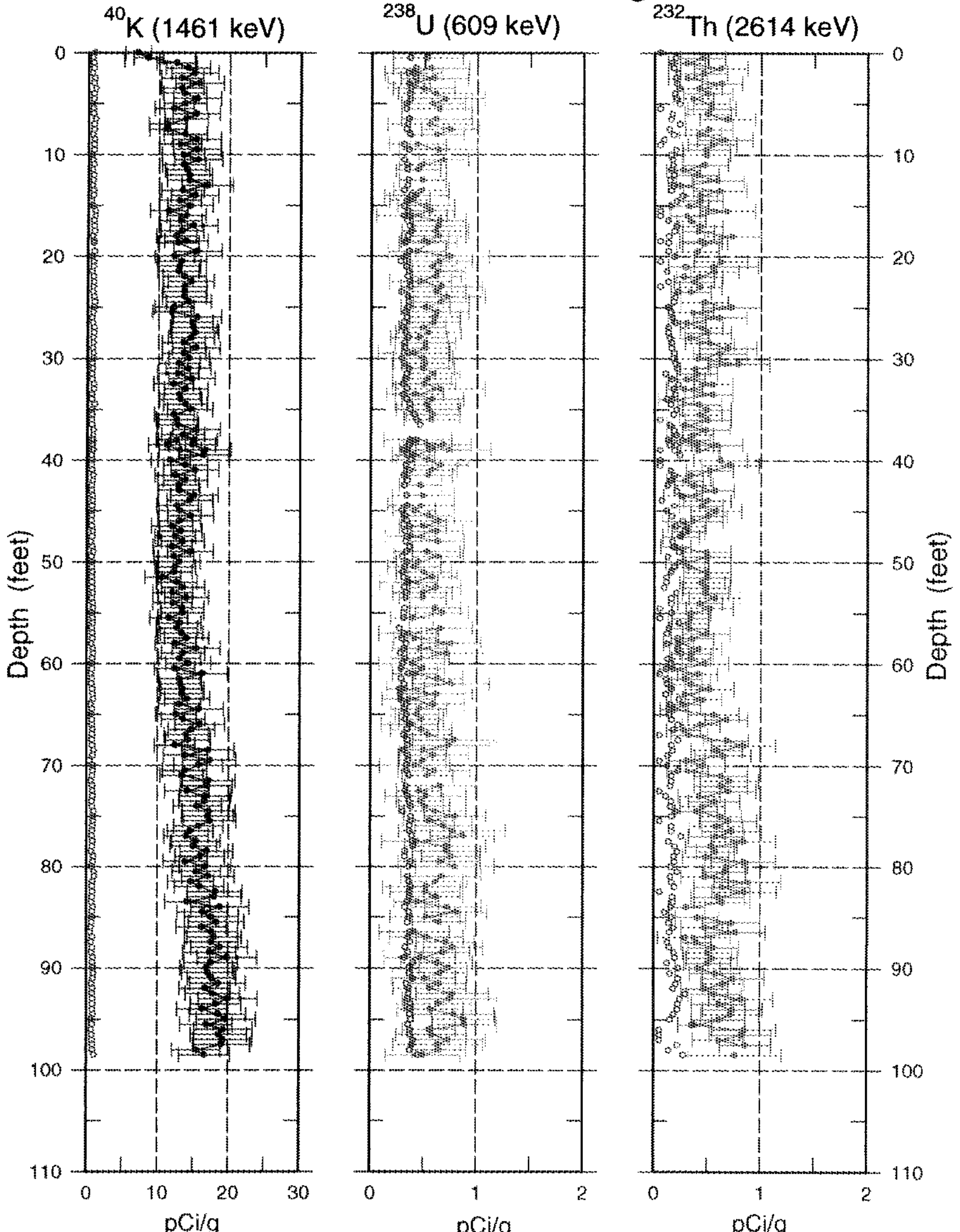
The interval from 28.5 to 45 ft was relogged as an additional quality check. A log of the re-run was prepared along with data from the original run and is provided with this data set.

A plot of representative historical gross gamma-ray logs from 1975 to 1992 is included. The headings of the plots identify the date on which the data in the plots were gathered.

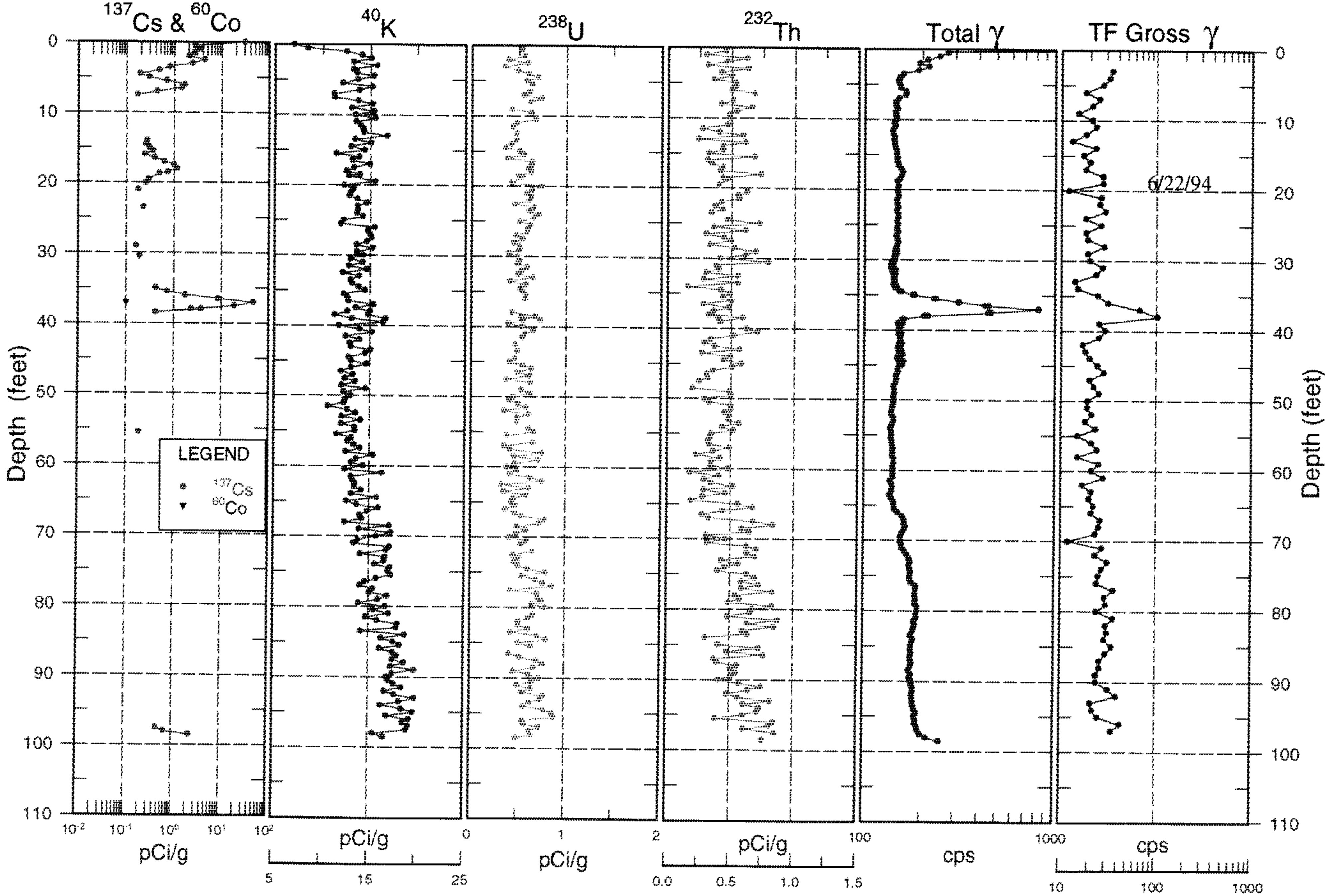
30-01-06
Man-Made Radionuclide Concentrations



30-01-06
Natural Gamma Logs

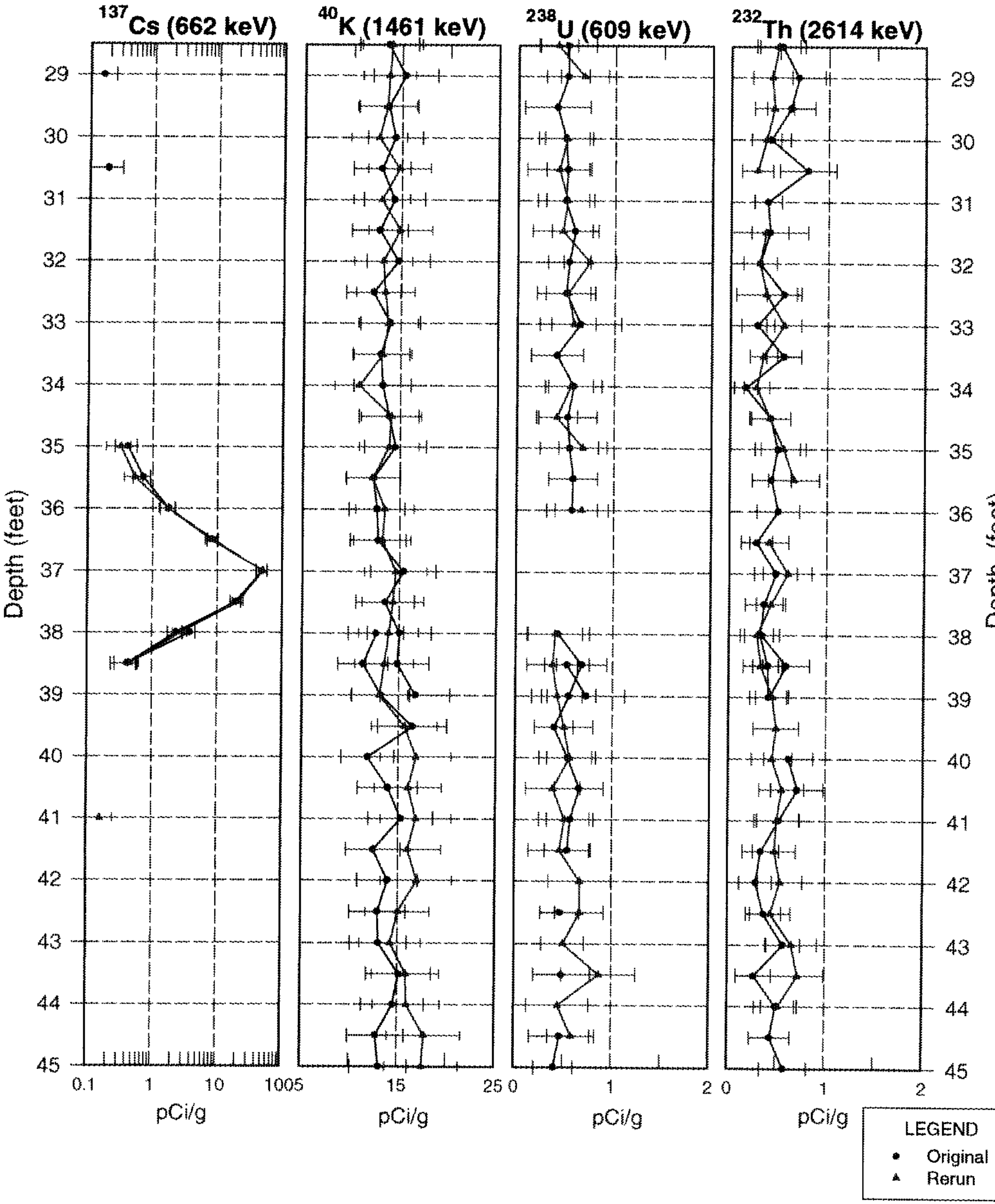


30-01-06 Combination Plot

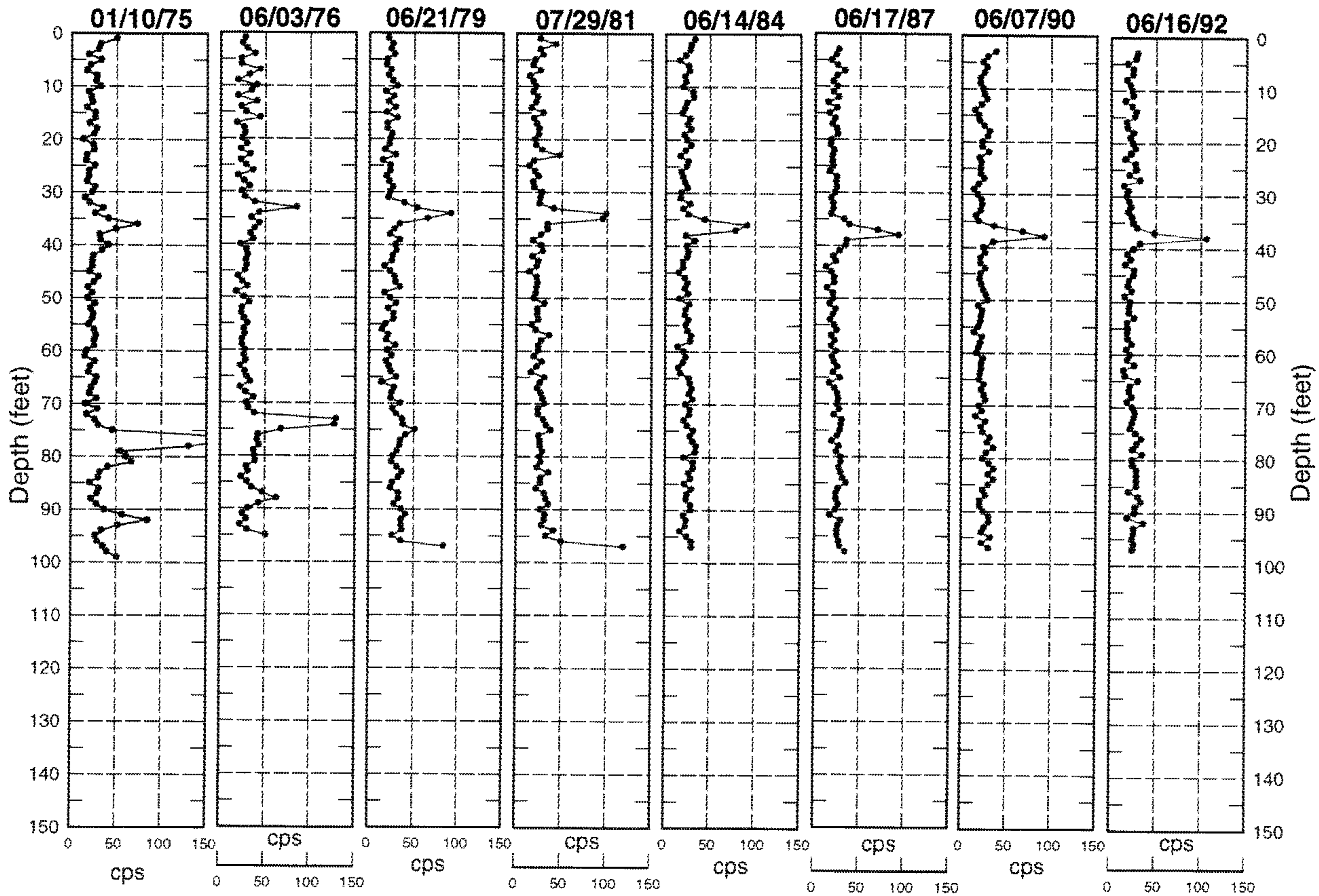


30-01-06

Rerun Section of the Manmade and Natural Gamma Logs



Historical Gross Gamma Logs for Borehole 30-01-06



Spectral Gamma-Ray Borehole Log Data Report

Log Event A

Borehole 30-00-06

Borehole Information

Farm :	C	Tank :	C	Site Number :	299-E27-55
N-Coord :	42,677	W-Coord :	48,370	TOC Elevation :	652.57
Water Level, ft :	None	Date Drilled :	12/31/44		

Casing Record

Type :	Steel-welded	Thickness, in. :	0.313	ID, in. :	8
Top Depth, ft. :	0	Bottom Depth, ft. :	154		
Type :	Steel-welded	Thickness, in. :	0.500	ID, in. :	12
Top Depth, ft. :	7	Bottom Depth, ft. :	58		

Cement Bottom, ft. : 155 **Cement Top, ft. :** 154

Borehole Notes:

This borehole was drilled in December 1944 and completed to a depth of about 154 ft with 8-in. casing. A string of 12-in. surface casing is also present and assumed to extend from just below the ground surface to a depth of about 54 ft. The top of the 12-in. casing is not visible at the ground surface, but the driller's log notes its presence. The space between the outer 12-in. and inner 8-in. casing may be grouted, although the driller's log contains no mention of grout in this interval. The driller's log indicates that the borehole was perforated from 53 to 154 ft with five perforations per foot and that the bottom 8 in. of the borehole was grouted with half a bag of cement.

The zero reference for the SGLS logs is the top of the 8-in. casing. This borehole is located in the side of a hill and the top of the 8-in. casing is approximately 7 ft above the tank farm ground surface. The current depth of the borehole, as verified with an electrical tape, is 111 ft. There is no information given as to when or how the bottom portion of the borehole was filled.

Equipment Information

Logging System :	2	Detector Type :	HPGe	Detector Efficiency :	35.0 %
Calibration Date :	10/96	Calibration Reference :	GJO-HAN-13	Logging Procedure :	P-GJPO-1783

Log Run Information

Log Run Number :	1	Log Run Date :	3/25/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	111.0	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	70.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Borehole 30-00-06

Log Event A

Log Run Number :	2	**Log Run Date :**	3/26/97	**Logging Engineer:**	Bob Spatz		
Start Depth, ft.:	71.0	**Counting Time, sec.:**	100	**L/R :**	L	**Shield :**	N
Finish Depth, ft. :	0.0	**MSA Interval, ft. :**	.5	**Log Speed, ft/min.:**	n/a		

Analysis Information

Analyst :	D.L. Parker		
Data Processing Reference :	P-GJPO-1787	Analysis Date :	6/27/97

Analysis Notes :

This borehole was logged by the SGLS in two log runs. The pre- and post-survey field verification spectra met the acceptance criteria established for the peak shape and detector efficiency, confirming that the SGLS was operating within specifications. The energy calibration and peak-shape calibration from these spectra were used to establish peak resolution and channel-to-energy parameters used in processing the spectra acquired during the logging operation. There was some gain drift during logging operations and it was necessary to adjust the established channel-to-energy parameters during processing of log data to maintain proper peak identification.

This borehole is double-cased from an unknown depth near the ground surface to about 58 ft. An appropriate casing correction factor for the double-cased portion of the borehole is not available. An appropriate correction factor would have to account for approximately 0.5-in.-thick steel casing (12-in.-diameter casing), an approximately 3-in.-thick section of air or possibly grout, and a 0.322-in.-thick second steel casing (8-in.-diameter casing). Data from above 58 ft could not be completely analyzed because of the attenuation caused by the double-steel casings in this interval, and the potential for grout between the two casings.

A casing correction factor for a 0.330-in.-thick casing was applied during the analysis of borehole data. This correction factor most closely matches the actual casing thickness (0.322-in.) below a depth of 58 ft. Use of this casing correction factor will cause the concentrations of radionuclides to be slightly overestimated below 58 ft.

The man-made radionuclides detected in this borehole are Cs-137 and Co-60. The presence of Cs-137 was measured almost continuously from the ground surface to a depth of 5 ft and intermittently from 57 ft to the bottom of the logged interval. Co-60 contamination was detected only at 77.5 ft.

The logs of the naturally occurring radionuclides show a decrease in K-40 concentrations at approximately 7 ft, and an increase at 58 ft. K-40 concentrations increase gradually from about 60 to 97 ft.

Additional information and interpretations of log data are included in the main body of the Tank Summary Data Report for tank C-101.

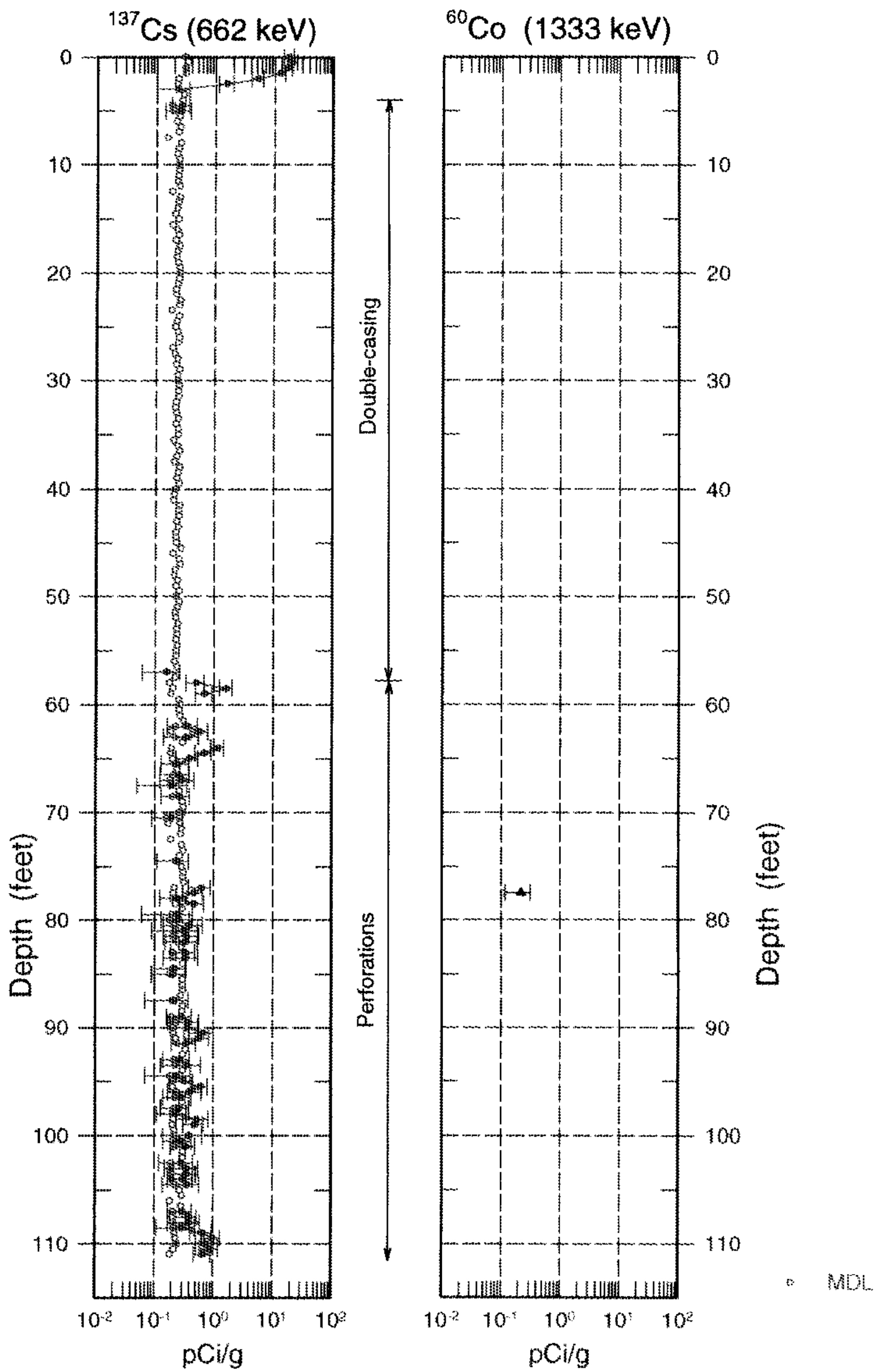
Log Plot Notes:

Separate log plots show the man-made and the naturally occurring radionuclides. The natural radionuclides can be used for lithology interpretations. The headings of the plots identify the specific gamma rays used to calculate the concentrations. Uncertainty bars on the plots show the statistical uncertainties for the measurements as 95-percent confidence intervals. Open circles on the plots give the MDL. The MDL of a radionuclide represents the lowest concentration at which positive identification of a gamma-ray peak is statistically defensible.

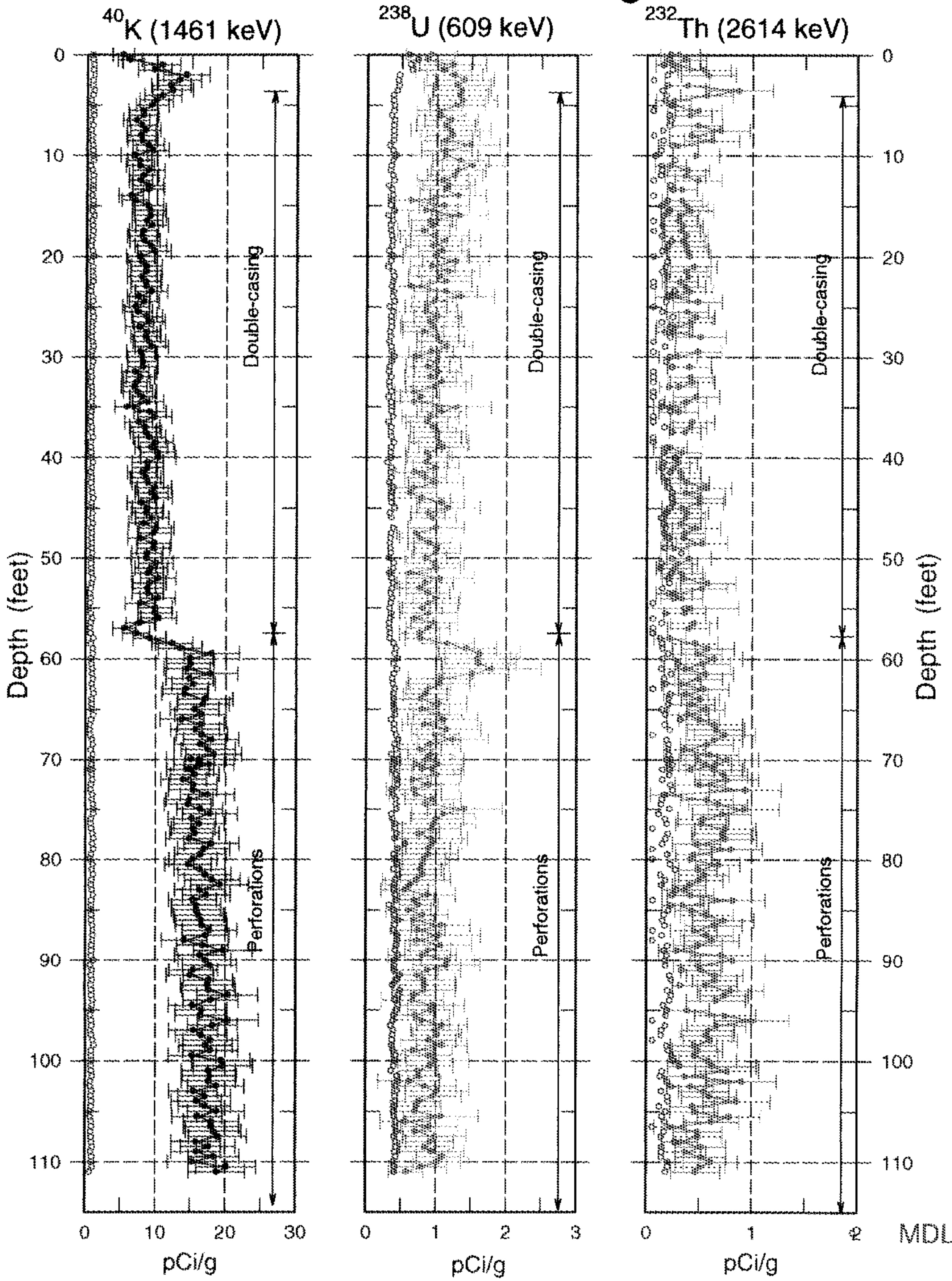
A combination plot includes the man-made and natural radionuclides, the total gamma derived from the spectral data, and the Tank Farms gross gamma log. The gross gamma plot displays the latest available digital data. No attempt has been made to adjust the depths of the gross gamma logs to coincide with the SGLS data.

A plot of representative historical gross gamma-ray logs from 1975 to 1992 is included. The headings of the plots identify the date on which the data in the plots were gathered.

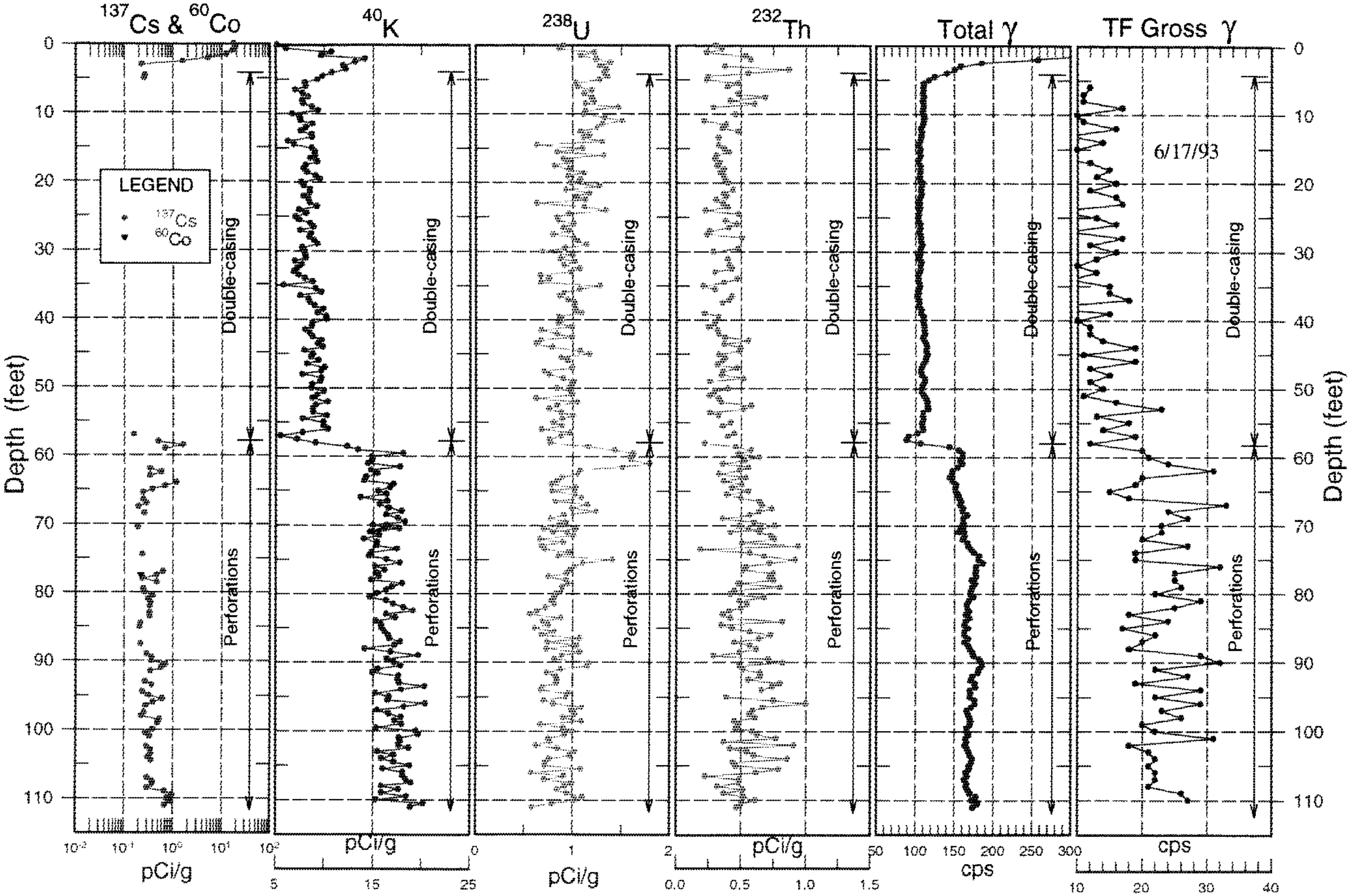
30-00-06
Man-Made Radionuclide Concentrations



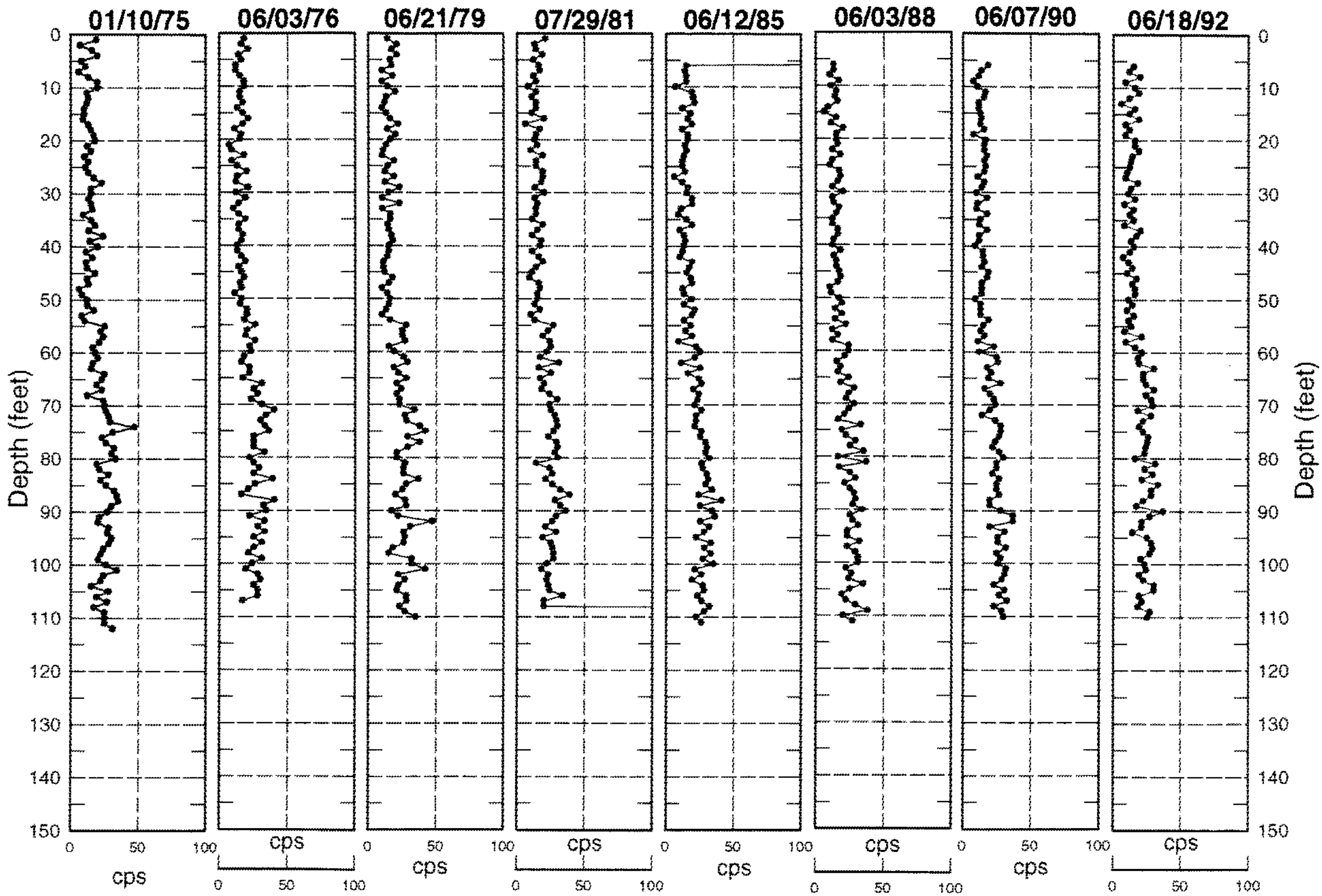
30-00-06
Natural Gamma Logs



30-00-06 Combination Plot



Historical Gross Gamma Logs for Borehole 30-00-06



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Spectral Gamma-Ray Borehole Log Data Report

Log Event A

Borehole 30-01-09

Borehole Information

Farm :	C	Tank :	C-101	Site Number :	299-E27-58
N-Coord :	42,719	W-Coord :	48,373	TOC Elevation :	647.25
Water Level, ft :	None	Date Drilled :	4/30/70		

Casing Record

Type :	Steel-welded	Thickness, in. :	0.280	ID, in. :	6
Top Depth, ft. :	0	Bottom Depth, ft. :	100		

Borehole Notes:

This borehole was drilled in April 1970 and completed to a depth of 100 ft with 6-in. casing. The casing thickness is presumed to be 0.280 in., on the basis of the published thickness for schedule-40, 6-in. steel tubing. No information was available that indicated the borehole was perforated or grouted; therefore, it is assumed that the borehole was not perforated or grouted. The top of the casing, which is the zero reference for the SGLS, is even with the tank farm ground surface.

Equipment Information

Logging System :	2	Detector Type :	HPGe	Detector Efficiency :	35.0 %
Calibration Date :	10/96	Calibration Reference :	GJO-HAN-13	Logging Procedure :	P-GJPO-1783

Log Run Information

Log Run Number :	1	Log Run Date :	3/24/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	97.5	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	39.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Log Run Number :	2	Log Run Date :	3/25/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	40.0	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	29.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Log Run Number :	3	Log Run Date :	3/25/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	30.0	Counting Time, sec.:	100	L/R :	R	Shield :	N
Finish Depth, ft. :	26.5	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Borehole 30-01-09

Log Event A

Log Run Number :	4	Log Run Date :	3/25/97	Logging Engineer:	Bob Spatz
Start Depth, ft.:	27.5	Counting Time, sec.:	100	L/R : L	Shield : N
Finish Depth, ft. :	0.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a

Analysis Information

Analyst : D.L. Parker

Data Processing Reference : P-GJPO-1787 Analysis Date : 6/27/97

Analysis Notes :

This borehole was logged by the SGLS in four log runs. The pre- and post-survey field verification spectra met the acceptance criteria established for the peak shape and detector efficiency, confirming that the SGLS was operating within specifications. The energy calibration and peak-shape calibration from these spectra were used to establish the peak resolution and channel-to-energy parameters used in processing the spectra acquired during the logging operation. No fine gain adjustments were necessary during these log runs.

The interval from 26.5 to 30 ft was logged using real time because the dead time exceeded 50 percent in this interval. Real time is a data acquisition method in which the data are gathered at each depth for a set period of time, in this case 100 seconds, and then the data is corrected for the dead time measured at each depth. This method allows data to be collected in relatively high activity zones using short counting times where, under normal circumstances, the short counting times would produce high uncertainty in the data.

Casing correction factors for a 0.280-in.-thick steel casing were applied during analysis.

The man-made radionuclides Cs-137, Co-60, Eu-152, and Eu-154 were detected. Cs-137 contamination was measured continuously from the ground surface to 6 ft, almost continuously from 9 to 16.5 ft, continuously from 24.5 to 32 ft, continuously from 34.5 to 37 ft, and at the bottom of the logged interval (97.5 ft). The largest Cs-137 plume occurred from 24 to 32 ft. Co-60 contamination was detected at 39.5 and 40 ft. Eu-152 and Eu-154 were both detected at 27.5 ft.

A thin zone of slightly higher K-40 concentrations occurs from 38 to 40.5 ft, and a gradual increase in K-40 concentrations occurs from 59.5 ft to the bottom of the logged interval.

Additional information and interpretations of log data are included in the main body of the Tank Summary Data Report for tank C-101.

Log Plot Notes:

Separate log plots show the man-made and the naturally occurring radionuclides. The natural radionuclides can be used for lithology interpretations. The headings of the plots identify the specific gamma rays used to calculate the concentrations. Uncertainty bars on the plots show the statistical uncertainties for the measurements as 95-percent confidence intervals. Open circles on the plots give the MDL. The MDL of a radionuclide represents the lowest concentration at which positive identification of a gamma-ray peak is statistically defensible.

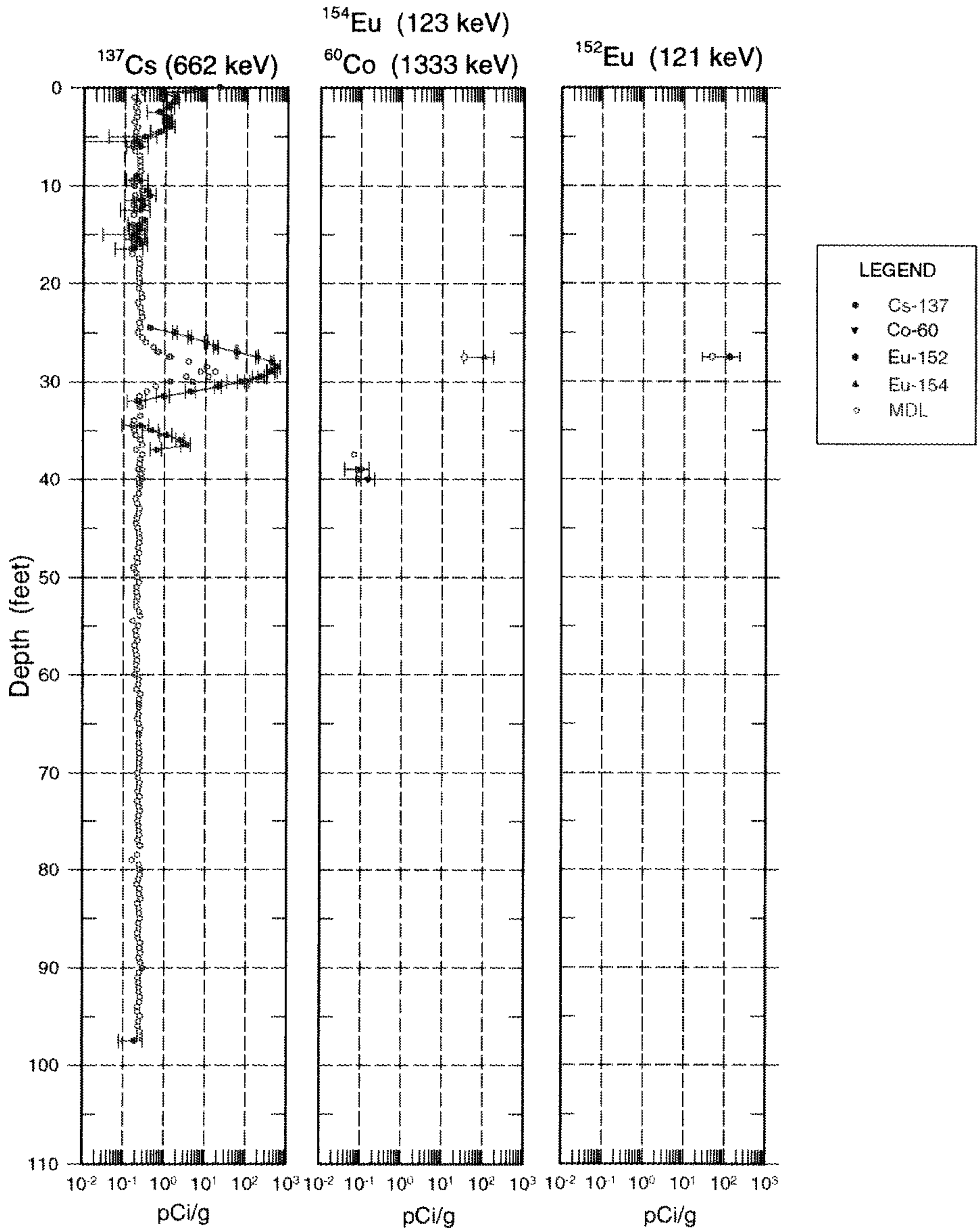
Log Event A

Borehole 30-01-09

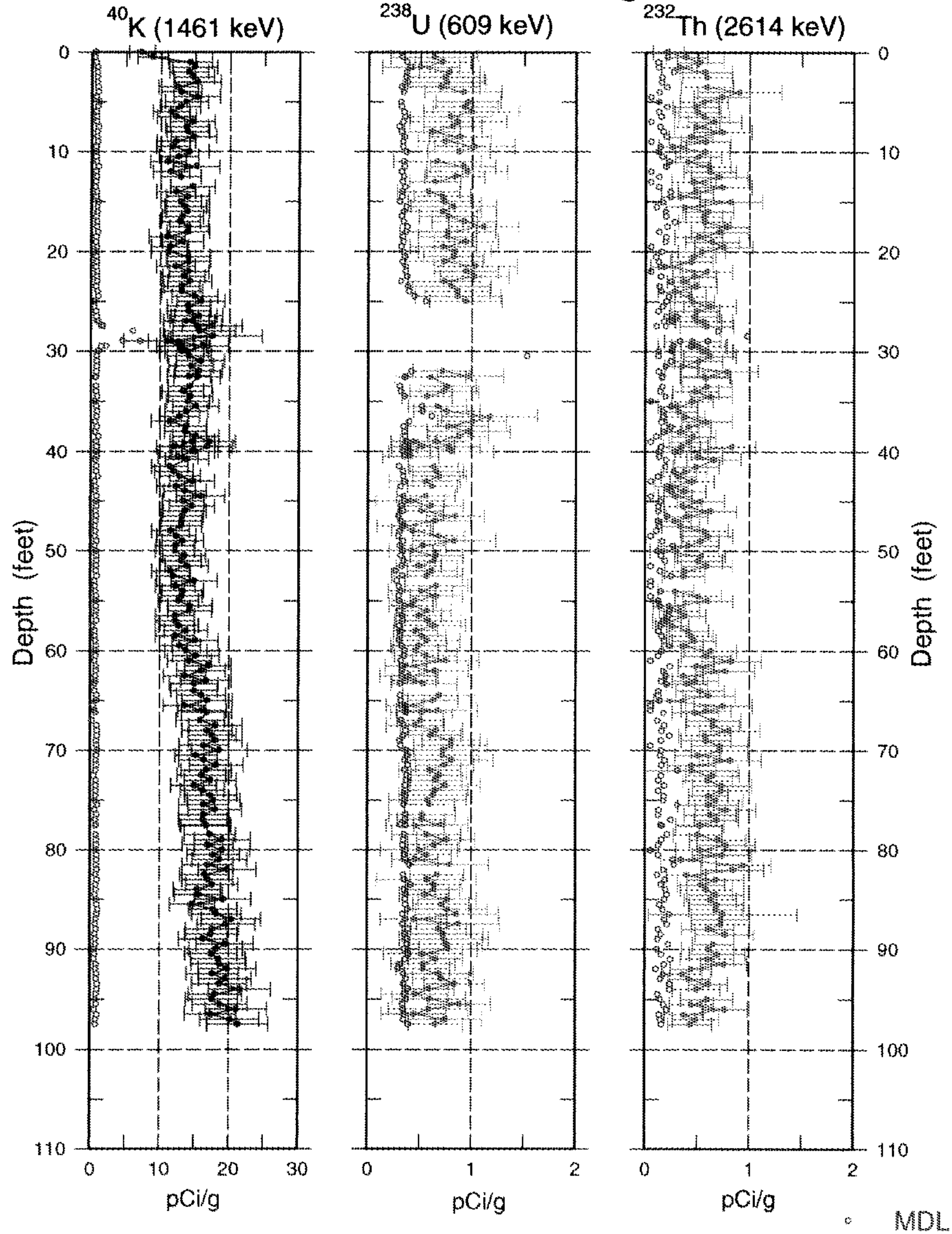
A combination plot includes the man-made and natural radionuclides, the total gamma derived from the spectral data, and the Tank Farms gross gamma log. The gross gamma plot displays the latest available digital data. No attempt has been made to adjust the depths of the gross gamma logs to coincide with the SGLS data.

A plot of representative historical gross gamma-ray logs from 1975 to 1992 is included. The headings of the plots identify the date on which the data in the plots were gathered.

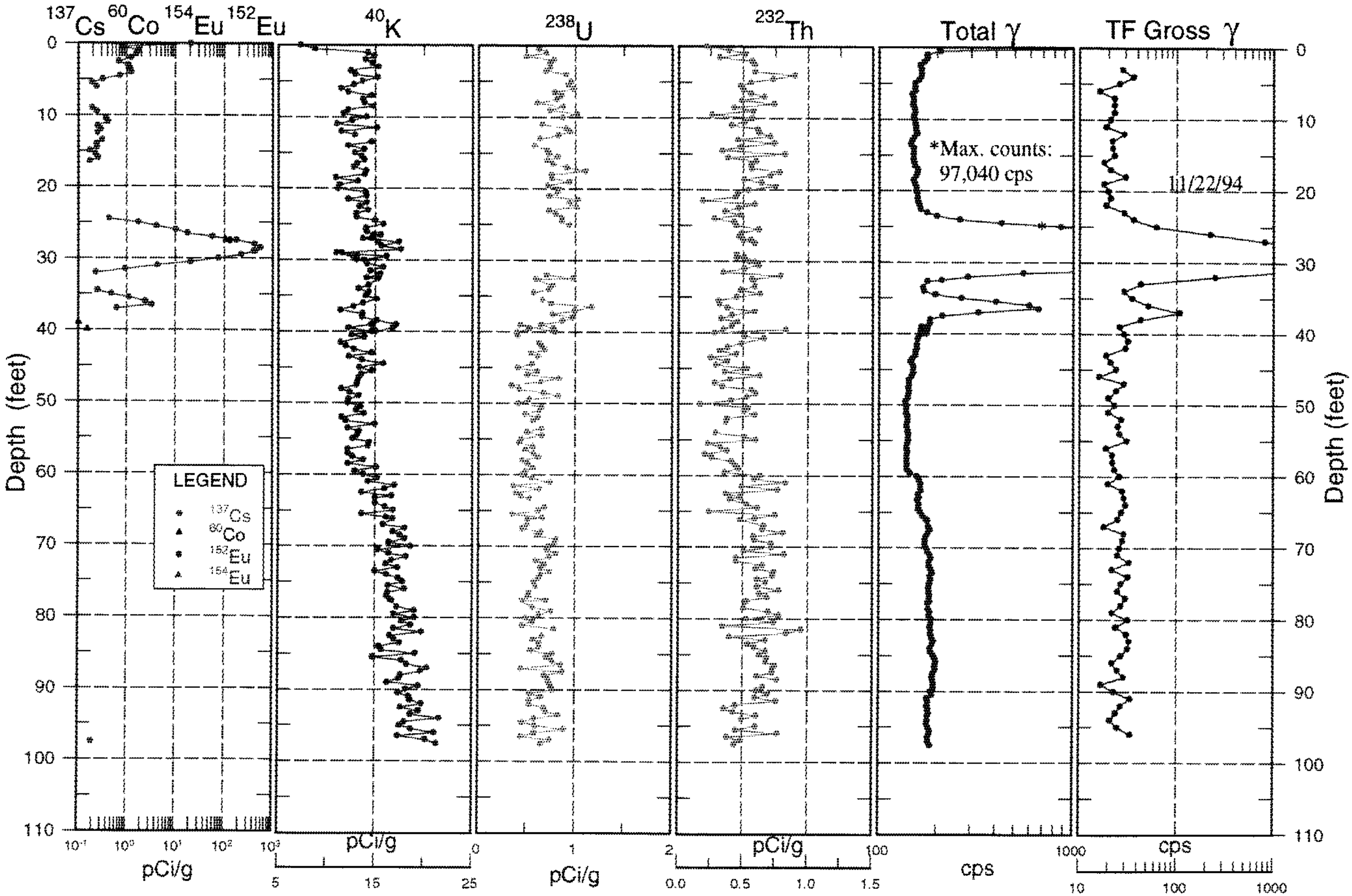
30-01-09
Man-Made Radionuclide Concentrations



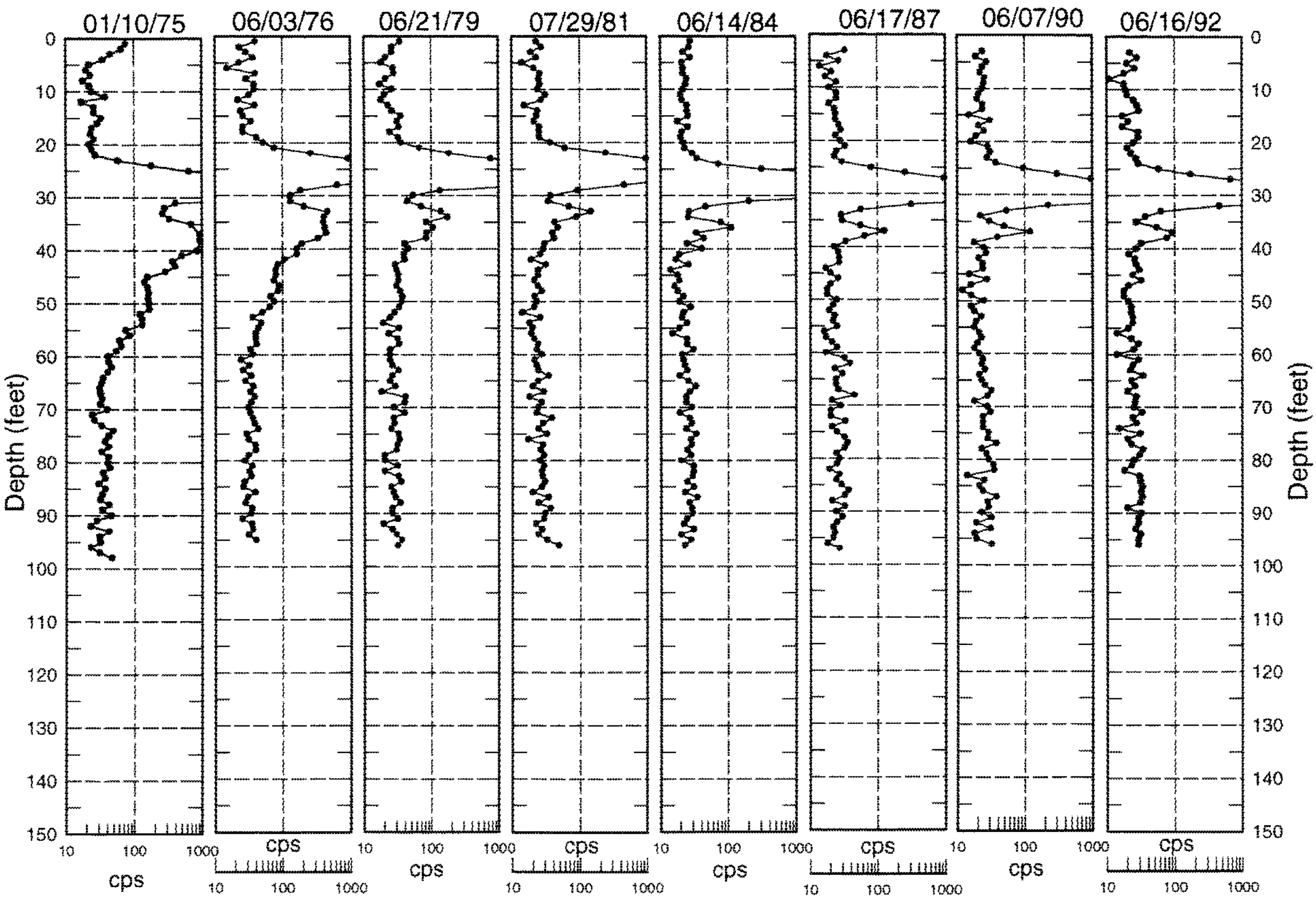
30-01-09
Natural Gamma Logs



30-01-09 Combination Plot



Historical Gross Gamma Logs for Borehole 30-01-09



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Spectral Gamma-Ray Borehole
Log Data Report

Log Event A

Borehole 30-04-05

Borehole Information

Farm : C
Tank : C-104
Site Number : 299-E27-80
N-Coord : 42,747
W-Coord : 48,377
TOC Elevation : 647.08
Water Level, ft : None
Date Drilled : 7/31/74

Casing Record

Type : Steel-welded
Thickness, in. : 0.280
ID, in. : 6
Top Depth, ft. : 0
Bottom Depth, ft. : 100

Borehole Notes:

This borehole was drilled in July 1974 to a depth of 100 ft with 6-in. casing. The casing thickness is presumed to be 0.280 in., on the basis of the published thickness for schedule-40, 6-in. steel tubing. No information concerning grouting or perforations was available; therefore, it is assumed that the borehole was not grouted or perforated. The top of the casing, which is the zero reference for the SGLS, is even with the ground surface.

Equipment Information

Logging System : 2
Detector Type : HPGe
Detector Efficiency : 35.0 %
Calibration Date : 10/96
Calibration Reference : GJO-HAN-13
Logging Procedure : P-GJPO-1783

Log Run Information

Log Run Number : 1
Log Run Date : 2/6/97
Logging Engineer: Bob Spatz
Start Depth, ft.: 0.0
Counting Time, sec.: 100
L/R : L
Shield : N
Finish Depth, ft. : 3.0
MSA Interval, ft. : .5
Log Speed, ft/min.: n/a

Log Run Number : 2
Log Run Date : 2/7/97
Logging Engineer: Bob Spatz
Start Depth, ft.: 98.5
Counting Time, sec.: 100
L/R : L
Shield : N
Finish Depth, ft. : 52.0
MSA Interval, ft. : .5
Log Speed, ft/min.: n/a

Log Run Number : 3
Log Run Date : 2/10/97
Logging Engineer: Bob Spatz
Start Depth, ft.: 2.0
Counting Time, sec.: 100
L/R : L
Shield : N
Finish Depth, ft. : 12.0
MSA Interval, ft. : .5
Log Speed, ft/min.: n/a

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Spectral Gamma-Ray Borehole
Log Data Report

Log Event A

Borehole 30-04-05

Log Run Number:	4	**Log Run Date:**	2/11/97	**Logging Engineer:**	Bob Spatz
Start Depth, ft.:	53.0	**Counting Time, sec.:**	100	**L/R:** L	**Shield:** N
Finish Depth, ft.:	11.0	**MSA Interval, ft.:**	.5	**Log Speed, ft/min.:**	n/a

Analysis Information

Analyst:	D.L. Parker		
Data Processing Reference:	P-GJPO-1787	Analysis Date:	6/27/97

Analysis Notes :

This borehole was logged by the SGLS in four log runs. The pre- and post-survey field verification spectra met the acceptance criteria established for the peak shape and detector efficiency, confirming that the SGLS was operating within specifications. The energy and peak-shape calibrations from these spectra were used to establish the channel-to-energy parameters used in processing the spectra acquired during the logging operation. No fine gain adjustments were necessary during these log runs.

Casing correction factors for a 0.280-in.-thick steel casing were applied during analysis.

The man-made radionuclide Cs-137 was detected in this borehole. The presence of Cs-137 was measured nearly continuously from the ground surface to a depth of 57.5 ft, intermittently from 69.5 to 91.5 ft, and continuously from 94.5 ft to the bottom of the logged interval.

The U-238 concentration data are absent between 11.5 and 14.5 ft and along numerous short intervals between the ground surface and 11 ft.

The K-40 concentrations increase to about 15 pCi/g from 38 to 45 ft. K-40 concentrations are slightly decreased and variable from 45.5 to about 58 ft, then increase gradually from 59 to 89 ft.

Additional information and interpretations of log data are included in the main body of the Tank Summary Data Reports for tanks C-101 and C-104.

Log Plot Notes:

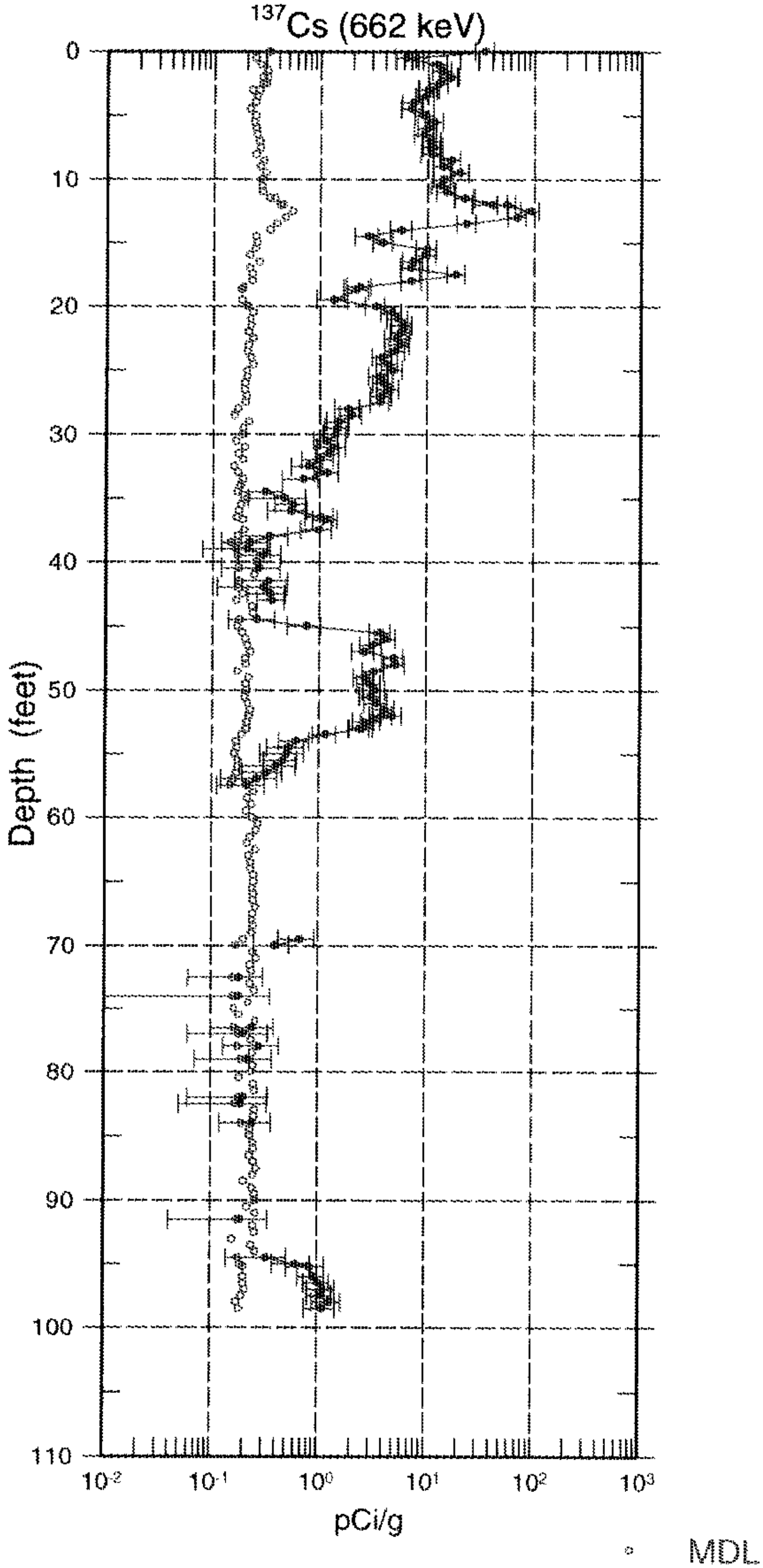
Separate log plots show the man-made and the naturally occurring radionuclides. The natural radionuclides can be used for lithology interpretations. The headings of the plots identify the specific gamma rays used to calculate the concentrations. Uncertainty bars on the plots show the statistical uncertainties for the measurements as 95-percent confidence intervals. Open circles on the plots give the MDL. The MDL of a radionuclide represents the lowest concentration at which positive identification of a gamma-ray peak is statistically defensible.

A combination plot includes the man-made and natural radionuclides, the total gamma derived from the spectral data, and the Tank Farms gross gamma log. The gross gamma plot displays the latest available digital data. No attempt has been made to adjust the depths of the gross gamma logs to coincide with the SGLS data.

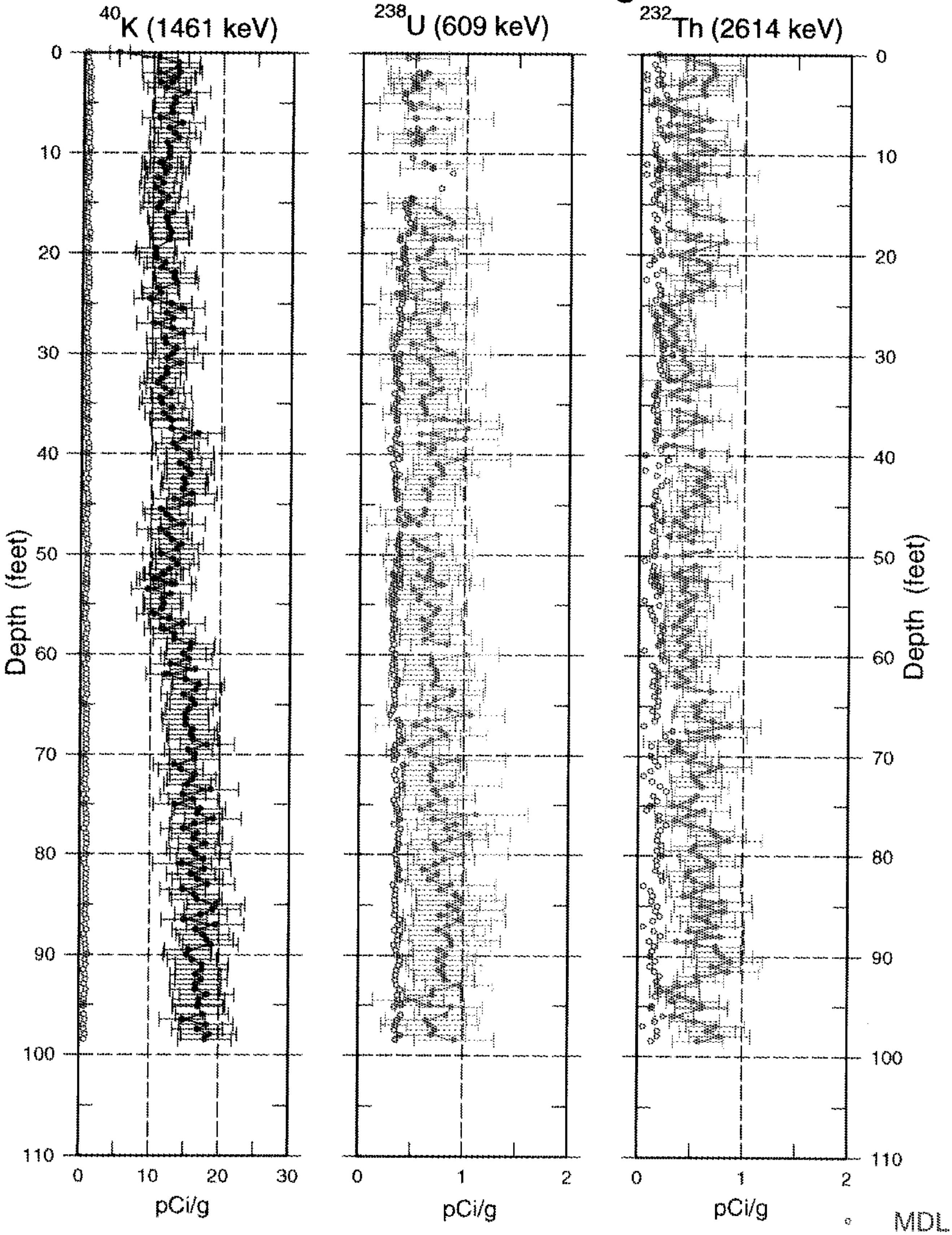
A plot of representative historical gross gamma-ray logs from 1975 to 1992 is included. An additional plot of historical gross gamma-ray logs is provided to show changes in activity recorded from January 1978 to March 1978. The headings of the plots identify the date on which the data in the plots were gathered.

30-04-05

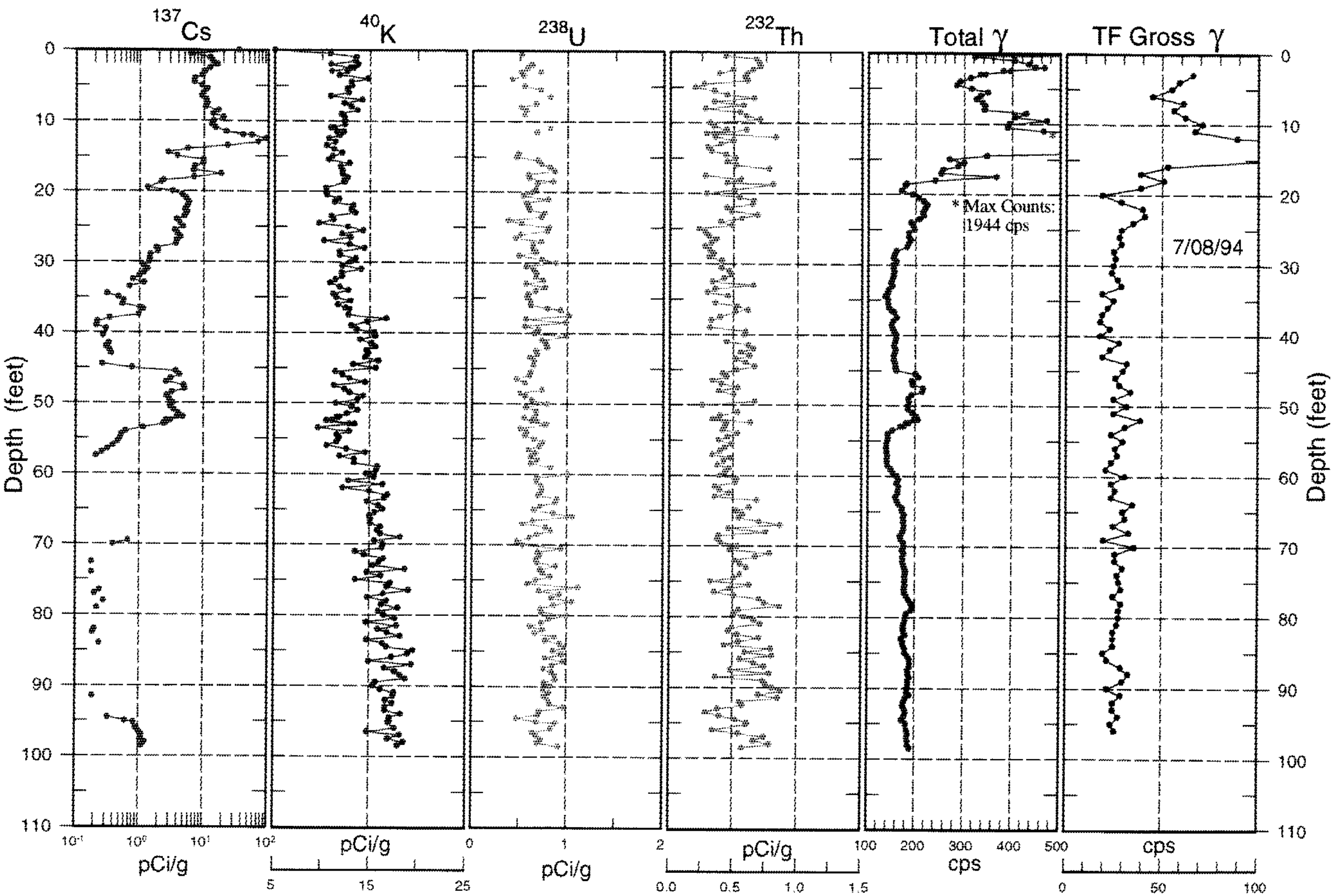
Man-Made Radionuclide Concentrations



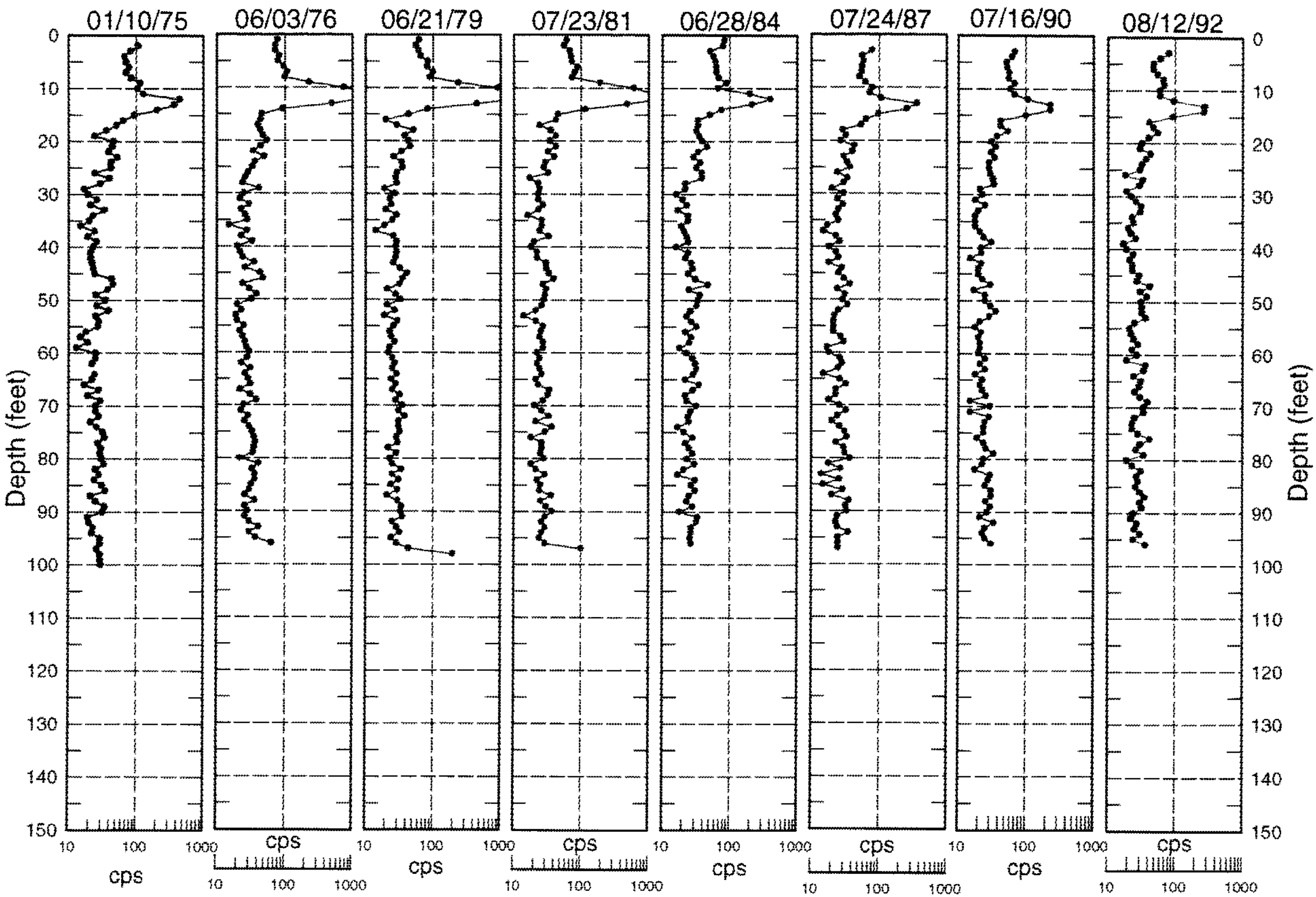
30-04-05
Natural Gamma Logs



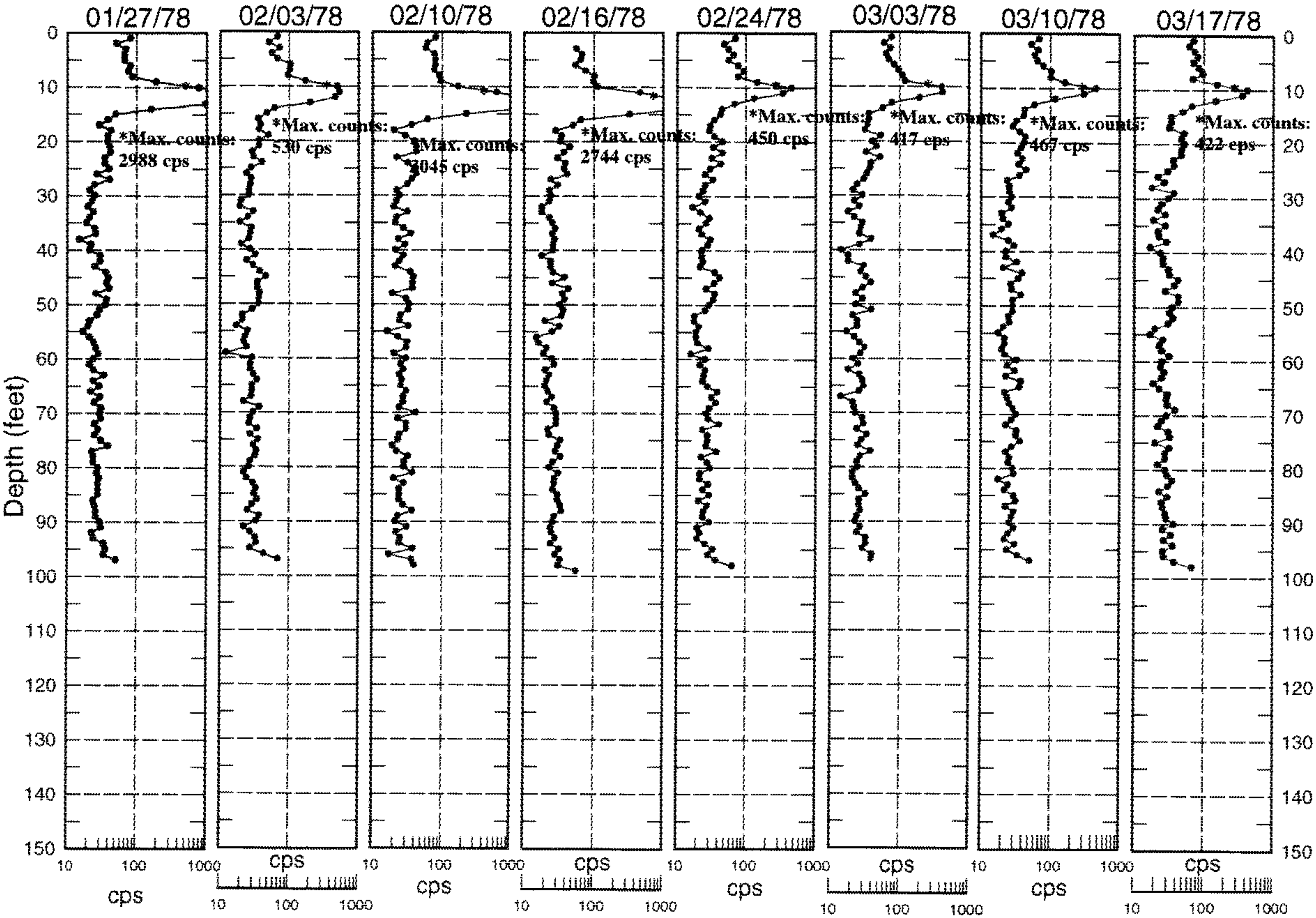
30-04-05 Combination Plot



Historical Gross Gamma Logs for Borehole 30-04-05



Changes in Gross Gamma Logs for Borehole 30-04-05



mactec-ers
MACTEC ENVIRONMENTAL RESTORATION SERVICES, LLC

Spectral Gamma-Ray Borehole Log Data Report

Log Event A

Borehole 30-01-12

Borehole Information

Farm :	C	Tank :	C-101	Site Number :	299-E27-61
N-Coord :	42,762	W-Coord :	48,339	TOC Elevation :	646.82
Water Level, ft :	None	Date Drilled :	3/31/70		

Casing Record

Type :	Steel-welded	Thickness :	0.280	ID, in. :	6
Top Depth, ft. :	0	Bottom Depth, ft. :	100		

Borehole Notes:
This borehole was drilled in March 1970 and completed to a depth of 100 ft with 6-in. casing. The casing thickness is presumed to be 0.280 in., on the basis of the published thickness for schedule-40, 6-in. steel tubing. No information was available that indicated the borehole was perforated or grouted; therefore, it is assumed that the borehole was not perforated or grouted. The top of the casing, which is the zero reference for the SGLS, is 6 in. above the tank farm ground surface.

Equipment Information

Logging System :	2	Detector Type :	HPGe	Detector Efficiency :	35.0 %
Calibration Date :	10/96	Calibration Reference :	GJO-HAN-13	Logging Procedure :	P-GJPO-1783

Log Run Information

Log Run Number :	1	Log Run Date :	3/20/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	0.0	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	18.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Log Run Number :	2	Log Run Date :	3/21/97	Logging Engineer:	Bob Spatz		
Start Depth, ft.:	99.5	Counting Time, sec.:	100	L/R :	L	Shield :	N
Finish Depth, ft. :	17.0	MSA Interval, ft. :	.5	Log Speed, ft/min.:	n/a		

Log Event A

Borehole 30-01-12

Analysis Information

Analyst : D.L. Parker

Data Processing Reference : P-GJPO-1787 Analysis Date : 6/27/97

Analysis Notes :

This borehole was logged by the SGLS in two log runs. The pre- and post-survey field verification spectra met the acceptance criteria established for the peak shape and detector efficiency, confirming that the SGLS was operating within specifications. The energy calibration and peak-shape calibration from these spectra were used to establish the peak resolution and channel-to-energy parameters used in processing the spectra acquired during the logging operation. There were no fine gain adjustments made during these log runs.

Casing correction factors for a 0.280-in.-thick steel casing were applied during analysis.

The man-made radionuclide Cs-137 was detected in this borehole. The Cs-137 contamination was detected nearly continuously from the ground surface to a depth of 40.5 ft. Isolated occurrences of Cs-137 were detected at 45, 60, and 66.5 ft, and at the bottom of the logged interval (99.5 ft).

The U-238 concentration data are almost entirely absent from the ground surface to 8 ft.

The K-40 concentrations increase to about 14 pCi/g between 38.5 and 50.5 ft. K-40 concentrations are slightly decreased from 51 to about 58 ft. The K-40 background concentrations increase gradually from 59.5 to 92.5 ft.

Additional information and interpretations of log data are included in the main body of the Tank Summary Data Reports for tanks C-101 and C-104.

Log Plot Notes:

Separate log plots show the man-made and the naturally occurring radionuclides. The natural radionuclides can be used for lithology interpretations. The headings of the plots identify the specific gamma rays used to calculate the concentrations. Uncertainty bars on the plots show the statistical uncertainties for the measurements as 95-percent confidence intervals. Open circles on the plots give the MDL. The MDL of a radionuclide represents the lowest concentration at which positive identification of a gamma-ray peak is statistically defensible.

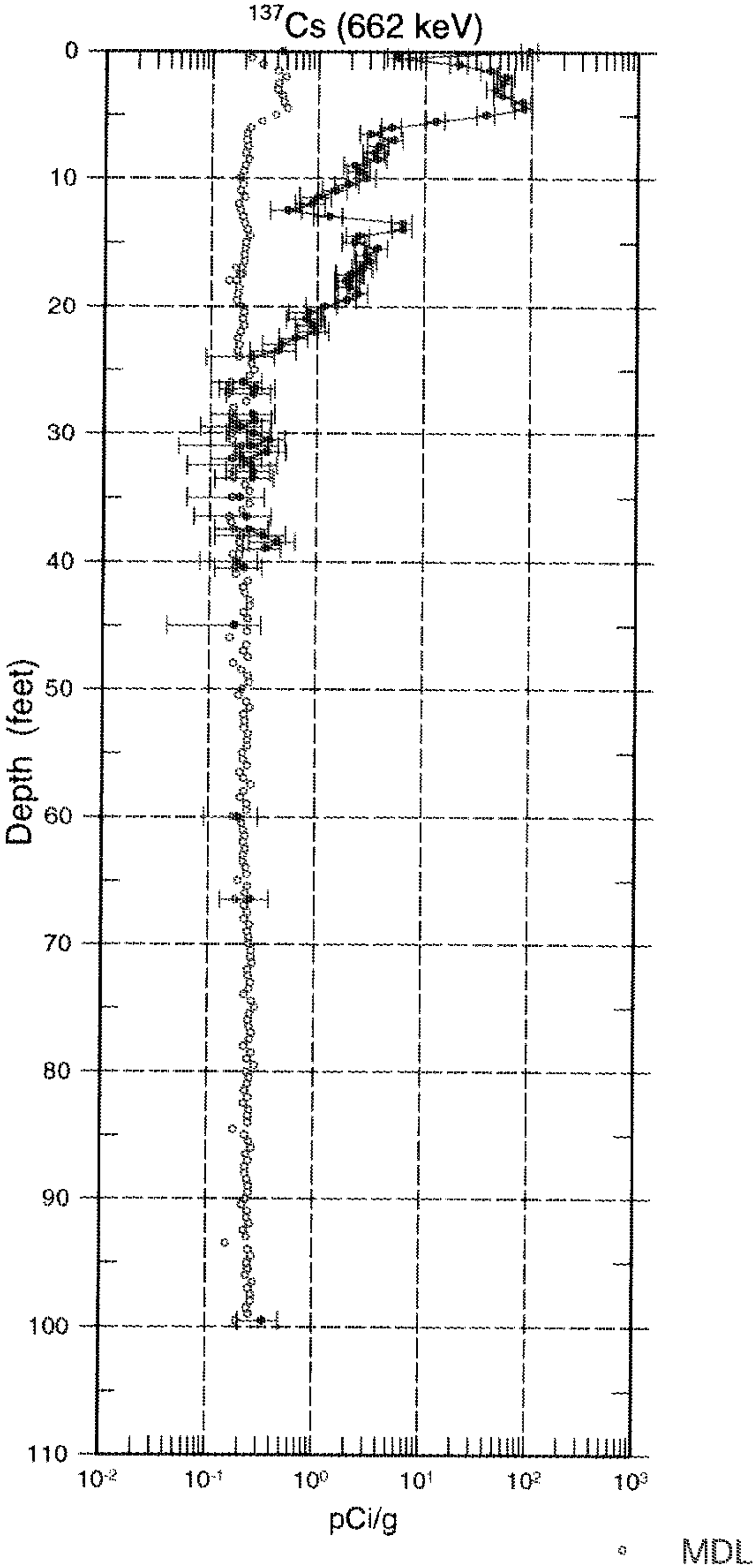
A combination plot includes the man-made and natural radionuclides, the total gamma derived from the spectral data, and the Tank Farms gross gamma log. The gross gamma plot displays the latest available digital data. No attempt has been made to adjust the depths of the gross gamma logs to coincide with the SGLS data.

A comparison plot is also provided showing the Cs-137 and Co-60 concentrations determined from the SGLS and those determined from the Radionuclide Logging System (RLS) in 1994.

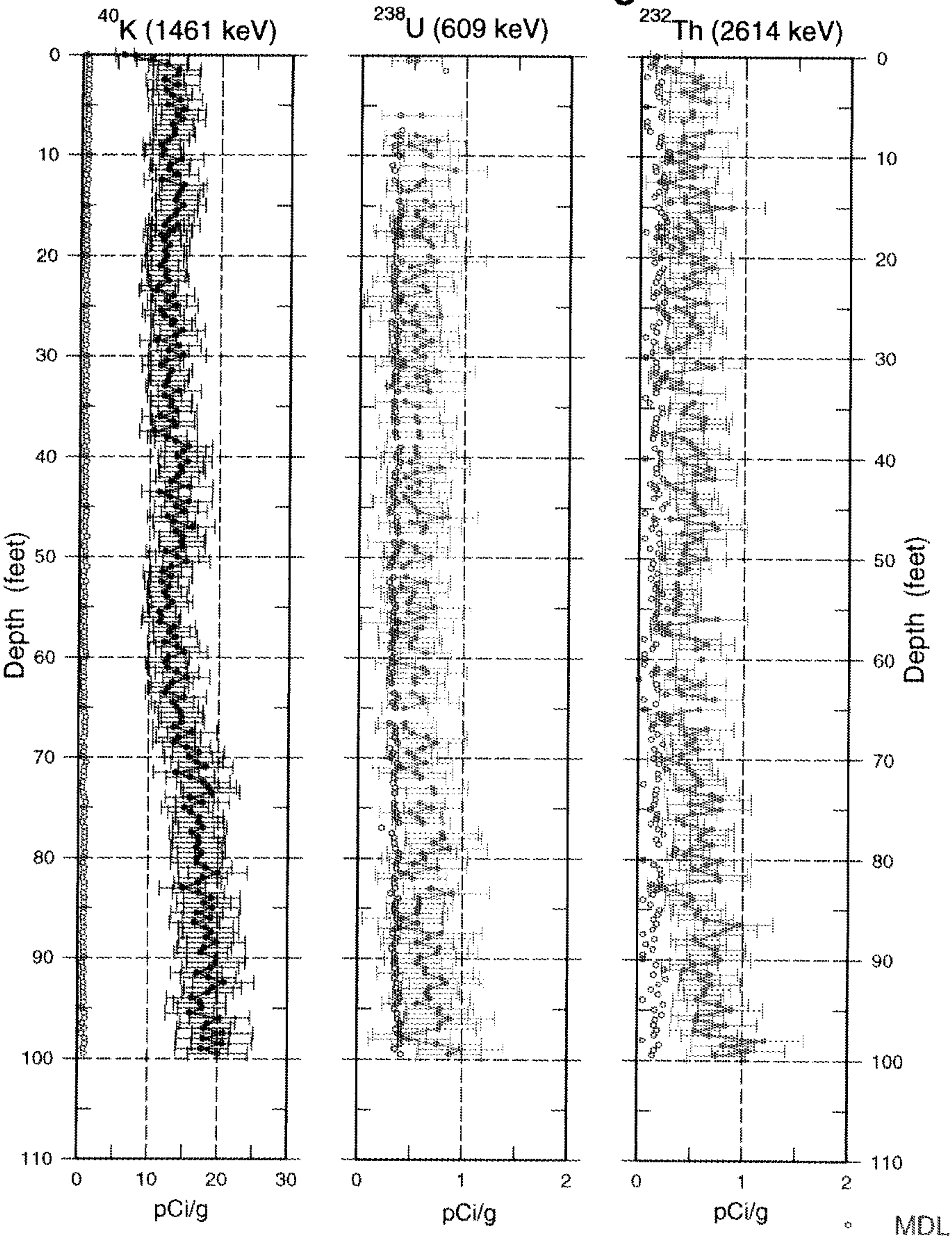
A plot of representative historical gross gamma-ray logs from 1975 to 1992 is included. The headings of the plots identify the date on which the data in the plots were gathered.

30-01-12

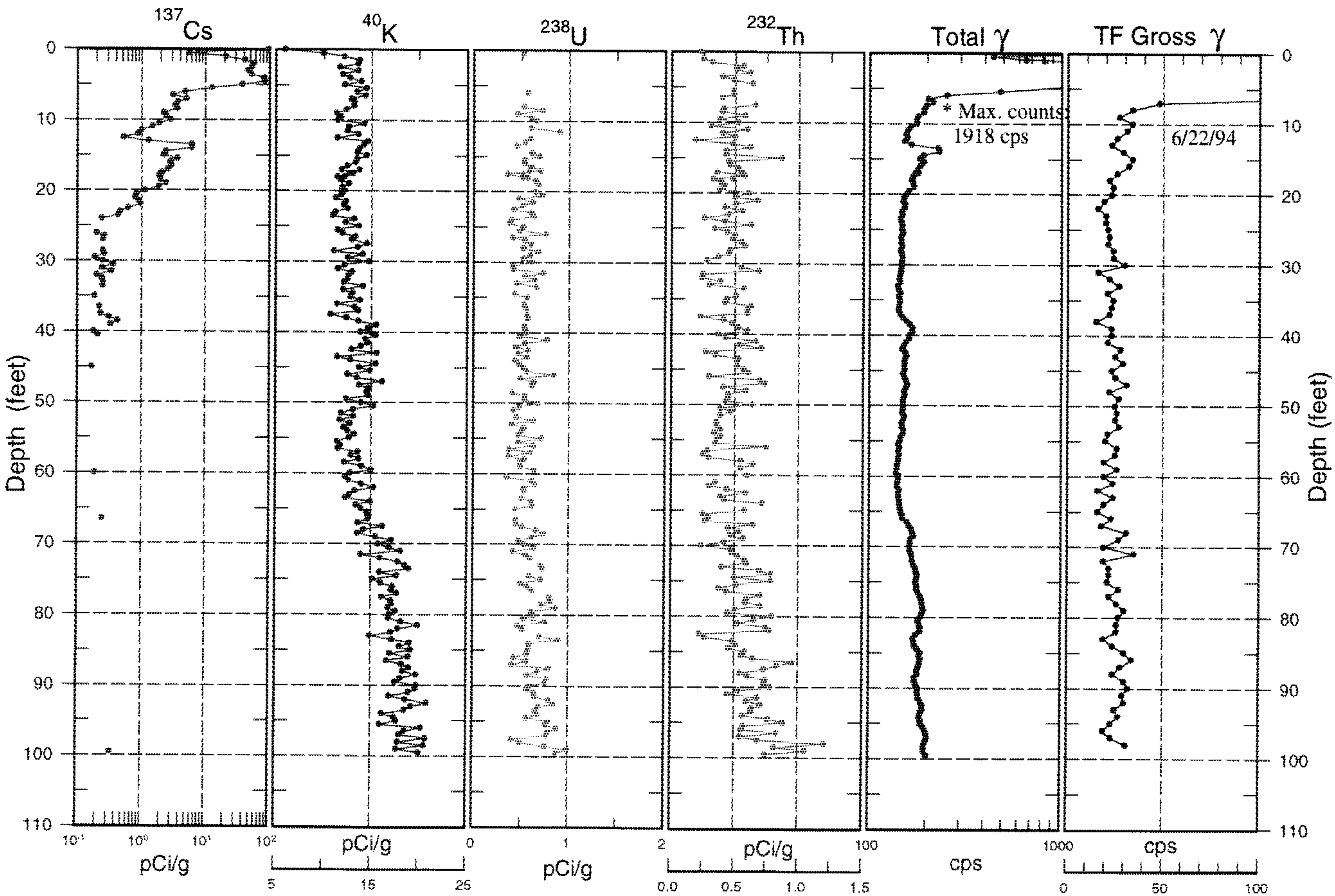
Man-Made Radionuclide Concentrations



30-01-12
Natural Gamma Logs



30-01-12 Combination Plot



Historical Gross Gamma Logs for Borehole 30-01-12