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Section 1 of 2

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Analysis of Historical Gross Gamma Logging Data from BY Tank Farm

D. A. Myers

Waste Management Northwest/Three Rivers Scientific
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Abstract: Gross gamma ray logs, recorded from January 1975 through mid-year 1994 as part of the Single-Shell Tank Farm Dry Well Surveillance Program, have been reanalyzed for the BY tank farm to locate the presence of mobile radionuclides in the subsurface. This report presents the BY tank farm gross gamma ray data in such a way as to assist others in their study of vadose zone mechanisms.

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**Summary of Data Analysis Results for the BY
Single Shell Tank Farm Dry Well Gross Gamma
Ray Surveillance Logs**

September 30, 1998

Glenda K. Jaeger
Benton City, Washington 99320

Summary of Data Analysis Results for the BY Single Shell Tank Farm Dry Well Gross Gamma Ray Surveillance Logs

1.0 Introduction

The single-shell tank farm dry well surveillance program was established 1947 as one of several methods used to identify leaking tanks and operated until 1994. Up until 1975, data were collected in a non-digital format and in 1975, the surveillance program was upgraded to a digital logging system. Under the new system, gross gamma ray logs were recorded in digital form utilizing several logging detector types and reviewed in order to identify leaks of radioactive liquid from the underground tanks. Gross gamma ray logs recorded from January 1975 through mid-year 1994 have been re-analyzed to locate the presence of mobile radionuclides in the subsurface not targeted under the original program (data acquired prior to 1975 are not in the correct format for this analysis). Details concerning how this was accomplished are in "Analysis Techniques Applied to the Dry Well Surveillance Gross Gamma Ray Data at the SX Tank Farm," WMNW-TRS-ES-VZMA-001.

A necessary element for the analysis of the gross gamma ray data is the use of information provided from the spectral gamma logging analysis implemented from 1996 to 1997. The analysis was performed on BY Tank Farm wells by MACTEC-ERS of Grand Junction, Colorado for the U.S. Department of Energy (DOE) under contract #DE-AC04-94AL96907 (MACTEC-ERS, 1997). The spectral gamma logging system (SGLS) employs a high-purity germanium (HPGe) detector to obtain data leading to the identification and depth of gamma ray emitting radioactive isotopes. Knowledge as to the isotopes that are present in the subsurface is required to adequately interpret the tank farm dry well surveillance logs. By integrating SGLS data with historical dry well surveillance data, knowledge is gained concerning the behavior of radionuclides in the vadose zone over time.

A goal of this report is to present the BY Tank Farm gross gamma ray data in such a way as to assist others in their study of vadose zone mechanisms, allowing them to further analyze the data and develop their own conclusions and interpretations. Overall trends in the data, as well as areas where additional information would be helpful in evaluating the unusual nature of some of the data, will be discussed. It is planned that this presentation will support Tank Waste Remediation System (TWRS) activities for closure, characterization, remediation, and other vadose zone issues. In general, the data analysis resulted in the identification of five types of subsurface conditions that occur within discrete depth intervals called zones. They are defined as follows:

- **CLEAN:** no systematic trend above the detection threshold for the gross gamma ray logs is indicated by the data.
- **STABLE:** the decay rate of the isotope(s) identified in the zone matches the change in concentration of the isotope(s) as measured over time, and no noticeable deviation from the match is apparent within the timeframe that gross gamma ray data were collected. Contaminants may be moving, but at a slow enough rate as to not be observable within the timeframe of data collection.
- **UNSTABLE/UNSTABLE EARLY:** the decay rate of the isotope(s) identified in the zone does not match the change in concentration of the isotope(s) as measured over time within the timeframe that gross gamma ray data were collected. Those zones that exhibit an unstable condition early in this timeframe, but currently exhibit a stable condition, are called unstable or unstable early in this report. Those that are currently unstable are labeled unstable. Currently, isotopes cannot be identified from gross gamma ray data alone. Therefore, isotopes with a rapid rate of decay, such as Ru-106, or at low enough levels to decay below detection limits, may not be identified if the period of instability is prior to the collection of SGLS data. Their presence is speculated based on the fit of the decay curve.
- **TANK FARM ACTIVITY:** an irregular change in the intensity of gross gamma rays between successive surveys at or near the surface suggests that contamination may be the result of tank farm activities or logging procedure changes and not vadose zone mechanics.
- **UNDETERMINED:** stability cannot be determined due to insufficient data, exceeding the system design criteria (both upper and lower limits) for recording gross gamma ray data, or possible affects of depth shift or surface activities.

Stable vs. unstable is an apparent condition limited by the time interval over which data were collected, the sensitivity of the tools, and the level of contamination, and is not a definitive statement concerning the fixed or mobile nature of a given isotope.

Note: The category names have changed since the SX report was produced, although the categories are basically the same (i.e., clean, stable, and changed vs. clean, stable, unstable early, and unstable). More kinds of instability were identified in the BY Tank Farm data than in the SX Tank Farm data, which lead to a change in terminology.

It is beyond the scope of this project, to identify the source, rate of movement, or migration pathway of mobile radioactive contaminants and their ultimate impact to the environment. It is also pointed out that where boreholes do not exist, movement can occur without detection. This investigation is limited to the immediate area (approximately 20 inches) around each borehole from which gamma rays are readily detected, and is not rigorous enough to interpret the condition of the space between boreholes and outside of the investigated area.

1.1 Background:

A series of twelve tanks were installed at the BY Tank Farm from 1946 to 1947 to receive liquid waste resulting from activities at the Hanford site (Brevick, et. al.). These tanks are 75 feet in diameter, constructed on 100-foot centers, with 25 feet between the sides of each tank, and are interconnected in a variety of ways. A network of vadose monitoring wells (dry wells) was installed throughout the BY Tank Farm over a number of years to monitor the subsurface condition of the tank farm (Figure 1). All of the 70 wells constructed have a single string of casing installed concurrent to the drilling activity to prevent collapse of the unconsolidated subsurface sediments (loose sand and gravel). An additional borehole (22-00-05) was drilled south of the 104 and 101 tanks for which there are no geophysical data available. The boreholes range in depth from 85 to 150 feet, with the majority being 100 feet deep. The gross gamma ray data that were acquired digitally from these wells between 1975 and 1994 were analyzed by Three Rivers Scientific and presented in "Analysis of Historical Gross Gamma Logging Data from BY Tank Farm," (Project No. 772028, Task No. 23020001).

1.2 Data Analysis Description:

Data from the dry well logs are compiled through a number of iterations until data sets are obtained that reveal any trend present. This process does not add or delete data, but merely compiles them into a useful, uncompromised data set. A depth vs. time plot, or stack plot, of the gross gamma ray data is created to identify trends and zones of contamination. All historical log surveys for one dry well (borehole) are analyzed as a whole for each radioactive zone in a well, thus allowing statements to be made about the apparent condition or rate of change of any given radioactive interval.

Review of the historical gross gamma ray data revealed that limits in the system design for collecting data prior to 1983 created a situation where the zero point for the start of data collecting was inconsistent (refer to WMNW-TRS-ES-VZMA-001 for details). This makes evaluating trends in the data difficult. Several methods can be employed to overcome varying zero points and to essentially create a common starting point from which to view the data, making trend identification easier. These methods apply a depth shift to the data, which is simply adjusting data up or down so that certain identifiable features in the data can be aligned and evaluated. By applying a depth shift to the data, the ability to identify downward movement of the isotopes can be hindered, so depth shifting is avoided as much as possible.

A summation of the values of logging instrument readings over the depth interval of interest minus background activity and times the distance between sample point depths yields a constant that is independent of the specific starting point. This calculation is called the grade thickness product (GTP) and can be applied over a depth interval wide enough to include all variances in depth so as not to require depth shifting. When the calculation is applied over the entire interval, the result is a more accurate representation of the condition of the zone over time.

Gross gamma ray log surveys contain data at one-foot intervals over the length of the borehole. Differences in the zero-depth reference point cause variations in the maximum count rate for thin radioactive zones as well as the apparent depth of contamination. The GTP technique is used to eliminate this variable sampling effect upon the overall net change for a given zone.

Applying a GTP calculation over an entire interval can mask the presence of discrete stable or unstable zones within the interval. Therefore, smaller intervals are evaluated to obtain a clearer understanding of the movement of

isotopes in the overall contaminated zone. Occasionally, the smaller intervals overlap in order to aid in the interpretation of trends in the overall zone of interest and to account for depth errors. For clarity of presentation in this summary report, the analysis for the entire interval is presented with a discussion of discrete zones included where appropriate. For detailed information about the analysis and the zones investigated, see the aforementioned BY Tank Farm analysis report. At very low levels of contamination, inconsistencies were observed between the gross gamma indications and the SGLS data. Also, inconsistencies in the data analysis (e.g., depth intervals analyzed, isotopes used in calculating decay curves [sometimes known, sometimes hypothesized]), interpretation of the data, incompleteness in reporting of the evaluation, and errors in the BY Tank Farm analysis report make summarizing difficult. These inconsistencies are driven in part by the complexity of the contaminate movement, and information gathered from the logging process. It is recommended that the BY Tank Farm analysis report and its authors be consulted when applying the information presented in this summary report.

Note: Gross gamma ray data were collected using a variety of probe types. The values generated by these probe types do not correlate with each other (e.g., the NaI probe type 04 does not record values that relate to those recorded with the Green or Red GM probe types 01 and 02). It is not within the scope of this project to normalize these values. Therefore, caution must be used when relating GTP values in zones recorded with different probe types. See WMNW-TRS-ES-VZMA-001 for a detailed discussion.

The average background activity of naturally occurring potassium, uranium, and thorium is obtained from review of the data for each survey and provides a level of confidence that the instrumentation worked consistently and the gross gamma ray data are valid. The percentage of data values that are considered as representing a natural background formation response (frequency clean) is also calculated. The average background activity value is calculated for all survey depth samples between a lower and upper count rate threshold. The lower count rate threshold is generally set at zero (0) c/s; a value defined as indicating a data gap. The upper count rate threshold is generally set at 50 c/s for probe type 04 (NaI), a conservative value near what is considered background activity, yet one fourth of the count rate considered reportable by the leak detection program.

Note: Spurious data are generated during normal data collecting activities. Spurious zero values are called data gaps and are considered as unrealistically low natural background activity when recorded with the sodium-iodide probes. Between 1975 and 1982, the equipment would occasionally record a spurious data value of minus one (-1) or zero (0). A value of minus one represents an invalid count rate. Data gaps occur at various locations in the surveys, including in the background or in the middle of a high contamination zone within a borehole. Data gaps are not included in the calculation of average background, grade thickness product, or frequency clean values.

Zones where contamination is identified are examined using the GTP evaluation. The average background activity is subtracted so that only the contaminated levels above background are included in the analysis. The GTP is plotted in a graph against time for each depth interval analyzed. One or more decay lines are then overlaid on the graph based on isotopes identified by the SGLS data, knowledge of tank constituents, and the known presence of isotopes in other boreholes. Sometimes decay lines can be fit through the data in a number of ways with none of them fitting perfectly. When two or more isotopes are identified, a least squares fit analysis for a multi-component decay is performed (for details, refer to the Appendix in the BX Tank Farm report) for those isotopes that are needed to make the decay curve fit the data. If an isotope was identified (usually at low levels) but is not useful in fitting the curve, it was not included in the GTP calculation. Isotopes that are known to exist in the inventory of the tank farm, or are identified in nearby wells, may not be identified by the SGLS due to being at or below detection levels. Such isotopes are hypothesized to have been present and are sometimes included in the least squares fit analysis when needed to make a fit. The decay rates for each of the components are held fixed in the fitting process and only the relative intensities of the components are calculated. The relative contribution of gross gamma rays from one component to another depends upon the nature of the isotopes and the detector design. Comparing the GTP data and the decay line(s) reveals information about the rate of change of contamination within a zone over the timeframe that data were collected. Multiple plots are generated to show the results for different zones within a borehole when appropriate. The details for the use of GTP are covered in WMNW-TRS-ES-VZMA-001.

The objective of the analysis is to assure that a thorough examination of dry well surveillance logs is performed. It is also to assure that no zones of contamination abruptly entered the borehole survey region and quickly migrated out. All surveys are examined so that no unusual problems or conditions remain as undetected. Table 1 contains a list of the wells located in the BY Tank Farm as well as information concerning the identity, level, and depth of contamination. Due to the complex nature of the data, detailed comments from the summaries in the BY data set are also provided to aid in understanding. In order to afford a spatial relationship to the subsurface contamination, a variety of maps depicting tank and data point locations are provided.

Table 1. BY Zones

Borehole Number	Total Depth feet	Number of Surveys	Probe Type	Subsurface Condition Category	Zone Depth feet	Max. GTP n°c/s	Year Max. GTP	Isotopes Identified	Comment
22-00-01	140	340	4	Stable	40-65	250	1975	¹³⁷ Cs	No SGLS data; ¹³⁷ Cs not identified
				Stable	70-84	70	1975	¹³⁷ Cs	
				Stable	84-100	70	1975	¹³⁷ Cs	
22-00-02	100	206	4	Stable	0-14	600	1975	¹³⁷ Cs	Borderline downward movement
				Undetermined	45-56	1,300	1975	⁶⁰ Co; ¹³⁷ Sb	Possible downward movement, but below detection
				Stable	56-64	1,200	1975	¹³⁷ Sb; ⁹⁰ Ku	
				Unstable	64-96	1,800	1975	⁶⁰ Co	Downward movement at low levels; ¹³⁷ Cs decay curve fits, but was not used as ¹³⁷ Cs was not identified by the SGLS
22-00-03	145	208	4	Stable	40-80	3,000	1975	⁶⁰ Co; ¹³⁷ Sb	
				Unstable early	80-117	12,000	1975	⁶⁰ Co	
				Stable	117-128	1,800	1975	⁶⁰ Co	
				Stable	128-140	1,100	1975	⁶⁰ Co; ¹³⁷ Sb	
22-00-04	100	210	4	TF Activity	0-10	200	1975	¹³⁷ Cs	
				Stable	48-70	500	1975	⁶⁰ Co; ¹³⁷ Sb	
				Stable	70-85	1,000	1975	⁶⁰ Co; ⁹⁰ Ku	
22-00-05		no data							No geophysical data available
22-00-10	120	385	4	TF Activity	0-10	150	1975	¹³⁷ Cs	¹³⁷ Cs id'd at 8 pCi/g should appear in gross gamma log at 46 feet, but doesn't
22-01-01	100	405	4	TF Activity	0-6	400	1985	¹³⁷ Cs	
				Appear stable	6-15	50	1975	¹³⁷ Cs	Low levels near threshold
22-01-03	100	395	4	TF Activity	0-10	100	1975	¹³⁷ Cs	
22-01-04	100	408	4	TF Activity	0-15	1,700	1975	¹³⁷ Cs	
				Stable	15-30	16,000	1975	¹³⁷ Cs	
				Stable	30-60	1,400	1975	⁶⁰ Co; ¹³⁷ Sb	
22-01-07	100	394	4	TF Activity	0-6	6,000	1975	¹³⁷ Cs	
				Stable	6-15	100	1975	¹³⁷ Cs	Low levels near threshold
				Stable	40-55	200	1975	⁶⁰ Co	
22-01-10	100	419	4	TF Activity	0-10	1,500	1975	¹³⁷ Cs	
				Stable	15-25	500	1975	¹³⁷ Cs	
				Stable	25-44	550	1975	¹³⁷ Cs; ⁶⁰ Co	
22-02-01	100	593	4	TF Activity	0-10	800	1985	¹³⁷ Cs	
				TF Activity	10-20	200	1984	¹³⁷ Cs	

					Stable	40-53	3,200	1975	¹³⁷ Cs	
					Stable	55-75	200	1975	¹⁰⁶ Ru	
					Stable	80-96	550	1975	⁶⁰ Co; ¹⁰⁶ Ru	
22-02-02	100	540			4 TF Activity	0-6	600	1975	¹³⁷ Cs	
					Stable	6-18	300	1975	¹³⁷ Cs	
22-02-05	100	545			4 TF Activity	0-10	300	1975	¹³⁷ Cs	
22-02-07	150	452			4 TF Activity	0-10	200	1986	¹³⁷ Cs	No SGLS due to high surface rad. area for personnel
22-02-09	100	607			4 TF Activity	0-10	400	1986	¹³⁷ Cs	
					Stable	20-26	200	1975	¹³⁷ Sb	
					Stable	26-34	450	1975	¹³⁷ Sb; ¹⁰⁶ Ru	
					Stable	34-44	1,800	1975	¹³⁷ Sb; ¹⁰⁶ Ru	
					Stable	44-52	2,500	1975	¹³⁷ Cs; ⁶⁰ Co; ¹⁰⁶ Ru	
					Undetermined	55-65	100	1975	⁶⁰ Co	Low levels near threshold
22-03-01	95	538			4 TF Activity	0-10	200	1986	¹³⁷ Cs	
22-03-04	100	457			4 TF Activity	0-10	900	1975	¹³⁷ Cs	
					TF Activity	10-30	800	1975	¹³⁷ Cs	
					Stable	40-55	2,800	1975	¹³⁷ Sb	
					Stable	55-85	900	1975	⁶⁰ Co; ¹³⁷ Sb	
22-03-05	100	235			1 Undetermined	0-5	300	1984	¹³⁷ Cs	Lack of depth control
					Stable	5-15	350	1980	¹³⁷ Cs	
					Stable	15-60	170,000	1980	¹³⁷ Cs	Count rate limits exceeded
					Stable	60-85	1,700	1980	¹³⁷ Cs	
22-03-06	100	490			4 TF Activity	0-10	900	1975	¹³⁷ Cs	
					Appear stable	20-28	2,300	1975	¹³⁷ Cs	
					Stable	37-48	13,000	1975	¹³⁷ Cs; ⁶⁰ Co; ¹³⁷ Sb	
					Stable	48-60	2,400	1975	¹³⁷ Sb; ¹⁰⁶ Ru	
					Stable	60-94	4,300	1975	⁶⁰ Co; ¹³⁷ Sb; ¹⁰⁶ Ru	
					Stable	94-100	1,000	1975	¹³⁷ Sb	Interval not logged after mld 1982
22-03-07	100	475			4 TF Activity	0-8	100	1975	¹³⁷ Cs	
					Stable	47-62	1,300	1975	⁶⁰ Co; ¹³⁷ Sb	
					Stable	62-90	1,100	1975	⁶⁰ Co; ¹⁰⁶ Ru	
22-03-08	100	504			4 TF Activity	0-8	200	1975	¹³⁷ Cs	
					Stable	40-60	1,300	1975	⁶⁰ Co; ¹⁰⁶ Ru	
					Appear stable	80-98	100	1975	⁶⁰ Co	Low levels near threshold
22-03-09	100	618			4 TF Activity	0-11	2,000	1975	¹³⁷ Cs; ¹⁴⁷ Eu	

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22-07-02	100	336	4	Appear stable	6-20	200	1975	¹³⁷ Cs	Downward movement; contamination may be below bottom of well
				Unstable early	42-95	2,800	1976	⁶⁰ Co	
22-07-05	100	238	4	Unstable early	40-78	3,800	1975	⁶⁰ Co	Downward movement within the zone from 42 to 65 feet
				Undetermined	90-100	500	1975	¹³⁷ Cs	
22-07-07	100	225	4	Unstable early	30-54	2,500	1975	¹³⁷ Cs; ¹²⁵ Sb; ¹⁰⁶ Ru	
				Unstable	80-98	1,800	1976	⁶⁰ Co; ¹³⁷ Sb	Stable from 1983 or 1990
22-07-09	100	393	4	TF Activity	0-9	2,500	1984	¹³⁷ Cs	
				Stable	9-17	1,400	1975	¹³⁷ Cs	
				Appear stable	17-36	50,000	1975	¹³⁷ Cs	Count rate may have been exceeded
				Unstable	62-100	2,200	1976	¹³⁷ Cs; ⁶⁰ Co	Downward movement to below well bottom in 1990
22-07-10	97	356	4	TF Activity	0-6	1,500	1975	¹³⁷ Cs	
				Stable	6-12	2,000	1975	¹³⁷ Cs	
				Stable	12-20	1,400	1975	¹³⁷ Cs	
				Stable	20-30	1,600	1975	¹³⁷ Cs	
				Stable	30-44	1,400	1975	¹³⁷ Cs	
22-08-01	100	312	4	TF Activity	0-12	200,000	1989	¹³⁷ Cs	Count rate may have been exceeded
				Stable	22-32	500	1976	⁶⁰ Co; ¹²⁵ Sb	
				Stable	32-42	2,400	1976	⁶⁰ Co; ¹²⁵ Sb	
				Stable	42-59	25,000	1975	⁶⁰ Co; ¹²⁵ Sb	
				Unstable	59-95	12,000	1975	⁶⁰ Co; ¹²⁵ Sb	Movement of isotopes is unclear; stable from 1985 to 1994
22-08-02	100	305	4	TF Activity	0-10	20,000	1993	¹³⁷ Cs	
				Stable	20-30	1,000	1975	¹²⁵ Sb	
				Unstable	44-100	15,000	1975	⁶⁰ Co; ¹²⁵ Sb	Downward movement, possibly below bottom of borehole
22-08-05	100	314	4	TF Activity	0-8	200	1975	¹³⁷ Cs	
				Stable	36-45	250	1975	⁶⁰ Co	
				Stable	45-53	700	1975	⁶⁰ Co	
				Stable	53-63	1,000	1975	⁶⁰ Co	
				Unstable early	63-84	900	1975	⁶⁰ Co	Downward movement
22-08-06	100	314	4	TF Activity	0-8	1,200	1975	¹³⁷ Cs	
				TF Activity	8-18	500	1975	¹³⁷ Cs	
				Stable	18-29	400	1975	¹³⁷ Cs	
				Stable	46-54	150	1975	¹³⁷ Cs; ⁶⁰ Co	
				Stable	54-63	200	1975	⁶⁰ Co	
				Stable	63-73	900	1975	⁶⁰ Co	
				Unstable early	73-83	450	1975	⁶⁰ Co	

22-08-07	135	296	4 TF Activity	0-8	500	1975	¹³⁷ Cs	
22-08-09	100	403	4 TF Activity	0-10	80,000	1984	¹³⁷ Cs	
			Unstable early	72-84	150	1975	¹³⁷ Cs; ¹⁰⁶ Ru	
22-08-12	105	380	4 TF Activity	0-8	10,000	1989	¹³⁷ Cs	
			Unstable early	25-40	300	1980	¹³⁷ Cs	¹³⁷ Cs decay curve does not fit GTP plot
			Unstable early	40-51	3,000	1975	⁶⁰ Co; ¹²⁵ Sb	
			Unstable early	51-60	3,000	1975	⁶⁰ Co	Possible downward movement
			Unstable early	60-82	1,000	1976	⁶⁰ Co	Downward movement within the zone
22-09-01	100	674	4 Stable	24-35	250	1975	¹⁰⁶ Ru	
			Stable	40-55	2,200	1975	¹²⁵ Sb; ¹⁰⁶ Ru	
22-09-02	100	468	4 TF Activity	0-10	2,000	1984	¹³⁷ Cs	
			TF Activity	10-14	300	1975	¹³⁷ Cs	
			Stable	14-34	1,200	1975	¹³⁷ Cs	
			Stable	42-64	500	1975	¹⁰⁶ Ru	
22-09-05	100	562	4 TF Activity	0-10	100	1975	¹³⁷ Cs	
			Stable	40-58	250	1975	¹³⁷ Cs; ¹²⁵ Sb	
22-09-07	97	481	4 Unstable early	20-40	12,000	1975	¹⁰⁶ Ru	
			Unstable early	40-50	9,000	1976	¹⁰⁶ Ru	
			Unstable early	50-64	2,700	1976	¹²⁵ Sb; ¹⁰⁶ Ru	
22-09-08	98	368	4 Undetermined	16-30	80,000	1985	¹³⁷ Cs	Count rate limits exceeded
			Stable	43-52	150	1981	⁶⁰ Co	
			Undetermined	76-90	100	1985	⁶⁰ Co	Levels below detection threshold
22-09-11	100	552	4 TF Activity	0-10	1,500	1975	¹³⁷ Cs	
			Stable	16-25	300	1975	¹³⁷ Cs; ¹²⁵ Sb	
			Stable	25-38	450	1975	¹⁰⁶ Ru	
			Unstable early	38-52	3,500	1975	¹⁰⁶ Ru	
22-10-05	100	400	4 Stable	45-55	200	1975	⁶⁰ Co	
			Unstable early	55-75	300	1979	⁶⁰ Co	
22-10-07	100	377	4 Unstable early	45-65	200	1983	⁶⁰ Co	
22-10-09	100	364	4 TF Activity	0-10	20,000	1975	¹³⁷ Cs	
22-10-10	100	406	4 Unstable early	58-76	1,500	1975	⁶⁰ Co	
22-11-01	100	415	4 TF Activity	0-5	1,000	1975	¹³⁷ Cs	
			TF Activity	5-10	900	1975	¹³⁷ Cs	
			Unstable	19-28	4,000	1984	¹³⁷ Cs	
22-11-05	100	450	4 TF Activity	0-10	3,000	1975	¹³⁷ Cs	

22-11-08	100	438	4 TF Activity	0-10	100	1975	¹³⁷ Cs
			Stable	56-66	120	1975	⁶⁰ Co; ²³⁸ U
22-11-09	100	437	4 TF Activity	0-8	8,000	1975	¹³⁷ Cs
			Stable	24-34	450	1975	⁶⁰ Co
			Unstable early	34-46	250	1975	⁶⁰ Co
22-12-01	100	424	4 Clean				
22-12-03	100	509	4 TF Activity	0-10	200,000	1980	¹³⁷ Cs
			Stable	10-20	300	1975	¹³⁷ Cs
22-12-05	100	426	4 TF Activity	0-20	1,000	1975	¹³⁷ Cs
22-12-06	100	428	4 TF Activity	0-20	8,000	1975	¹³⁷ Cs
22-12-07	100	418	4 TF Activity	0-10	1,500	1984	¹³⁷ Cs
22-12-09	100	429	4 Clean				
22-12-10	100	424	4 Clean				

*Probe type: 1 = Green GM, moderately sensitive; reads moderate levels of gamma ray activity.

4 = NaI, most sensitive, reads lowest level of gamma ray activity.

Caution must be used when relating GTP values in zones recorded with different probe types.

*The decay rate of the isotope(s) identified in the zone matches the change in concentration of the isotope(s) as measured over time, and no noticeable deviation from the match is apparent within the timeframe that gross gamma ray data were collected.

*Stability cannot be determined due to insufficient data, exceeding the system design criteria (both upper and lower limits) for recording gross gamma ray data, or possible affects of depth shift or surface activities.

*The decay rate of the isotope(s) identified in the zone does not match the change in concentration of the isotope(s) as measured over time within the timeframe that gross gamma ray data were collected. Those zones that exhibit an unstable condition early in this timeframe, but currently exhibit a stable condition, are called unstable or unstable early in this report.

*An irregular change in the intensity of gross gamma rays between successive surveys at or near the surface suggests that contamination may be the result of tank farm activities or logging procedure changes and not vadose zone mechanics.

*The decay rate of the isotope(s) identified in the zone appears to match the change in concentration of the isotope(s) as measured over time, but stability cannot be rigorously determined.

*Well 22-03-09 exhibits downward movement with lateral influx from 1975 to 1977 and downward movement from 1977 to 1995 (it is not possible to tell if there is lateral movement during this time period); stringers of contamination are left behind after the majority of the contamination moves through; the leading edge of the contamination moves below the bottom of the borehole in 1985 to 1986 and continues to move down until the trailing edge of the contamination moves below the bottom of the borehole in 1991 to 1992.

*No systematic trend above the detection threshold for the gross gamma ray logs is indicated by the data.

*Currently, isotopes cannot be identified from gross gamma ray data alone; therefore, isotopes with a rapid rate of decay, such as Ru-106, may not be identified if the period of instability is prior to the collection of SGLS data. Also, isotopes that are at low enough levels to decay below detection limits when SGLS data were collected may not be identified.

Stable vs. unstable is an apparent condition limited by the time interval over which data were collected and the level of contamination, and is not a statement concerning the fixed or mobile nature of a given isotope.

Certain limitations in the data available for analysis make evaluation less complete. Some of the limitations are as follows:

- Inability to identify when down-hole contamination is a result of vadose zone mechanics or drag down during well installation
- Insufficient gross gamma ray data to establish a statistical trend or rigorous statistical analysis
- Incomplete timeframe over which data are available
- Lack of data below well bottom
- Inability to identify isotopes that have decayed to levels below the detection limits of the SGLS.

2.0 Subsurface Condition Categories

2.1. Clean:

A clean well is one that exhibits no observable change in the character of the activity over the logging history of the well, and does not have any statistically significant levels above natural background over the timeframe of gross gamma ray data collection. Although spurious surveys (those readings that do not repeat over time) may exist in the frequency clean and the average background plots, the trend of the data is clear. Five out of 70 wells in the BY Tank Farm are considered clean (Figure 2) and are listed in Table 2. The remaining 65 wells are considered contaminated and are further categorized and discussed in the following sections.

Table 2. Clean Zones

Borehole Number	Total Depth feet	Subsurface Condition Category
22-04-05	100	Clean
22-04-07	100	Clean
22-12-01	100	Clean
22-12-09	100	Clean
22-12-10	100	Clean

2.2. Contaminated:

Identification of specific gamma emitting isotopes that are in the subsurface is attainable from data acquired by the SGLS. Integration of the decay rate of the radionuclide species with the gross gamma ray data collected during the dry well surveillance program provides insight as to the rate of change, if any, of radionuclides in the subsurface. During the analysis of BY Tank Farm data, seven isotopes were identified through SGLS analysis or hypothesized to occur in radioactive zones. They are cesium-137 (Cs-137), cobalt-60 (Co-60), antimony-125 (Sb-125), uranium-235 and -238 (U-235/8), europium-154 (Eu-154), and ruthenium-106 (Ru-106).

The most commonly found isotope is Cs-137, which is primarily found by itself throughout the tank farm from surface to 20 feet. It is found with various combinations of the other isotopes from 20 to 100 feet. Cobalt-60 is found from 22 to 140 feet and occurs primarily to the northwest and southeast of the 103 tank, spread between the 107 and 109 tanks, to the west of the 110 and 111 tanks, and to the south of the 107 and 110 tanks. It is found deeper than 100 feet in only two wells: 22-00-03 and 22-04-09. Antimony-125 is found from 16 to 140 feet and is fairly localized around the 109 tank, to the northeast side of the 108 tank, to the southeast of the 103 tank, with a few occurrences elsewhere in the tank farm. It is often hypothesized to have been present as levels of Sb-125 fell below the detection threshold by the time of the SGLS analysis. It is hypothesized to be deeper than 100 feet only in well 22-00-03. In a few instances, Sb-125 was not identified by the SGLS, yet the levels of radioactivity in 4 zones in 4 wells prior to the SGLS analysis suggest that there was sufficient Sb-125 present to have been identified by SGLS given stable conditions. These zones are: 48 to 70 feet in well 22-00-04, 34 to 44 feet in well 22-02-09, 42 to 59 feet in well 22-08-01, and 40 to 51 feet in well 22-08-12. Review of the raw SGLS data gathered from these intervals might provide supporting documentation for the hypothesized presence of Sb-125. Ruthenium-106 is hypothesized to have been present from 11 to 96 feet in the north part of the tank farm around the 109, 106, and 103 tanks and to the

south part of the tank farm, primarily around the 104 tank. Uranium-235/8 is identified in only one well, 22-11-08 from 56 to 66 feet. Europium-154 is identified in only one well, 22-03-09 from 0 to 11 feet.

Ruthenium-106 is not currently present above the detection threshold in any of the wells examined by the SGLS. This is due to the very rapid exponential decline over a short half-life of 1.02 years. Ruthenium-106 is hypothesized to have been present in 17 wells in 1975 and in one well in 1976 on the basis of the gross gamma ray data, the resulting GTP calculations that mimic the decay rate of Ru-106, and the inventory list of known radionuclides for that time period. It must be noted, however, that the method of fitting a decay curve to the observed GTP trend identifies only those contaminants that are not changing. Therefore, it is assumed that Ru-106 is present if the decay curve for Ru-106 matches the GTP plot. If any decay curve does not match, then the contaminants cannot be identified with this method without additional information. The isotopes identified with the SGLS are primarily found to be present under four subsurface conditions: stable, unstable/unstable early, tank farm activity, and undetermined. The location of wells labeled with the conditions of subsurface zones is shown in Figure 2. A different condition can be indicated for each zone within a well with multiple zones.

2.2.1 Tank Farm Activity:

An irregular change in the intensity of gross gamma rays between successive surveys at or near the surface suggest that contamination may be the result of tank farm activities or logging procedure changes and not vadose zone mechanics. Cs-137 exists near the surface in 47 wells, affecting as much as 30 feet below surface, apparently as the result of tank farm activities (i.e., logging procedure changes, transfer line operations, valve box and conduit leaks, spills, etc.). The wells affected by tank farm activities are listed in Table 3. Thirty three of these wells are or appear to be stable from 1986 to the end of gross gamma ray data collection and are labeled as such in the table. Thirty-five wells have additional radioactive zones at depth that are categorized according to the rate of change, if any, exhibited by the radionuclides present and are included in the discussions that follow.

Table 3. BY Tank Farm Activity Zones

Borehole Number	Total Depth feet	Subsurface Condition Category	Zone Depth feet	Max. GTP ft*c/s	Year Max. GTP	Isotopes Identified	Comment
22-00-04	100	TF Activity	0-10	200	1975	¹³⁷ Cs	
22-00-10	120	TF Activity	0-10	150	1975	¹³⁷ Cs	
22-01-01	100	TF Activity	0-6	400	1985	¹³⁷ Cs	
22-01-03	100	TF Activity	0-10	100	1975	¹³⁷ Cs	
22-01-04	100	TF Activity	0-15	1,700	1975	¹³⁷ Cs	
22-01-07	100	TF Activity	0-6	6,000	1975	¹³⁷ Cs	
22-01-10	100	TF Activity	0-10	1,500	1975	¹³⁷ Cs	
22-02-01	100	TF Activity	0-10	800	1985	¹³⁷ Cs	
		TF Activity	10-20	200	1984	¹³⁷ Cs	
22-02-02	100	TF Activity	0-6	600	1975	¹³⁷ Cs	
22-02-05	100	TF Activity	0-10	300	1975	¹³⁷ Cs	
22-02-07	150	TF Activity	0-10	200	1986	¹³⁷ Cs	No SGLS; high surface radiation area
22-02-09	100	TF Activity	0-10	400	1986	¹³⁷ Cs	
22-03-01	95	TF Activity	0-10	200	1986	¹³⁷ Cs	
22-03-04	100	TF Activity	0-10	900	1975	¹³⁷ Cs	
		TF Activity	10-30	800	1975	¹³⁷ Cs	
22-03-06	100	TF Activity	0-10	900	1975	¹³⁷ Cs	
22-03-07	100	TF Activity	0-8	100	1975	¹³⁷ Cs	
22-03-08	100	TF Activity	0-8	200	1975	¹³⁷ Cs	
22-03-09	100	TF Activity	0-11	2,000	1975	¹³⁷ Cs; ¹⁵⁴ Eu	
22-03-10	100-85	TF Activity	0-8	300	1975	¹³⁷ Cs	Borehole filled in to 85 feet in 1980
22-04-09	100-125	TF Activity	0-8	200	1984	¹³⁷ Cs	
22-04-11	100	TF Activity	0-8	200	1984	¹³⁷ Cs	
22-05-01	100	TF Activity	0-10	130,000	1985	¹³⁷ Cs	Some surveys are near count rate limits

22-05-05	100	TF Activity	0-10	120	1975	¹³⁷ Cs	
22-06-01	100	TF Activity	0-8	400	1984	¹³⁷ Cs	Very low levels after 1986
22-06-05	100	TF Activity	0-8	70	1975	¹³⁷ Cs	
22-06-07	140	TF Activity	0-8	200	1984	¹³⁷ Cs	
22-06-11	100	TF Activity	0-10	200	1975	¹³⁷ Cs	
22-07-01	100	TF Activity	0-10	300	1975	¹³⁷ Cs	
22-07-09	100	TF Activity	0-9	2,500	1984	¹³⁷ Cs	
22-07-10	97	TF Activity	0-6	1,500	1975	¹³⁷ Cs	
22-08-01	100	TF Activity	0-12	200,000	1989	¹³⁷ Cs	Count rate may have been exceeded
22-08-02	100	TF Activity	0-10	20,000	1993	¹³⁷ Cs	
22-08-05	100	TF Activity	0-8	200	1975	¹³⁷ Cs	
22-08-06	100	TF Activity	0-8	1,200	1975	¹³⁷ Cs	
		TF Activity	8-18	500	1975	¹³⁷ Cs	
22-08-07	135	TF Activity	0-8	500	1975	¹³⁷ Cs	
22-08-09	100	TF Activity	0-10	80,000	1984	¹³⁷ Cs	
22-08-12	105	TF Activity	0-8	10,000	1989	¹³⁷ Cs	
22-09-02	100	TF Activity	0-10	2,000	1975	¹³⁷ Cs	
		TF Activity	10-14	300	1975	¹³⁷ Cs	
22-09-05	100	TF Activity	0-10	100	1975	¹³⁷ Cs	
22-09-11	100	TF Activity	0-10	1,500	1975	¹³⁷ Cs	
22-10-09	100	TF Activity	0-10	20,000	1975	¹³⁷ Cs	
22-11-01	100	TF Activity	0-5	1,000	1975	¹³⁷ Cs	
		TF Activity	5-10	900	1975	¹³⁷ Cs	
22-11-05	100	TF Activity	0-10	3,000	1975	¹³⁷ Cs	
22-11-08	100	TF Activity	0-10	100	1975	¹³⁷ Cs	
22-11-09	100	TF Activity	0-8	8,000	1975	¹³⁷ Cs	
22-12-03	100	TF Activity	0-10	200,000	1980	¹³⁷ Cs	Count rate limits possibly exceeded
22-12-05	100	TF Activity	0-20	1,000	1975	¹³⁷ Cs	
22-12-06	100	TF Activity	0-20	8,000	1975	¹³⁷ Cs	
22-12-07	100	TF Activity	0-10	1,500	1984	¹³⁷ Cs	Mostly below detection limit except around 1985

*Stable or appears to be stable after 1986.

2.2.2 Undetermined:

Infrequently, the subsurface condition of a zone with radioactive contamination cannot be determined and the zone is therefore classified as undetermined. There are eight zones in seven wells examined that are undetermined (Table 4). These zones occur throughout the subsurface and have:

- Data that are too near or below the threshold for detection limits, or timeframe of data collection is too short to determine stability due to statistical variations
- Possibly been affected by depth shift or surface activities
- An isotope(s) that is not identified through SGLS analysis, and a decay curve for a hypothesized isotope that does not fit the GTP trend
- Data that were collected with inappropriate equipment.

Table 4. BY Undetermined Zones

Borehole Number	Total Depth feet	Subsurface Condition Category	Zone Depth feet	Max. GTP ft*c/s	Year Max. GTP	Isotopes Identified	Comment
22-00-02	100	Undetermined	45-56	1,300	1975	⁶⁰ Co; ¹²⁵ Sb	Unable to obtain a satisfactory decay curve fit to GTP plot
22-02-09	100	Undetermined	55-65	100	1975	⁶⁰ Co	Low levels near threshold of gross gamma ray detection
22-03-05	100	Undetermined	0-5	300	1984	¹³⁷ Cs	Lack of depth control at surface and short time span of data
22-03-09	100	Undetermined	11-24	2,600	1975	¹⁰⁶ Ru	Unable to obtain a satisfactory decay curve fit to GTP plot
22-04-11	100	Undetermined	90-100	1,000	1975	⁶⁰ Co	
22-07-05	100	Undetermined	90-100	500	1975	¹³⁷ Cs	
22-09-08	98	Undetermined	16-30	80,000	1985	¹³⁷ Cs	Count rate limits exceeded
22-09-08		Undetermined	76-90	100	1985	⁶⁰ Co	Levels below detection threshold

*Currently, isotopes cannot be identified from gross gamma ray data alone; therefore, isotopes with a rapid rate of decay, such as Ru-106, or at low enough levels to decay below detection limits, may not be identified if the period of instability is prior to the collection of SGLS data.

2.2.3 Stable:

The subsurface condition of a zone with radioactive contamination is considered stable when:

- The decay rate of the isotope(s) identified with SGLS and/or hypothesized to have been present matches the trend observed in the GTP of the gross gamma ray data
- Contaminants continue to decrease at a rate consistent with the isotope(s) half-life
- No noticeable change in concentration is apparent over the timeframe that data were collected.

Eighty zones are considered stable or apparently stable and are listed in Table 5. Stability is also assumed even if conditions are such that isotopes may be moving at a rate slow enough as to not be observed over the timeframe of gross gamma ray data collection. Currently, there is no way to know the condition prior to or after the data collection period. If a new driver were introduced, such as the influx of a large volume of liquid, contamination could be remobilized. Given the current data, it cannot be determined if remobilization will occur or not, or whether contaminants are currently mobile and changing at levels below detection by the logging system.

Table 5. BY Stable Zones

Borehole Number	Total Depth feet	Subsurface Condition Category	Zone Depth feet	Max. GTP ft*c/s	Year Max. GTP	Isotopes Identified
22-00-01	140	*Stable	40-65	250	1975	¹³⁷ Cs
		Stable	70-84	70	1975	¹³⁷ Cs
		Stable	84-100	70	1975	¹³⁷ Cs
22-00-02	100	Stable	0-14	600	1975	¹³⁷ Cs
		Stable	56-64	1,200	1975	Sb ¹²⁵ ; ¹⁰⁶ Ru
22-00-03	145	Stable	40-80	3,000	1975	⁶⁰ Co; ¹²⁵ Sb
		Stable	117-128	1,800	1975	⁶⁰ Co
		Stable	128-140	1,100	1975	⁶⁰ Co; ¹²⁵ Sb
22-00-04	100	Stable	48-70	500	1975	⁶⁰ Co; ¹²⁵ Sb
		Stable	70-85	1,000	1975	⁶⁰ Co; ¹⁰⁶ Ru
22-01-01	100	*Appear stable	6-15	50	1975	¹³⁷ Cs
22-01-04	100	Stable	15-30	16,000	1975	¹³⁷ Cs
		Stable	30-60	1,400	1975	⁶⁰ Co; ¹²⁵ Sb
22-01-07	100	Stable	6-15	100	1975	¹³⁷ Cs
		Stable	40-55	100	1975	⁶⁰ Co
22-01-10	100	Stable	15-25	500	1975	¹³⁷ Cs

		Stable	25-44	550	1975	¹³⁷ Cs; ⁶⁰ Co
22-02-01	100	Stable	40-53	3,200	1975	¹³⁷ Cs
		Stable	55-75	200	1975	⁶⁰ Co; ¹⁰⁶ Ru
		Stable	80-96	550	1975	⁶⁰ Co; ¹⁰⁶ Ru
22-02-02	100	Stable	6-18	300	1975	¹³⁷ Cs
22-02-09	100	Stable	20-26	200	1975	¹²⁵ Sb
		Stable	26-34	450	1975	¹²⁵ Sb; ¹⁰⁶ Ru
		Stable	34-44	1,800	1975	¹²⁵ Sb; ¹⁰⁶ Ru
		Stable	44-52	2,500	1975	¹³⁷ Cs; ⁶⁰ Co; ¹⁰⁶ Ru
22-03-04	100	Stable	40-55	2,800	1975	¹²⁵ Sb
		Stable	55-85	900	1975	⁶⁰ Co; ¹²⁵ Sb
22-03-05	100	Stable	5-15	350	1980	¹³⁷ Cs
		Stable	15-60	170,000	1980	¹³⁷ Cs
		Stable	60-85	1,700	1980	¹³⁷ Cs
22-03-06	100	Appear stable	20-28	2,300	1975	¹³⁷ Cs
		Stable	37-48	13,000	1975	¹³⁷ Cs; ⁶⁰ Co; ¹²⁵ Sb
		Stable	48-60	2,400	1975	¹²⁵ Sb; ¹⁰⁶ Ru
		Stable	60-94	4,300	1975	⁶⁰ Co; ¹²⁵ Sb; ¹⁰⁶ Ru
		Stable	94-100	1,000	1975	¹²⁵ Sb
22-03-07	100	Stable	47-62	1,300	1975	⁶⁰ Co; ¹²⁵ Sb
		Stable	62-90	1,100	1975	⁶⁰ Co; ¹⁰⁶ Ru
22-03-08	100	Stable	40-60	1,300	1975	⁶⁰ Co; ¹⁰⁶ Ru
		Appear stable	80-98	100	1975	⁶⁰ Co
22-03-10	100-85	Stable	8-30	170	1975	¹³⁷ Cs
22-04-01	100	Appear stable	20-35	250	1975	¹⁰⁶ Ru
		Stable	35-45	150	1975	¹⁰⁶ Ru
22-04-09	100-125	Stable	105-120	500	1984	⁶⁰ Co
22-04-11	100	Stable	10-25	200	1975	¹³⁷ Cs
		Stable	25-50	1,500	1975	¹⁰⁶ Ru
22-06-01	100	Stable	42-52	200	1975	¹²⁵ Sb
		Stable	52-65	600	1975	⁶⁰ Co; ¹⁰⁶ Ru
22-06-05	100	Appear stable	28-36	500	1975	⁶⁰ Co; ¹²⁵ Sb
22-07-01	100	Stable	52-70	3,500	1975	⁶⁰ Co
		Stable	70-92	3,000	1975	⁶⁰ Co
22-07-02	100	Appear stable	6-20	200	1975	¹³⁷ Cs
22-07-09	100	Stable	9-17	1,400	1975	¹³⁷ Cs
		Appear stable	17-36	50,000	1975	¹³⁷ Cs
22-07-10	97	Stable	6-12	2,000	1975	¹³⁷ Cs
		Stable	12-20	1,400	1975	¹³⁷ Cs
		Stable	20-30	1,600	1975	¹³⁷ Cs
		Stable	30-44	1,400	1975	¹³⁷ Cs
22-08-01	100	Stable	22-32	500	1976	⁶⁰ Co; ¹²⁵ Sb
		Stable	32-42	2,400	1976	⁶⁰ Co; ¹²⁵ Sb
		Stable	42-59	25,000	1975	⁶⁰ Co; ¹²⁵ Sb
22-08-02	100	Stable	20-30	1,000	1975	¹²⁵ Sb
	100	Stable	36-45	250	1975	⁶⁰ Co
		Stable	45-53	700	1975	⁶⁰ Co
		Stable	53-56	1,000	1975	⁶⁰ Co
22-08-06	100	Stable	18-29	400	1975	¹³⁷ Cs

		Stable	46-54	150	1975	¹³⁷ Cs; ⁶⁰ Co
		Stable	54-63	200	1975	⁶⁰ Co
		Stable	63-73	900	1975	⁶⁰ Co
22-09-01	100	Stable	24-35	250	1984	¹⁰⁶ Ru
		Stable	40-55	2,200	1975	¹²⁵ Sb; ¹⁰⁶ Ru
22-09-02	100	Stable	14-34	1,200	1975	¹³⁷ Cs
		Stable	42-64	500	1975	¹⁰⁶ Ru
22-09-05	100	Stable	40-58	250	1975	¹³⁷ Cs; ¹²⁵ Sb
22-09-08	98	Stable	43-52	150	1981	⁶⁰ Co
22-09-11	100	Stable	16-25	300	1975	¹³⁷ Cs; ¹²⁵ Sb
		Stable	25-38	450	1975	¹⁰⁶ Ru
22-10-05	100	Stable	45-55	200	1975	⁶⁰ Co
22-11-08	100	Stable	56-66	120	1975	⁶⁰ Co; ²³⁸ U
22-11-09	100	Stable	24-34	450	1975	⁶⁰ Co
22-12-03	100	Stable	10-20	300	1975	¹³⁷ Cs

*The decay rate of the isotope(s) identified in the zone matches the change in concentration of the isotope(s) as measured over time, and no noticeable deviation from the match is apparent within the timeframe that gross gamma ray data were collected.

†The decay rate of the isotope(s) identified in the zone appears to match the change in concentration of the isotope(s) as measured over time, but stability cannot be rigorously determined.

*Currently, isotopes cannot be identified from gross gamma ray data alone; therefore, isotopes with a rapid rate of decay, such as Ru-106, or at low enough levels to decay below detection limits, may not be identified when SGLS data were obtained.

2.2.4 Unstable:

The condition of a subsurface zone with radioactive contamination is considered unstable when, at some point within the timeframe of data collection, contamination was not decreasing at the decay rate of the isotope(s) identified with SGLS. In this case, the decay curve does not match the trend observed in the GTP of the data. In the BY Tank Farm, 34 zones in 26 wells are identified which exhibit periods of instability early in the timeframe (prior to 1990) that gross gamma ray data were collected. Most of these unstable zones have since developed a consistent rate of decrease through when the last data were collected. Many of the unstable zones have decayed to levels too low to determine stability and are therefore called unstable. Four wells appear to have contamination that has moved below the bottom of the well: 22-03-09, 22-07-02, 22-07-09, and 22-08-02. The estimated rate of movement of the contamination in well 22-03-09 appears to be about 2 feet per year. See Table 6 for list of unstable zones.

Downward movement is seen for the first time in the BY Tank Farm analysis report in 13 wells. Well 22-06-07 also appears to exhibit lateral movement into the zone from 52 to 80 feet. Downward movement is typically identified in the stack plot by an apparent widening of a depth zone of contamination over time. Lateral movement is postulated when the decay curve of isotopes known to be present in the well do not match the GTP plot of the gross gamma ray data and the stack plot does not indicate downward movement. Due to the limited range in distance around the borehole that the logging instruments can record information for, it is not possible to identify if downward movement is restricted to the annulus of the borehole or in the formation adjacent to it. It is also not possible to identify if the contamination is coming from outside of the area of the borehole, or whether it is coming from above or below the contaminated zone within the well area.

Table 6. BY Unstable Zones

Borehole Number	Total Depth feet	Subsurface Condition Category	Zone Depth feet	Max. GTP n°c/s	Year Max. GTP	Isotopes Identified	Comment
22-00-02	100	Unstable	64-96	1,800	1975	⁶⁰ Co	Downward movement at low levels
22-00-03	145	Unstable early	80-117	12,000	1975	⁶⁰ Co	
22-03-09	100	Unstable early	24-52	29,000	1976	⁶⁰ Co; ¹¹³ Sb; ¹⁰⁶ Ru	
		Unstable	48-95	15,000	1976	⁶⁰ Co; ¹¹³ Sb	Downward movement below bottom of well in 1993. Appears to be moving at an estimated rate of 2 feet per year
22-04-09	100-125	Unstable early	75-95	1,800	1980	⁶⁰ Co	
22-05-09	100	Unstable early; undetermined late	55-90	1,000	1975	⁶⁰ Co	Downward movement
22-06-05	100	Unstable	40-84	10,000	1984	⁶⁰ Co; ¹¹³ Sb	Downward movement
22-06-07	140	Unstable early	40-52	300	1975	¹³⁷ Cs	
		Unstable early	52-80	1,100	1979	⁶⁰ Co	Downward and lateral movement
22-06-09	100	Unstable early	70-90	650	1975	¹⁰⁶ Ru	
22-07-01	100	Unstable early	40-52	800	1976	¹³⁷ Cs	
22-07-02	100	Unstable early	42-95	2,800	1976	⁶⁰ Co	May be downward movement along casing; contaminant may be below bottom of well
22-07-05	100	Unstable early	40-78	3,800	1975	⁶⁰ Co	Downward movement within the zone from 42 to 65 feet
22-07-07	100	Unstable early	30-54	2,500	1975	¹³⁷ Cs; ¹¹³ Sb; ¹⁰⁶ Ru	
		Unstable	80-98	1,800	1976	⁶⁰ Co; ¹¹³ Sb	Stable since 1983 or 1990
22-07-09	100	Unstable	62-100	2,200	1976	¹³⁷ Cs; ⁶⁰ Co	Downward movement to below well bottom in 1990
22-08-01	100	Unstable	59-95	12,000	1975	⁶⁰ Co; ¹¹³ Sb	Movement of isotopes is unclear; stable from 1985 to 1994
22-08-02	100	Unstable	44-100	15,000	1975	⁶⁰ Co; ¹¹³ Sb	Downward movement, possibly below bottom of borehole
22-08-05	100	Unstable early	63-84	900	1975	⁶⁰ Co	Downward movement
22-08-06	100	Unstable early	73-83	450	1975	⁶⁰ Co	Levels too low to identify downward movement
22-08-09	100	Unstable early	72-84	150	1975	¹³⁷ Cs; ¹⁰⁶ Ru	
22-08-12	105	Unstable early	25-40	300	1980	¹³⁷ Cs	¹³⁷ Cs decay curve does not fit GTP plot
		Unstable early	40-51	3,000	1975	⁶⁰ Co; ¹¹³ Sb	
		Unstable early	51-60	3,000	1975	⁶⁰ Co	Possible downward movement
		Unstable early	60-82	1,000	1976	⁶⁰ Co	Downward movement within the zone
22-09-07	100	Unstable early	20-40	12,000	1975	¹⁰⁶ Ru	
		Unstable early	40-50	9,000	1976	¹⁰⁶ Ru	
		Unstable early	50-64	2,700	1976	¹¹³ Sb; ¹⁰⁶ Ru	
22-09-11	100	Unstable early	38-52	3,500	1975	¹⁰⁶ Ru	
22-10-05	100	Unstable early	55-75	300	1979	⁶⁰ Co	
22-10-07	100	Unstable early	45-65	200	1983	⁶⁰ Co	
22-10-10	100	Unstable early	58-76	1,500	1975	⁶⁰ Co	
22-11-01	100	Unstable	19-28	4,000	1984	¹³⁷ Cs	
22-11-09	100	Unstable early	34-46	250	1975	⁶⁰ Co	

Currently, isotopes cannot be identified from gross gamma ray data alone; therefore, isotopes with a rapid rate of decay, such as Ru-106, or at low enough levels to decay below detection limits, may not be identified if the period of instability is prior to the collection of SGLS data.

3.0 Details of Contaminated Conditions

3.1 Stable Zones:

Many zones within a number of wells exhibit gross gamma ray activity above natural background. Eighty of these radioactive intervals are observed to be stable as verified by the change in GTP over time coinciding with the decay rate of the isotope(s) identified with SGLS as, or hypothesized to have been present in the well within the timeframe data were collected. The isotopes present in these stable zones vary and are presented in Table 1. In general, they occur as follows:

- Cs-137 occurs as nearly the only man-made isotope present from 0 to 20 feet, and with other isotopes at depth.
- Co-60 occurs as the only man-made isotope present in 46 zones, less commonly with other isotopes.
- Sb-125 is usually present with other isotopes, occasionally by itself.
- Ru-106 is hypothesized to exist early in the history of a well with other isotopes or by itself.
- U-235/8 appears only once to the southwest of the 111 tank.
- Eu-154 appears only once to the west of the 103 tank.

The fixed decay rate of the isotope(s) present is used to calculate the decay line (Figure 3). Table 7 illustrates the half-life of the isotopes encountered in this tank farm. When a contaminated interval contains multiple isotopes, the intensity of each isotope is included in the calculation for the decay curve that is then overlain on the GTP plot. When the decay curve does not fit with the GTP values over the entire timeframe, then it is usually fit to the later years in order to align the data so trends can be observed. When the decay curve fits the GTP plot, a stable condition is said to exist. When the decay curve does not fit the GTP plot, stability cannot be established.

Table 7. Half-life of Isotopes Identified or Hypothesized to be present in the BY Tank Farm

Isotope	Half-life Years
¹³⁷ Cs	30.17
⁶⁰ Co	5.27
¹²⁵ Sb	2.77
¹⁵⁴ Eu	8.5
^{235/8} U	7.00E+08/4.7E+09
¹⁰⁶ Ru	1.02

3.2 Depth of Contamination:

The range in depth of contamination is variable throughout the BY Tank Farm as determined by gross gamma ray logging, which is less sensitive than SGLS analysis. The following general statements are from review of the gross gamma ray logging data. In general, Cs-137 occurs in the top 20 feet of the subsurface throughout the tank farm. Contamination is deepest and mostly continuous from surface to total depth of logging around tank 103 in the northeast corner of the tank farm and shallowest in the northwest corner of the tank farm around tank 112. Contamination is also deep around the 109, 108, and 107 tanks. Contamination commonly occurs from 40 to 80 feet throughout the farm, often as deep as 100 feet at various locations. The top of contamination identified in wells within the BY Tank Farm is shown in Figure 4, and the bottom of the contamination identified in these wells is shown in Figure 5. The range in depth of contamination varies according to localized areas of the tank farm. A significant portion of the contamination appears in two zones separated by 10 to 30 feet. The top zone is usually from surface to 10 feet, with the top of the second zone starting at 20 to 40 feet and ending at 80 to 100 feet. The majority of these split zones occur around the 103 tank and on all sides of the 107, 108, and 109 tanks and around the 111 tank. Occasionally, wells have contamination from surface to 40 or 60 feet. These occur primarily at the east-end of the tank farm.

Caution must be used when relating GTP values in zones recorded with different probe types since they were designed to read different intensities of contamination. There are isolated areas of high GTP throughout the tank

farm, surrounded by areas of lower level contamination. Well 22-03-05 stands out as one with very high GTP over several depth intervals. It has GTP values that range from 350 to 170,000 ft*c/s detected with the Green GM probe, over a depth range from 0 to 85 feet. A series of wells located between the 112, 109, 108, and 105 tanks also have high GTP values ranging from 10,000 to 200,000 ft*c/s with data collected using the NaI probe. Many of the high readings taken with both the Green GM and the NaI probes were obtained even though the readings exceeded or nearly exceeded the upper detection threshold. The distribution of GTP values with depth range (in order of depth range) and contributing isotope(s) is shown in Table 8. Figure 6 shows the location and GTP values for these wells. Wells with contamination in excess of 10,000 ft*c/s are presented in Figure 7. These higher levels of contamination occur primarily from the west side of the 109 tank to the east side of the 108 tank and to the west and southeast of the 103 tank.

Table 8. BY Tank Farm Isotope Depth Range

Borehole Number	*Probe Type	Zone Depth feet	Max. GTP ft*c/s	Year Max. GTP	Isotopes Identified				
22-00-05	No data								
22-03-05	1	0-5	300	1984	¹³⁷ Cs				
22-11-01	4	0-5	1,000	1975	¹³⁷ Cs				
22-01-01	4	0-6	400	1985	¹³⁷ Cs				
22-02-02	4	0-6	600	1975	¹³⁷ Cs				
22-07-10	4	0-6	1,500	1975	¹³⁷ Cs				
22-01-07	4	0-6	6,000	1975	¹³⁷ Cs				
22-06-05	4	0-8	70	1975	¹³⁷ Cs				
22-03-07	4	0-8	100	1975	¹³⁷ Cs				
22-03-08	4	0-8	200	1975	¹³⁷ Cs				
22-04-09	4	0-8	200	1984	¹³⁷ Cs				
22-04-11	4	0-8	200	1984	¹³⁷ Cs				
22-06-07	4	0-8	200	1984	¹³⁷ Cs				
22-08-05	4	0-8	200	1975	¹³⁷ Cs				
22-03-10	4	0-8	300	1975	¹³⁷ Cs				
22-06-01	4	0-8	400	1984	¹³⁷ Cs				
22-08-07	4	0-8	500	1975	¹³⁷ Cs				
22-08-06	4	0-8	1,200	1975	¹³⁷ Cs				
22-11-09	4	0-8	8,000	1975	¹³⁷ Cs				
22-08-12	4	0-8	10,000	1989	¹³⁷ Cs				
22-07-09	4	0-9	2,500	1984	¹³⁷ Cs				
22-01-03	4	0-10	100	1975	¹³⁷ Cs				
22-09-05	4	0-10	100	1975	¹³⁷ Cs				
22-11-08	4	0-10	100	1975	¹³⁷ Cs				
22-05-05	4	0-10	120	1975	¹³⁷ Cs				
22-00-10	4	0-10	150	1975	¹³⁷ Cs				
22-00-04	4	0-10	200	1975	¹³⁷ Cs				
22-02-07	4	0-10	200	1986	¹³⁷ Cs				
22-03-01	4	0-10	200	1986	¹³⁷ Cs				
22-06-11	4	0-10	200	1975	¹³⁷ Cs				
22-02-05	4	0-10	300	1975	¹³⁷ Cs				
22-07-01	4	0-10	300	1975	¹³⁷ Cs				
22-02-09	4	0-10	400	1986	¹³⁷ Cs				
22-02-01	4	0-10	800	1985	¹³⁷ Cs				
22-03-04	4	0-10	900	1975	¹³⁷ Cs				
22-03-06	4	0-10	900	1975	¹³⁷ Cs				
22-01-10	4	0-10	1,500	1975	¹³⁷ Cs				

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22-09-11	4	0-10	1,500	1975	¹³⁷ Cs						
22-12-07	4	0-10	1,500	1984	¹³⁷ Cs						
22-09-02	4	0-10	2,000	1975	¹³⁷ Cs						
22-11-05	4	0-10	3,000	1975	¹³⁷ Cs						
22-08-02	4	0-10	20,000	1993	¹³⁷ Cs						
22-10-09	4	0-10	20,000	1975	¹³⁷ Cs						
22-08-09	4	0-10	80,000	1984	¹³⁷ Cs						
22-05-01	4	0-10	130,000	1985	¹³⁷ Cs						
22-12-03	4	0-10	200,000	1980	¹³⁷ Cs						
22-03-09	4	0-11	2,000	1975	¹³⁷ Cs					¹⁵⁴ Eu	
22-08-01	4	0-12	200,000	1989	¹³⁷ Cs						
22-00-02	4	0-14	600	1975	¹³⁷ Cs						
22-01-04	4	0-15	1,700	1975	¹³⁷ Cs						
22-12-05	4	0-20	1,000	1975	¹³⁷ Cs						
22-12-06	4	0-20	8,000	1975	¹³⁷ Cs						
22-11-01	4	5-10	900	1975	¹³⁷ Cs						
22-03-05	1	5-15	350	1980	¹³⁷ Cs						
22-07-10	4	6-12	2,000	1975	¹³⁷ Cs						
22-01-01	4	6-15	50	1975	¹³⁷ Cs						
22-01-07	4	6-15	100	1975	¹³⁷ Cs						
22-02-02	4	6-18	300	1975	¹³⁷ Cs						
22-07-02	4	6-20	200	1975	¹³⁷ Cs						
22-08-06	4	8-18	500	1975	¹³⁷ Cs						
22-03-10	4	8-30	170	1975	¹³⁷ Cs						
22-07-09	4	9-17	1,400	1975	¹³⁷ Cs						
22-09-02	4	10-14	300	1975	¹³⁷ Cs						
22-02-01	4	10-20	200	1984	¹³⁷ Cs						
22-12-03	4	10-20	300	1975	¹³⁷ Cs						
22-04-11	4	10-25	200	1975	¹³⁷ Cs						
22-03-04	4	10-30	800	1975	¹³⁷ Cs						
22-03-09	4	11-24	2,600	1975				¹⁰⁶ Ru			
22-07-10	4	12-20	1,400	1975	¹³⁷ Cs						
22-09-02	4	14-34	1,200	1975	¹³⁷ Cs						
22-01-10	4	15-25	500	1975	¹³⁷ Cs						
22-01-04	4	15-30	16,000	1975	¹³⁷ Cs						
22-03-05	1	15-60	170,000	1980	¹³⁷ Cs						
22-09-11	4	16-25	300	1975	¹³⁷ Cs		¹²⁵ Sb				
22-09-08	4	16-30	80,000	1985	¹³⁷ Cs						
22-07-09	4	17-36	50,000	1975	¹³⁷ Cs						
22-08-06	4	18-29	400	1975	¹³⁷ Cs						
22-11-01	4	19-28	4,000	1984	¹³⁷ Cs						
22-02-09	4	20-26	200	1975			¹²⁵ Sb				
22-03-06	4	20-28	2,300	1975	¹³⁷ Cs						
22-08-02	4	20-30	1,000	1975			¹²⁵ Sb				
22-07-10	4	20-30	1,600	1975	¹³⁷ Cs						
22-04-01	4	20-35	250	1975				¹⁰⁶ Ru			
22-09-07	4	20-40	12,000	1975				¹⁰⁶ Ru			
22-08-01	4	22-32	500	1976		⁶⁰ Co	¹²⁵ Sb				
22-03-09	4	24-52	29,000	1976		⁶⁰ Co					

22-11-09	4	24-34	450	1975		⁶⁰ Co				
22-09-01	4	24-35	250	1984				¹⁰⁶ Ru		
22-09-11	4	25-38	450	1975				¹⁰⁶ Ru		
22-08-12	4	25-40	300	1980	¹³⁷ Cs					
22-01-10	4	25-44	550	1975	¹³⁷ Cs	⁶⁰ Co				
22-04-11	4	25-50	1,500	1975				¹⁰⁶ Ru		
22-02-09	4	26-34	450	1975			¹²⁵ Sb	¹⁰⁶ Ru		
22-06-05	4	28-36	500	1975		⁶⁰ Co	¹²⁵ Sb			
22-07-10	4	30-44	1,400	1975	¹³⁷ Cs					
22-07-07	4	30-54	2,500	1975	¹³⁷ Cs		¹²⁵ Sb	¹⁰⁶ Ru		
22-01-04	4	30-60	1,400	1975		⁶⁰ Co	¹²⁵ Sb			
22-08-01	4	32-42	2,400	1976		⁶⁰ Co	¹²⁵ Sb			
22-02-09	4	34-44	1,800	1975			¹²⁵ Sb	¹⁰⁶ Ru		
22-11-09	4	34-46	250	1975		⁶⁰ Co				
22-04-01	4	35-45	150	1975				¹⁰⁶ Ru		
22-08-05	4	36-45	250	1975		⁶⁰ Co				
22-03-06	4	37-48	13,000	1975	¹³⁷ Cs	⁶⁰ Co	¹²⁵ Sb			
22-09-11	4	38-52	3,500	1975				¹⁰⁶ Ru		
22-09-07	4	40-50	9,000	1976				¹⁰⁶ Ru		
22-08-12	4	40-51	3,000	1975		⁶⁰ Co	¹²⁵ Sb			
22-06-07	4	40-52	300	1975	¹³⁷ Cs					
22-07-01	4	40-52	800	1976	¹³⁷ Cs					
22-02-01	4	40-53	3,200	1975	¹³⁷ Cs					
22-01-07	4	40-55	200	1975		⁶⁰ Co				
22-09-01	4	40-55	2,200	1975			¹²⁵ Sb	¹⁰⁶ Ru		
22-03-04	4	40-55	2,800	1975			¹²⁵ Sb			
22-07-05	4	40-57	3,800	1975		⁶⁰ Co				
22-09-05	4	40-58	250	1975	¹³⁷ Cs		¹²⁵ Sb			
22-03-08	4	40-60	1,300	1975		⁶⁰ Co		¹⁰⁶ Ru		
22-00-01	4	40-65	250	1975	¹³⁷ Cs					
22-00-03	4	40-80	3,000	1975		⁶⁰ Co	¹²⁵ Sb			
22-06-01	4	42-52	200	1975		⁶⁰ Co				
22-08-01	4	42-59	25,000	1975		⁶⁰ Co	¹²⁵ Sb			
22-09-02	4	42-64	500	1975				¹⁰⁶ Ru		
22-09-08	4	43-52	150	1981		⁶⁰ Co				
22-02-09	4	44-52	2,500	1975	¹³⁷ Cs	⁶⁰ Co		¹⁰⁶ Ru		
22-08-02	4	44-60	15,000	1975		⁶⁰ Co	¹²⁵ Sb			
22-08-05	4	45-53	700	1975		⁶⁰ Co				
22-10-05	4	45-55	200	1975		⁶⁰ Co				
22-00-02	4	45-56	1,300	1975		⁶⁰ Co	¹²⁵ Sb			
22-10-07	4	45-65	200	1983		⁶⁰ Co				
22-07-02	4	42-95	2,800	1976		⁶⁰ Co				
22-08-06	4	46-54	150	1975	¹³⁷ Cs	⁶⁰ Co				
22-03-07	4	47-62	1,300	1975		⁶⁰ Co	¹²⁵ Sb			
22-03-06	4	48-60	2,400	1975			¹²⁵ Sb	¹⁰⁶ Ru		
22-00-04	4	48-70	500	1975		⁶⁰ Co	¹²⁵ Sb			
22-09-07	4	50-64	2,700	1976			¹²⁵ Sb	¹⁰⁶ Ru		
22-08-12	4	51-60	3,000	1975		⁶⁰ Co				
22-06-01	4	52-65	600	1975		⁶⁰ Co		¹⁰⁶ Ru		

22-07-01	4	52-70	3,500	1975		⁶⁰ Co				
22-06-07	4	52-80	1100	1979		⁶⁰ Co				
22-08-05	4	53-56	1,000	1975		⁶⁰ Co				
22-08-06	4	54-63	200	1975		⁶⁰ Co				
22-02-09	4	55-65	100	1975		⁶⁰ Co				
22-05-09	4	55-90	1,000	1975		⁶⁰ Co				
22-02-01	4	55-75	200	1975				¹⁰⁶ Ru		
22-10-05	4	55-75	300	1979		⁶⁰ Co				
22-03-04	4	55-85	900	1975		⁶⁰ Co				
22-00-02	4	56-64	1,200	1975			¹²⁵ Sb	¹⁰⁶ Ru		
22-11-08	4	56-66	120	1975		⁶⁰ Co			²³⁵ U	
22-07-05	4	57-65	1,200	1982		⁶⁰ Co				
22-10-10	4	58-76	1,500	1975		⁶⁰ Co				
22-08-01	4	59-82	12,000	1975		⁶⁰ Co	¹²⁵ Sb			
22-08-12	4	60-70	1,000	1976		⁶⁰ Co				
22-03-05	1	60-85	1,700	1980	¹³⁷ Cs					
22-03-06	4	60-94	4,300	1975		⁶⁰ Co	¹²⁵ Sb	¹⁰⁶ Ru		
22-08-02	4	62-72	10,000	1976		⁶⁰ Co	¹²⁵ Sb			
22-07-09	4	62-74	2,200	1976	¹³⁷ Cs					
22-03-07	4	62-90	1,100	1975		⁶⁰ Co		¹⁰⁶ Ru		
22-08-06	4	63-73	900	1975		⁶⁰ Co				
22-08-05	4	63-74	900	1975		⁶⁰ Co				
22-06-05	4	64-84	3,700	1984		⁶⁰ Co				
22-00-02	4	64-96	1,800	1975		⁶⁰ Co				
22-07-05	4	65-78	900	1986		⁶⁰ Co				
22-08-12	4	70-82	500	1980		⁶⁰ Co				
22-00-01	4	70-84	70	1975	¹³⁷ Cs					
22-00-04	4	70-85	1,000	1975		⁶⁰ Co		¹⁰⁶ Ru		
22-06-09	4	70-90	650	1975				¹⁰⁶ Ru		
22-07-01	4	70-92	3,000	1975		⁶⁰ Co				
22-08-09	4	72-84	150	1975	¹³⁷ Cs			¹⁰⁶ Ru		
22-08-02	4	72-84	4,000	1985		⁶⁰ Co				
22-08-06	4	73-83	450	1975		⁶⁰ Co				
22-08-05	4	74-84	200	1991		⁶⁰ Co				
22-07-09	4	74-84	1,200	1982		⁶⁰ Co				
22-04-09	4	75-95	1,800	1980		⁶⁰ Co				
22-09-08	4	76-90	100	1985		⁶⁰ Co				
22-03-09	4	78-82	16,000	1976		⁶⁰ Co				
22-03-09	4	48-95	5,000	1979		⁶⁰ Co				
22-02-01	4	80-96	550	1975		⁶⁰ Co		¹⁰⁶ Ru		
22-03-08	4	80-98	100	1975		⁶⁰ Co				
22-07-07	4	80-98	1,800	1976		⁶⁰ Co	¹²⁵ Sb			
22-00-03	4	80-117	12,000	1975		⁶⁰ Co				
22-08-01	4	82-95	450	1987		⁶⁰ Co	¹²⁵ Sb			
22-07-09	4	84-94	1,000	1985		⁶⁰ Co				
22-00-01	4	84-100	70	1975	¹³⁷ Cs					
22-08-02	4	84-100	3,000	1975		⁶⁰ Co				
22-07-05	4	90-100	500	1975	¹³⁷ Cs					
22-04-11	4	90-100	1,000	1975		⁶⁰ Co				

22-07-09	4	94-100	900	1986		⁶⁰ Co				
22-03-06	4	94-100	1,000	1975			¹²⁵ Sb			
22-04-09	4	105-120	500	1984		⁶⁰ Co				
22-00-03	4	117-128	1,800	1975		⁶⁰ Co				
22-00-03	4	128-140	1,100	1975		⁶⁰ Co	¹²⁵ Sb			

*Probe type: 1 = Green GM, moderately sensitive; reads moderate levels of gamma ray activity.

4 = NaI, most sensitive, reads lowest level of gamma ray activity.

Caution must be used when relating GTP values in zones recorded with different probe types.

*Currently, isotopes cannot be identified from gross gamma ray data alone; therefore, isotopes with a rapid rate of decay, such as Ru-106, or at low enough levels to decay below detection limits, may not be identified if the period of instability is prior to the collection of SGLS data.

3.3 Isotopes Identified:

Seven man-made isotopes are known or hypothesized to be present in the BY Tank Farm at or above the detection limit for the gross gamma ray logging equipment. They are listed in Table 7 along with their half-life. Cesium-137 and Co-60 are the most common isotopes found in the BY Tank Farm and occur throughout the farm at varying depths and intensities. The Cs-137 occurs primarily in the top 20 feet of the subsurface usually by itself, and Co-60 occurs from 20 to 140 feet, often by itself but commonly with other isotopes. It is found deeper than 100 feet in only two wells: 22-00-03 and 22-04-09. Antimony-125 occurs between 16 and 140 feet and is localized primarily at the southeast side of the 103 tank and the southeast and north regions of the 109 tank. Antimony-125 is identified in only six wells; the rest of the occurrences are hypothesized. Only in well 22-00-03 is Sb-125 hypothesized to occur deeper than 100 feet. Uranium-235/8 appears only once at 56 to 66 feet in well number 22-11-08. Europium-154 appears only once at 0 to 11 feet in well number 22-03-09. Ruthenium-106 is hypothesized to have been present in a number of wells, mostly around the 109 and 103 tanks with some occurrences in the southeast end of the tank farm. The half-life of Ru-106 is short (1.02 years) and Ru-106 is no longer detectable in the wells by the HPGe detector. However, it was an inventoried isotope and the decay line calculated for Ru-106 matches well with the GTP calculations in most wells. The distribution and depth to top of the isotopes that occur in the BY Tank Farm are shown in Figure 4.

3.4 Timeframe:

The time range over which data were evaluated is limited from when gross gamma ray digital data were first captured in 1975 to the last digital data-collecting event in 1994. Three general conditions are observed concerning the life cycle of contamination events with respect to the timeframe in which digital data are available for analysis. Within this timeframe, the data appear to represent:

- The middle or end of a period (initiated prior to inception of digital data collection) where subsurface conditions were unstable and the beginning of apparent stability.
- Stable subsurface conditions at the beginning of data collection, whereby an unstable condition develops (indicated by a rate of change that is inconsistent with the decay rate of known isotopes in the well), followed by apparent stability.
- Stable subsurface conditions at the beginning of data collection, whereby an unstable condition develops (indicated by a rate of change that is inconsistent with the decay rate of known isotopes in the well) that does not become stable within the timeframe of data collection.

There is insufficient information available to determine if contamination at depth may be the result of well installation activities.

Usually, the maximum GTP calculated for the gross gamma ray data seems to coincide with the start of digital data collection. The exceptions are listed in Table 9.

Table 9. BY Tank Farm Zones with Highest GTP After Start of Data Collection

Borehole Number	Total Depth feet	Subsurface Condition Category	Zone Depth feet	Max. GTP ft*c/s	Year Max. GTP	Isotopes Identified
22-01-01	100	TF Activity	0-6	400	1985	¹³⁷ Cs
22-02-01	100	TF Activity	0-10	800	1985	¹³⁷ Cs
		TF Activity	10-20	200	1984	¹³⁷ Cs
22-02-07	150	TF Activity	0-10	200	1986	¹³⁷ Cs
22-02-09	100	TF Activity	0-10	400	1986	¹³⁷ Cs
22-03-01	95	TF Activity	0-10	200	1986	¹³⁷ Cs
22-03-05	100	Undetermined	0-5	300	1984	¹³⁷ Cs
22-03-09	100	Unstable early	24-52	29,000	1976	⁶⁰ Co; ¹²⁵ Sb; ¹⁰⁶ Ru
		Unstable	48-95	16,000	1976	⁶⁰ Co; ¹²⁵ Sb
22-04-09	100-125	TF Activity	0-8	200	1984	¹³⁷ Cs
		Unstable early	75-95	1,800	1980	⁶⁰ Co
		Stable	105-120	500	1984	⁶⁰ Co
22-04-11	100	TF Activity	0-8	200	1984	¹³⁷ Cs
22-05-01	100	TF Activity	0-10	130,000	1985	¹³⁷ Cs
22-06-01	100	TF Activity	0-8	400	1984	¹³⁷ Cs
22-06-07	140	TF Activity	0-8	200	1984	¹³⁷ Cs
		Unstable early	52-80	1,100	1979	⁶⁰ Co
22-07-01	100	Unstable early	40-52	800	1976	¹³⁷ Cs
22-07-02	100	Unstable	42-95	2,800	1976	⁶⁰ Co
22-07-07	100	Unstable	80-98	1,800	1976	⁶⁰ Co
22-07-09	100	TF Activity	0-9	2,500	1984	¹³⁷ Cs
22-08-01	100	TF Activity	0-12	200,000	1989	¹³⁷ Cs
		Stable	22-32	500	1976	⁶⁰ Co; ¹²⁵ Sb
		Stable	32-42	2,400	1976	⁶⁰ Co; ¹²⁵ Sb
22-08-02	100	TF Activity	0-10	20,000	1993	¹³⁷ Cs
22-08-09	100	TF Activity	0-10	80,000	1984	¹³⁷ Cs
22-08-12	105	TF Activity	0-8	10,000	1989	¹³⁷ Cs
		Unstable early	25-40	300	1980	¹³⁷ Cs
		Unstable early	60-82	1,000	1976	⁶⁰ Co
22-09-02	100	TF Activity	0-10	2,000	1984	¹³⁷ Cs
22-09-07	97	Unstable early	40-50	9,000	1976	¹⁰⁶ Ru
		Unstable early	50-64	2,700	1976	¹²⁵ Sb; ¹⁰⁶ Ru
22-09-08	98	Undetermined	16-30	80,000	1985	¹³⁷ Cs
		Stable	43-52	150	1981	⁶⁰ Co
		Undetermined	76-90	100	1985	⁶⁰ Co
22-10-05	100	Unstable early	55-75	300	1979	⁶⁰ Co
22-10-07	100	Unstable early	45-65	200	1983	⁶⁰ Co
22-11-01	100	Unstable	19-28	4,000	1984	¹³⁷ Cs
22-12-03	100	TF Activity	0-10	200,000	1980	¹³⁷ Cs
22-12-07	100	TF Activity	0-10	1,500	1984	¹³⁷ Cs

Currently, isotopes cannot be identified from gross gamma ray data alone; therefore, isotopes with a rapid rate of decay, such as Ru-106, or at low enough levels to decay below detection limits, may not be identified if the period of instability is prior to the collection of SGLS data.

3.5 Unstable Zones:

Periods of instability are generally complex and occur throughout the timeframe over which digital data were collected. For many unstable zones, data collection started in 1975 while conditions in the zone were still unstable. See Table 10 for a list of wells that had unstable zones of contamination and details of the instability. Well 22-11-01 represents an unusual occurrence where Cs-137 appears stable in the zone from 19 to 28 feet until 1982, and becomes unstable after 1982. Cesium-137 appears as stable in other wells in the BY Tank Farm.

Table 10. BY Tank Farm Unstable Zone Parameters

Borehole Number	Total Depth feet	Subsurface Condition Category	Zone Depth feet	Interval of Instability	Isotopes Identified	**Comment
22-00-02	100	Unstable	64-96	1979-1994	^{60}Co	^{137}Cs decay curve fits, but was not used as ^{137}Cs was not id'd by the SGLS
22-00-03	145	Unstable early	80-117	1975-1976	^{60}Co	
22-03-09	100	Unstable early	24-52	1975-1977	^{60}Co ; ^{90}Sr ; ^{106}Ru	Incr. 1975-1976; decr. 1976-1977
		Unstable early	44-52	1975-1984	^{60}Co ; ^{90}Sr	Incr. 1975-1980; sharp incr. 1980-mid 1982
		Unstable	78-92	1975-1985	^{60}Co ; ^{90}Sr ; ^{106}Ru	Incr. 1975-1979; decr. 1979-1985
		Unstable	48-95	1975-1990	^{60}Co ; ^{90}Sr ; ^{106}Ru	Incr. 1975-1976; stable 1976-1978; unstable decr. 1978-1990; stable 1990-1994
22-04-09	100-125	Unstable early	75-95	1974-1984	^{60}Co	Incr. 1979-1980; decr. 1980-0982; decr. 1982-1984
22-05-09	100	Unstable	55-90	1975-1985	^{60}Co	Decr.
22-06-05	100	Unstable	36-50	1978-1981	^{60}Co ; ^{90}Sr ; ^{106}Ru	Decr.
		Unstable	62-84	1986-mid1991	^{60}Co	Decr.
		Unstable	28-84	1975-mid1975	^{60}Co ; ^{90}Sr ; ^{106}Ru	Incr.
		Unstable	40-84	1979-1994	^{60}Co ; ^{90}Sr ; ^{106}Ru	Decr. mid 1975-1976; decr. 1979-1994
22-06-07	140	Unstable early	40-52	1975-mid1982	^{137}Cs	Decr.
		Unstable early	52-64	1975-1985	^{60}Co	Incr. 1975-1977; decr. 1977-mid1977; incr. mid1977-1979; decr. 1979-1985
		Unstable early	64-80	1975-1984	^{60}Co	Incr. 1975-1981; decr. 1981-1984
		Unstable early	52-80	1975-mid1979	^{60}Co	Incr. 1975-1977; decr. 1977-mid1977; incr. mid1977-1979
22-06-09	100	Unstable early	70-90	1976-1976	^{90}Sr	Incr. 1975-mid1975; decr. mid1975-1976
22-07-01	100	Unstable early	40-52	1975-1981	^{137}Cs	Incr. 1975-1976; decr. 1976-1981
22-07-02	100	Unstable early	42-53	1975-1994	^{60}Co	Incr. 1975-mid1975; decr. mid1975-1984; decr. 1981-1994
		Unstable early	53-70	1975-1994	^{60}Co	Incr. 1975-1979; rapid incr. 1979-early 1979; decr. early 1979-1981; decr. 1981-1994
		Unstable early	70-82	1980-mid1987	^{60}Co	Incr. 1980-1981; decr. 1981-1987
		Unstable early	82-95	1975-1987	^{60}Co	Decr. 1975-1980; incr. 1982-mid1983; decr. mid1983-1987
22-07-05	100	Unstable early	40-57	1975-1994	^{60}Co	Incr. 1975-mid1975; decr. mid1975-mid1978; incr. mid1978-1979; decr. 1979-1985
		Unstable early	57-65	mid1978-mid1986	^{60}Co	Incr. mid1978-mid1983; decr. mid1983-mid1986
		Unstable early	65-78	1981-mid1987	^{60}Co	Incr.
22-07-07	100	Unstable early	30-54	1980-1994	^{137}Cs ; ^{90}Sr ; ^{106}Ru	Step decr. 1980-1981; flat near 0 to 1994
		Unstable	80-98	1975-1985	^{60}Co ; ^{90}Sr ; ^{106}Ru	Incr. 1975-1976; decr. 1976-1981; incr. 1981-mid1981; decr. mid1981-1985
22-07-09	100	Unstable	62-74	1975-1986	^{137}Cs	Incr. 1975-mid1976; decr. mid1976-1986
		Unstable	74-84	1975-mid1988	^{60}Co	Incr. 1975-1979; decr. 1979-mid1980; incr. mid1980-1982; decr. 1982-mid1988
		Unstable	84-94	1982-1989	^{60}Co	Incr. 1982-1986; decr. mid1981-1985; decr. 1985-1994
		Unstable	94-100	1981-1990	^{60}Co	Incr. 1981-mid1981; decr. mid1981-mid1982; incr. 1984-mid1986; decr. mid1986-1990
22-08-01	100	Unstable	59-95	1975-1986	^{60}Co ; ^{90}Sr ; ^{106}Ru	Decr.

22-08-02	100	Unstable	44-62	1975-1994	^{60}Co ; ^{115}Sb	Decr. 1975-1982 flat near 0 1982-1994
		Unstable	62-72	1975-1994	^{115}Sb	Incr. 1975-1977; decr. 1977-1994
		Unstable	72-84	1975-1994	^{115}Sb	Decr. 1975-1981; incr. 1981-1985; decr. 1985-1994
		Unstable	84-100	1975-1994	^{115}Sb	Decr. 1975-1988; incr. 1988-1991; decr. 1991-1994
22-08-05	100	Unstable early	63-74	1975-1986	^{60}Co	Decr.
		Unstable early	74-84	mid1984-1990	^{60}Co	Incr.
22-08-06	100	Unstable early	73-83	1975-1977	^{60}Co	Flat
22-08-09	100	Unstable early	72-84	1975-1976	^{137}Cs ; ^{106}Ru	Incr.
22-08-12	105	Unstable early	25-40	1975-1994	^{137}Cs	Incr. 1975-mid1976; decr. mid1976-1978; incr. 1978-mid1980; decr. mid1980-1983; flat near 0 1983-1994
		Unstable early	40-51	1975-1989	^{60}Co ; ^{115}Sb	Decr.
		Unstable early	51-60	1975-1983	^{60}Co	Decr. 1975-1979; incr. 1979-mid1983
		Unstable early	60-70	1975-1987	^{60}Co	Decr.
		Unstable early	70-82	1975-1983	^{60}Co	Incr.
22-09-07	100	Unstable early	20-40	mid1978-1982	^{106}Ru	Decr.
		Unstable early	40-50	1975-1984	^{106}Ru	Incr. 1975-1976; decr. 1980-1984
		Unstable early	50-64	1980-1990	^{115}Sb ; ^{106}Ru	Decr.
22-09-11	100	Unstable early	38-52	1975-1976	^{106}Ru	Decr.
22-10-05	100	Unstable early	55-75	1975-1979	^{60}Co	Incr.
22-10-07	100	Unstable early	45-65	1980-1994	^{60}Co	Incr. 1980-1983; decr. 1983-1985; flat near 0 1985-1994
22-10-10	100	Unstable early	58-76	1975-1980	^{60}Co	Decr.
22-11-01	100	Unstable	19-28	1982-1994	^{137}Cs	Incr. 1982-1984; decr. 1984-1994
22-11-09	100	Unstable early	34-46	1975-mid1978	^{60}Co	Flat

*Currently, isotopes cannot be identified from gross gamma ray data alone; therefore, isotopes with a rapid rate of decay, such as Ru-106, or at low enough levels to decay below detection limits, may not be identified if the period of instability is prior to the collection of SGLS data.

**Unless otherwise noted, the GTP plot decreases consistent with the decay curve of known isotopes.

5.0 Summary

A summary of the radionuclides present in the vadose zone of BY Tank Farm has been presented in this report. By integrating SGLS data with historical dry well surveillance data, knowledge is gained concerning the behavior of radionuclides in the vadose zone over time. The SGLS data allow a rigorous conclusion about the identity, character, and decay trends of isotopes present in a contaminated zone identified within the twenty-year period that the dry well data were collected.

Five subsurface conditions were discerned during the analysis of the historical dry well data: clean, stable, unstable/unstable early, tank farm activity, and undetermined. This classification reflects the conditions in which contamination is present (or not present) within the timeframe gross gamma ray data were collected electronically, but says nothing about the conditions within the subsurface today. However, an assumption that the trend of the data might continue unaltered seems reasonable, barring any event that changes the hydrogeologic or geochemical conditions in the subsurface. On the basis of the data available at the time and within the scope of this report, a statement cannot be made as to whether any of the isotopes present in the subsurface of the BY Tank Farm can be remobilized.

Three of the clean wells occur in the northwest corner of the tank farm, and two are south of the 104 tank. One third of the contaminated zones appear to exist under a stable condition. Within the timeframe that digital data are available, most of the zones that exhibit an unstable condition early on are currently stable and occur primarily in the west half of the tank farm and around the 103 and 106 tanks. Six wells currently exhibit unstable conditions. Additional wells may be exhibiting unstable conditions, but the contamination levels are too low to make a rigorous determination. There were only six (three around the 103 tank) zones spread throughout the tank farm where the subsurface condition is undetermined. More than half of the wells have indications of tank farm activity at the surface and occur throughout the tank farm.

The most common isotopes present throughout the subsurface of the BY Tank Farm are Cs-137 and Co-60. Cesium-137 occurs in the top 20 feet of the subsurface throughout the tank farm in all but ten of the contaminated wells. Cobalt-60 occurs throughout the tank farm below 20 feet, primarily around tanks 101, 103, 107, 108, and 109, as well as to the west of tanks 110 and 111. Antimony-125 occurs below 15 feet and is located primarily around the 109 tank and the southeast region of the 103 tank. It is often hypothesized to have been present since, by the time of the SGLS analysis, levels decayed to below the detection threshold. In a few instances, Sb-125 was not identified by the SGLS, yet the levels of radioactivity in four zones in four wells prior to the SGLS analysis suggest that there was sufficient Sb-125 present to have been identified by SGLS, given stable conditions. These zones are: 48 to 70 feet in well 22-00-04, 34 to 44 feet in well 22-02-09, 42 to 59 feet in well 22-08-01, and 40 to 51 feet in well 22-08-12. Further analysis of these zones may be warranted. Uranium-235/8 is identified only in well 22-11-08 from 56 to 66 feet. Europium-154 is identified only in well 22-03-09 from 0 to 11 feet. Ruthenium-106 is hypothesized to have existed in the subsurface, although it is no longer at detectable levels, primarily around the 103 and 109 tanks from 11 to 96 feet.

Two areas of the tank farm have wells with contamination at greater than 10,000 ft*c/s GTP. They are from the east of the 109 tank to the west of the 108 tank and southeast of the 103 tank. The contamination occurs primarily in two zones, surface (0 to 10 feet), and between 20 and 40 feet to between 80 and 100 feet except in well 22-03-05 where the contamination is fairly consistent from the surface to 85 feet. Well 22-03-05 has high level contamination, but it is currently stable. The wells containing high levels of contamination in these areas of the tank farm are surrounded by wells with significantly lower levels of contamination or no contamination at all and may indicate proximity to point sources. These wells with high levels of contamination typically have very high levels of Cs-137 and are many times surrounded by wells with different isotopes. It may be possible that the presence of other isotopes is masked by the strong presence of Cs-137.

Nine wells have unstable conditions at the end of data collection in 1994. Of these, the contamination in six wells is less than 100 ft*c/s. Well 22-08-02 is currently unstable from 44 to 100 feet and has contamination levels just under 4,000 ft*c/s. Well 22-03-09 is currently unstable with contamination less than 500 ft*c/s that has passed through the bottom of the well in 1993 and appears to continue moving down at an estimated rate of 2 feet per year.

Isotopes appear to move through the vadose at different rates depending on subsurface conditions. In general and given similar conditions, of the isotopes found or hypothesized to be present in the BY Tank Farm, Cs-137 usually moves downward the least and U-235/8 usually moves the deepest, with mobility of the other isotopes falling somewhere in between. Cs-137 occurs throughout the subsurface of the tank farm, both by itself and with other isotopes. It occurs primarily by itself in the top 20 feet of 53 wells. This may indicate a high retention factor related

to Cs-137 and soil interaction. U-235/8 occurs at a fairly shallow depth in only one well in the BY Tank Farm. The other isotopes identified through SGLS analysis, and those hypothesized and supported by tank inventories, occur throughout the tank farm from 20 to 140 feet. It is not known if contamination exists deeper than the bottom of any given well although it is suspected in wells 22-03-09, 22-07-02, 22-07-09, and 22-08-02. Several anomalies present in the data seem to stand out:

- In wells 22-00-01, 22-03-05, 22-07-05, and 22-07-09, Cs-137 exists deep in the wells (as deep or deeper than Co-60) with little or no Cs-137 remaining in the upper portions of the borehole.
- In well 22-00-02, Cs-137 is not identified with the SGLS analysis in the zone from 64 to 96 feet. Even though the decay rate for Cs-137 fits the GTP plot, Cs-137 is not listed as existing in this zone.
- In well 22-00-10, Cs-137 was identified at 8 pCi/g during SGLS analysis and should appear in the gross gamma ray logs at 46 feet, but doesn't.
- Occasionally, Cs-137 and Co-60 are viewable in the gross gamma ray data and not in the SGLS data.
- Ru-106 is very mobile according to the current understanding of chemistry, and should therefore be found deeper and more laterally extensive than is indicated in the BY Tank Farm.
- In the GTP plot for the surface contamination in the majority of wells is what appears to be a data spike occurring in or near 1985 (Figure 8). The GTP values range from approximately 300 ft*c/s to 9000 ft*c/s with the highest values occurring to the southwest of the 101 and 112 tanks. These spikes in the data are noticeably absent from wells near the center of the tank farm and to the southwest around the 110 tank. In well 22-11-01, the spike appears in GTP in two additional plots below the surface to 29 feet. In several wells, more than one spike appears in the GTP plot of the surface correlating with different timeframes.

Limits in the data available for examination make evaluation of the data incomplete and as such, the apparent anomalies are unable to be explained. Information as to how or whether geology and/or geochemistry effect the direction and extent of isotope migration in the subsurface is not considered in this report.

References

- Brevick, C. H., R. L. Newell, J. W. Funk, May 1996, "Supporting Document for the Historical Tank Content Estimate for BY Tank Farm," WHC-SD-WM-ER-311, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- MACTEC-ERS 1997, Work performed under contract #DE-AC04-94AL96907, U.S. Department of Energy, 1996 to 1997, by MACTEC-ERS, Grand Junction, CO.
- WMNW/TRS-ES-VZMA-001; Randall, R. R., R. K. Price, "Analysis Techniques Applied to the Dry Well Surveillance Gross Gamma Ray Data at the SX Tank Farm," 1998, Waste Management Federal Services, Inc., Northwest Operations, Richland, Washington.
- WMNW/TRS-ES-VZMA-002; Randall, R. R., R. K. Price, "Monitoring Results for the SX Single Shell Tank Farm Dry Well Gamma Ray Surveillance Log Surveys," 1998, Waste Management Federal Services, Inc., Northwest Operations, Richland, Washington.
- WMNW 1998, "Analysis of Historical Gross Gamma Logging Data from BY Tank Farm," Project 772028, Task 23020001, 3 Rivers Scientific, West Richland, Washington.

Errata:

At the time of publication, the following errors were noted in the enclosed figures:

Figure 2:

Missing scale; map is at same scale as the other maps

Figure 6:

22-00-04 has Ru-106 48-85'

22-02-01 has Co-60 40-96'

22-03-07 has Ru-106 47-90'

Figure 7:

Sub-title should read all readings obtained with NaI probe except where noted.

22-03-05 should read Green GM probe 0-5' 300; 5-15' 350; 15-60' 170K, 60-85' 1.7K

22-08-01 should read 59-82' 12K

Figure 8:

22-00-10 should read 1985 (400)

22-03-08 should read 1985 (1200); 1987 (1500); 1993 (1400)

22-12-05 should read 1984-85 (3500-3800)

22-12-09 should not have anything

BY Tank Farm

Figure 2. BY Tank Farm Radiation Zone Conditions

Figure 3. Isotope Half-life Decay Curves

- Radio-Isotopes
& Top Depth (ft)
- Cesium-137
 △ Cobalt-60
 □ Antimony-125
 ● Ruthenium-106
 ▲ Uranium 235/8
 ■ Europium-154

BY Tank Farm

Scale (100 ft)

Figure 4. BY Tank Farm Isotope Top Depth

BY-Isotope-Top-Depth

BY Tank Farm

Borehole Identification & Radiation Zone Bottom Depth (ft)

Figure 5. BY Tank Farm Radiation Zone Bottom Depth

Borehole Identification & Contamination Depth Range with Isotopes Present

BY Tank Farm

Scale (100 ft) 100 N/D = No Data

Figure 6. BY Tank Farm Depth Range of Contamination with Isotopes

**Borehole Identification &
GTP > 10,000 ft*c/s**

BY Tank Farm

Figure 7. BY Tank Farm Plot of GTP > 10,000 ft*c/s

BY-GTP-10K.mxd

Borehole Identification & Spike in GTP at surface

Figure 8. BY Tank Farm Spike in GTP at Surface

Borehole 22-00-01

Contamination (Cs-137) from 40-65 feet appears Stable
 Contamination (Cs-137) from 70-84 feet appears Stable
 Contamination (Cs-137) from 84-100 feet appears Stable

Grade thickness product from 40 to 65, 70 to 84, and 84 to 100 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993. Note that the grade thickness product is at low levels for these intervals.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	140 ft
Survey Depth :	140 ft
First Survey Date :	1/16/1975
Last Survey Date :	10/7/1993
Number Surveys :	340

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	40-65, 70-84, & 84-100 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-00-01

Depth: 40-65 ft

No HPGe data

Cs-137 Decay Line

Analysis by: Three Rivers Scientific

Borehole 22-00-01

Depth: 70-84 ft

No HPGe data

Cs-137 Decay Line

01/16/75

Borehole 22-00-01

Depth: 84-100 ft

No HPGe data

Cs-137 Decay Line

10/07/93

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Borehole 22-00-01

Borehole 22-00-02

Contamination (Cs-137) from 0-14 feet is Stable
 Contamination (Sb-125) from 45-56 feet is Undetermined
 Contamination (Sb-125 & Ru-106) from 56-64 feet is Stable
 Contamination (Co-60) from 64-96 feet is UNSTABLE

Grade thickness product from 0 to 14 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993.

Grade thickness product from 45 to 56 feet is not decreasing consistent with Sb-125 (HPGe identified), but the deviation cannot be precisely fit to known radionuclide decay rates. Thus the classification is undetermined. Special note, there may be a possibility of downward migration, but well below detection.

Grade thickness product from 56 to 64 feet is decreasing consistent with a least squares fit for Sb-125 (HPGe identified) and Ru-106 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Sb-125 to Ru-106 of 0.72 as of Jan 1975.

Grade thickness product from 64 to 96 feet is not decreasing consistent with Co-60 (HPGe identified). A slower decay rate such as Cs-137 makes an excellent least squares fit, however, there is no indication of Cs-137 and cannot be justified. Downward movement is present at low levels indicated by the stack plot, but the grade thickness product was computed over the entire depth interval in order to conserve downward spreading.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	6/17/1993
Number Surveys :	206

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-14 & 56-64 Stable, 45-56 Undetermined 64-96 UNSTABLE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-00-02

Depth: 0-14 ft

01/16/75

Borehole 22-00-02

Depth: 45-56 ft

06/17/93

Gamma (c/s)

06/17/93

Gamma (c/s)

Borehole 22-00-02

Depth: 64-96 ft

Analysis by: Three Rivers Scientific

Borehole 22-00-02

Borehole 22-00-03

Contamination (Co-60 & Sb-125) from 40-80 feet is Stable
 Contamination (Co-60) from 80-117 feet is UNSTABLE Early
 Contamination (Cs-60) from 117-128 feet is Stable
 Contamination (Co-60 & Sb-125) from 128-140 feet is Stable

Grade thickness product from 40 to 80 feet is decreasing consistent with Co-60 & Sb-125 (both HPGe identified) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Sb-125 to Co-60 of 0.11 as of June 1993.

Grade thickness product from 80 to 117 feet is decreasing consistent with Co-60 (HPGe identified) from 1976 to 1993. However, from 1975 to 1976 there is a rapid decrease in the grade thickness product in excess of Co-60 decay.

Grade thickness product from 117 to 128 feet is decreasing consistent with Co-60 (HPGe identified) from 1975 to 1993.

Grade thickness product from 128 to 140 feet is decreasing consistent with Co-60 (HPGe identified) & Sb-125 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Sb-125 to Co-60 of 0.22 as of June 1993.

Special note, Cs-137 is also HPGe identified, but not at high enough levels to register with gross gamma for both intervals at 40-80 & 80-117 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	145 ft
Survey Depth :	145 ft
First Survey Date :	1/16/1975
Last Survey Date :	6/17/1993
Number Surveys :	208

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold 0<val<50
Depth(s) where Contamination Identified in Gross Gamma Surveys :	40-80, 117-128, & 128-140 Stable 80-117 UNSTABLE EARLY
Analyst Name :	R.R. Randall
Company Name :	Three Rivers Scientific

Borehole 22-00-03

Depth: 40-80 ft

01/16/75

06/17/93

Borehole 22-00-03

Depth: 80-117 ft

Analysis by: Three Rivers Scientific

Borehole 22-00-03

Depth: 117-128 ft

01/16/75

06/17/93

Borehole 22-00-03

Depth: 128-140 ft

01/16/75

Analysis by: Three Rivers Scientific

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Borehole 22-00-03

Borehole 22-00-04

Contamination (Cs-137) from 0-10 feet is Tank Farm Activities

Contamination (Co-60 & Sb-125) from 48-70 feet is Stable

Contamination (Co-60 & Ru-106) from 70-85 feet is Stable

Grade thickness product from 0 to 10 feet is changing erratically indicative of tank farm activities such as changes in transfer lines.

Grade thickness product from 48 to 70 feet is decreasing consistent with Co-60 (HPGe identified) & Sb-125 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Sb-125 to Co-60 of 3.52 as of June 1993.

Grade thickness product from 70 to 85 feet is decreasing consistent with Co-60 (HPGe identified) & Ru-106 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 3.00 as of Jan 1975.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	6/17/1993
Number Surveys :	210

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10, 48-70, & 70-85 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-00-04

Depth: 0-10 ft

06/17/93

Borehole 22-00-04

Depth: 48-70 ft

01/16/75

06/17/93

01/16/75

Borehole 22-00-04

Depth: 70-85 ft

06/17/93

HNF-3532 -REV0

Borehole 22-00-04

Borehole 22-00-10**Contamination (Cs-137) from 0-10 feet is Tank Farm Activities**

Grade thickness product from 0 to 10 feet is changing erratically indicative of tank farm activities such as changes in transfer lines.

Cs-137 was identified with HPGe detection at 46 feet to levels of 8 pCi/g, which would normally show on the gross gamma log data, but does not, refer to stack plot.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	120 ft
Survey Depth :	120 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/4/1993
Number Surveys :	385

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific

Borehole 22-00-10

Depth: 0-10 ft

Borehole 22-00-10

BY Dry Well Survey Analysis - Notes

Borehole 22-00-01Total # Surveys 343Probe Type 04Log Date: 1-16-75 1st# neutron surveys 3
10-7-93 Last# GR Surveys 340
Presentation Plot Dates (If different from 1st & Last)Contamination Zone Depth(s): all HT ZonesIsotope from Spectral Survey: not reported?Max Survey Depth 140

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

As appropriate fit each interval but @ very low levels

Analyst Name S/W ver TFGROSS 2.2

BY 37 Dry Well Survey Analysis - Notes

Borehole 22-00-02Total # Surveys 211Probe Type 04Log Date: 1-16-75 1st# neutron surveys 5
6-17-92 Last# GR Surveys 206

Presentation Plot Dates _____

(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: no reportMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
			<u>56-64 could be Rn + Sb</u>

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg Bkg	Comment

Analysis Notes

From stack 45-56 56-64 64-84 rapid decay
& 0-14 standard
No reasonable fits are generated, & believe
downward movement → 100-20' in Top 3000 ft
for 45-95 & rev!

Analyst Name Russell RandallS/W ver TFGRPS.2.2

filein := "two45-56.txt"

Well 21-00-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 194

i := 0..N

k := 0..300

j := 0..299

tau := 5.27

tauco := 5.27

taucs := 2.77

aco := 00

acs := 1415

Eu variables are Co-60

aeu := -38

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Sb-125

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 1.425 \cdot 10^3$$

Sb-125

$$\alpha_{eu} = -46.978$$

Co-60

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = -30.338$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Eu_N}{Cs_N} = -0.162$$

Unreasonable fit

filein := "two56-64.txt"

Well 21-00-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 198

i := 0..N

k := 0..300

j := 0..299

 $\tau_{eu} := 1$ $\tau_{co} := 5.27$ $\tau_{cs} := 2.77$

aco := 0

acs := 534

Eu variables are

Ru-106 aeu := 744

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are SAB-125

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$acs = 534$$

Sb-125

$$\alpha_{eu} = 744$$

Ru-106

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.718$$

$$tot_i := Cs_i + Eu_i$$

out<0> := yr

out<1> := tot

WRITEPRN("twop56-64.txt") := out

$$\frac{Eu_N}{Cs_N} = 3.915 \cdot 10^{-4}$$

Two comp decay56-64.mcd

8/28/98

Page 1

BY Dry Well Survey Analysis - Notes

Borehole 22-00-03Total # Surveys 209Probe Type 04Log Date: 1-16-75 1st# neutron surveys 1# GR Surveys 2086-17-93 LastPresentation Plot Dates (If different from 1st & Last)Contamination Zone Depth(s): 48-138Isotope from Spectral Survey: no reportMax Survey Depth 175

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg Bkg	Comment

Analysis Notes

40-90	good fit with Co #56
117-128	" / " " Co
128-140	can't automatically (math) get late good fit
	but did after better starting values

Analyst Name Russ RandallS/W ver TFGR 35.2.2

01/16/75

Borehole 22-00-03

Depth: 0-10 ft

Reference Only

Cs-137 Decay Line

06/17/93

Analysis by: Three Rivers Scientific

filein := "two40-80.txt"

Well 21-00-03

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 197

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

taucs := 5.27

aco := 0

acs := 15120

Eu variables are

Ru-106

aeu := 14790

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Co-60

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 1.496 \cdot 10^4$$

Co-60

$$\alpha_{eu} = 1.47 \cdot 10^4$$

Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 1.018$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop40-80.txt") := out$$

$$\frac{Eu_N}{Cs_N} = 0.11$$

filein := "two128-140.txt" Well 21-00-03

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 199

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

taucs := 5.27

aco := 0

acs := 400

Eu variables areSb-125 aeu := 700

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Co-60

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[\frac{gross_i}{(yr_i - 74)^5} - \frac{a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}}{(yr_i - 74)^5} \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$1 = 1$$

$$\begin{bmatrix} acs \\ aeu \end{bmatrix} := \text{Minerr}(acs, aeu)$$

acs = 388.289
Co-60aeu = 688.076
Sb-125

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{acs}{aeu} = 0.564$$

$$\frac{Eu_N}{Cs_N} = 0.223$$

out<0> := yr

out<1> := tot

WRITEPRN("twop40-80.txt") := out

BY
Dry Well Survey Analysis - Notes

Borehole 22-00-04Total # Surveys 212Probe Type 04Log Date: 1-16-75 1st# neutron surveys 2# GR Surveys 2106-17-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs & Co - Eric RandoMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>A leak @ 80' & 0-10</u>
			<u>with build up from 60-75</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg Bkg	Comment

Analysis Notes

<u>0-10</u>	<u>48-70</u>	<u>70-85</u>

Analyst Name

Eric Rando

S/W ver

TFGROSS 2.2

filein := "two48-70.txt"

Well 21-00-04

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 193

i := 0..N

k := 0..300

j := 0..299

teu := 2.77

 $\tau_{co} := 5.27$ $\tau_{cs} := 5.27$

aco := 00

acs := 20

Eu variables are

Sb-125 aeu := 480

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Co-60

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 19.557$$

Co-60

$$\alpha_{eu} = 485.548$$

Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.04$$

out<0> := yr

out<1> := tot

WRITEPRN("twop48-70.txt") := out

$$\frac{Eu_N}{Cs_N} = 3.525$$

filein := "two70-85.txt"

Well 21-00-04

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 199

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

taucs := 5.27

aco := 00

acs := 270

Eu variables are

Ru-106

aeu := 820

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$gross_i := net_i$$

Cs variables are Co-60

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 272.956$$

Co-60

$$\alpha_{eu} = 818.978$$

Ru-106

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.333$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop70-85.txt") := out$$

$$\frac{Eu_N}{Cs_N} = 9.422 \cdot 10^{-5}$$

BY
Dry Well Survey Analysis - Notes

Borehole 22-00-10Total # Surveys 389Probe Type 04Log Date: 1-9-75 1st# neutron surveys 4
10-4-93 Last# GR Surveys 385
Presentation Plot Dates (If different from 1st & Last)Contamination Zone Depth(s): Isotope from Spectral Survey: Cs surf to 45'Max Survey Depth 120

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>no show of Cs at 50'</u>
			<u>stack looks clean also</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

<u>higher than normal Cs for no show in TF GR</u>

Analyst Name Russ HamiltonS/W ver TFGROSS 2.2

01/09/75

Borehole 22-00-10

Depth: 35-60 ft
Reference Only

10/04/93

Borehole 22-01-01

Contamination (Cs-137) from 0-6 feet is Tank Farm Activity
Contamination (Cs-137) from 6-15 feet appears Stable

Grade thickness product from 0 to 6 feet is intermittently changing from 1975 to 1987 which is indicative of tank farm activities such as a transfer line activity. The grade thickness product for this interval is decreasing consistent with Cs-137 (HPGe identified) from 1987 to 1993.

Grade thickness product from 6 to 15 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993. The levels are near threshold.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	10/4/1993
Number Surveys :	406

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-6 Tank farm activity, 6-15 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-01-01

Depth: 0-6 ft

10/04/93

01/16/75

Borehole 22-01-01

Depth: 6-15 ft

10/04/93

Borehole 22-01-01

Borehole 22-01-03**Contamination (Cs-137) from 0-10 feet is Tank Farm Activity**

Grade thickness product from 0 to 10 feet is intermittently changing from 1975 to 1986 which is indicative of tank farm activities such as a transfer line activity. The grade thickness product for this interval is decreasing consistent with Cs-137 (HPGe identified) from 1986 to 1993.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	10/4/1993
Number Surveys :	395

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank farm activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-01-03

Depth: 0-10 ft

10/04/93

Borehole 22-01-03

Borehole 22-01-04

Contamination (Cs-137) from 0-15 feet is Tank Farm Activities

Contamination (Cs-137) from 15-30 feet is Stable

Contamination (Co-60 & Sb-125) from 30-60 feet is Stable

Grade thickness product from 0 to 15 feet is changing erratically indicative of tank farm activities such as changes in transfer lines.

Grade thickness product from 15 to 30 feet is decreasing consistent with Cs-137 (HPGe identified) 1975 to 1993, within systematic limitations.

Grade thickness product from 30 to 60 feet is decreasing consistent with Co-60 (HPGe identified) & Sb-125 (hypothesis) from 1975 to 1993, within systematic limitations. The least squares fit results in gross gamma contribution ratio of Sb-125 to Co-60 of 6.38 as of Oct 1993.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	10/4/1993
Number Surveys :	408

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold 0<val<50
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-15 Tank Farm Activity, 15-30 & 30-60 Stable
Analyst Name :	R.R. Randall
Company Name :	Three Rivers Scientific

Borehole 22-01-04

Depth: 0-15 ft

Analysis by: Three Rivers Scientific

01/16/75

Borehole 22-01-04

Depth: 15-30 ft

Analysis by: Three Rivers Scientific

10/04/93

Borehole 22-01-04

Depth: 30-60 ft

Analysis by: Three Rivers Scientific

Borehole 22-01-04

Borehole 22-01-07

Contamination (Cs-137) from 0-6 feet is Tank Farm Activity

Contamination (Cs-137) from 6-15 feet is Stable

Contamination (Co-60) from 40-55 feet is Stable

Grade thickness product from 0 to 6 feet is intermittently changing from 1975 to 1987 which is indicative of tank farm activities such as a transfer line activity. The grade thickness product for this interval is decreasing consistent with Cs-137 (HPGe identified) from 1987 to 1993.

Grade thickness product from 6 to 15 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993. The levels are near threshold.

Grade thickness product from 40 to 55 feet is decreasing consistent with Co-60 (HPGe identified) from 1975 to 1985.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/4/1993
Number Surveys :	394

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-6 Tank farm activity 6-15 & 40-55 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/09/75

Borehole 22-01-07

Depth: 0-6 ft

10/04/93

01/09/75

Borehole 22-01-07

Depth: 6-15 ft

10/04/93

01/09/75

Borehole 22-01-07

Depth: 40-55 ft

10/04/93

Borehole 22-01-07

Borehole 22-01-10

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity

Contamination (Cs-137) from 15-25 feet is Stable

Contamination (Cs-137 & Co-60) from 25-44 feet is Stable

Grade thickness product from 0 to 10 feet is intermittently changing from 1975 to 1987 which is indicative of tank farm activities such as a transfer line activity. The grade thickness product for this interval is decreasing consistent with Cs-137 (HPGe identified) from 1987 to 1993.

Grade thickness product from 15 to 25 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993.

Grade thickness product from 25 to 44 feet is decreasing consistent with Cs-137 (HPGe identified) & Co-60 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Co-60 to Cs-137 of 0.03 as of Oct 1993. The very low level of Co-60 is only required to have the grade thickness product follow a consistent trend.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/4/1993
Number Surveys :	419

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity, 15-25 & 25-44 Stable,	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/09/75

Borehole 22-01-10

Depth: 0-10 ft

10/04/93

01/09/75

Borehole 22-01-10

Depth: 15-25 ft

10/04/93

01/09/75

Gamma (c/s)

Borehole 22-01-10

Depth: 25-44 ft

10/04/93

Gamma (c/s)

HNF-3532 -REV0

Borehole 22-01-10

Dry Well Survey Analysis - Notes

Borehole B1 22-01-01Total # Surveys 408Probe Type 04Log Date: 1-16-75 1"# neutron surveys 2# GR Surveys 40610-4-93 Last

Presentation Plot Dates

(If different from 1" & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs 137 levels 100 @ surfaceMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

Russ Randall

S/W ver

TFGROS 2.2

Dry Well Survey Analysis - Notes

Borehole 22-01-03Total # Surveys 397Probe Type 04Log Date: 1-16-79 1st# neutron surveys 2# GR Surveys 39510-4-93 Last

Presentation Plot Dates

(If different from 1st & Last)Contamination Zone Depth(s): 0-10Isotope from Spectral Survey: Cs 137 except @ surfaceMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name Russ RandallS/W ver TFGRDS.2.2

BY BY
 Dry Well Survey Analysis - Notes

Borehole 22-01-04Total # Surveys 410Probe Type 04Log Date: 1-16-75 1st# neutron surveys 2# GR Surveys 40810-4-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs + CoMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			2-15 Cs Peak 22 Cs
			30-60 Co from Hi Zones

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

0-15	15-30	30-60

Analyst Name

Russell Randall

S/W ver

TFGRSS.2.2

filein := "two30-60.txt"

Well 21-01-04

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 391

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

tcsc := 5.27

aco := 00

acs := 24

Eu variables areSb-125 aeu := 1384

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcsc}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Co-60

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcsc}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 24$$

Co-60

$$\alpha_{eu} = 1.384 \cdot 10^3$$

Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tcsc}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.017$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Eu_N}{Cs_N} = 6.287$$

Dry Well Survey Analysis - Notes

Borehole 22-01-07Total # Surveys 396Probe Type 04Log Date: 1-9-75 1st# neutron surveys 2# GR Surveys 39410-4-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs down to 50 cm Co very low 45-50 Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>40-60 on gamma</u>
<u>from stack 0-6 16-15 40-50</u>
<u>looked at 40-50 & 40-60 both have linear drop?</u>

Analyst Name Ronald PancherS/W ver TFGRD55.2.2

BY

Dry Well Survey Analysis - Notes

Borehole 22-01-10Total # Surveys 421Probe Type 04Log Date: 1-9-75 1st# neutron surveys 2
10-4-93 Last# GR Surveys 419Presentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): _____
Isotope from Spectral Survey: CsMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<i>looks like no depth strips required</i>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>0-10</u>	<u>15-25</u>	<u>25-44</u>	<i>→ changes based on depth? or real?</i>

Analyst Name Russ RandalS/W ver TFGRSS 2.2

Well 21-01-10

filein := "two.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 407

i := 0..N

k := 0..300

j := 0..299

tau := 5.27

tauco := 5.27

taucs := 30.17

aco := 00

acs := 463

Eu variables are Co-60

aeu := 116

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} acs \\ aeu \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$acs = 463$$

Cs-137

$$aeu = 116$$

Co-60

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{acs}{aeu} = 3.991$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Eu_N}{Cs_N} = 0.033$$

Borehole 22-02-01

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity

Contamination (Cs-137) from 10-20 feet is Tank Farm Activity

Contamination (Cs-137) from 40-53 feet is Stable

Contamination (Ru-106) from 55-75 feet is Stable

Contamination (Co-60 & Ru-106) from 80-96 feet is Stable

Grade thickness product, Cs-137 (HPGe identified), from 0 to 10 and 10 to 20 feet is erratic, indicative of tank farm activities such as transfer line operations. The grade thickness product appears stable from 1986 to 1993 for 0-10 feet and stable from 1984 to 1993 for 10-20 feet.

Grade thickness product from 40 to 53 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993. (Special note the possibility of Co-60 at very low levels may account for the very slight deviation from 1975 to 1983.

Grade thickness product from 55 to 75 feet is decreasing consistent with Ru-106 (hypothesis) from 1975 to 1993, but at very low levels.

Grade thickness product from 80 to 96 feet is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Ru-106 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 2.18 as of Jan 1975.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/27/1993
Number Surveys :	593

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 & 10-20 Tank Farm Activity 40-53, 55-75, & 80-96 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific

Borehole 22-02-01

Depth: 0-10 ft

Analysis by: Three Rivers Scientific

Borehole 22-02-01

Depth: 10-20 ft

Analysis by: Three Rivers Scientific

Borehole 22-02-01

Depth: 40-53 ft

Analysis by: Three Rivers Scientific

Borehole 22-02-01

Depth: 55-75 ft

Analysis by: Three Rivers Scientific

Borehole 22-02-01

Depth: 80-96 ft

Analysis by: Three Rivers Scientific

Borehole 22-02-01

Borehole 22-02-02

Contamination (Cs-137) from 0-6 feet is Tank Farm Activity

Contamination (Cs-137) from 6-18 feet is Stable

Grade thickness product from 0 to 6 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 6 to 18 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/27/1993
Number Surveys :	540

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-6 Tank Farm Activity 6-18 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/09/75

Borehole 22-02-02

Depth: 0-6 ft

10/27/93

01/09/75

Borehole 22-02-02

Depth: 6-18 ft

10/27/93

Borehole 22-02-02

Borehole 22-02-05**Contamination (Cs-137) from 0-10 feet is Tank Farm Activity**

Grade thickness product from 0 to 10 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 0 to 10 feet is decreasing consistent with Cs-137 (HPGe identified) from 1986 to 1993.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	10/27/1993
Number Surveys :	545

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-02-05

Depth: 0-10 ft

10/27/93

Borehole 22-02-05

Borehole 22-02-07**Contamination (Cs-137) from 0-10 feet is Tank Farm Activity**

Grade thickness product from 0 to 10 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 0 to 10 feet is decreasing consistent with Cs-137 (hypothesis, no HPGe data) from 1986 to 1993.

Special note, the average background changed consistently after May 25, 1978.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/20/1993
Number Surveys :	452

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity
Analyst Name :	R.R. Randall
Company Name :	Three Rivers Scientific

01/09/75

Borehole 22-02-07

Depth: 0-10 ft

10/20/93

Borehole 22-02-07

Borehole 22-02-09

Page 1 of 2

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity
Contamination (Sb-125) from 20-26 feet is Stable
Contamination (Sb-125 & Ru-106) from 26-34 feet is Stable
Contamination (Sb-125 & Ru-106) from 34-44 feet is Stable
Contamination (Co-60 & Cs-137 & Ru-106) from 44-52 feet is Stable
Contamination (Co-60) from 55-65 feet is Undetermined

Grade thickness product, Cs-137 (HPGe identified), from 0 to 10 feet is erratic, indicative of tank farm activities such as transfer line operations. The grade thickness product appears stable from 1986 to 1993 for 0-10 feet.

Grade thickness product from 20 to 26 feet is decreasing consistent with Sb-125 (hypothesis) from 1975 to 1993.

Grade thickness product from 26 to 34 feet is decreasing consistent with a least squares fit for Sb-125 (hypothesis) and Ru-106 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Ru-106 to Sb-125 of 5.34 as of Jan 1975. Note, Cs-137 HPGe identified, but at low enough levels to not register above threshold.

Grade thickness product from 34 to 44 feet is decreasing consistent with a least squares fit for Sb-125 (hypothesis) and Ru-106 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Ru-106 to Sb-125 of 0.19 as of Jan 1975. Note, Cs-137 HPGe identified, but at low enough levels to not register above threshold.

Grade thickness product from 44 to 52 feet is decreasing consistent with a least squares fit for Ru-106 (hypothesis) and Co-60 (HPGe identified) and Cs-137 (HPGe identified) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Ru-106:Co-60:Cs-137 of 1780:613:106 as of Jan 1975.

Grade thickness product from 55 to 65 feet is decreasing consistent with Co-60 (HPGe identified) from 1975 to 1993, but at very low levels. There may be some indication of Ru-106 at low levels very early (1975-1976), but such a short time cannot be used to differentiate stable from a hypothesis fit.

Borehole 22-02-09

Page 2 of 2

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	10/27/1993
Number Surveys :	607

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity, 20-26, 26-34, 34-44, & 44-52 Stable, 55-65 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-02-09

Depth: 0-10 ft

Depth Shifted

10/27/93

01/16/75

Borehole 22-02-09

Depth: 20-26 ft

Depth Shifted

10/27/93

01/16/75

Borehole 22-02-09

Depth: 26-34 ft

Depth Shifted

10/27/93

Borehole 22-02-09

Depth: 34-44 ft

Depth Shifted

01/16/75

Borehole 22-02-09

Depth: 44-52 ft

Depth Shifted

10/27/93

10/27/93

Borehole 22-02-09

Depth: 55-65 ft

Depth Shifted

01/16/75

HNF-3532 - REV 0

Borehole 22-02-09

Borehole 22-02-09 Depth Shifted

BY
Dry Well Survey Analysis - Notes

Borehole 22-02-61Total # Surveys 602Probe Type 04Log Date: 1-9-75 1st# neutron surveys 9
10-27-93 Last# GR Surveys 593Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Ce & Co deep & LmoMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>0-10</u>	<u>10-20</u>	<u>40-53</u>	<u>80-96</u>
<u>Cs</u>		<u>Ce + Ru</u>	
		<u>55-75 → Ru</u>	

Analyst Name

Paul R. Rasmussen

S/W ver

TFGR05 2.2

Well 21-02-01

filein := "two.txt"

A := READPRN(filein)
80-96 feet

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 515

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

taucs := 5.27

aco := 00

acs := 172

Eu variables are

Ru-106 aeu := 375

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Co-60

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 172.836$$

Co-60

$$\alpha_{eu} = 375.357$$

Ru-106

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.46$$

$$\frac{Eu_N}{Cs_N} = 6.068 \cdot 10^{-5}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

Dry Well Survey Analysis - Notes

Borehole BY 22-02-02Total # Surveys 545Probe Type 04Log Date: 1-9-75 1st# neutron surveys 5# GR Surveys 54010-27-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs @ surfaceMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>11 samples & 11 shallow Cs 7-18 ft</u>
			<u>from stack 0-6 & 6-18</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

Russ Randall

S/W ver

FFR0552.2

BY Dry Well Survey Analysis - Notes

Borehole 22-02-05Total # Surveys 549Probe Type 04 02Log Date: 1-16-78 1st# neutron surveys 3
10-27-73 Last# GR Surveys 545Presentation Plot Dates
(If different from 1st & Last)Contamination Zone Depth(s): 0-10Isotope from Spectral Survey: Cs most @ anyMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>0-10 ft hgs above</u>
			<u>& erratic</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name Russ RandallS/W ver TFGROSS2.2

HNF-3532 - REV0

Dry Well Survey Analysis - Notes

Borehole 22-02-07

Total # Surveys 454

Probe Type D4

Log Date: 1-9-75 1st

neutron surveys 2

GR Surveys 452

10-20-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s): 0-10

Isotope from Spectral Survey: no log

Max Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>0-10 erratic count</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Req. Clean	Avg Bkg	Comment

Analysis Notes

The average background changed mid '75 ?
this is only well log for

Analyst Name Russ Randall

S/W ver TFEXES 2.2

Dry Well Survey Analysis - Notes

Borehole 22-02-09Total # Surveys 610Probe Type 04Log Date: 1-16-75 1st# neutron surveys 3# GR Surveys 60710-27-99 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs & CoMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			0-10 show peak @ 22
			28-52 wind zone
			peak @ 60 see ent

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

0-10	all after depth shift
20-26	
26-34	
34-44	
44-52	
52-65	

Analyst Name Russ RandallS/W ver TFGRSS 2.2

filein := "two26-34.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 577

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

taucs := 2.77

aco := 00

acs := 82

Eu variables are

Ru-106

aeu := 419

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Sb-125

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 79.253$$

Sb-125

$$\alpha_{eu} = 423.444$$

Ru-106

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.187$$

out<0> := yr

out<1> := tot

WRITEPRN("twop26-34.txt") := out

$$\frac{Eu_N}{Cs_N} = 1.279 \cdot 10^{-3}$$

filein := "two34-44.txt"

Well 21-02-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 586

i := 0..N

k := 0..300

j := 0..299

teu := 1

 $\tau_{co} := 5.27$ $\tau_{cs} := 2.77$

aco := 00

acs := 1630

Eu variables are

Ru-106

aeu := 300

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Sb-125

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 1.637 \cdot 10^3$$

Sb-125

$$\alpha_{eu} = 311.536$$

Ru-106

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 5.255$$

out<0> := yr

out<1> := tot

WRITEPRN("twop34-44.txt") := out

$$\frac{Eu_N}{Cs_N} = 4.556 \cdot 10^{-5}$$

filein := "two44-52.txt"

Well 21-02-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 589

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

taes := 30.17

aco := 613

acs := 106

Eu variables are

Ru-106 aeu := 1780

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, a2) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right] \right]^2$$

Given

$$ssq(acs, aeu, aco) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aeu, aco)$$

 $\alpha_{cs} = 106$
Cs-137

 $\alpha_{eu} = 1.78 \cdot 10^3$
Ru-106

 $\alpha_{co} = 613$
Co-60

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.06$$

$$tot_i := Cs_i + Eu_i + Co_i$$

out<0> := yr

out<1> := tot

WRITEPRN("twop44-52.txt") := out

$$\frac{Eu_N}{Cs_N} = 5.576 \cdot 10^{-5}$$

Borehole 22-03-01

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity

Grade thickness product from 0 to 10 feet is erratic indicative of tank farm activities such as transfer line operations.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	95 ft
Survey Depth :	95 ft
First Survey Date :	1/16/1975
Last Survey Date :	4/22/1994
Number Surveys :	538

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-03-01

Depth: 0-10 ft

01/16/75

04/22/94

Analysis by: Three Rivers Scientific

Borehole 22-03-01

Borehole 22-03-04

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity
 Contamination (Cs-137) from 10-30 feet is Tank Farm Activity
 Contamination (Sb-125) from 40-55 feet is Stable
 Contamination (Co-60 & Sb-125) from 55-85 feet is Stable

Grade thickness products from 0 to 10 and 10 to 30 feet are erratic, indicative of tank farm activities such as transfer line operations.

Grade thickness product from 40 to 55 feet is decreasing consistent with Sb-125 (HPGe identified) from 1975 to 1994. Note that Co-60 is HPGe identified, but at low levels for this interval.

Grade thickness product from 55 to 85 feet is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Sb-125 (hypothesis) from 1975 to 1994.

The least squares fit results in gross gamma contribution ratio of Co-60 to Sb-125 of 0.36 as of Jan 1975. Special note, the HPGe did identify Sb-125 at shallower depths than 55-85, but the Sb-125 in 55-85 feet decayed to a level below detection.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	4/20/1994
Number Surveys :	457

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 & 10-30 Tank Farm Activity 40-55 & 55-85 Stable
Analyst Name :	R.R. Randall
Company Name :	Three Rivers Scientific

Borehole 22-03-04

Depth: 0-10 ft

Borehole 22-03-04

Depth: 10-30 ft

Analysis by: Three Rivers Scientific

01/16/75

Borehole 22-03-04

Depth: 40-55 ft

04/20/94

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Borehole 22-03-04

Borehole 22-03-05

Contamination (Cs-137) from 0-5 feet is Undetermined

Contamination (Cs-137) from 5-15 feet appears Stable

Contamination (Cs-137) from 15-60 feet appears Stable

Contamination (Cs-137) from 60-85 feet appears Stable

Grade thickness product from 0 to 5 feet is undetermined due to lack of depth control near the surface and the short time span of the data.

Grade thickness product from 5 to 15 feet is decreasing consistent with Cs-137 (HPGe identified) from 1980 to 1990.

Grade thickness product from 15 to 60 feet is decreasing consistent with Cs-137 (HPGe saturated, but observed above and below) as determined by the red GM, since the green GM count rate limits were exceeded.

Grade thickness product from 60 to 85 feet is decreasing consistent with Cs-137 (HPGe identified). The very slight deviation from Cs-137 early cannot be claimed as deviation given the short duration of the data collection. Special note, the HPGe did identify Co-60 in this interval, but the levels are low and dominated by the very high Cs-137 concentration.

Gross Gamma Survey Information

Probe Type :	01: Green GM, & 02: Red GM
Other Probe Types :	14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980 tool 01 & 5/5/80 tool 02
Last Survey Date :	11/8/1989 tool 01 & 11/8/89 tool 02
Number Surveys :	235 tool 01 & 255 tool 02

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold 0<val<50 tool 02 Threshold 0<val<20 tool 01
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-5 Undetermined 5-15, 15-60, & 60-85 Stable
Analyst Name :	R.R. Randall
Company Name :	Three Rivers Scientific

Borehole 22-03-05

Depth: 0-5 ft

Tool 01: Green GM

Cs-137 Decay Line

07/24/80

11/08/89

Analysis by: Three Rivers Scientific

Borehole 22-03-05

Depth: 5-15 ft

Tool 01: Green GM

Cs-137 Decay Line

07/24/80

Analysis by: Three Rivers Scientific

Borehole 22-03-05

07/24/80

11/08/89

Depth: 15-60 ft

Tool 01: Green GM

Count Rate Limits Exceeded
Refer to Red GM Grade Thickness Plot
for this same interval to evaluate stability

Cs-137 Decay Line

Analysis by: Three Rivers Scientific

Borehole 22-03-05

Depth: 60-85 ft

Tool 01: Green GM

Analysis by: Three Rivers Scientific

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Borehole 22-03-05 Tool 01: Green GM

00 156

Borehole 22-03-05

Depth: 15-60 ft

Tool 02: Red GM

Analysis by: Three Rivers Scientific

Borehole 22-03-05 Tool 02: Red GM

Borehole 22-03-06

Page 1 of 2

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity

Contamination (Cs-137) from 20-28 feet appears Stable

Contamination (Cs-137, Co-60, & Sb-125) from 37-48 feet is Stable

Contamination (Ru-106, & Sb-125) from 48-60 feet is Stable

Contamination (Co-60, Ru-106, & Sb-125) from 60-94 feet is Stable

Contamination (Sb-125) from 94-105 feet is Stable (when logged)

Grade thickness product Cs-137 (HPGe identified) from 0 to 10 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 20 to 28 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993. Note that background subtraction may account for the small deviations observed.

Grade thickness product from 37 to 48 feet is decreasing consistent with a least squares fit for Cs-137 (HPGe identified), Co-60 (HPGe identified), and Sb-125 (HPGe identified) from 1975 to 1993. The least squares fit results in gross gamma contribution ratios of Cs-137:Sb-125:Co-60 of 690:80:1265 as of Jan 1975. The stack plots shows this interval to change profile over 1975 to 1993, which indicates the slower decay components are located in the upper section.

Grade thickness product from 48 to 60 feet is decreasing consistent with a least squares fit for Ru-106 (hypothesis), and Sb-125 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratios of Ru-106 to Sb-125 of 0.25 as of Jan 1975. Note, Co-60 was marginally identified in this interval, but not visible in gross gamma due to large Sb-125 contribution. Sb-125 present; but not at detection levels when HPGe data collected.

Grade thickness product from 60 to 94 feet is decreasing consistent with a least squares fit for Ru-106 (hypothesis), Co-60 (HPGe identified), and Sb-125 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratios of Ru-106:Sb-125:Co-60 of 581:3440:299 as of Jan 1975.

Grade thickness product from 94 to 105 feet is decreasing consistent with Sb-125 (hypothesis) from 1975 to mid 1983, when logging of this interval ceased.

Due to the complex nature of the intervals in this borehole, a depth shifting was required for all zones analyzed.

Borehole 22-03-06

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Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	4/20/1994
Number Surveys :	490

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50 all zones but 60-94 least squares fit background	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity 20-28, 37-48, 48-60, & 60-94 Stable 94-105 Stable (when logged)	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific

Borehole 22-03-06

Depth: 20-28 ft

Depth Shifted

Analysis by: Three Rivers Scientific

Borehole 22-03-06

Depth: 37-48 ft

Depth Shifted

Analysis by: Three Rivers Scientific

01/16/75

Borehole 22-03-06

Depth: 48-60 ft

Depth Shifted

04/20/94

01/16/75

Borehole 22-03-06

Depth: 60-94 ft

Depth Shifted & Background Fit

Analysis by: Three Rivers Scientific

Borehole 22-03-06

Depth: 94-105 ft

Depth Shifted

Analysis by: Three Rivers Scientific

Borehole 22-03-06 Depth Shifted

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Borehole 22-03-06

Borehole 22-03-07

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity

Contamination (Co-60 & Sb-125) from 47-62 feet is Stable

Contamination (Ru-106, & Co-60) from 62-90 feet is Stable

Grade thickness product Cs-137 (HPGe identified) from 0 to 8 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 47 to 62 feet is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Sb-125 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Sb-125 to Co-60 of 2.10 as of Jan 1975.

Grade thickness product from 62 to 90 feet is decreasing consistent with a least squares fit for Ru-106 (hypothesis) and Co-60 (HPGe identified) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 1.0 as of Jan 1975. Note, the background was least squares fit and subsequently subtracted for this interval grade thickness product.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	4/20/1994
Number Surveys :	475

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < val < 50$ all zones but 62-90 with least squares fit background	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity 47-62 & 62-90 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-03-07

Depth: 0-8 ft

01/16/75

Borehole 22-03-07

Depth: 47-62 ft

04/20/94

01/16/75

Borehole 22-03-07

Depth: 62-90 ft

Background Fit

04/20/94

HNF-3532 -REV0

Borehole 22-03-07

Borehole 22-03-08

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity

Contamination (Co-60 & Ru-106) from 40-60 feet is Stable

Contamination (Co-60) from 80-98 feet appears Stable

Grade thickness product Cs-137 (HPGe identified) from 0 to 8 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 40 to 60 feet is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Ru-106 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 5.92 as of Jan 1975.

Grade thickness product (Co-60) from 80 to 98 feet is decreasing consistent Co-60 (HPGe identified) from 1975 to 1993. The levels are near threshold for gross gamma.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	4/20/1994
Number Surveys :	504

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity 40-60 & 80-98 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-03-08

Depth: 0-8 ft

Borehole 22-03-08

Depth: 40-60 ft

01/15/75

04/20/94

04/20/94

Borehole 22-03-08

Depth: 80-98 ft

01/15/75

HNF-3532 -REV0

Borehole 22-03-08

Borehole 22-03-09

Page 1 of 2

Contamination (Cs-137 & Eu-154) from 0-11 feet is Tank Farm Activity
Contamination (Ru-106) from 11-24 feet is Undetermined
Contamination (Ru-106 & Sb-125) from 24-52 feet is Unstable Early
Contamination (Ru-106) from 44-52 feet is Unstable Early
Contamination (Co-60) from 78-82 feet is Unstable Early
Contamination (Co-60) from 48-95 feet has downward Movement*

*During downward movement could be any radionuclide

Grade thickness product Cs-137 (HPGe identified) from 0 to 11 feet is erratic indicative of tank farm activities such as transfer line operations, but also contains Eu-154 (HPGe identified) that shows stable from 1986 to 1994. Note Co-60 HPGe identified levels are too low to be seen.

The interval from 11 to 52 feet has possible downward movement, refer to stack plot. Thus this interval is broken into several sections, 11-24, 24-52, 44-52, and 11-52 feet. Co-60 and Cs-137 were both identified by HPGe logging system; however, Sb-125 & Ru-106 are hypothesized for some of the intervals. Grade thickness product from 11 to 24 feet is decreasing nearly consistent with Ru-106 (hypothesis) and the HPGe identified Cs-137 is too low to register. Depth errors may cause the small deviation observed, but due to possible downward movement depth correction is not computed. Grade thickness product from 24-52 feet follows a least squares fit for Sb-125 &

Ru-106 (both hypothesized) after initial increase and fixing from 1975 through 1977. Given these radionuclides, the gross gamma contribution ratio of Sb-125 to Ru-106 is 0.23 in Jan 1975.

If the upper zone from 11-24 is Ru-106, then the increase from 1975 to 1977 for 24-52 feet is lateral. Grade thickness product from 44 to 52 feet is observed for the structure from 1984 to 1994. Before 1984, there is possible downward movement into this zone, but after 1984 the possibility of fixing in this bed exists. Given the isotope is Ru-106, then the interval is stable after 1984. May be a case for downward movement to a fixing zone. The entire zone from 11-52 feet has the dominant character of 24-52 feet, and stable after 1977 for Sb-125 and Ru-106.

Therefore, the total conserved radionuclides are stable within this encompassing zone and any downward movement is confined to this total depth interval. The least squares fit results for the gross gamma contribution ratio of Sb-125 to Ru-106 is 0.20 in Jan 1975.

The interval from 48 to 95 feet is chosen in order to view the clearly downward moving front and avoid depth control problems. An attempt to process a grade thickness product over this interval to cover all the downward movement range is not possible since the movement is below the borehole depth. However, the interval from 48 to 95 feet should cover all downward movement from 1975 to mid 1985, and over this time there is no stability. This indicates lateral influx as well as the downward migration. An Sb-125 decay curve (hypothesis) is shown over a possible early (and thus stable) time from 1976 to 1978. The Sb-125 may have been stable and still not register on the HPGe due to detection thresholds, but could have also been remobilized and flushed from the zone. Final note, from 1991 to 1994 the interval appears to be stable Co-60

Borehole 22-03-09

Page 2 of 2

(HPGe identified), which indicates a residual left behind. Likewise, the interval from 78-82 feet may be a lense that retained Co-60 after the front moved down. Thus the grade thickness plot

for 78-82 feet should be viewed from about 1987 to 1994. Over this time, the interval does match the Co-60 (HPGe identified) suggesting fixed Co-60 after passage of the front. Note that in 1975 the front covered this thin zone, therefore, it is possible this fixed Co-60 was in place before the front moved through. The front in this entire interval is moving at a rate near 2 ft/year downward. Given this rate is maintained, then the present leading ledge of the front is now (Aug 1998) at a depth of 122 feet.

During instability, no identification of isotopes is possible, and any one or combination may in fact be the mobile species.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	4/20/1994
Number Surveys :	618

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50 all zones but 24-52 with least squares fit background	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-11 Tank Farm Activity 11-24 Undetermined 24-52 & 44-52 & 78-82 Unstable Early 48-95+ Downward Movement	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-03-09

Depth: 0-11 ft

04/20/94

01/16/75

Borehole 22-03-09

Depth: 24-52 ft

04/20/94

Borehole 22-03-09

Depth: 44-52 ft

01/16/75

Borehole 22-03-09

Depth: 11-52 ft

04/20/94

Borehole 22-03-09

Depth: 78-82 ft

01/16/75

Borehole 22-03-09

Depth: 48-95 ft

Addressing entire wavefront from 1975 to 1985. From start of 1985 until 1992 wave front is passing downward out of this zone. After 1992 possible residual Co-60.

04/20/94

HNF-3532 - REV0

Borehole 22-03-09

Borehole 22-03-10

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity

Contamination (Cs-137) from 8-30 feet is Stable

Grade thickness product Cs-137 (HPGe identified) from 0 to 8 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 8 to 30 feet is decreasing consistent with Cs-137 (HPGe identified) 1975 to 1994. The activity levels are near threshold for the gross gamma logging system.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft 1975 85 ft from 1980-1994
Survey Depth :	100 ft 1975 85 ft from 1980-1994
First Survey Date :	1/16/1975
Last Survey Date :	4/20/1994
Number Surveys :	472

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity 8-30 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific

Borehole 22-03-10

Depth: 0-8 ft

01/16/75

Borehole 22-03-10

Depth: 8-30 ft

04/20/94

HNF-3532 -REV0

Borehole 22-03-10

Dry Well Survey Analysis - Notes

Borehole 22-03-01Total # Surveys 547Probe Type 04 ² 02Log Date: 1-16-75 1st# neutron surveys 7# GR Surveys 5384-22-94 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs 137 & P 32Max Survey Depth 95

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

Mark Roubal

S/W ver

TFGRS 2-2

Well 21-03-01

Special study in low grade Cs over all well depths and sensitivity to background.

filein := "two.txt"
15-95 feet

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 515

i := 0..N

k := 0..300

j := 0..299

teu := 30.17

 $\tau_{co} := 5.27$
 $\tau_{cs} := 3 \cdot 10^9$

aco := 00

acs := 1600

Eu variables are
Ru-106 aeu := 500

 $Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$
 $Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$
 $Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$
 $tot_i := Cs_i + Eu_i$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

ssq(acs, aeu) = 0

l = 1

 $\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$
 $\alpha_{cs} = 1.562 \cdot 10^3$
U-238

 $\alpha_{eu} = 532.09$
Sb-125

 $Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$
 $Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$
 $tot_i := Cs_i + Eu_i$
 $\frac{\alpha_{cs}}{\alpha_{eu}} = 2.935$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

 $\frac{Eu_N}{Cs_N} = 0.219$

Dry Well Survey Analysis - Notes

Borehole BY 22-03-04Total # Surveys 466Probe Type 04Log Date: 1-16-75 1st# neutron surveys 9# GR Surveys 4574-20-94 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Ca and Pb CoMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			same zones as HSP
			the start to peak interval

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

Ronan Randall

S/W ver

TFGR0522

filein := "two55-85.txt"

Well 21-03-04

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 435

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauo := 5.27

tc := 5.27

aco := 00

acs := 230

Eu variables are

Ru-106 aeu := 640

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tc}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauo}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tc}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

l = 1

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 229.704$$

Co-60

$$\alpha_{eu} = 638.998$$

Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tc}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.359$$

$$\frac{Eu_N}{Cs_N} = 0.281$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

Dry Well Survey Analysis - Notes

Borehole 27-03-05Total # Surveys 532Probe Type 01 02 04 14Log Date: 7-24-88 1st (01)# neutron surveys 4# GR Surveys 11-8-89 LastPresentation Plot Dates (If different from 1st & Last)Contamination Zone Depth(s): Isotope from Spectral Survey: Cs high (sat) CoMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>1 RM 8-16 20-60 60-90</u>
			<u>Not used for zones</u>
			<u>inverted</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>0-5</u>	<u>5-15</u>	<u>15-60</u>	<u>60-85</u>
<u>5-5-88</u>	<u>11-8-89</u>	<u>for 02 tool</u>	<u>some averages in set 02 are really 01</u>

Analyst Name Ronald RandallS/W ver IFGROSS 2.2

BY Dry Well Survey Analysis - Notes

Borehole 22-03-06Total # Surveys 496Probe Type 04Log Date: 1-16-75 1st# neutron surveys 6# GR Surveys ~~490~~ 4904-20-94 LastPresentation Plot Dates
(If different from 1st & Last)Contamination Zone Depth(s): Isotope from Spectral Survey: Cs Co SbMax Survey Depth 100Cs/gross not corrected

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>Lot of activity made depth stops</u>
			<u>Stall for power</u>
			<u>0-10 20-28 37-48</u>
			<u>48-60 60-94 94-105</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>Rapid gain as fast on 40-46</u>
<u>Cs not scale with gross near surface</u>
<u>37-48 gross required Background in LSR fit refers to</u>
<u>neutron fit. This fit must use then another fit</u>
<u>from GTS for plot presentation</u>

Analyst Name Russ RandallS/W ver TEGRAS 2.2

filein := "two37-48.txt"

Well 21-03-06

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 472

i := 0..N

k := 0..300

j := 0..299

 $\tau_{eu} := 2.77$ $\tau_{co} := 5.27$ $\tau_{cs} := 30.17$

aco := 80

acs := 690

Eu variables are

Ru-106

aeu := 12650

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + Co_i$$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

$$ssq(a1, a3, a2) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right] \right]^2$$

Given

$$ssq(acs, aeu, aco) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aeu, aco)$$

$$\alpha_{cs} = 689.623$$

U-238

$$\alpha_{eu} = 1.265 \cdot 10^4$$

Sb-125

$$\alpha_{co} = 79.7$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.055$$

$$\frac{Eu_N}{Cs_N} = 0.228$$

$$tot_i := Cs_i + Eu_i + Co_i$$

out<0> := yr

out<1> := tot

WRITEPRN("two37-48.txt") := out

Two comp decay37-48.mcd

8/18/98

Page 1

filein := "two48-60.txt"

Well 21-03-06

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 473

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 1

tauco := 30.17·10⁹

aco := 500

acs := -60

Eu variables are

Ru-106

aeu := 2000

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + C_i$$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

bkg := -50

$$ssq(a1, a3, bkg) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + bkg \right] \right] \right]^2$$

Given

$$ssq(aco, aeu, bkg) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \\ Bkg \end{bmatrix} := \text{Minerr}(aco, aeu, bkg)$$

Bkg = -59.013
Background $\alpha_{eu} = 1.998 \cdot 10^3$
Sb-125 $\alpha_{co} = 501.47$
Ru-106

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$\frac{Eu_N}{Cs_N} = -0.266$$

$$tot_i := Bkg + Eu_i + Co_i$$

Negative background from overstripping

out<0> := yr out<1> := tot

WRITEPRN("threep48-60.txt") := out

Three comp decay48-60.mcd

8/28/98

Page 1

filein := "two60-94b.txt"

Well 21-03-06

Includes bkg, i.e. no background subtraction

A := READPRN(filein)

yr := A<1>

net := A<7>

bkggrp := A<6>

max := A<4>

b := 34.28.1

N := last(yr)

N = 470

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

tc := 1

aco := 299

acs := 581

Eu variables are

Sb-125

aeu := 3440

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tc}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$tot_i := Cs_i + Eu_i + Co_i +$$

gross_i := net_i

Cs variables are Ru-106

This data edited for spurious points

$$ssq(a1, a3, a2, b) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tc}} + b \right] \right] \right]^2$$

Given

$$ssq(aco, aeu, acs, b) = 0$$

1=1

2=2

3=3

$$\begin{bmatrix} \alpha co \\ \alpha eu \\ \alpha cs \\ bkg \end{bmatrix} := \text{Minerr}(aco, aeu, acs, b)$$

acs = 581
Ru-106

aeu = $3.44 \cdot 10^3$
Sb-125

aco = 299
Co-60

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tc}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}}$$

$$\frac{\alpha co}{\alpha eu} = 0.087$$

$$\text{bkg} = 955.4$$

$$\frac{Eu_N}{Cs_N} = 3.056 \cdot 10^4 \quad \frac{955.4}{35 \text{ yr}} = 27.3 \text{ cl. BKG}$$

$$tot_i := bkg + Eu_i + Co_i + Cs_i$$

out<0> := yr

out<1> := tot

WRITEPRN("twop60-94Bkg.txt") := out

Three comp decay60-94Bkg.mcd

8/20/98

Page 1

Dry Well Survey Analysis - Notes

Borehole 22-03-07Total # Surveys 483Probe Type 04 02Log Date: 1-16-75 1st# neutron surveys 7
4-20-94 Last# GR Surveys 425
Presentation Plot Dates(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs CoMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			2 separate dry zone zone by end
			from 47-62 62-90 0-8

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

Russ Randall

S/W ver

TFGROSS 2.2

filein := "two47-62.txt"

Well 21-03-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 460

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

tauco := $3 \cdot 10^9$

aco := 408

acs := 00

Eu variables are

Ru-106 aeu := 856

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$
tot_i := Co_i + Eu_igross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

ssq(aco, aeu) = 0

l = 1

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

$$\alpha_{co} = 407.175$$

Co-60

$$\alpha_{eu} = 856.208$$

Sb-125

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$
tot_i := Co_i + Eu_i

$$\frac{\alpha_{co}}{\alpha_{eu}} = 0.476$$

$$\frac{Eu_N}{Co_N} = 0.213$$

out<0> := yr

out<1> := tot

WRITEPRN("twop47-62.txt") := out

filein := "two62-90B.txt"

Well 21-03-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

B := 28.28

N := last(yr)

N = 455

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

taucs := 3.10⁹

aco := 558

acs := 00

Eu variables are

Ru-106

aeu := 562

Cs_i := acs · e^{-(yr_i - 75) · $\frac{\ln(2)}{\tau_{cs}}$}

Co_i := aco · e^{-(yr_i - 75) · $\frac{\ln(2)}{\tau_{co}}$}

Eu_i := aeu · e^{-(yr_i - 75) · $\frac{\ln(2)}{\tau_{eu}}$}

tot_i := Co_i + Eu_i + B

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, B) := \sum_i \left[\text{gross}_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + B \right] \right]^2$$

Given

ssq(aco, aeu, B) = 0

1 = 1

2 = 2

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \\ B_{kg} \end{bmatrix} := \text{Minerr}(aco, aeu, B)$$

α_{co} = 572.423
Co-60

α_{eu} = 548.753
Ru-106

B_{kg} = 798.926

 $\frac{B_{kg}}{28} = 28.533$

Co_i := α_{co} · e^{-(yr_i - 75) · $\frac{\ln(2)}{\tau_{co}}$}

Eu_i := α_{eu} · e^{-(yr_i - 75) · $\frac{\ln(2)}{\tau_{eu}}$}

tot_i := Co_i + Eu_i + B_{kg}
 $\frac{\alpha_{co}}{\alpha_{eu}} = 1.043$
 $\frac{Eu_N}{Co_N} = 1.878 \cdot 10^{-5}$

out<0> := yr

out<1> := tot

WRITEPRN("two62-90.txt") := out

Co_N = 45.202

tot_N - 799 = 45.129

BY Dry Well Survey Analysis - Notes

Borehole 22-03-08Total # Surveys 510Probe Type 04Log Date: 1-15-95 1st# neutron surveys 6# GR Surveys 5044-20-94 LastPresentation Plot Dates (If different from 1st & Last)Contamination Zone Depth(s): Isotope from Spectral Survey: Co Amf Co ~50 & 90-100 Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>40-60 strong 80-90 weak</u>
			<u>anyone</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>From attack # 0-8</u>	<u>40-60</u>	<u>80-95</u>

Analyst Name Russ RandalS/W ver TFE PASS 2.2

filein := "two40-60.txt"

Well 21-03-08

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 496

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

tc := 3·10⁹

aco := 198

acs := 0

Eu variables areRu-106

aeu := 1174

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tc}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau} \cdot 1}$$

$$tot_i := Co_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}} \right] \right]^2$$

Given

$$ssq(aco, aeu) = 0$$

l = 1

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

 $\alpha_{co} = 198$
Co-60

 $\alpha_{eu} = 1.174 \cdot 10^3$
Ru-106

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tauco}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{tau}}$$

$$tot_i := Co_i + Eu_i$$

$$\frac{\alpha_{co}}{\alpha_{eu}} = 0.169$$

$$\frac{Eu_N}{Co_N} = 1.162 \cdot 10^{-4}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop40-60.txt") := out

Dry Well Survey Analysis - Notes

Borehole 22-03-09Total # Surveys 627Probe Type 04Log Date: 1-16-75 1st# neutron surveys 9
4-20-94 Last# GR Surveys 678Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs Co En 154Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<p>Can't do depth shift due to downward movement Cs 137 & Ru decay rates are close enough to back like 1-48 yr T samples over the time span</p>

Analyst Name Paul RandallS/W ver TF6R05E2.2

filein := "two00-11.txt"

Well 21-03-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 227

i := 0..N

k := 0..300

j := 0..299

tau := 8.5

tauco := 5.27

taucs := 30.17

aco := 00

acs := 830

Eu variables are

Ru-106

aeu := 1236

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

l=1

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 830.143$$

Cs-137

$$\alpha_{eu} = 1.237 \cdot 10^3$$

Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.671$$

out<0> := yr

out<1> := tot

WRITEPRN("twop00-11.txt") := out

$$\frac{Eu_N}{Cs_N} = 0.481$$

filein := "two11-52.txt"

Well 21-03-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

B := 0

N := last(yr)

N = 528

i := 0..N

k := 0..300

j := 0..299

tau := 1

 $\tau_{co} := 5.27 \cdot 10^9$ $\tau_{cs} := 2.77$

aco := 0

acs := 10570

Eu variables are

Ru-106

aeu := 53160

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + Co_i + B$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + 0 \right] \right]^2$$

Given

ssq(acs, aeu) = 0

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

 $\alpha_{cs} = 1.057 \cdot 10^4$
Sb-125

 $\alpha_{eu} = 5.316 \cdot 10^4$
Ru-106

Bkg =

$$yrf_i := 75 + 20 \cdot \frac{i}{N}$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yrf_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yrf_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$\frac{Bkg}{28} =$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.199 \quad \alpha_{co} =$$

$$\frac{Eu_N}{Cs_N} = 7.152 \cdot 10^{-4}$$

$$tot_i := Cs_i + Eu_i$$

 out<0> := yrf
two11-52bkg.mcd

out<1> := tot

WRITEPRN("twop11-52.txt") := out

8/31/98

00 209

filein := "two24-52B.txt"

Well 21-03-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

B := 432

N := last(yr)

N = 513

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27·10⁹

tauco := 2.77

aco := 0

acs := 11670

Eu variables are

Ru-106

aeu := 50890

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + Co_i + B$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, B) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + B \right] \right]^2$$

Given

ssq(acs, aeu, B) = 0

1 = 1

2 = 2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \\ n_{kg} \end{bmatrix} := \text{Minerr}(acs, aeu, B)$$

$$yrf_i := 75 + 20 \cdot \frac{1}{N}$$

$$\alpha_{cs} = 1.167 \cdot 10^4$$

Co-137
Sb-125

$$\alpha_{eu} = 5.089 \cdot 10^4$$

Sb-125
Ru-106

$$B_{kg} = 432$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yrf_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yrf_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$\frac{B_{kg}}{28} = 15.429$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.229$$

$$\alpha_{co} =$$

$$tot_i := Cs_i + Eu_i + B_{kg}$$

$$\frac{Eu_N}{Cs_N} = 6.201 \cdot 10^{-4}$$

out<0> := yrf

out<1> := tot

WRITEPRN("twop-sb-24-52Bkg.txt") := out

SB tryTwo comp decay24-52Bkg.mcd

8/31/98

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PAPER.

Borehole 22-03-09

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HNF-3532 -REV0

Borehole 22-03-09

BY Dry Well Survey Analysis - Notes

Borehole 22-03-10Total # Surveys 479Probe Type 04Log Date: 1-16-75 1st# neutron surveys 7
4-20-94 Last# GR Surveys 472Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS lowMax Survey Depth 90

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
			Some time after '80 100' → 85'

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Surf & 10-30' Long hole

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

0-8	8-30

Analyst Name Russ RandallS/W ver TF6ROSS 2.2

Borehole 22-04-01

Contamination (Ru-106) from 20-35 feet is Stable

Contamination (Ru-106) from 35-45 feet is Stable

Grade thickness product over 20 to 35 feet is decreasing consistent with Ru-106 (hypothesis) decay. There may be some indication of non-stability from 1981 through 1987, but the levels are near threshold and no definite conclusion can be reached.

Grade thickness product over 35 to 45 feet is decreasing consistent with Ru-106 (hypothesis) decay.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/4/1993
Number Surveys :	439

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50 for 20-35 & 35-45 Threshold 0<val<40 for 20-45	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	20-35 & 35-45 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/09/75

Borehole 22-04-01

Depth: 20-35 ft

10/04/93

Borehole 22-04-01

Depth: 35-45 ft

01/09/75

10/04/93

Borehole 22-04-01

Borehole 22-04-05

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/4/1993
Number Surveys :	403

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-04-05**Oldest Survey****1/09/1975****Gamma (c/s)** **No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

HNF-3532 -REV0

Borehole 22-04-05

Borehole 22-04-07

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1975 and 1993 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	10/4/1993
Number Surveys :	409

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-04-07

Oldest Survey

1/09/1975

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

HNF-3532 -REV0

Borehole 22-04-07

Borehole 22-04-09

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity
 Contamination (Co-60) from 75-95 feet is **UNSTABLE** Early
 Contamination (Co-60) from 105-120 feet Stable (when logged)

Grade thickness product, Cs-137 (HPGe identified), from 0 to 8 feet is erratic, indicative of tank farm activities such as transfer line operations. The grade thickness product for this interval appears stable from 1986 to 1993.

Grade thickness product over 75 to 95 feet is increasing starting mid 1979. After the rapid increase stops in mid 1980 until 1982 the grade thickness product is not changing consistent with Co-60 (HPGe identified) from mid 1979 to 1982. A rapid decrease indicated by four surveys in early 1982 ends with a data gap, and when logging data resumes, the decay appears consistent with Co-60, but at low levels.

Grade thickness product, Co-60 (HPGe identified) from 105 to 120 feet first appears 12-22-83 due to apparent well deepening and from this time to 1993 is stable. Special note that there are no data to indicate downward movement if it occurred; however, the contaminant could be in this interval (105-120 feet) as a result of the drilling process.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	125 ft present
Survey Depth :	100 ft at start and 125 ft after 12-22-83
First Survey Date :	1/9/1975
Last Survey Date :	10/7/1993
Number Surveys :	451

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold 0<val<50
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity, 75-95 UNSTABLE , 105-120 Stable (when logged)
Analyst Name :	R.R. Randall
Company Name :	Three Rivers Scientific

Borehole 22-04-09

Depth: 0-8 ft

01/09/75

01/09/75

Borehole 22-04-09

Depth: 75-95 ft

10/07/93

01/09/75

Borehole 22-04-09

Depth: 105-120 ft

10/07/93

Borehole 22-04-09

Borehole 22-04-11

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity

Contamination (Cs-137) from 10-25 feet is Stable

Contamination (Ru-106) from 25-50 feet is Stable

Contamination (Co-60) from 90-100 feet is Undetermined

Grade thickness product, Cs-137 (HPGe identified), from 0 to 8 feet is erratic, indicative of tank farm activities such as transfer line operations. The grade thickness product appears stable from 1986 to 1994.

Grade thickness product from 10 to 25 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1994.

Grade thickness product from 25 to 50 feet is decreasing nearly consistent with Ru-106 (hypothesis) from 1975 to 1994. Special note, there is a very slight deviation early from a single Ru-106 decay. The addition of a longer lived component cannot be computed since the levels of confidence do not allow such a procedure and a definitive statement.

Grade thickness product from 90 to 100 feet is decreasing consistent with Co-60 (HPGe identified), between 1976 and mid 1982, but gross gamma logging was not designed to accurately measure near the surface or bottom of the borehole. Also, some presence of a rapid decay is indicated from 1975 to 1976, but system limitations do not allow a conclusion.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI, 02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/4/1993
Number Surveys :	405

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity 10-25 & 25-50 Stable 90-100 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific

Borehole 22-04-11

Depth: 0-8 ft

Borehole 22-04-11

Depth: 10-25ft

01/09/75

10/04/93

Borehole 22-04-11

Depth: 25-50 ft

Borehole 22-04-11

Depth: 90-100 ft

Borehole 22-04-11

BY Dry Well Survey Analysis - Notes

Borehole 22-04-01Total # Surveys 441Probe Type 04Log Date: 1-9-75 1st# neutron surveys 2
10-4-73 Last# GR Surveys 439Presentation Plot Dates
(If different from 1st & Last)Contamination Zone Depth(s): Isotope from Spectral Survey: Ca done levels all togetherMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>Two zones early 20-35 & @ 40</u>
			<u>gone by 77</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>20-45, need 0-40 threshold bkg</u>
<u>Also checked bkg change & not due to Ru</u>
<u>interference all experience flat.</u>

Analyst Name Russ RandallS/W ver TFEPROSS 2.2

01/09/75

Borehole 22-04-01

Depth: 20-45 ft
Reference Only

10/04/93

Borehole 22-04-01

Analysis by: Three Rivers Scientific

BY

Dry Well Survey Analysis - Notes

Borehole 22-04-05Total # Surveys 405Probe Type 04Log Date: 1-9-75 1st# neutron surveys 2
10-4-93 Last# GR Surveys 403Presentation Plot Dates _____
(If different from 1st & Last)Contamination Zone Depth(s): CleanIsotope from Spectral Survey: Cs shallow & low levelsMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Intermittent from surface
			Stack → clean

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

1st Clean well in this farm

Analyst Name Renee R. SmithS/W ver TFGRBS2.2

Dry Well Survey Analysis - Notes

Borehole 22-04-07Total # Surveys 411Probe Type 04Log Date: 1-9-75 1st# neutron surveys 2
10-4-93 Last# GR Surveys 409Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs 137 surf Co deep & low level Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>84-86 every other has surface hit</u>
			<u>Clean - Co does <u>not</u> show</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

Russ Randal

S/W ver

TFGR055 2.2

BY
Dry Well Survey Analysis - Notes

Borehole 22-04-09Total # Surveys 456Probe Type D4Log Date: 1-9-75 1st# neutron surveys 5# GR Surveys 45110-7-93 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Co 100% 100% Co 100% 100%Max Survey Depth 128

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>75-95</u> looks like well dispersed start
			<u>84</u>
			<u>also 105-120</u>
			<u>dispersed between 6-8-82 & 12-22-83</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>75-95</u>
<u>105-120</u>
<u>0-8 TF activity but stable rate</u>

Analyst Name

Bruce Randall

S/W ver

TFGRSS 2.2

BY
Dry Well Survey Analysis - Notes

Borehole 22-04-11Total # Surveys 407Probe Type 04Log Date: 1-9-75 1st# neutron surveys 2# GR Surveys 40510-4-93 LastPresentation Plot Dates (If different from 1st & Last)Contamination Zone Depth(s): Isotope from Spectral Survey: Cs low shallow core very low edge Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>a quick decay @ 70' ± 10'</u>
			<u>surface 0-8' a bottom 95-100 ± 77</u>
			<u>a long lived peak @ 18'</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>From Stack</u>	<u>0-8</u>	<u>10-25</u>	<u>25-50</u>	<u>40-100</u>

Analyst Name Russ RandallS/W ver TFGROSS 2.2

Borehole 22-05-01**Contamination (Cs-137) from 0-10 feet is Tank Farm Activity**

Grade thickness product Cs-137 (HPGe identified) from 0 to 10 feet is erratic indicative of tank farm activities such as transfer line operations. However, some of the surveys are near the limits of count rate at 20,000 to 40,000 c/s. Also, the consistent steady decline from Jan 10, 1975 to Jul 11, 1975 is not usual for such "Tank Farm Activity".

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/10/1975
Last Survey Date :	4/22/1994
Number Surveys :	737

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-05-01

Depth: 0-10 ft

01/10/75

Analysis by: Three Rivers Scientific

Borehole 22-05-01

Borehole 22-05-05**Contamination (Cs-137) from 0-10 feet is Tank Farm Activity**

Grade thickness product Cs-137 (HPGe identified) from 0 to 10 feet is erratic indicative of tank farm activities such as transfer line operations. There is also some indication of problems associated with depth control near the surface.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	4/22/1994
Number Surveys :	704

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/09/75

Borehole 22-05-05

Depth: 0-10 ft

04/22/94

HNF-3532 - REV0

Borehole 22-05-05

Borehole 22-05-09

Contamination (Co-60) from 55-66 feet is Unstable Early
Contamination (Co-60) from 55-90 feet is Unstable Early, Undetermined
Late

Grade thickness product Co-60 (HPGe identified) from 55 to 66 feet appears stable from 1977 to 1994, and the rapid change before 1977 could be movement or a rapid decay component. The stack plot clearly displays downward movement from a peak at 70 feet down, and after 1985 there is not enough signal to determine if the movement down continues. The grade thickness product is processed for 55 to 66 feet in order to view stability after possible movement down clears out of the region.

The stack plot clearly shows downward movement of the peak at 70 feet. After 1984, the levels are too low to make a determination of continued movement from the stack plot. Therefore, a grade thickness product is computed for the entire interval of 55 to 90 feet to quantitatively assess the dynamics after 1984. The trend does not clearly match the Co-60 decay from 1984 to 1994, but the deviation is near threshold at the end and a definitive classification is not possible.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	4/22/1994
Number Surveys :	643

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	55-66 & 55-90 UNSTABLE EARLY & Downward Movement (Undetermined late)	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/09/75

Borehole 22-05-09

Depth: 55-66 ft

04/22/94

01/09/75

Borehole 22-05-09

Depth: 55-90 ft

04/22/94

HNF-3532 -REV0

Borehole 22-05-09

BY Dry Well Survey Analysis - Notes

Borehole 22-05-01Total # Surveys 744Probe Type 04Log Date: 1-10-75 1st# neutron surveys 7# GR Surveys 7374-22-94 LastPresentation Plot Dates
(If different from 1st & Last)Contamination Zone Depth(s): Isotope from Spectral Survey: Cs low Co @ bottomMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>Stack → 0-10'</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name Paul RandallS/W ver TEGROS 2.2

BY Dry Well Survey Analysis - Notes

 rehole 22-05-05

 Total # Surveys 708

 Probe Type 04

 Log Date: 1-9-75 1st

 # neutron surveys 4
4-22-94 Last

 # GR Surveys 704
 Presentation Plot Dates

 (If different from 1st & Last)

 Contamination Zone Depth(s):

 Isotope from Spectral Survey: Cs Surf & low all depths

 Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>0-10 90-100</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Example of GTP all well = Bkg + C2

TF activity but depth problems also

 Analyst Name Anna Randall

 S/W ver TF6R055 2.2

Dry Well Survey Analysis - Notes

Corehole 22-05-09Total # Surveys 648Probe Type 04 02Log Date: 1-9-75 1st# neutron surveys 4# GR Surveys 6434-22-94 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs & Co $\approx$ 60'Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>55-75 don't fit early rapid decay</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Freq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>Stack above down movement</u>	<u>55-90</u>
<u>Traced Bkg fit, matched, for 55-90 ft - still</u>	
<u>no good match</u>	

Analyst Name

Max Randall

S/W ver

TIFCROSS2.2

filein := "two55-90.txt"

Well 21-05-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 394

i := 0..N

k := 0..300

j := 0..299

tau := 5.27

tauo := 5.27

tau_s := 3·10⁹

aco := 00

acs := 52

Eu variables are

Ru-106 aeu := 427

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are Bkg

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(acs, aeu) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

$$\alpha_{cs} = 51.942$$

U-238

$$\alpha_{eu} = 425.811$$

Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.122$$

out<0> := yr

out<1> := tot

WRITEPRN("twop55-90.txt") := out

$$\frac{Eu_N}{Cs_N} = 0.647$$

Borehole 22-06-01

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity

Contamination (Sb-125) from 42-52 feet is Stable

Contamination (Co-60 & Ru-106) from 52-65 feet is Stable

Grade thickness product Cs-137 (HPGe identified) from 0 to 8 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product Sb-125 (hypothesis) from 42 to 52 feet is stable from 1975 to 1994. The levels are near threshold early, and at background late. Co-60 is HPGe identified, but at levels too low to register with gross gamma.

Grade thickness product is consistent with a least squares fit for Co-60 (HPGe identified) and Ru-106 (hypothesis). The least squares fit results in gross gamma contribution ratio of Co-60 to Ru-106 of 1.07 as of Jan 1975.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	4/20/1994
Number Surveys :	726

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity 42-52 & 52-65 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-06-01

Depth: 0-8 ft

01/09/75

04/20/94

Analysis by: Three Rivers Scientific

Borehole 22-06-01

Depth: 42-52 ft

Borehole 22-06-01

Depth: 52-65 ft

01/09/75

04/20/94

Borehole 22-06-01

Borehole 22-06-05

Page 1 of 2

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity
 Contamination (Sb-125 & Co-60) from 28-36 feet is Stable
 Contamination (Sb-125 & Co-60) from 36-50 feet is Unstable Early
 (Down Movement)
 Contamination (Co-60) from 62-84 feet is Unstable (Down Movement)
 Contamination (Co-60) from 28-84 feet is Unstable (Down Movement)*

*Zone used to assess downward migration

Grade thickness product Cs-137 (HPGe identified) from 0 to 8 feet is erratic indicative of tank farm activities such as transfer line operations. However, the majority of history is low level.

Grade thickness product from 28 to 36 feet is consistent with a least squares fit of Sb-125 (hypothesis) and Co-60 (HPGe identified) decay from 1975 to 1994. The gross gamma contribution ratio of Sb-125 to Co-60 is 0.54 on 4/20/94.

The stack plot clearly shows downward contaminant movement from 40 to 84 feet. Grade thickness product from 36 to 50 feet is computed and displayed on expanded scale in order to assess the later years for stability after the front may have passed through. After 1981 through 1993, the grade thickness product is consistent with least squares fit of Sb-125 (hypothesis) and Co-60 (HPGe identified) from 36 to 50 feet. Given the presence of Sb-125, the conclusion is that after the contaminant front moved through this zone a stable residual of Sb-125 and Co-60 remain.

The gross gamma contribution ratio of Sb-125 to Co-60 is 6.5 as of 4/20/94.

As the contaminant front moves below 62 feet, there is clear indication of possible hang-up at 62 feet. Therefore, a grade thickness product was computed for 62 to 84 feet in order to assess the later years for stability after the front moved into the zone. This interval covers the deepest depth for the front advancement, as of the data collection. A match to Co-60 (HPGe identified) is not clear, and at most only for the last 2 years. This indicates that from 1987 to 1992 there may be lateral influx into this interval as well as downward movement.

Grade thickness product from 28 to 84 feet is computed that covers all downward movement span (refer to stack plot). Thus all contaminant intervals is conserved, but the trend does not match an exponential decay except for possibly 1977 to 1980 for a Co-60 decay. Note also some indication of very early increase.

Borehole 22-06-05

Page 2 of 2

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	4/20/1994
Number Surveys :	718

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity 28-36 Stable 36-50 & 62-84 Unstable early (Downward Movement) 28-84 Downward movement not conserved	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

01/16/75

Borehole 22-06-05

Depth: 0-8 ft

04/20/94

Borehole 22-06-05

Depth: 28-36 ft

01/16/75

04/20/94

01/16/75

Borehole 22-06-05

Depth: 36-50 ft

04/20/94

01/16/75

Borehole 22-06-05

Depth: 62-84 ft

04/20/94

01/16/75

Borehole 22-06-05

Depth: 28-84 ft

04/20/94

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Borehole 22-06-05

Borehole 22-06-07

Page 1 of 2

Contamination (Cs-137) from 0-8 feet is Tank Farm Activity
Contamination (Cs-137) from 40-52 feet is Unstable Early
Contamination (Co-60) from 52-64 feet is Unstable Early
Contamination (Co-60) from 64-80 feet is Unstable Early
Contamination (Co-60) from 52-80 feet is Unstable Early*

**Zone computed to assess downward movement*

Grade thickness product Cs-137 (HPGe identified) from 0 to 8 feet is erratic indicative of tank farm activities such as transfer line operations.

Grade thickness product from 40 to 52 feet is not consistent with Cs-137 (HPGe identified) decay from 1975 to 1985. Since 1985 there is no gross gamma indication of contaminant.

Grade thickness product from 52-64 feet is increasing from 1975 until 1980, refer to stack plot. Since 1985 this interval is decreasing consistent with Co-60 (HPGe identified) until 1994. The rapid increase is followed by a faster decrease than Co-60 decay until onset of stability near 1985. Note Cs-137 is also HPGe identified, but at too low a level to register on the gross gamma.

Grade thickness product from 64-80 feet is increasing from 1975 until 1980, refer to stack plot. Since 1984 this interval is decreasing consistent with Co-60 (HPGe identified) until 1994. Unlike the upper zone, this zone increases asymptotically to stability near 1984. Note Cs-137 is also HPGe identified, but at too low a level to register on the gross gamma.

The grade thickness product for the entire interval from 52 to 80 feet is processed to assess the possibility of downward contaminant movement. Since this complete zone shows an increase from 1975 to 1980, and stability from 1980 to 1994 there is lateral influx into this total interval. Also, the onset of stability is sooner than either sub zone indicates some downward transfer of contaminant between the sub zones.

Borehole 22-06-07

Page 2 of 2

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM & 03: Neutron
Borehole Depth :	140 ft
Survey Depth :	140 ft
First Survey Date :	1/9/1975
Last Survey Date :	4/20/1994
Number Surveys :	535

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold $0 < \text{val} < 50$	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 Tank Farm Activity 40-52 & 52-64 & 64-80 UNSTABLE Early 52-80 Unstable early (some downward movement)	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 22-06-07

Depth: 0-8 ft

01/09/75

04/20/94

01/09/75

Borehole 22-06-07

Depth: 40-52 ft

04/20/94

Borehole 22-06-07

Depth: 52-64 ft

01/09/75

Borehole 22-06-07

Depth: 64-80 ft

04/20/94

01/09/75

Borehole 22-06-07

Depth: 52-80 ft

Borehole 22-06-07

Borehole 22-06-09**Contamination (Ru-106) from 70-90 feet is Unstable Early**

Grade thickness product Ru-106 (hypothesis) from 70 to 90 feet is decreasing consistent with a least squares fit to Ru-106 and a constant background after the initial very short time of increase from 1975 to 1976.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/9/1975
Last Survey Date :	5/23/1996
Number Surveys :	709

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50, rest least squares fit	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	70-90 UNSTABLE Early	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific

Borehole 22-06-09

Borehole 22-06-09

Borehole 22-06-11**Contamination (Cs-137) from 0-10 feet is Tank Farm Activity**

Grade Thickness Product from 0 to 10 feet is erratic from 1975 through 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	4/20/1994
Number Surveys :	543

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-06-11

Depth: 0-10 ft

01/09/75

4/20/94

Borehole 22-06-11

Dry Well Survey Analysis - Notes

Borehole 22-06-01Total # Surveys 733Probe Type 04 02Log Date: 1-9-75 1st# neutron surveys 6# GR Surveys 7264-20-94 LastPresentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs (low) Co lowMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>Peak @ 47 g 10 rapid decay</u>
			<u>random surface</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<u>Proton Stack</u>	<u>42-52</u>	<u>52-65</u>	<u>0-3</u>

Analyst Name Russ RandallS/W ver TFGRDS 2.2

filein := "two52-65.txt"

Well 21-06-01

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 698

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

taucs := $3 \cdot 10^9$

aco := 300

acs := 0

Eu variables areRu-106 aeu := 281

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(aco, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

$$\alpha_{co} = 300.405$$

Co-60

$$\alpha_{eu} = 281.326$$

Ru-106

$$Cs_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

$$\frac{\alpha_{co}}{\alpha_{eu}} = 1.068$$

$$\frac{Eu_N}{Co_N} = 1.837 \cdot 10^{-5}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop52-65.txt") := out

Dry Well Survey Analysis - Notes

BY
Borehole 22-06-06

Total # Surveys 724
neutron surveys 5
4-20-94 Last

Probe Type 04 ¹₀₂
GR Surveys 718
Presentation Plot Dates _____
(If different from 1st & Last)

Log Date: 1-16-75 1st

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs & Co (high)

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<i>more down & starting? surface erratic</i>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

<i>Down more must & top range up after 86 & continue to broaden</i>

Analyst Name Russ Randall

S/W ver TPGRDS 2.2

(

filein := "two36-50.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

B := 0

N := last(yr)

N = 442

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

tcsc := 30.17

aco := 42

acs := 0

Eu variables are

Sb-125 aeu := 2940

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(a1, a3) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

$$\alpha_{co} = 42$$

Co-60

$$\alpha_{eu} = 2.94 \cdot 10^3$$

Sb-125

$$yr_i := 75 + \frac{i}{N} \cdot 20$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

$$\frac{\alpha_{co}}{\alpha_{eu}} = 0.014$$

$$\frac{Eu_N}{Co_N} = 6.517$$

out<0> := yr

out<1> := tot

WRITEPRN("twop36-50.txt") := out

HNF-3532 - REV0

Well 21-06-05

filein := "two28-36.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

B := 0

N := last(yr)

N = 704

i := 0..N

k := 0..300

j := 0..299

tau := 2.77

tauco := 5.27

taucs := 30.17

aco := 89

acs := 0

Eu variables are

Sb-125 aeu := 477

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

$$ssq(aco, aeu) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(aco, aeu)$$

α_{co} = 89
Co-60

α_{eu} = 477
Sb-125

$$Cs_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Co_i + Eu_i$$

$$\frac{\alpha_{co}}{\alpha_{eu}} = 0.187$$

$$\frac{Eu_N}{Co_N} = 0.542$$

out<0> := yr

out<1> := tot

WRITEPRN("twop28-36.txt") := out

Dry Well Survey Analysis - Notes

Borehole 22-06-07

Total # Surveys 540

Probe Type 04 02

Log Date: 1-9-75 1st

neutron surveys 4

GR Surveys 535

H-20-94 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs & CoMax Survey Depth 140

130

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			0-8 40-52 52-80
			HZ shrimp increase ↑

BackGnd.Txt

[illegible]

Analysis Notes

[illegible]**Analyst Name**

SNW ver TF6ROSS 2.2

Dry Well Survey Analysis - Notes

Borehole 22-06-09Total # Surveys 715Probe Type 04 02Log Date: 1-9-75 1st# neutron surveys 5# GR Surveys 7095-23-96 Last

Presentation Plot Dates

(If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs low Co low

Max Survey Depth

100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			<u>Sp. detected @ 80' rapid decay</u>
			<u>Stack</u>

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment

Analysis Notes

Analyst Name

Russ Randall

S/W ver

TFGRSS2-2

filein := "two70-90.txt"

Well 21-06-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 649

i := 0..N

k := 0..300

j := 0..299

tau := 1

tauco := 5.27

 $\tau_{cs} := 3 \cdot 10^9$
BKG

aco := 00

acs := 43

Eu variables are

Ru-106 aeu := 986

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

gross_i := net_i

Cs variables are U238

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} \right] \right]^2$$

Given

ssq(acs, aeu) = 0

l = 1

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \end{bmatrix} := \text{Minerr}(acs, aeu)$$

 $\alpha_{cs} = 43.037$
Background

 $\alpha_{eu} = 982.617$
Ru-106

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.044$$

$$\frac{Eu_N}{Cs_N} = 8.28 \cdot 10^{-6}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

Dry Well Survey Analysis - Notes

Borehole B4/22-06-11Total # Surveys 548Probe Type 04Log Date: 75-01-09 1st# neutron surveys 4# GR Surveys 54394-04-20 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: CS-137 (0-37FT) $\leq 10 \mu Ci/g$ Max Survey Depth 100Contamination Zone Depth(s): 0-10 FT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-07-21	44	85	
76-07-29	12	90	
77-08-12	27	70	
79-12-27	46	95	
82-01-27	21	95	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-06-26	HI BKG	95	
76-09-09	HI BKG	95	
78-06-08	TOOL FAIL	100	
93-04-13	TOOL FAIL	100	
94-02-23	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-07-21	% CLEAN	88	50%	28.9	
76-08-09	% CLEAN	97	11%	46.5	
77-08-12	% CLEAN	75	57%	36.6	
77-12-01	Avg BKG	98	81%	36.6	
78-06-08	Avg BKG	97	93%	35.4	
79-10-03	Avg BKG	98	87%	35.7	
93-04-13	% CLEAN	97	37%	34.8	
94-02-23	% CLEAN	97	44%	33.2	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0<val<50)

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name Randall P...S/W ver (TFGROSS) V2.20.

**This document was too large to scan
as a single document. It has
been divided into smaller sections.**

Section 2 of 2

Document Information			
Document #	HNF-3532	Revision	0
Title	ANALYSIS OF HISTORICAL GROSS GAMMA LOGGING DATA FROM BY TANK FARM		
Date	10/13/99		
Originator	MYERS DA	Originator Co.	WMNW,OTHE R
Recipient		Recipient Co.	
References	EDT-625638		
Keywords	VODOSE ZONE, BY TANK FARM, DRY WELL GROSS GAMMA		
Projects	RPP, TANK FARM		
Other Information			

Borehole 22-07-01

Contamination (Cs-137) from 0 to 10 feet is Tank Farm Activity

Contamination (Cs-137) from 40-52 feet is **UNSTABLE**

Contamination (Co-60) from 52-70 feet is Stable

Contamination (Co-60) from 70-92 feet is Stable

Grade Thickness Product from 0 to 10 feet is erratic from 1975 to 1986, and is categorized as Tank Farm activity. Then from 1986 to 1995 the Grade Thickness Product is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for radioactive zone (40-52 feet) shows a consistent INCREASE from 1975 to mid-year 1976, then from 1976 to 1979 a decrease is shown that is not consistent with the decay rate of Cs-137 (identified from HPGe detector). The contaminant responsible for much of the gross gamma may be other than Cs-137, but moved out laterally, since the lower zones are stable. After 1986 the Grade Thickness Product is essentially at background activity.

Grade Thickness Product for the two radioactive zones (52-70 and 70-92 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Co-60 (identified from HPGe detector) between 1975 and 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (7 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	4/22/1994
Number Surveys :	242

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	10 to 40 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 40-51 feet was <u>UNSTABLE</u> 52-70, 70-92 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/10/75

Borehole 22-07-01

Depth: 0-10 ft

04/22/94

Analysis by: Three Rivers Scientific

01/10/75

Borehole 22-07-01

Depth: 40-52 ft

04/22/94

Analysis by: Three Rivers Scientific

Borehole 22-07-01

Depth: 70-92 ft

Analysis by: Three Rivers Scientific

Borehole 22-07-01

Borehole 22-07-02

page 1 of 2

Contamination (Cs-137) from 6 to 20 feet is Appears Stable

Contamination (Co-60) from 42-53 feet is UNSTABLE

Contamination (Co-60) from 53-70 feet is UNSTABLE

Contamination (Co-60) from 70-82 feet is UNSTABLE

Contamination (Co-60) from 82-95 feet is UNSTABLE

Grade Thickness Product for the low level radioactive zone from 6 to 20 feet appears to be decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector), except for 1976 when the Grade Thickness Product was below the decay line.

Grade Thickness Product for radioactive zone (42-53 feet) has a significant INCREASE in 1975, then from mid year 1975 to 1980 the rate of decrease is significantly greater than the decay rate of Co-60 (identified from HPGe detector). In 1980 a large step change in the Grade Thickness Product occurs. The Co-60 decay line is plotted to show the activity in the radioactive zone does not match the decay rate.

Grade Thickness Product for the radioactive zone (53-70 feet) is slowly INCREASING from 1975 to 1979, then in 1979 a large and rapid increase occurs, followed by a rapid decrease to 1983. The stack plot shows the rapid occurrence of a radioactive zone that coincides with the depletion of the radioactive zone from 42-53 feet. The decay line for Co-60 (identified from HPGe detector) is plotted but does not match the Grade Thickness Product.

Grade Thickness Product for the radioactive zone (70-82 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Co-60 (identified from HPGe detector), except from 1980 to 1987. In 1980 an INCREASE in the Grade Thickness Product occurs, then from 1981 to 1987 the rate of decrease is much greater than the decay rate of Co-60.

Grade Thickness Product for the radioactive zone (82-95 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Co-60 (identified from HPGe detector) during two time intervals (1978-1982 and 1987-1995). During the other times (1975-1978 and 1982-1987) an INCREASE followed by an extended period of accelerated decrease was recorded.

Borehole 22-07-02

page 2 of 2

Grade Thickness Product for the combined radioactive zone (42-95 feet) has two periods of rapid INCREASE (1975 and 1979) followed by two periods of accelerated decrease (1976-1979 and 1980-1987), indicating that two releases of radioactive materials occurred.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (6 surveys)
Borehole Depth :	97 ft
Survey Depth :	97 ft
First Survey Date :	1/09/1975
Last Survey Date :	4/22/1994
Number Surveys :	336

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	20 to 40 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	6-20 feet is appears Stable 42-53, 53-70, 70-82, 82-95 feet is <u>UNSTABLE</u>
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-07-02

Depth: 42-53 ft

04/22/94

Borehole 22-07-02

Depth: 53-70 ft

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-07-02

Depth: 70-82 ft

04/22/94

Analysis by: Three Rivers Scientific

Borehole 22-07-02

Borehole 22-07-02

Borehole 22-07-05

page 1 of 2

Contamination (Co-60) from 40-57 feet is **UNSTABLE**
Contamination (Co-60) from 57-65 feet is **UNSTABLE**
Contamination (Co-60) from 65-78 feet is **UNSTABLE**
Contamination (Co-60) from 90-100 feet is Undetermined

Grade Thickness Product for radioactive zone (40-57 feet) is decreasing at a rate that is much greater than the decay rate of Co-60 (identified from HPGe detector) from 1975 to 1983. The Co-60 decay line is plotted to show the activity in the radioactive zone does not match the decay rate.

Grade Thickness Product for the radioactive zone (57-65 feet) is decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector) during two time intervals (1975-1979 and 1986-1995). However, from 1979 to 1986 an INCREASE followed by an elevated decrease in the Grade Thickness Product occurred. The stack plot shows the migration of contamination down through this zone.

Grade Thickness Product for the radioactive zone (65-78 feet) is decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector) during two time intervals (1975-1982 and 1988-1995). However, from 1982 to 1988 an INCREASE in the Grade Thickness Product occurred.

Grade Thickness Product for the radioactive zone (90-100 feet) is erratic from 1975 to 1985. Surveillance logging activities were not designed to monitor low contamination levels near the surface or bottom of the borehole. Grade Thickness Product from 1985 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for the combined radioactive zone (40-78 feet) is decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector) between 1975 and 1994, indicating that no additions to the radioactive materials occurred while the contaminants were migrating through the vadose zone.

Borehole 22-07-05

page 2 of 2

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	97 ft
Survey Depth :	97 ft
First Survey Date :	1/09/1975
Last Survey Date :	4/22/1994
Number Surveys :	238

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	10 to 35 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	40-57, 57-65, 65-78 feet is <u>UNSTABLE</u> 90-100 feet is <u>Undetermined</u>
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-07-05

Depth: 40-57 ft

Analysis by: Three Rivers Scientific

Analysis by: Three Rivers Scientific

Analysis by: Three Rivers Scientific

Borehole 22-07-05

Depth: 40-78 ft

Analysis by: Three Rivers Scientific

Borehole 22-07-05

Borehole 22-07-05

Borehole 22-07-07

Contamination (Cs-137 & Ru-106 & Sb-125) from 30-54 feet
is **UNSTABLE**

Contamination (Co-60 & Sb-125) from 80-98 feet is **UNSTABLE**

Grade Thickness Product for radioactive zone (30-54 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Ru-106 and Sb-125 (both hypotheses) and Cs-137 (identified from HPGe detector) from 1975 to 1980, then in 1981 the Grade Thickness Product decreases rapidly in a few months to background levels.

Grade Thickness Product for the radioactive zone (80-98 feet) is INCREASING in 1975 then from 1976 to 1983 has an erratic rate or decrease. The rate of decrease (since 1983) does not clearly identify the radionuclides that may have been present, other than Co-60 (identified from HPGe detector). The presence of Sb-125 (hypothesis) is considered because of its probable presence in the shallower zone and other boreholes in this Tank Farm. Two decay lines are presented. The decay line for Co-60 shows stability since about 1990. The decay line for Sb-125 and Co-60 shows stability since 1983.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	4/22/1994
Number Surveys :	225

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	55 to 80 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	30-54 feet is <u>UNSTABLE</u> 80-98 feet is <u>UNSTABLE</u>
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-07-07 **Depth: 80-98 ft**

Analysis by: Three Rivers Scientific

Borehole 22-07-07

Borehole 22-07-09

page 1 of 2

Contamination (Cs-137) from 0-9 feet is Tank Farm Activity

Contamination (Cs-137) from 9-17 feet is Stable

Contamination (Cs-137) from 17-36 feet is Appears Stable

Contamination (Cs-137) from 62-74 feet is UNSTABLE

Contamination (Co-60) from 74-84 feet is UNSTABLE

Contamination (Co-60) from 84-94 feet is UNSTABLE

Contamination (Co-60) from 94-100 feet is UNSTABLE

Grade Thickness Product from 0 to 9 feet is erratic in 1975 and from 1982 to 1986, and is categorized as Tank Farm activity. Grade Thickness Product is decreasing within counting statistics in two time intervals (1976-1982 and 1986-1994) at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for the radioactive zone (9-17 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Cs-137 (identified from HPGe detector) between 1975 and 1994.

Grade Thickness Product for the radioactive zone (17-36 feet) appears to be decreasing sensitivity at a rate consistent with the decay of Cs-137 (identified from HPGe detector) except prior to 1981. The gross gamma activity is at the 30,000 counts per second rate which may be beyond the linear region of the counting system.

Grade Thickness Product for radioactive zone (62-74 feet) is INCREASING from 1975 to mid-year 1976 then is decreasing at a rate that would appear to be stable contamination. However, the stack plot shows the migration of contamination out of this zone (i.e. vertical movement to lower depths), therefore, fitting the decrease in grade thickness product to a radionuclide decay would be incorrect since movement is apparent. The grade thickness product fits the decay of Cs-137 (identified from HPGe detector) from 1987 to 1995.

Grade Thickness Product for the radioactive zone (74-84 feet) has two time intervals of INCREASING radioactivity (1975-1978 and 1980-1982) followed by decreases. The decrease would appear to be stable contamination, however, the stack plot shows migration down from this zone to the lower zones. Therefore, fitting the decrease in grade thickness product to radioactive decay would be incorrect even though the decrease is consistent with the decay of Antimony-125 (hypothesis) and Cobalt-60 (identified from HPGe detector). The grade thickness product does not fit the decay of Co-60 (HPGe identified) until very recently from 1990 to 1995.

Borehole 22-07-09

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Grade Thickness Product for the radioactive zone (84-94 feet) shows background activity from 1975 to 1982, then INCREASING radioactivity from 1982 to 1985. The Grade Thickness Product has been decreasing from 1989 to 1995 at a rate consistent with the decay of Co-60 (identified from HPGe detector) within observed systematic limitations.

Grade Thickness Product for the radioactive zone (94-100 feet) shows background activity from 1975 to 1984, then INCREASING radioactivity from 1984 to 1986. The Grade Thickness Product has been decreasing from 1990 to 1995 at a rate consistent with the decay of Co-60 (identified from HPGe detector) within observed systematic limitations.

Grade Thickness Product for the combined radioactive zone (62-100 feet) shows three time intervals of INCREASED radioactivity (1975, 1980, 1984). The Grade Thickness Product has been decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector) from 1990 to 1995.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	4/22/1994
Number Surveys :	393

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	40 to 60 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-9 feet is TF Activity 9-17 feet is Stable 17-36 feet Appears Stable 62-74, 74-84, 84-94, and 94-100 feet are UNSTABLE
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-07-09

Depth: 9-17 ft

Analysis by: Three Rivers Scientific

Borehole 22-07-09

Depth: 17-36 ft

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-07-09

Depth: 62-74 ft

04/22/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-07-09

Depth: 84-94 ft

Analysis by: Three Rivers Scientific

Borehole 22-07-09 **Depth: 94-100 ft**

Analysis by: Three Rivers Scientific

Depth Shifted

Borehole 22-07-09

Depth Shifted

Borehole 22-07-09

Borehole 22-07-10

Contamination (Cs-137) from 0-6 feet is Tank Farm Activity

Contamination (Cs-137) from 6-12 feet is Stable

Contamination (Cs-137) from 12-20 feet is Stable

Contamination (Cs-137) from 20-30 feet is Stable

Contamination (Cs-137) from 30-44 feet is Stable

Grade Thickness Product from 0 to 6 feet is erratic for the 20 years of surveillance logging. The decay line for Cs-137 (identified from HPGe detector) is shown on the plot but is not fitted to any set of survey data.

Grade Thickness Product for the four radioactive zones (6-12, 12-20, 20-30, and 30-44 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Cs-137 (identified from HPGe detector) between 1975 and 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	97 ft
Survey Depth :	97 ft
First Survey Date :	1/09/1975
Last Survey Date :	4/22/1994
Number Surveys :	356

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	45 to 70 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-6 feet is TF Activity 6-12, 12-20, 20-30, 30-44 feet are Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-07-10

Depth: 0-6 ft

01/09/75

Analysis by: Three Rivers Scientific

Borehole 22-07-10

Depth: 20-30 ft

Analysis by: Three Rivers Scientific

Borehole 22-07-10 **Depth: 30-44 ft**

Analysis by: Three Rivers Scientific

Borehole 22-07-10

Depth Shifted

Borehole 22-07-10

Dry Well Survey Analysis - Notes

Borehole B4(22-07-01)Total # Surveys 249Probe Type 04Log Date: 75-01-09 1st# neutron surveys 7# GR Surveys 24294-04-22 Last

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey: _____

Max Survey Depth 100Contamination Zone Depth(s): 0-10, 40-52, 52-70, 70-92

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-04-29	16	90	
76-09-02	19	95	
78-09-13	25	92	
80-09-18	10	90	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
75-03-05	NO RAD ZONE	170	
76-05-20	TOOL FAIL	95	
77-12-08A	BAD LOG	40	
78-11-01	HI-BKG	100	
80-12-02	NO RAD ZONE	100	
94-04-22	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-12	AVG BKG	100	42%	38.5	
76-05-20	% CLEAN	97	11%	32.0	
77-12-08	AVG BKG	35	28%	41.8	
78-11-01	% CLEAN	98	21%	44.7	
79-10-03	% CLEAN	98	2%	49.0	
81-05-13	LOW TH	12	58%	37.3	
94-04-22	% CLEAN	97	0%	0.0	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 < val < 50) <u>10-40</u>
<u>0-10 FT; TF ACTIVITY</u>	
<u>40-52 FT; INCR 1975 TO 1976 THEN RAD DEC 1976 TO 1980, NON DETECT AFTER 1981</u>	
<u>ISOTOPES NOT CONSISTENT W/ CS-137</u>	
<u>52-70 FT; STABLE 6-60</u>	
<u>70-92 FT; STABLE 6-60</u>	

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name

Randall Puro

S/W ver (TFGROSS)

V2.20

Dry Well Survey Analysis - Notes

Borehole B4(22-07-027)Total # Surveys 342Probe Type 04Log Date: 75-01-09st# neutron surveys 6# GR Surveys 33694-04-22 Last

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey:

Max Survey Depth 97Contamination Zone Depth(s): 6-20, 42-53, 53-70, 70-82, 82-9542-95 FT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
75-08-27	14	100	
76-04-29	20	95	
76-09-02	19	90	
79-04-12	98	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
76-05-20	Tool Fail	95	
78-11-01	BAD LOG	100	
79-04-23A	BAD LOG	70	
79-10-03	HI BKG	100	
80-12-02	MISS-RAD	95	
94-04-20	Tool Fail		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-12	% CLEAN	102	14%	41.3	
76-07-02	% CLEAN	94	29%	42.6	
77-05-08	% CLEAN	100	1%	44.0	
78-11-01	Avg BKG	100	17%	43.8	
79-12-20	Avg BKG	96	32%	41.0	
94-04-20	% CLEAN	99	8%	32.6	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 val 50) <u>20-40</u>
STACK PLOT (PRALIM VIEW) INDICATES RAPID DOWNWARD MOVEMENT OF A PLUM FRONT (53-82 FT) 1979 TO 1983	
MOVEMENT IS PROBABLY NOT DOWN THE BOREHOLE.	
RAPID MOVEMENT FROM 57 FT IN 1979 TO 62 FT MAY BE A FLUSHING DOWN THE WELL CASING (OUTSIDE)	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name Randall PuroS/W ver (TFGROSS) V2.20.

Dry Well Survey Analysis - Notes

Borehole B4 (22-07-05)Total # Surveys 5
neutron surveys 243
94-04-22 LastProbe Type 04
GR Surveys 238
Presentation Plot Dates(If different from 1st & Last)Max Survey Depth 97

Isotope from Spectral Survey:

Contamination Zone Depth(s): 40-57, 57-65, 65-78, 90-100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-03-25	97	95	
76-04-29	38	80	
76-07-28	118	160	
79-07-24	18	100	
80-09-18	16	80	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-03-10	NO RADZON	100	
76-05-20	TOOL FAIL	100	
76-07-28	BAO LOG	80	
78-11-01	HI-BKG	100	
80-10-29	HI-BKG	100	
94-04-20	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-12	% CLEAN	99	49%	36.5	
76-03-25	% CLEAN	94	0%	0.0	
76-09-23	AVG BKG	96	58	38.1	
77-02-03	AVG BKG	95	53	38.7	
78-11-01	AVG BKG	95	35	40.0	
94-04-20	% CLEAN	96	12%	32.8	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 50 < 50) <u>10-35</u>

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name Randall PuroS/W ver (TFGROSS) V2.20

Dry Well Survey Analysis - Notes

Borehole BY(22-07-07)Total # Surveys 227Probe Type 04Log Date: 75-01-09 1st# neutron surveys 2# GR Surveys 22594-04-22 Last

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey: _____

Max Survey Depth 100Contamination Zone Depth(s): 30-54, 80-98

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
77-02-03	15	110	
78-09-14	14	90	
80-09-18	19	85	
85-06-12	22	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
76-02-24	TO 76-63-30		NO RAD ZONE (130 RT)
76-12-07	NO RAD ZONE 100		
77-02-03	BAD LOG	110	
78-06-08	SHORT LOG	80	
80-09-03	BAD LOG	40	
94-04-20	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-12-01	AVG BKG	98	66%	36.2	
77-02-03	AVG BKG	98	68%	37.5	
79-12-26	AVG BKG	96	71%	41.0	
80-09-03	LENGTH	30	53%	31.4	
94-04-20	% CLEAN	98	0%	0.0	

ZONE 30-54 FT; GTP DECAY CURVE FIT 7/1/95 = $S_1 = 400$

Analysis Notes

 $R_0 = 2000$
 $CS = 20$

num surveys rejected: (0) ZERO	Background = (0.50) 55-80
CHECK GTP (ZONE 55-80 FT W/BKG 10-30 FT)	
THEN (10-30 FT GTP) W/BKG = 55-80 FT	
IF CHECK PRODUCES EXPECTED RESULTS; IF BKG < CLEAN ZONE THEN NOT REANALYZE	
IN LOG SURVEYS W/ TIME	
ZONE 30-54' CHANGED (CS CONC. < DETECT THRESHOLD, RU DELAY LINE SHOWS DEVIATION)	
ZONE 80-98' CHANGED (CS & S ₁ DELAY DO NOT FIT TREND OF DATA)	
Category: (Stable, TF Activity, Undetermined, CHANGED) RATIO $S_1/C_0 = \frac{10.05}{12.09} = 0.14$ ON JAN 1995	

Analyst Name Randall PinedaS/W ver (TFGROSS) V2.20

Dry Well Survey Analysis - Notes

Borehole B4(22-07-09)Total # Surveys 399Probe Type 04Log Date: 75-01-04 1st# neutron surveys 4# GR Surveys 39394-04-22 Last

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey: _____

Max Survey Depth 100Contamination Zone Depth(s): 0-9, 9-17, 17-36, 62-74, 74-84, 84-94, 94-100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-04-29	44	90	
76-07-28	30	60	
78-09-17	18	90	
80-09-18	14	90	

84-08-10 30 100

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-01-29	BAD LOG	170	
75-05-02	BAD LOG	170	
80-06-18	TOOL FAIL	105	
83-06-15	BAD LOG	100	
84-08-10	BAD LOG	100	
94-04-20	TOOL FAIL	100	

77-02-03 TOOL FAIL 100

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-04-29	% CLEAN	91	31%	26.2	
77-02-03	% CLEAN	98	0%	0.0	
78-11-01	AVG BKG	97	34%	42.0	
79-12-26	AVG BKG	96	47%	42.0	
80-10-29	% CLEAN	99	21%	47.1	
81-01-14	% CLEAN	81	38%	30.1	
85-01-23	% CLEAN	99	39%	30.3	
94-04-20	% CLEAN	98	0%	0.0	

Analysis Notes

num surveys rejected: (0) <u>26/0</u>	Background = (0) <u><50</u>	<u>40-60</u>
ZONES 62-74' GTP FIT: $C_0=150, S_b=1000, R_0=4500$ on $1/17.5$		
ZONES 74-84' GTP FIT: $C_0=1200, S_b=4000$ on $1/17.5$ $C_0=76$ on $1/96$ $RATIO=0.2858$		

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name Randall PuraS/W ver (TFGROSS) V2.20

filein := "GTP62-74.txt"

Well 22-07-09

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 291

i := 0..N

k := 0..300

j := 0..299

 $\tau_{cs} := 30.17$ $\tau_{co} := 2.77$ $\tau_{eu} := 1.02$

Co variables are

acs := 80

aco := 1200

aeu := 4000

Sb-125

Eu variables are

Ru

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := aeu \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, a2) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right] \right]^2$$

Given

$$ssq(acs, aeu, aco) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aeu, aco)$$

$$\alpha_{cs} = 57.073$$

Cs-137

$$\alpha_{eu} = 3.6 \cdot 10^3$$

Ru-106

$$\alpha_{co} = 1.484 \cdot 10^3$$

Sb-125

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.016$$

$$tot_i := Cs_i + Eu_i + Co_i$$

$$\frac{Eu_N}{Cs_N} = 1.969 \cdot 10^{-4}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop44-52.txt") := out

HNF-3532 - REV 0 Well 22-07-09

filein := "GTP74-84.txt"

A := READPRN(filein) yr := A<1> net := A<7> bkg := A<6> max := A<4>

N := last(yr) N = 96 i := 0..N k := 0..300 j := 0..299

1st Isotope is Co (5.27 yrs) $\tau_{co} := 5.27$ $a_{co} := 1000$

2nd Isotope is Sb (2.77 yrs) $\tau_2 := 2.77$ $a_2 := 4400$

$$Co_i := a_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \quad X2_i := a_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Co_i + X2_i$$

gross_i := net_i This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(a_{co}, a_2) = 0 \quad 1 = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(a_{co}, a_2)$$

$$\alpha_{co} = 1 \cdot 10^3$$

Co-60

$$\alpha_2 = 4.405 \cdot 10^3$$

Sb-125

$$\frac{\alpha_{co}}{\alpha_2} = 0.227$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \quad X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Co_i + X2_i$$

out<0> := yr out<1> := tot WRITEPRN("twop.txt") := out

$$\frac{Co_N}{X2_N} = 2.246$$

Ratio Co/Sb

Dry Well Survey Analysis - Notes

Borehole BY(22-07-10)Total # Surveys 360Probe Type 04Log Date: 15-01-09^{1st}# neutron surveys 4
94-04-22 Last# GR Surveys 356

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey:

Max Survey Depth 97Contamination Zone Depth(s): 0-6, 6-12, 12-20, 20-30, 30-44

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
75-12-24	10	98	
76-04-29	43	90	
80-09-18	11	95	
85-04-03	15	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-04-29	BAD LOG	90	
76-07-02	BAD LOG	90	
77-08-04	TOOL FAIL	100	
78-11-01	TOOL FAIL	100	
79-10-07	BAD LOG	40	
94-04-20	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-12	Avg BKG	99	53%	37.2	
76-04-29	%CLEAN	91	37%	29.9	
76-07-02	Avg BKG	92	54%	40.4	
77-05-05	Avg BKG	95	58%	35.5	
78-11-01	Avg BKG	96	45%	40.6	
79-12-26	Avg BKG	93	51%	40.0	
80-10-29	Avg BKG	95	40%	44.7	
94-04-20	%CLEAN	96	0%	0.0	

Analysis Notes

num surveys rejected: (0) <u>260</u>	Background = (0 50) <u>45-70</u>

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name

Randall Puro

S/W ver (TFGROSS)

V2.20

Borehole 22-08-01

page 1 of 2

Contamination (Cs-137) from 0-12 feet is Tank Farm Activity
Contamination (Co-60 & Sb-125) from 22-32 feet is Stable
Contamination (Co-60 & Sb-125) from 32-42 feet is Stable
Contamination (Co-60 & Sb-125) from 42-59 feet is Stable
Contamination (Co-60 & Sb-125) from 59-82 feet is UNSTABLE
Contamination (Co-60 & Sb-125) from 82-95 feet is UNSTABLE

Grade Thickness Product from 0 to 10 feet is erratic from 1975 through 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within observed systematic limitations at a rate consistent with Cs-137 (identified from HPGe detector). The gross gamma activity is at the 30,000 counts per second rate, which may be beyond the linear region of the counting system.

Grade Thickness Product for three radioactive zones (22-32, 32-42, 42-59 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Sb-125 (hypothesis) and Co-60 (identified from HPGe detector) from 1975 through 1994. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Co-60 of 0.7, 0.1, and 0.3, respectively for each zone, on June, 1994.

Grade Thickness Product for the radioactive zone (59-82 feet) is decreasing at a rate that exceeds the decay of Sb-125 (hypothesis) and Co-60 (identified from HPGe detector) from 1976 to 1979, then is less than the decay rate from 1980 to 1984, and then is consistent with the decay rate from 1985 to 1995. Movement in this zone is unclear on the stack plot. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Co-60 of 0.04 on June 1994.

Grade Thickness Product for the radioactive zone (82-95 feet) shows the zone is clean until 1982, then from 1982 to 1987 the radioactive contaminant is INCREASING, and begins to decrease at a rate consistent with the decay of Co-60 (identified from HPGe detector) from 1987 to 1995. This can be seen in the stack plot upon close examination.

Grade Thickness Product for the combined radioactive zone (22-95 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Sb-125 (hypothesis) and Co-60 (identified from HPGe detector) from 1975 to 1995. This indicates the contaminants likely entered the subsurface in a single event and the contaminant movement is ongoing redistribution. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Co-60 of 0.14 in 1995.

Borehole 22-08-01

page 2 of 2

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	312

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	12 to 22 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-12 feet is TF Activity 22-32, 32-42, 42-59 feet is Stable 59-82, 82-95 feet UNSTABLE
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-08-01

Depth: 0-12 ft

6/13/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-01

Depth: 22-32 ft

6/13/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-01

Depth: 32-42 ft

6/13/94

Analyse by: Three Rivers Scientific

01/09/75

Borehole 22-08-01

Depth: 42-59 ft

6/13/94

Analysis by: Three Rivers Scientific

Borehole 22-08-01

Depth: 59-82 ft

01/09/75

6/13/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-01

Depth: 82-95 ft

6/13/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-01

Depth: 22-95 ft

6/13/94

Analysis by: Three Rivers Scientific

Borehole 22-08-01

Borehole 22-08-02

page 1 of 2

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity

Contamination (Sb-125) from 20-30 feet is Stable

Contamination (Sb-125) from 44-62 feet is UNSTABLE

Contamination (Sb-125) from 62-72 feet is UNSTABLE

Contamination (Sb-125) from 72-84 feet is UNSTABLE

Contamination (Sb-125) from 84-100 feet is UNSTABLE

Grade Thickness Product from 0 to 10 feet is erratic for the 20 years of surveillance monitoring, and is categorized as Tank Farm activity. The decay line for Cs-137 (identified from HPGe detector) is shown but does not agree with any significant number of surveys.

Grade Thickness Product for the radioactive zone (20-30 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Sb-125 (hypothesis) between 1975 and 1994.

Grade Thickness Product for the radioactive zone (44-62 feet) is decreasing at a rate from 1975 to 1981 that does not fit the decay of Sb-125 (hypothesis) or Co-60 (identified from HPGe detector). The decay line for Sb-125 is shown as a reference. The stack plot shows that radioactive materials migrated down, out of this zone.

Grade Thickness Product for the radioactive zone (62-72 feet) is INCREASING in 1975 then decreases at a rate from 1977 to 1988 that does not fit the decay of Sb-125 (hypothesis) or Co-60 (identified from HPGe detector). The decay line for Sb-125 is shown as a reference.

Grade Thickness Product for the radioactive zone (72-84 feet) is INCREASING from 1981 to 1985 with decreasing rates the other times (1975-1981 and 1985-1995). The decay line for Co-60 (identified from HPGe detector) is shown as a reference. The stack plot shows that radioactive materials migrated down, through this zone.

Grade Thickness Product for the radioactive zone (84-100 feet) is INCREASING from 1988 to 1991 with decreasing or constant rates the other times (1975-1988 and 1991-1995). The decay line for Co-60 (identified from HPGe detector) is shown as a reference.

Grade Thickness Product of the combined radioactive zone (44-100 feet) is decreasing at a rate that is consistent with a least squares fit of Sb-125 (hypothesis) and Co-60 (identified from HPGe detector) from 1975-1985 and deviates from 1985-1995. The deviation may indicate added contamination in the zone. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Co-60 of 0.1 on June 1994.

Borehole 22-08-02

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Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	305

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	10 to 20 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 20-30 feet is Stable 44-62, 62-72, 72-84, 84-100 are <u>UNSTABLE</u>
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-08-02

Depth: 0-10 ft

01/09/75

Analysis by: Three Rivers Scientific

Borehole 22-08-02

Depth: 20-30 ft

01/09/75

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-02

Depth: 44-62 ft

6/13/94

Analysis by: Three Rivers Scientific

Borehole 22-08-02

Depth: 62-72 ft

01/09/75

Borehole 22-08-02

Depth: 72-84 ft

01/09/75

6/13/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-02

Depth: 84-100 ft

6/13/94

01/09/75

Borehole 22-08-02

Depth: 44-100 ft

6/13/94

Borehole 22-08-02

Borehole 22-08-05

page 1 of 2

Contamination (Cs-137) from 0 to 8 feet is Tank Farm Activity

Contamination (Co-60) from 36-45 feet is Stable

Contamination (Co-60) from 45-53 feet is Stable

Contamination (Co-60) from 53-63 feet is Stable

Contamination (Co-60) from 63-74 feet is UNSTABLE early

Contamination (Co-60) from 74-84 feet is UNSTABLE

Grade Thickness Product from 0 to 8 feet is erratic from 1975 through 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for three radioactive zones (36-45, 45-53, 53-63 feet) is decreasing within observed systematic limitations at a rate consistent with Co-60 (identified from HPGe detector) from 1975 through 1994.

Grade Thickness Product for the radioactive zone (63-74 feet) is decreasing at a rate that is significantly less than the decay of Co-60 (identified from HPGe detector) from 1975 to 1986. Then from 1986 to 1995 the decrease in grade thickness product is consistent with the decay rate. The stack plot shows the radioactive contaminants to be migrating deeper in the formation.

Grade Thickness Product for the radioactive zone (74-84 feet) shows the zone is clean until 1985, then from 1985 to 1990 the radioactive contaminant is INCREASING, and begins to decrease at a rate consistent with the decay of Co-60 (identified from HPGe detector) from 1990 to 1995.

Grade Thickness Product for the combined radioactive zone (36-84 feet) is decreasing within the gross gamma sensitivity at a rate consistent with Co-60 (identified from HPGe detector) from 1975 to 1995.

Borehole 22-08-05

page 2 of 2

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	314

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	10 to 35 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 feet is TF Activity 36-45, 45-53, 53-63 feet is Stable 63-74, 74-84 feet was UNSTABLE
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-08-05

01/09/75

06/13/94

Analysis by: Three Rivers Scientific

Borehole 22-08-05

Depth: 36-45 ft

01/09/75

06/13/94

Borehole 22-08-05

Depth: 45-53 ft

Analysis by: Three Rivers Scientific

Borehole 22-08-05

Depth: 53-63 ft

01/09/75

06/13/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-05

Depth: 63-74 ft

06/13/94

Analysis by: Three Rivers Scientific

Borehole 22-08-05

Depth: 74-84 ft

Analysis by: Three Rivers Scientific

Borehole 22-08-05

Depth: 36-84 ft

Analysis by: Three Rivers Scientific

Borehole 22-08-05

HNF-3532 -REV0

Borehole 22-08-05

Borehole 22-08-06

page 1 of 2

Contamination (Cs-137) from 0 to 8 feet is Tank Farm Activity
Contamination (Cs-137) from 8 to 18 feet is Tank Farm Activity
Contamination (Cs-137) from 18-29 feet is Stable
Contamination (Cs-137 & Co-60) from 46-54 feet is Stable
Contamination (Co-60) from 54-63 feet is Stable
Contamination (Co-60) from 63-73 feet is Stable
Contamination (Co-60) from 73-83 feet is UNSTABLE early

Grade Thickness Product from 0 to 8 feet is erratic from 1975 through 1986, and is categorized as Tank Farm activity. In the radioactive zone from 8 to 18 feet the Grade Thickness Product from 1976 to 1985 is lower than the other time interval. In both zones the Grade Thickness Product from 1986 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for radioactive zone (18-29 feet) is decreasing within the gross gamma sensitivity at a rate consistent with Cs-137 (identified from HPGe detector) from 1975 through 1994.

Grade Thickness Product for radioactive zone (46-54 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with Cs-137 and Co-60 (both identified from HPGe detector) from 1975 to 1995. The gross gamma contribution ratio for Co-60 to Cs-137 was 0.4 in 1995.

Grade Thickness Product for two radioactive zones (54-63 and 63-73 feet) is decreasing within the gross gamma sensitivity at a rate consistent with Co-60 (identified from HPGe detector) from 1975 through 1994.

Grade Thickness Product for the radioactive zone (73-83 feet) is roughly constant and below the radionuclide decay line for 1975, then from 1976 to 1995 the radioactive contaminant is decreasing within the gross gamma sensitivity at a rate consistent with Co-60 (HPGe detector identified). The stack plot shows on close review that the broad gamma ray peak becomes better defined after 1975.

Grade Thickness Product of the combined radioactive zone (46-83 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Co-60 and Cs-137 (both identified from HPGe detector) from 1975 to 1995. The least squares fit results in a gross gamma contribution ratio for Co-60 to Cs-137 of 1.1 on June 1994.

Borehole 22-08-06

page 2 of 2

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	314

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	30 to 46 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8, 8-18 feet is TF Activity 18-29, 46-54, 54-63, 63-73 feet is Stable 73-83 feet was UNSTABLE early
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-08-06

Depth: 0-8 ft

Analysis by: Three Rivers Scientific

Borehole 22-08-06

Depth: 8-18 ft

01/09/75

Analysis by: Three Rivers Scientific

Borehole 22-08-06

Depth: 18-29 ft

01/09/75

Analysis by: Three Rivers Scientific

Borehole 22-08-06

Depth: 46-54 ft

Analysis by: Three Rivers Scientific

Borehole 22-08-06

Depth: 54-63 ft

01/09/75

06/13/94

Analysis by: Three Rivers Scientific

Borehole 22-08-06

Depth: 63-73 ft

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-08-06

Depth: 73-83 ft

Analysis by: Three Rivers Scientific

06/13/94

01/09/75

Borehole 22-08-06

Depth: 46-83 ft

06/13/94

Borehole 22-08-06

Borehole 22-08-07

Contamination (Cs-137) from 0 to 8 feet is Tank Farm Activity

Grade Thickness Product from 0 to 8 feet is erratic from 1975 through 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	135 ft
Survey Depth :	135 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	296

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	20 to 40 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-08-07

Depth: 0-8 ft

06/13/94

Borehole 22-08-07

Borehole 22-08-09

Contamination (Cs-137) from 0 to 10 feet is Tank Farm Activity
 Contamination (Cs-137 & Ru-106) from 72 to 84 feet was
UNSTABLE early

Grade Thickness Product from 0 to 8 feet is erratic from 1975 through 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for the radioactive zone (72-84 feet) for 1975 was **INCREASING**. Then from 1976 to 1995 Grade Thickness Product was decreasing at a rate consistent with the decay of Ru-106 (hypothesis) and Cs-137 (identified from HPGe detector). The gross gamma contribution ratio for Ru-106 to Cs-137 was 3.5 on January 1, 1976.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/10/1975
Last Survey Date :	6/13/1994
Number Surveys :	403

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	50 to 70 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 72-84 feet was <u>UNSTABLE</u> early
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/10/75

Borehole 22-08-09

Depth: 0-10 ft

06/13/94

HNF-3532 -REV0

Borehole 22-08-12

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Contamination (Cs-137) from 0 to 8 feet is Tank Farm Activity
Contamination (Cs-137) from 25-40 feet is **UNSTABLE**
Contamination (Co-60 & Sb-125) 40-51 feet **UNSTABLE** early
Contamination (Co-60) from 51-60 feet is **UNSTABLE**
Contamination (Co-60) from 60-70 feet is **UNSTABLE** early
Contamination (Co-60) from 70-82 feet is **UNSTABLE** early

Grade Thickness Product from 0 to 8 feet is erratic for the 20 year surveillance period, and is categorized as Tank Farm activity. Grade Thickness Product is plotted on a logarithmic scale to show the variability of the computed results. A decay line for Cs-137 (identified from HPGe detector) is shown but does not fit a significant number of surveys.

Grade Thickness Product for radioactive zone (25-40 feet) shows a consistent INCREASE from 1978 to 1980 then a decrease from 1980 to 1983. The decay rate of the isotope that migrated through the zone (25-40 feet) could not be identified. A decay line for Cs-137 (low level identified from HPGe detector) is shown but does not fit the data.

Grade Thickness Product for the radioactive zone (40-51 feet) is decreasing in 1975 at a rate that is greater than the decay of Sb-125 (hypothesis) and Co-60 (identified from HPGe detector), then after 1976 exhibits a reasonable fit to the decay line. In 1982 a decrease in the Grade Thickness Product is observed. The gross gamma contribution ratio for Sb-125 to Co-60 was 0.4 in 1995.

Grade Thickness Product for the radioactive zone (51-60 feet) shows a decrease from 1975 to 1980 that does not fit the remainder of the monitoring logs. From 1980 to 1982 the Grade Thickness Product is erratic and increases, then begins to decrease at a rate consistent with the decay of Co-60 (identified from HPGe detector) from 1982 to 1995. Downward movement of the contamination may be occurring.

Grade Thickness Product for the radioactive zone (60-70 feet) is greater than the decay rate of Co-60 (identified from HPGe detector) from 1975 to 1983. Then from 1983 to 1995 the Grade Thickness Product decay rate is consistent with Co-60. The stack plot shows movement down of contamination through this zone to the next lower zone.

Grade Thickness Product for the radioactive zone (70-82 feet) shows the contaminants to be INCREASING from 1975 to 1983. Then from 1983 to 1995 the Grade Thickness Product is decreasing at a rate that is consistent with Co-60 (identified from HPGe detector).

Borehole 22-08-12

page 2 of 2

Grade Thickness Product for the combined radioactive zone (40-82 feet) is greater than the decay rate of Sb-125 (hypothesis) and Co-60 (identified from HPGe detector) in 1975. Then from 1976 to 1995 the Grade Thickness Product rate of decrease is consistent with the decay of Sb-125 and Co-60. The gross gamma contribution ratio for Sb-125 to Co-60 of 0.04 on January 1996.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	105 ft
Survey Depth :	105 ft
First Survey Date :	1/10/1975
Last Survey Date :	6/13/1994
Number Surveys :	380

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	10 to 24 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 feet is TF Activity 24-40, 40-51, 51-60, 60-70, and 70-82 feet was <u>UNSTABLE</u>
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-08-12

Depth: 60-70 ft

Analysis by: Three Rivers Scientific

Analysis by: Three Rivers Scientific

Borehole 22-08-12

Depth: 40-82 ft

Analysis by: Three Rivers Scientific

Borehole 22-08-12

HNF-3532-REV0

Borehole 22-08-12

Dry Well Survey Analysis - Notes

Borehole B4 (22-08-01)Total # Surveys 314Probe Type 04Log Date: 75-01-09 1st# neutron surveys 2
94-06-13 Last# GR Surveys 312

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: CS (23000 P (1/1)) Co (27-100')Max Survey Depth 100'Contamination Zone Depth(s): 0-12, 22-32, 32-42, 42-59, 59-82, 82-95

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-07-21	41	95	
80-09-18	22	80	
93-12-17	26	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-06-05	HI BKG	95	
76-07-21	BAD SURVAY	95	
78-04-06	BAD SURVAY	60	
93-12-17	NORR 60'	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-07-21	% CLEAN	95	21%	33.8	
76-09-09	AUG BKL	98	29%	42.1	
78-04-06	LENETHA	63	46%	30.6	
79-10-03	AUG BKL	98	30%	44.3	
80-09-18	% CLEAN	86	25%	30.1	
81-08-17	% CLEAN	98	27%	34.6	
83-01-03	% CLEAN	96	33%	33.1	
93-12-17	AUG BKL	98	68%	11.0	

Analysis Notes

num surveys rejected: (0) <u>Z380</u>	Background = (<u>0</u> val <u>50</u>) <u>12-22</u>
ZONE 23-32', FIT TO GTP $Co60=50$, $SA=400 @ 1/175$, $RATIO Co/SA = \frac{3.16}{2.31} @ 1/196$	
ZONE 32-42', FIT TO GTP $Co60=800$, $SA125=1400 @ 1/175$, $RATIO SA/Co = \frac{50.53}{2.31} @ 1/96$	
ZONE 23-95' (combined) FIT $Co=15000$, $SA=25,000 @ 1/175$, $RATIO Co/SA = \frac{2.31}{1.30} @ 1/96$	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name

Randall Puro

S/W ver (TFGROSS)

filein := "two42-59.txt"

Well 22-08-01

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 308

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co (5.27 yrs)

 $\tau_{co} := 5.27$

aco := 5000

2nd Isotope is Sb-125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 21000

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 6.202 \cdot 10^3$$

$$\alpha_2 = 1.952 \cdot 10^4$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 0.318$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{X2_N}{Co_N} = 0.313$$

22-32 FT Sb/Co = 0.66 (1996)
32-42 FT Sb/Co = 0.14 (1996)

Well 22-08-01

filein := "two59-82.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 308

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co (5.27 yrs)

 $\tau_{co} := 5.27$

aco := 6000

2nd Isotope is Sb-125 (2.77 yrs) $\tau_2 := 2.77$

a2 := 7000

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 8.634 \cdot 10^3$$

$$\alpha_2 = 3.401 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 2.539$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\text{Ratio Sb/Co} = \frac{X2_N}{Co_N} = 0.039$$

Dry Well Survey Analysis - Notes

Borehole BY(22-08-02)Total # Surveys 307Probe Type 04Log Date: 75-01-09 1st# neutron surveys 2
94-06-13 Last# GR Surveys 305

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey:

Max Survey Depth 100Contamination Zone Depth(s): 0-10, 20-30, 44-62, 62-72, 72-84, 84-100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
80-09-18	29	95	
81-04-30	97	95	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-06-05	HI-BKG	100	
76-01-22	LONG SURVAY	170	
80-09-29A	BAD LOG	100	
81-04-30	WRONG HOLE	95	
82-01-07A	BAD LOG	50	
RNO ZONE - DPTA STOP CHG (5/1-82 to 6-2-82) - 4' BARM ADDED			
93-12-17	POOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-06-05	% CLEAN	98	0%	0.0	
75-09-10	% CLEAN	98	22%	4.7	
76-09-09	AUG BKG	97	27%	40.4	
76-10-15	AUG BKG	97	25%	42.3	
81-04-30	% CLEAN	97	0%	0.0	
85-12-12	AUG BKG	102	90	12.5	
93-12-17	% CLEAN	101	13%	3.5.4	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 < val < 50) <u>10-20 FT</u>
TF ACTIVITY	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name

Randall Pineda

S/W ver (TFGROSS)

V2.20.

filein := "GTP44-100.txt"

Well 22-08-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 300

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co (5.27 yrs)

 $\tau_{co} := 5.27$

aco := 13000

2nd Isotope is Sb (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 14000

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 1.304 \cdot 10^4$$

Co-60

$$\alpha_2 = 1.417 \cdot 10^4$$

Sb-125

$$\frac{\alpha_{co}}{\alpha_2} = 0.92$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{X2_N} = 9.261$$

Ratio Co/Sb

filein := "GTP20-30.txt"

Well 22-08-02

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 290

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co (5.27 yrs)

 $\tau_{co} := 5.27$

aco := 0

2nd Isotope is Sb (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 1000

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = -53.762$$

Co-60

$$\alpha_2 = 1.014 \cdot 10^3$$

Sb-125

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = -0.053$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{X2_N} = -0.534$$

Ratio Co/Sb

Borehole 22-08-02

1975 1980 1985 1990 1995

Date (Year)

CHORDA 71 FROM CAPSULE 10/10/92

Depth (feet)

00 416

Borehole 22-08-02

Survey start 0 (100)

Borehole 22-08-02

Survey start 150 (100)

Borehole 22-08-02

Survey start 75 (100)

HNF-3532 -REV0

UPPER
Zone
RAD
MIGRA
Down

00 419

Borehole 22-08-02

Survey start 225

Contamination Zone Depth(s): 0-8, 36-45, 45-53, 53-63, 63-74, 74-84

filein := "GTP46-83.txt"

HNF = 3532 - REV0

Well 22-08-06

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 298

i := 0..N

k := 0..300

j := 0..299

$\tau_{cs} := 30.17$

$acs := 150$

$\tau_{co} := 5.27$

$aco := 1430$

$$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$tot_i := Cs_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right]^2$$

Given

$$ssq(acs, aco) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aco)$$

$$\alpha_{cs} = 150.188$$

$$\alpha_{co} = 1.439 \cdot 10^3$$

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$tot_i := Cs_i + Co_i$$

$$\frac{\alpha_{cs}}{\alpha_{co}} = 0.104$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\frac{Co_N}{Cs_N} = 1.153$$

Dry Well Survey Analysis - Notes

Borehole BY (22-08-07)Total # Surveys 301Probe Type 04Log Date: 75-01-09 1st# neutron surveys 5# GR Surveys 29694-06-13 Last

Presentation Plot Dates

Isotope from Spectral Survey: Cs $< 8 \mu\text{Ci/g}$ (40-100')(If different from 1st & Last)Max Survey Depth 125Contamination Zone Depth(s): 0-8, 40-70, 70-90, 90-100, 100-120
CLEAN ZONE

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-07-28	72	140	
80-09-17	20	130	
84-05-03	24	135	
93-12-01	129	130	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
75-03-12	HI-BKG	140	
76-05-20A	TOOL FAIL	140	
76-07-21	PEAK ATD	140	
78-11-01	HI-BKG	140	
80-10-29	HI-BKG	140	
81-07-14	HI-BKG	140	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-12	Avg BKG	140	60%	32.2	
76-05-20	% CLEAN	137	20%	34.5	
78-11-01	Avg BKG	136	83%	40.6	
80-10-29	% CLEAN	137	66%	44.8	
92-11-03	LENGTH	178	100%	23.9	
93-04-21	LENGTH	300	99%	24.0	
93-12-01	% CLEAN	132	2%	4.7	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 < val < 50) <u>20-40 RT</u>
<u>REVIEW OF RADIATION ZONES (40-70, 70-90, 90-100, 100-120)</u>	
<u>CONFIRM VERY LOW LEVEL ACTIVITY ABOVE BKG (20-40')</u>	
<u>AND (EXCEPT FOR SHORT LIVED ZONE (70-90 FT) FROM 1975 TO 1978)</u>	
<u>NO SIGNIFICANT QUANTITIES OF RADIATION ARE PRESENT OR</u>	
<u>ABRUPTLY INTRODUCED INTO THE ZONES</u>	
<u>* 0-8 FT : TF ACTIVITY</u>	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name

Randall Pineda

S/W ver (TFGROSS)

V2.20

Dry Well Survey Analysis - Notes

Borehole B4(22-08-09)Total # Surveys 405Probe Type 04Log Date: 75-01-10 1st# neutron surveys 2# GR Surveys 40394-06-13 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: CS-137Max Survey Depth 100Contamination Zone Depth(s): 0-1027, 72-84

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-07-28	48	80	
76-09-03	19	95	
77-06-02	89	95	
94-03-24	93	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-06-05	HI BKG	100	
76-03-18	NOISE	100	
76-00-15	TOOL FALL	95	
77-04-14	HI-BKG	100	
77-10-27	WRONG-HOLE	95	
86-08-22	NOISE	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-06-05	% CLEAN	99	0%	0.0	
76-03-18	% CLEAN	100	66%	29.8	
77-06-02	% CLEAN	98	9%	2.3	
79-03-22	AVG BKG	97	27%	11.5	
80-10-29	% CLEAN	99	54%	44.3	
86-08-22	% CLEAN	99	68%	25.5	
93-10-04	LENGTH	173	94%	33.0	
94-03-24	% CLEAN	98	3%	13.7	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 < val < 50) <u>50 - 70</u>
<u>0-1027: TF ACTIVITY</u>	
<u>72-84 FT: Low Level RAD ZONE, incl 1975 to 1976, Trans</u>	
<u>DECA2ASB > CS-137 DATA 1976 to 1978</u>	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name

Randall PuroS/W ver (TFGROSS) V 2.20

Dry Well Survey Analysis - Notes

Borehole BY(22-08-12)Total # Surveys 383Probe Type 04Log Date: 75-01-10 1st# neutron surveys 3# GR Surveys 38094-06-13 Last

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey:

Max Survey Depth 105Contamination Zone Depth(s): 0-8, 25-40, 40-51, 51-60, 60-70, 70-82

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-07-21	28	85	
76-09-03	28	90	
77-06-02	60	100	
80-09-18	22	95	

93-12-17 94 100

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-06-05	HI-BKGL	100	
76-03-25	NO RAOZME	100	
76-07-21	TOOL FAIL	80	
78-04-20	BAD SURVEY	40	
80-09-29	NOISA	100	
86-08-22	HI-NOISA	100	

3 FT DEPTH CML (82-05-11 TO 82-06-02)

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-06-05	% CLEAN	100	0%	0.0	
76-03-25	AVG BKG	98	100%	5.8	
76-09-09	% CLEAN	100	32%	46.1	
77-06-02	% CLEAN	98	38%	1.4	
78-04-20	LONG TR	41	63%	27.1	
79-11-14	AVG BKG	99	50%	36.2	
80-09-18	% CLEAN	96	53%	30.6	
93-12-17	% CLEAN	102	7%	4.4	

Analysis Notes

num surveys rejected: (0) ZEROBackground = (0-~~val~~50) 10-24

DEPTH SHORT NOT IF POSSIBLE

25-40 FT : INCREASE 1979-1982

40-51 FT : RAPID DECREASE - SHOW MATCH W 56960 DEGRAY

51-60 FT : RAPID DECREASE 1975, STABLE 6-60 AFTER 1982

60-70 FT : 6-60 DECREASE AT RATE 7 DEGRAY 1975-1983 THEN STABLE

70-82 FT : 6-60 EN GROWTH 1975 TO 1982 THEN STABLE

Category: (Stable, TF Activity, Undetermined, CHANGED)

COMBINED 60-82 FT) SHOWS SMOOTH RATE OF DECREASE (60-58-125 DEGRAY LINE POTENTIAL)

Analyst Name DanallS/W ver (TFGROSS) V 2.20

Borehole 22-09-01

Contamination (Ru-106) from 24 to 35 feet is Stable
Contamination (Sb-125 & Ru-106) from 40 to 55 feet is Stable

Grade Thickness Product for the radioactive zone (24-35 feet) is decreasing within observed systematic limitations at a rate consistent with Ru-106 (hypothesis) between 1975 and 1978. The gamma ray activity decreases quickly to background activities.

Grade Thickness Product for the radioactive zone (40-55 feet) is decreasing within observed systematic limitations and relative intensity at a rate consistent with a least squares fit of Ru-106 (hypothesis), Sb-125 (hypothesis) between 1975 and 1994. Cobalt-60 (identified from HPGe detector at low concentrations, less than 0.7 pCi/g) was not included in the least squares fit and is below the gross gamma detection threshold. When included the concentration for Co-60 resulted in a negative quantity contribution to the resultant fit. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Ru-106 on January 1975 was 0.36.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (6 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	12/28/1993
Number Surveys :	674

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	10 to 20 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	24-35 feet is Stable 40-55 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-09-01

Depth: 24-35 ft

Analysis by: Three Rivers Scientific

Borehole 22-09-01

Depth: 40-55 ft

01/09/75

12/28/93

Borehole 22-09-01

Borehole 22-09-02

**Contamination (Cs-137) from 0-10 and 10-14 feet is
Tank Farm Activity**

**Contamination (Cs-137) from 14 to 34 feet is Stable
Contamination (Ru-106) from 42 to 64 feet is Stable**

Grade Thickness Product from 0-10 and 10-14 feet is erratic from 1975 to 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1993 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for the radioactive zone (14-34 feet) is decreasing within the gross gamma sensitivity at a rate consistent with Cs-137 (identified from HPGe detector) between January 1975 and December 1993.

Grade Thickness Product for the radioactive zone (42-64 feet) is decreasing within the gross gamma sensitivity at a rate consistent with Ru-106 (hypothesis) from 1975 to 1982.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	12/28/1993
Number Surveys :	468

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	34 to 42 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 & 10-14 ft is TF Activity 14-34 feet is Stable 42-64 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-09-02

Depth: 0-10 ft

12/28/93

01/09/75

Borehole 22-09-02

Depth: 10-14 ft

12/28/93

Analysis by: Three Rivers Scientific

Borehole 22-09-02

Depth: 14-34 ft

Analysis by: Three Rivers Scientific

Borehole 22-09-02

Depth: 42-64 ft

Analysis by: Three Rivers Scientific

Borehole 22-09-02

Borehole 22-09-05

Contamination (Cs-137) from 0 to 10 feet is Tank Farm Activity
Contamination (Sb-125) from 40 to 58 feet is Stable

Grade Thickness Product from 0-10 feet is erratic from 1984 to 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1976 through 1993 (except 1984 to 1986) is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for the radioactive zone (40-58 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Sb-125 (hypothesis) and Cs-137 (identified from HPGe detector) between 1975 and 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.1 on December 1993.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	12/28/1993
Number Surveys :	562

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	12 to 38 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 40-58 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-09-05

Depth: 0-10 ft

12/28/93

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-09-05

Depth: 40-58 ft

12/28/93

Borehole 22-09-05

01/16/75

Borehole 22-09-07

Depth: 20-40 ft

12/28/93

Analysis by: Three Rivers Scientific

Borehole 22-09-07

Contamination (Ru-106) from 20 to 40 feet is **UNSTABLE**
 Contamination (Ru-106) from 40 to 50 feet is **UNSTABLE** early
 Contamination (Sb-125 & Ru-106) 50 to 64 feet **UNSTABLE**

Grade Thickness Product for the radioactive zone (20-40 feet) from 1975 to 1978 is decreasing at a rate consistent with Ru-106 (hypothesis) decay, however from mid-year 1978 to 1982 the Grade Thickness Product is consistently greater than the fitted decay curve, indicating additional contaminants in this zone.

Grade Thickness Product for the radioactive zone (40-50 feet) is **Increasing** during 1975 then becomes stable and in 1976 the Grade Thickness Product is decreasing within the gross gamma sensitivity at a rate consistent Ru-106 (hypothesis) from 1976 to 1981. The Grade Thickness Product is greater than the decay curve from 1981 to 1983.

Grade Thickness Product for the radioactive zone (50-64 feet) is erratic from 1975 to 1976, then is decreasing at a rate consistent with Ru-106 and Sb-125 decay (both hypothesis) to 1980, however from 1980 to 1986 the Grade Thickness Product is consistently less than the fitted decay curve.

Grade Thickness Product for the combined radioactive zone (20-64 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Sb-125 and Ru-106 for the 20 year surveillance period from 1975 through 1994. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Ru-106 of 0.22 on January 1975.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	97 ft
Survey Depth :	97 ft
First Survey Date :	1/10/1975
Last Survey Date :	12/28/1993
Number Surveys :	481

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	20-40 feet is UNSTABLE 40-50 feet is UNSTABLE 50-64 feet is UNSTABLE
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/16/75

Borehole 22-09-07

Depth: 40-50 ft

12/28/93

Analysis by: Three Rivers Scientific

00 443

01/16/75

Borehole 22-09-07

Depth: 50-64 ft

Analyse by: Three Rivers Scientific

01/16/75

Borehole 22-09-07

Depth: 20-64 ft

12/28/93

HNF-3532 -REV0

Borehole 22-09-07

Borehole 22-09-08

Contamination (Cs-137) from 16 to 30 feet is Undetermined

Contamination (Co-60) from 43 to 52 feet is Stable

Contamination (Co-60) from 76 to 90 feet is Undetermined

Grade Thickness Product from 16 to 30 feet does not match the decay rate of Cs-137 (identified from HPGe detector) and the gross gamma activity is at the 30,000 counts per second rate which may be beyond the linear region of the counting system.

Grade Thickness Product for the radioactive zone (43-52 feet) is decreasing within the gross gamma sensitivity at a rate consistent with Co-60 (identified by HPGe detector) from 1980 to 1993.

Grade Thickness Product for the radioactive zone (76-90 feet) is at low levels (detection threshold) and appears to be constant from 1984 to 1994. Stability of the zone from 1980 to 1984 can not be determined. Agreement with the decay rate of Co-60 (identified by HPGe detector) can not be determined.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys) 14: Shielded NaI (29 surveys; 1980)
Borehole Depth :	98 ft
Survey Depth :	98 ft
First Survey Date :	7/24/1980
Last Survey Date :	12/28/1993
Number Surveys :	368

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	55 to 74 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	16-30 feet is Undetermined 43-52 feet is Stable 76-90 feet is Undetermined
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

07/24/80

Gamma (c/s)

Borehole 22-09-08

Depth: 16-30 ft

Grade Thickness Product (feet*c/s)

Frequency Clean (%)

12/28/93

Gamma (c/s)

Analysis by: Three Rivers Scientific

Borehole 22-09-08

Depth: 43-52 ft

07/24/80

12/28/93

Analysis by: Three Rivers Scientific

Borehole 22-09-08

Depth: 76-90 ft

07/24/80

Analysis by: Three Rivers Scientific

Borehole 22-09-08

Borehole 22-09-11

Contamination (Cs-137) from 0 to 10 feet is Tank Farm Activity
 Contamination (Cs-137 & Sb-125) from 16 to 25 feet is Stable
 Contamination (Ru-106) from 25 to 38 feet is Stable
 Contamination (Ru-106) from 38 to 52 feet **UNSTABLE** early

Grade Thickness Product from 0 to 10 feet is erratic from 1975 through 1986, and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within observed systematic limitations at a rate consistent with Cs-137 (HPGe detector identified).

Grade Thickness Product for the radioactive zone (16-25 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Sb-125 (hypothesis) and Cs-137 (HPGe detector identified) between January 1975 and 1994. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.03 on December 1993.

Grade Thickness Product for the radioactive zone (25-38 feet) is decreasing within observed systematic limitations at a rate consistent with the decay of Ru-106 (hypothesis) between 1975 and 1994.

Grade Thickness Product for the radioactive zone (38-52 feet) is decreasing at a rate that exceeds the decay of Ru-106 (hypothesis) in 1975 then from 1976 to 1993 the rate of decrease is consistent with the decay of Ru-106.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	12/29/1993
Number Surveys :	552

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	60 to 90 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 16-25 feet is Stable 25-38 feet is Stable 38-52 feet was UNSTABLE early
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-09-11

Depth: 0-10 ft

12/28/93

01/09/75

Borehole 22-09-11

Depth: 16-25 ft

Analysis by: Three Rivers Scientific

Borehole 22-09-11

Depth: 25-38 ft

Analysis by: Three Rivers Scientific

12/28/93

Borehole 22-09-11

Depth: 38-52 ft

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-09-11

Dry Well Survey Analysis - Notes

Borehole B4 (22-09-01)Total # Surveys 682Probe Type 07Log Date: 75-01-09 1st# neutron surveys 6# GR Surveys 67793-12-28 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: Cs < 0.8 pCi/g / Co < 0.7 pCi/g BOTHMax Survey Depth 100Contamination Zone Depth(s): 24-35 / 40-55 FT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-07-01	85	90	
77-06-02	83	95	
76-07-28	16	98	
80-09-17	19	90	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
78-03-22	NOISY	100	
82-02-02	BAD SURVEY	40	
91-02-16	HI-BKG	100	
92-09-22	BAD SURVEY	100	
93-04-13	TOOL FAIL	100	
93-07-16	BAD SURVEY	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-07-01	% CLEAN	91	5%	1.2	
76-09-03	Avg BKG	97	68%	33.4	
76-12-16	Avg BKG	95	73%	40.8	
77-02-04	% CLEAN	95	57%	44.6	
77-06-02	% CLEAN	95	11%	1.3	
78-07-12	Avg BKG	95	96%	14.6	
93-04-13	% CLEAN	96	38%	30.6	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 <u><</u> 50) <u>10-20</u>
<u>24-35' ZONE HAS SHORT LIVE RAD (FITS RU-106 W/IN STATS)</u>	
<u>40-55FT ZONE CAN BE FIT (ALMOST W/IN STATS) TO 80% RU DEGRAY</u>	
<u>SINCE 1985 - RAD (40-55') IS < DETECT. FOR TF-NAL SURVEY</u>	
<u>CO-60 < 0.7 pCi/g (1997 NOT REQUIRED FOR FIT OF TF DATA)</u>	
Category: (Stable, TF Activity, Undetermined, CHANGED) <u>BOTH ZONES (24-35 & 40-55')</u>	

Analyst Name

Randall Prince

S/W ver (TFGROSS)

V2.20

Well 22-09-01

2-COMPONENT FIT

filein := "two40-55.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 659

i := 0..N

k := 0..300

j := 0..299

1st Isotope is ⁵⁶Co (5.27 yrs) $\tau_{co} := 2.77$

aco := 510

2nd Isotope is Ru-106 (1.02 yrs) $\tau_2 := 1.020$

a2 := 1800

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\overset{56-125}{\alpha_{co}} = 514.041$$

$$\overset{Ru-106}{\alpha_2} = 1.8 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\overset{56}{\alpha_{co}}}{\overset{Ru}{\alpha_2}} = 0.286$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\text{Ratio } \frac{\overset{56}{Ru} Co_N}{X2_N} = 994.027$$

HNF=3532 - REV0

filein := "GTP40-55.txt"

Well 22-09-01

3-Component Fit

A := READPRN(filein)

N := last(yr)

yr := A<1>

N = 655

net := A<7>

i := 0..N

bkg := A<6>

k := 0..300

max := A<4>

j := 0..299

 $\tau_{cs} := 2.77$ $\tau_{co} := 5.27$ $\tau_{eu} := 1$ $\alpha_{cs} := 600$ $\alpha_{co} := 10$ $\alpha_{eu} := 1700$ Eu variables are
Ru-106Cs variables are
Sb

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$tot_i := Cs_i + Eu_i + Co_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3, a2) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + \left[a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}} + a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right] \right]^2$$

Given

$$ssq(\alpha_{cs}, \alpha_{eu}, \alpha_{co}) = 0$$

1=1

2=2

$$\begin{bmatrix} \alpha_{cs} \\ \alpha_{eu} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(\alpha_{cs}, \alpha_{eu}, \alpha_{co})$$

 $\alpha_{cs} = 621.888$
Sb-125

 $\alpha_{eu} = 1.733 \cdot 10^3$
Ru-106

 $\alpha_{co} = -39.742$
Co-60
Co-60 NOT REQ'D
FOR FIT

$$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$$

$$Eu_i := \alpha_{eu} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{eu}}}$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$\frac{\alpha_{cs}}{\alpha_{eu}} = 0.359$$

$$tot_i := Cs_i + Eu_i + Co_i$$

$$\frac{Eu_N}{Cs_N} = 6.186 \cdot 10^{-4}$$

out<0> := yr

out<1> := tot

WRITEPRN("twop44-52.txt") := out

Dry Well Survey Analysis - Notes

Borehole B4(22-09-02)Total # Surveys 476Probe Type 04Log Date: 75-01-091st# neutron surveys 5# GR Surveys 46893-12-28 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: CS-137 (2000014 MAX 1RT)Max Survey Depth 100Contamination Zone Depth(s): 0-10, 10-14, 14-34, 42-64

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-07-21	46	80	
77-06-02	66	100	
77-08-12	17	45	
80-09-17	19	90	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-07-21	NO RAD ZONE	85	
77-06-02	WRONG HOLE	95	
77-11-23	NORMAL ZONE	60	
78-08-31	NO RAD ZONE	100	
85-07-31	TRUNCATED	100	MISSING ACTIVITY AT SURFACE
92-02-13	BAD RUN	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-07-21	7% CLEAN	84	40%	29.5	
76-10-15	Avg Bkg	97	60%	39.1	
76-10-21	Avg Bkg	98	65%	39.5	
77-06-02	0% CLEAN	96	31%	1.3	
77-08-12	0% CLEAN	49	30%	34.7	
77-12-01	Avg Bkg	98	68%	37.9	
79-10-03	Avg Bkg	98	64%	38.5	
92-02-13	0% CLEAN	98	0%	0.0	

Analysis Notes

num surveys rejected: (0) ZERO Background = (0.5 val < 50) 34-42.5
0-

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name Bandall F. CoS/W ver (TFGROSS) V2.20

HNF-3532 - REVO Well 22-09-05

filein := "GTP40-58.txt"

A := READPRN(filein) yr := A<1> net := A<7> bkg := A<6> max := A<4>
N := last(yr) N = 548 i := 0..N k := 0..300 j := 0..299

1st Isotope is Cs (30.17 yrs) $\tau_{co} := 30.17$ $\alpha_{co} := 30$

2nd Isotope is Sb-125 (2.77 yrs) $\tau_2 := 2.77$ $\alpha_2 := 250$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \quad X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Co_i + X2_i$$

gross_i := net_i This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(\alpha_{co}, \alpha_2) = 0 \quad l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(\alpha_{co}, \alpha_2)$$

$$\alpha_{co} = 29.993$$

$$\alpha_2 = 250.811$$

Cs-137

Sb-125

$$\frac{\alpha_{co}}{\alpha_2} = 0.12$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \quad X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \quad tot_i := Co_i + X2_i$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\text{Ratio Sb/Cs} = \frac{X2_N}{Co_N} = 0.112$$

Dry Well Survey Analysis - Notes

Borehole B4(22-09-07)Total # Surveys 487Probe Type 04Log Date: 75-01-10 1st# neutron surveys 5# GR Surveys 48193-12-28 LastPresentation Plot Dates 75-05-16(If different from 1st & Last)Isotope from Spectral Survey: CS (10-20FT) Co (25-85FT)Max Survey Depth 97Contamination Zone Depth(s): 20-64FT (GTR 20 (1988-93))

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-07-21	17	60	
76-07-28	54	80	
77-06-02	47	95	
77-08-12	22	90	
80-09-17	22	90	
82-01-27	18	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
75-03-27	BAD SURVEY	170	
75-06-03	HI-BKG	100	
76-07-28	BAD SURVEY	70	
78-03-22	BAD SURVEY	100	
79-10-03	HI-BKG	100	
92-02-13	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-06-05	0% CLEAN	97	0%	0.0	
76-09-09	0% CLEAN	96	42%	71.2	
77-06-02	Avg BKG	95	50%	2.0	
78-03-22	Avg BKG	96	84%	18.1	
79-10-03	9% CLEAN	96	7%	45.4	
80-09-17	0% CLEAN	89	41%	31.2	
82-01-27	Avg BKG	95	80%	18.0	
92-02-13	0% CLEAN	96	0%	0.0	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0<val<50)
<u>ALSO FIT GTR FOR 3-250 TO 1/25 (RUSB, Co)</u>	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name Randall ReedS/W ver (TFGROSS) V2.20

Well 22-09-07

filein := "two20-64.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 463

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Sb125 (2.77 yrs) $\tau_{co} := 2.77$ $aco := 4300$ 2nd Isotope is Ru106 (1.02 yrs) $\tau_2 := 1.02$ $a_2 := 19000$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 4.289 \cdot 10^3$$

$$\alpha_2 = 1.917 \cdot 10^4$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\text{Ratio Sb/Ru} = \frac{Co_N}{X2_N} = 778.729$$

filein := "GTP20-40.txt"

Well 22-09-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 465

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Sb125 (2.77 yrs) $\tau_{co} := 2.77$ $aco := 0$ 2nd Isotope is Ru106 (1.02 yrs) $\tau_2 := 1.02$ $a_2 := 11000$

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a_2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = -453.63$$

$$\alpha_2 = 1.17 \cdot 10^4$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = -0.039$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\text{Ratio Sb/Ru} = \frac{Co_N}{X2_N} = -134.997$$

filein := "GTP40-50.txt"

Well 22-09-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 472

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Sb125 (2.77 yrs) $\tau_{co} := 2.77$

aco := 0

2nd Isotope is Ru106 (1.02 yrs) $\tau_2 := 1.02$

a2 := 14000

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 2.009 \cdot 10^3$$

$$\alpha_2 = 8.467 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \cdot \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 0.237$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\text{Ratio Sb/Ru} = \frac{Co_N}{X2_N} = 825.736$$

filein := "GTP50-64.txt"

Well 22-09-07

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 469

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Sb125 (2.77 yrs) $\tau_{co} := 2.77$ $\alpha_{co} := 2930$ 2nd Isotope is Ru106 (1.02 yrs) $\tau_2 := 1.02$ $\alpha_2 := 180$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(\alpha_{co}, \alpha_2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(\alpha_{co}, \alpha_2)$$

$$\alpha_{co} = 2.921 \cdot 10^3$$

$$\alpha_2 = 183.627$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = 15.91$$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

$$\text{Ratio Sb/Ru} = \frac{Co_N}{X2_N} = 5.538 \cdot 10^4$$

Dry Well Survey Analysis - Notes

Borehole B4(22-09-08)Total # Surveys 402Probe Type 04 ^{04 = 368} 142 29 (1980)Log Date: 80-07-24 1st# neutron surveys 4
93-12-28 Last# GR Surveys 368
Presentation Plot DatesIsotope from Spectral Survey: CS (1200 P/G @ 24 FT)(If different from 1st & Last)Contamination Zone Depth(s): 16-30, 43-52, 76-84Max Survey Depth 98

90

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
80-09-17	21	95	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp'l's	Comment
89-10-17	RAD ZONE CHG	100	
90-06-15A	RAD ZONE CHG	100	
91-02-19A	BIG RAD ZONE	100	
93-04-13	BAD SURVEY	100	
93-04-27B	BAD SURVEY	100	
80-01-22A	BAD SURVEY	50	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
80-09-17	% CLEAN	93	66%	31.2	
80-11-05	Avg BKG	97	88%	34.5	
81-07-23	Avg BKG	97	84%	34.1	
93-04-13	% CLEAN	96	100%	44.5	
80-02-21	Avg BKG	96	95%	6.2	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0 val <u><50</u>) <u>55-74</u>
<u>16-30 FT (HIGH C/S - TOOK DT PROBS)</u>	

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name Randall ReedS/W ver (TFGROSS) V2.20

Dry Well Survey Analysis - Notes

Borehole B4(22-09-11)Total # Surveys 559Probe Type 04Log Date: 75-01-09^{1st}# neutron surveys 5# GR Surveys 55293-12-29 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: CS (0.35AT) Co 21-50AMax Survey Depth 100Contamination Zone Depth(s): 0-10, 16-25, 38-52 FT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-09-03	17	100	
77-06-02	74	100	
80-09-17	13	90	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
78-03-22A	BAD SURVEY	98	
79-04-06	SHORT SURVEY	40	
85-12-30A	HI-BKG	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-10-15	AVG BKG	98	63%	42.4	
76-12-16	AVG BKG	98	62%	41.2	
77-05-05	AVG BKG	96	78%	38.0	
77-06-02	AVG BKG	98	24%	1.5	
78-08-10	AVG BKG	97	83%	36.2	
85-08-27	AVG BKG	98	8.9%	19.7	

Analysis Notes

num surveys rejected: (0) ZEROBackground = (0 < val < 50) 60-90K70-10 TF ACTIVITY16-25 FT (PROBABLY 3-ISOTOPE DECAY) Cs, Co, SbCS=106, Sb=125=214 AT 1/1475 Sb/Co = 0.028 @ 12-9338-52 DECAY > Ru-106 (1975-1976) BUT RATE DECAY 1975-76IS GREATER THAN Ru-106 (DATA ABOUT PRECISE CURVE)

Category: (Stable, TF Activity, Undetermined, CHANGED)

Analyst Name Randall PinedaS/W ver (TFGROSS) V2.20

filein := "GTP16-25.txt"

Well 22-09-11

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 545

i := 0..N

k := 0..300

j := 0..299

56-125
τ_{co} := 2.77

τ_{cs} := 30.17

aco := 220

acs := 108

$Cs_i := acs \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$

$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$

tot_i := Cs_i + Co_i

gross_i := net_i

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} \right] \right]^2$$

Given

ssq(acs, aco) = 0

1 = 1

$\begin{bmatrix} \alpha_{cs} \\ \alpha_{co} \end{bmatrix} := \text{Minerr}(acs, aco)$

α_{cs} = 105.825

56-125
α_{co} = 214.287

$Cs_i := \alpha_{cs} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{cs}}}$

$Eu_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$

tot_i := Cs_i + Co_i

$\frac{\alpha_{cs}}{\alpha_{co}} = 0.494$

out<0> := yr

out<1> := tot

WRITEPRN("twop.txt") := out

56-125
 $\frac{Co_N}{Cs_N} = 0.028$

Borehole 22-10-05

Contamination (Co-60) from 45 to 55 feet is Stable
 Contamination (Co-60) from 55 to 75 feet **UNSTABLE** early

Grade Thickness Product for the radioactive zone (45-55 feet) is decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector) between 1975 and 1994.

Grade Thickness Product for the radioactive zone (55-75 feet) is decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector) from 1979 to 1994. However, from 1975 to 1979 the radiation zone was below the Co-60 decay rate (i.e. increasing radioactive contaminants.) The activity in the radiation zone is at low levels.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	10/4/1993
Number Surveys :	400

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	20 to 40 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	45-55 feet is Stable 55-75 feet was UNSTABLE early
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-10-05

Depth: 45-55 ft

Borehole 22-10-05

Depth: 55-75 ft

Borehole 22-10-05

Borehole 22-10-07**Contamination (Co-60) from 45 to 65 feet UNSTABLE**

Grade Thickness Product for the radioactive zone (45-65 feet) shows only background activity except for a brief time period (1980-1985) in which radioactive contaminants migrated past the gamma probe investigation radius. During the time period of 1980 to 1983 the contaminant concentration was increasing, followed by a brief period from 1983 to 1985 of decreasing activity. The rate of decrease of the grade thickness product does not appear to be the decay of a stable radionuclide. A half life decay curve for Co-60 (identified from HPGe detector) is shown to demonstrate that the radioactive contaminants were not stable.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	10/4/1993
Number Surveys :	377

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	45-65 feet <u>UNSTABLE</u>
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-10-07

Depth: 45-65 ft

10/04/94

Borehole 22-10-07

Borehole 22-10-07

Borehole 22-10-09**Contamination (Cs-137) from 0 to 10 feet is TF Activity**

Grade Thickness Product from 0 to 10 feet is erratic for the 20 years of survey data and is categorized as Tank Farm activity. Changes in the logging procedure when logging surface radiation zones perturbs reliable calculation of the Grade Thickness Product. A decay line for Cs-137 (identified from HPGe detector) fitted to the last few survey values is presented.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	10/4/1993
Number Surveys :	364

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	10 to 40 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-10-09

Depth: 0-10 ft

10/04/93

Borehole 22-10-09

Borehole 22-10-10**Contamination (Co-60) from 58 to 76 feet UNSTABLE early**

Grade Thickness Product for the radioactive zone (58-76 feet) exhibits a rate of change that does not fit the gross gamma response characteristics for a stable radioactive zone. The high rate of decrease from 1975 to 1985 in the gamma-ray activity is confirmed by multiple and frequent surveillance logs. The conclusion is that the radioactive zone (58-76 feet) from 1975 to 1980 was not stable. The Co-60 (identified from HPGe detector) decay line fits the grade thickness product data from 1980 to 1995 and is used to establish the later stability. A combined decay line of Sb-125 (hypothesis) & Co-60 is presented on the plot for reference to show the poor fit.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	01/09/1975
Last Survey Date :	10/04/1993
Number Surveys :	406

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	80 to 95 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	58-76 feet <u>UNSTABLE</u> early
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-10-10

Depth: 58-76 ft

Borehole 22-10-10

Dry Well Survey Analysis - Notes

Borehole B7(22-10-05)Total # Surveys 406Probe Type 04Log Date: 75-01-09^{1st}# neutron surveys 4# GR Surveys 40093-10-04 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: Co 60 (45-75') < 1 A G/gMax Survey Depth 100Contamination Zone Depth(s): 45-55, 55-75 FT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
76-04-29	31	92	
76-07-28	56	90	
77-06-02	86	100	
80-09-18	15	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	H1 BKL	100	
76-07-28	BAD SURVEY	90	
77-02-03	TOOL FAIL	100	
77-03-16A	BAD SURVEY	100	
78-11-01	H1 BKL	100	
88-01-06	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	AUG BKL	98	4%	47.5	
76-04-22	% CLEAN	95	31%	42.4	
76-07-28	% CLEAN	89	16%	28.0	
77-02-03	AUG BKL	97	0%	0.0	
77-06-02	% CLEAN	96	10%	1.0	
77-08-18	% CLEAN	97	56%	41.9	
78-11-01	% CLEAN	97	54%	40.7	
88-01-06	% CLEAN	98	8%	32.8	

Analysis Notes

num surveys rejected: (0) ZERO	Background = (0 < val < 50) 20-40
POSSIBLE Low Level Zone (BECN 197.5.5 AT 56 FT - WAS MOVING DOWN)	
DEPTH START NOT POSSIBLE.	
GTP- ANALYSIS CONFIRMS DOWNWARD MOVEMENT (97.5 TO 19.80)	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name Randall PinedaS/W ver (TFGROSS) V2.20

Dry Well Survey Analysis - Notes

Borehole B4(22-10-07)Total # Surveys 381Probe Type 04Log Date: 75-01-09 1st# neutron surveys 4# GR Surveys 37793-10-04 Last

Presentation Plot Dates

Isotope from Spectral Survey: Co-60(If different from 1st & Last)Contamination Zone Depth(s): 45-60 FTMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-05-26	31	95	
77-06-02A	94	100	
78-09-14	14	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-04-22	HI-BKG	100	
78-11-01	HI-BKG	100	
88-01-06	NOISY SURV	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-07-31	LENGTH	54	100%	27.1	
76-04-22	AVG BKG	94	37%	43.4	
76-05-26	0% CLEAN	92	64%	27.1	
76-07-02	AVG BKG	91	92%	38.9	
76-09-16	AVG BKG	95	81%	44.4	
76-09-22	AVG BKG	95	95%	36.7	
77-06-02	10% CLEAN	95	1%	1.0	
78-11-01	AVG BKG	96	60%	42.0	

Analysis Notes

num surveys rejected: (0)	Background = (0 < val < 50) <u>65-90 FT</u>
Low Level Rad Zone (5 FT)	
Radio Active Zone (45-60 FT) MIGRATED THRU 1980 TO 1995	
DOWNWARD MOVEMENT IS SEEN IN STACK PLOT	
(FROM 1980 @ 50 FT TO 1984 @ 59 FT)	
Category: (Stable, TF Activity, Undetermined) <u>CHANGED</u>	

Analyst Name Randall DineenS/W ver (TFGROSS) V2.00.

Dry Well Survey Analysis - Notes

Borehole BY (22-10-09)Total # Surveys 370Probe Type 04Log Date: 75-01-09^{1st}# neutron surveys 5# GR Surveys 36793-10-04 Last

Presentation Plot Dates

Isotope from Spectral Survey: CS CSP 61g 0.5RT(If different from 1st & Last)Contamination Zone Depth(s): 070 FTMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
75-12-03	13	100	
76-05-26	20	100	
76-07-28	45	65	
77-06-02	95	100	
80-09-17	13	95	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI BKG	100	
76-04-22	HI BKG	100	
76-09-16	HI BKG	100	
77-08-17	BAD SURVEY	95	
78-11-01	HI BKG	100	
— LOST	RAD ZONE	82-06-15 TO 84-02-23	
88-01-06	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-04-22	AVG BKG	97	39%	73.2	
76-07-28	% CLEAN	69	34%	26.0	
76-09-16	% CLEAN	98	0%	0.0	
77-06-02	AVG BKG	98	1%	6.0	
78-06-28	AVG BKG	97	73%	39.6	
78-11-01	AVG BKG	98	75%	40.0	
88-01-06	% CLEAN	98	54%	27.4	

Analysis Notes

num surveys rejected: (0) ZEROBackground = (0 < ~~val~~ < 50) 10-40Category: (Stable) TF Activity, Undetermined, CHANGEDAnalyst Name Randall FureS/W ver (TFGROSS) V2.20

HNF-3532 - REV0

Dry Well Survey Analysis - Notes

Borehole B4(22-10-10)Total # Surveys 410Probe Type 04Log Date: 75-01-09 1st# neutron surveys 4
93-10-04 Last# GR Surveys 406

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey: _____

Max Survey Depth 100Contamination Zone Depth(s): 58-76 FT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
75-12-03	13	100	
76-05-26	13	95	
76-07-28	45	85	
77-06-02	82	100	
81-10-13	13	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-20	TOOL FAIL	95	
75-05-15	No RADZONES	170	
76-04-22	HI BKG	100	
76-07-28	BAD SURVEY	90	
77-02-03	HI BKG	105	
78-05-11	TOOL FAIL	100	
88-01-06	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-05-15	LENGTH	198	89%	26.9	
76-04-22	AVG BKG	95	37%	42.8	
76-07-28	% CLEAN	86	45%	22.1	
77-02-03	% CLEAN	101	0%	0.0	
77-05-05	AVG BKG	95	87%	37.2	
78-05-11	% CLEAN	98	0%	0.0	
78-06-28	AVG BKG	96	85%	37.8	
88-01-06	% CLEAN	98	44%	22.9	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = <u>(Data 50) 30-55 80-95 FT</u>
RADIATION DECAY RATE (58-76 FT) SAME GENERAL PROFILE AS G-TP FOR 22-08-12 (BUT WELLS ARE NOT IN PROXIMITY) (SB-125 DECAY LINE INCLUDED TO SHOW THAT RATE OF DECAY DOES NOT FIT) IDENTITY OF OTHER ISOTOPES (IF PRESENT) CAN NOT BE ESTABLISHED.	
Category: (Stable, TF Activity, Undetermined, <u>CHANGED</u>) <u>ZONE 58-76 FT</u>	

Analyst Name Randall PuroS/W ver (TFGROSS) V2.20

Well 22-10-10

filein := "two58-76.txt"

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 393

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co (5.27 yrs)

 $\tau_{co} := 5.27$

aco := 200

2nd Isotope is Sb125 (2.77 yrs)

 $\tau_2 := 2.77$

a2 := 1000

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$l = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = -65.318$$

$$\alpha_2 = 1.534 \cdot 10^3$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$\frac{\alpha_{co}}{\alpha_2} = -0.043$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\text{Ratio Co/Sb} = \frac{Co_N}{X2_N} = -0.395$$

Borehole 22-11-01

Contamination (Cs-137) from 0-5 and 5-10 feet is TF Activity
Contamination (Cs-137) from 19 to 28 feet is UNSTABLE

Grade Thickness Product from 0 to 5 feet is erratic for the 20 years of survey data and is categorized as Tank Farm activity. Changes in the logging procedure when logging surface radioactive zones perturbs reliable calculation of the Grade Thickness Product. A decay line for Cs-137 (identified from HPGe detector) that was fitted to the last few non-zero survey values is presented.

Grade Thickness Product from 5 to 10 feet is erratic from 1983 to 1986 and is categorized as Tank Farm activity. Grade Thickness Product from 1984 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Grade Thickness Product for the radioactive zone (19-28 feet) has four time intervals of changed activity. (1) Grade Thickness Product was decreasing within the gross gamma sensitivity at a rate consistent with Cs-137 (identified from HPGe detector) from 1975 to 1980, then a step change in concentration may have occurred. (2) From 1980 to 1983 the Grade Thickness Product continued to decrease with Cs-137 decay. (3) From 1983 to 1989 the Grade Thickness Product was erratic with five pulses of increased and decreased activity. (4) From 1989 to the end of the surveys (1993) the Grade Thickness Product has decreased dramatically.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	10/4/1993
Number Surveys :	415

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Zones 0-10': Threshold (0 < val < 50) Zone 19-28': Bkg = 30-45'
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-5, 5-10 feet is TF Activity 19-28 feet is UNSTABLE
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-11-01

Depth: 0-5 ft

Analysis by: Three Rivers Scientific

Borehole 22-11-01

Depth: 5-10 ft

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-11-01

Depth: 19-28 ft

10/04/93

Borehole 22-11-01 Depth Shifted; Reverse Time Scale

Borehole 22-11-05

Contamination (Cs-137) from 0 to 10 feet is TF Activity

Grade Thickness Product from 0 to 10 feet is erratic from 1975 to 1985 and is categorized as Tank Farm activity. A decay line for Cs-137 (identified from HPGe detector) shows the surveys since 1985 are consistent with the radionuclide decay.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	10/4/1993
Number Surveys :	450

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-11-05

Depth: 0-10 ft

10/04/93

Analysis by: Three Rivers Scientific

Borehole 22-11-05

Borehole 22-11-08

**Contamination (Cs-137) from 0 to 10 feet is TF Activity
Contamination (U-238/Pa-234 & Co-60) from 56 to 66 feet
is Stable**

Grade Thickness Product from 0 to 10 feet is erratic during 1975, 1981, 1984 to 1986, and is categorized as Tank Farm activity. A decay line for Cs-137 (identified from HPGe detector) is shown for reference.

Grade Thickness Product for the radioactive zone (56-66 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Co-60 (hypothesis) and U-238/Pa-234 (identified from HPGe detector) between January 1979 and October 1994. Protactinium (Pa-234) is a decay product of U-238. The least squares fit results in a gross gamma contribution ratio for Co-60 to U-238/Pa-234 of 0.5 on October 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	10/4/1993
Number Surveys :	438

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	40 to 50 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 56-66 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-11-08

Depth: 0-10 ft

10/04/93

01/09/75

Borehole 22-11-08

Depth: 56-66 ft

10/04/93

Borehole 22-11-08

Borehole 22-11-09

Contamination (Cs-137) from 0 to 8 feet is TF Activity

Contamination (Co-60) from 20 to 34 feet is Stable

Contamination (Co-60) from 34 to 46 feet was UNSTABLE early

Grade Thickness Product from 0 to 8 feet is erratic for the 20 years of survey data and is categorized as Tank Farm activity. A decay line for Cs-137 (identified from HPGe detector) is shown for reference and was fitted to the last few years of survey data.

Grade Thickness Product for the radioactive zone (20-34 feet) is decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector) between 1975 and 1994.

Grade Thickness Product for the radioactive zone (34-46 feet) from 1975 to 1978 was not showing radioactive decay and is classified as UNSTABLE. Then from 1978 to 1994 the radiation zone is decreasing within observed systematic limitations at a rate consistent with the decay of Co-60 (identified from HPGe detector.)

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	10/4/1993
Number Surveys :	437

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	10 to 20 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-8 feet is TF Activity 20-34 feet is Stable 34-46 feet was <u>UNSTABLE</u> early
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-11-09

Depth: 0-8 ft

10/04/94

Borehole 22-11-09

Depth: 20-34 ft

01/09/75

10/04/94

Analysis by: Three Rivers Scientific

01/09/75

Borehole 22-11-09

Depth: 34-46 ft

10/04/94

Analysis by: Three Rivers Scientific

Borehole 22-11-09

Dry Well Survey Analysis - Notes

Borehole B4(22-11-01)Total # Surveys 419Probe Type 04Log Date: 75-01-09 1st# neutron surveys 5# GR Surveys 41593-10-04 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: CS-137 < 100pCi/g (0-9AT)Max Survey Depth 100'Contamination Zone Depth(s): 0-5AT, 5-10, 19-28

GAPS.Txt

Survey Date	num. Gaps	approx #Samp'l's	Comment
75-12-31	12	100	
77-06-02	86	100	
84-03-16	12	100	
84-11-21	12	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-26	Tool Noise	100	
76-05-20A	Tool Noise	100	
77-04-21A	NO RAD ZONES	100	
79-00-31	NO RAD ZONES	100	
80-06-19	Tool Noise	95	
84-03-01	BAD SURVEY	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-26	Avg Bkg	101	28%	37.1	
76-04-22	%CLEAN	98	53%	42.1	
76-04-09	Avg Bkg	99	88%	32.7	
77-06-02	%CLEAN	101	14%	42.0	
77-07-22	Avg Bkg	98	96%	5.3	
78-06-28	Avg Bkg	99	81%	38.8	
80-06-19	%CLEAN	95	61%	7.0	
84-03-01	%CLEAN	98	0%	0.0	

Analysis Notes

num surveys rejected: (0) ZERO	Background = (0 < val < 50) 30-45AT 19-28AT
RADIATION ZONE (32 0-5, 5-10, 19-28)	DL VAL < 50 (0-595-10AT)
DEPTH SECTION ON TRAIL RAD OF 9AT PEAK	
0-5, 5-10 TA ACTIVITY	
19-28 (CHANGING)	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name Randall KuoS/W ver (TFGROSS) V 2.20

Dry Well Survey Analysis - Notes

Borehole B4 (22-11-08)Total # Surveys 443Probe Type 04Log Date: 7501-09st# neutron surveys 5# GR Surveys 43893-10-04 Last

Presentation Plot Dates

Isotope from Spectral Survey: Cs-137 (< 8 p.u. @ 0-10)(If different from 1st & Last)

Contamination Zone Depth(s):

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
77-06-02	93	100	
79-07-11 A,B	184	170	
81-10-13	15	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI-BKG	100	
76-05-05	HI CPS/OFT	170	
77-02-03	HI-BKG	102	
78-09-14A	BAD SURVEY	180	
84-03-01	BAD SURVEY	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-04-22	Avg BKG	95	61%	42.8	
76-07-21	LENGTH	202	87%	28.2	
77-02-03	%CLEAN	98	0%	0.0	
78-09-14	%CLEAN	97	13%	25.4	
79-07-11	BSURVEY	230	20%	23.8	
85-12-12	Avg BKG	97	98%	9.0	
89-03-01	%CLEAN	96	0%	0.0	

Analysis Notes

40-50 FT

num surveys rejected: (0) ZERO

Background = (0 < val < 50)

65 ~~40-95~~ZONE 56-64ZONE 0-10 BKG 15-40

* SUSPECT (56-64 FT) ANOTHER SHORT LONG ISOTOPE (56, Co, Ru)
 BUT SINCE NONE IDENTIFIED BY HPIC, WILL NOT PRESENT
 UNTIL OTHER INPUT RECEIVED

REVIEW W/ NEW BKG CMC (40-50 FT) FOR ZONE 56-64: FIT W/ Co & U.

Category: (Stable) TF Activity, Undetermined, CHANGED

Analyst Name Randall PinedaS/W ver (TFGROSS) V L. 20.

filein := "GTP56-66.txt"

Well 22-11-08

A := READPRN(filein)

yr := A<1>

net := A<7>

bkg := A<6>

max := A<4>

N := last(yr)

N = 426

i := 0..N

k := 0..300

j := 0..299

1st Isotope is Co (5.27 yrs)

 $\tau_{co} := 5.27$

aco := 98

2nd Isotope is U (4.5 ~~eq~~ yrs) $\tau_2 := 4.5 \cdot 10^9$

a2 := 16

$$Co_i := aco \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := a2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$gross_i := net_i$$

This data edited for spurious points

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}} + a3 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}} \right] \right]^2$$

Given

$$ssq(aco, a2) = 0$$

$$1 = 1$$

$$\begin{bmatrix} \alpha_{co} \\ \alpha_2 \end{bmatrix} := \text{Minerr}(aco, a2)$$

$$\alpha_{co} = 98.175$$

Co-60

$$\alpha_2 = 16.748$$

Uranium

$$\frac{\alpha_{co}}{\alpha_2} = 5.862$$

$$Co_i := \alpha_{co} \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_{co}}}$$

$$X2_i := \alpha_2 \cdot e^{-\left(yr_i - 75\right) \frac{\ln(2)}{\tau_2}}$$

$$tot_i := Co_i + X2_i$$

$$out^{<0>} := yr$$

$$out^{<1>} := tot$$

$$\text{WRITEPRN}("twop.txt") := out$$

$$\frac{Co_N}{X2_N} = 0.497$$

Ratio Co/U

Dry Well Survey Analysis - Notes

Borehole BY(22-11-09)Total # Surveys 441Probe Type 04Log Date: 75-01-09 1st# neutron surveys 4# GR Surveys 43793-10-04 Last

Presentation Plot Dates

(If different from 1st & Last)

Isotope from Spectral Survey: _____

Max Survey Depth 100Contamination Zone Depth(s): 0-8', 22-30', 30-44

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
77-06-02	79	100	
81-10-13	20	100	
84-01-16	15	100	
85-09-19	10	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-09-18A	TRUNCATED SURVEY	80	
76-05-20A	NOISE		81-04-22: 115' - No Rad Zone
77-06-02	No Rad Zone	100	82-06-02 to 84-02-15 = No Rad.
77-07-22	No Rad Zone	98	
78-08-23	TOOL FAIL	100	
80-05-06	WRONG HOLE		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-04-22	Avg Bkg	98	55%	42.5	
76-05-20	% CLEAN	98	57%	35.3	
76-10-22	Avg Bkg	98	52%	43.5	
77-02-03	Avg Bkg	98	0%	0.0	
77-06-02	Avg Bkg	98	19%	1.9	
78-06-28	Avg Bkg	98	80%	40.6	
78-08-23	% CLEAN	99	0%	0.0	
85-09-18	Avg Bkg	99	88%	18.4	

Analysis Notes

num surveys rejected: (0) ZERO	Background = (0 < val < 50) -45-95 10-20
RADIATION ZONES (20-34' & 34-46 RT)	
20-34' - STABLE Co-60	
34-46' - LOW LEVEL - BUT SHOWS INDICATIONS OF MIGRATION FROM FORMATION INTO TILES ZONE (UNDETERMINED)	
0-8 FT - TF ACTIVITY	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name Randall PinnerS/W ver (TFGROSS) V2.20

Borehole 22-12-01**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1995 in the vadose zone from 2 to 100 feet.

Surveillance logging activities were not designed to monitor low contamination levels near the surface or bottom of the borehole. Low levels of Cesium-137 (identified from HPGe detector) present at/near the surface and at the bottom were are below the detection threshold as shown on the Grade Thickness Product plots for 0 to 25 and 90 to 105 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	424

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 22-12-01**Oldest Survey
1/09/1975**

Gamma (c/s)

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

HNF-3532 -REV0

Borehole 22-12-01

01/09/75

Borehole 22-12-01

Depth: 0-25 ft

06/13/94

01/09/75

Borehole 22-12-01

Depth: 90-105 ft

06/13/94

Borehole 22-12-03

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity

Contamination (Cs-137) from 10-20 feet is Stable

Grade Thickness Product from 0 to 10 feet is erratic for the 20 years of surveillance monitoring, and is categorized as Tank Farm activity. The gross gamma activity exceeds 30,000 counts per second which may be beyond the linear region of the counting system. The decay line for Cs-137 (identified from HPGe detector) approximately agrees with the decrease in Grade Thickness Product.

Grade Thickness Product for the radioactive zone (10-20 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Cesium-137 (identified from HPGe detector) between 1975 and 1994.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/10/1975
Last Survey Date :	6/13/1994
Number Surveys :	509

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	28 to 42 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity 10-20 feet is Stable
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/16/75

Borehole 22-12-03

Depth: 0-10 ft

6/13/94

Analysis by: Three Rivers Scientific

01/16/75

Borehole 22-12-03

Depth: 10-20 ft

6/13/94

HNF-3532 -REV0

Depth Shifted

Borehole 22-12-03

1995

1990

1985
Date (Year)

1980

1975

125 00
Depth (feet)

HNF-3532 -REV0

Borehole 22-12-03

Borehole 22-12-05**Contamination (Cs-137) from 0 to 20 feet is Tank Farm Activity**

Grade Thickness Product from 0 to 20 feet is erratic from 1975 through 1986 primarily from logging procedure changes and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	426

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	25 to 40 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-20 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-12-05

Depth: 0-20 ft

06/13/94

Borehole 22-12-05

Borehole 22-12-06

Contamination (Cs-137) from 0 to 20 feet is Tank Farm Activity

Grade Thickness Product from 0 to 20 feet is erratic from 1975 through 1986 primarily from logging procedure changes and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing within counting statistics at a rate consistent with Cs-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	428

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	20 to 40 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-20 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/16/75

Borehole 22-12-06

Depth: 0-20 ft

06/13/94

Gamma (c/s)

Gamma (c/s)

HNF-3532 -REV0

Borehole 22-12-06

Borehole 22-12-07**Contamination (Cs-137) from 0 to 10 feet is Tank Farm Activity**

Grade Thickness Product from 0 to 10 feet is erratic throughout the monitoring interval and is categorized as Tank Farm activity. Grade Thickness Product shows that on occasion the gamma log response exceeded the background activity. A decay line for Cs-137 (identified from HPGe detector) is presented for the surveys from 1986 to 1991 that were above background.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1975
Last Survey Date :	6/13/1994
Number Surveys :	418

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 feet is TF Activity
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

01/09/75

Borehole 22-12-07

Depth: 0-10 ft

06/13/94

Borehole 22-12-07

Borehole 22-12-09**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1995 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	6/13/1994
Number Surveys :	429

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	≤ 0
Method Used to Compute Background :	Threshold ($0 < \text{val} < 50$)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

HNF-3532 - REV 0
Borehole 22-12-09

**Oldest Survey
1/16/1975**

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 22-12-09

Borehole 22-12-10**No Gamma-Ray Emitting Contamination was identified**

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1975 and 1995 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	6/13/1994
Number Surveys :	424

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0 < val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	No Contamination
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

HNF-3532 - REV0
Borehole 22-12-10

**Oldest Survey
1/16/1975**

**No Gamma-Ray Emitting Contamination
Above Survey Detection Threshold**

Analysis by: Three Rivers Scientific

Borehole 22-12-10

Dry Well Survey Analysis - Notes

Borehole BY(22-12-01)Total # Surveys 428Probe Type 04Log Date: 75-01-09^{1st}# neutron surveys 3
94-06-13 Last# GR Surveys 424
Presentation Plot Dates _____Isotope from Spectral Survey: Cs-137 20-25 FT(If different from 1st & Last)Contamination Zone Depth(s): NONEMax Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-07-21	23	85	
77-06-02	95	100	
79-12-27	9	98	
84-11-21	13	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
78-04-21A	SHORT SURVEY	45	
76-03-03A	SHORT SURVEY	40	
79-03-06A	SHORT SURVEY	40	
91-10-14	SHORT SURVEY	20	
83-05-03	BAD SURVEY	100	HIGH NOISE (AT BOTTOM)
91-01-03	BAD SURV	100	HIGH NOISE
93-12-17	HIGH BKG	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-03A	DEPTH	34	97%	26.8	
77-06-02	AUG BKG	98	3%	1.7	
78-04-21	DEPTH	34	50%	22.4	
79-03-06	DEPTH	33	36%	28.4	
79-10-03	AUG BKG	99	82%	41.0	
83-05-03	% CLEAN	96	52%	24.6	
91-01-03	% CLEAN	98	39%	29.1	
93-12-17	AUG BKG	98	2%	48.5	

Analysis Notes

num surveys rejected: (0) <u>YES</u> RKP NONE Background = (0 < val < 50)
0-25 FT (BKG = 25-40)
90-105 FT (BKG = 45-90 FT)
UPPER & LOWER ZONE HAVE EXCESSIVE VARIATION IN DATA
TYPICAL OF VERY LOW ACTIVITY ZONES & POOR LOGGING
PROCEDURES AT TOP & BOTTOM OF HOLE
Category: (Stable, TF Activity, Undetermined, CHANGED) <u>CLEAN</u>

Analyst Name Randall P.S/W ver (TFGROSS) 2.20

Dry Well Survey Analysis - Notes

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
77-06-02	80	100	
77-08-18	21	110	
94-09-06	91	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-04-01A	BAD SURVEY		
77-05-12	SHORT	50	MISSING RAD ZONE
77-06-02	BAD SURVEY	98	DEPRESSED IN RAD ZONE
77-08-18	BAD SURVEY	110	HIGH ACTIVITY (L/S) FULL RAD RUN
78-07-27	NO RAD ZONE	80	
79-10-03	No Rad Zone	100	81-09-02 NO RAD ZONE 82-06-02 TRUNCATED RAD ZONE
79-11-28	LOW RAD ZONE		92-04-13 TOOL FAILURE
80-06-25	NO RAD ZONE	100	93-12-17 TOOL FAIL
80-10-16	LOW RAD ZONE	95	94-03-24 BAD RAD ZONE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-12-16	HS BKL	98	86%	39.4	
77-05-05	HI BKG	97	87%	38.2	
77-06-02	% CLEAN	96	13%	6.9	
77-08-18	% CLEAN	106	11%	31.7	
78-06-01	AVG BSL	98	82%	43.3	
79-10-03	AVG BKG	99	42%	44.2	
92-02-13	FAST CLEAN	98	0%	0.0	
94-03-24	AVG BKL	98	91%	3.5	
94-04-06	0% CLEAN	99	40%	10.0	

Analysis Notes

num surveys rejected: (0) *NONE* Background = (0 ~~> val~~ < 50) *28-42 FT*

Category: (Stable, TF Activity, Undetermined, CHANGED)

S/W ver (TFGROSS) V2.20

HNF-3532 - REV 0

Dry Well Survey Analysis - Notes

Borehole B4(22-12-05)Total # Surveys 429Probe Type 04Log Date: 75-01-04 1st# neutron surveys 3# GR Surveys 42694-06-13 Last

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: Cs-137 < 20 pCi/g (0-20FT)Max Survey Depth 100Contamination Zone Depth(s): 0-20FT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-07-28	131	160	
77-06-02	84	100	
94-03-24	31	100	
94-04-06	58	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-05-20	TOOL FAIL	100	
91-01-03	HIGH BKG	100	LOW IN DEPTH RANGE
80-07-02	HC CLS	105	AT SURFACE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	AVG BKG	100	69%	35.7	
76-04-22	AVG BKG	76	78%	39.4	
76-05-20	% CLEAN	99	41%	29.7	
77-02-03	AVG BKG	98	68%	43.3	
78-06-28	AVG BKG	98	89%	32.1	
91-01-03	% CLEAN	98	61%	31.0	
94-03-24	AVG BKG	98	63%	1.1	

Analysis Notes

num surveys rejected: (0)	Background = (0-50) 25-40
SHARP LOW RADIATION ZONE AT SURFACE, HIGH RADIATION ZONE 84-02-23 TO 85-12-12	
RADIOACTIVE ZONE ERRATIC, CATEGORIZED AS TF ACTIVITY	
LOGGING OPERATION PROCEDURES CAUSED TRUNCATED SURVEYS 1983-84	
HIGH ACTIVITY ZONE (84-02-23 TO 85-02-12) RECORDED WHEN SURVEYS ALLOWED TOP ADDITIONAL 2 FT TO BE RECORDED ON SURVEY	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name Randall PriceS/W ver (TFGROSS) V 2.20

HNF-3532 - REV0

Dry Well Survey Analysis - Notes

Borehole B4 (22-12-06)Total # Surveys 432Probe Type 04Log Date: 75-01-09 1st# neutron surveys 4# GR Surveys 42894-06-13 LastPresentation Plot Dates 75-01-16(If different from 1st & Last)Isotope from Spectral Survey: CS-137 <20 pCi/g (0-17AT) Max Survey Depth 100Contamination Zone Depth(s): 0 TO 20 FT (HI VARIATION - TR ACTIVITY)

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
75-12-31	19	98	85-09-18 (A,B) 20, 100 FT
77-06-02	80	100	85-09-19 (A,B) 12, 100'
80-09-18	30	80	
81-10-27	24	85	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-01-09	BAD SURVEY	170	RAD ZONE NOT AT PROPER DEPTH
75-08-21A	NO RAD ZONE	60	
76-05-20A	BAD SURVEY	100	NDISH 82-06-02 LOST RAD ZONE
77-06-02	NO RAD ZONE	100	→ TO 84-02-23
79-07-12	NO RAD ZONE	30	DATE LOG OPER PROC CHANGES:
80-07-30	NO PEAK		82-12-29 / 84-02-23 / 86-06-04.

81-01-29

NORAD

HI CLS AT

LOST HI

BackGnd.Txt

SURFACE

CLS AT 0'

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-04-22	Avg BKG	96	45%	43.0	
76-05-20	% CLEAN	97	13%	33.4	
76-09-09	Avg BKG	97	80%	37.3	
77-06-02	Avg BKG	98	18%	2.1	
79-09-18	Avg BKG	97	85%	32.2	
81-10-27	% CLEAN	89	62%	29.3	
85-09-19	Avg BKG	99	78%	16.7	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (<u>0</u> val <u>50</u>) <u>20-40</u>
RADIATION ZONE 0-17 AT, HIGH VARIATION: TR ACTIVITY	
AND HAS LOGGING OPER PROCEDURE PROBLEMS	
Category: (Stable, TF Activity, Undetermined, CHANGED)	

Analyst Name Randall PuroS/W ver (TFGROSS) V2-20

Dry Well Survey Analysis - Notes

Borehole B4 (22-12-07)Total # Surveys 421Probe Type 04Log Date: 75-01-09 1st# neutron surveys 2
94-06-13 Last# GR Surveys 418

Presentation Plot Dates

(If different from 1st & Last)Isotope from Spectral Survey: CS-137 0-SAT < 5 pCi/gMax Survey Depth 102Contamination Zone Depth(s): 0-10AT

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-05-26	16	98	
77-06-02	96	100	
85-09-19	13	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-05-20B	TOOL FAIL	100	
76-04-22	HI BKG	100	
HI ACTIVITY AT SURFACE (VARIABLE) 84-02-01 TO 90-10-10			

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-04-22	AVG BKG	97	55%	43.2	
76-05-20	% CLEAN	97	3%	30.0	
76-09-09	AVG BKG	97	92%	40.0	
76-10-27	AVG BKG	100	96%	36.3	
77-06-02	% CLEAN	97	1%	1.0	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0<val<50) <u>YES</u>
<u>ERRATIC ACTIVITY, ASSIGN AS TF ACTIVITY</u>	
Category: (Stable, <u>TF Activity</u> , Undetermined, CHANGED)	

Analyst Name Randall PinedaS/W ver (TFGROSS) V2.20

Dry Well Survey Analysis - Notes

Max Survey Depth 100

Survey Date	num. Gaps	approx #Sampl's	Comment
76-09-02	59	60	
77-06-02	96	100	
78-09-27	54	100	
81-10-27	38	60	

Survey Date	Reason Selected	approx #Samp's	Comment
76-05-20A	Noise AT Bottom	100	
77-02-10A	Noisy Survey	100	
79-03-06	HI CPS AT 60AT	100	

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-02-07	LENGTH	202	88%	31.9	
76-04-22	AVG-BKG	99	57%	41.8	
76-09-02	LENGTH	60	0%	0.0	
76-09-09	AVG-BKG	98	56%	42.0	
77-06-02	% CLEAN	97	1%	1.0	
78-09-24	% CLEAN	98	44%	24.9	
74-02-21	AVG-BKG	98	97%	4.1	
94-04-06	AVG-BKG	98	95%	12.5	

num surveys rejected: (0) <i>None</i>	Background = (0<val<50) <i>0.5</i>
Category: (Stable, TF Activity, Undetermined, CHANGED) <i>CLEAN</i>	

S/W ver (TFGROSS) 2.20

00 543

HNF-3532 - REV 0

Dry Well Survey Analysis - Notes

Borehole B4(22-12-10)

Total # Surveys 428

Probe Type 04

Log Date: 75-01-16^{1st}

neutron surveys 4

GR Surveys 424

94-06-13 Last

Presentation Plot Dates

Isotope from Spectral Survey: CS-137 < 2 pCi/g 0-10 FT

(If different from 1st & Last)

Contamination Zone Depth(s):

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Samp's	Comment
76-07-28	18	20	
77-06-02	94	100	
77-11-23	85	80	
79-12-21	17	95	

81-09-02 14 50

94-04-06 99 100

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-06-05	H1 BKG	100	
76-06-04	TOOL NOISE	100	
93-12-17	H1 NOISE	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-06-05	AUG-BKG	98	0%	0.0	
76-04-22	AUG-BKG	97	58%	40.4	
77-01-20	AUG-BKG	95	93%	37.8	
77-06-02	AUG-BKG	96	2%	1.0	
77-11-23	9% CLEAN	87	0%	0.0	
79-09-18	79-10-03	98	89%	40.3	
93-12-17	AUG-BKG	98	11%	43.2	
94-01-06	9% CLEAN	96	0%	0.0	

Analysis Notes

num surveys rejected: (0) <u>ZERO</u>	Background = (0<val<50)
<u>NO RADIATION ZONE PRESENT (75-95)</u>	
Category: (Stable, TF Activity, Undetermined, CHANGED) <u>CLEAN</u>	

Analyst Name

Randall Pineda

S/W ver (TFGROSS) V 2.20

00 544