OCT 12 1999 (21) Station 15

ENGINEERING DATA TRANSMITTAL

Page 1 of 1 KN

1. EDT 627796

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) RPP Vadose Zone Project	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.:	6. Design Authority/Design Agent/Cog. Engr.:	7. Purchase Order No.: N/A
8. Originator Remarks: For Approval/Release		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 200E/BX Tank Farm
		12. Major Assm. Dwg. No.: N/A
11. Receiver Remarks:	11A. Design Baseline Document? ○ Yes ◉ No	13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-3531	All	0	Analysis of Historical Gross Gamma Logging Data from BX Tank Farm	N/A	2	1	

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
		Design Authority									
		Design Agent									
1	1	Cog. Eng. D. A. Myers		10/8/99	H0-22						
1	1	Cog. Mgr. A. J. Knepp		10/8/99	H0-22						
		QA									
		Safety									
		Env.									

18.	19.	20.	21. DOE APPROVAL (if required)
Signature of EDT Originator — Date 10/8/99	Authorized Representative for Receiving Organization — Date 10-8-99	Design Authority/ Cognizant Manager — Date	Ctrl No. ○ Approved ○ Approved w/comments ○ Disapproved w/comments

BD-7400-172-2 (10/97)

BD-7400-172-1

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	RPP Vadose Zone Project	Date 10/6/99
Project Title/Work Order		EDT No. 627796
HNF-3531, Rev. 0, Analysis of Historical Gross Gamma Logging Data from BX Tank Farm		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
J. F. Bertsch	B1-42	X			
B. H. Ford	H0-21	X			
J. C. Henderson	H0-22	X			
A. J. Knepp	H0-22	X			
D. J. Moak	H1-11				X
D. A. Myers	H0-22	X			
T. L. Steward	H0-21				X
R. M. Yasek	H0-12	X			
Central Files	B1-07	X			
DOE/RL Reading Room	H2-53	X			

A-6000-135 (10/97)

1239269
[0076053H]

HNF-3531, Rev. 0

Analysis of Historical Gross Gamma Logging Data from BX Tank Farm

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

EDT/ECN: 627796 UC: 2010
Org Code: 73100 Charge Code: ~~106561~~ 110167/CA4D HMLM0131
B&R Code: EW3130010 Total Pages: ~~442~~ 442

Key Words: Vadose Zone, BX Tank Farm, Dry Well Gross Gamma, Gross Gamma Logs

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 BX tank farm to locate the presence of mobile radionuclides in the subsurface. This report presents the BX 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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Karen M. Noland 10/12/99
Release Approval Date

OCT 12 1999 DATE: STA: 15 HANFORD RELEASE ID: 21
Release Stamp

Approved For Public Release

C05CE51

WMNW

Project: 772028
Task: 23020001

ANALYSIS OF HISTORICAL GROSS GAMMA LOGGING DATA FROM BX TANK FARM

RECEIVED
JUL 02 2015
EDMC

Data Analysis By: 3 Rivers Scientific

Borehole 21-00-01

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 145 feet.

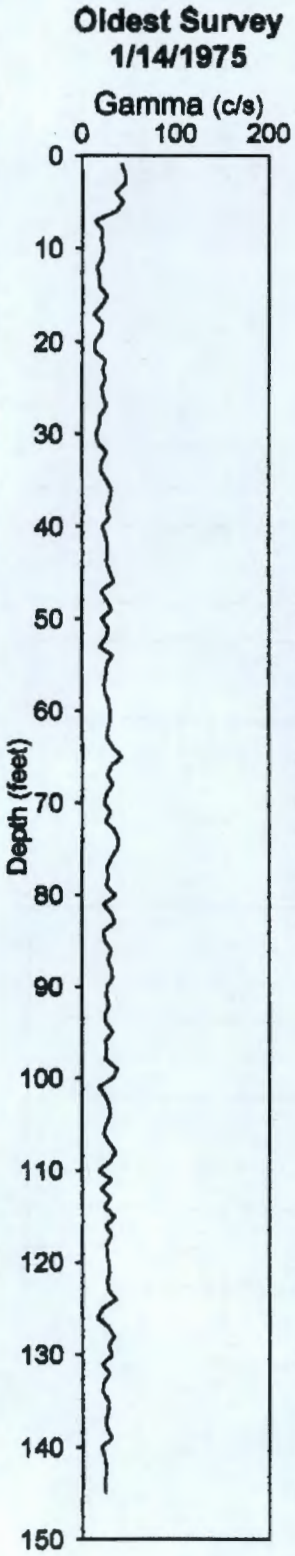
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	145 ft
Survey Depth :	145 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	154

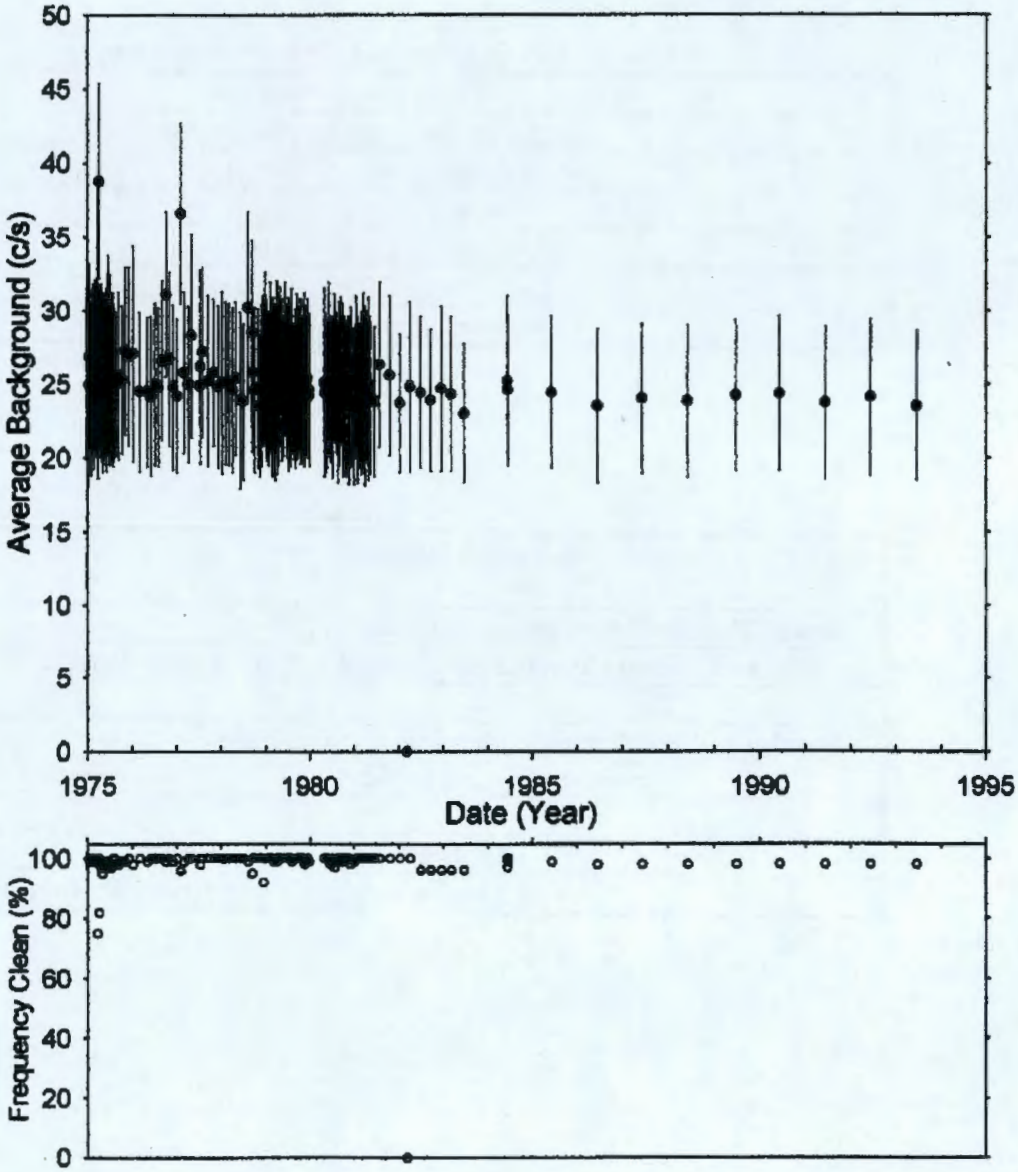
Analysis Notes

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	

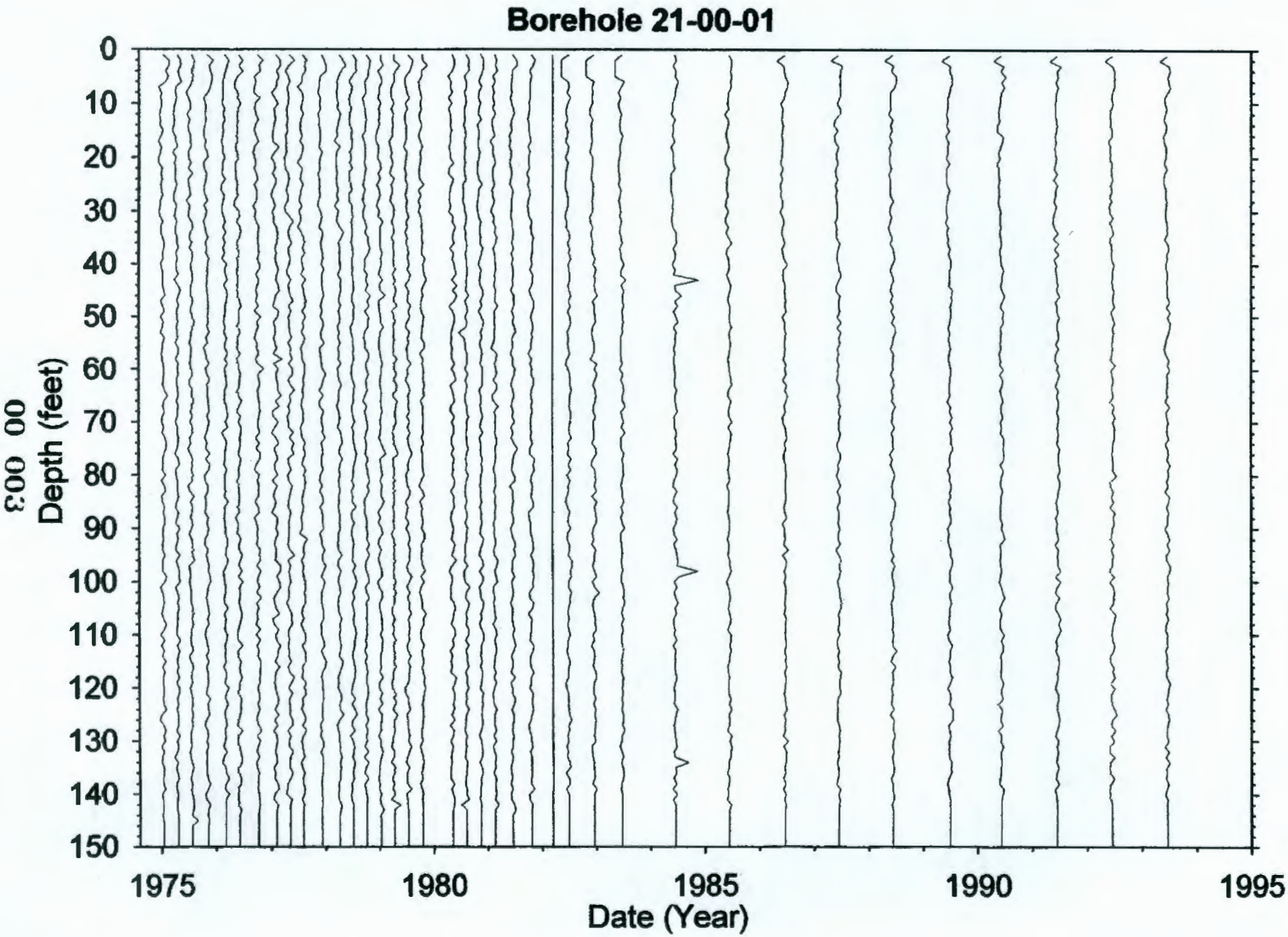
Borehole 21-00-01



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-00-01
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21 BX-00-01 | Total # Surveys 156 | Probe Type 04

neutron surveys 2 | # GR Surveys 154

Log Date: 1-14-75 1st | 6-17-93 Last | Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): none GR

Isotope from Spectral Survey: Cs | Max Survey Depth 145

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

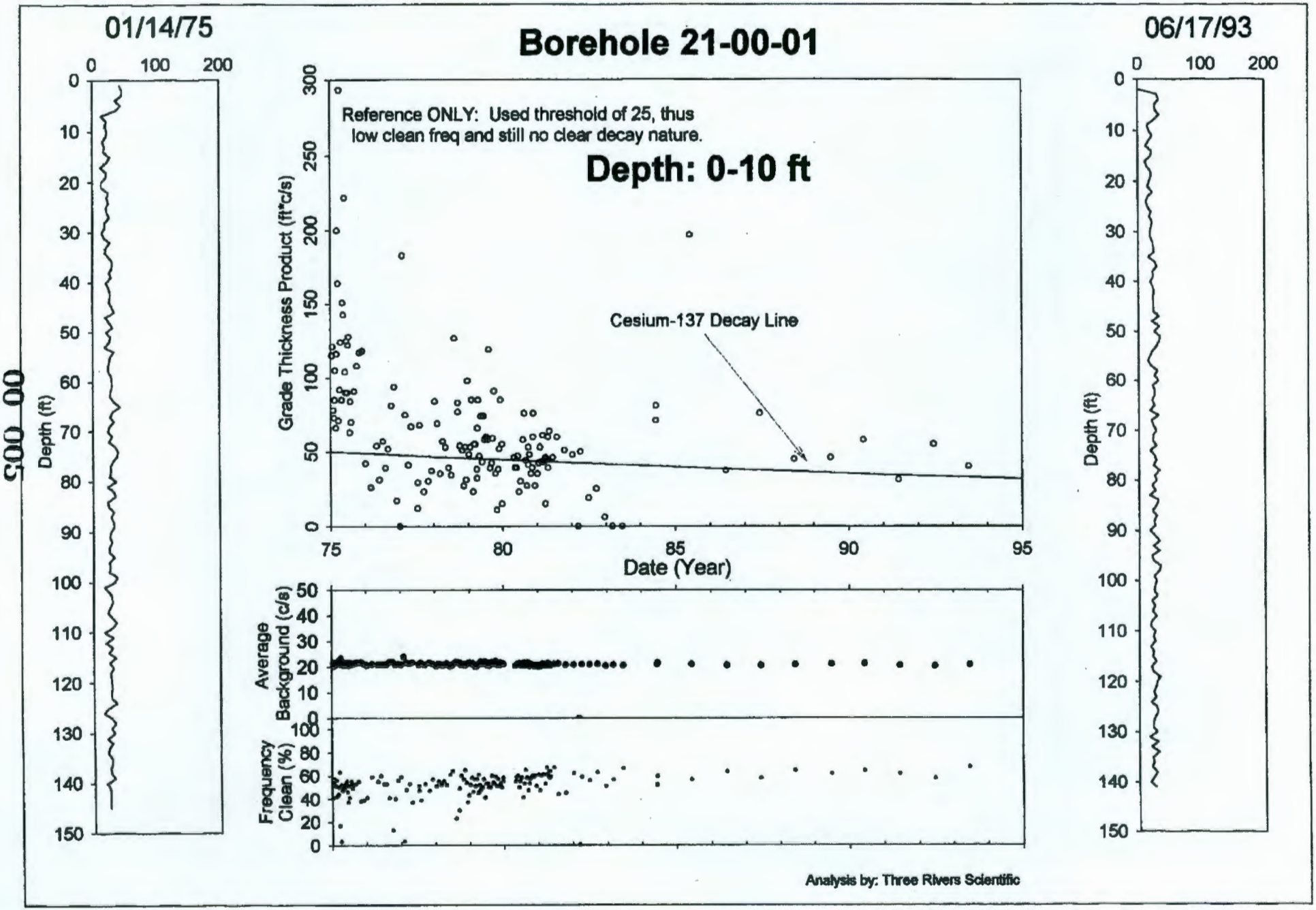
BackGnd.Txt

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

Analysis Notes

Cs low on HPGe - tried 0-25 bkg but still no clean
as clean decay in Clean using 0-50 produces
(For example, take 12-10 @ 25 bkg)

Analyst Name R³ | S/W ver TF6R0ES202



HNF-3531 -REV0

00 005

Borehole 21-00-02

Contamination (Cs-137 & Ru-106) from 70-80 feet is Stable, late Contamination (Co-60) from 80-90 feet is Stable

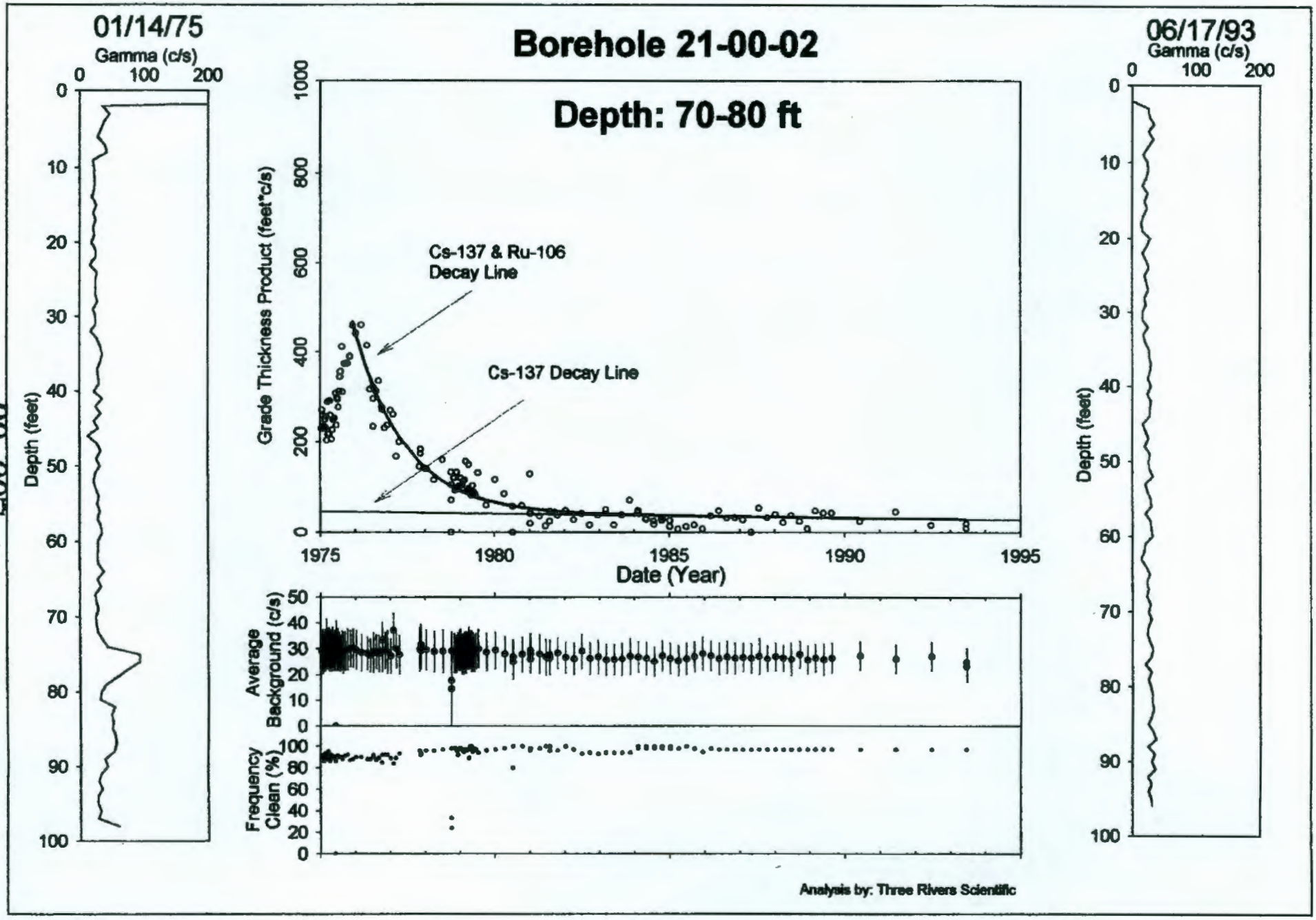
Grade thickness product from 70 to 80 feet increased starting 1975, but consistent with a least squares fit for Cs-137 (HPGe identified) and Ru-106 (hypothesis) from 1976 to 1994. The least squares fit results in a gross gamma contribution ratio of Ru-106 to Cs-137 of 17.1 as of Dec 1975. This zone appears stable since 1976.
Grade thickness product from 80 to 90 feet appears stable from 1975 to 1993.

Gross Gamma Survey Information

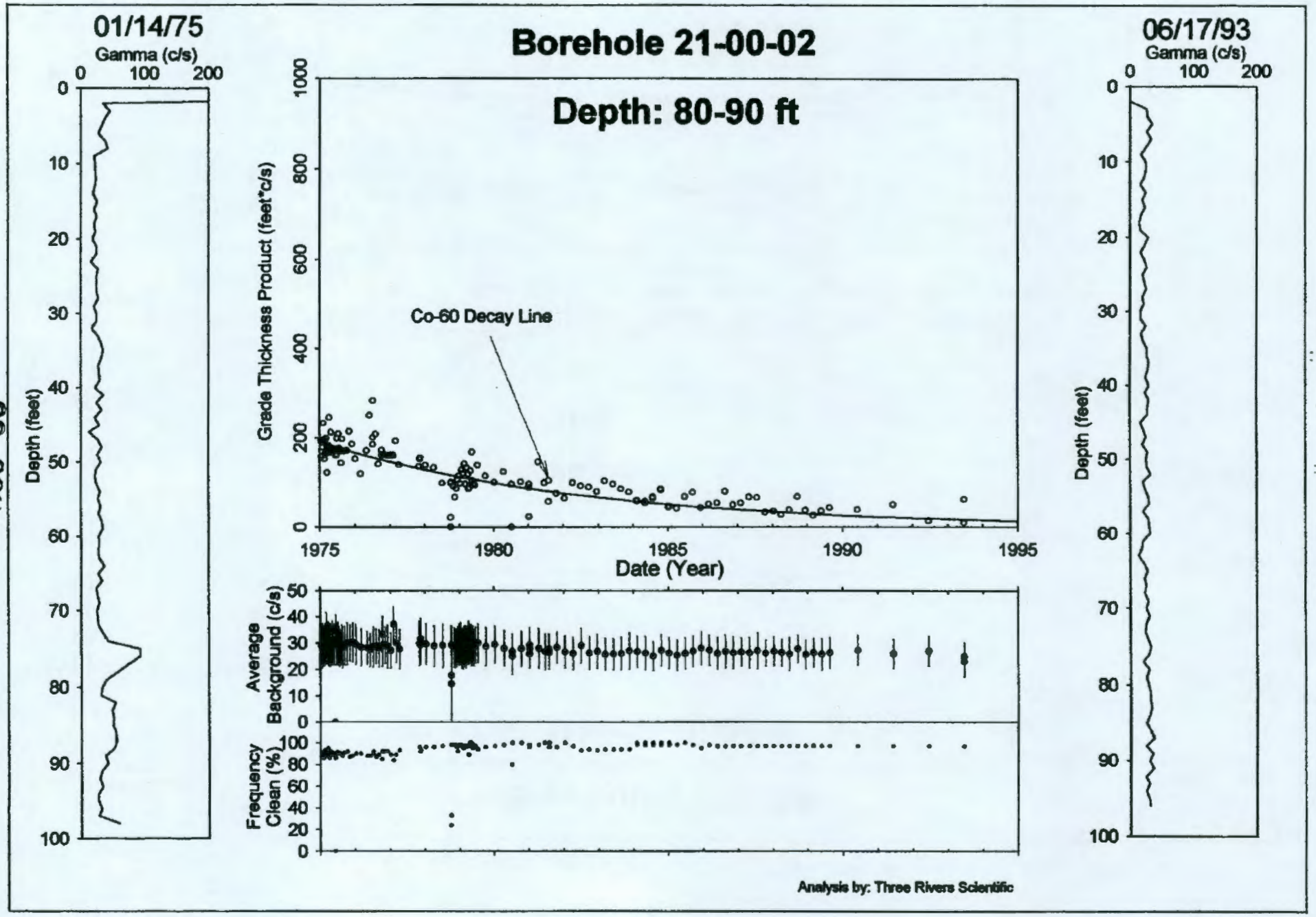
Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	141

Analysis Notes

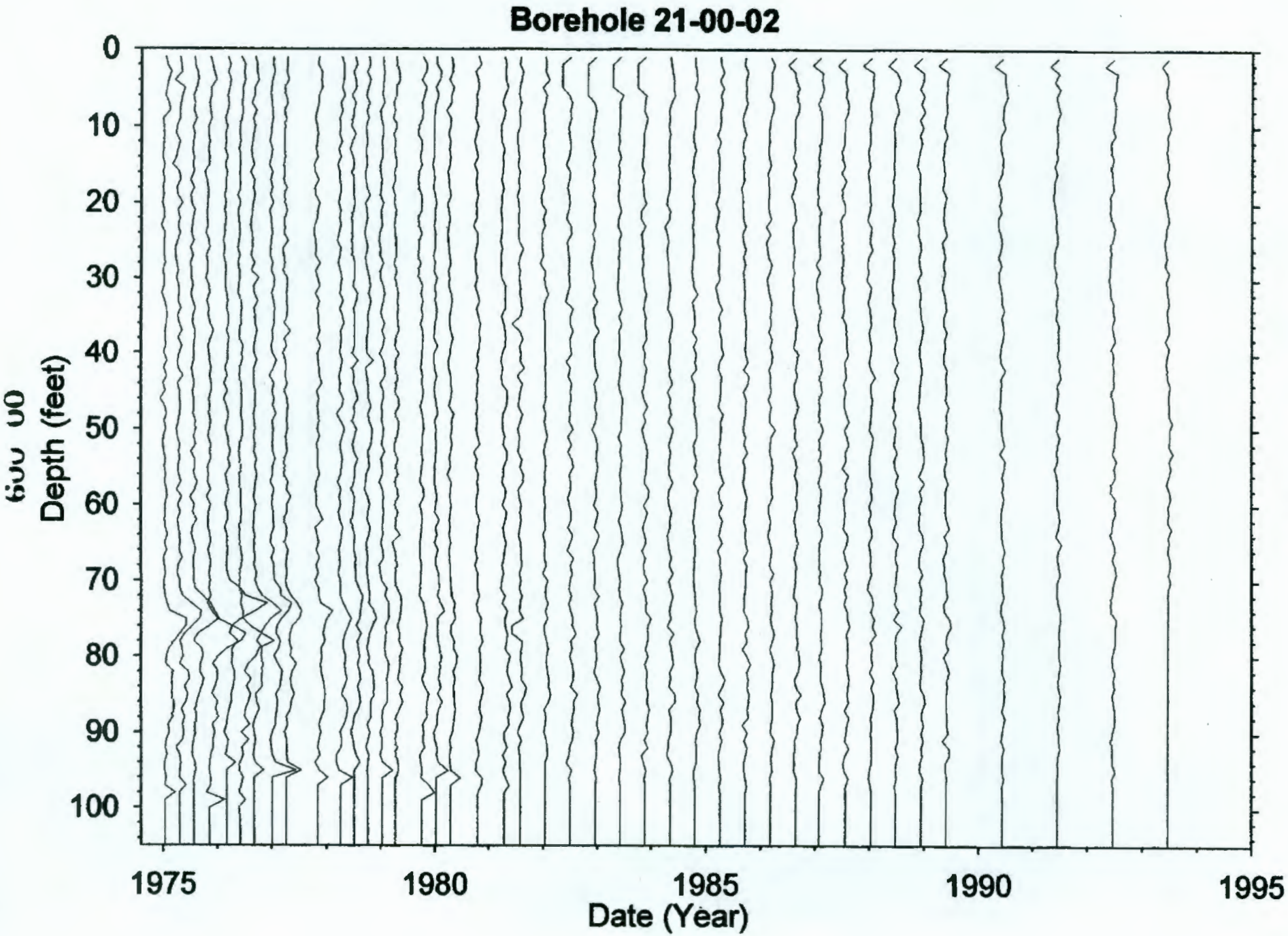
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	70-80 Stable late, 80-90 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



HNF-3531 -REV0



HNF-3531 -REV0



HNF-3531 -REV0

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole BX 21-00-02

Total # Surveys ~~145~~ 145

Probe Type 04

neutron surveys 4

GR Surveys ~~142~~ 141

Log Date: 1-14-75 1st

6-17-93 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 70-90 70-80 & 80-90

Isotope from Spectral Survey: Cs @ low levels 0-10'
Co @ " " 80-90

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

Co^{60} @ low levels in 1st 8 ft, but history was that past scrap. No depth shift & lower part stable

Analyst Name [illegible]

S/W ver TFGRAS 2.2

00 010

filein := "two.txt"

Well 21-00-02

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 107$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := \frac{368.2}{365.25}$

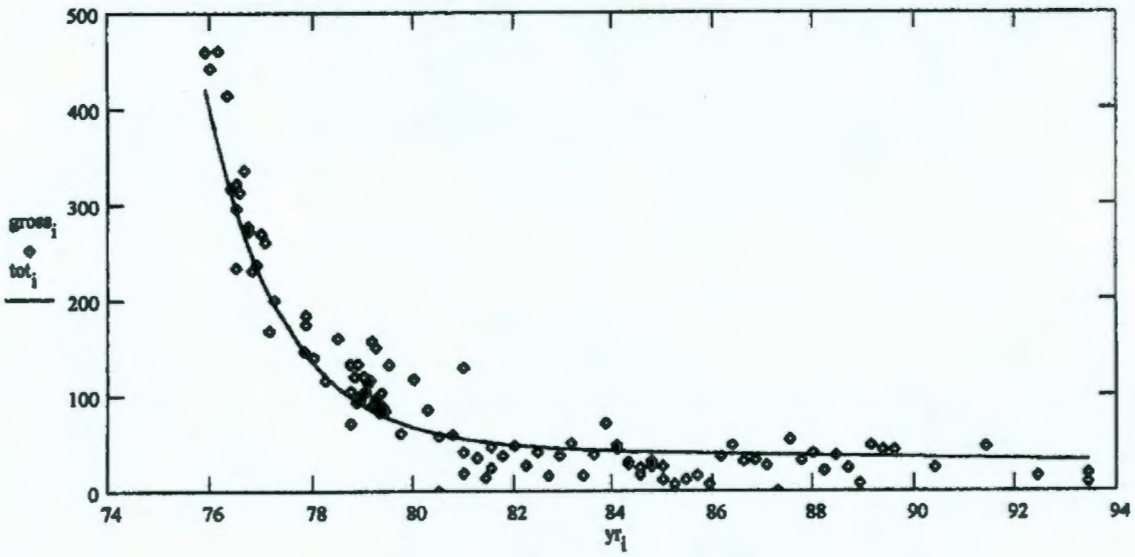
$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 00$ $\quad acs := 50$

Eu variables are Ru-106 $\quad aeu := 700$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aeu) = 0$ $\quad 1 = 1$

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

$\alpha cs = 46.585$ $\quad \alpha eu = 799.464$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Cs_i + Eu_i$

$\frac{\alpha cs}{\alpha eu} = 0.058$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

$\frac{Eu_N}{Cs_N} = 8.048 \cdot 10^{-5}$

Borehole 21-00-05

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 5 to 140 feet.

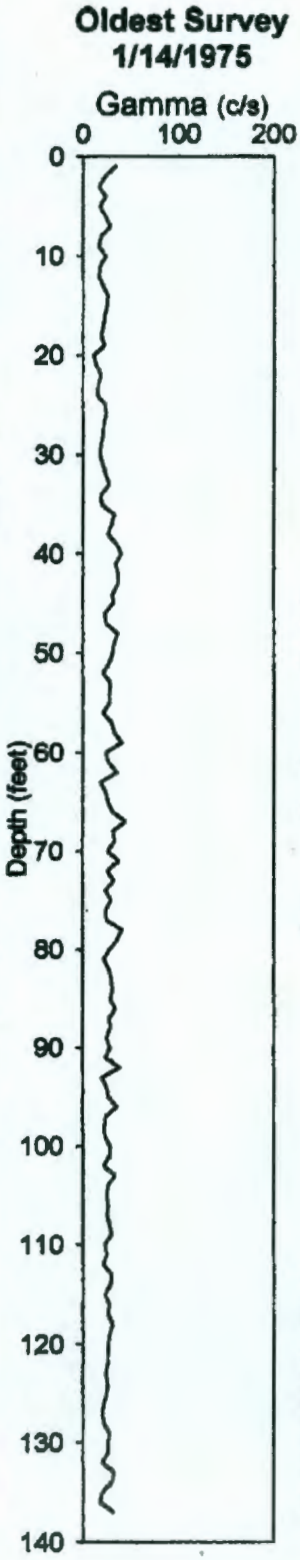
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	140 ft
Survey Depth :	140 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	100

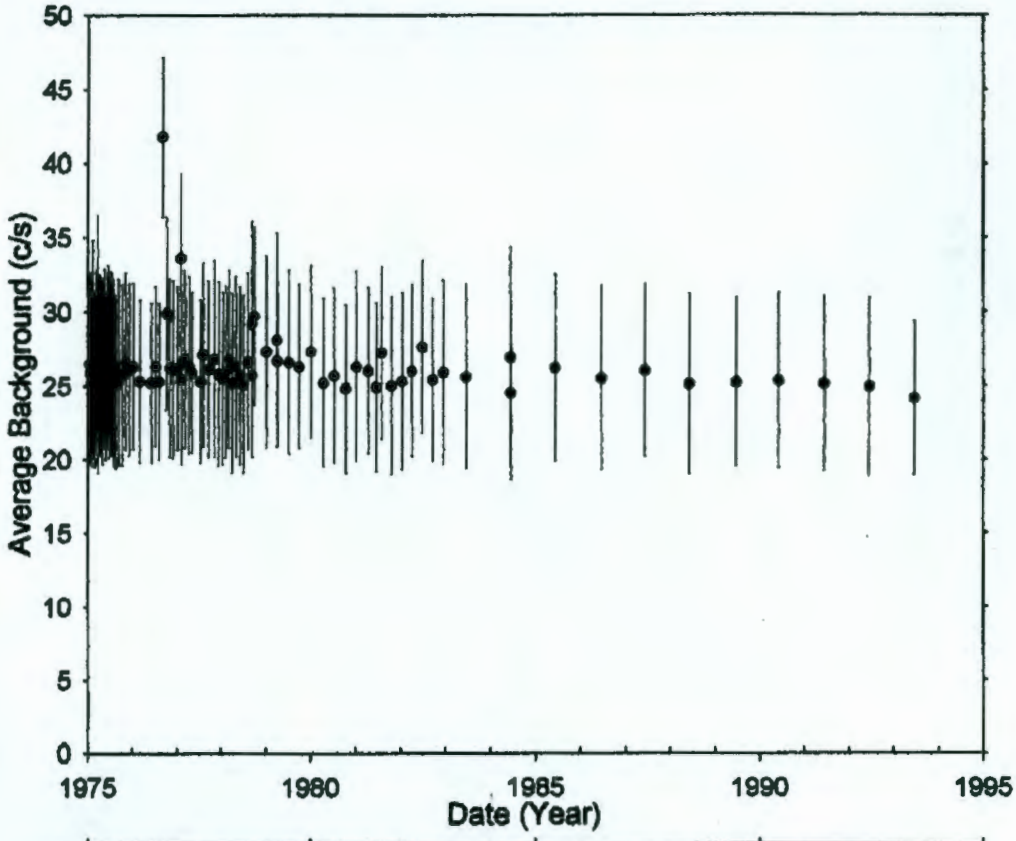
Analysis Notes

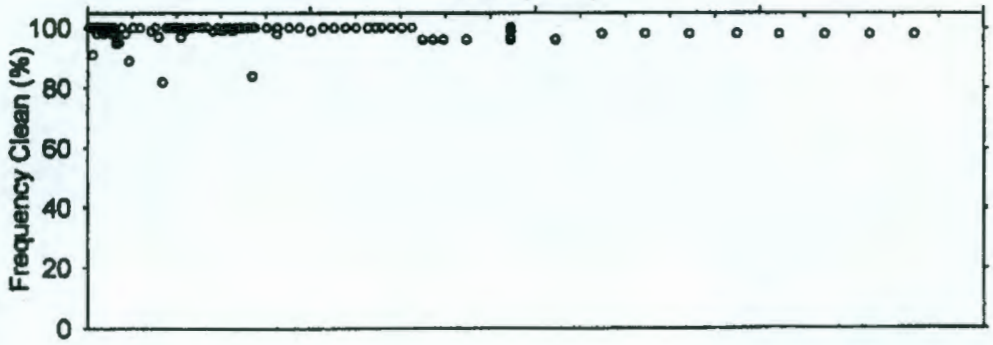
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-00-05

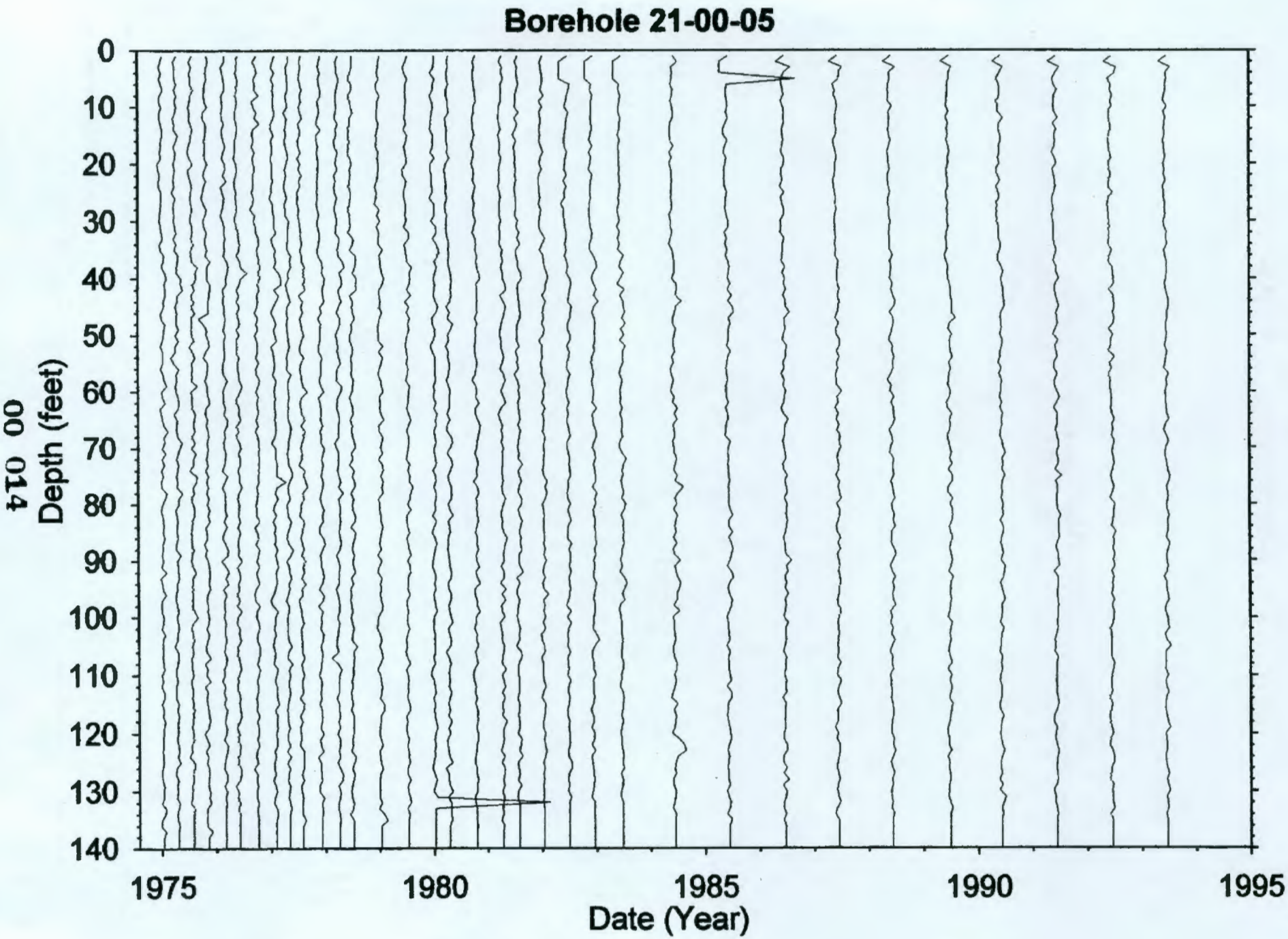


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-00-05
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1975
1980
1985
1990
1995
Date (Year)

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole 21-00-05 (BX)

Total # Surveys 100

neutron surveys 3

Probe Type 04

GR Surveys 97

Log Date: 1-14-75 1st

6-17-93 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): none by gross

Isotope from Spectral Survey: Cs-low Co-1 3pCi/g

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

Clean, tried 0-5 with no show. Natural bkg changes more than contaminated zones.

Analyst Name Brian Kendall

S/W ver TF-GRDS 2.2

Borehole 21-00-07

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 5 to 145 feet.

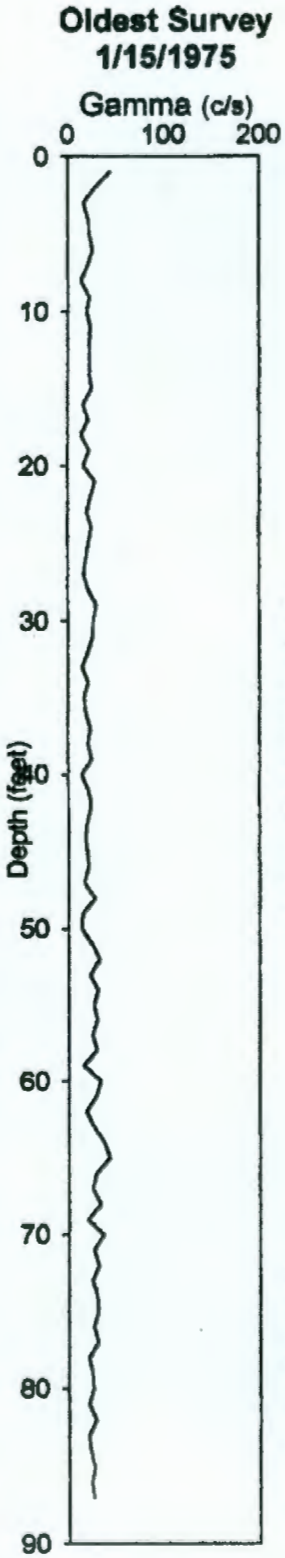
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI, 02: GM; 04: Neutron
Borehole Depth :	90 ft
Survey Depth :	90 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/5/1993
Number Surveys :	358

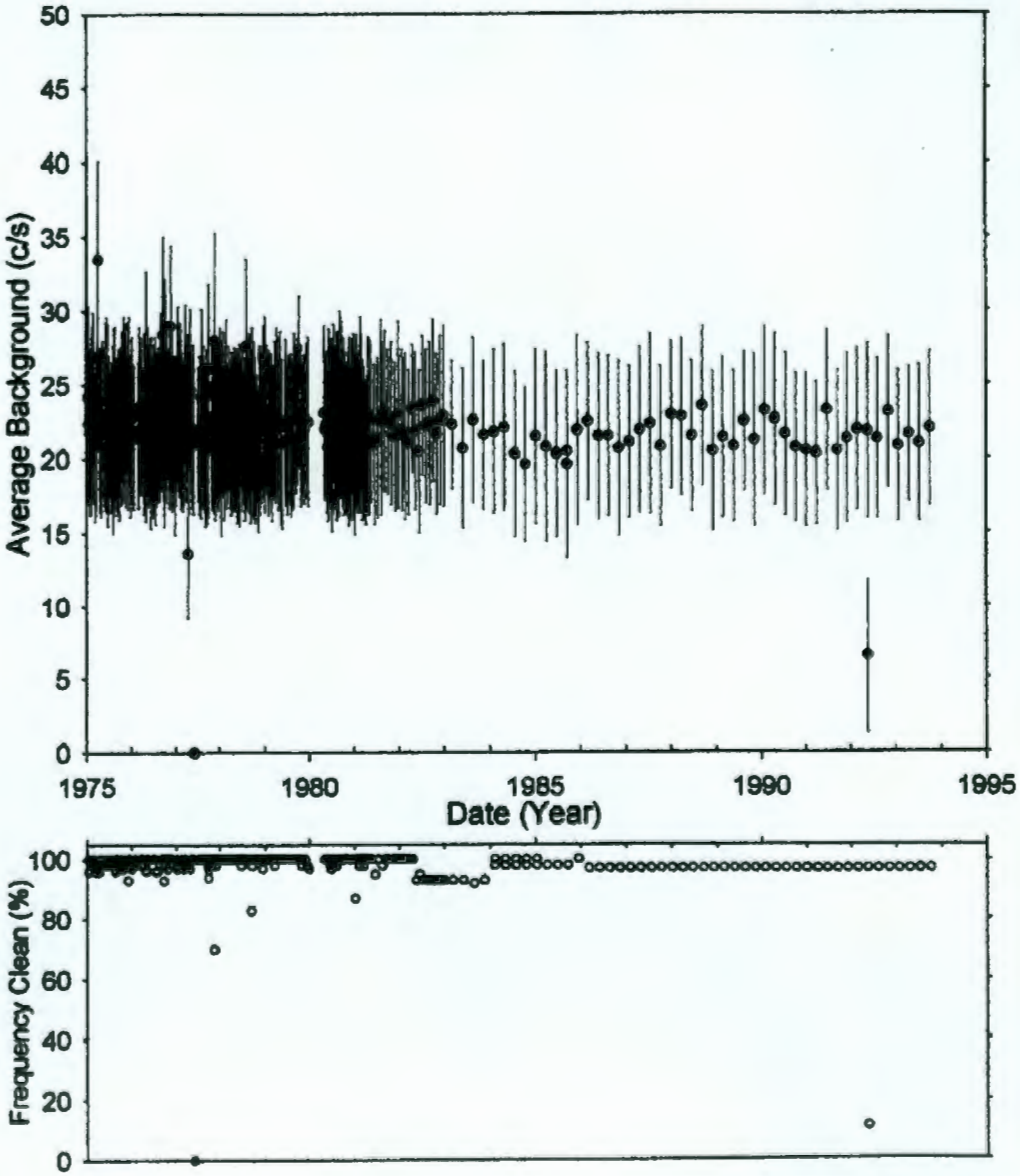
Analysis Notes

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	

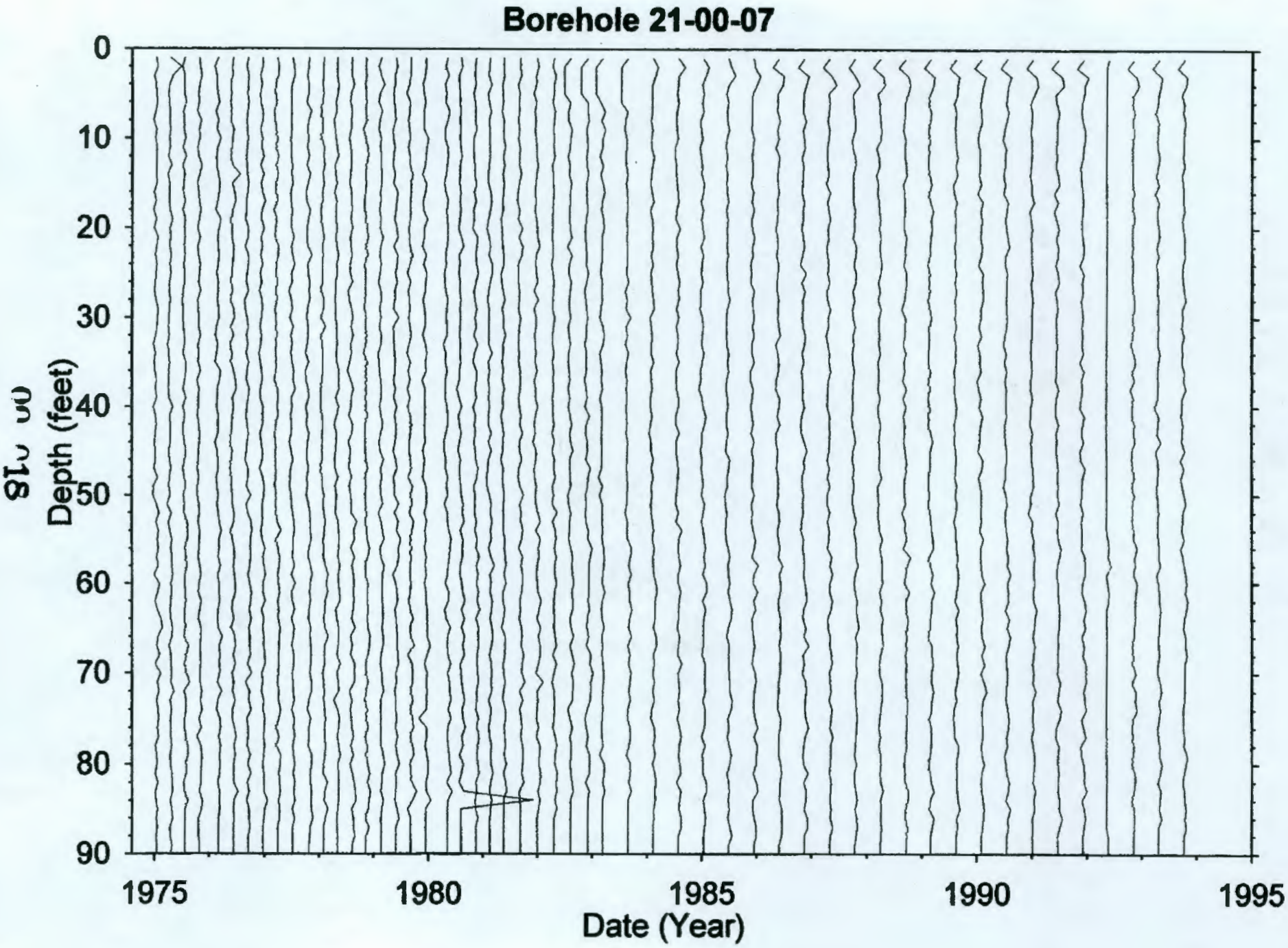
Borehole 21-00-07



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-00-07
0
10
20
30
40
50
60
70
80
90
Depth (feet)
1975
1980
1985
1990
1995
Date (Year)

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

02 14
1 1

Borehole 21-00-07

Total # Surveys 363

Probe Type 04

neutron surveys 3

GR Surveys 358

Log Date: 1-15-75 1st

10-5-93 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): None Idd

Isotope from Spectral Survey: Cs very low

Max Survey Depth 87

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

Very low HPGe levels does not show on graph

Analyst Name R3

S/W ver TFGROSS 2.2

Borehole 21-00-09

Contamination (Ru-106) from 45-60 feet is Undetermined

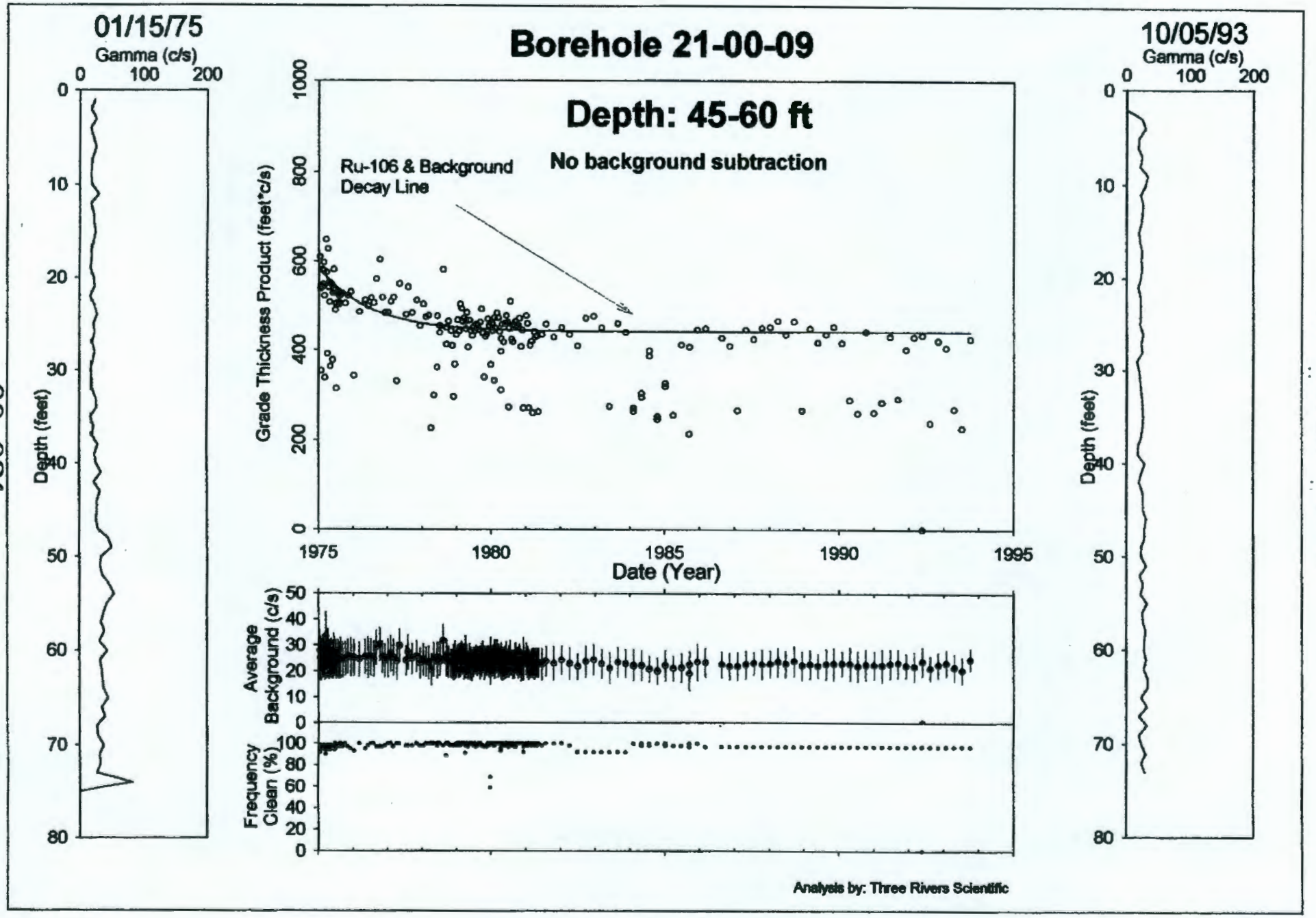
Grade thickness product from 45 to 60 feet was specially processed with no natural background subtraction, due to fitting inconsistencies. There is only a possible show of Ru-106 early provided no background subtraction. Activity levels are near threshold.

Gross Gamma Survey Information

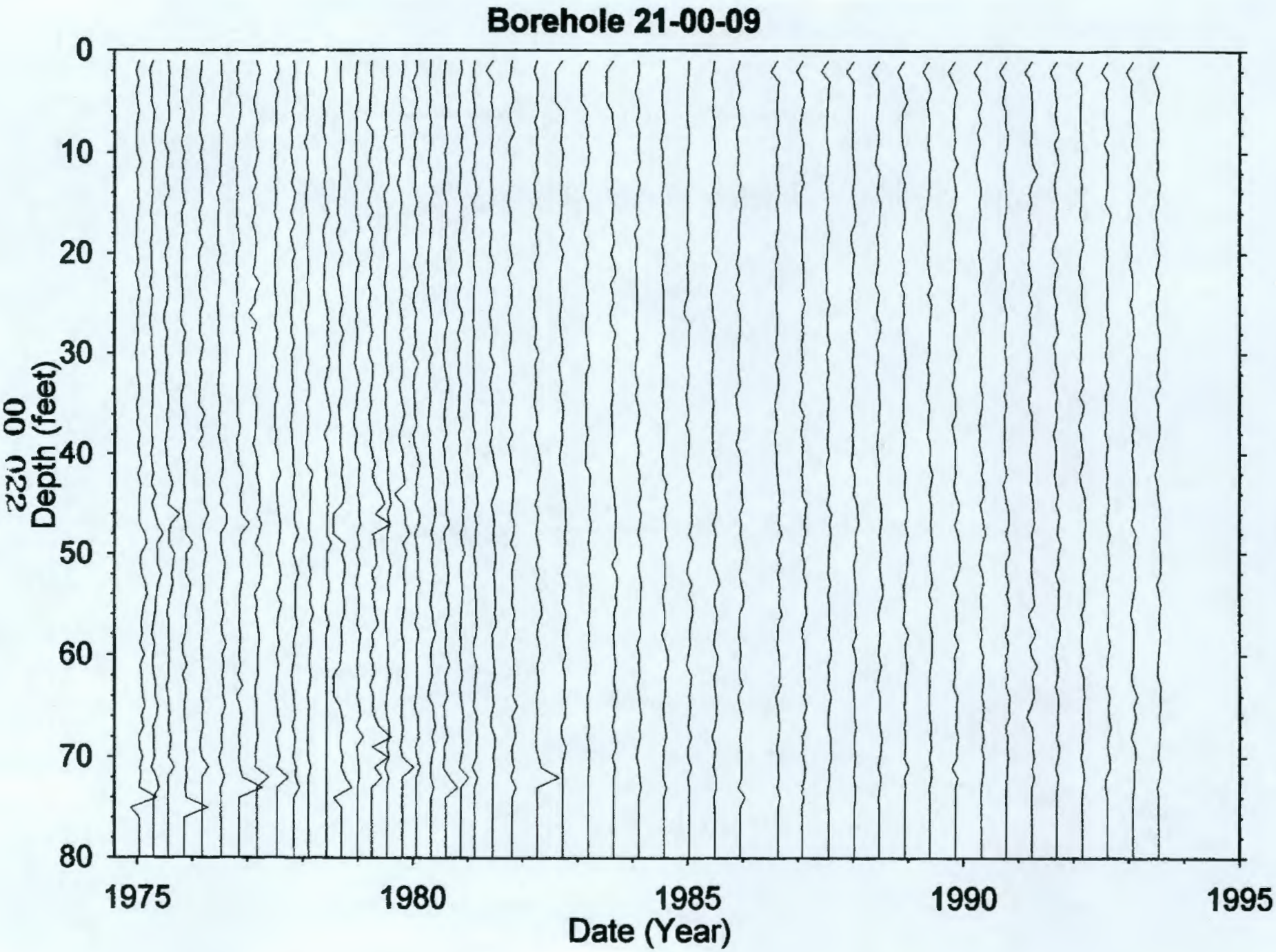
Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	75 ft
Survey Depth :	75 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/5/1993
Number Surveys :	205

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<10	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	45-60 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



HNF-3531 -REV0



HNF-3531 -REV0
00 022

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

BX

Borehole 21-00-09 | Total # Surveys 208 | Probe Type 04

neutron surveys 3 | # GR Surveys 205

Log Date: 1-15-75 1st | ~~7-12-93~~ 10-5-93 Last | Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): Cs + Rn?

Isotope from Spectral Survey: Very low Cs | Max Survey Depth 75

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
	Co from HPGe too low, but stack #				
	low bkg above Rn carry ∴ want to no				
	bkg of Rn → Vadose				
	a 45-60 b		high bkg		→ 0's Rn
	a 45-60 c		"	"	miss 75'
MCA →	a 45-60 d		no bkg		
	a or a 45-60		needed total well bkg		
	left out for uniformity				

Analysis Notes

Very early Rn 106 possible in last part of warm front
Data labels are low & Rn history very short

Given levels on HPGe & was surprised GR area decay
especially at end (93)

Analyst Name RS | S/W ver TFGROSS2.2

00 023

filein := "two.txt"

Well 21-00-09

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 131$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := \frac{368.2}{365.25}$

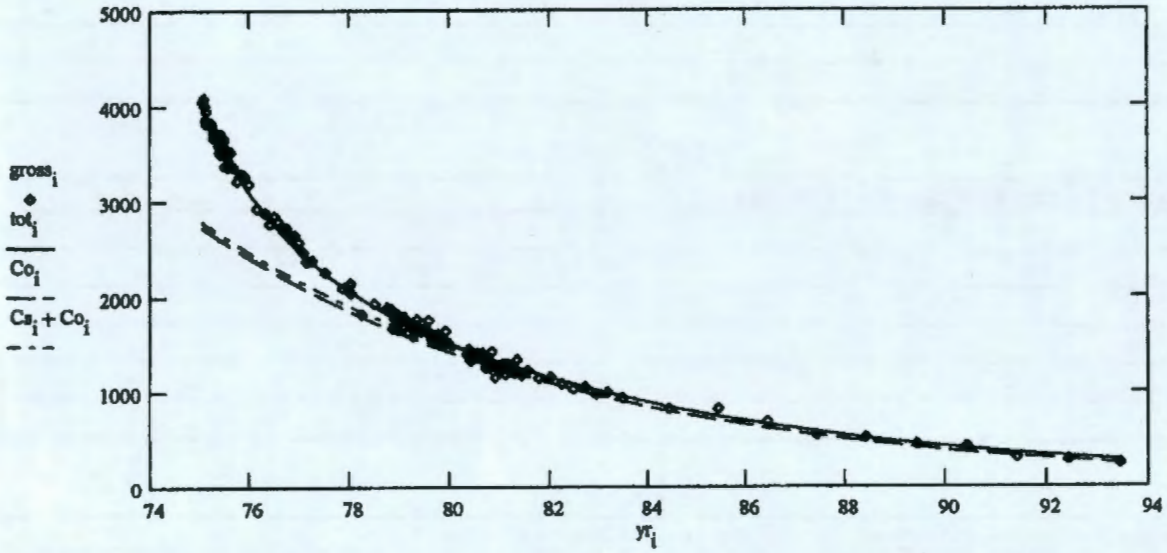
$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 2760$ $\quad acs := 56$

Eu variables are
Ru-106 $\quad aeu := 1270$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Cs_i + Eu_i + C$

$gross_i := net_i$

This data edited for spurious points



$a2 := aco$

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

Given

$ssq(acs, aeu, aco) = 0$ $\quad 1 = 1$ $\quad 2 = 2$

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

$\alpha cs = 48.288$ $\quad \alpha eu = 1.281 \cdot 10^3$ $\quad \alpha co = 2.769 \cdot 10^3$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad \frac{\alpha cs}{\alpha eu} = 0.038$

$tot_i := Cs_i + Eu_i + Co_i$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$ $\quad \frac{Eu_N}{Cs_N} = 1.244 \cdot 10^{-4}$

filein := "twor3.txt"

Well 21-00-09

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := \mathrm{last}(yr)$ $\quad N = 160$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := \frac{368.2}{365.25}$

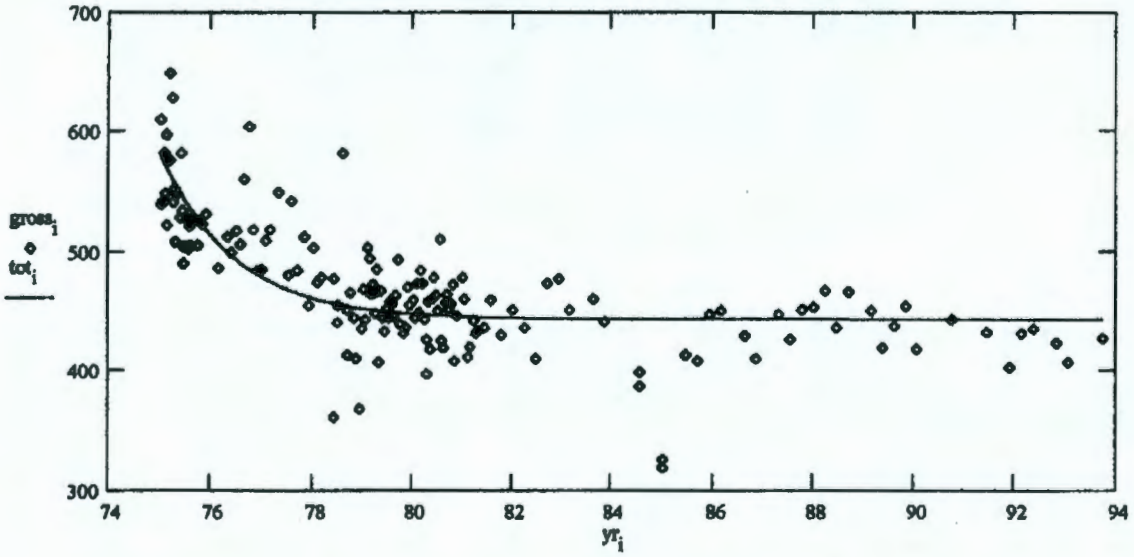
$\tau co := 5.27$ $\quad \tau cs := 10^9$ $\quad aco := 00$ $\quad acs := 443$

Eu variables are Ru-106 $\quad aeu := 142$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aeu) = 0$ $\quad 1 = 1$

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

$\alpha cs = 443.157$ $\quad \alpha eu = 142.533$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Cs_i + Eu_i$

$\frac{\alpha cs}{\alpha eu} = 3.109$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

$\frac{Eu_0}{Cs_0} = 0.313$

Borehole 21-00-11

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 140 feet.

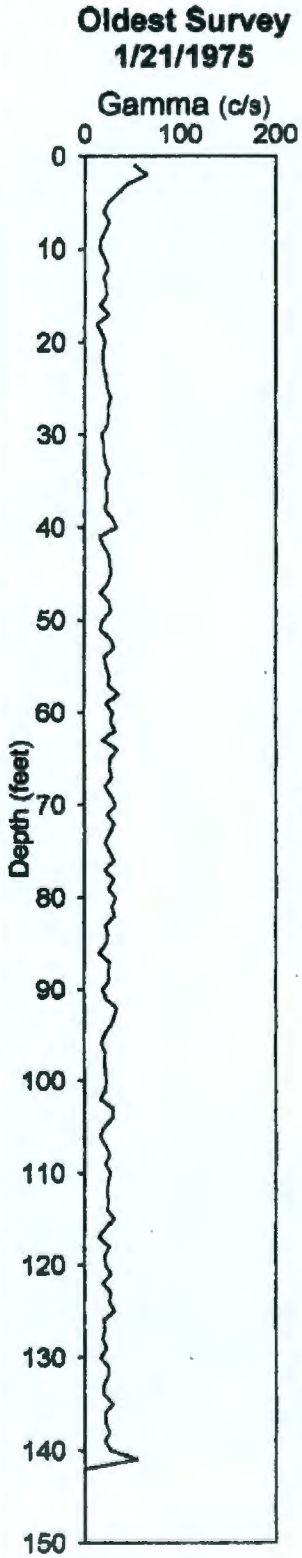
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	140 ft
Survey Depth :	140 ft
First Survey Date :	1/21/1975
Last Survey Date :	10/5/1993
Number Surveys :	189

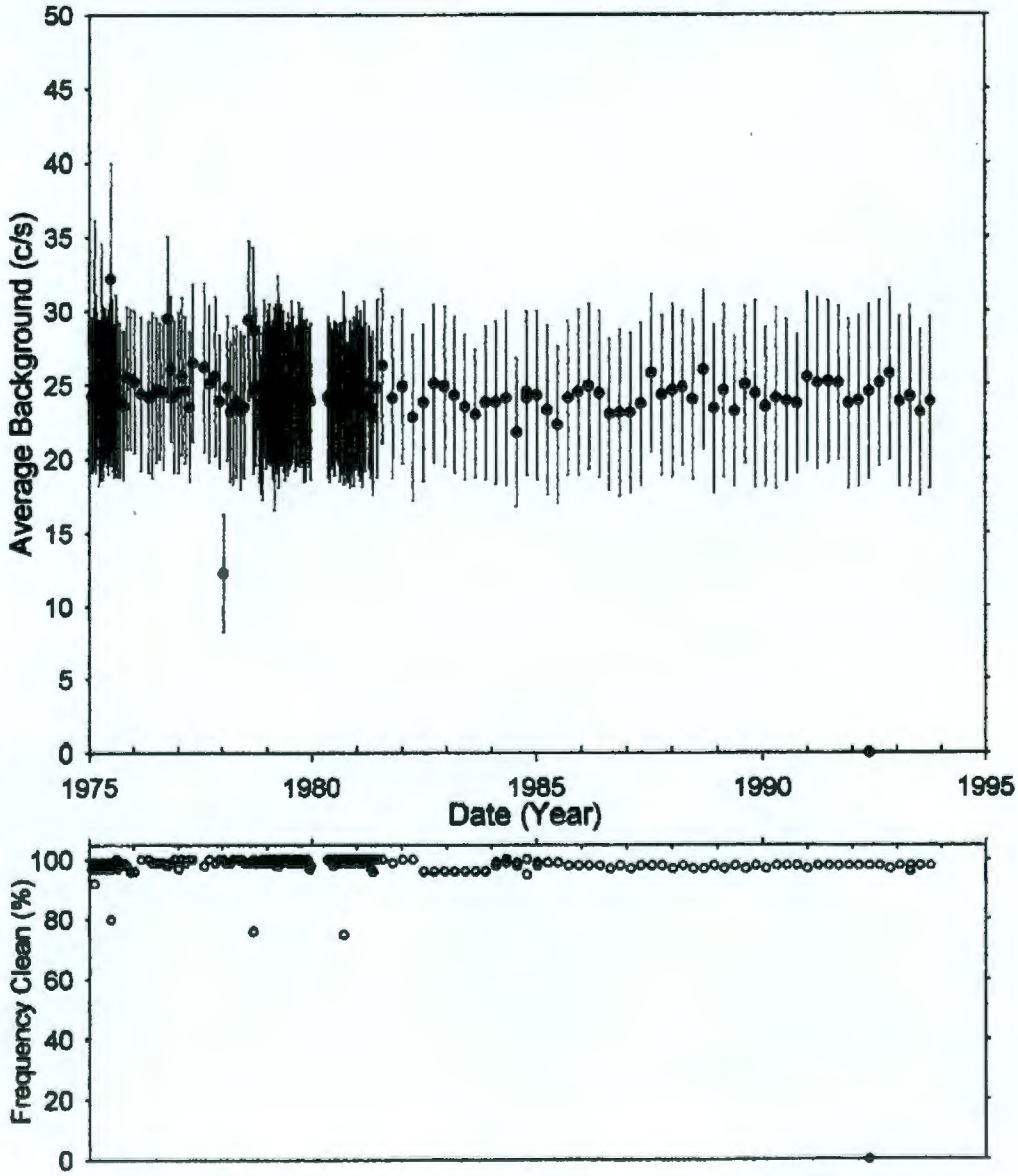
Analysis Notes

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	

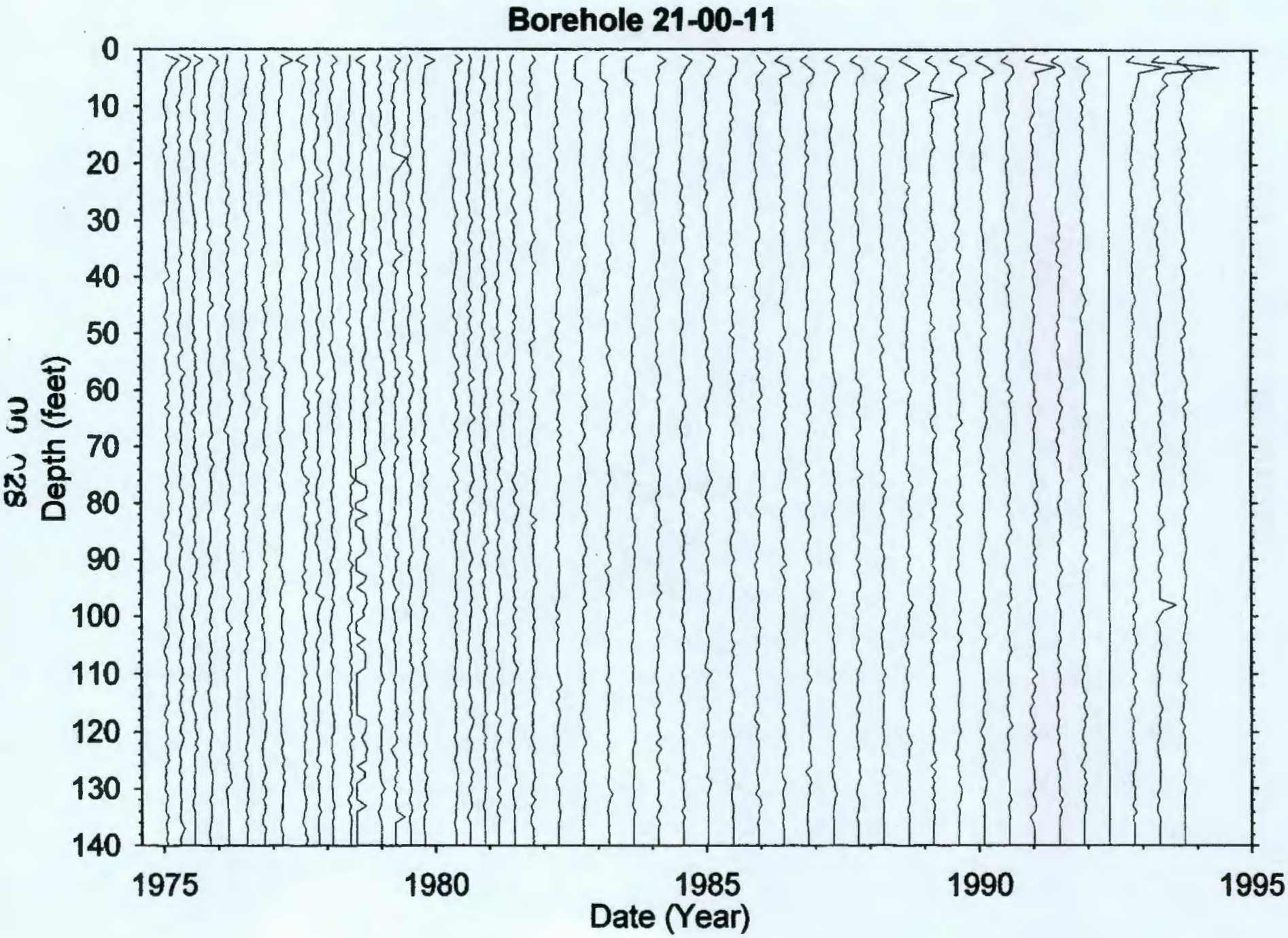
Borehole 21-00-11



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific



HNF-3531 -REV0

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

BX

Borehole 21-00-11 | Total # Surveys 192 | Probe Type 04

neutron surveys 3 | # GR Surveys 189

Log Date: 1-21-75 1st | 10-5-93 Last | Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): none (name?)

Isotope from Spectral Survey: Co low ~~marginal~~ non-uniform Max Survey Depth ~~135~~ 13

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

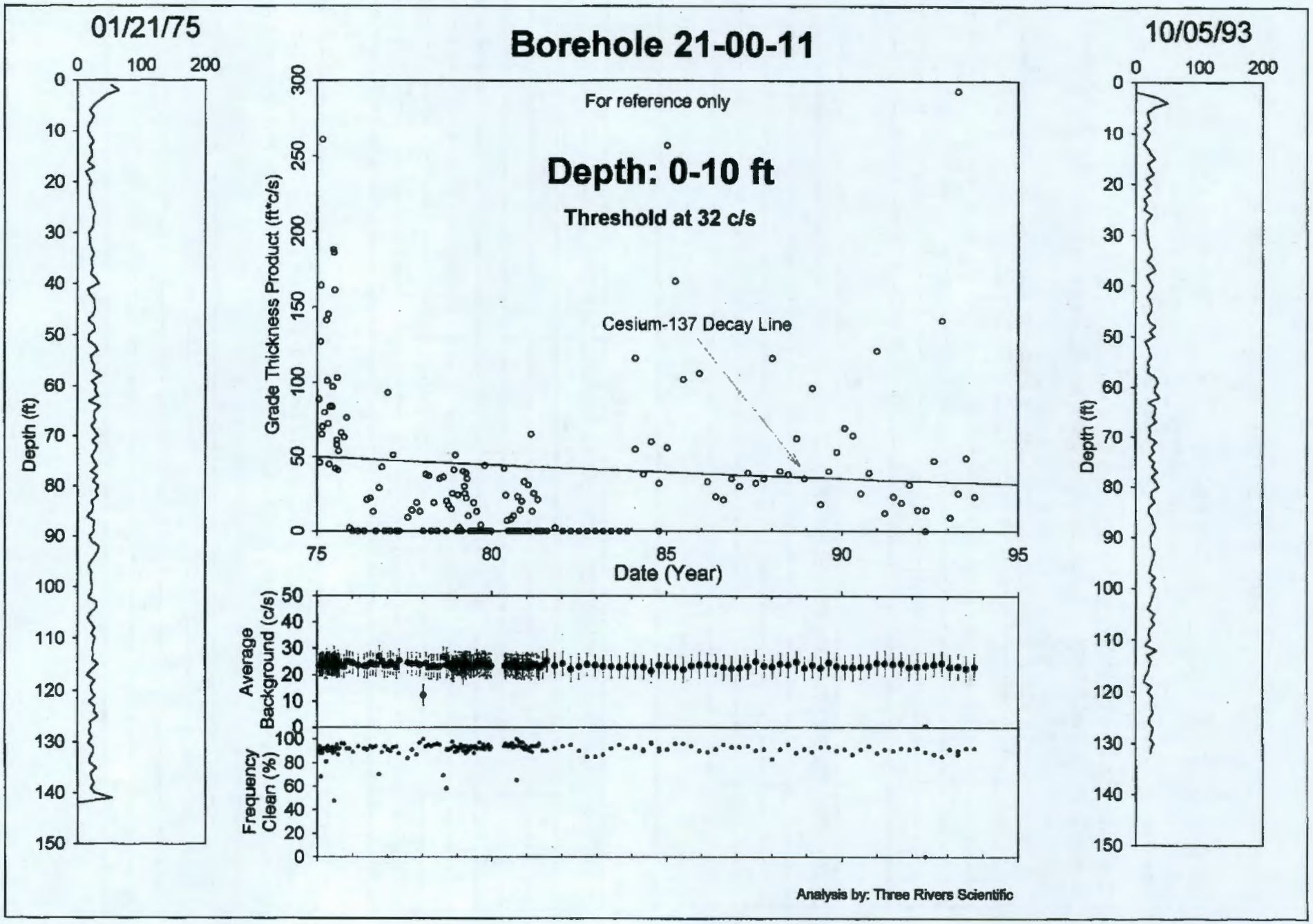
BackGnd.Txt

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

Analysis Notes

Near surface, but has consistency problem: left paper field plot, but not electronic.

Analyst Name R³ S/W ver TFGR0522



HNF-3531 -REV0

Borehole 21-00-21

Contamination (Co-60, Cs-137 & Ru-106) from 45-80 feet appears Stable

Grade thickness product from 45 to 80 feet is decreasing consistent with a least squares fit for Co-60 (HPGe identified), Cs-137 (HPGe identified and Ru-106 (hypothesis) from 1975 to 1993.
The least squares fit results in gross gamma contribution ratios of Ru-106:Cs-137:Co-60 of 1281:48.3:2769 as of Jan 1975. Special note, a fit can be obtained for Ru & Co just as well since this low level of Cs is not a significant factor in the total gross gamma observed. Likewise the confidence for the stability of Cs is extremely low.

Gross Gamma Survey Information

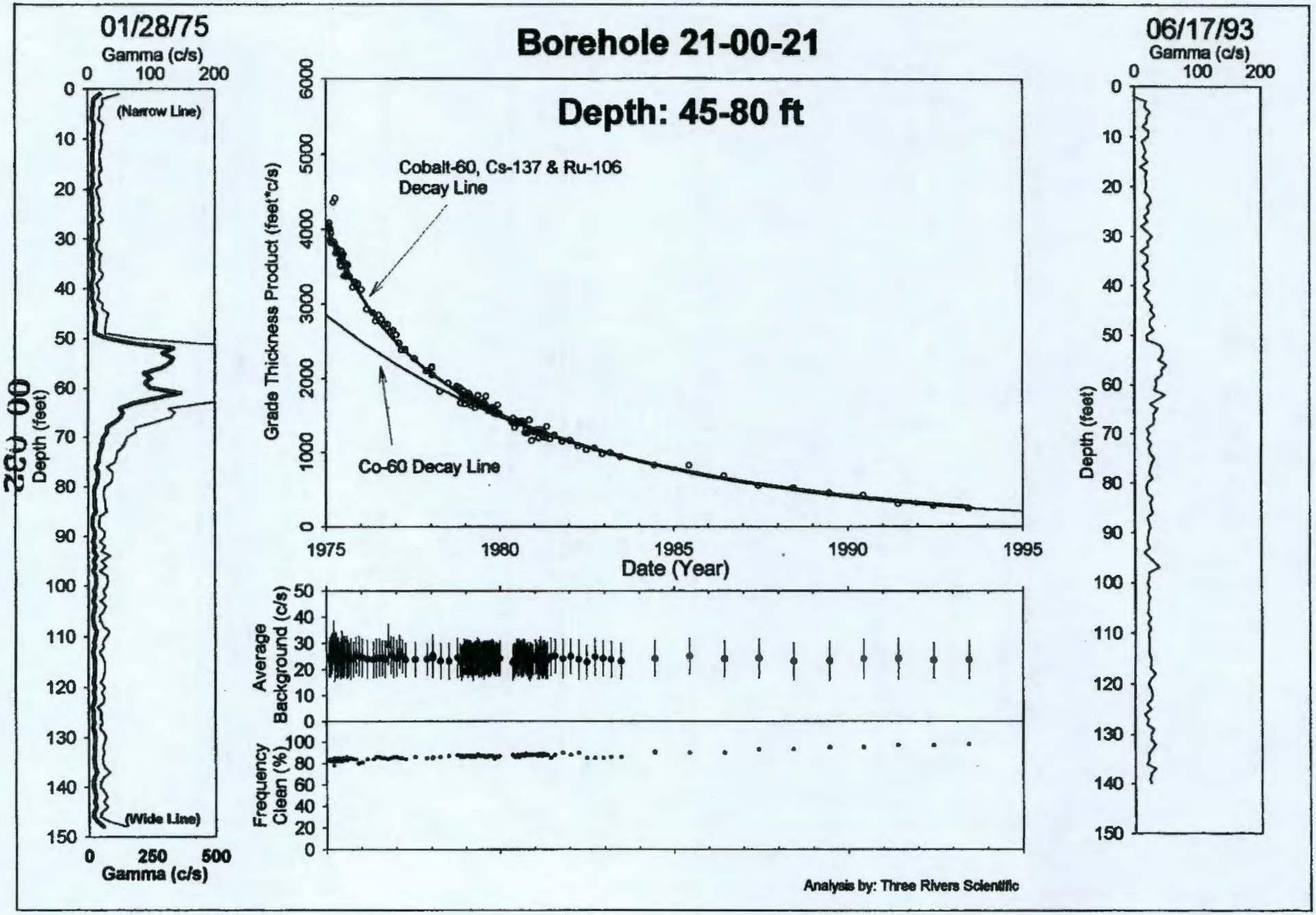
Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	145 ft
Survey Depth :	145 ft
First Survey Date :	1/28/1975
Last Survey Date :	6/17/1993
Number Surveys :	134

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 :	45-80 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

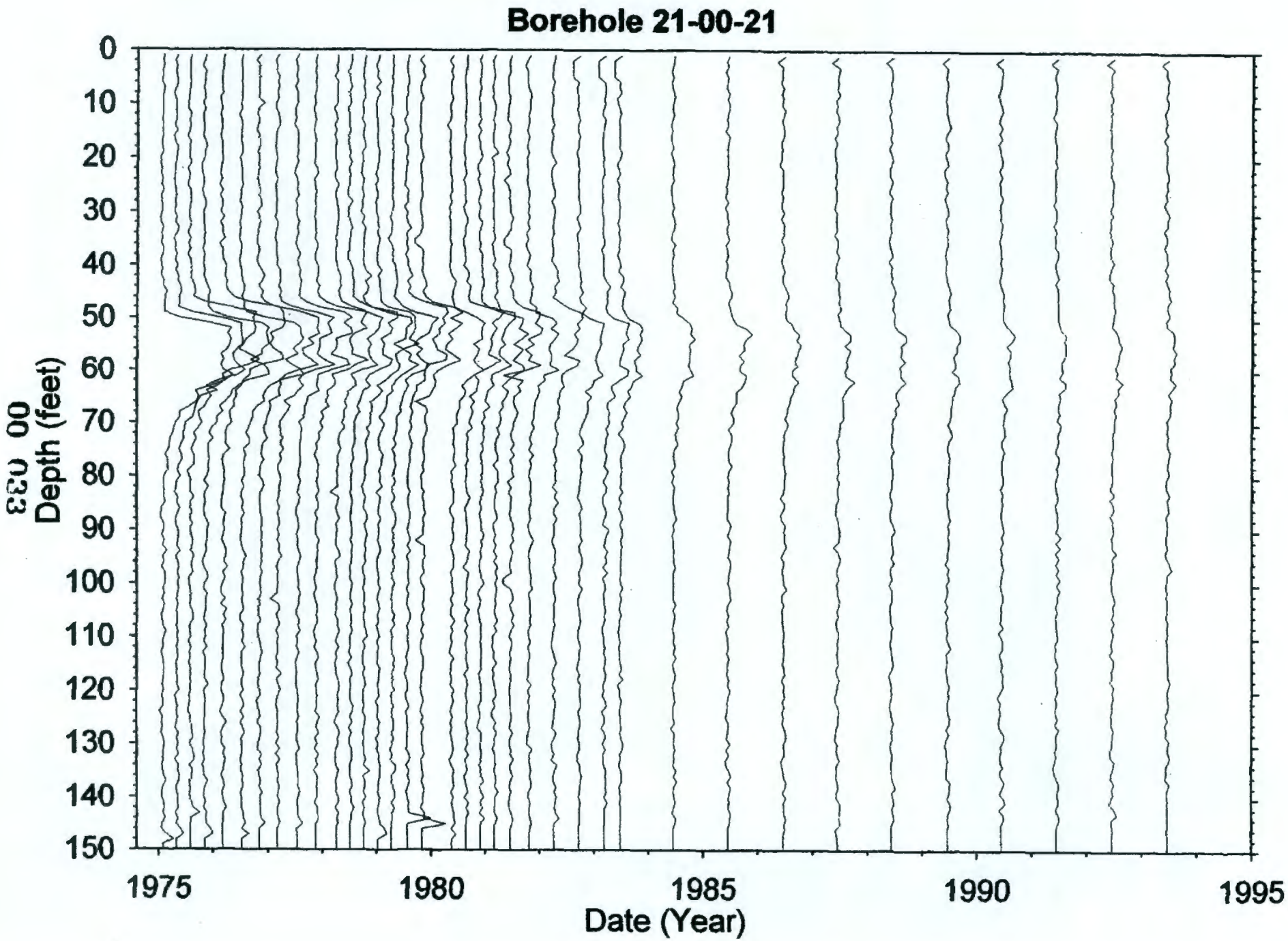
Borehole 21-00-21

Depth: 45-80 ft



HNF-3531 -REV0

00 032



HNF-3531 -REV0

00 033

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole 21-00-21 (Px)

Total # Surveys 137

neutron surveys 3

Probe Type 04

GR Surveys 134

Log Date: 1-28-75 1st

6-17-93 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): Rn + Co (least squares)

Isotope from Spectral Survey: Co & Cs (40-50 & 85-90) ↳ 50-75

Max Survey Depth 145

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

Cannot depth separate ∴ 1 zone least squares Rn+Co

Analyst Name R³

S/W ver TF6RPF22

Borehole 21-00-22

Contamination (Ru-106) from 10-26 feet appears Stable
Contamination (Co-60) from 26-40 feet is Undetermined

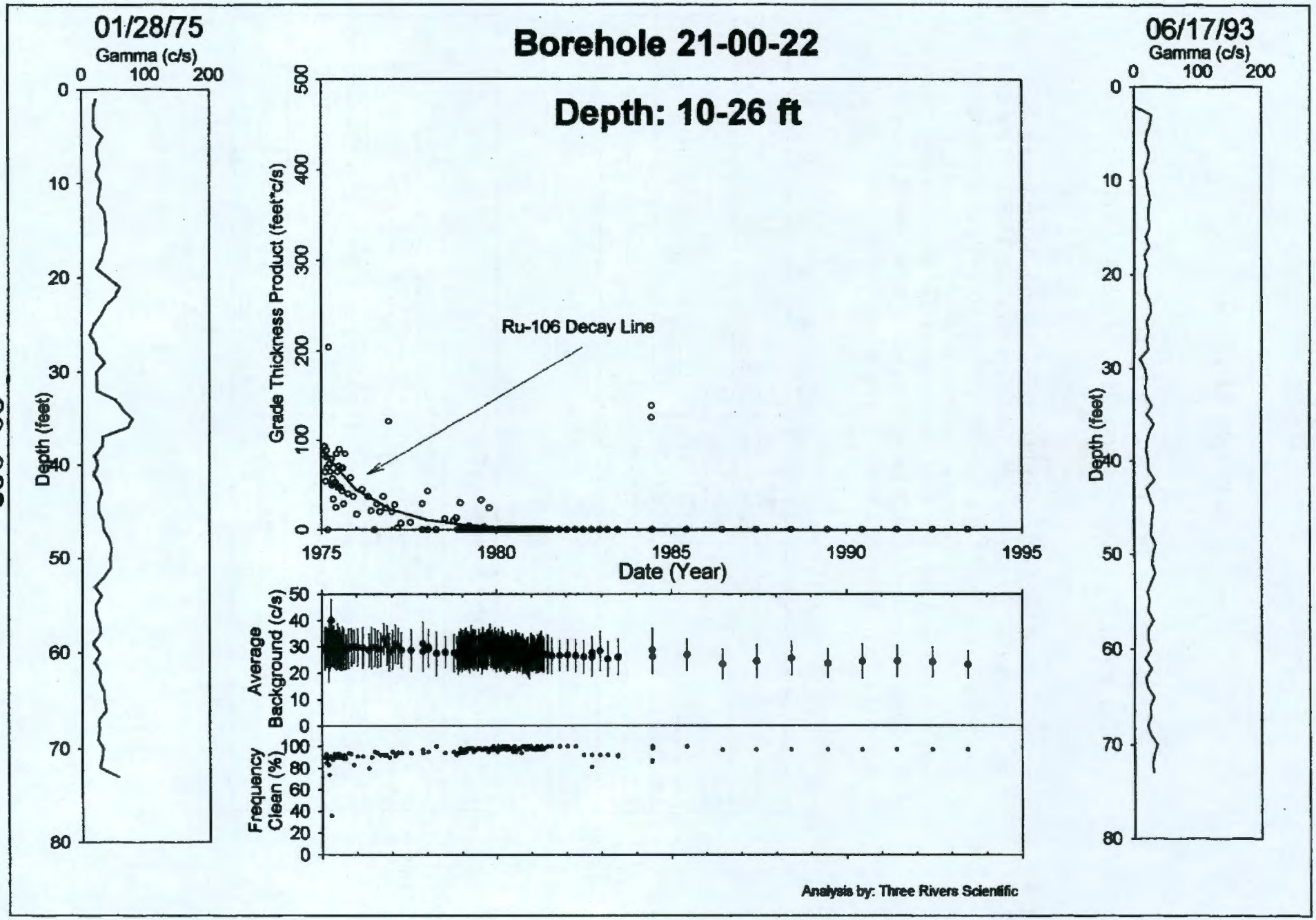
Grade thickness product from 10 to 26 feet is decreasing consistent with Ru-106 (hypothesis). The level of Ru-106 is near threshold. The Cs-137 and Co-60 istotopes identified by the HPGe detector are at sufficiently low levels to not register with the gross gamma log data.
Grade thickness product from 26 to 40 feet is undetermined due to low levels. The Co-60 concentrations identified with the HPGe are higher in this interval, but statistical precision is lacking for a rigorous conclusion.

Gross Gamma Survey Information

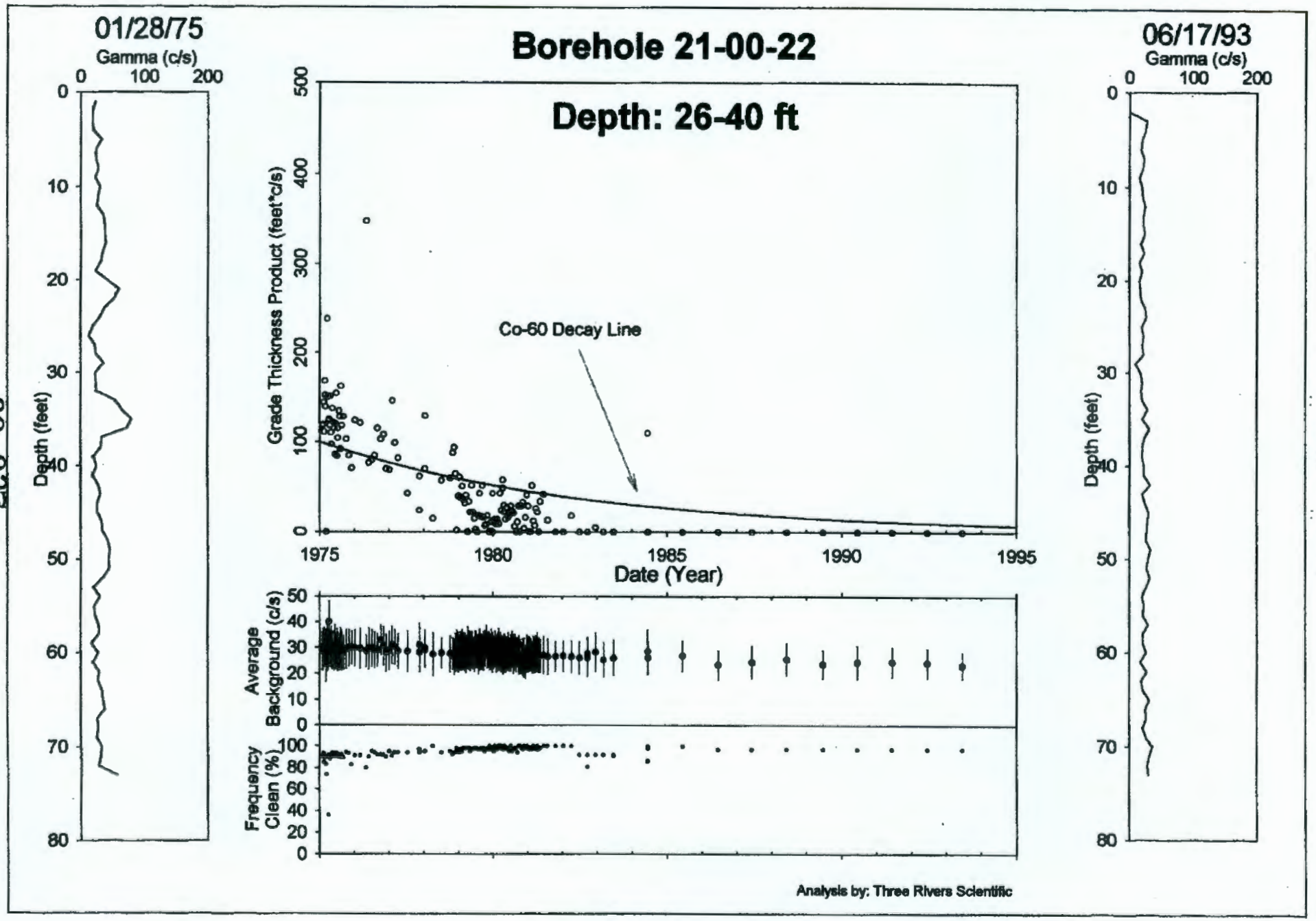
Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	75 ft
Survey Depth :	75 ft
First Survey Date :	1/28/1975
Last Survey Date :	6/17/1993
Number Surveys :	154

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<32	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	10-26 Appears Stable, 26-40 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

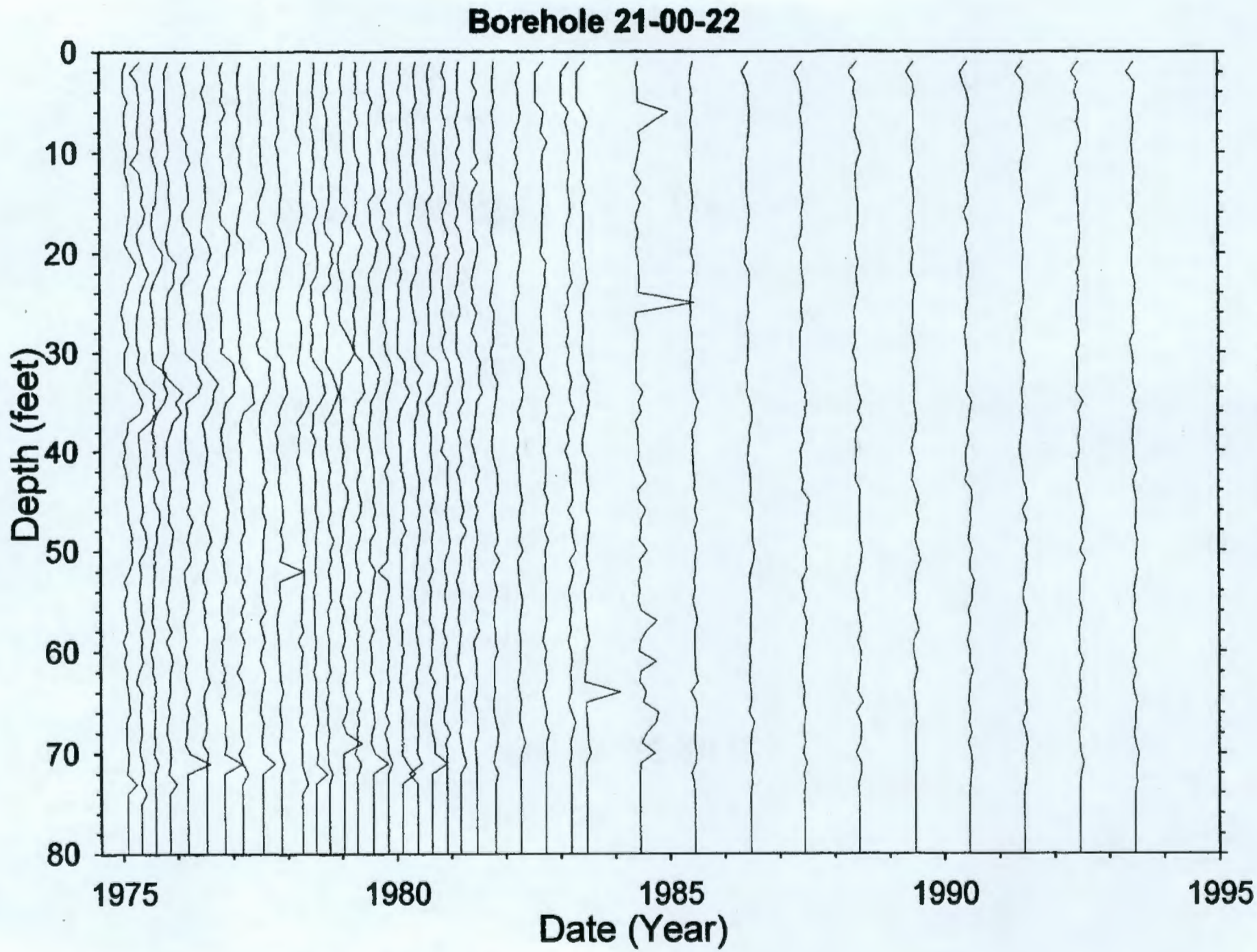


HNF-3531 -REV0



HNF-3531 -REV0

00 037



HNF-3531 -REV 0

BX

Dry Well Survey Analysis - Notes

Borehole 21-00-22 Total # Surveys 157 Probe Type 04

neutron surveys 3 # GR Surveys 154

Log Date: 1-28-75 1st 6-17-93 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 10-26 25-40 Ru

Isotope from Spectral Survey: Co & Cs Dam levels Max Survey Depth 75

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

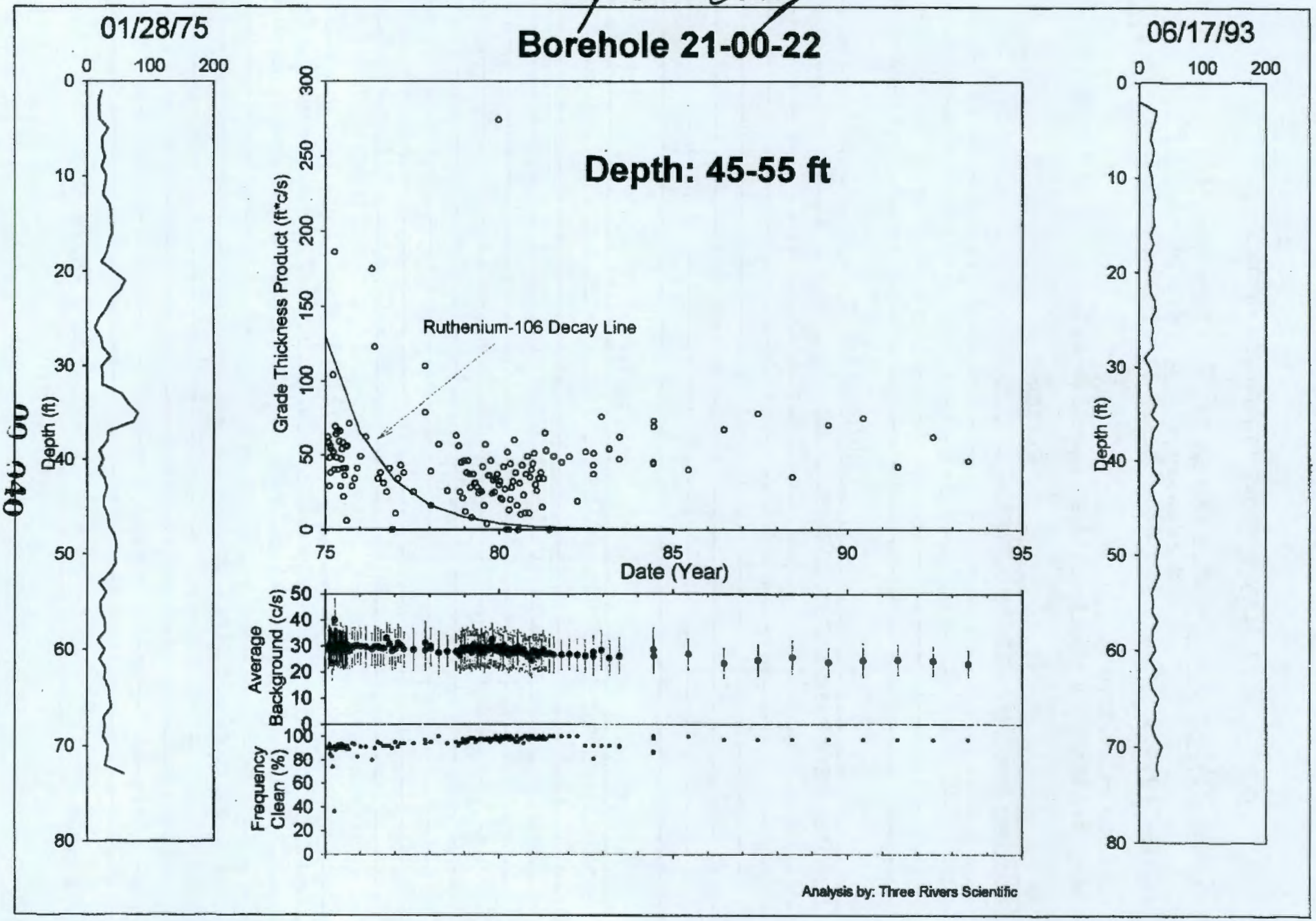
Analysis Notes

26-40 & 10-26 from stack Dao 215-55 → may be material ∴ 0 = Ru
32 c/s threshold does not help 26-40 discrepance these fits not saved
30-40 is Co + Cs

Analyst Name R3 S/W ver TFGRPH 2.2

Reference Only

Borehole 21-00-22



HNF-3531 -REV0

00 040

Borehole 21-01-01

Contamination (Cs-137) from 0-6 feet is Undetermined
Contamination (Cs-137) from 6-13 feet is Undetermined
Contamination (Cs-137) from 13-23 feet is Stable, late
Contamination (Eu-154, Co-60, & Ru-106) from 23-37 feet is Stable
Contamination (Eu-154, Co-60, & Ru-106) from 37-49 feet is Stable
Contamination (Sb-125) from 49-53 feet is Undetermined*
Contamination (Sb-125 & Co-60) from 53-60 feet is **UNSTABLE** early
Contamination (Sb-125) from 70-79 feet is Stable
Contamination (Sb-125 & Ru-106) from 79-86 feet is Stable
Contamination (Sb-125) from 86-90 feet is Stable

*Believed UNSTABLE, but conservative classification

These data for this well over the history is complex. Several items need explanation. Depth shifting is necessary in order to analyze the historical data, and one or two zones exhibit downward movement after depth shifting. The other zones display very consistent depth control after the depth shift, indicating accurate depth shifting. Two low level zones near the surface are labeled undetermined due to possible surface effects, (i.e. 0-6 and 6-13 feet). Cs is identified by the HPGe for the classification of stable late for the zone 13-23 feet.

The two zones over 23-37 and 37-49 feet were identified by the HPGe to contain various combinations of Cs-137, Co-60, Sb-125, & Eu-154; however, Ru-106 is necessary in order to achieve a reasonable least squares fit to the historical trends. The interval from 23-37 feet shows consistent decay with a least squares fit for Co-60 (identified by HPGe), Eu-154 (identified by HPGe), and Ru-106 (hypothesis), with relative gross contributions of 32,210:79,250:194,900 ft*c/s for Co:Eu:Ru as of 1/14/75. Note that Sb-125 and Cs-137 were identified by the HPGe in this interval, but does not affect the least squares fit results. The interval from 37-49 feet shows consistent decay with a least squares fit for Co-60 (identified by HPGe), Eu-154 (identified by HPGe), and Ru-106 (hypothesis), with relative gross contributions of 39,140:1,723:97,060 ft*c/s for Co:Eu:Ru as of 1/14/75. Note that very low levels of Sb-125 were identified by HPGe in this interval, but does not affect the quoted least squares fit. The interval from 53-60 feet shows consistent decay with a least squares fit for Co-60 (identified by HPGe) and Sb-125 (hypothesis) from mid 1980 to 1994, with relative gross contributions of 1,014:5,542 ft*c/s for Co:Sb as of 1/14/75. The interval from 79-86 feet shows consistent decay with a least squares fit for Sb-125 and Ru-106, (both hypothesized), with relative gross contributions of 898:70 ft*c/s for Sb:Ru as of 1/14/75.

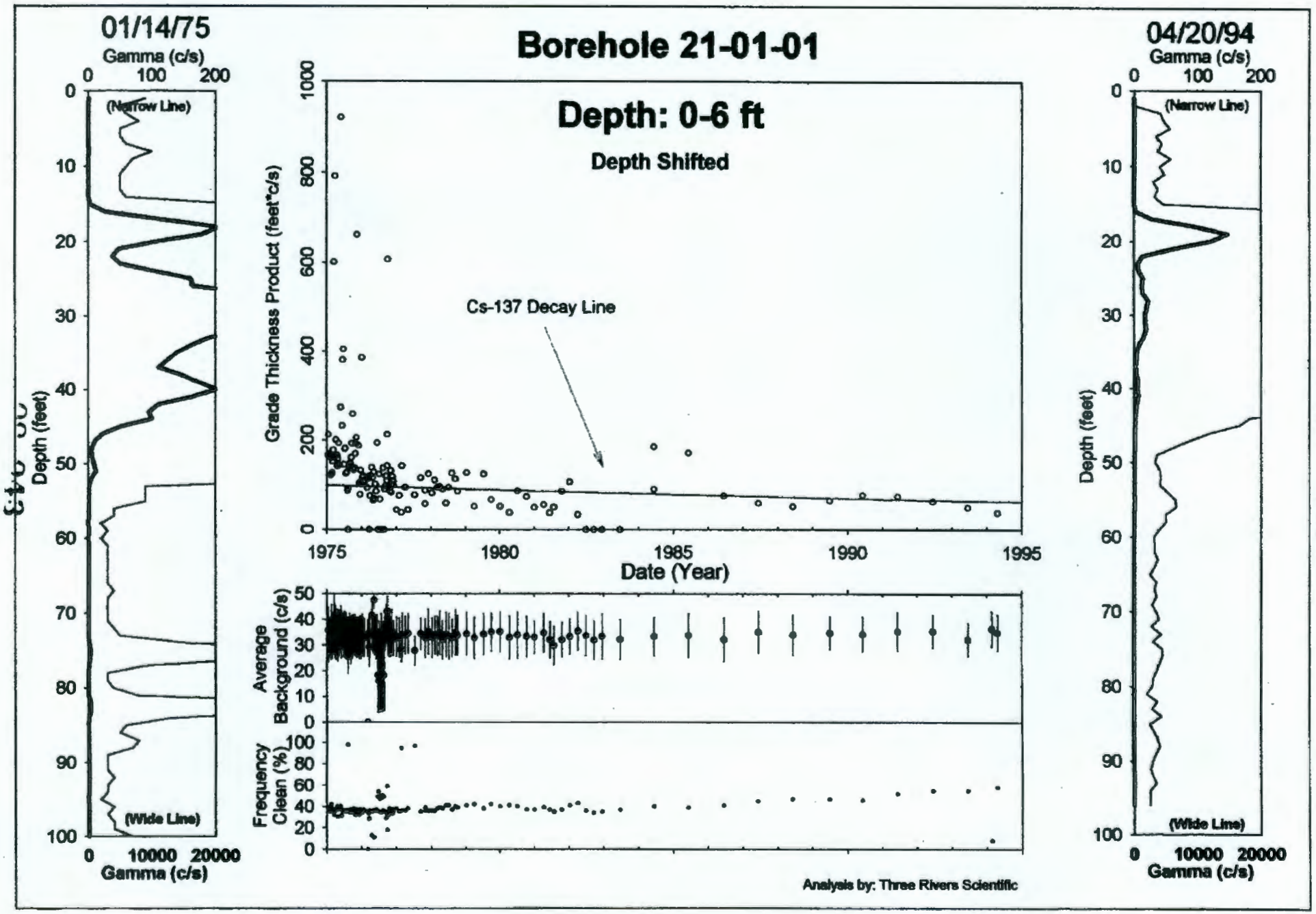
The zone from 49-53 feet is believed unstable, but conservatively classified as undetermined due to low levels and possible nearby zone influences. The zone from 53 to 60 feet is unstable early, refer to expanded stack plot. This interval has only Co-60 identified from the HPGe data, and the historical trend definitely requires Sb-125 and Co-60 decay; furthermore, the depth shifting is judged to be precise based upon the results for the two zones centered at 76 and 83 feet (refer to expanded stack plot). The zone at 70-79 feet follows Sb-125 (hypothesis) decay to low enough levels to not be detectable with the HPGe system. The low level contaminated zone from 86-90 feet is consistent with Sb-125 (hypothesis) decay at levels below detection threshold for the HPGe system.

Gross Gamma Survey Information

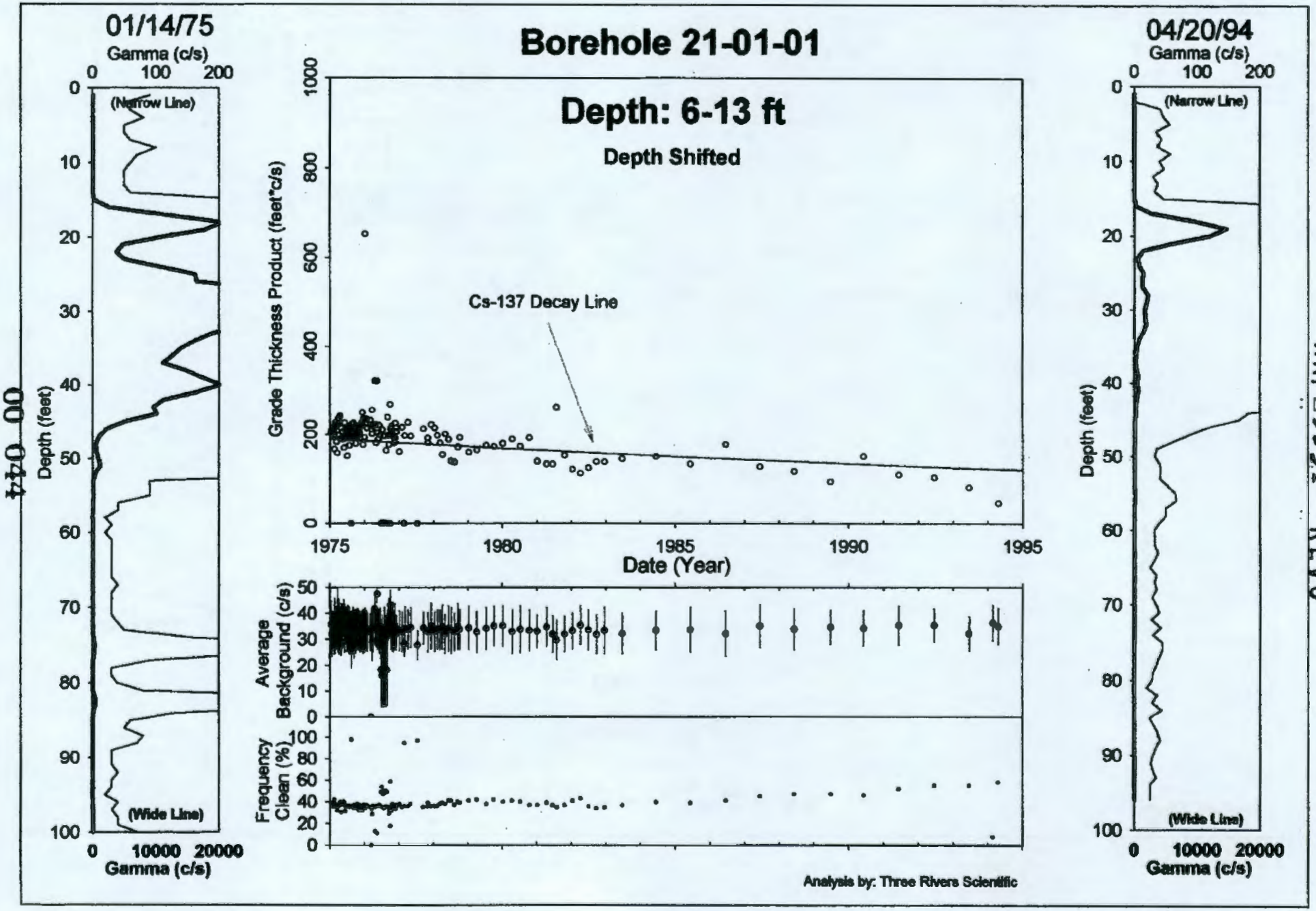
Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI 03:Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	4/20/1994
Number Surveys :	238

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 & 6-13 Undetermined 13-23 Stable late 23-37 & 37-49 Stable 49-53 Undetermined 53-60 **UNSTABLE** 70-79 & 79-86 & 86-90 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

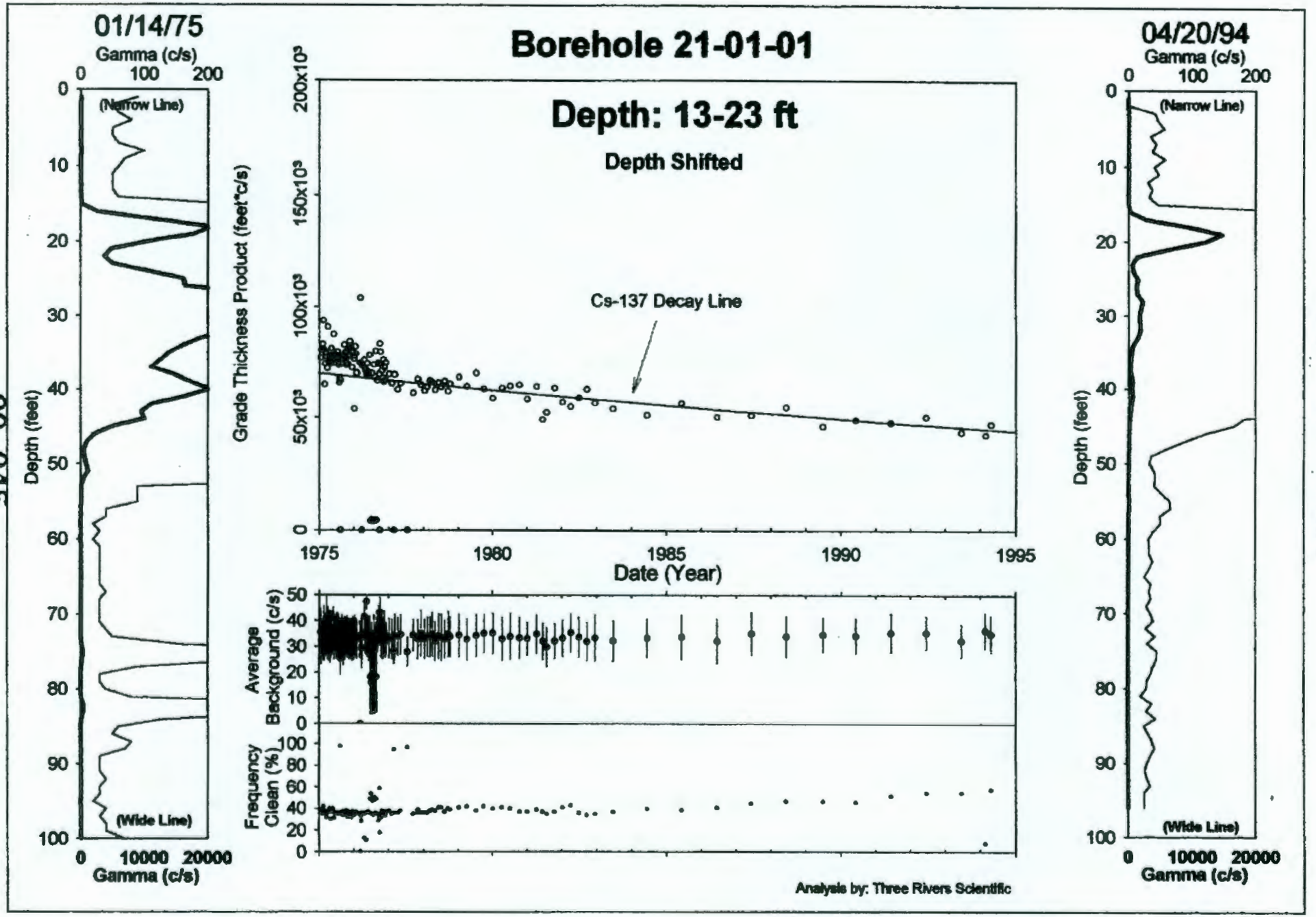


HNF-3531 -REV0



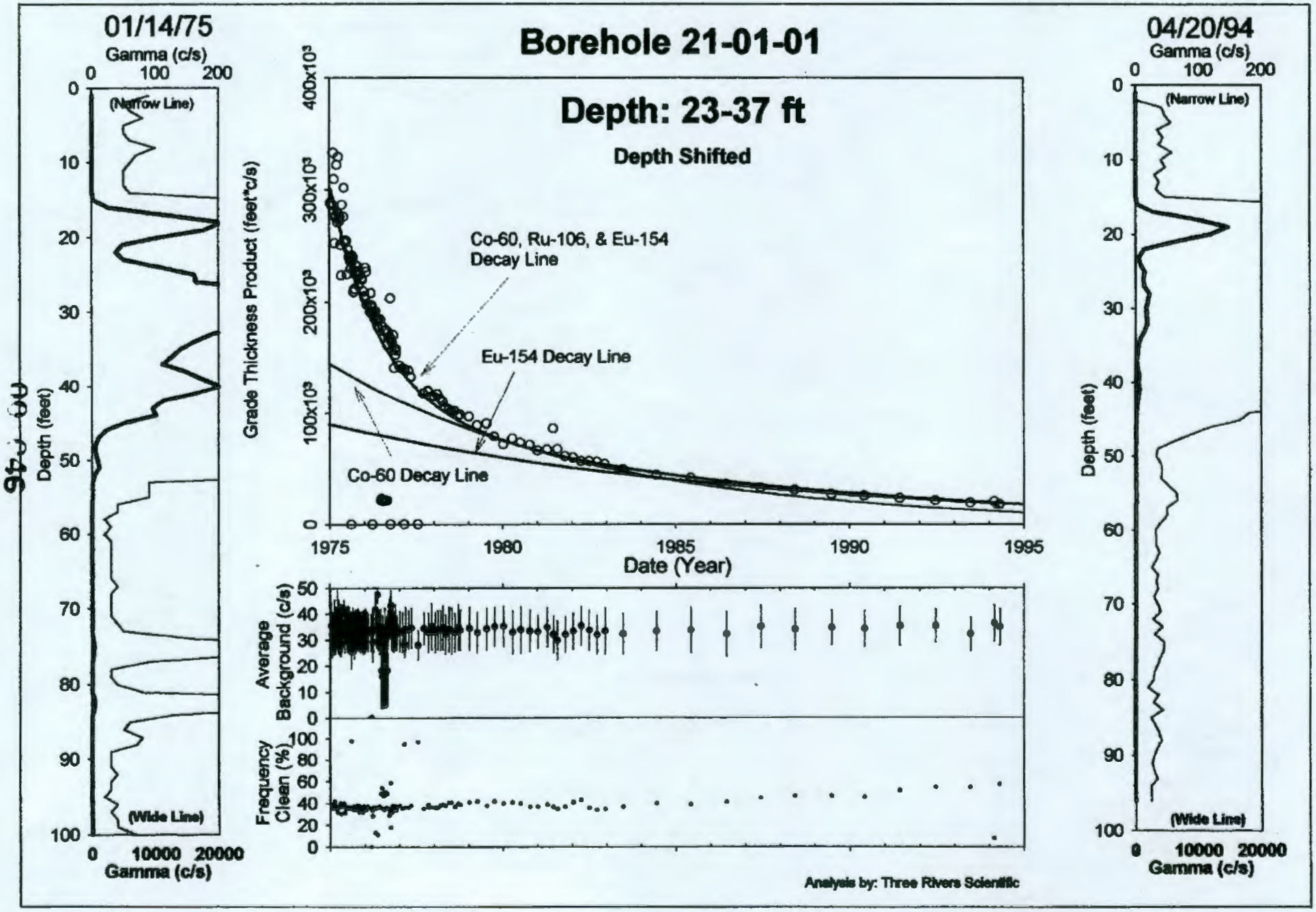
HNF-3531 -REV0

00 044



HNF-3531 -REV0

00 045



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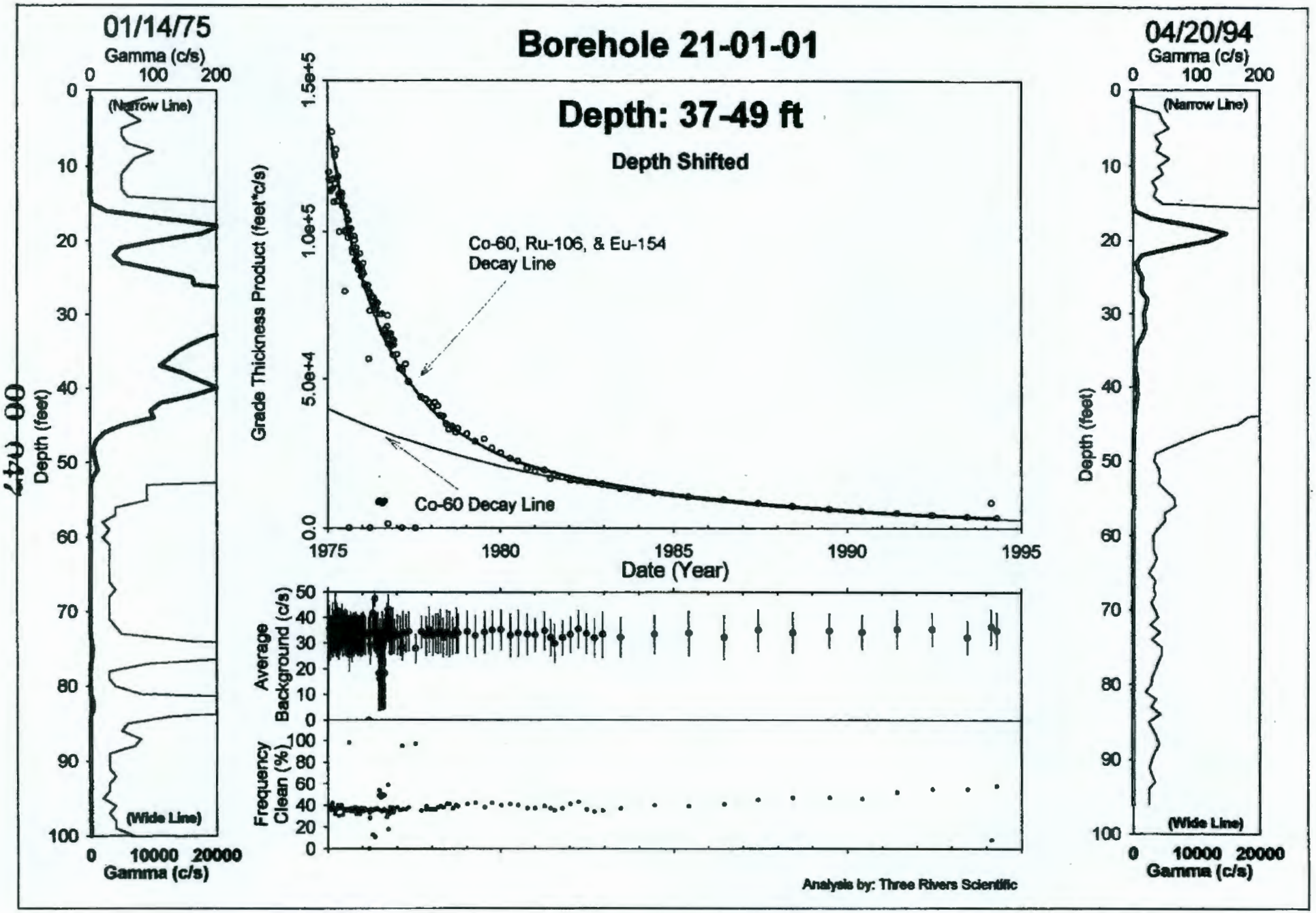

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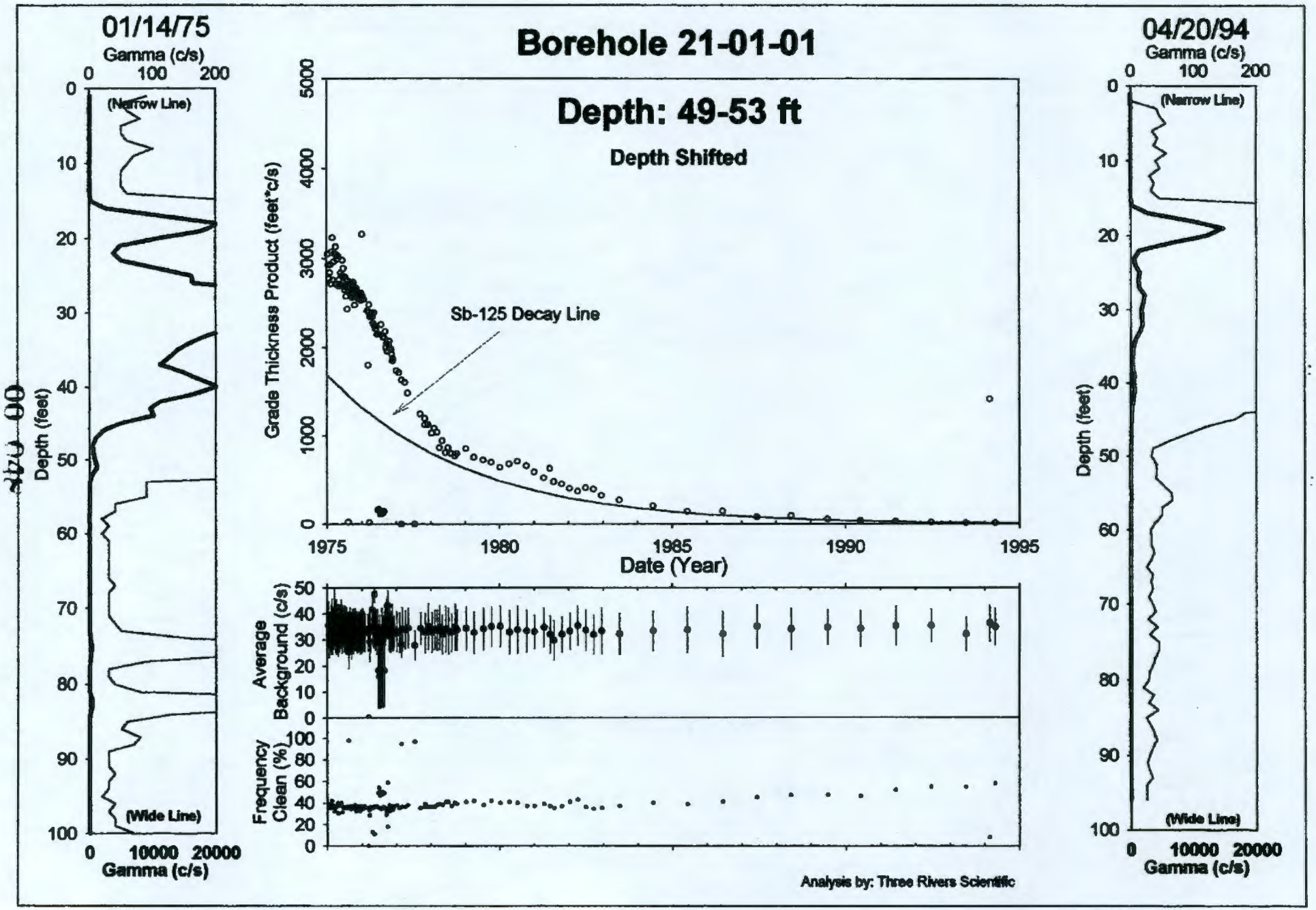

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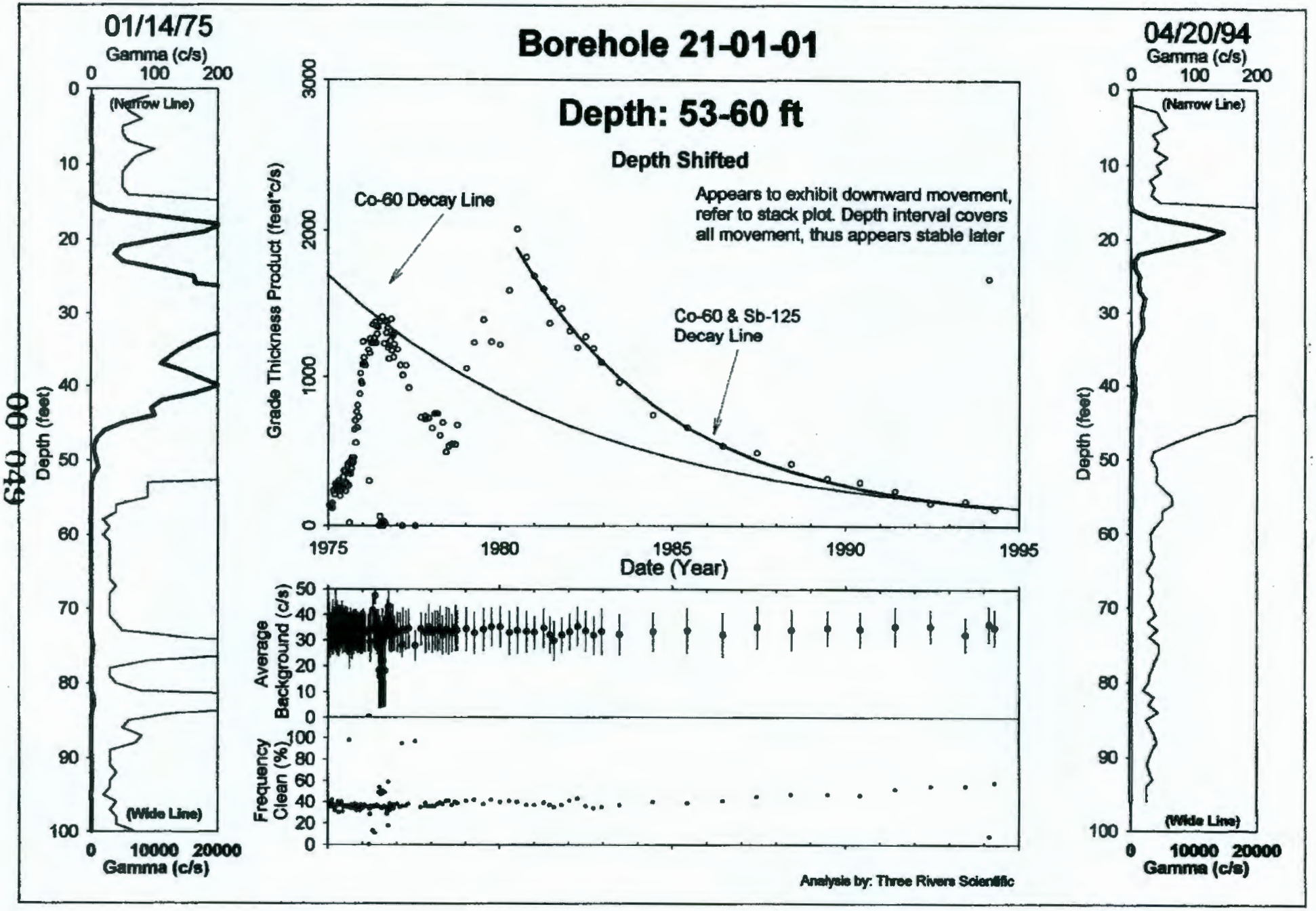
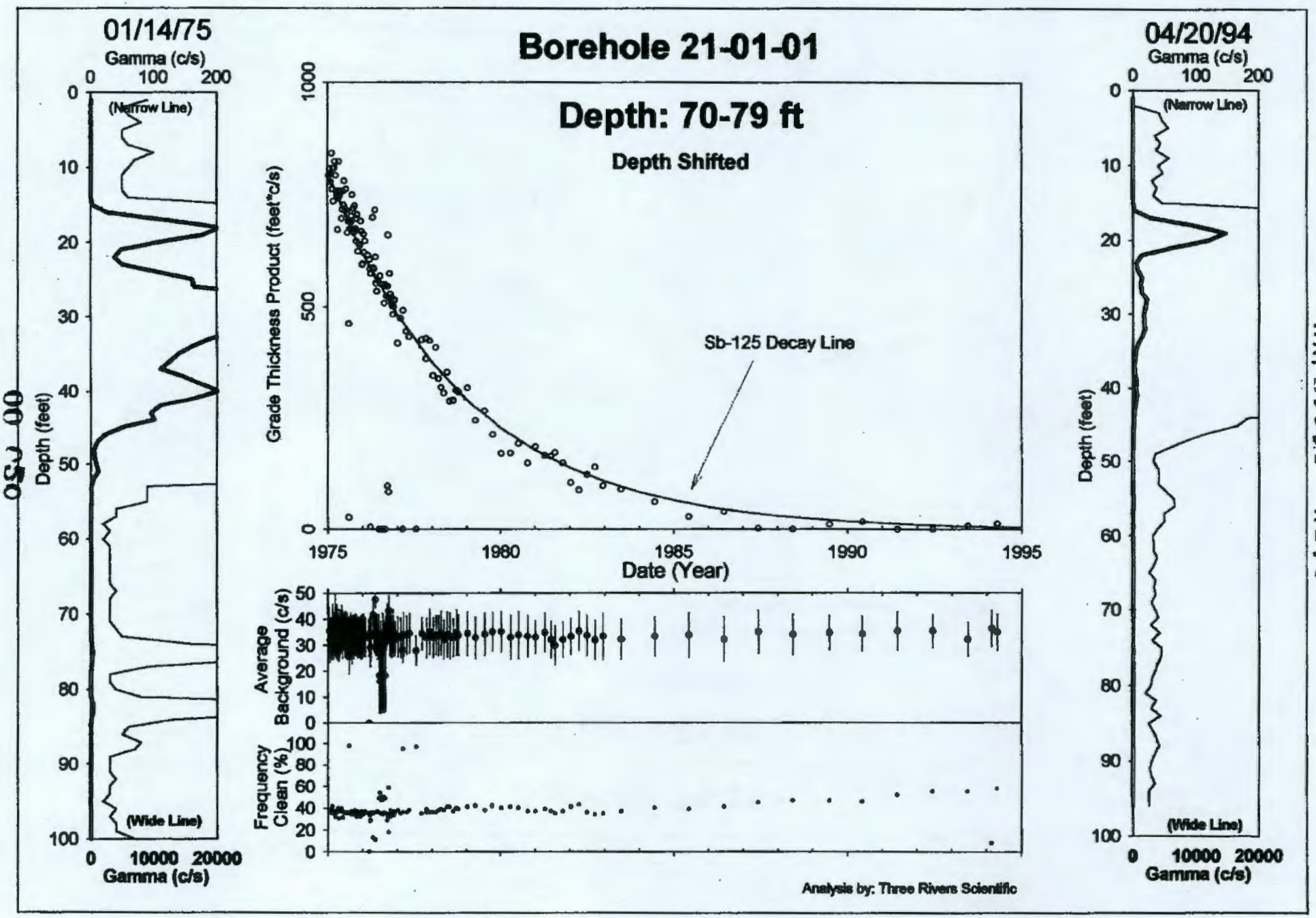
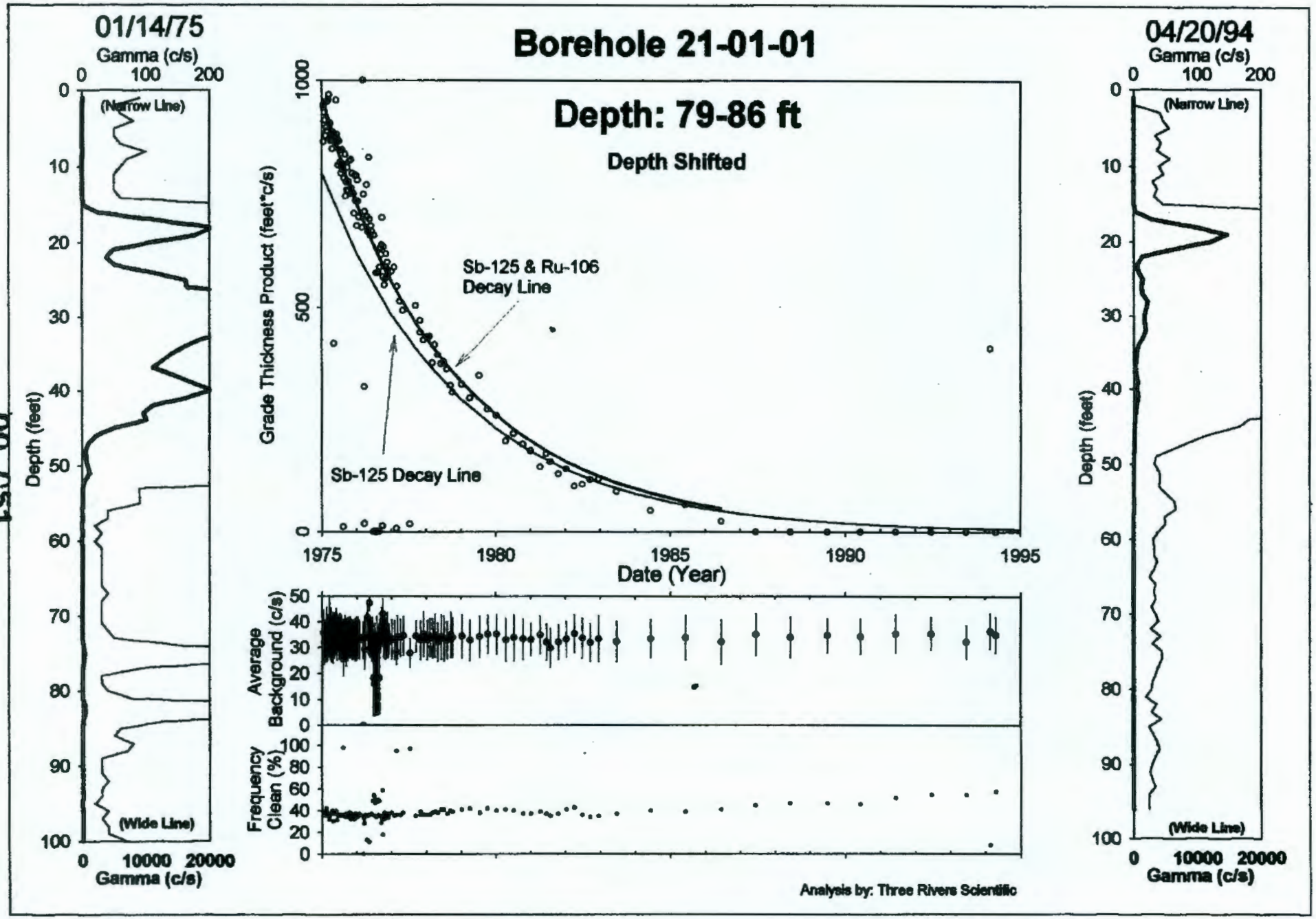


HNF-3531 -REV0

00 049

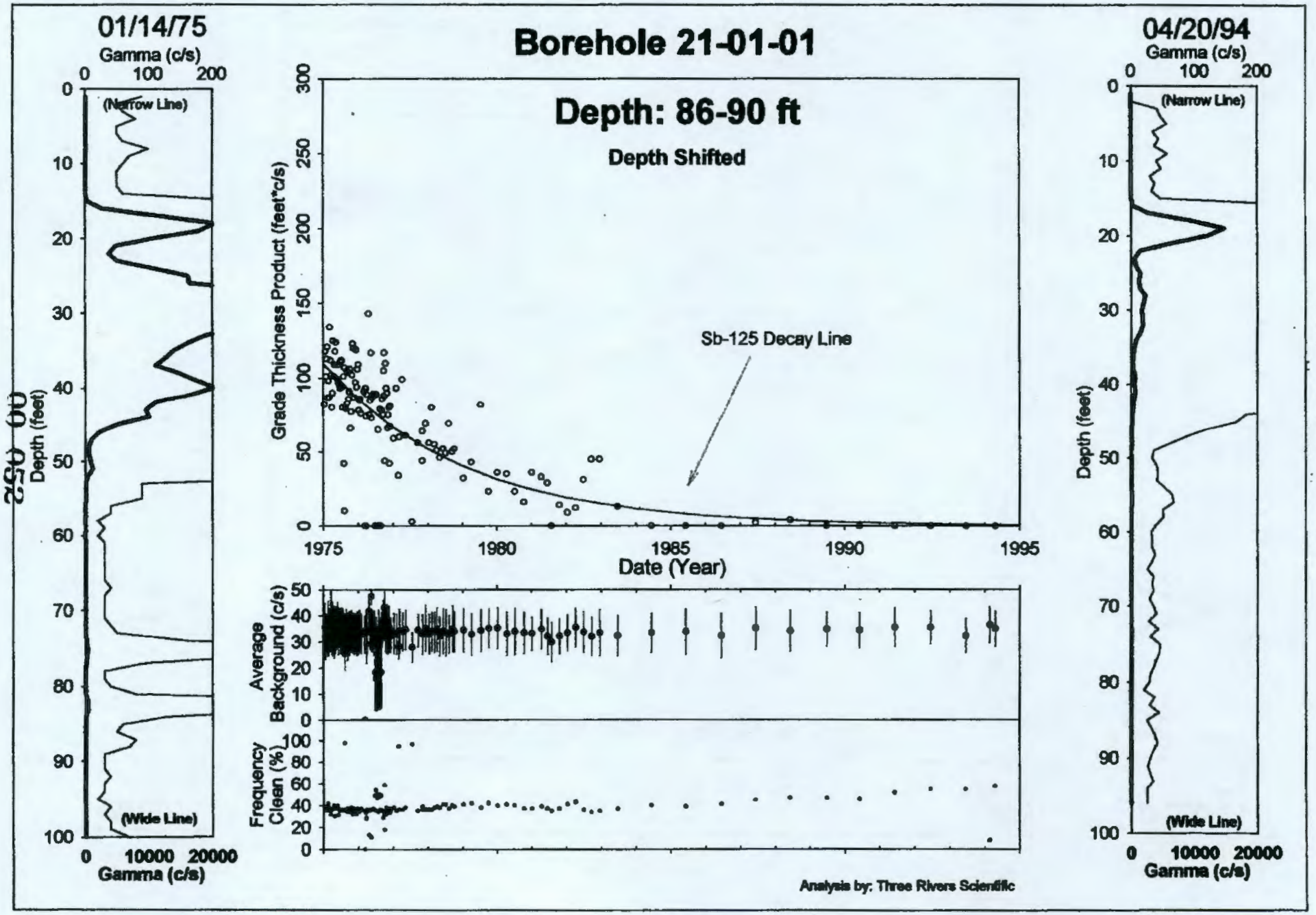


HNF-3531 -REV0



HNF-3531 -REV0

00 (51



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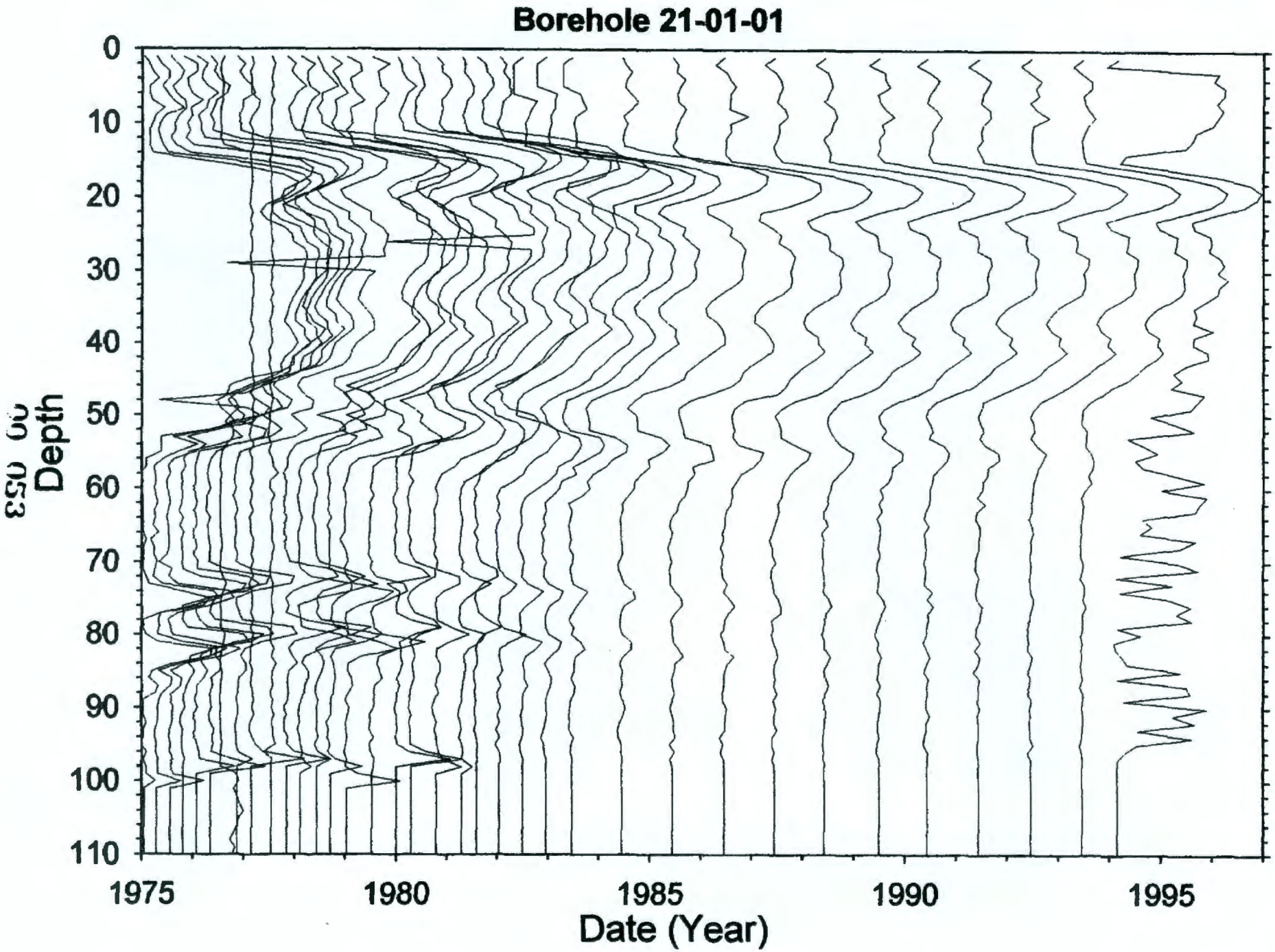
250 052



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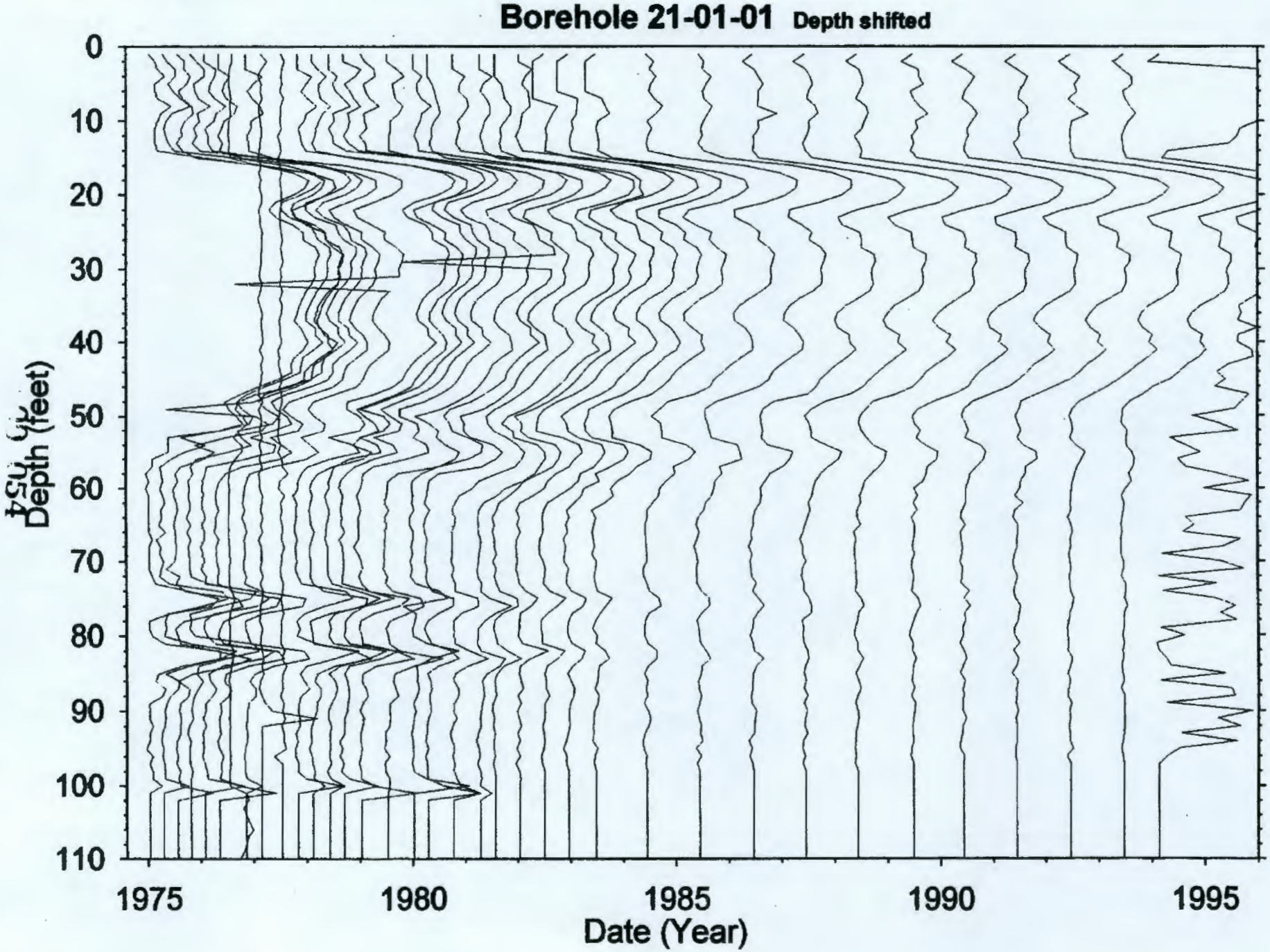

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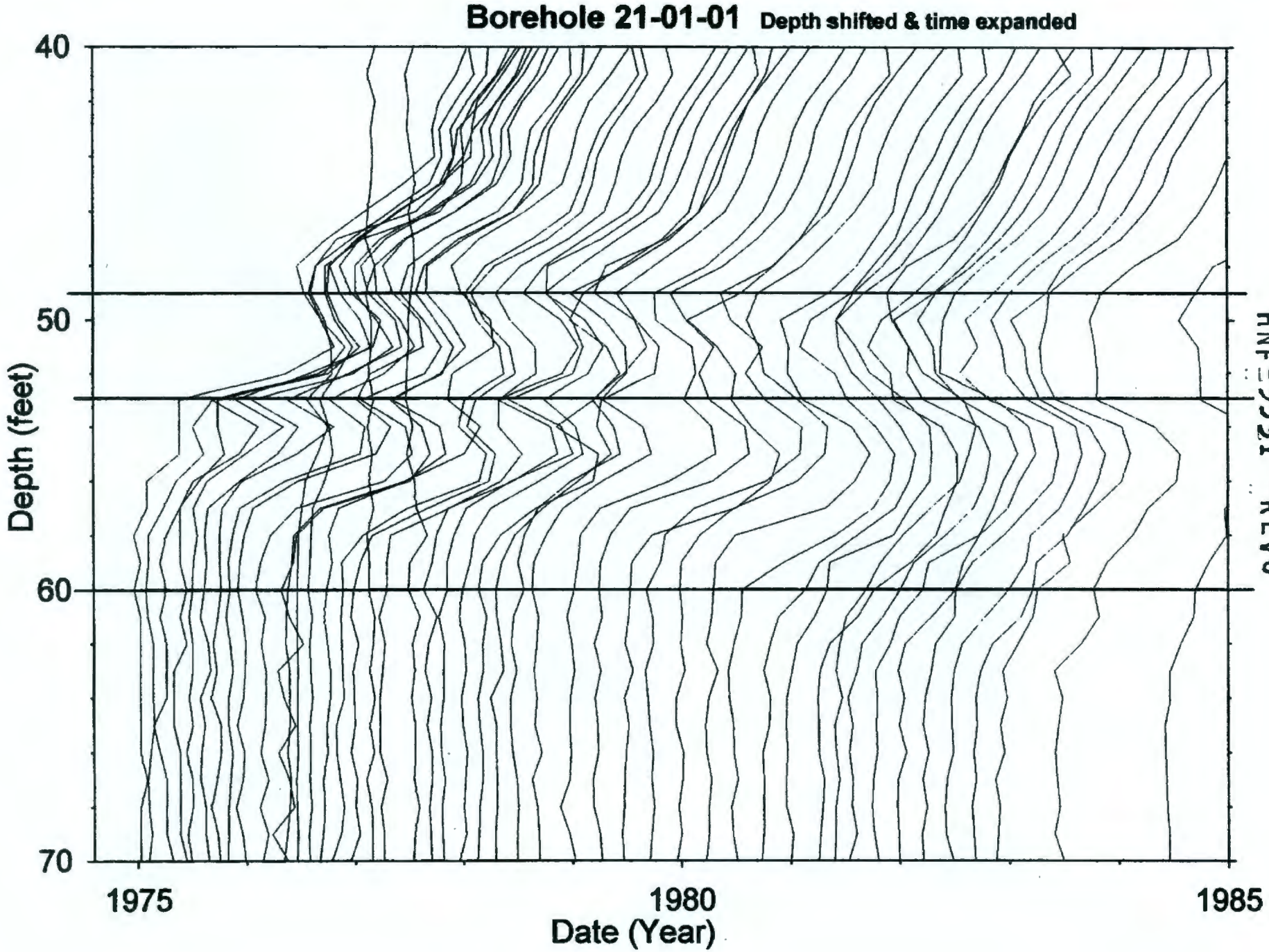
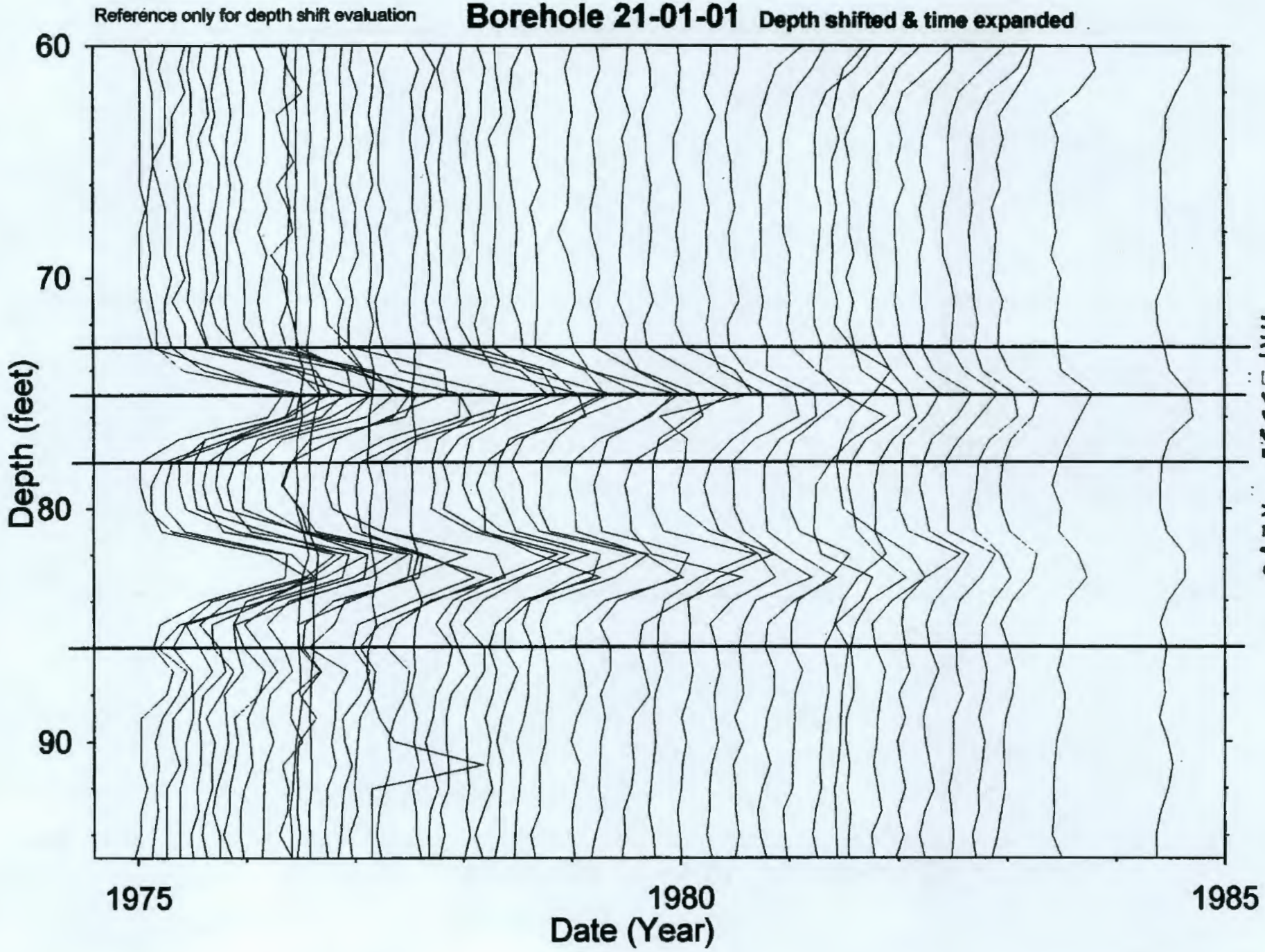


HNF-3531 -REV 0

00 055



HNF-3531 -REV0

950 056

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

BX

Borehole 21-01-01

Total # Surveys 247

neutron surveys 9

Log Date: 1-14-75 1st 4-20-94 Last

Probe Type D4 147 91 14

GR Surveys 238

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): Several are not attach

Isotope from Spectral Survey: Cs Co Eu154 U Sb

Max Survey Depth ~~145~~ 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

Depth problems (Rn from stack in likely)
Need depth shift (SHFAUTO)
3 components in around zones (maybe 4) Sb in 49-53 non
compare may be depth controls problem with wings of nearby zones
53-60 called U Co + Sb in better shape
Downward movement verified by 2 lower peak after depth shift = con

Analyst Name Russ Rawfal

S/W ver TFGROSS 2.2

filein := "two23-37.txt" **Well 21-01-01** $\tau eu := 30.17$ $\tau 4 := 8.5$

$A := READPRN(filein)$ $yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$ $a4 := 80000$

$\tau eu := \frac{368.2}{365.25}$

$N := last(yr)$ $N = 132$ $i := 0..N$ $k := 0..300$ $j := 0..299$

$\tau co := 5.27$ $\tau cs := 2.77$ $aco := 33000$ $acs := 000$

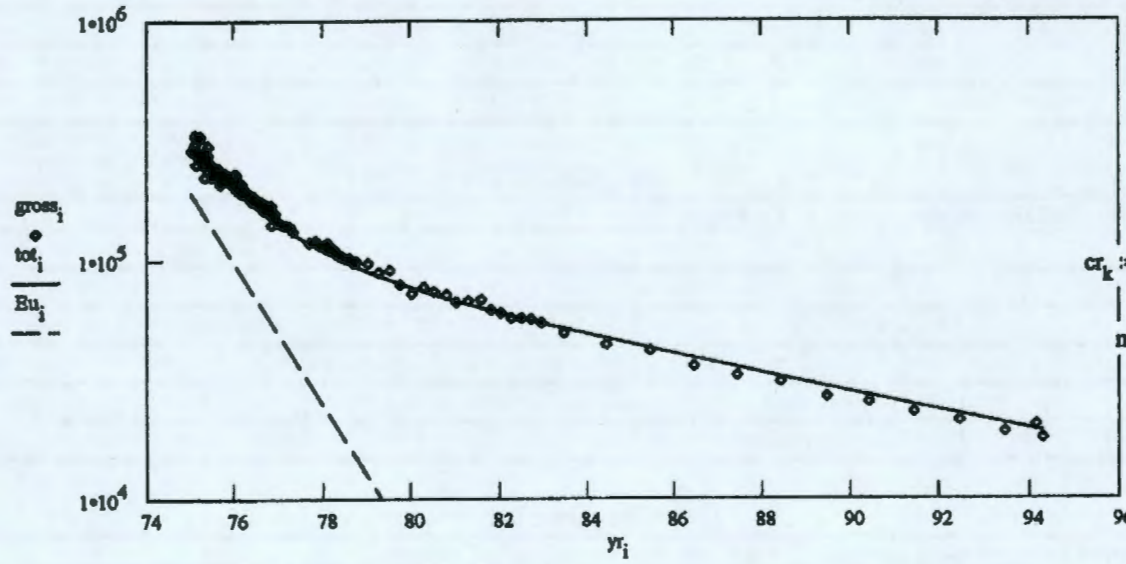
Eu variables are
Ru-106 $aeu := 196000$

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

$gross_i := net_i$

This data edited for spurious points

$tot_i := Co_i + Eu_i + Cs_i + \left[a4 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 4}}\right]$



$yr_{113} = 81.805$

$k := 0..N - 112$

$t_k := (yr_{k+112})$

$cr_k := \ln(gross_{k+112})$

$m := slope(t, cr)$

$m = -0.098$

$\frac{\ln(2)}{-m} = 7.097$

$$ssq(a3, a2, a4) := \sum_i \left[\frac{gross_i}{(yr_i - 74)^6} - \frac{\left[a3 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} + \left[a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} + a4 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 4}}\right]\right]}{(yr_i - 74)^6}\right]^2$$

$cs := 0$ $\alpha co := 0$

Given

$ssq(aeu, aco, a4) = 0$ $1 = 1$ $2 = 2$

$\begin{bmatrix} \alpha eu \\ \alpha co \\ \alpha eur \end{bmatrix} := Minerr(aeu, aco, a4)$

$\alpha co = 3.221 \cdot 10^4$ $\alpha eu = 1.949 \cdot 10^5$ $\alpha cs = 0$

$\alpha eur = 7.925 \cdot 10^4$ $\frac{\alpha co}{\alpha eu} = 0.165$

$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $Eur_i := \alpha eur \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 4}}$

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

$out^{<0>} := yr$ $out^{<1>} := tot$ $WRITEPRN("twop23-37.txt") := out$ $\frac{Eu_N}{Co_N} = 1.319 \cdot 10^{-4}$

filein := "two37-49.txt" **Well 21-01-01**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 130$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := \frac{368.2}{365.25}$

$\tau co := 5.27$ $\quad \tau cs := 8.5$ $\quad aco := 30000$ $\quad acs := 8000$

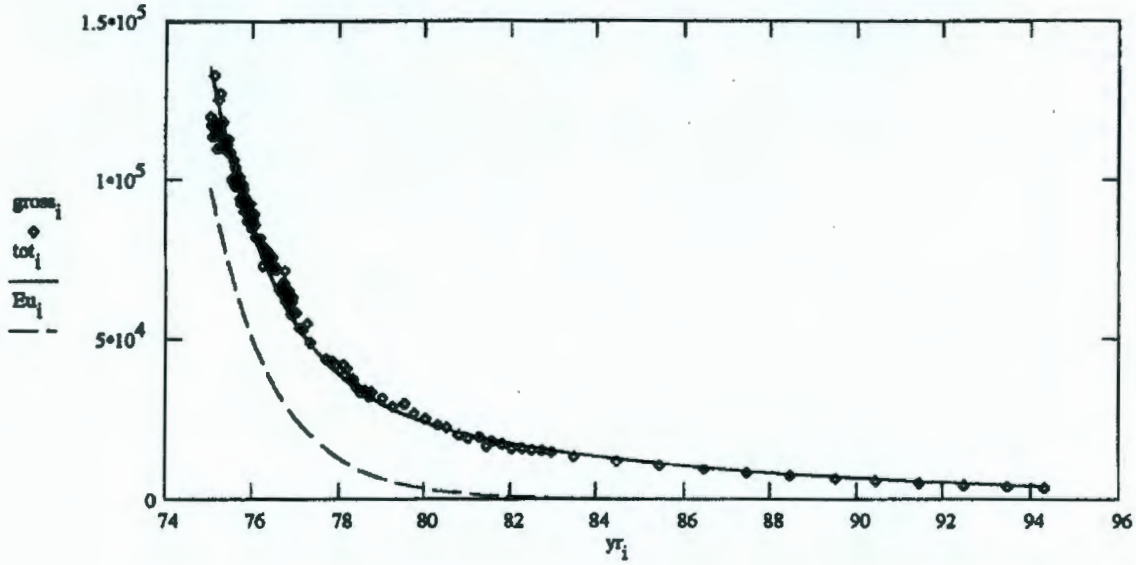
Eu variables are Ru-106 $\quad aeu := 100000$

$Cs_i := acs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Co_i + Eu_i + C$

$gross_i := net_i$

This data edited for spurious points

Cs variable is Eu-154



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

Given

$ssq(aco, aeu, acs) = 0$ $\quad 1 = 1$ $\quad 2 = 2$

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

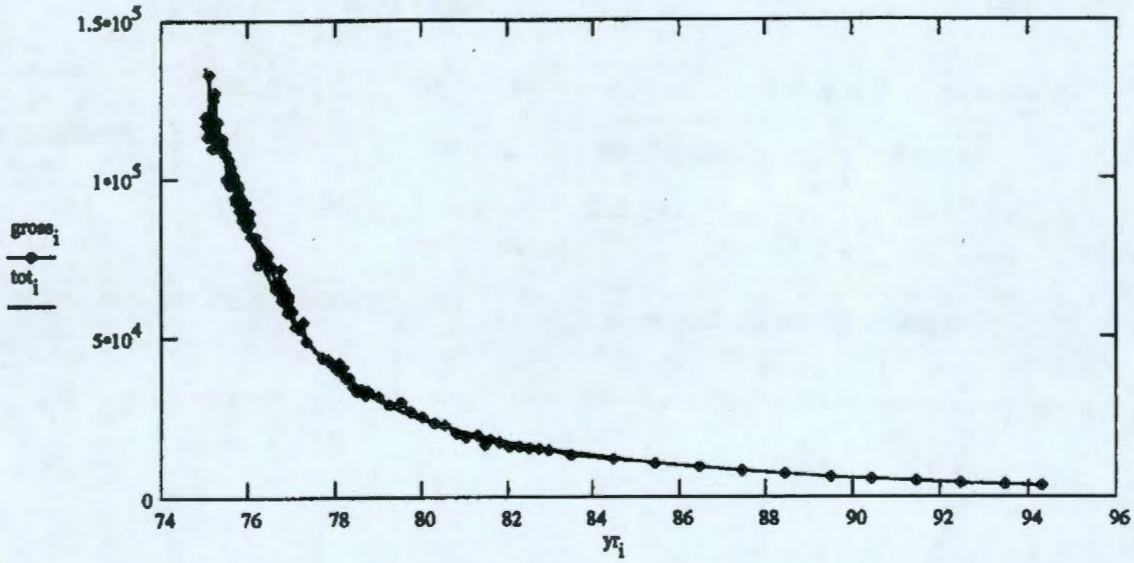
$\alpha co = 3.914 \cdot 10^4$ $\quad \alpha eu = 9.706 \cdot 10^4$ $\quad \alpha cs = 1.723 \cdot 10^3$

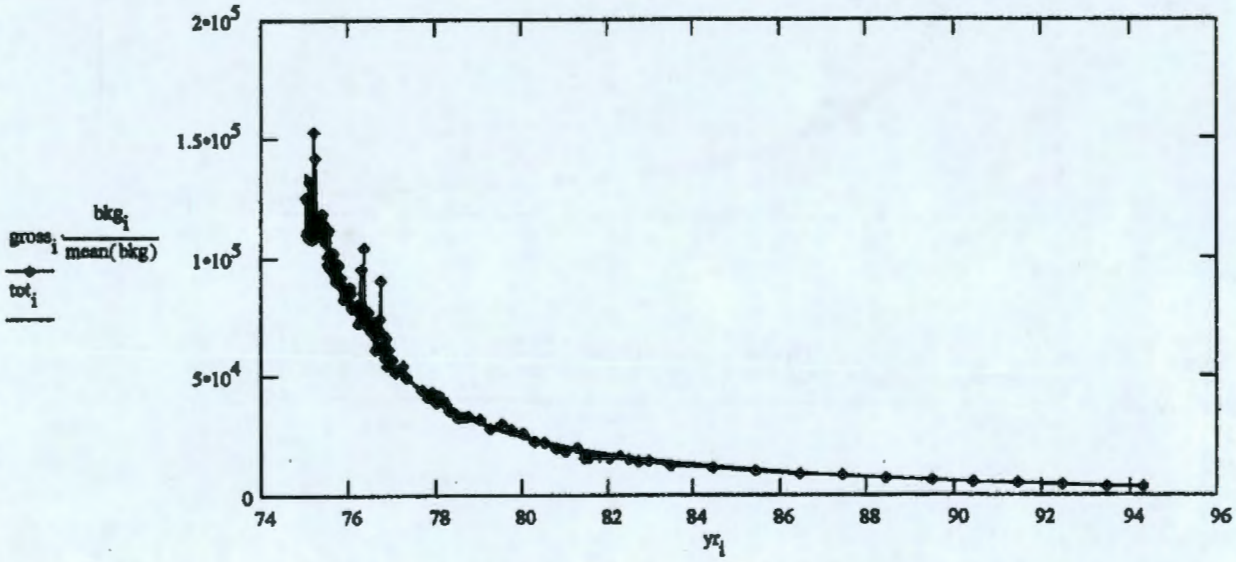
$\frac{\alpha co}{\alpha eu} = 0.403$

$Co_i := \alpha co \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau eu}}$ $\quad Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$

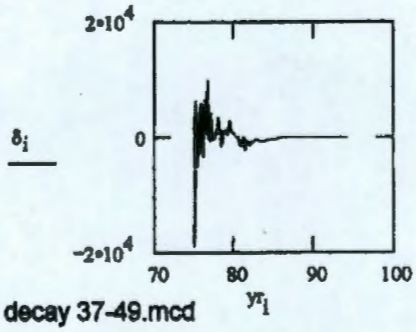
$tot_i := Co_i + Eu_i + Cs_i$

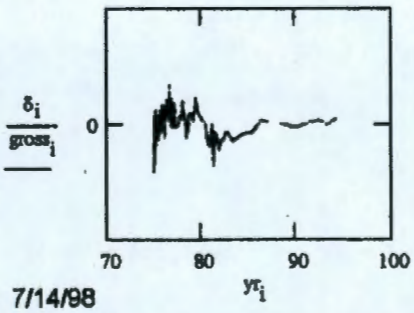
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop37-49.txt"}) := out$ $\quad \frac{Eu_N}{Co_N} = 5.409 \cdot 10^{-5}$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





filein := "two53-60.txt" **Well 21-01-01**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 24$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 2.77$

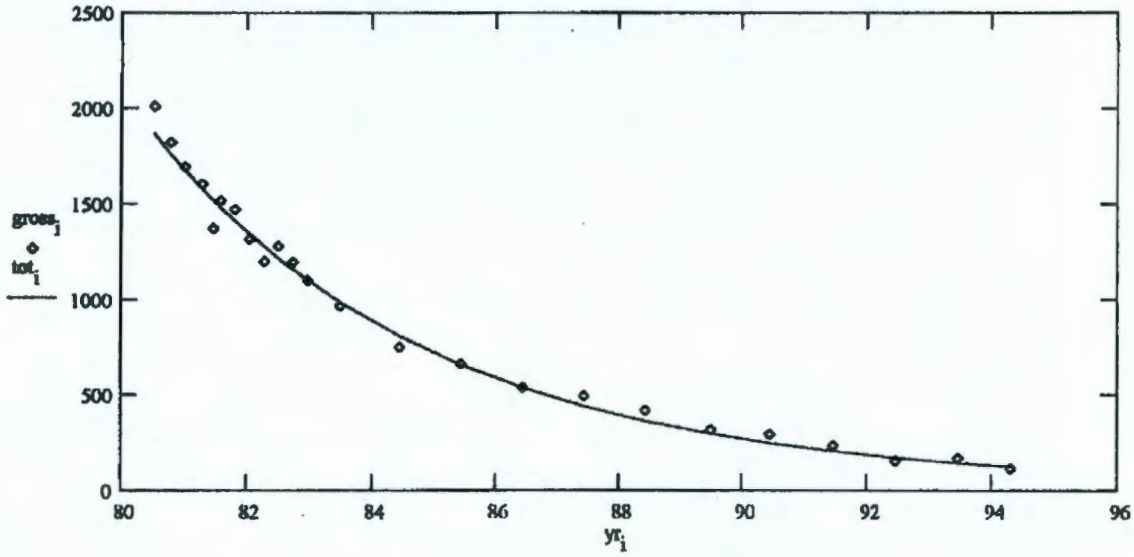
$\tau co := 5.27$ $\quad \tau cs := 32.17$ $\quad aco := 1000$ $\quad acs := 0$

Eu variables are Sb-125 $\quad aeu := 5500$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Co_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



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

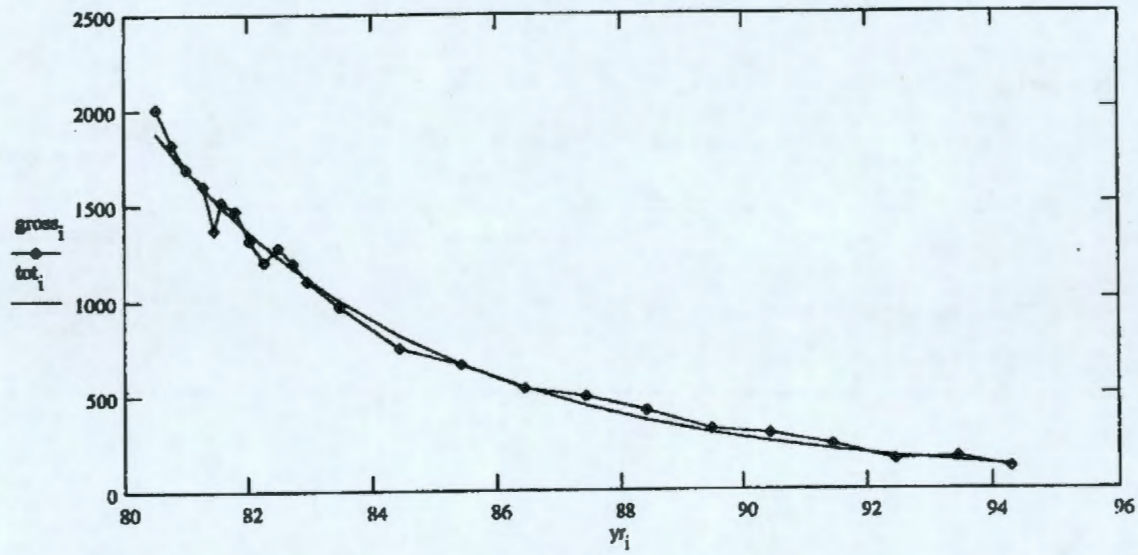
Given

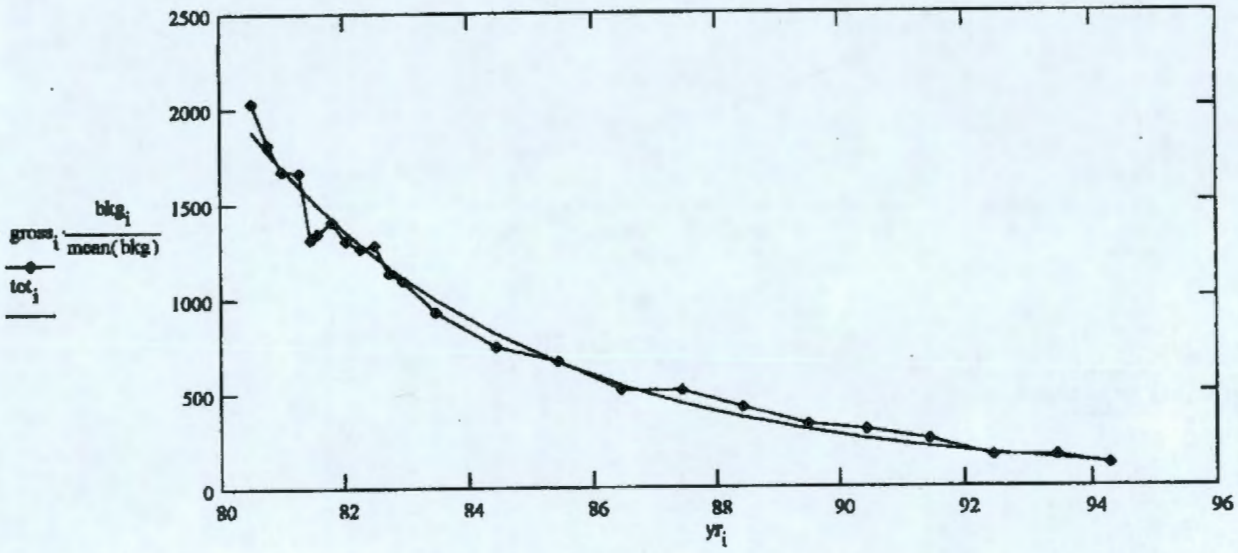
$ssq(aco, aeu) = 0$ $\quad 1 = 1$

$\begin{bmatrix} \alpha co \\ \alpha eu \end{bmatrix} := \mathrm{Minerr}(aco, aeu)$ $\quad \alpha co = 1.014 \cdot 10^3$ $\quad \alpha eu = 5.542 \cdot 10^3$

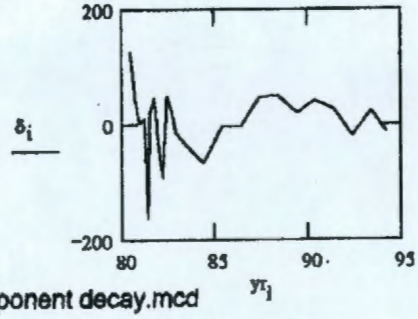
$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Co_i + Eu_i$ $\quad \frac{\alpha co}{\alpha eu} = 0.183$

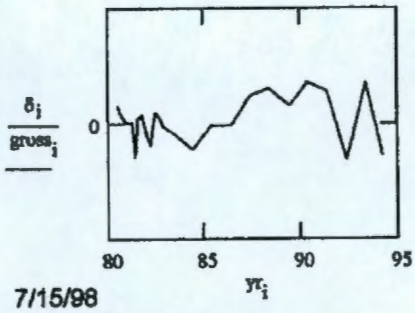
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop53-60.txt"}) := out$ $\quad \frac{Eu_N}{Co_N} = 0.553$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





filein := "two79-86.txt" **Well 21-01-01**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 123$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 2.77$

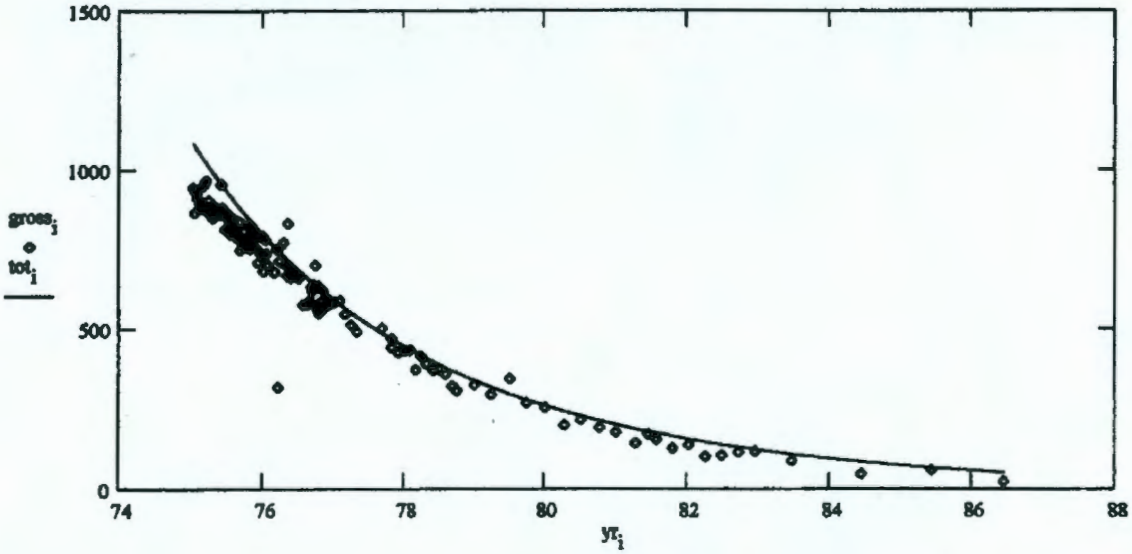
$\tau co := 1$ $\quad \tau cs := 32.17$ $\quad aco := 200$ $\quad acs := 0$

Eu variables are Sb-125 $\quad aeu := 900$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Co_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



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

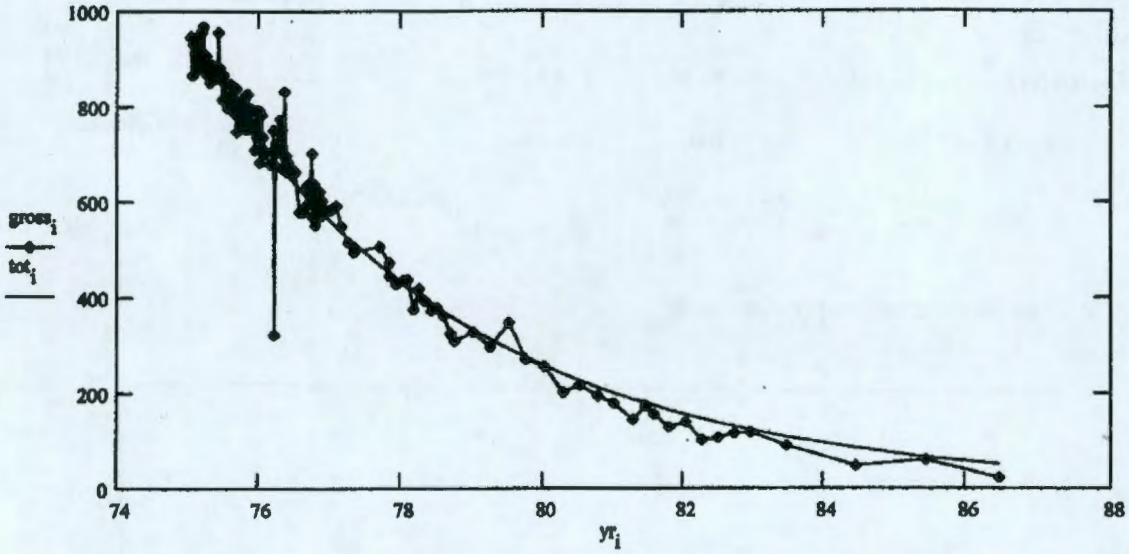
Given

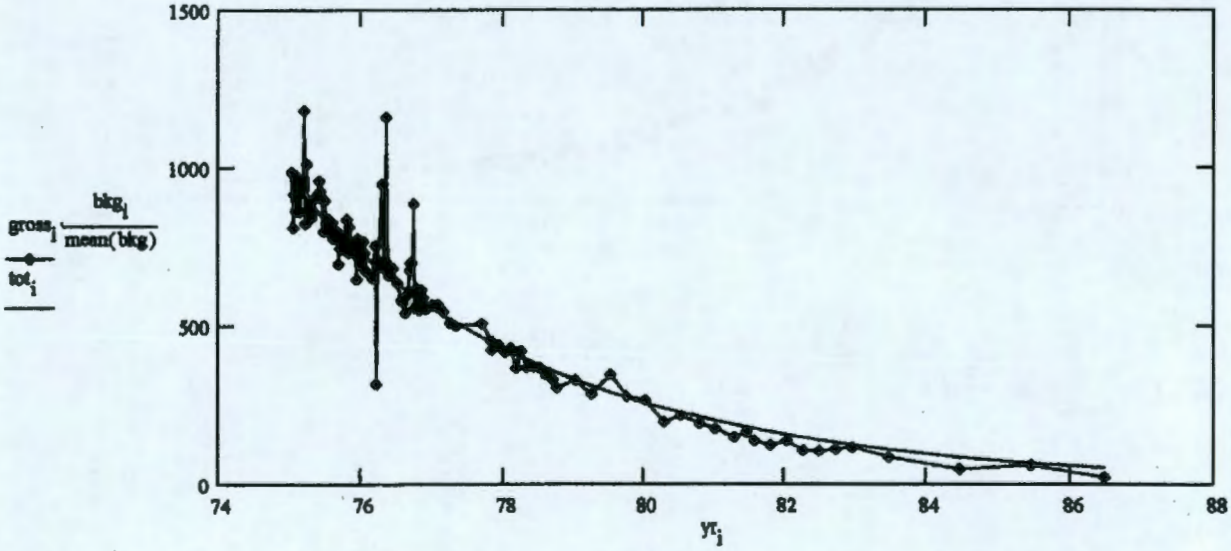
$ssq(aco, aeu) = 0$ $\quad 1 = 1$

$\begin{bmatrix} \alpha co \\ \alpha eu \end{bmatrix} := \mathrm{Minerr}(aco, aeu)$ $\quad \alpha co = 69.557$ $\quad \alpha eu = 898.178$

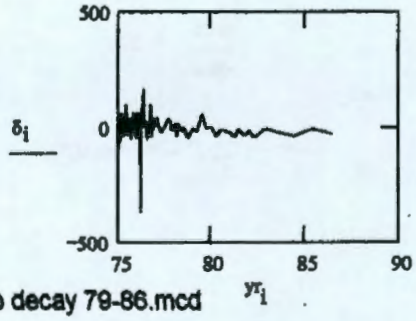
$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Co_i + Eu_i$ $\quad \frac{\alpha co}{\alpha eu} = 0.077$

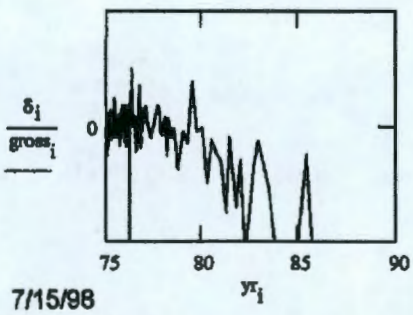
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop79-86.txt"}) := out$ $\quad \frac{Eu_N}{Co_N} = 2.066 \cdot 10^3$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$

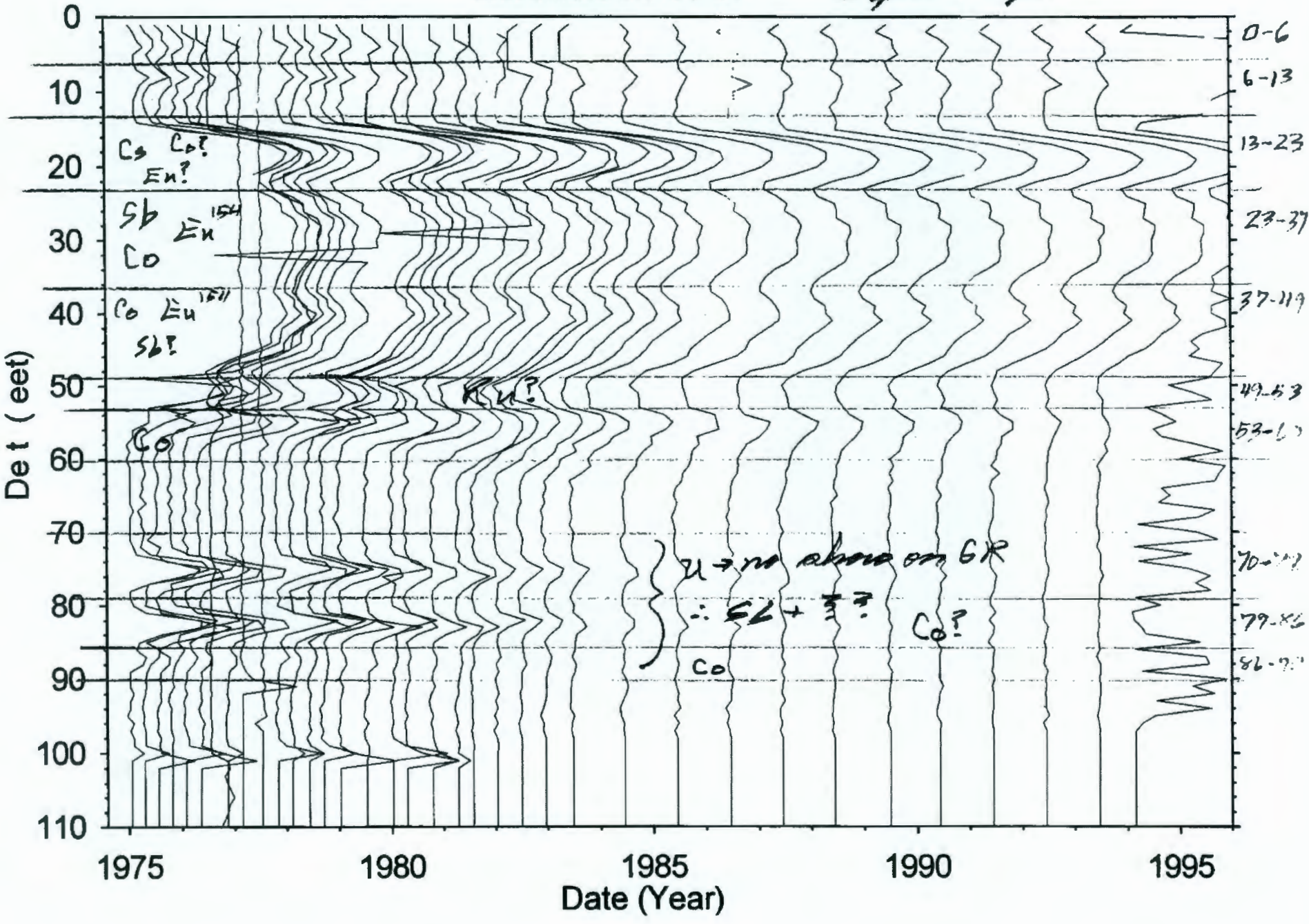




Reference

Borehole 21-01-01

Depth Shift



Borehole 21-01-02

Contamination (Cs-137) from 5-12 feet is **UNSTABLE** early
Contamination (Co-60 & Ru-106) from 54-64 feet is **UNSTABLE** early
Contamination (Co-60 & Ru-106) from 64-72 feet is **UNSTABLE** early
Contamination (Co-60) from 72-78 feet is **UNSTABLE** early

Grade thickness product over 5 to 12 feet sharply increased at the start of 1977 and again just before 1978. The character since this time is consistent with the natural decay of the HPGe identified Cs-137. Grade thickness product from 54 to 64 feet appears unstable from 1975 to 1977. Since 1977 the grade thickness product is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Ru-106 (hypothesis) until1994. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 8.8 as of Jan 1975. Grade thickness product from 64 to 72 feet is unstable from 1975 to 1977. Since 1977 the grade thickness product is decreasing consistent with a least squares fit for Co-60 (HPGe identified) and Ru-106 (hypothesis) until1994. The least squares fit results in gross gamma contribution ratio of Ru-106 to Co-60 of 4.3 as of Jan 1975. Grade thickness product from 72 to 78 feet begins an increase in 1980 and rises until 1985. Since 1985 this interval appears stable for Co-60 as identified by HPGe detector.

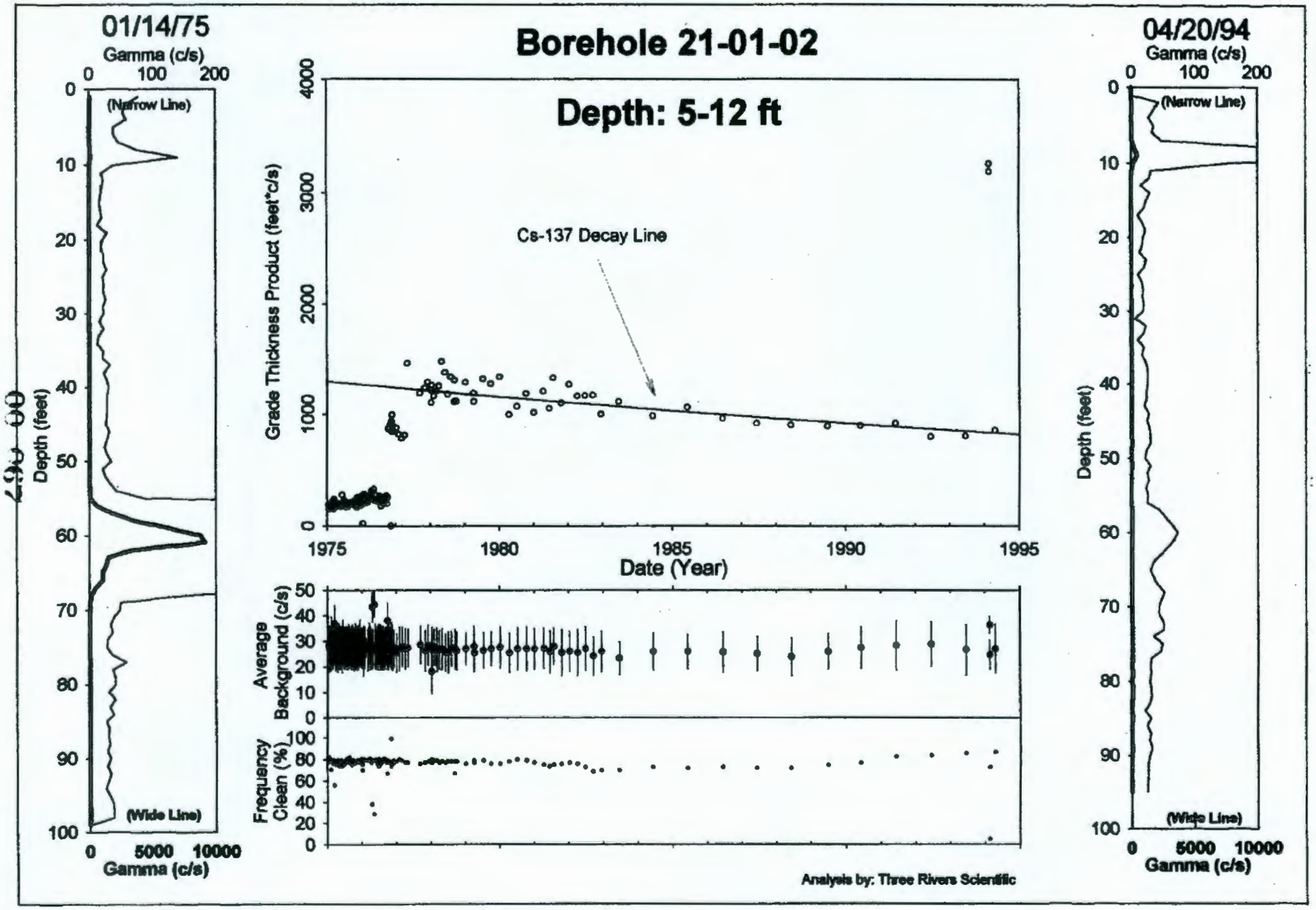
Special note: There may be some indication of Ru-106 moving down from the 54-64 feet zone to the 64-72 feet zone between 1975 and 1977, but more study would be required to make this conclusion, (refer to grade thickness product plot from 54 to 72 feet). Likewise, pre 1975 data would assist this study. Additionally, the Co-60 increase in the 72-78 feet interval is most likely not due to downward movement from the Co-60 in the adjacent interval above, since this interval above is stable from 1980 to 1985.

Gross Gamma Survey Information

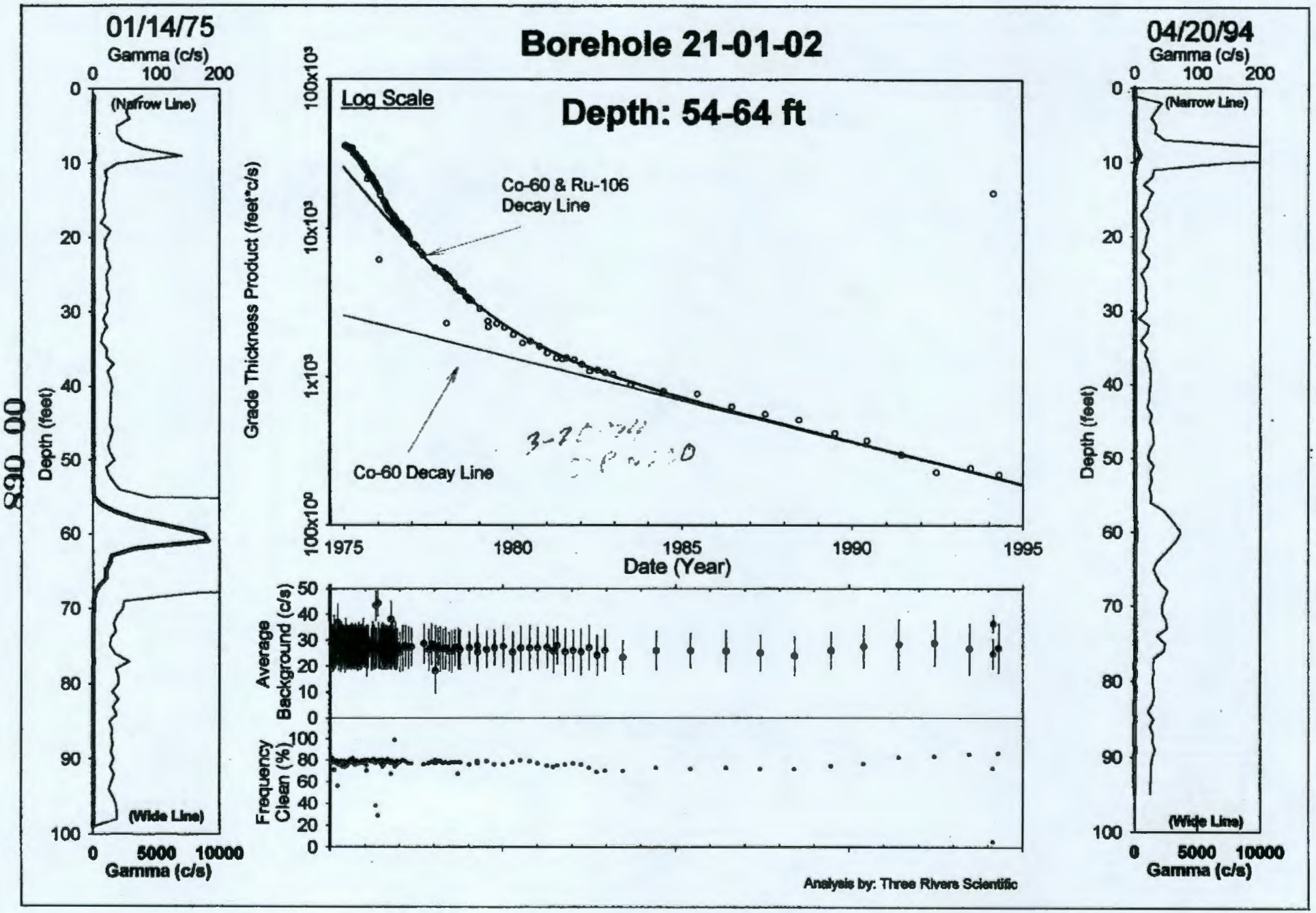
Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	4/20/1994
Number Surveys :	147

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 :	5-12, 54-64, 64-72, & 72-78 **UNSTABLE** early	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

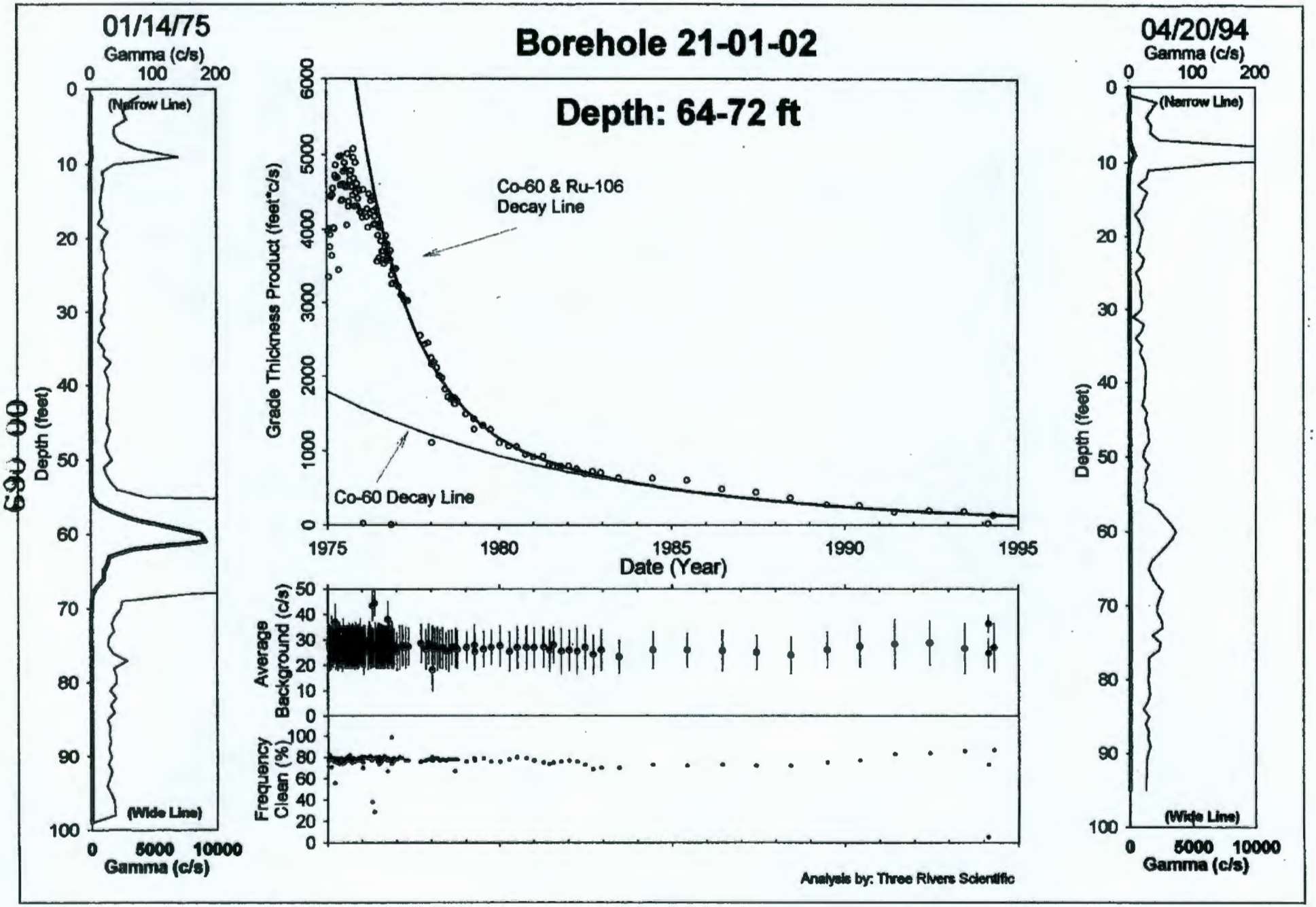


HNF-3531 -REV0

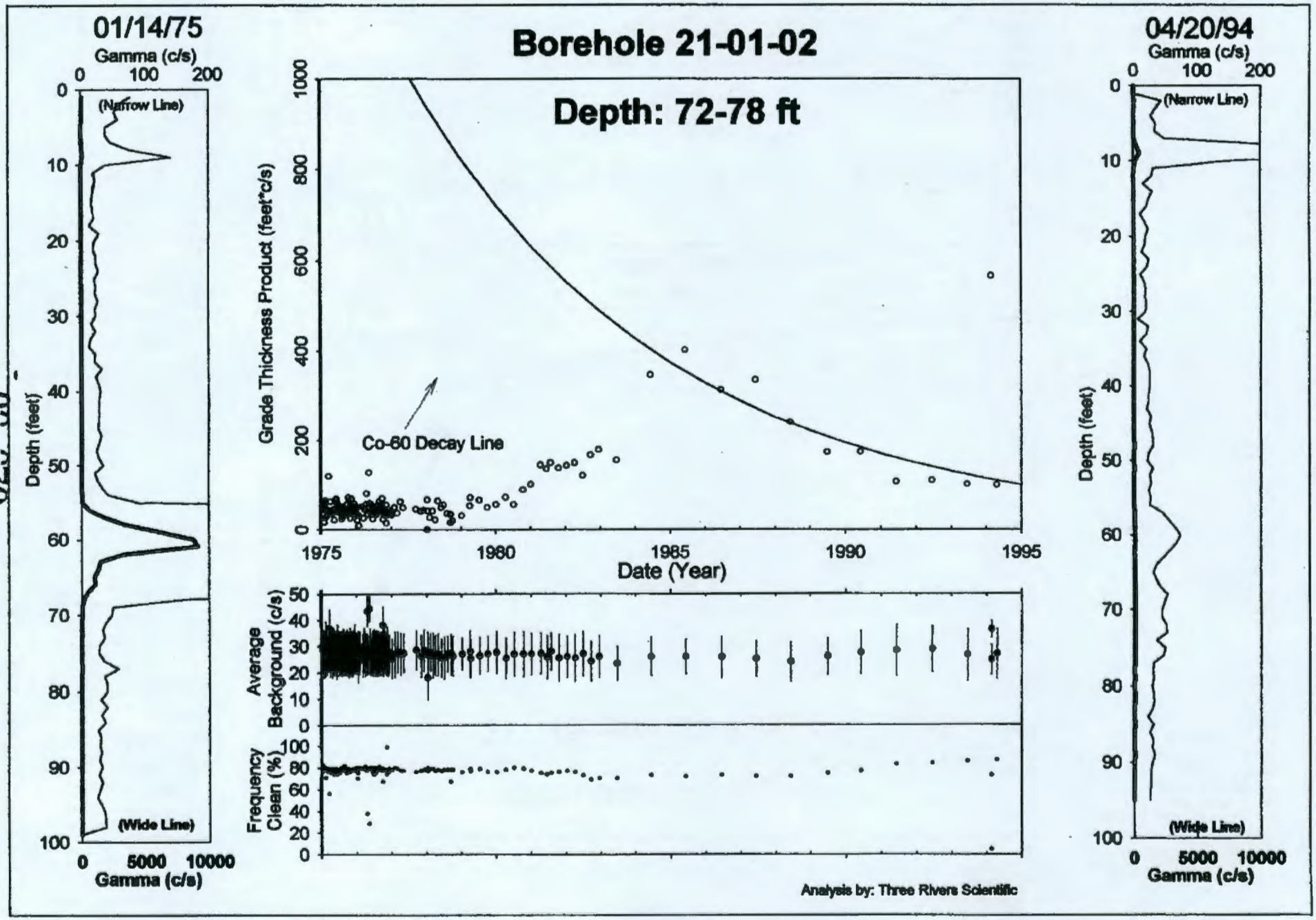


HNF-3531 -REV0

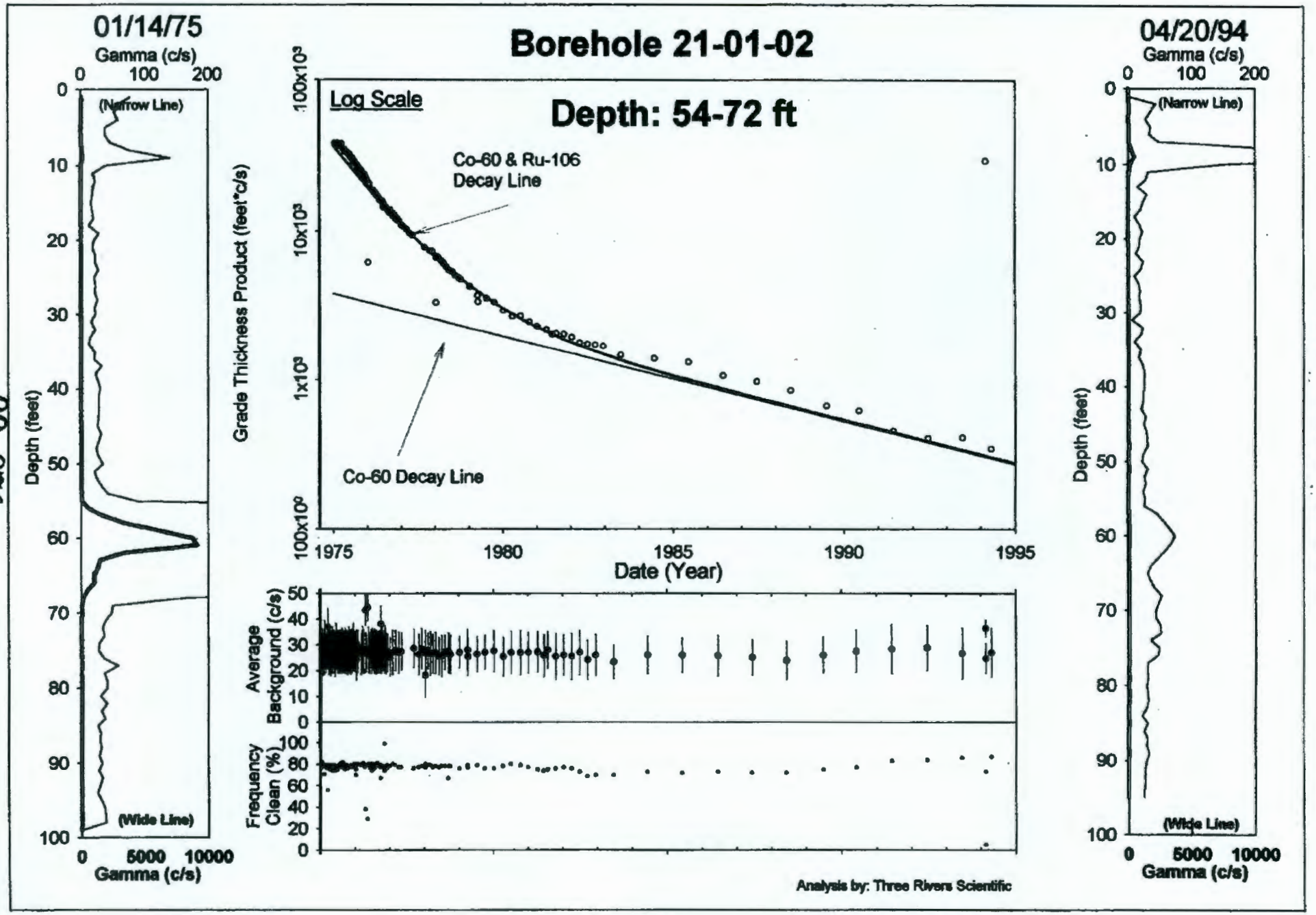
890 00



HNF-3531 -REV0

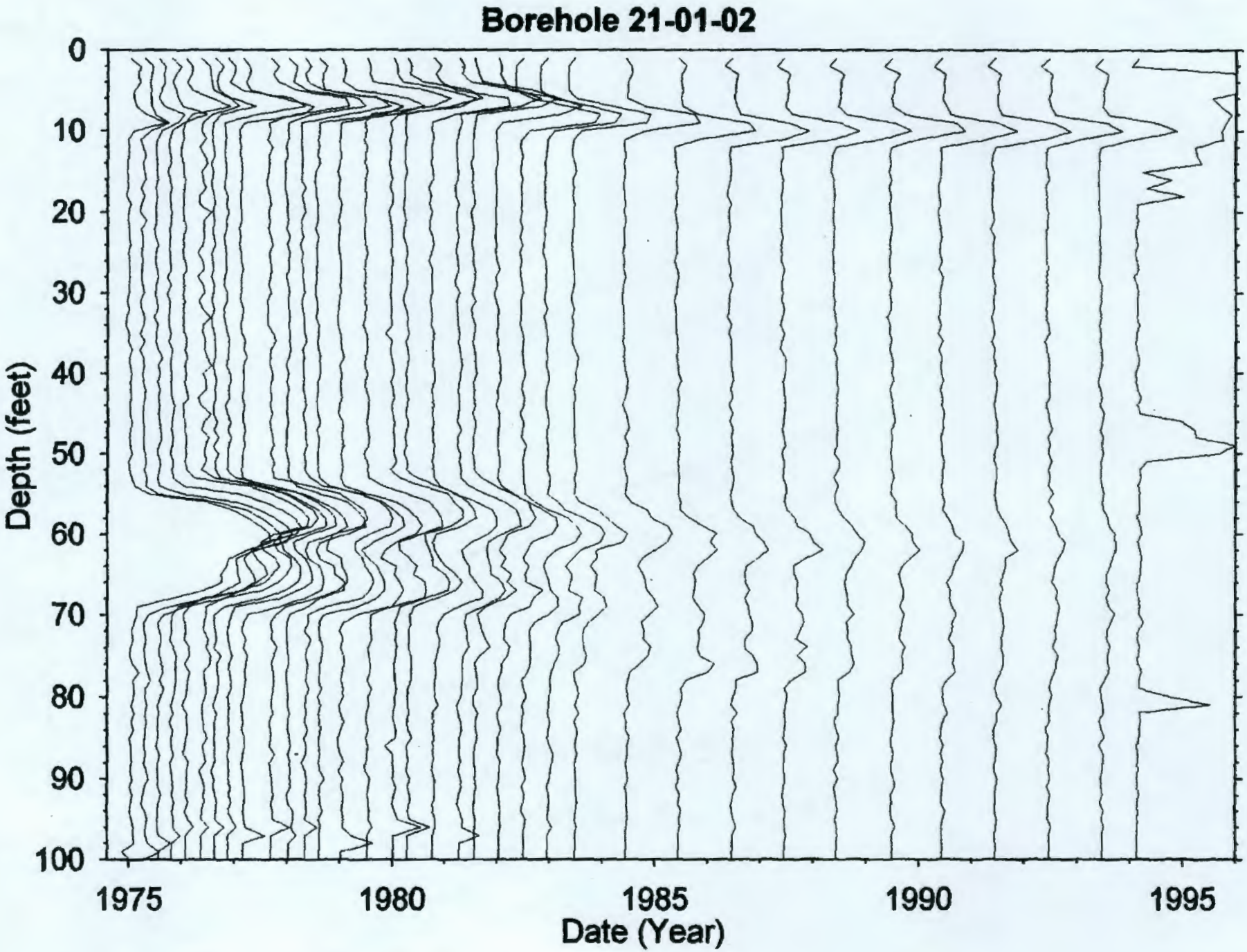


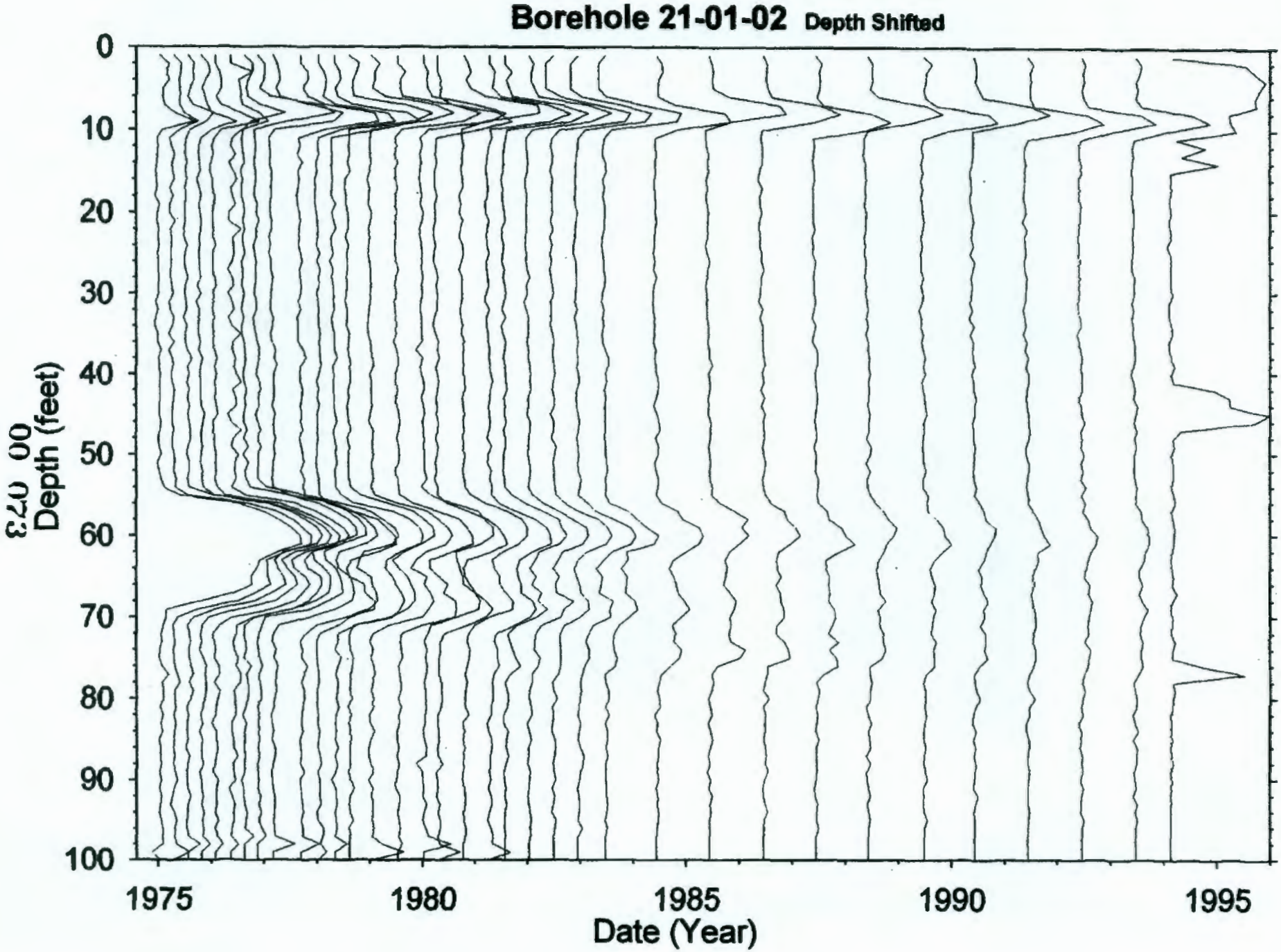
HNF-3531 -REV0



00 071

HNF-3531 -REV0


Borehole 21-01-02
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)



HNF-3531 -REV0

00 0723

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

BX

Borehole 21-01-02

Total # Surveys 157

neutron surveys 8

Log Date: 1-14-75 1st

4-20-94 Last

Probe Type 04 147 02 14

GR Surveys 147

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): Ru Cs Co

Isotope from Spectral Survey: Cs Co U Eu154

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

Depth control critical on Co anomaly zone at 72-79'
Early character 4-14 not tool (due to 1) bkg const. 2) other zones stuff same tools) 54-64 have Eu but as low no effect but fit (not lengthened in Ru + Co data

Analyst Name Bruce Rambo

S/W ver TF6R0SE2.2

filein := "two54-64.txt" **Well 21-01-02**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 46$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 2.77$

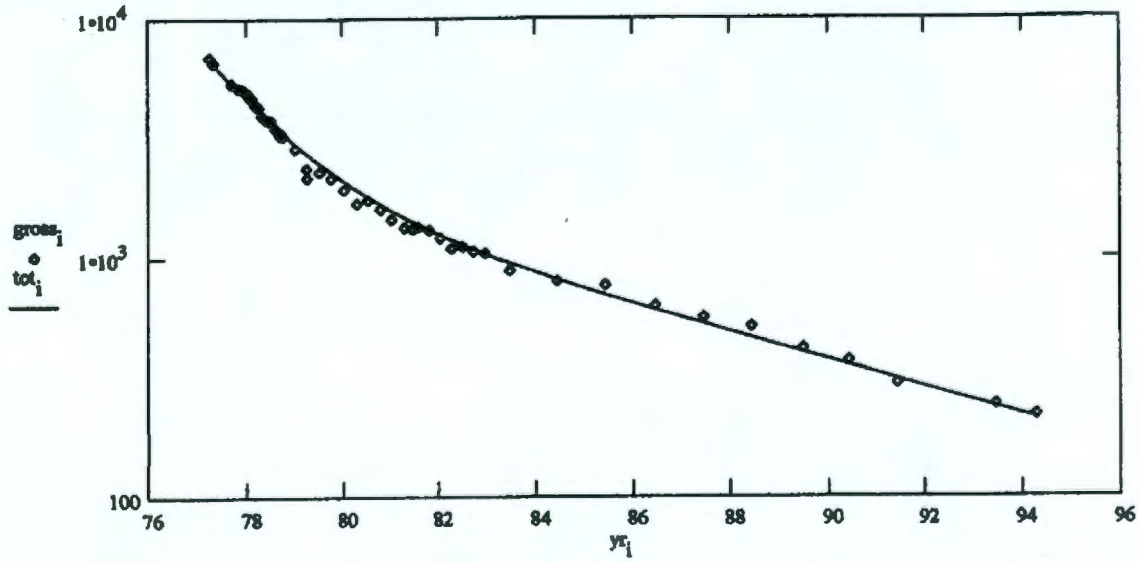
$\tau co := 5.27$ $\quad \tau cs := 1$ $\quad aco := 2700$ $\quad acs := 23000$

Eu variables are Sb-125 $\quad aeu := 0$

$Cs_i := acs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Co_i + Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



$\tau eu := 1$

$$ssq(a1, a3) := \sum_i \left[gross_i - \left[a1 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}} + a3 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}} \right] \right]^{1.0}$$

Given

$ssq(aco, acs) = 0$ $\quad 1 = 1$

$\begin{bmatrix} \alpha co \\ \alpha cs \end{bmatrix} := \mathrm{Minerr}(aco, acs)$ $\quad \alpha co = 2.621 \cdot 10^3$ $\quad \alpha cs = 2.3 \cdot 10^4$

$\frac{\alpha co}{\alpha cs} = 0.114$

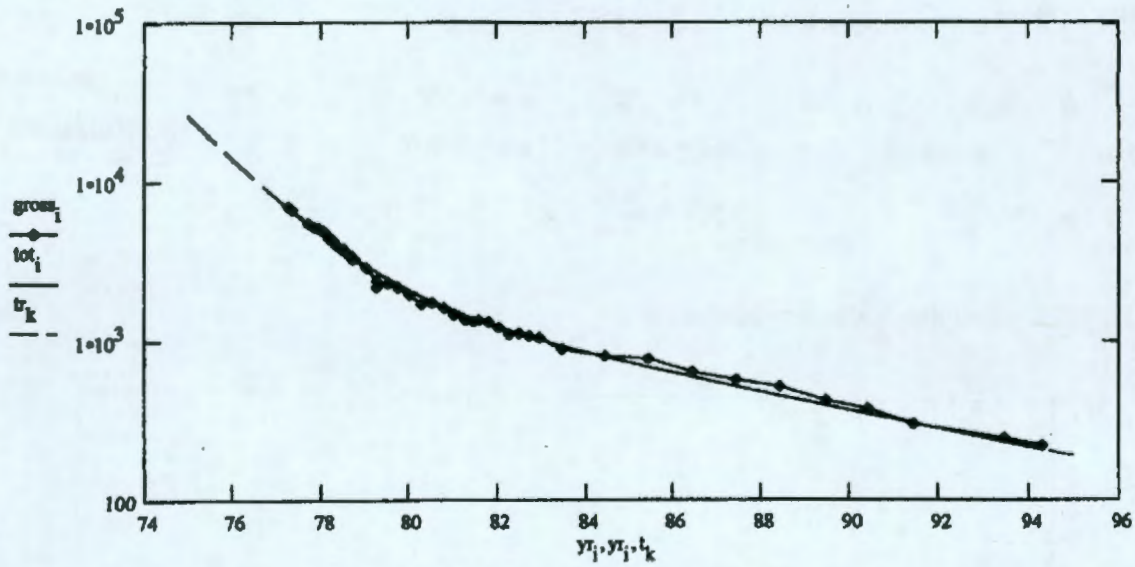
$Co_i := \alpha co \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad tot_i := Co_i + Cs_i$

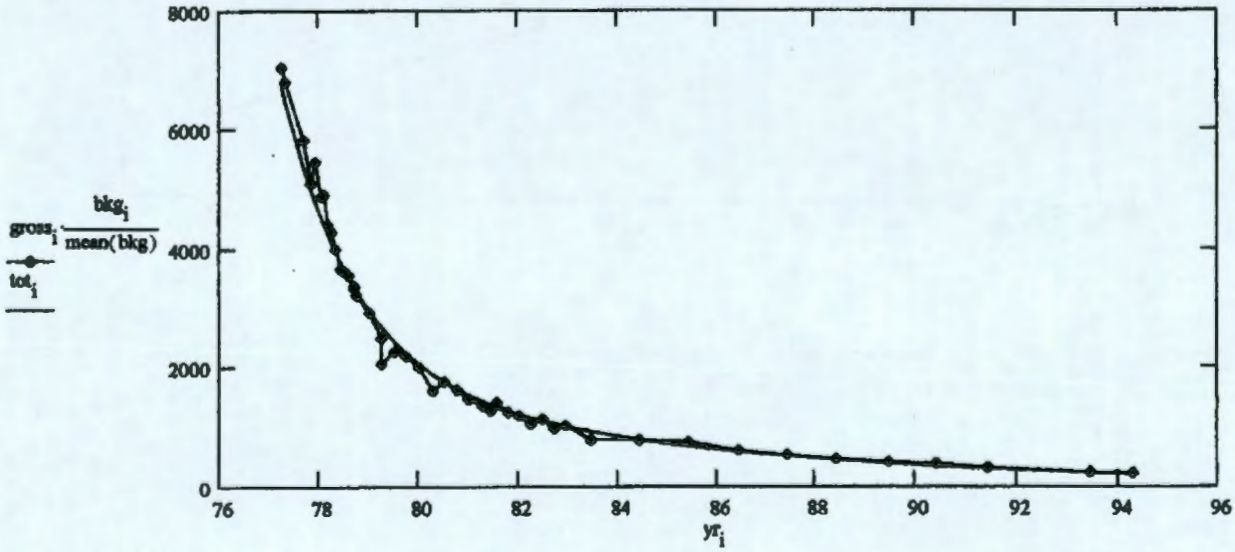
$\frac{Eu_N}{Co_N} = 0$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop54-64.txt"}) := out$

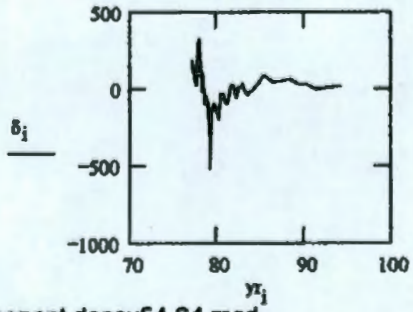
$k := 0..100$ $\quad t_k := 75 + \frac{k}{100} \cdot 20$ $\quad tr_k := \alpha co \cdot e^{-(t_k - 75)\cdot\frac{\ln(2)}{\tau co}} + \alpha cs \cdot e^{-(t_k - 75)\cdot\frac{\ln(2)}{\tau cs}}$

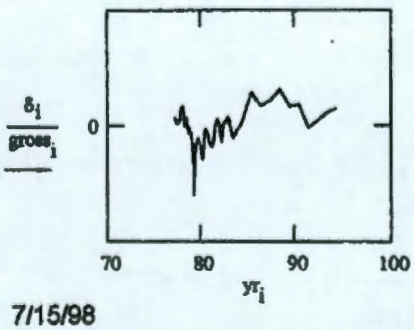
$out^{<0>} := t$ $\quad out^{<1>} := tr$ $\quad$ WRITEPRN("twop54-64.txt") := out





$\delta_i := gross_i - tot_i$ $\qquad \delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





filein := "two64-72.txt" **Well 21-01-02**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 60$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 2.77$

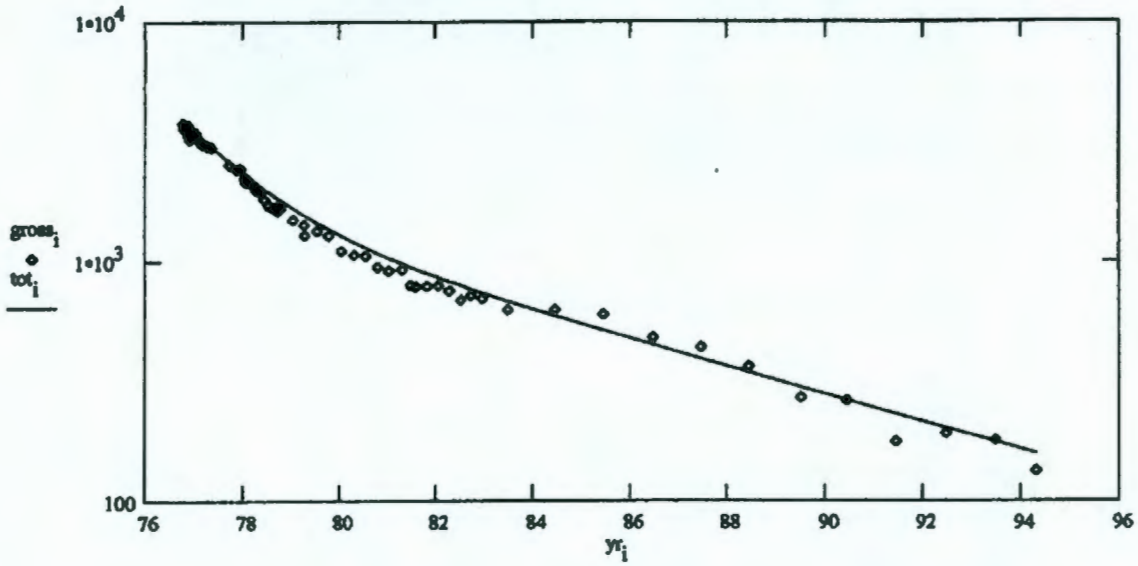
$\tau co := 5.27$ $\quad \tau cs := 1$ $\quad aco := 2000$ $\quad acs := 8000$

Eu variables are Sb-125 $\quad aeu := 0$

$Cs_i := acs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Co_i + Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



$\tau eu := 1$

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

Given

$ssq(aco, acs) = 0$ $\quad 1 = 1$

$\begin{bmatrix} \alpha co \\ \alpha cs \end{bmatrix} := \mathrm{Minerr}(aco, acs)$ $\quad \alpha co = 1.811 \cdot 10^3$ $\quad \alpha cs = 7.801 \cdot 10^3$

$\frac{\alpha co}{\alpha cs} = 0.232$

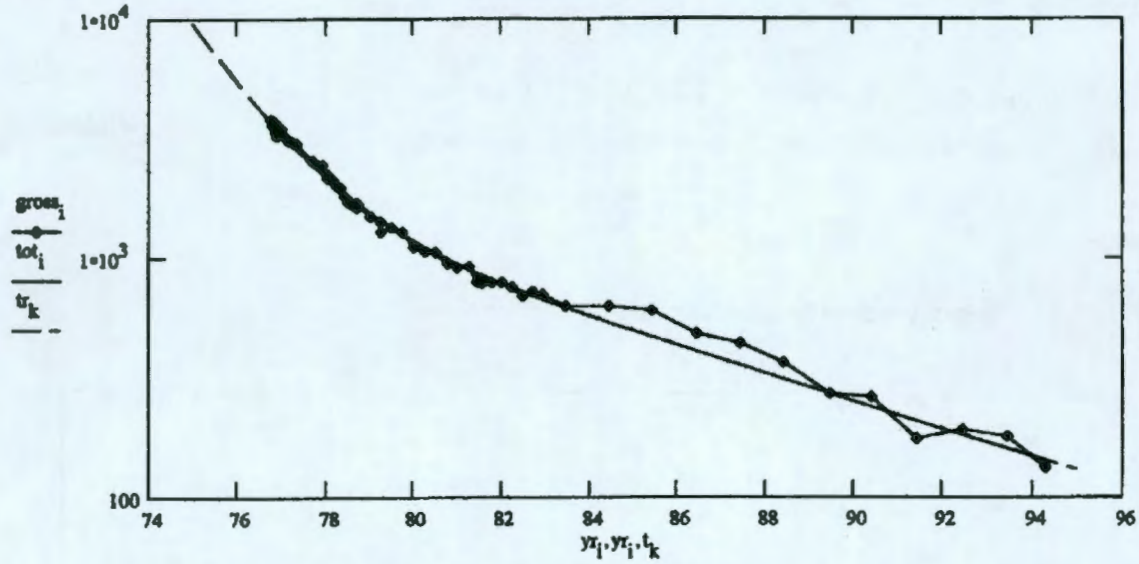
$Co_i := \alpha co \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad tot_i := Co_i + Cs_i$

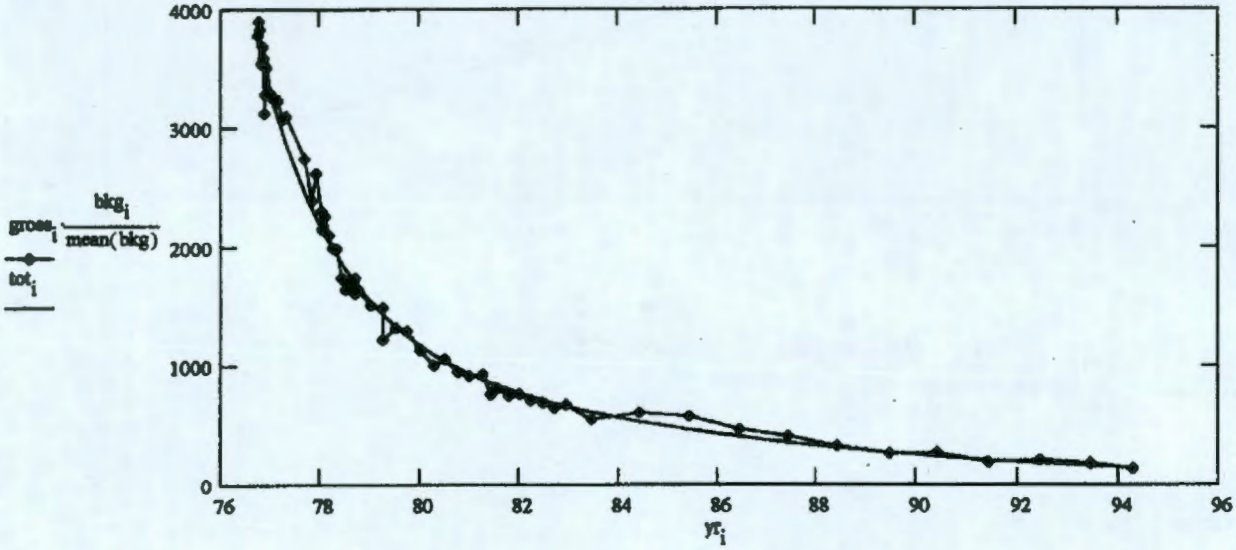
$\frac{Eu_N}{Co_N} = 0$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop64-72.txt"}) := out$

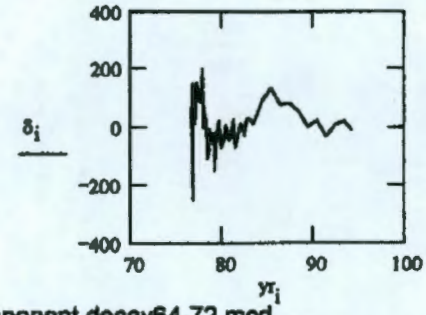
$k := 0..100$ $\quad t_k := 75 + \frac{k}{100} \cdot 20$ $\quad tr_k := \alpha co \cdot e^{-(t_k - 75)\cdot\frac{\ln(2)}{\tau co}} + \alpha cs \cdot e^{-(t_k - 75)\cdot\frac{\ln(2)}{\tau cs}}$

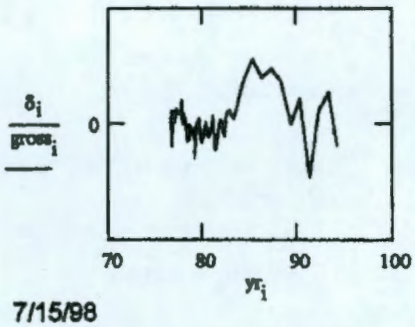
$out^{<0>} := t$ $\quad out^{<1>} := tr$ $\quad$ WRITEPRN("twop64-72.txt") := out

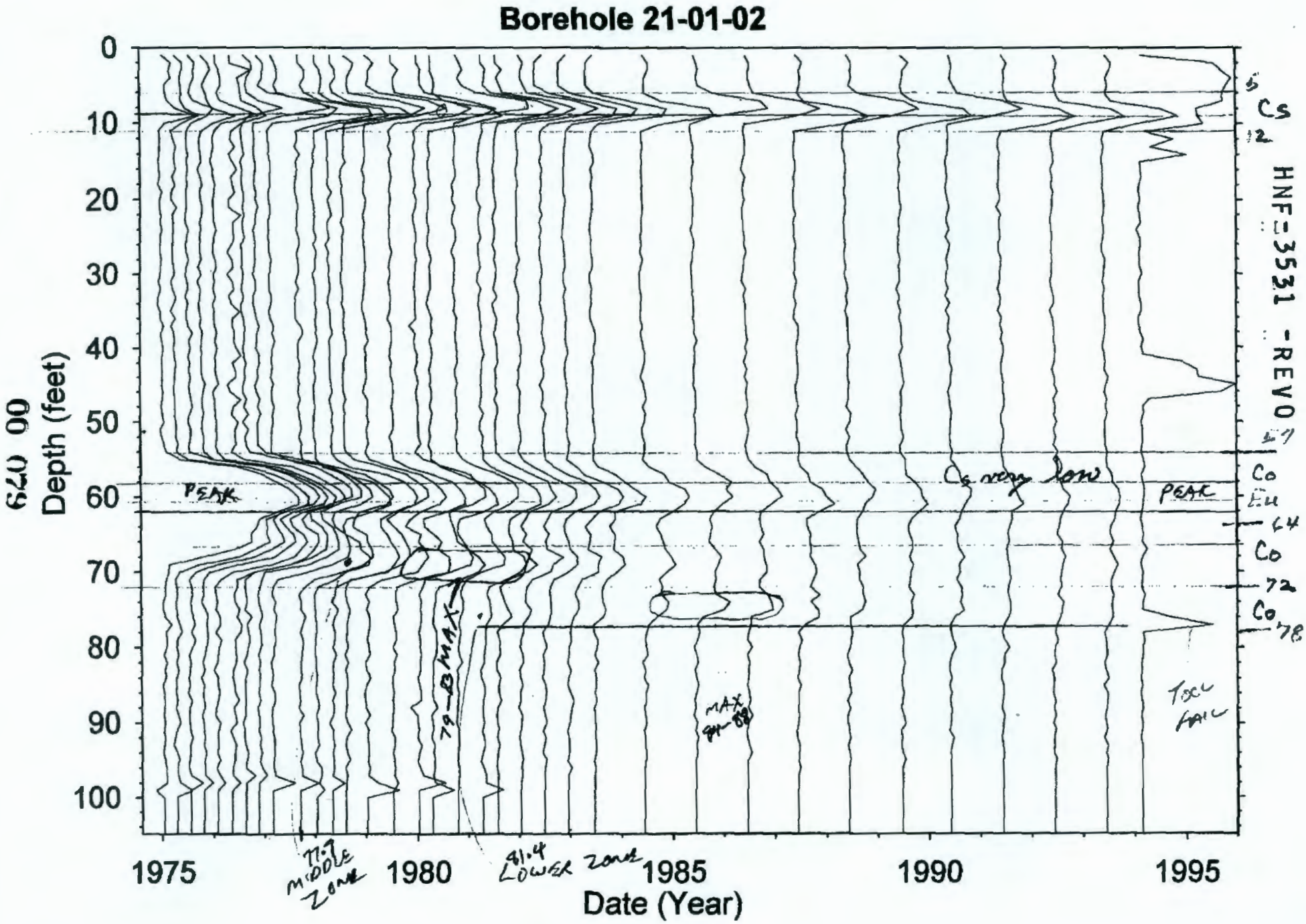




$\delta_i := gross_i - tot_i$ $\qquad \delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$






Borehole 21-01-02
Depth (feet)
Date (Year)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
PEAK
79-B MAX
MAX 91-92
Cs very low
PEAK
TOC FALL
77.7 MIDDLE ZONE
81.4 LOWER ZONE
Cs
Co
Eu
Co
Co
HNF-3531 -REV0

Borehole 21-02-01

Contamination (Cs-137) from 0-5 feet is Tank Farms Activity
Contamination (Cs-137) from 5-10 feet is Stable

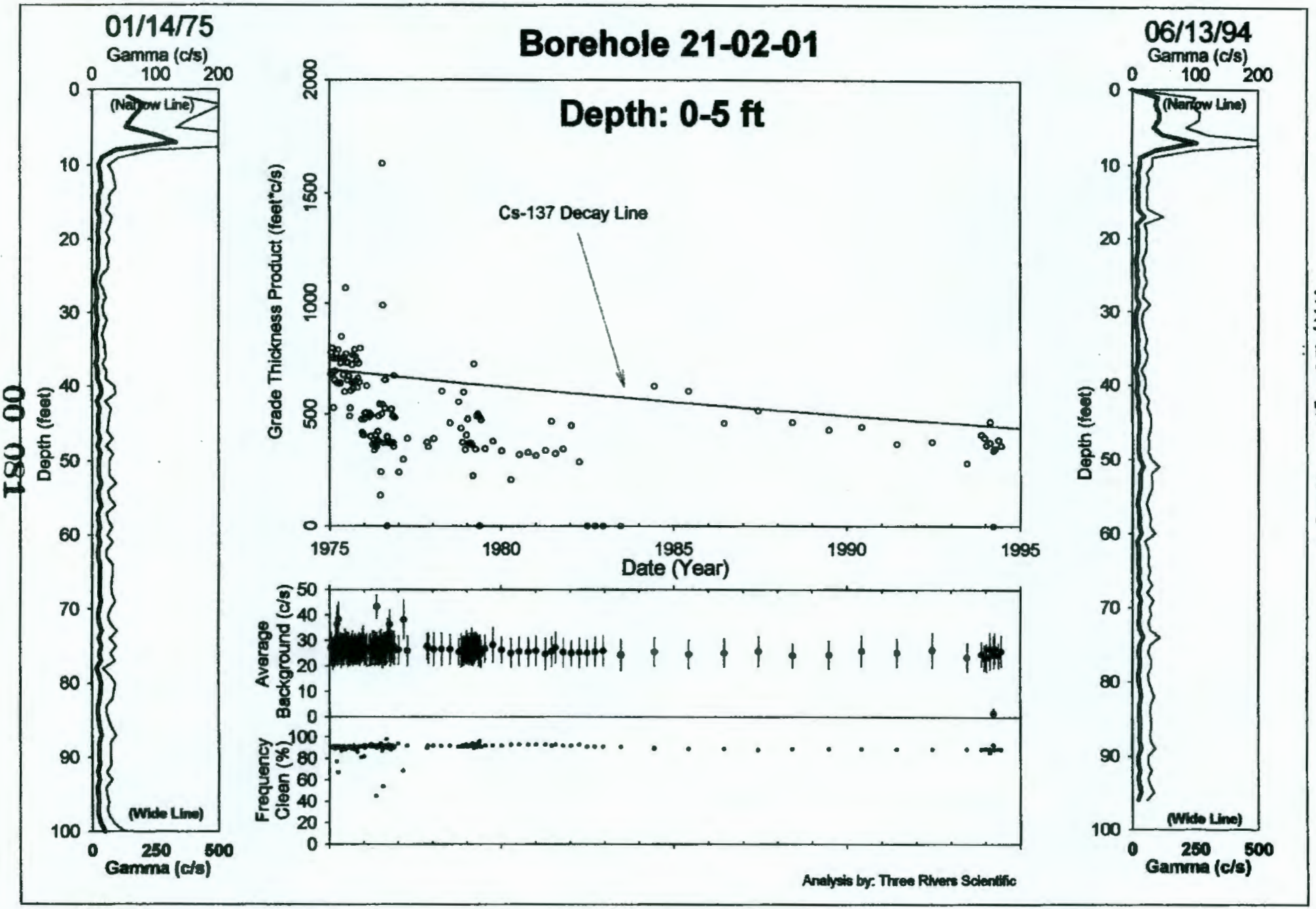
Grade thickness product from 0 to 5 feet has the characteristic signature of very rapid changes indicative of tank farm activities such as transfer lines close to surface and this borehole.
Grade thickness product from 5 to 10 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1994.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	159

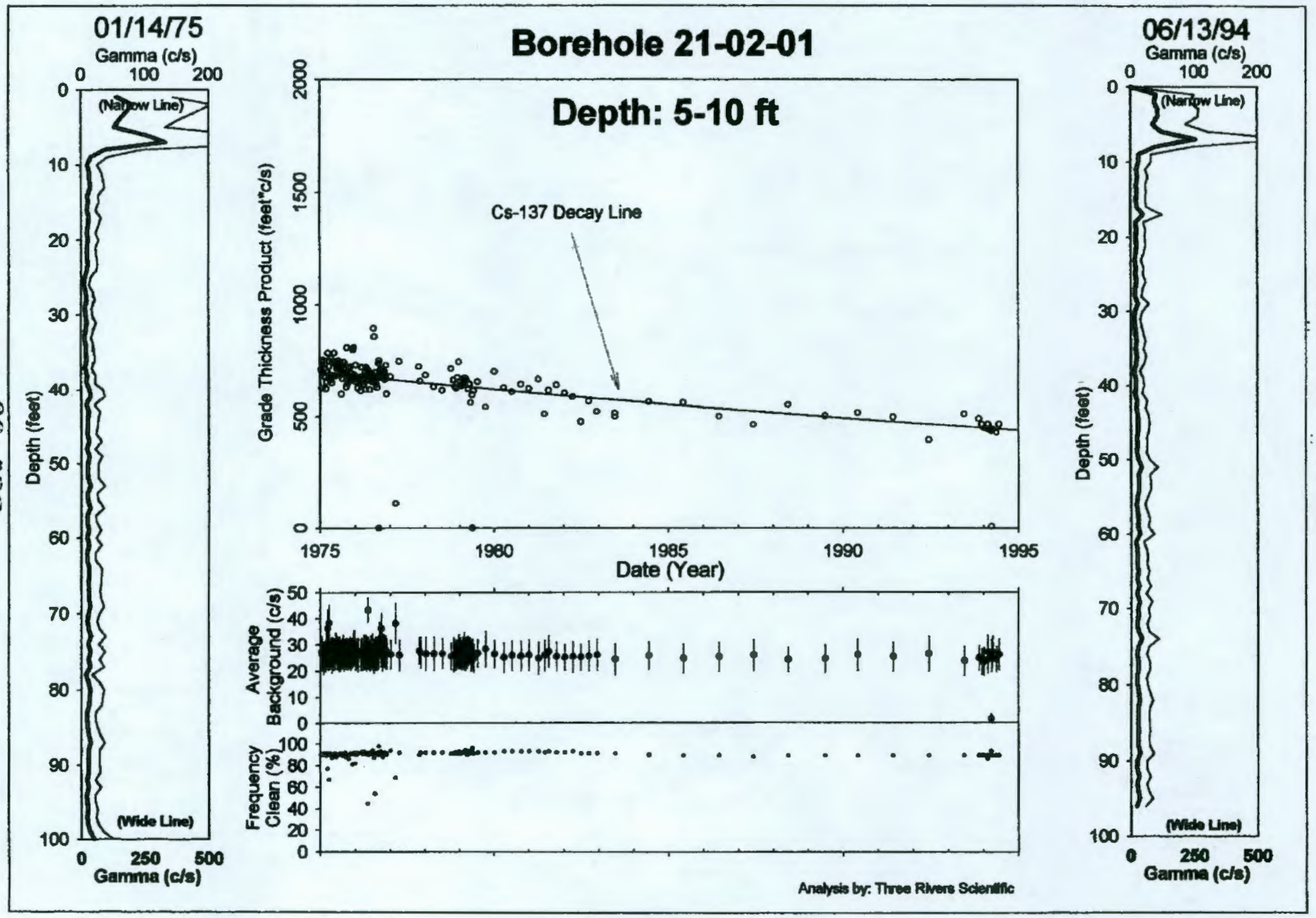
Analysis Notes

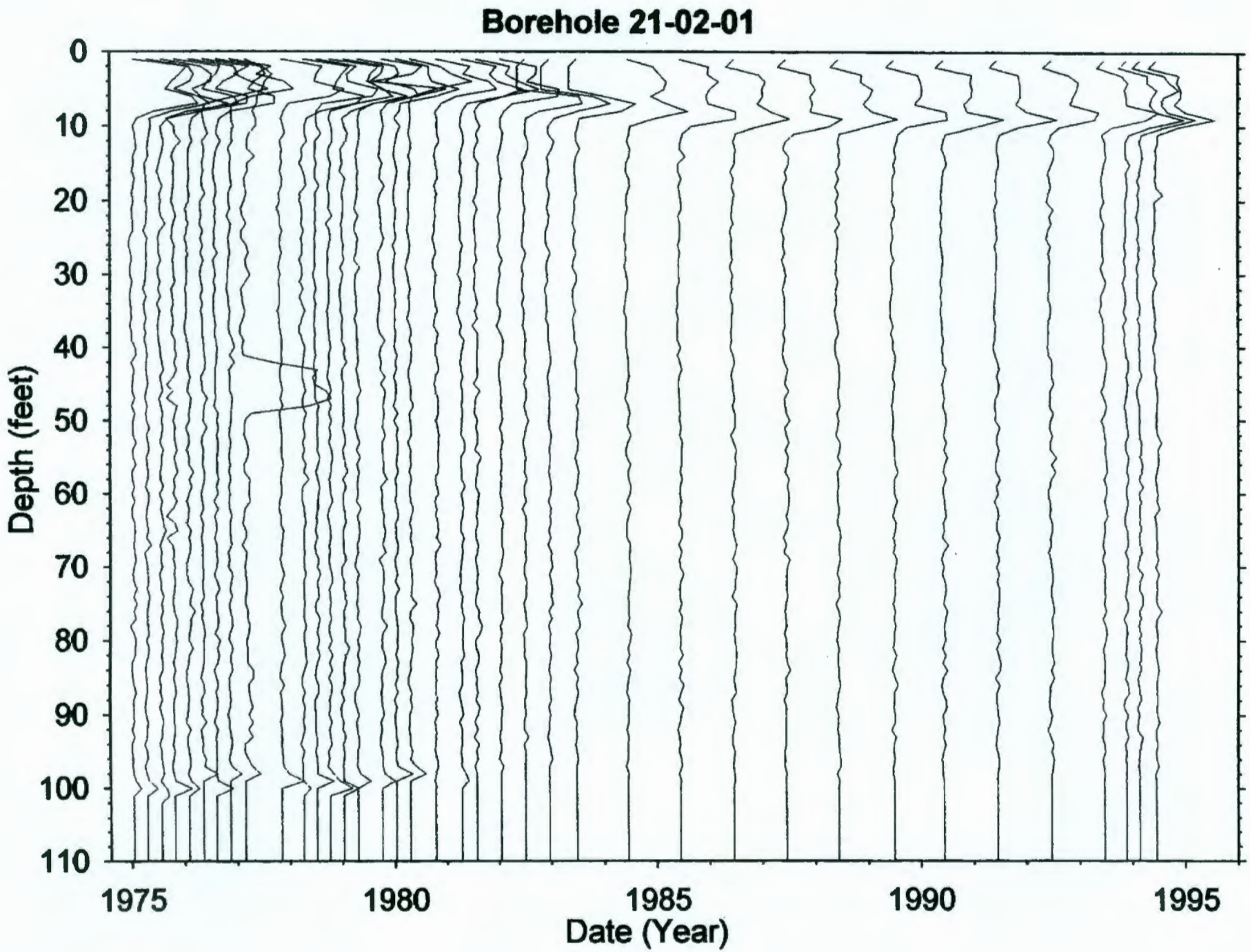
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-5 Tank Farm Activities 5-10 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



HNF-3531 -REV0

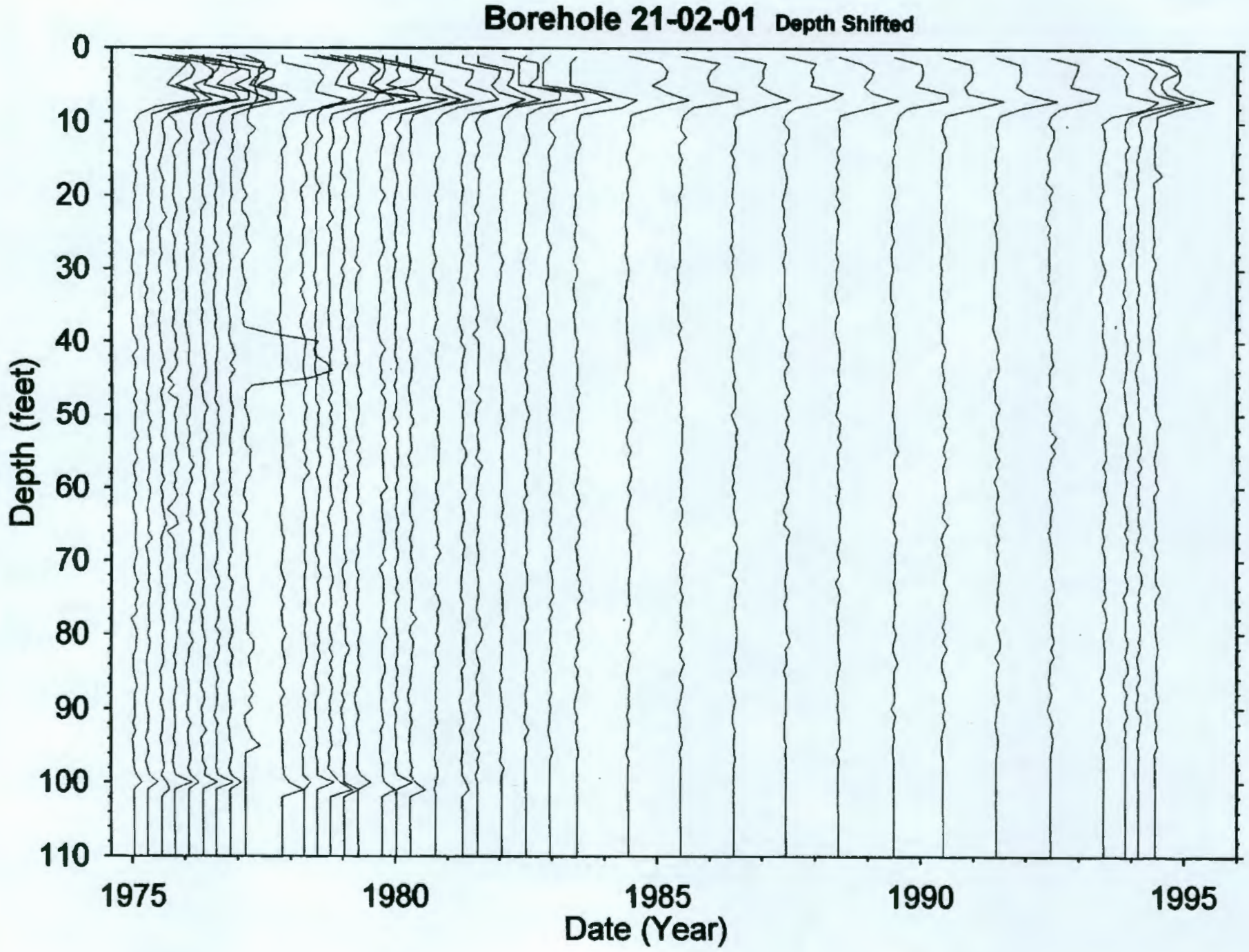
00 031


Borehole 21-02-01
Depth: 5-10 ft
01/14/75
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/13/94
Analysis by: Three Rivers Scientific



HNF-3531 -REV 0

00 083


Borehole 21-02-01 Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-02-01 Total # Surveys 163 Probe Type 04

neutron surveys 4 # GR Surveys 159

Log Date: 1-14-95 1st 6-13-94 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): ~~2-5~~ (2-5) & 5-10

Isotope from Spectral Survey: Cs Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

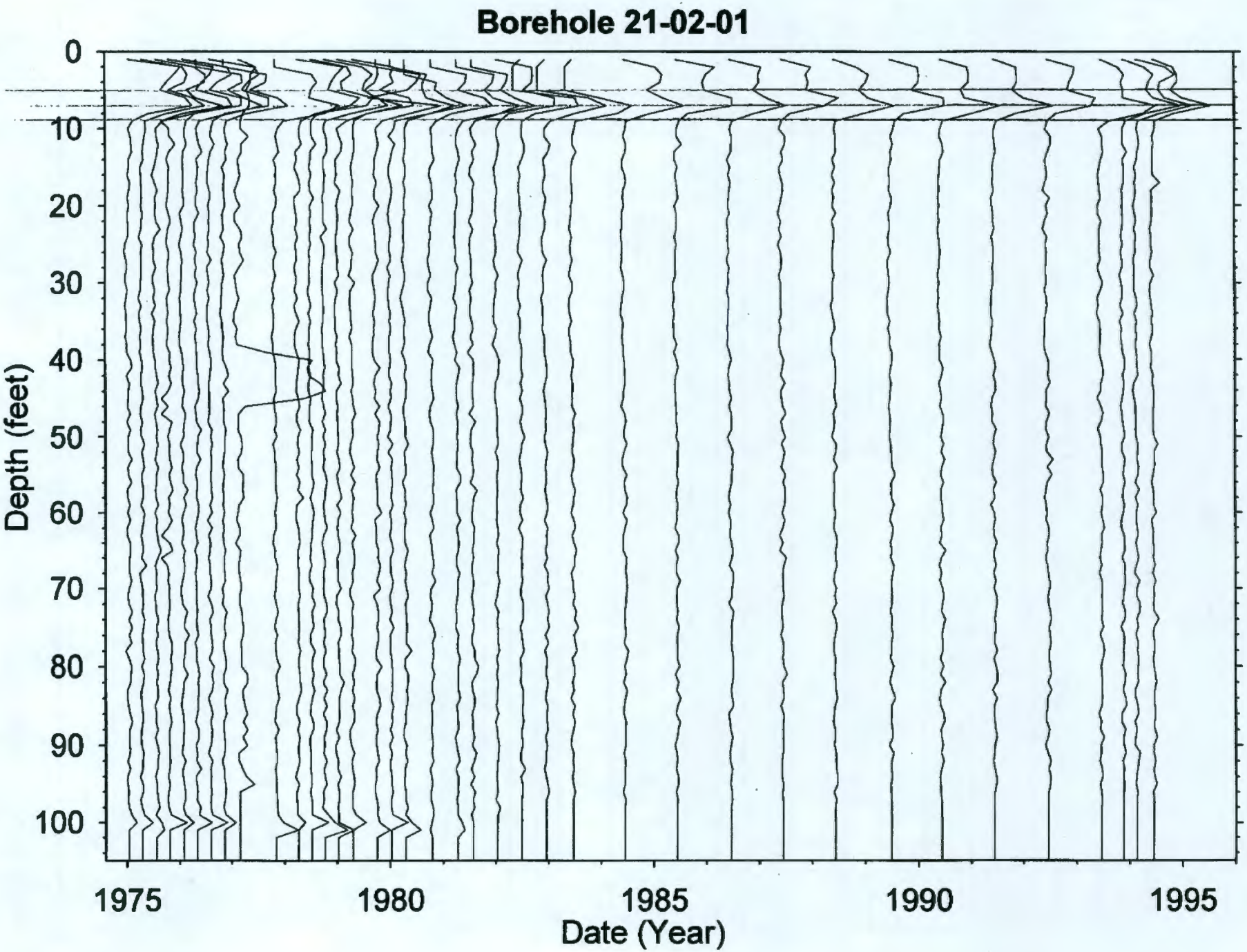
BackGnd.Txt

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

Analysis Notes

Depth at surface may be problem in negotiated road STAFF Auto

Analyst Name [illegible] S/W ver TFGROS 2.2



980 00

HNF-3531 -REV0

Borehole 21-02-03

Contamination (Cs-137) from 36-42 feet is Stable
Contamination (Sb-125 & U238/235) from 70-75 feet is Stable
Contamination (Sb-125 & U238/235) from 80-86 feet is Stable
Contamination (Sb-125 & Co-60 & U238/235) from 86-95 feet is Stable

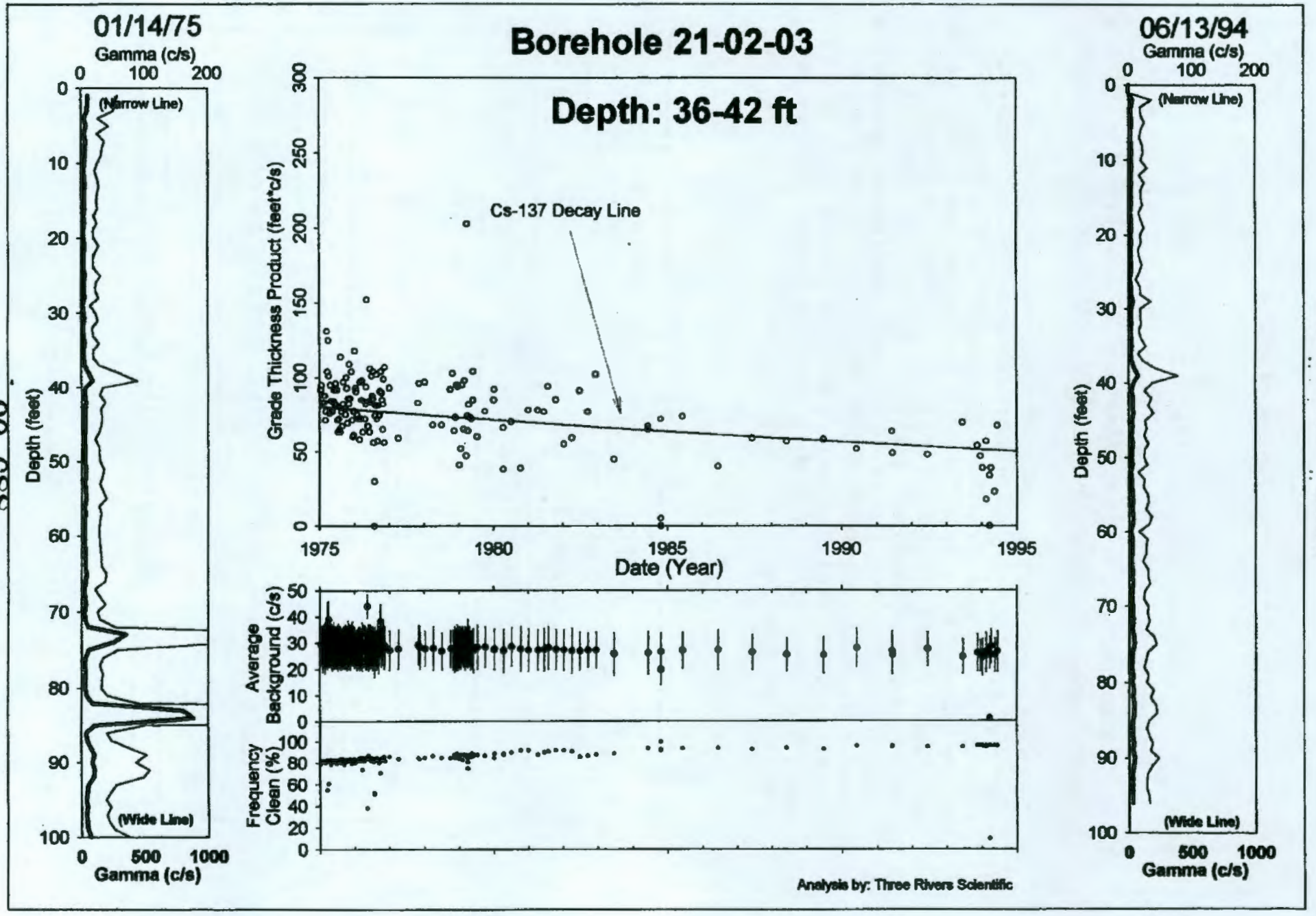
Grade thickness product from 36 to 42 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1994. Grade thickness product from 70 to 75 feet is decreasing consistent with a least squares fit for Sb-125 (hypothesis) and U-238/235 (HPGe identified) from 1975 to 1994. The least squares fit results in gross gamma contribution ratio of U-238/235 to Sb-125 of 0.068 as of Jan 1975. Grade thickness product from 80 to 86 feet is decreasing consistent with a least squares fit for Sb-125 (HPGe identified) and U-238/235 (HPGe identified) from 1975 to 1994. The least squares fit results in gross gamma contribution ratio of U-238/235 to Sb-125 of 0.020 as of Jan 1975. Grade thickness product from 86 to 95 feet is decreasing consistent with a least squares fit for Sb-125 (hypothesis), Co-60 (HPGe identified) and U-238/235 (HPGe identified) from 1975 to 1994. The least squares fit results in gross gamma contribution relation of Sb:Co:U of 291:80:41 as of Jan 1975.

Gross Gamma Survey Information

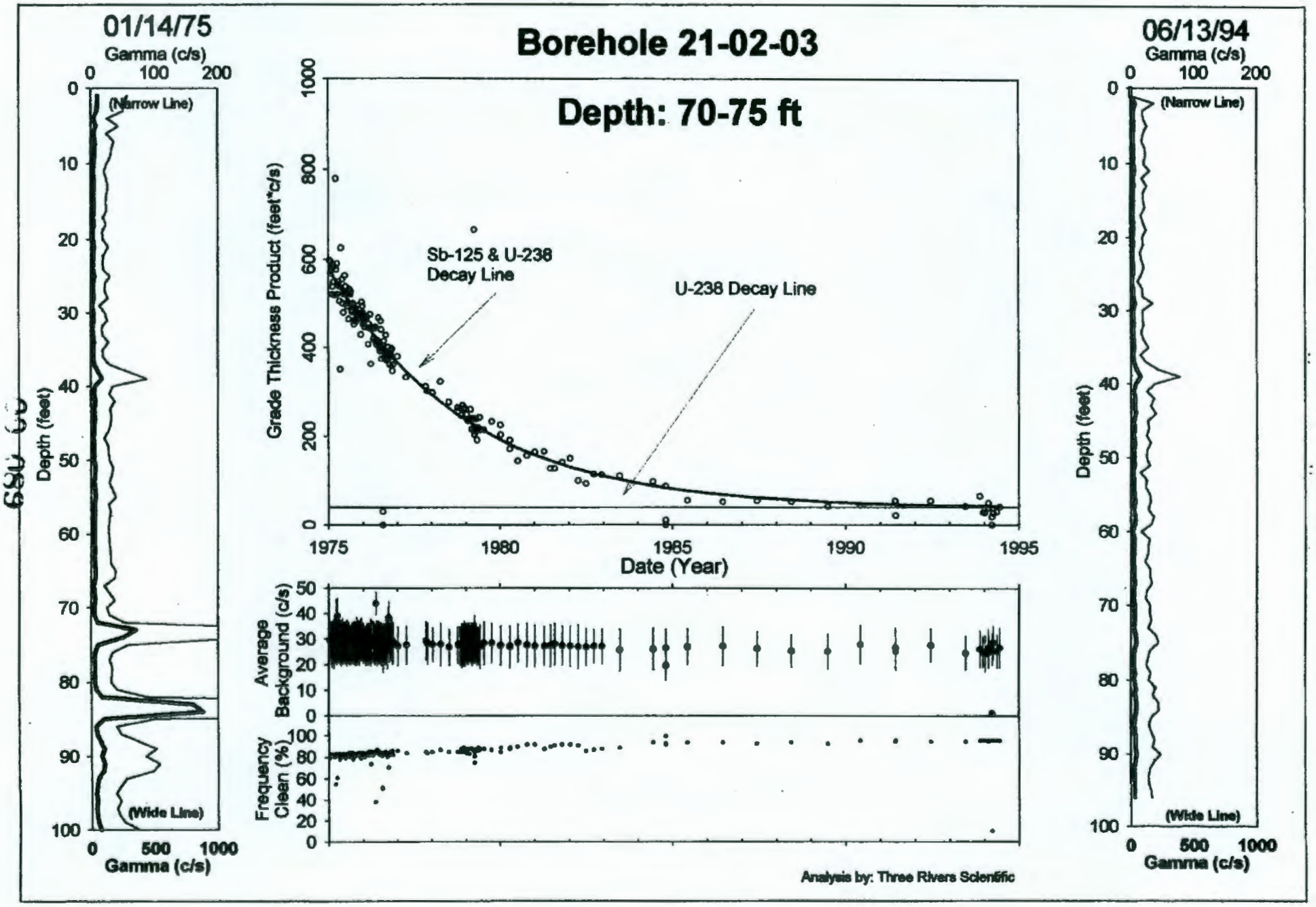
Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	169

Analysis Notes

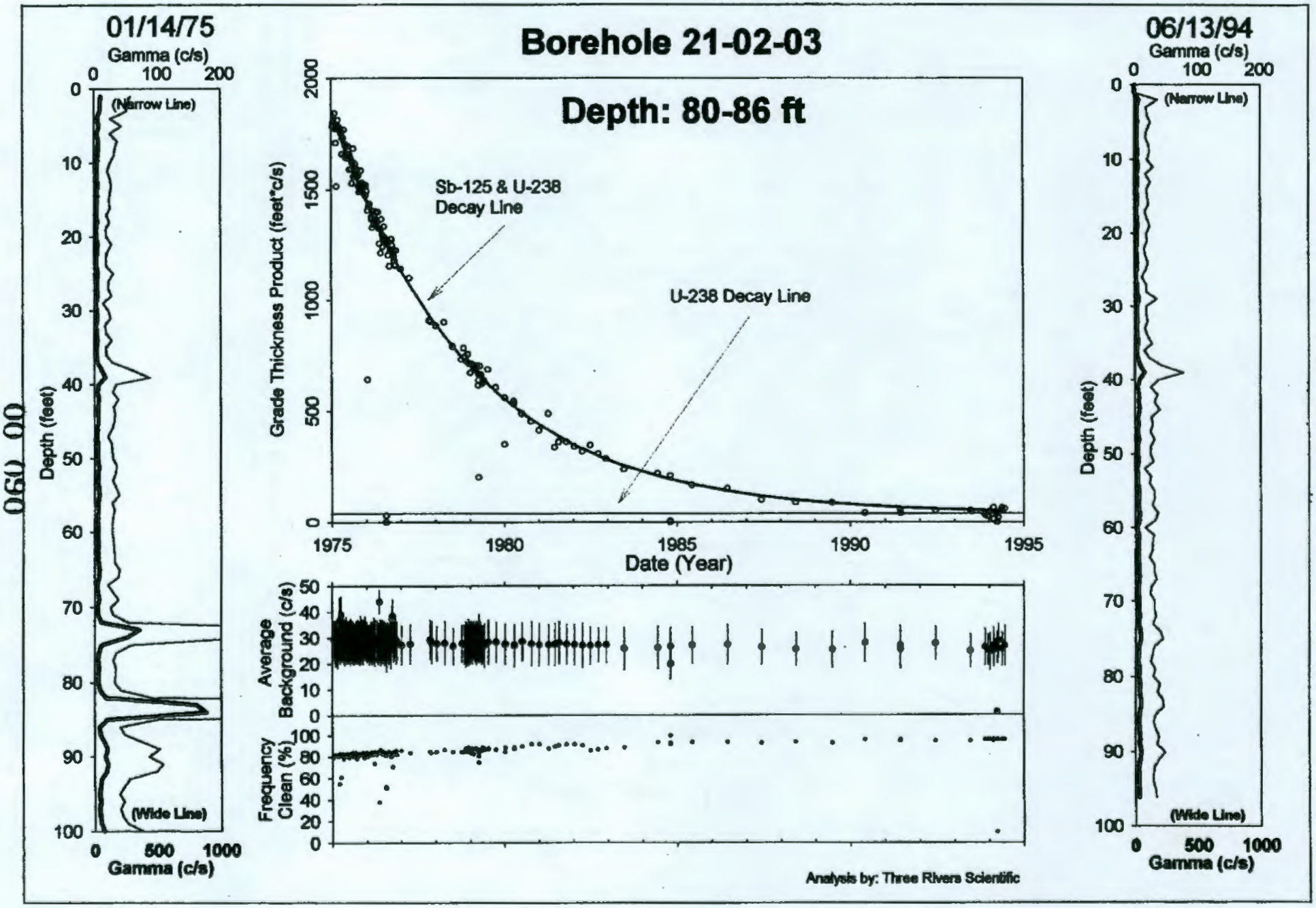
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	36-42, 70-75, 80-86, & 86-95 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



HNF-3531 -REV0

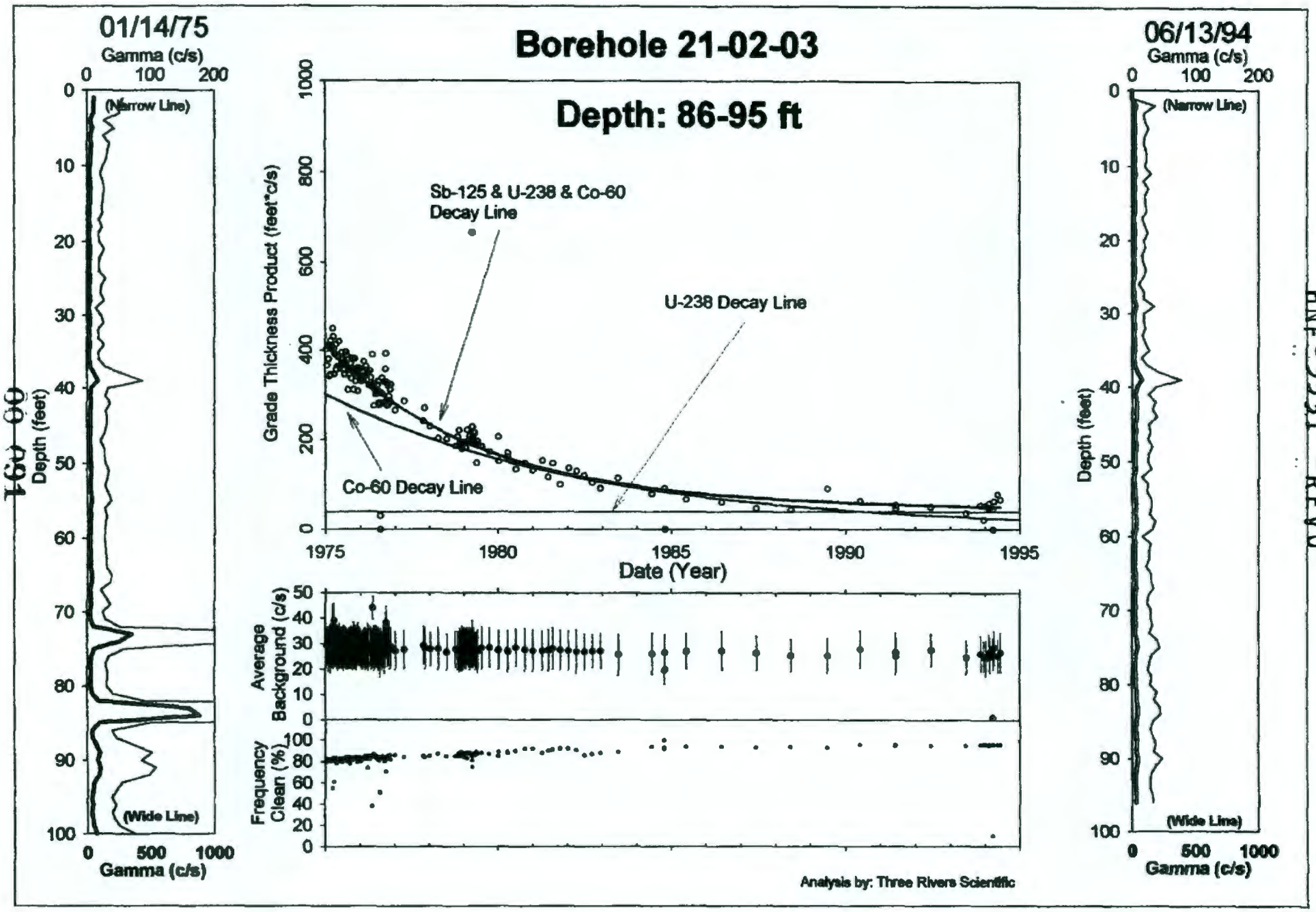


HNF-3531 -REV0

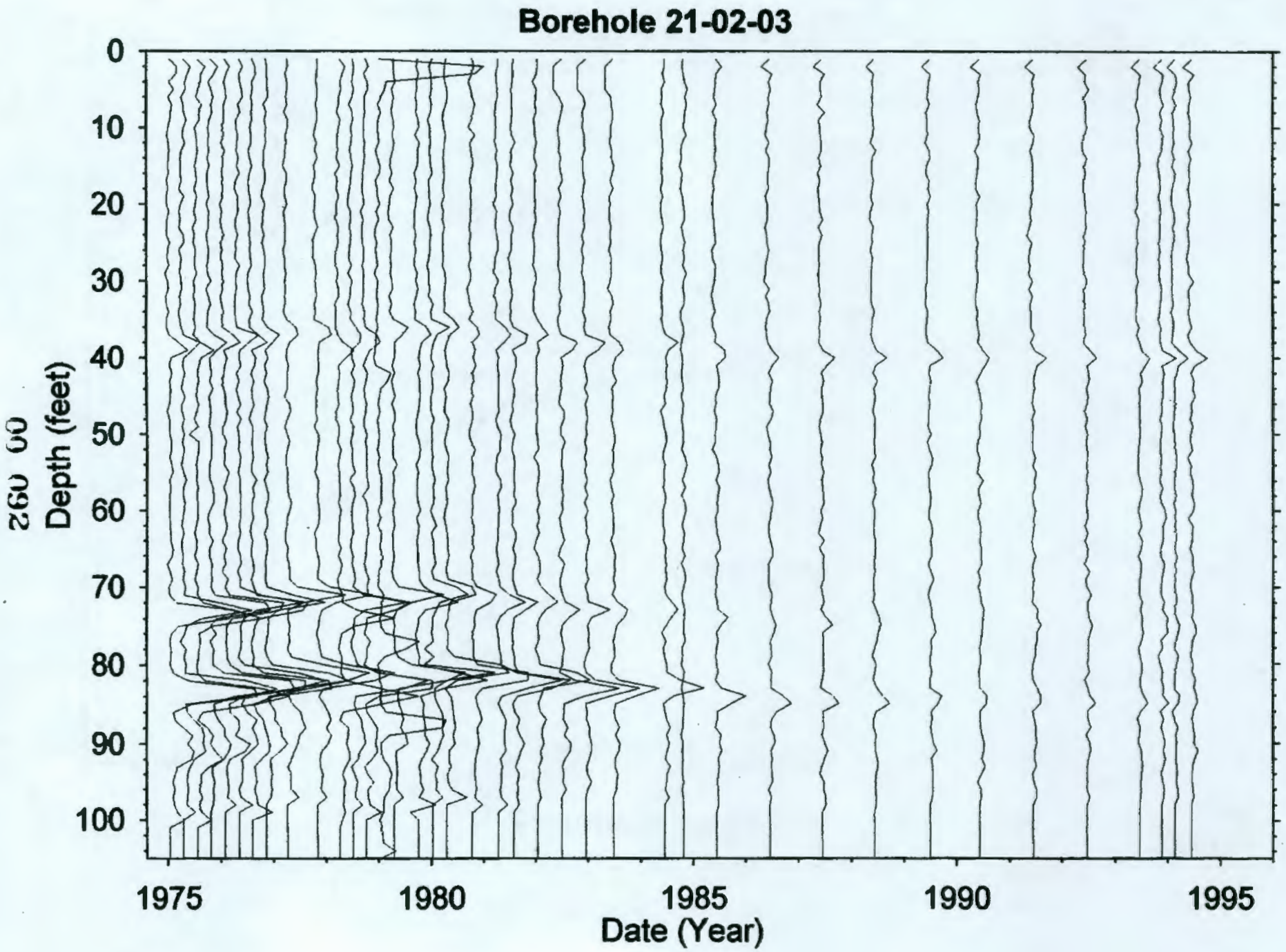


HNF-3531 -REV0

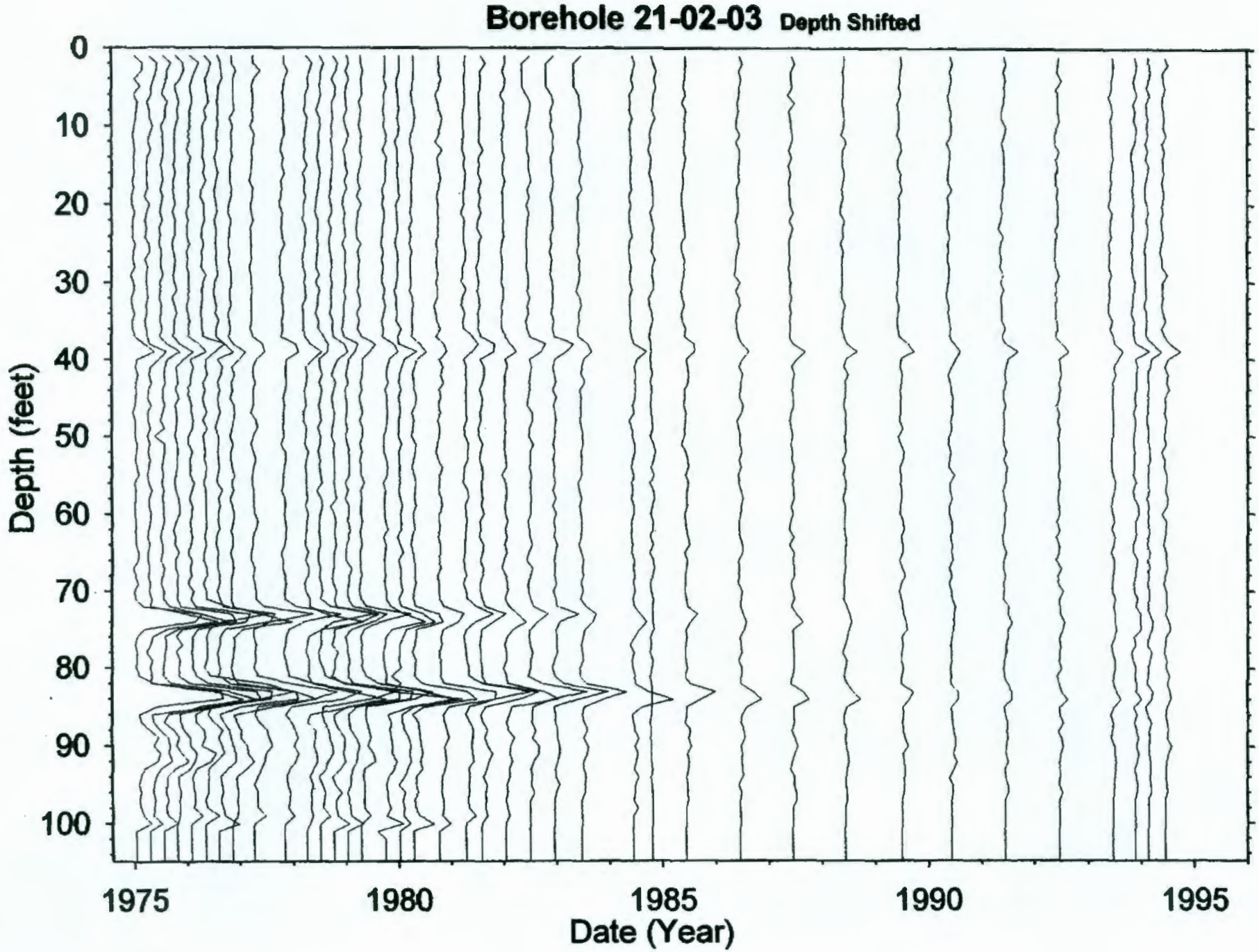
060 00



HNF-3531 -REV0



HNF-3531 -REV 0



HNF-3531 -REV0

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole BX 21-02-03 | Total # Surveys 172 | Probe Type 04
neutron surveys 3 | # GR Surveys 169

Log Date: 1-14-75 1st | 6-13-94 Last | Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs Co Ni's Sb | Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

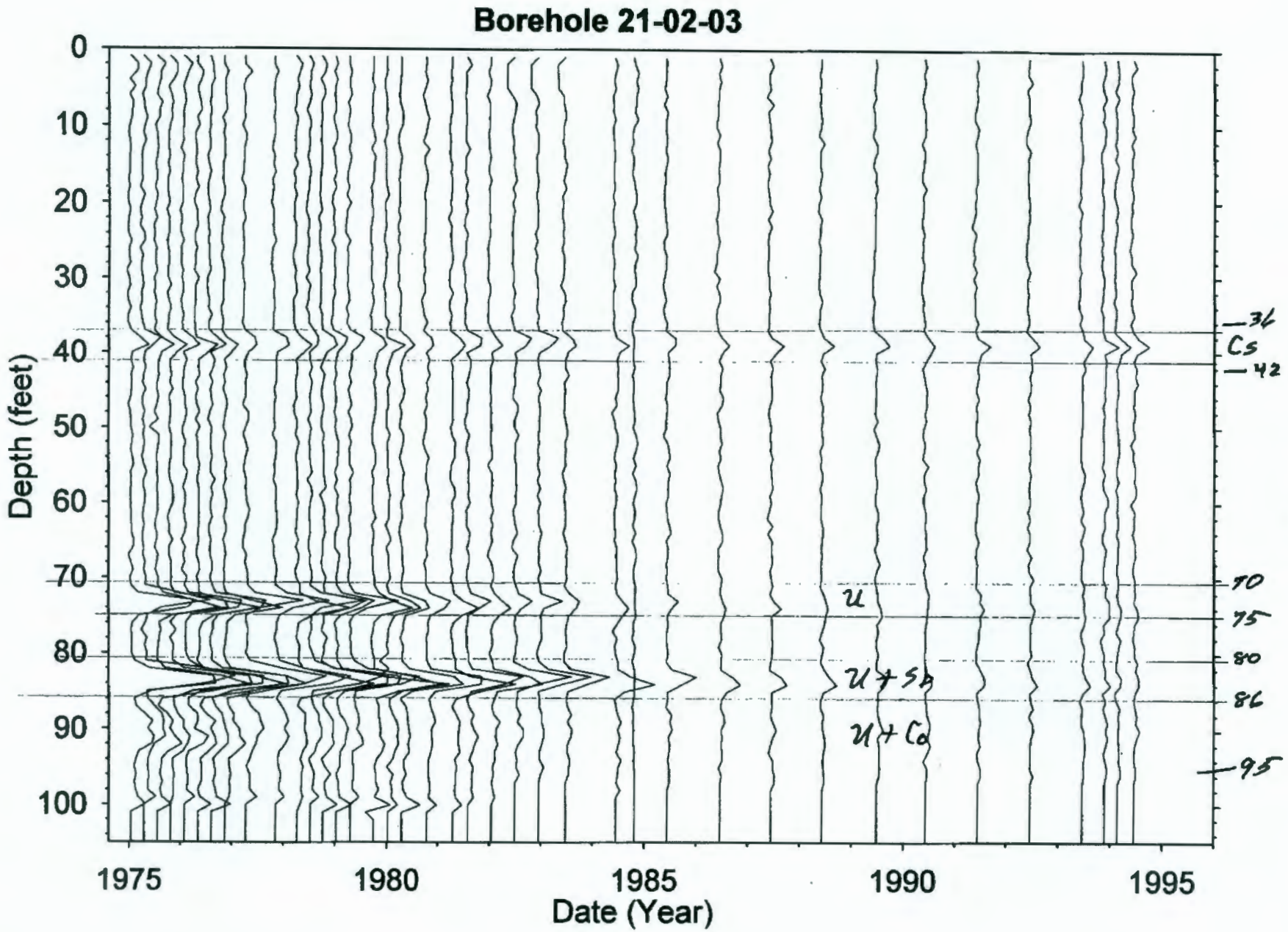
BackGnd.Txt

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

Analysis Notes

Rapid Changes in Cs @ 40' may be real based on other zones well behaved with some inst. & Co's good.
Sb detected & SGLS not in 70-75 & 86-95 SGLS does show Sb in 75-80 Ni now showing at threshold

Analyst Name Rmc | S/W ver TFGROSS 2.2



HNF-3531 -REV0

filein := "two70-75.txt" **Well 21-02-03**

$A := READPRN(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 157$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 2.77$

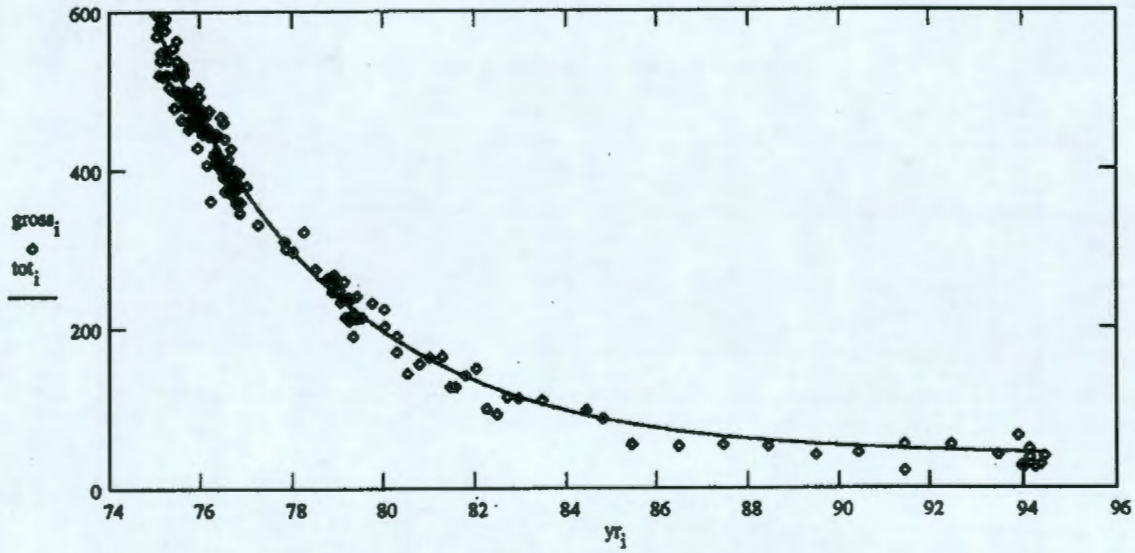
$\tau co := 5.27$ $\quad \tau cs := 4.7 \cdot 10^9$ $\quad aco := 00$ $\quad acs := 40$

Eu variables are Sb-125 $\quad aeu := 550$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



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

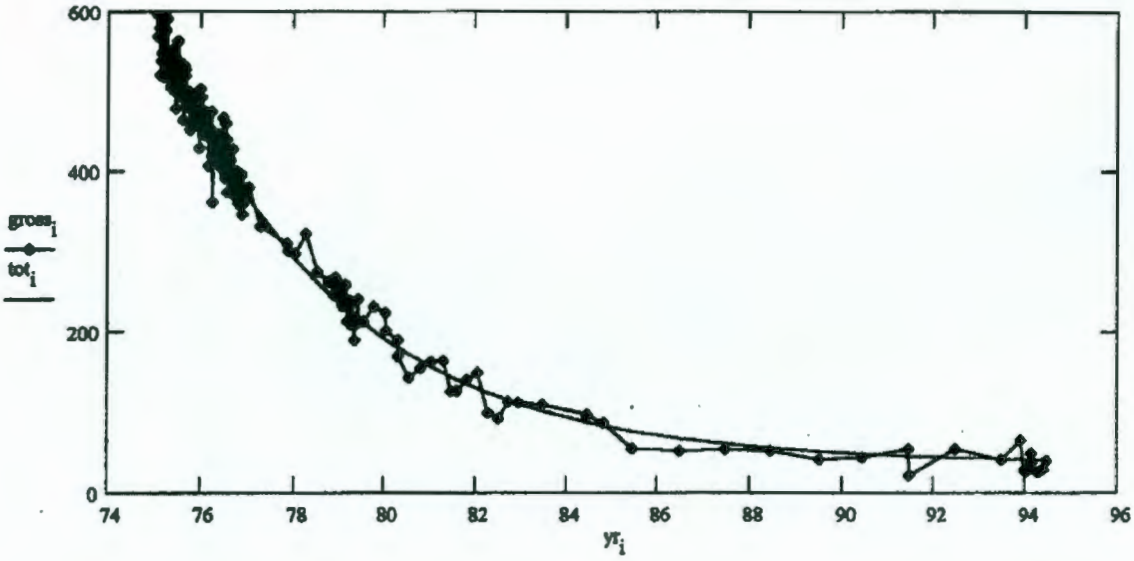
Given

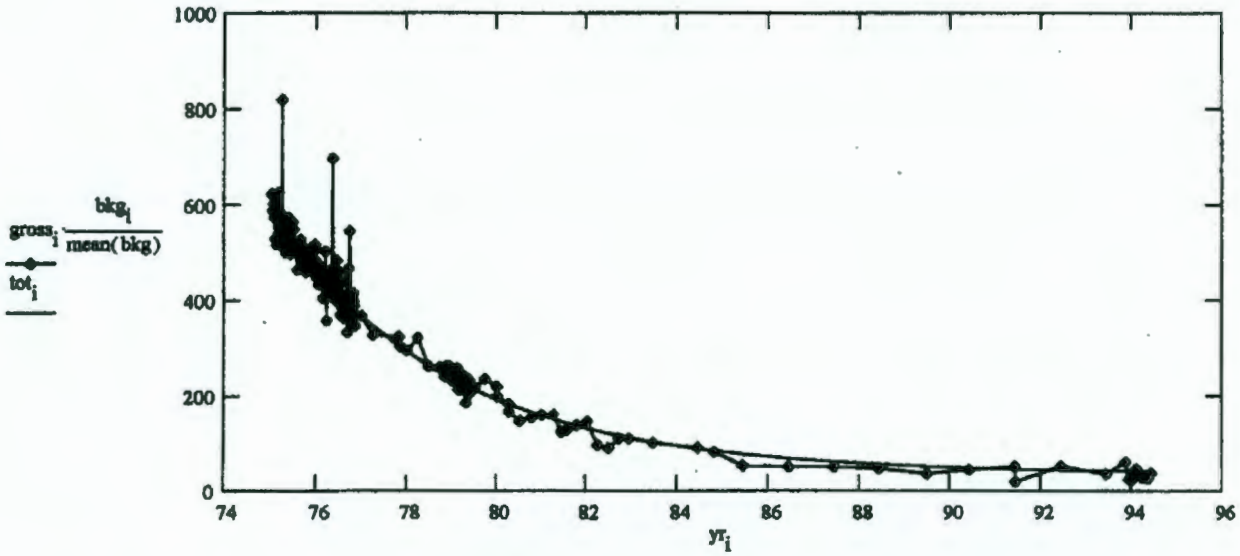
$ssq(acs, aeu) = 0$ $\quad 1 = 1$

$\begin{bmatrix} \alpha cs \\ \alpha eu \end{bmatrix} := Minerr(acs, aeu)$ $\quad \alpha cs = 36.937$ $\quad \alpha eu = 545.202$

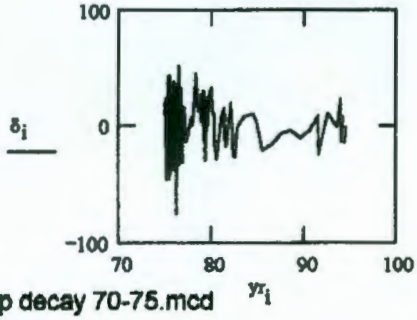
$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Cs_i + Eu_i$ $\quad \frac{\alpha cs}{\alpha eu} = 0.068$

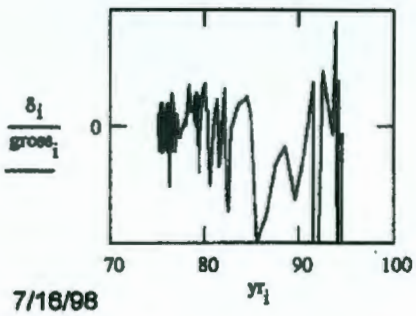
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad WRITEPRN(\text{"twop70-75.txt"}) := out$ $\quad \frac{Eu_N}{Cs_N} = 0.114$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





filein := "two80-86.txt" **Well 21-02-03**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 159$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 2.77$

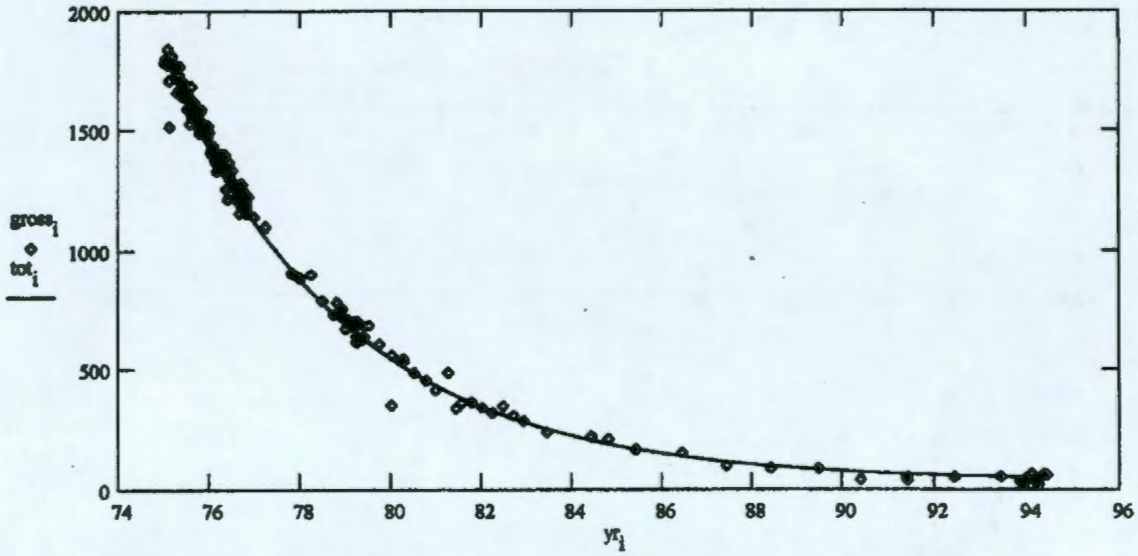
$\tau co := 5.27$ $\quad \tau cs := 4.7 \cdot 10^9$ $\quad aco := 00$ $\quad acs := 35$

Eu variables are Sb-125 $\quad aeu := 1800$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aeu) = 0$ $\quad 1 = 1$

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

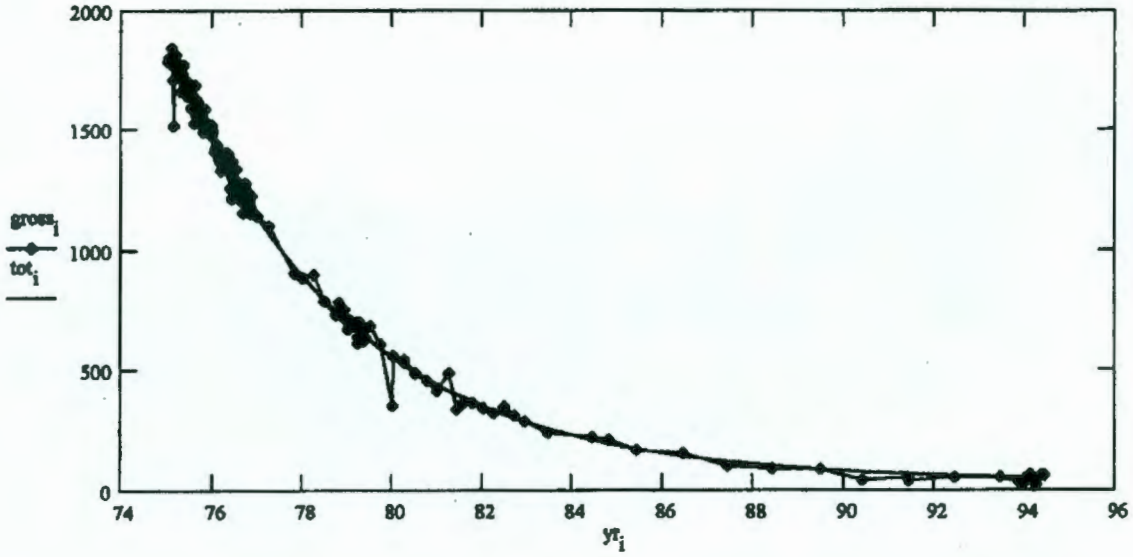
$\alpha cs = 37.091$ $\quad \alpha eu = 1.825 \cdot 10^3$

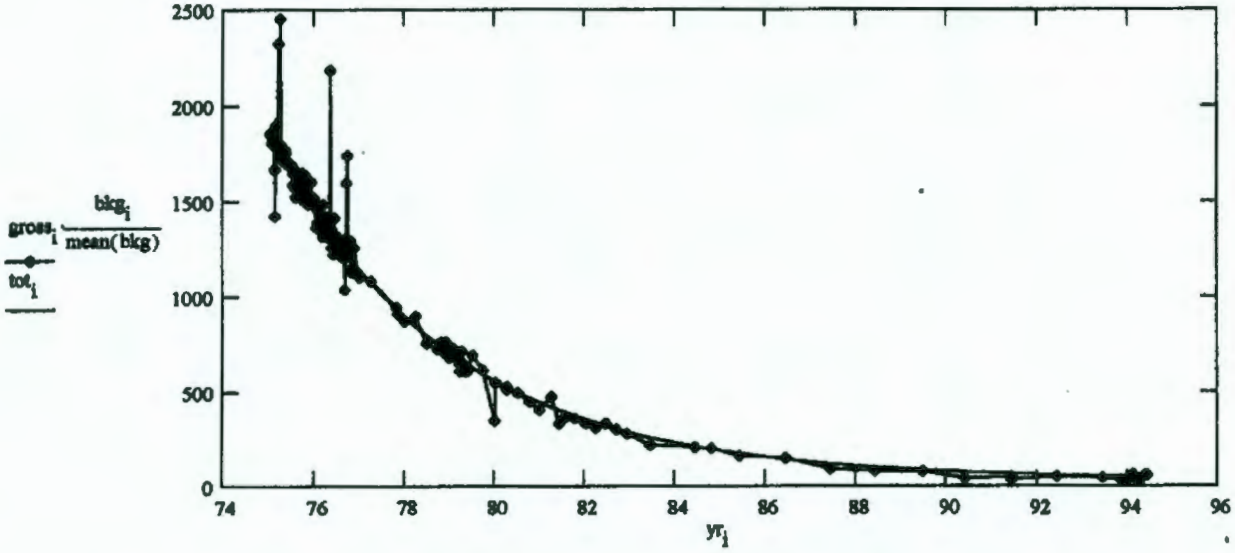
$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Cs_i + Eu_i$

$\frac{\alpha cs}{\alpha eu} = 0.02$

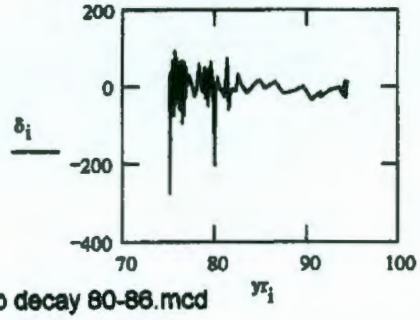
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop80-86.txt"}) := out$

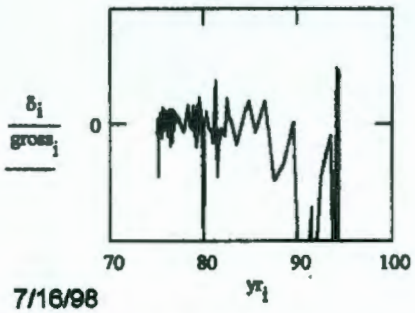
$\frac{Eu_N}{Cs_N} = 0.379$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





filein := "two86-95.txt" **Well 21-02-03**

$A := READPRN(filein)$ $yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

$N := last(yr)$ $N = 161$ $i := 0..N$ $k := 0..300$ $j := 0..299$ $\tau eu := 2.77$

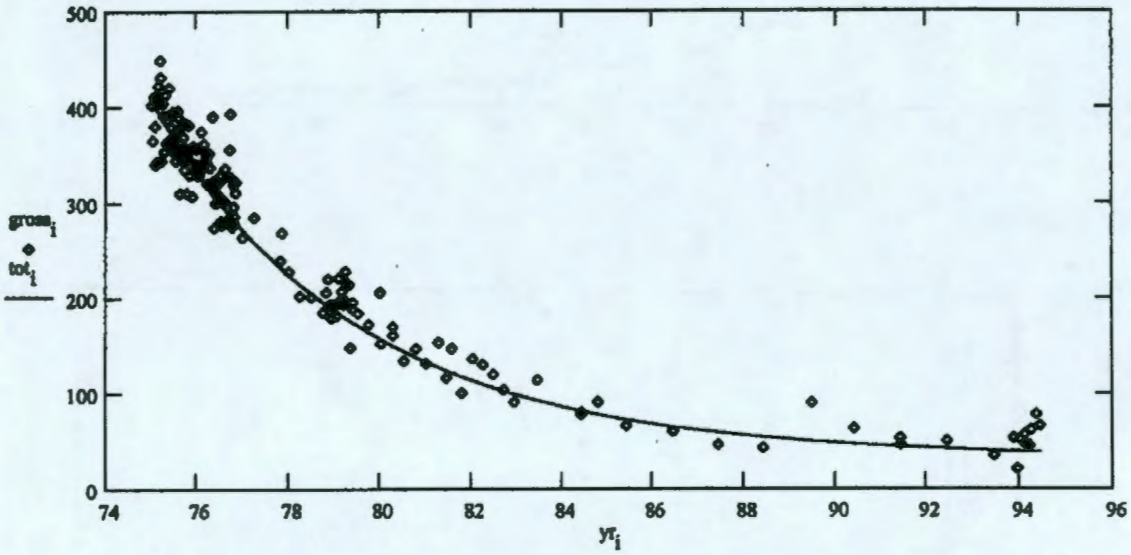
$\tau co := 5.27$ $\tau cs := 4.7 \cdot 10^9$ $aco := 80$ $acs := 30$

Eu variables are Sb-125 $aeu := 300$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $tot_i := Cs_i + Eu_i + C$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aeu, aco) = 0$ $1 = 1$ $2 = 2$

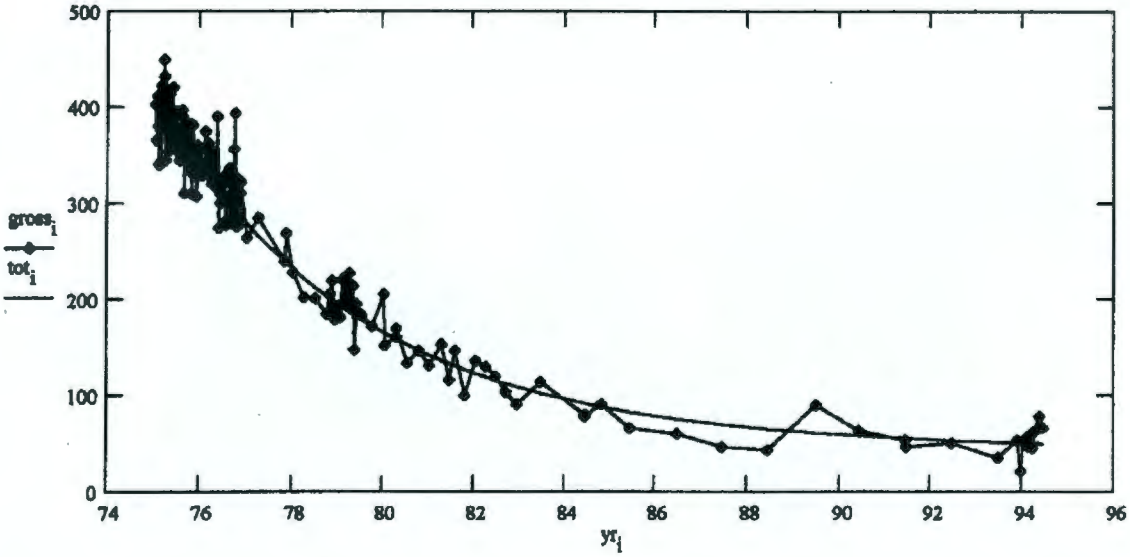
$$\begin{bmatrix} \alpha cs \\ \alpha eu \\ \alpha co \end{bmatrix} := Minerr(acs, aeu, aco)$$

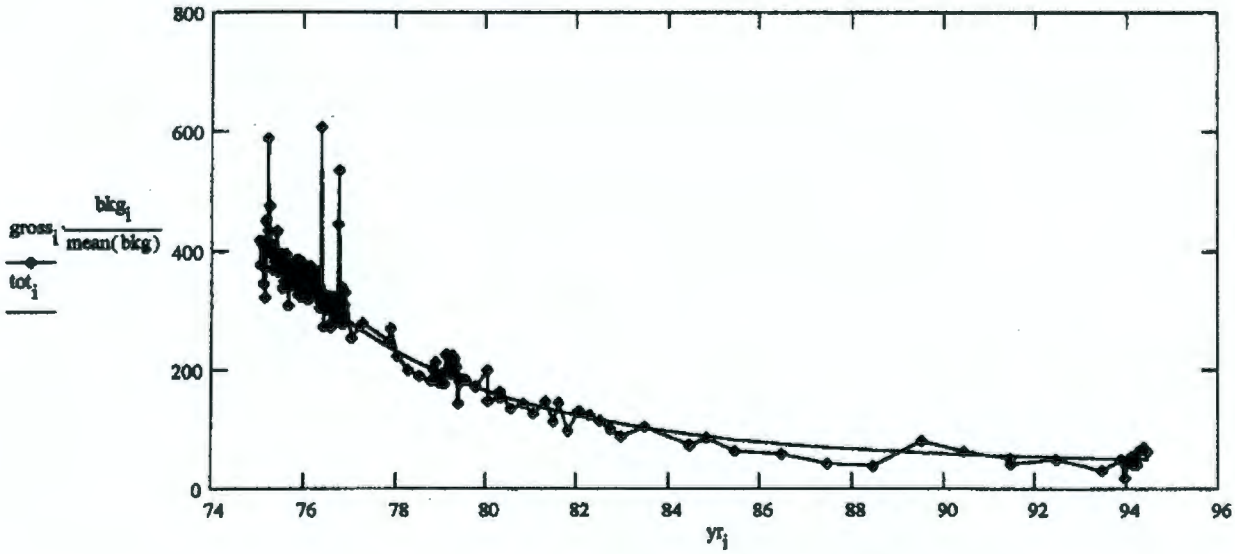
$\alpha cs = 41.212$ U-238 $\alpha eu = 291.286$ Sb-125 $aco = 80$ Co-60

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\frac{\alpha cs}{\alpha eu} = 0.141$

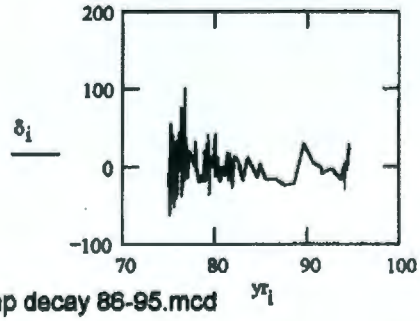
$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $tot_i := Cs_i + Eu_i + Co_i$ $\frac{Eu_N}{Cs_N} = 0.054$

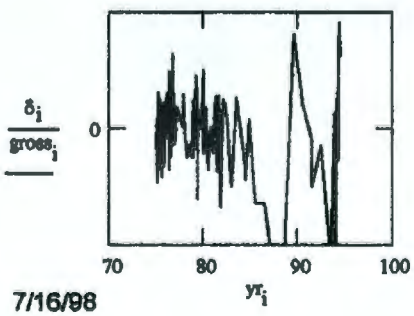
$out^{<0>} := yr$ $out^{<1>} := tot$ $WRITEPRN("twop86-95.txt") := out$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





Borehole 21-02-04

Contamination (Cs-137) from 0-8 feet is Stable
Contamination (Cs-137) from 8-15 feet is Stable
Contamination (Cs-137) from 29-38 feet is Stable
Contamination (Cs-137) from 38-62 feet is Stable
Contamination (Cs-137) from 62-74 feet is Stable
Contamination (Cs-137) from 74-84 feet is Stable
Contamination (Cs-137) from 84-110 feet is Stable
Contamination (Cs-137) from 125-134 feet is Stable
Contamination (Cs-137) from 134-144 feet is Stable
Contamination (Cs-137) from 144-148 feet is Stable

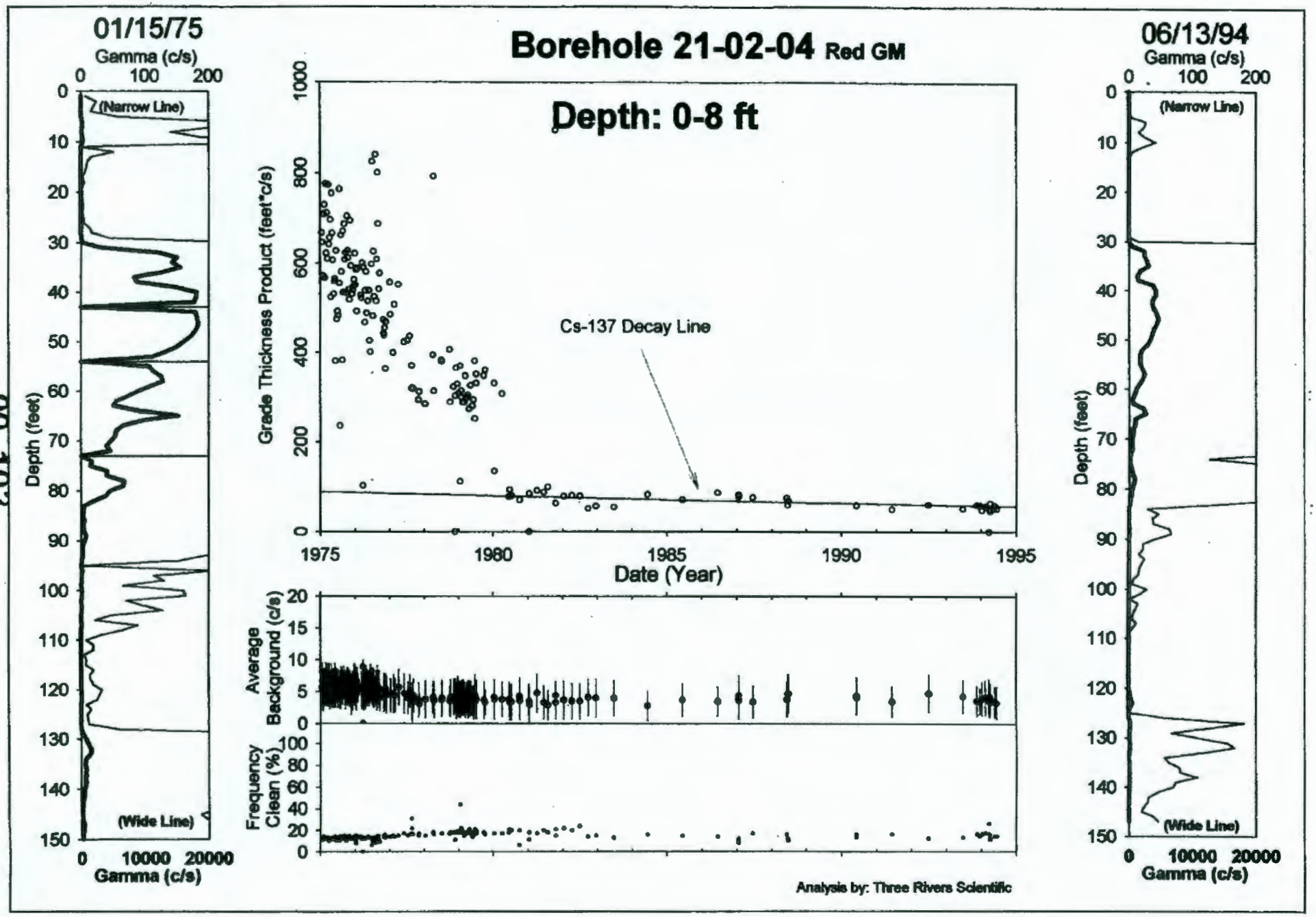
Grade thickness products for each of the intervals listed above exhibit the same historical character. Early stages of instrumentation development for the red GM resulted in calibration changes prior to mid 1980, but apparent consistency after this time. All zones exhibit decreases in grade thickness product consistent with Cs-137 (HPGe identified in zones below detector saturation) from mid 1980 to 1994. Note the reason for computing grade thickness products for discreet intervals within a contaminated zone is to analyze for possible downward migration.

Gross Gamma Survey Information

Probe Type :	02: Red GM
Other Probe Types :	04: NaI, 14: Shielded NaI
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	1/15/1975
Last Survey Date :	6/13/1994
Number Surveys :	181

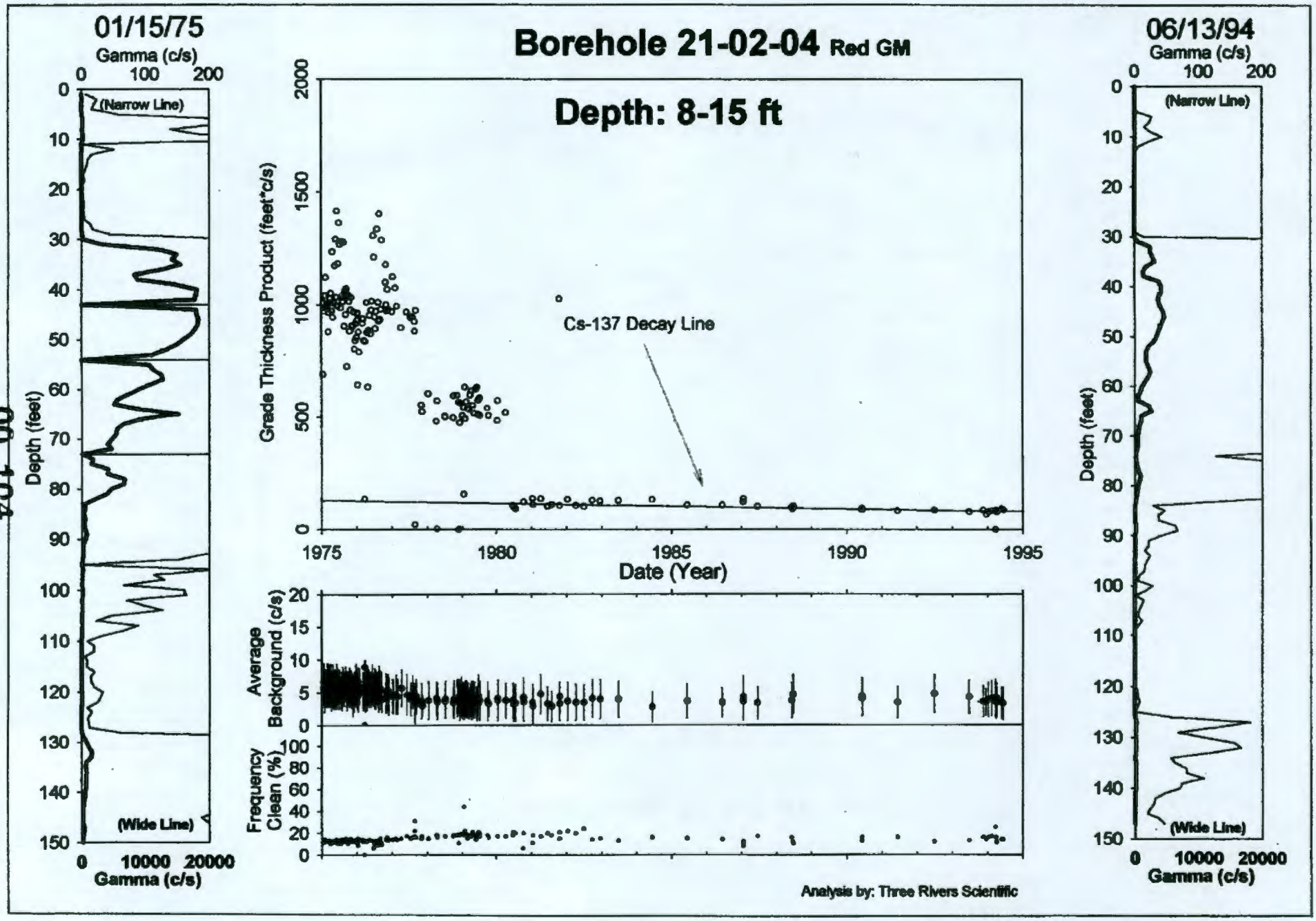
Analysis Notes

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, 8-15, 29-38, 38-62, 62-74, 74-84, 84-110, 125-134, 134-144, and 144-148 Stable 1980-1994	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



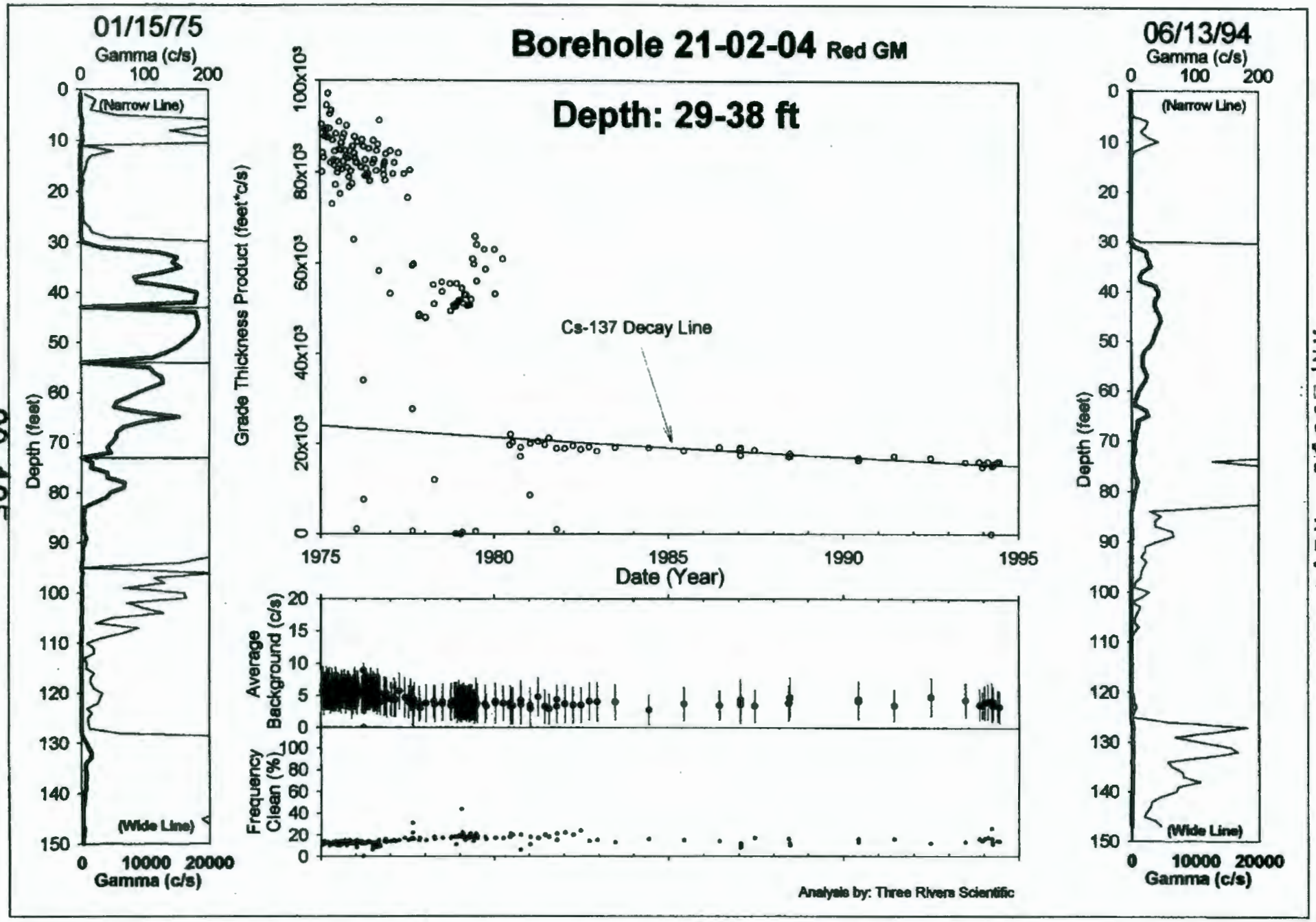
00 103

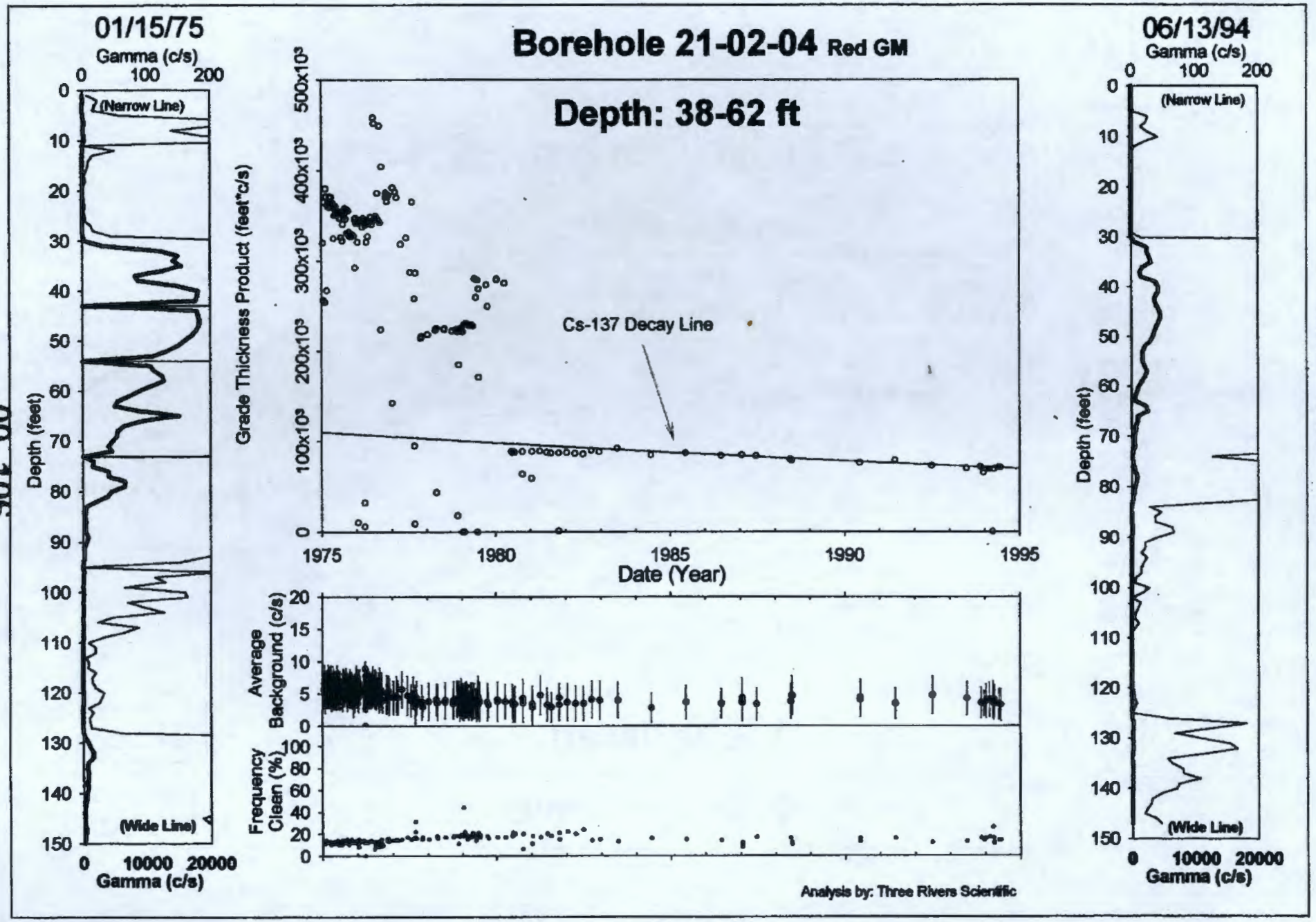
HNF-3531 -REV0



00 104

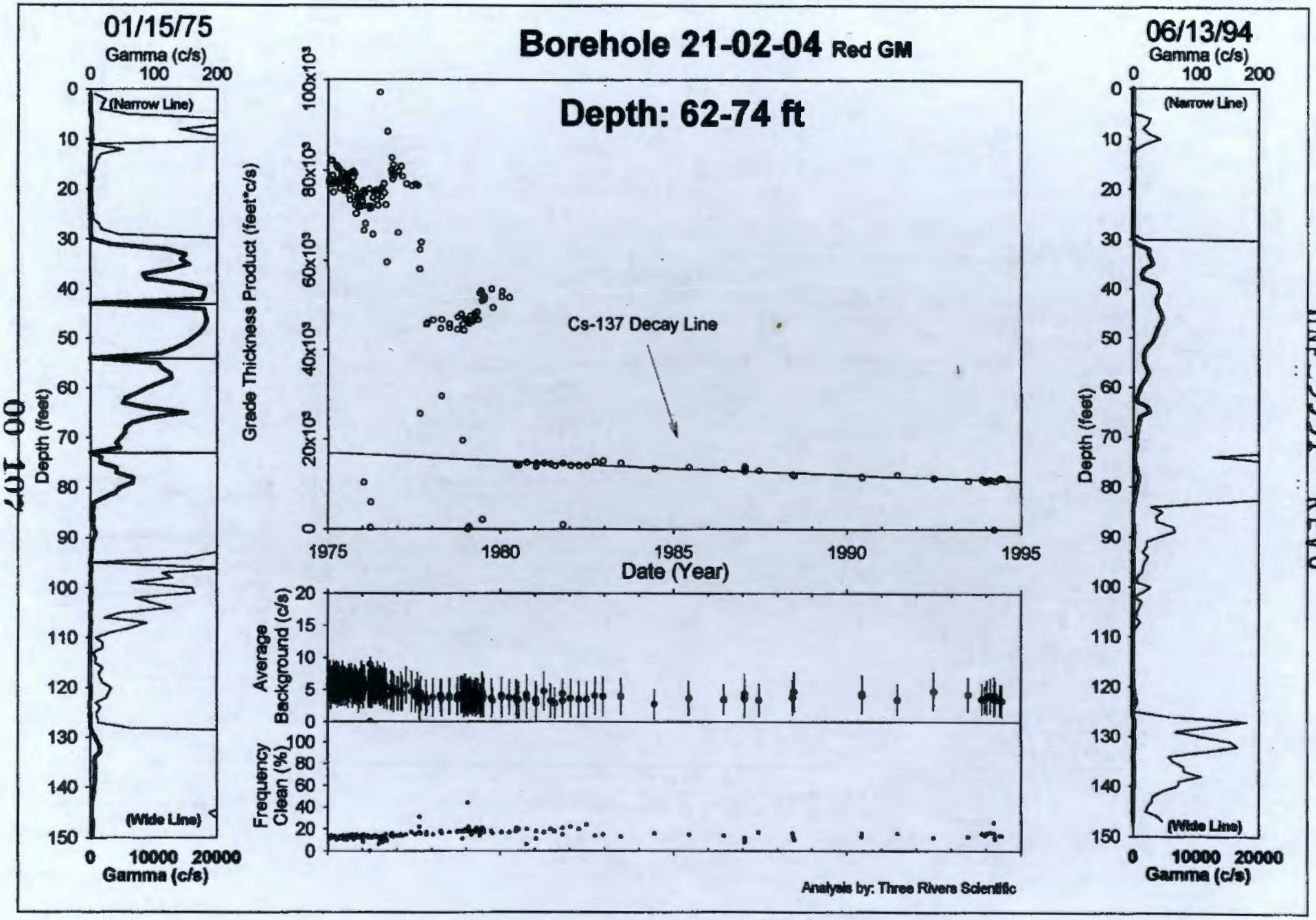
HNF-3531 -REV0


Borehole 21-02-04 Red GM
Depth: 29-38 ft
01/15/75
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/13/94
Analysis by: Three Rivers Scientific



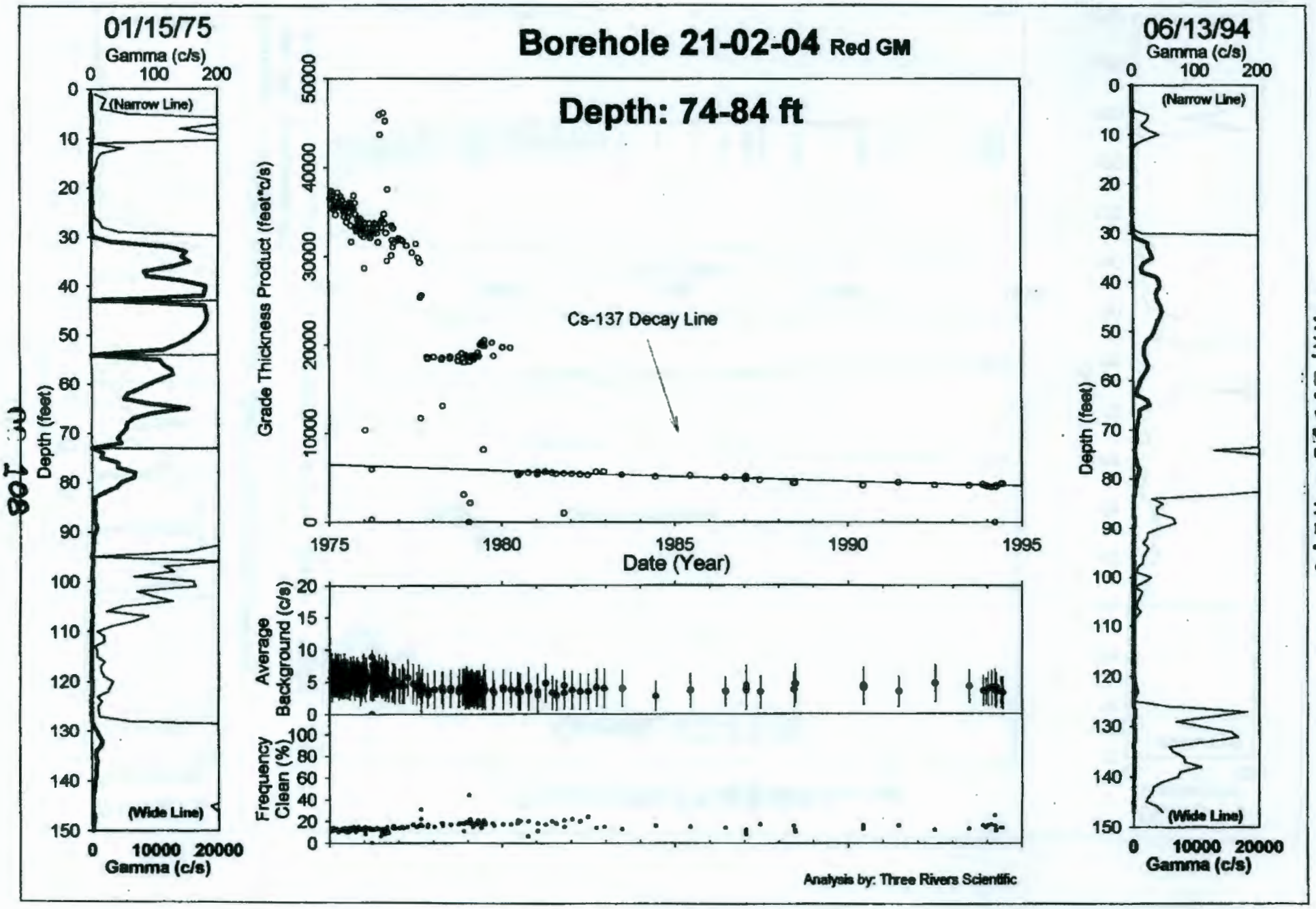
HNF-3531 -REV0

00 106

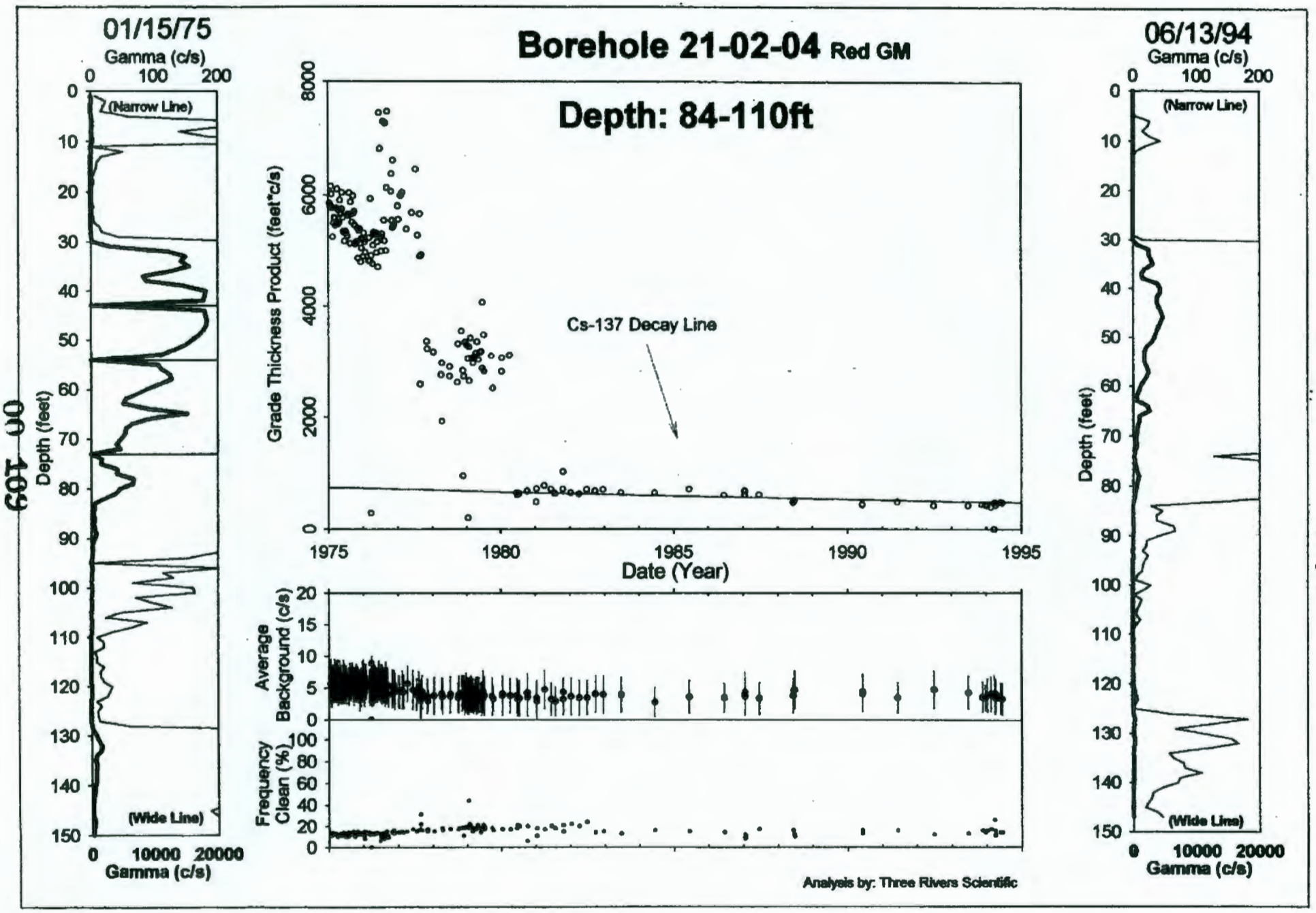


00 107

HNF-3531 -REV0

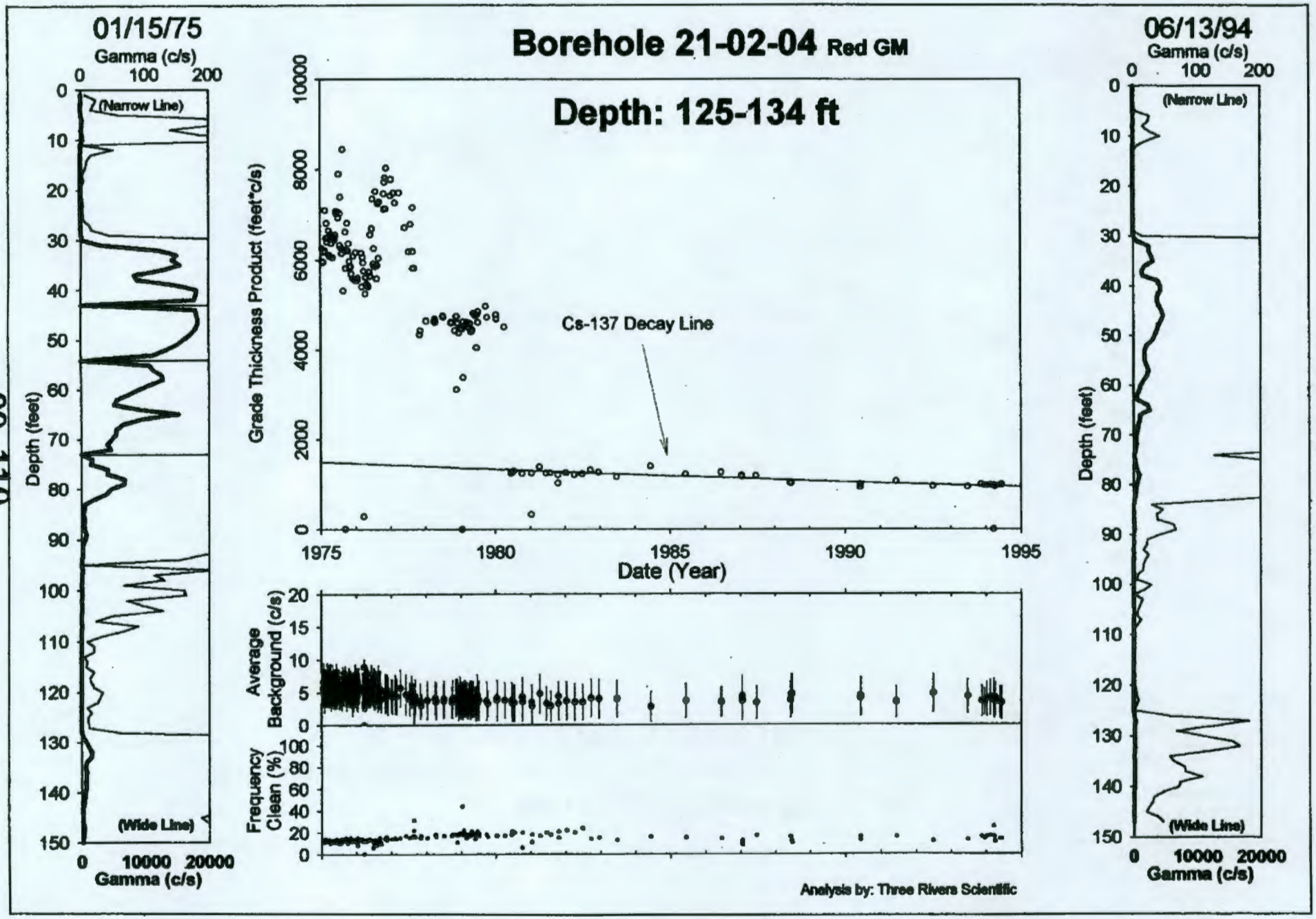


HNF-3531 -REV0



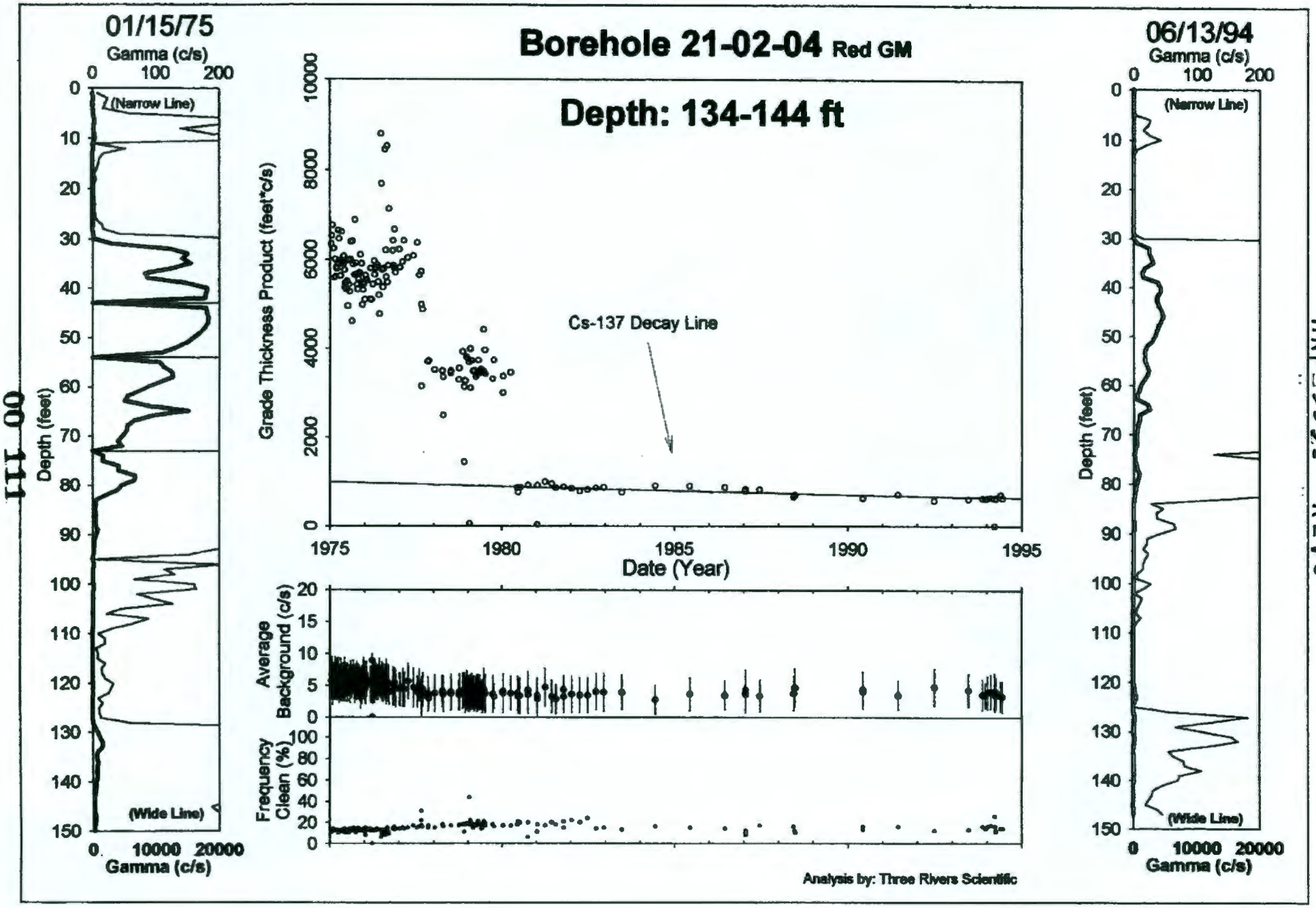
HNF-3531 -REV0

00 109



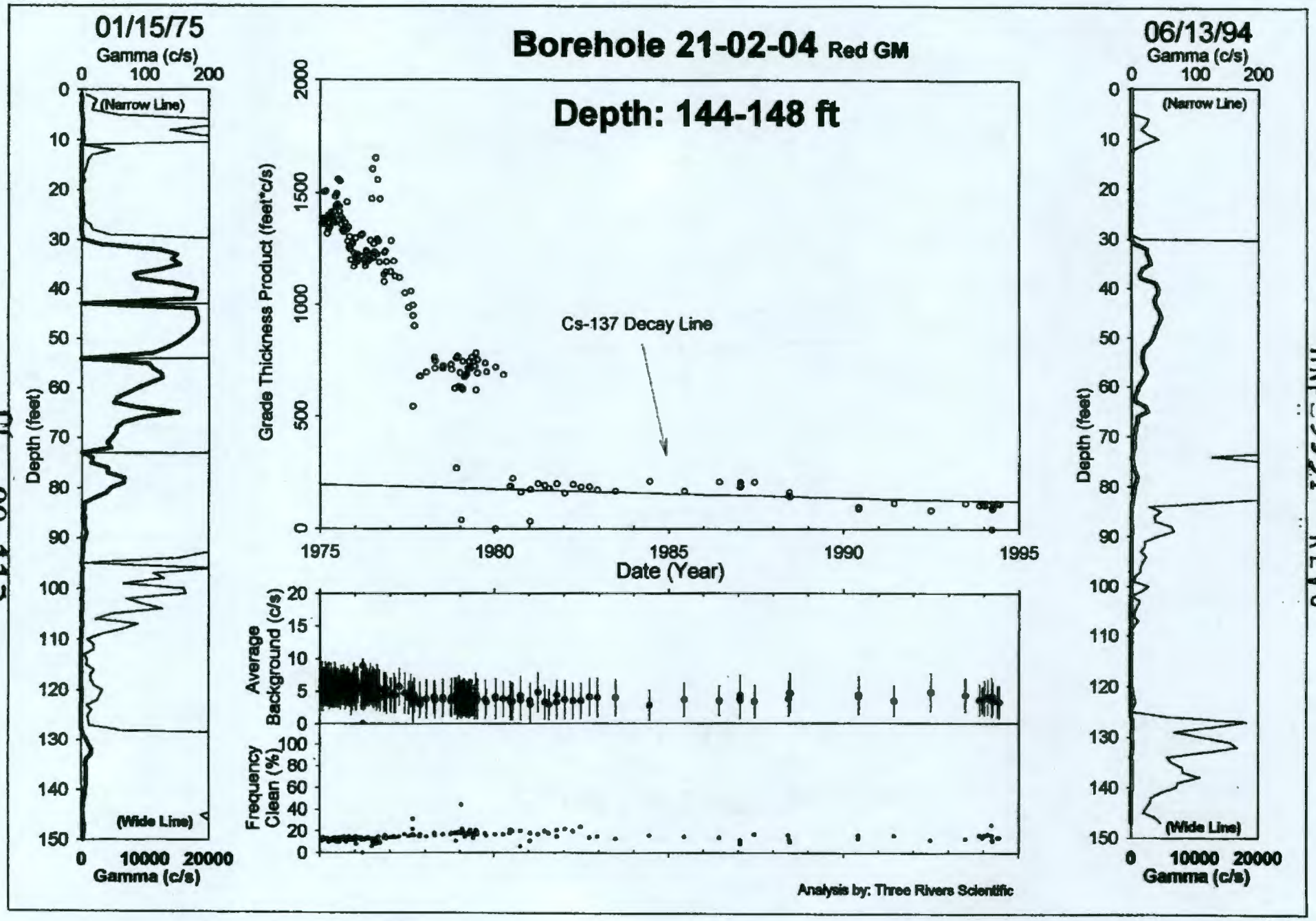
00 110

HNF-3531 -REV0

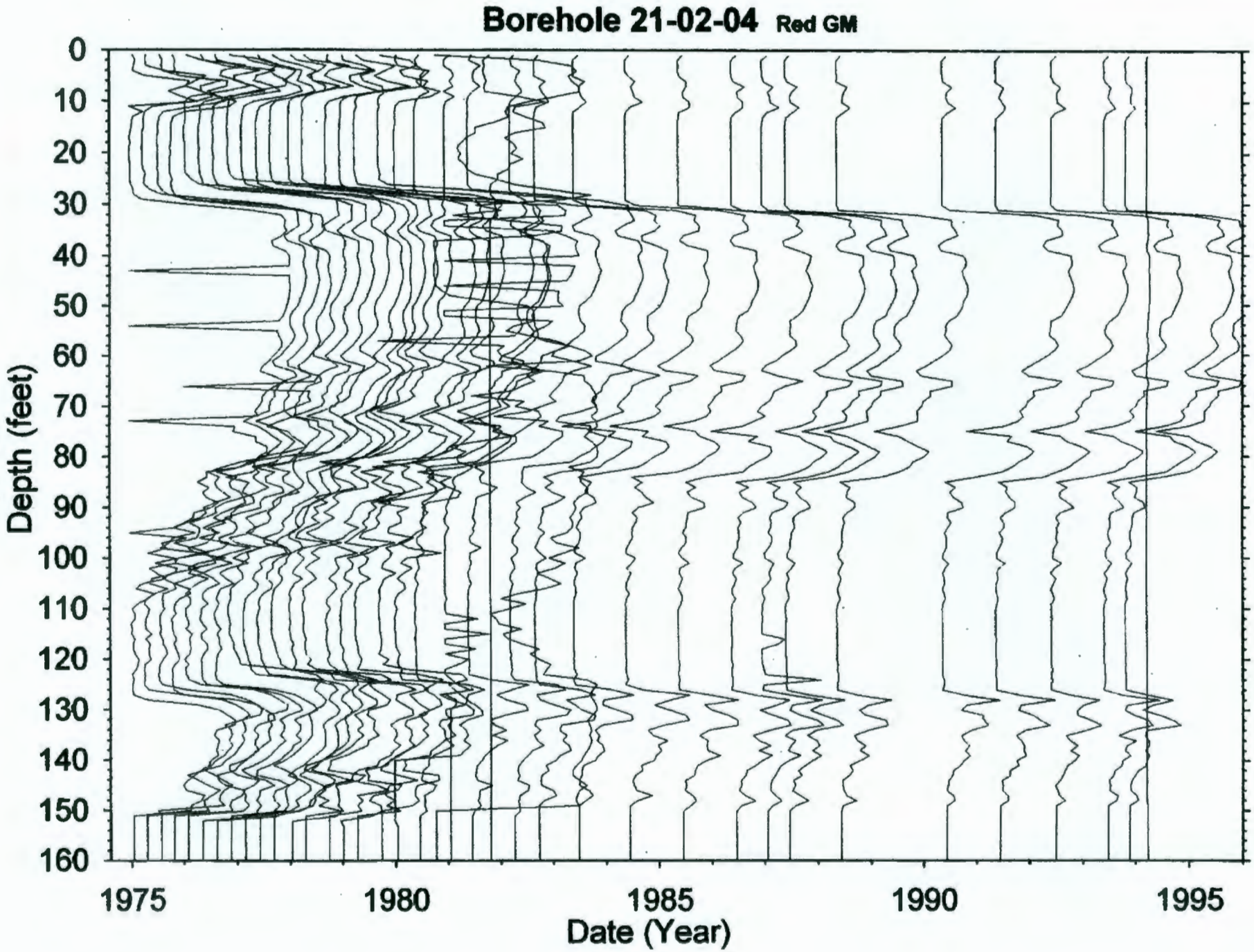


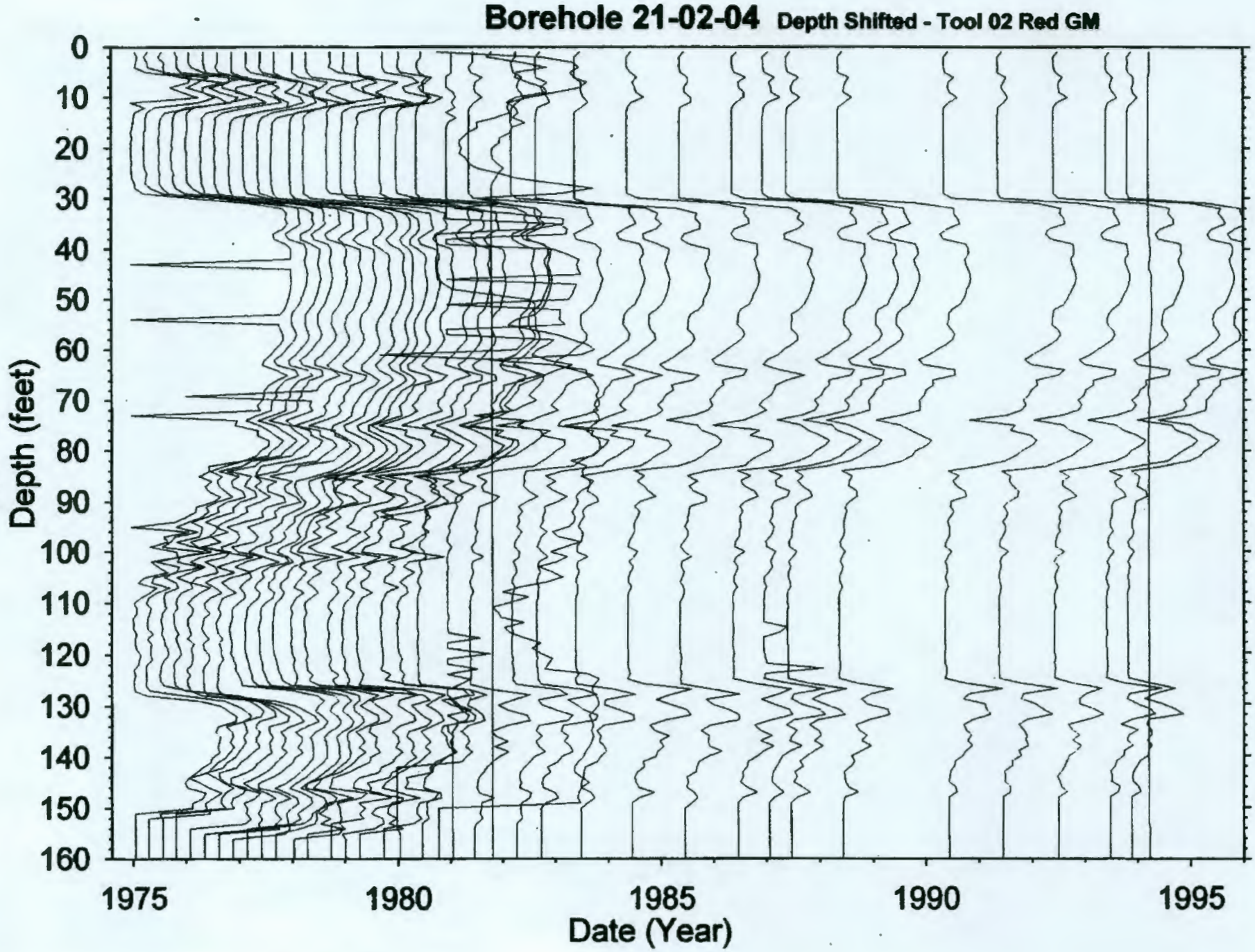
00 111

HNF-3531 -REV0



HNF-3531 -REV0


Borehole 21-02-04 Red GM
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
1975
1980
1985
1990
1995
Date (Year)


Borehole 21-02-04 Depth Shifted - Tool 02 Red GM
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
1975
1980
1985
1990
1995
Date (Year)

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

BX

Borehole 21-02-04

Total # Surveys 228

neutron surveys 17

Log Date: 1-15-75 1st

6-13-94 Last

Probe Type 04 11 14 19 (181 02)

GR Surveys 181

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs

Max Survey Depth _____

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

BackGnd.Txt

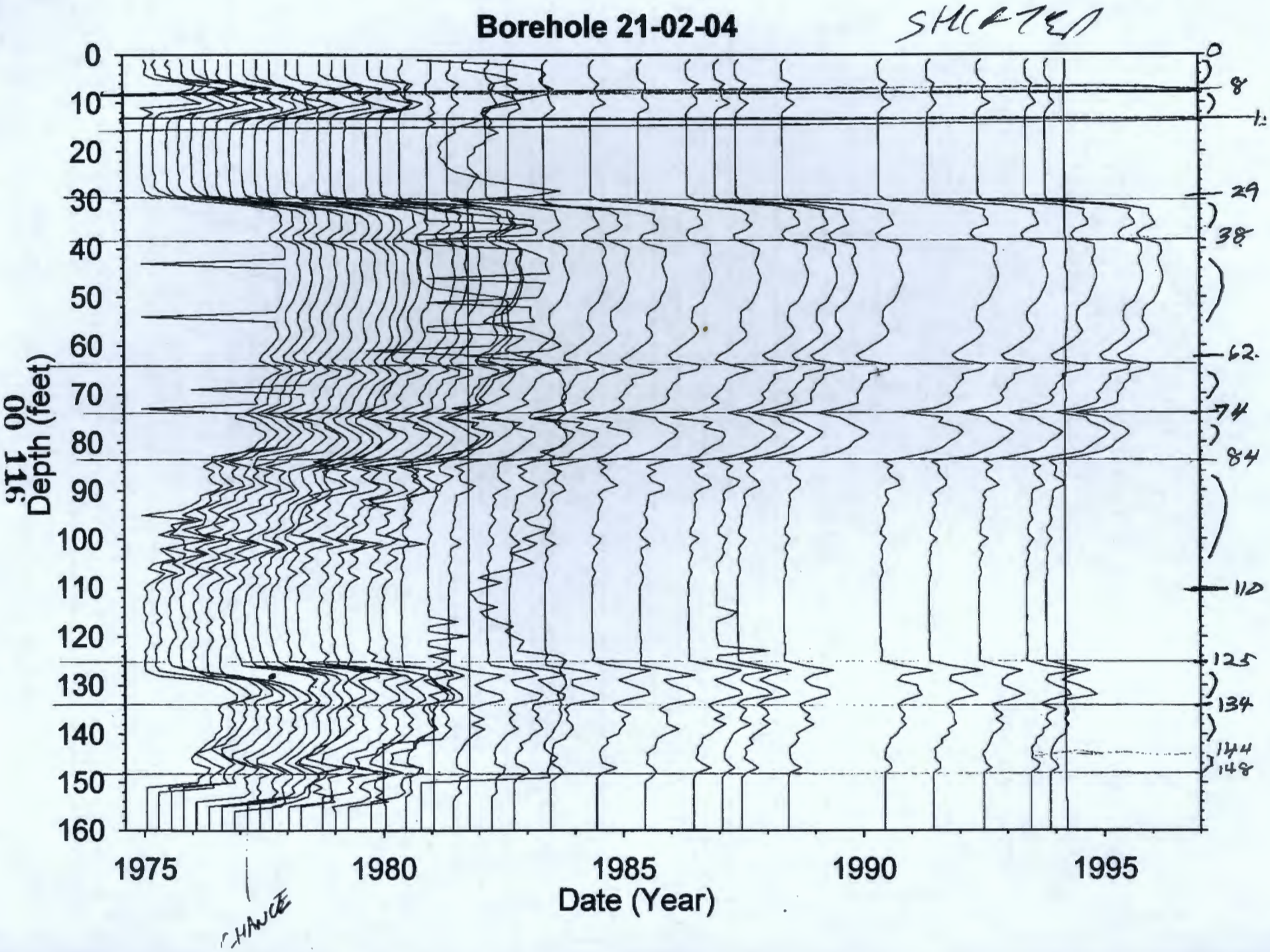
Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

CM system field testing (all zones same changes)
multiple zones fit attack plot
All have same characteristics - no background

Analyst Name [illegible]

S/W ver TFGROSS22


Borehole 21-02-04
SHORTEN
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
1975
1980
1985
1990
1995
Date (Year)
CHANGE
0
8
29
38
62
74
84
110
125
134
144
148

Borehole 21-02-06

Contamination (Co-60) from 34-46 feet is **UNSTABLE**

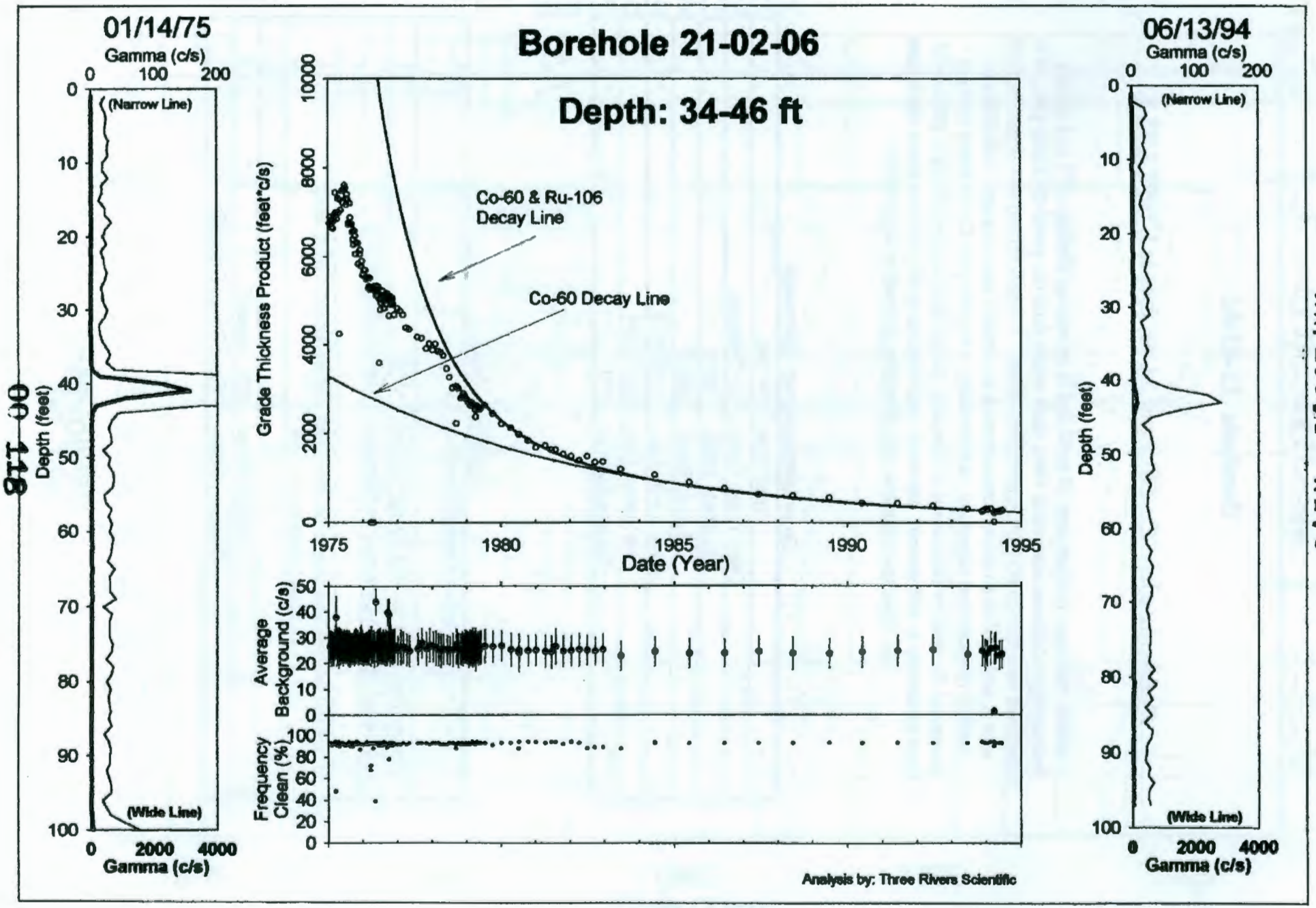
Grade thickness product over 34 to 46 feet is increasing starting 1975 and rapidly decreasing at different rates until 1984, from which time the grade thickness product is consistent with the Co-60 (HPGe identified) decay. A depth shifted and expanded stack plot is provided as an aid to demonstrating no vertical zone changes, indicating no vertical contaminant migration. Additionally, a Ru-106 plus Co-60 decay curve is presented for relative indications of intensity, but no least squares fitting is performed since instability is still present. However, possibilities of Ru-106 may prove significant for other investigations and should be pointed to as possible.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	171

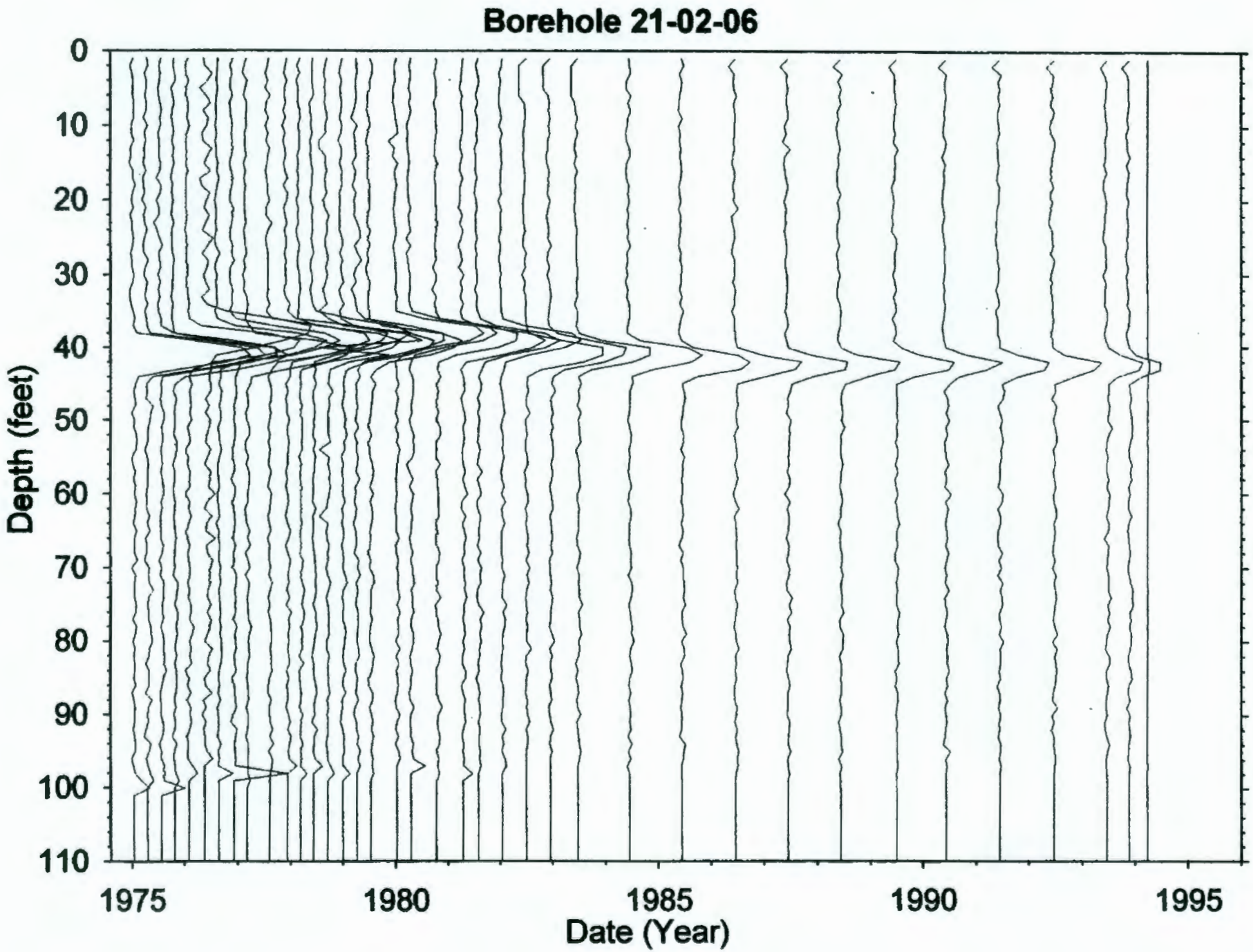
Analysis Notes

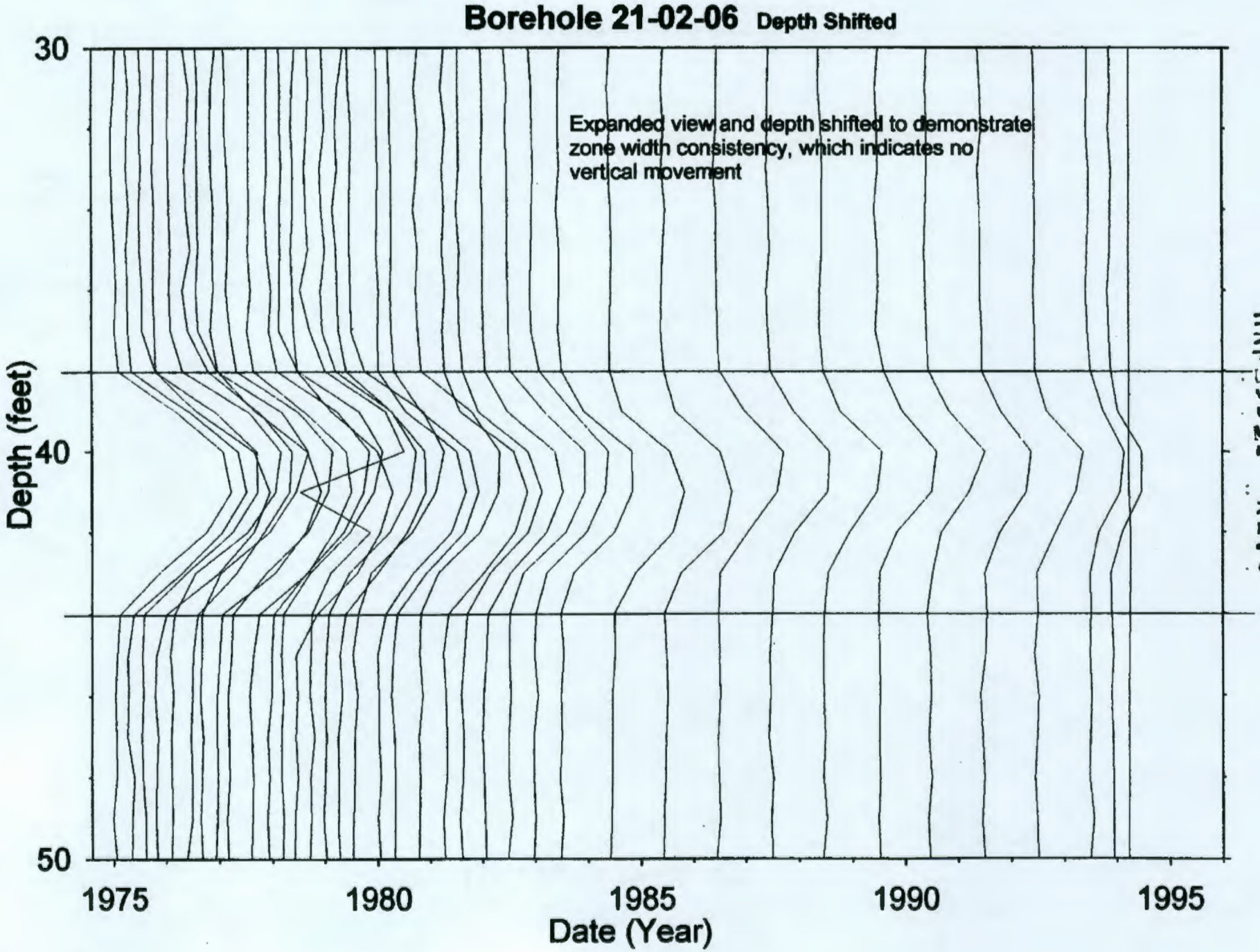
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	34-46 **UNSTABLE** early	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



HNF-3531 -REV0

00 118


Borehole 21-02-06
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)


Borehole 21-02-06 Depth Shifted
Expanded view and depth shifted to demonstrate zone width consistency, which indicates no vertical movement
30
40
50
Depth (feet)
1975
1980
1985
1990
1995
Date (Year)

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

BX

Borehole 21-02-06

Total # Surveys 174

Probe Type 04

neutron surveys 3

GR Surveys 171

Log Date: 1-14-75 1st

6-13-94 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 32-48

Isotope from Spectral Survey: Co 2 U's

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

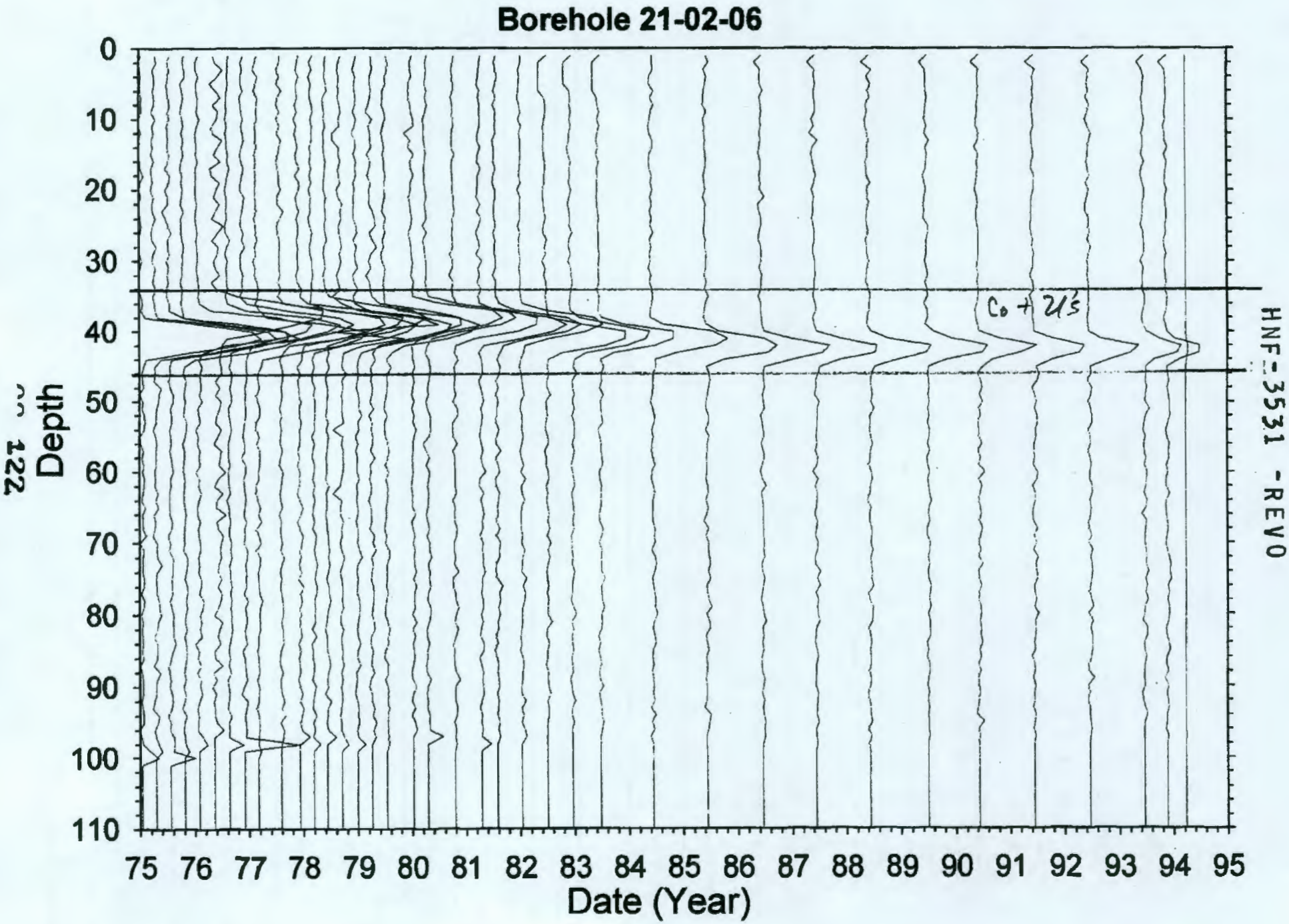
Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

Probable, could be argued down movement (very unlikely) moved up -- depth control. ie
ASL14-46 is on depth shifted for ref.

Analyst Name [illegible]

S/W ver TFGRSS 2.2


Borehole 21-02-06
Depth
0
10
20
30
40
50
60
70
80
90
100
110
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Date (Year)
Co + U's

Borehole 21-02-07

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 1994 in the vadose zone from 2 to 100 feet.

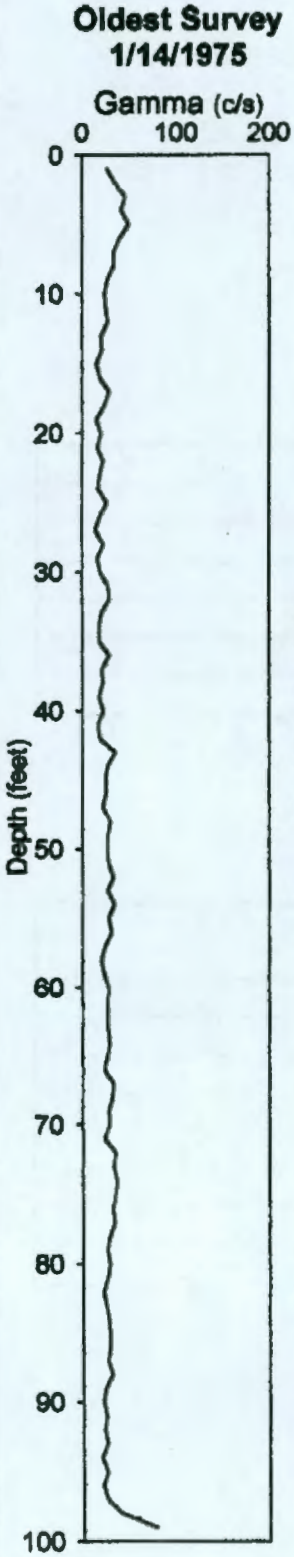
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	179

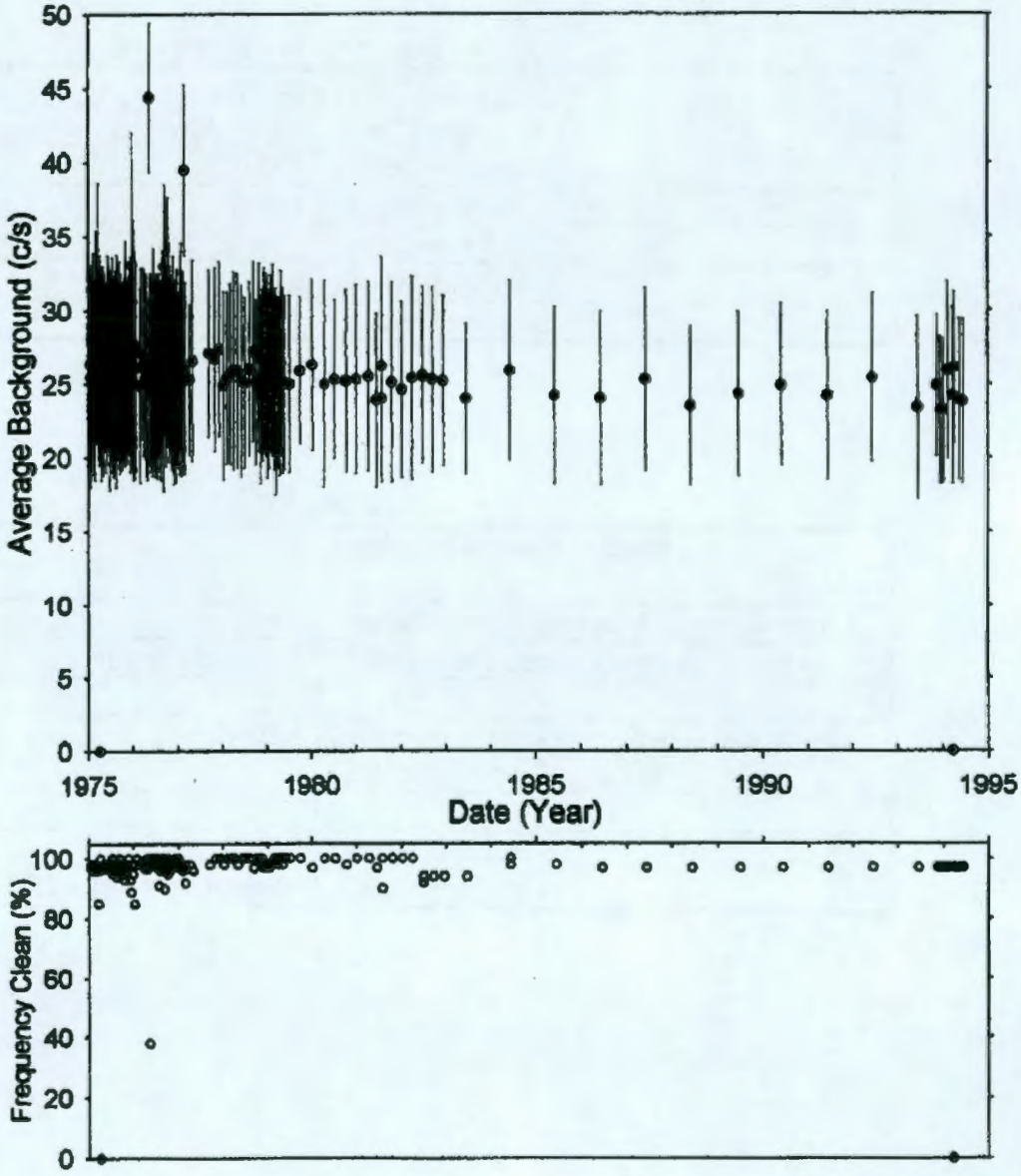
Analysis Notes

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	

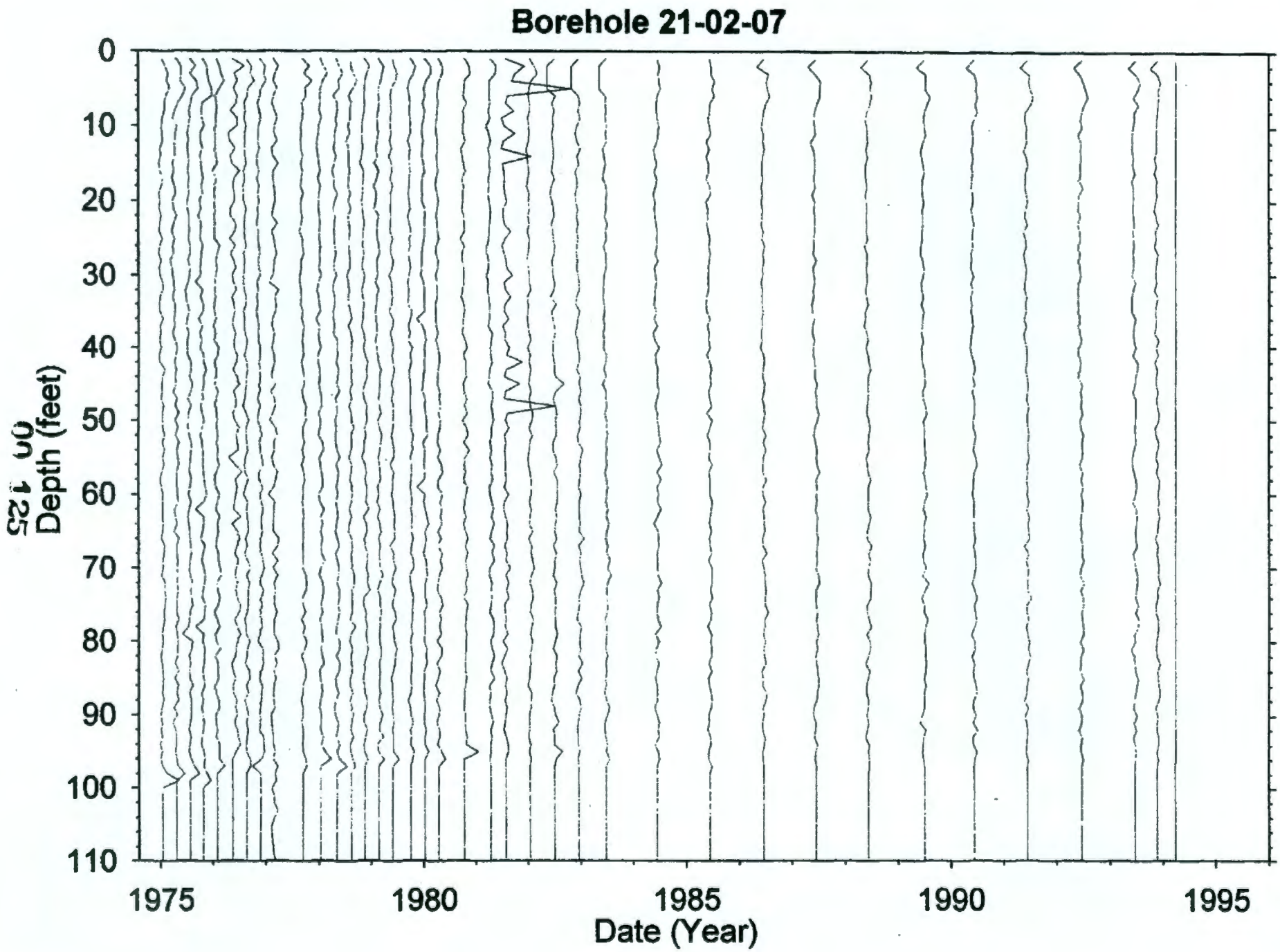
Borehole 21-02-07



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific



HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole 21-02-07 Total # Surveys 181 Probe Type 04

neutron surveys 2 # GR Surveys 179

Log Date: 1-14-75 1st 6-13-94 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): none

Isotope from Spectral Survey: Cs from @ surface Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment

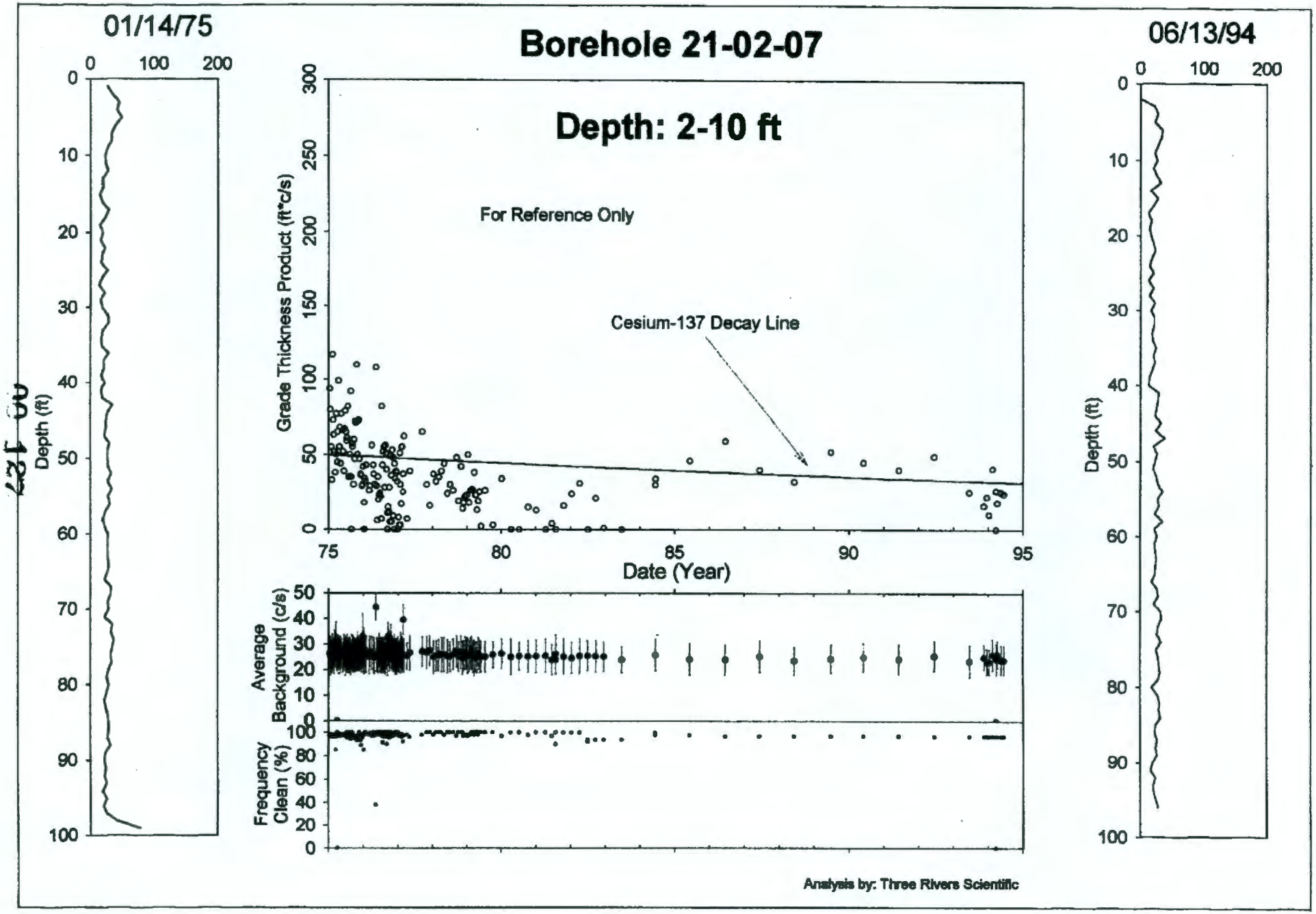
BackGnd.Txt

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

Analysis Notes

very from @ surface have ref. plot but labeled clean. Also depth possible all surface

Analyst Name Rme S/W ver TFGROSS 2.2


Borehole 21-02-07
Depth: 2-10 ft
For Reference Only
Cesium-137 Decay Line
01/14/75
06/13/94
Depth (ft)
Grade Thickness Product (ft*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific

Borehole 21-02-11

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 1994 in the vadose zone from 2 to 100 feet.

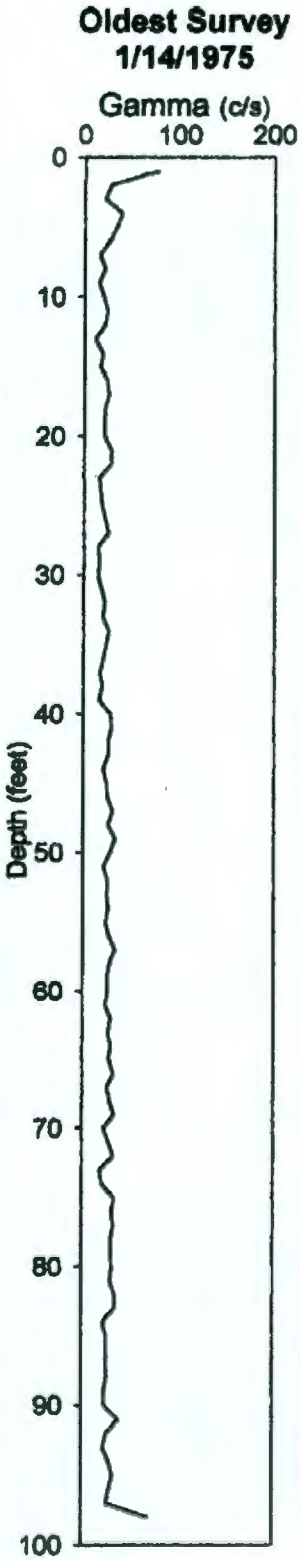
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	156

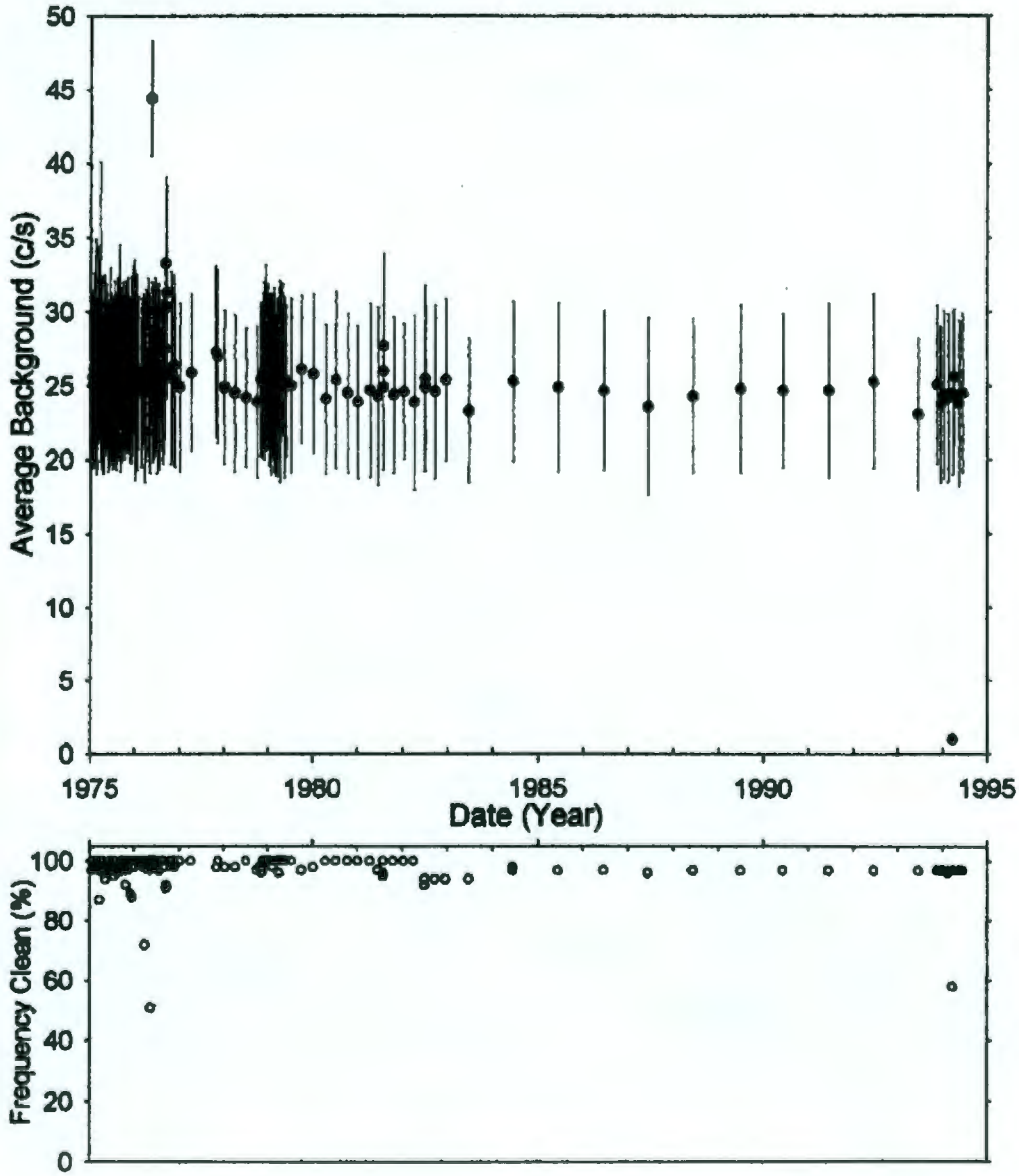
Analysis Notes

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	

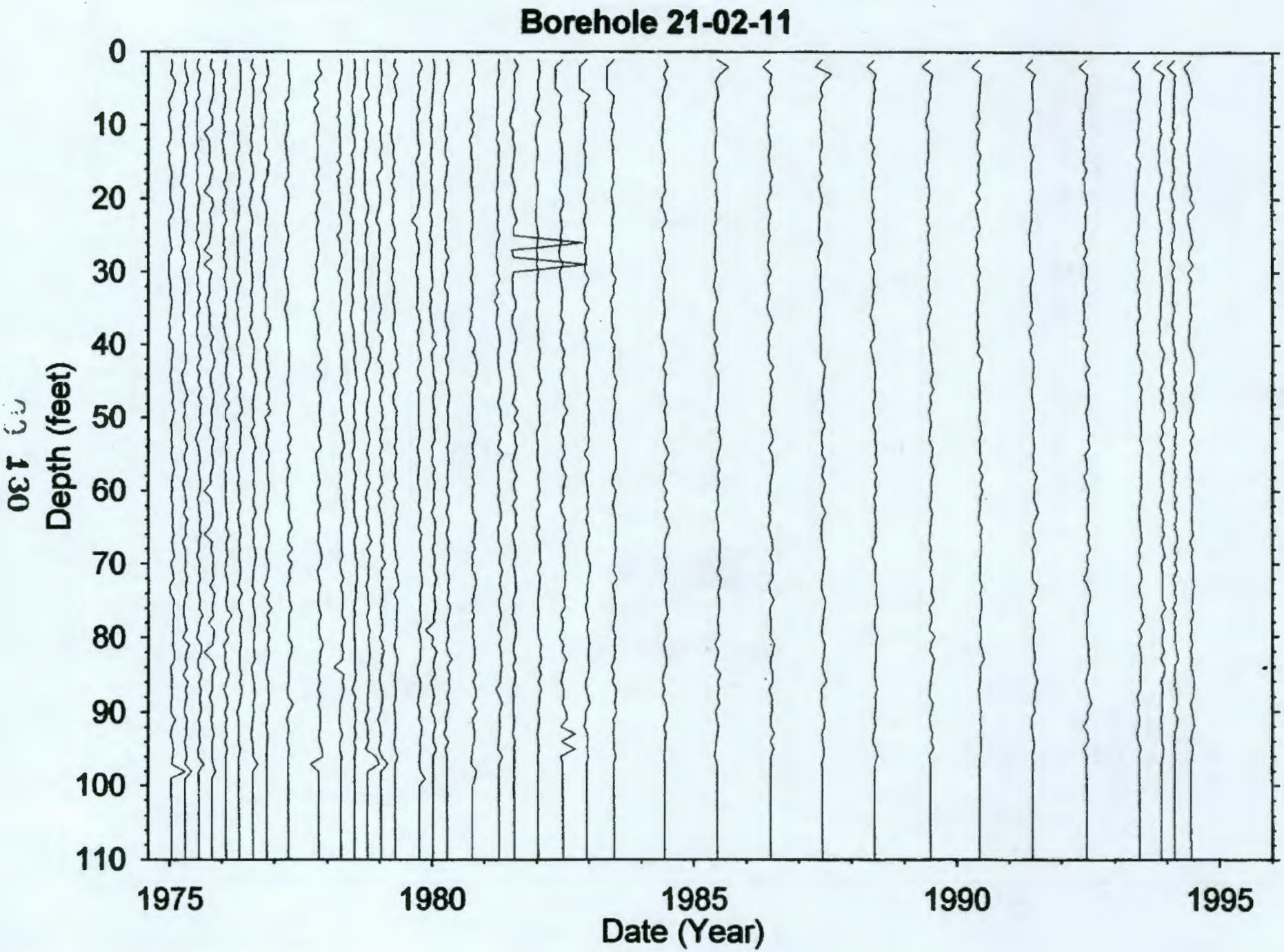
Borehole 21-02-11



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific



HNF-3531 -REV0

HNF-3531 -REV0

BX

Dry Well Survey Analysis - Notes

Borehole 21-02-11

Total # Surveys 158

Probe Type 04

neutron surveys 2

GR Surveys 156

Log Date: 1-14-75 1st

6-13-94 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs Low @ any

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

Analyst Name [illegible]

S/W ver TFGROSS 2.2

Borehole 21-03-03

Contamination (Ru-106) from 60-80 feet is Stable late

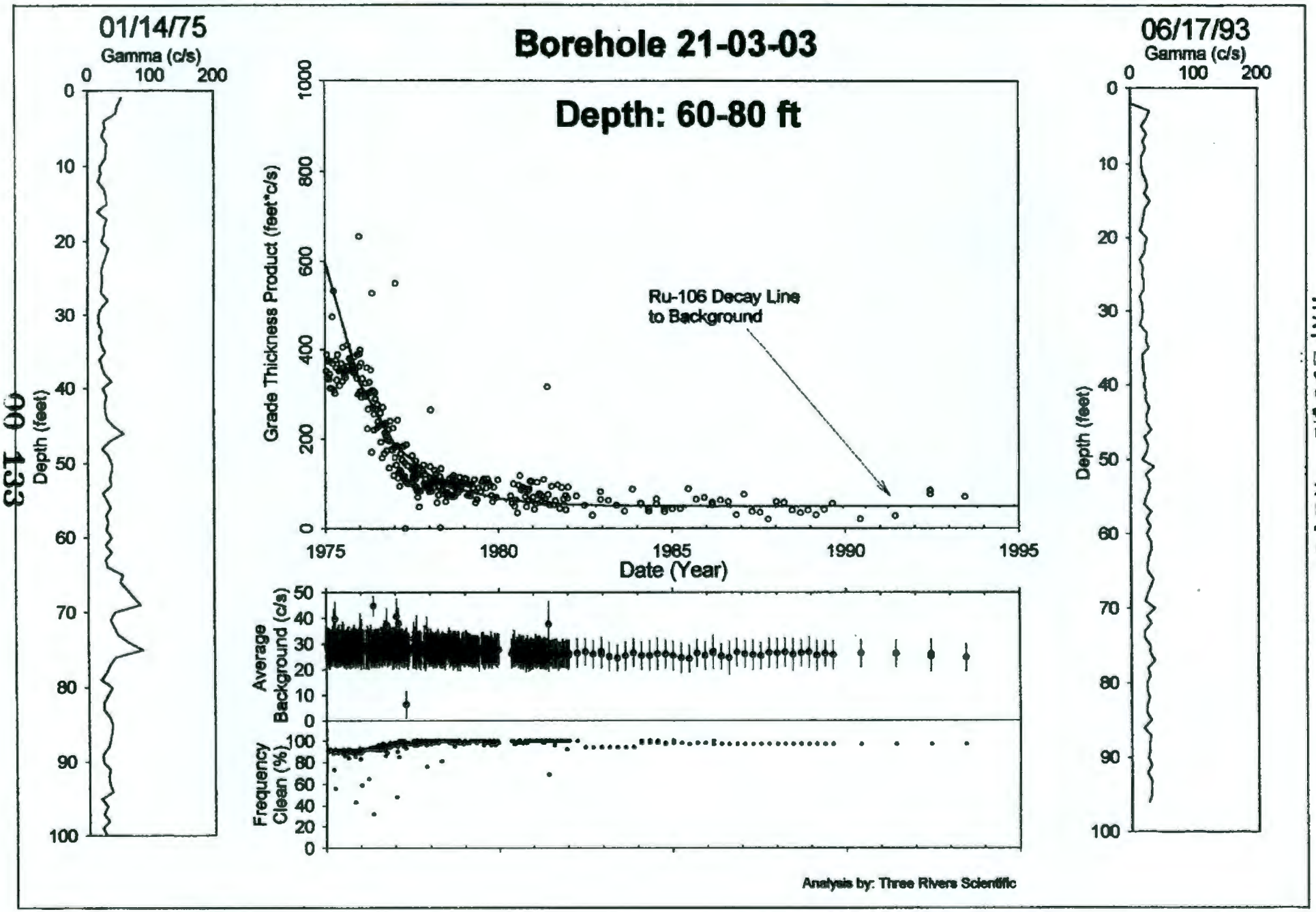
Grade thickness product over 60 to 80 feet increased starting 1975 and from mid 1976 exhibits the decay rate of Ru-106 (hypothesis) down to background levels near 1980.

Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	324

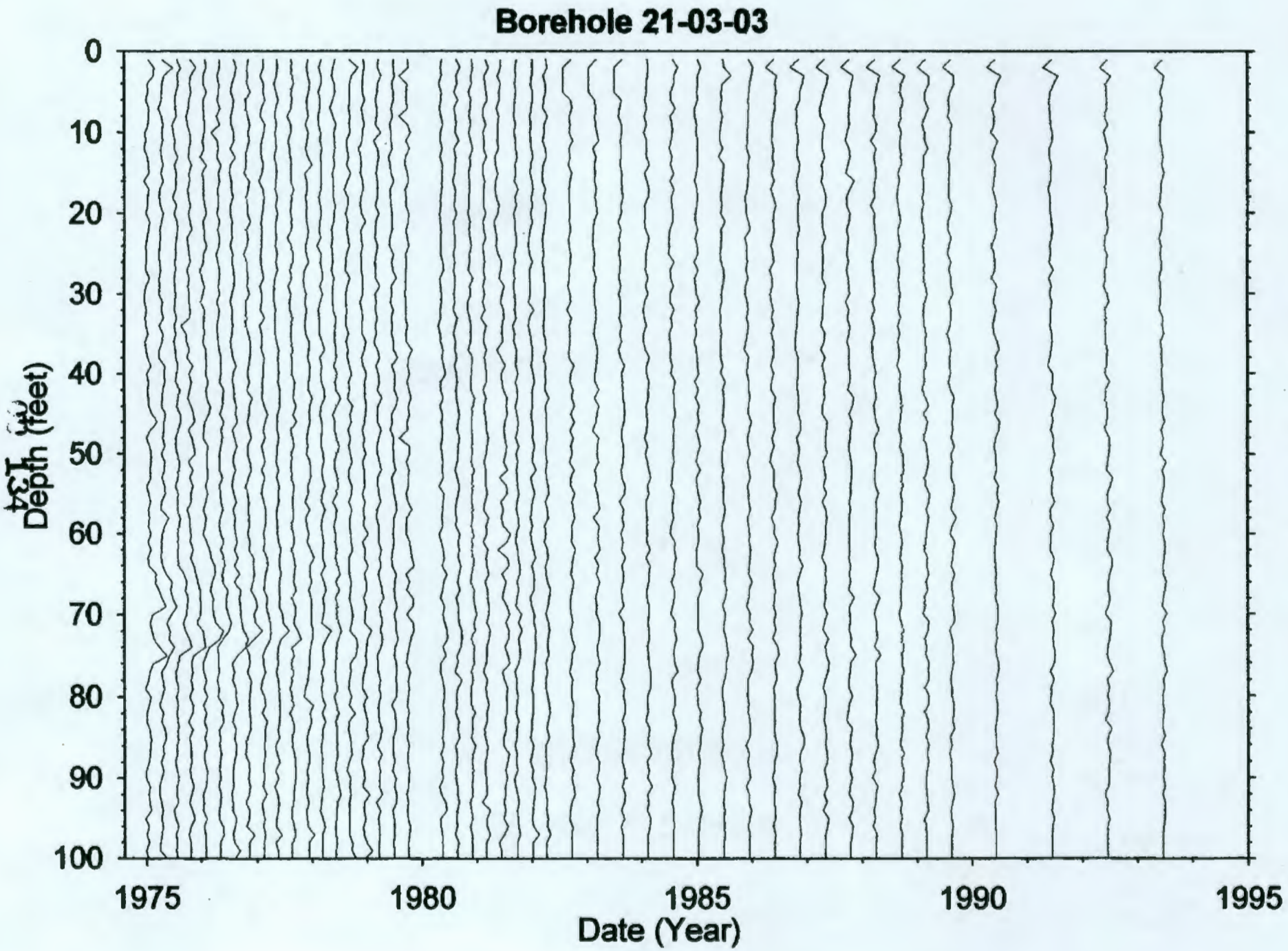
Analysis Notes

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 :	60-80 Stable late	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

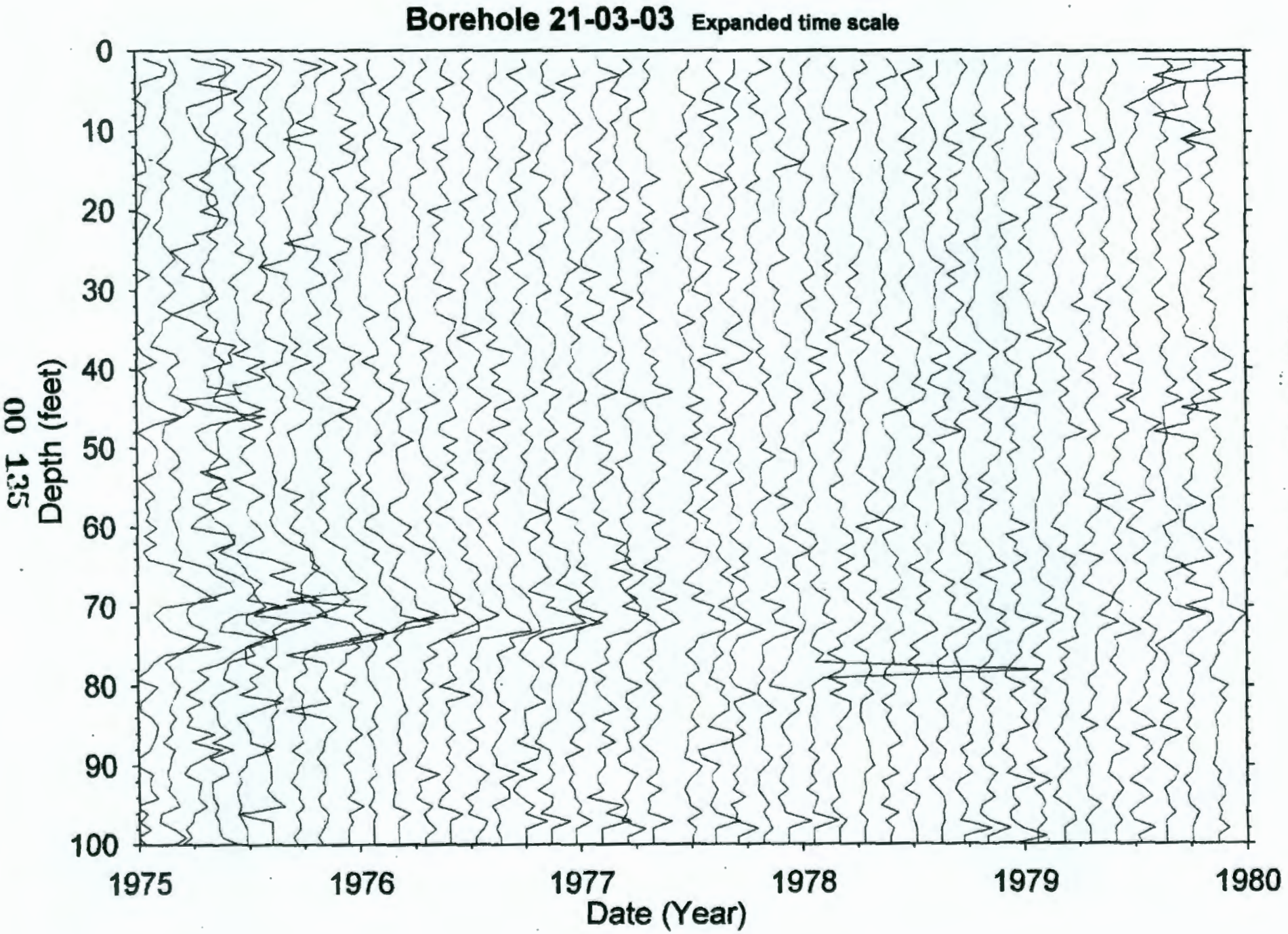


00 133

HNF-3531 -REV0



HNF-3531 -REV0



00 135

HNF-3531 -REV0

HNF-3531 -REVO

Dry Well Survey Analysis - Notes

BX

Borehole 21-03-03

Total # Surveys 328

Probe Type 04

neutron surveys 4

GR Surveys 324

Log Date: 1-14-78 1st

6-17-93 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs low @ any 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
Shows early signal + rapid decay			

BackGnd.Txt

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

2-10

Analysis Notes

Run from 60-80

From expanded stack looks like upper gross starts & lower gross rise & then falls (note total rises / 2nd then falls)

Analyst Name [signature]

S/W ver TFGRSS 2.2

Borehole 21-03-05

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

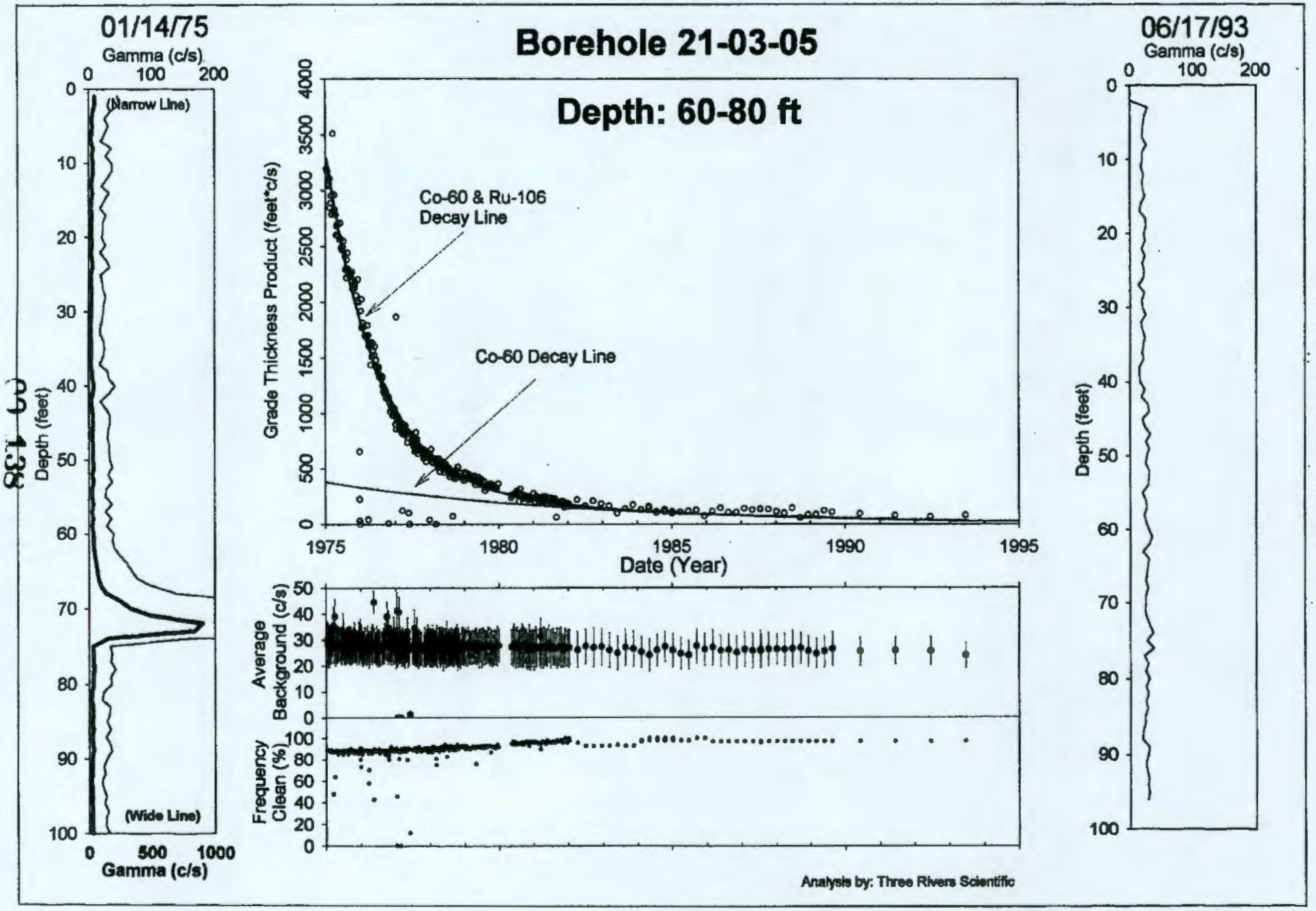
Grade thickness product from 60 to 80 feet is decreasing consistent with
a least squares fit for Co-60 (HPGe identified)
and Ru-106 (hypothesis) from 1975 to 1993.
The least squares fit results in gross gamma contribution ratio of
Ru-106 to Co-60 of 7.7 as of Jan 1975.

Gross Gamma Survey Information

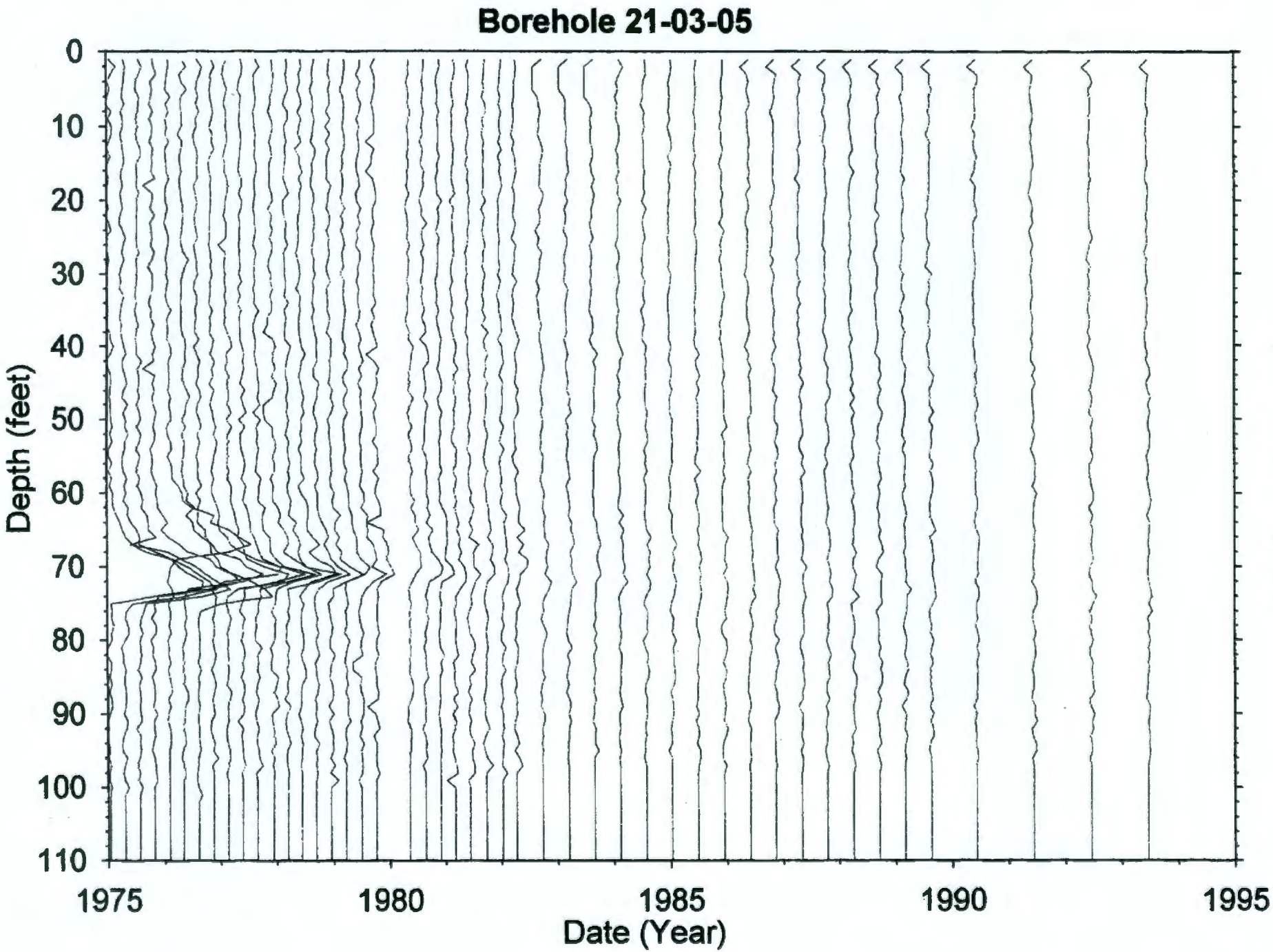
Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI, 01: Green GM, 02: Red GM, & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/17/1993
Number Surveys :	332

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 :	60-80 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



HNF-3531 -REV0


Borehole 21-03-05
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-03-05 | Total # Surveys 343 | Probe Type 332 04 1 01 4 02 1 14

neutron surveys 5 | # GR Surveys 332

Log Date: 1-14-75 1st | 6-17-93 Last | Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs Sow Band Co (60-75) | Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
	Rn 60-80		gone by 84

BackGnd.Txt

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

Analysis Notes

2-10
Rn 60-80

Analyst Name [illegible] | S/W ver TFGROSS 2.

filein := "two.txt"

Well 21-03-05

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 317$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := \frac{368.2}{365.25}$

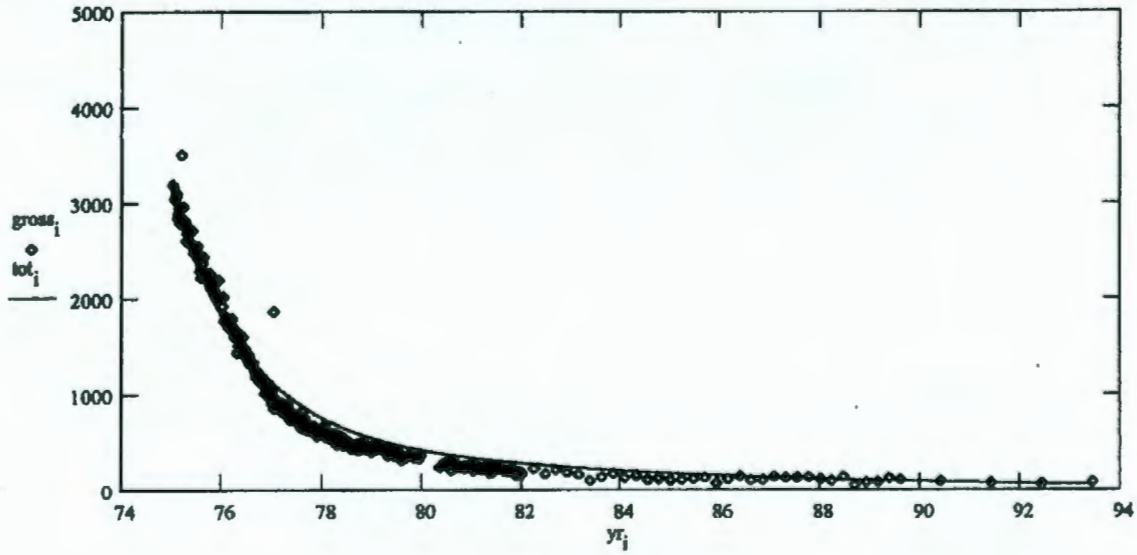
$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 650$ $\quad acs := 0$

Eu variables are Ru-106 $\quad aeu := 2500$

$Cs_i := acs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Co_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



$\tau eu := 1$

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

Given

$ssq(aco, aeu) = 0$ $\quad 1 = 1$

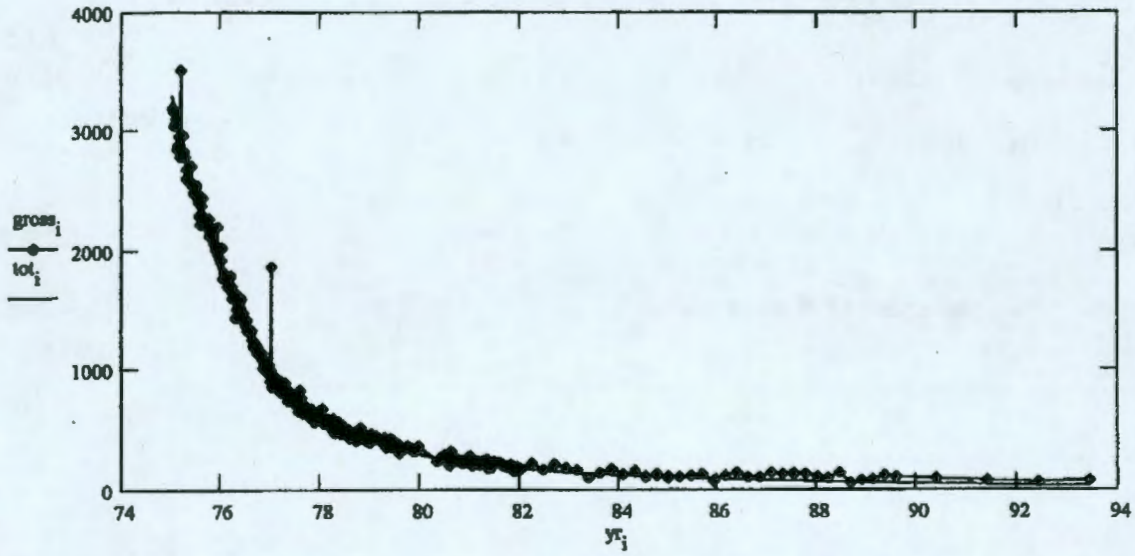
$\begin{bmatrix} \alpha co \\ \alpha eu \end{bmatrix} := \mathrm{Minerr}(aco, aeu)$ $\quad \alpha co = 386.758$ $\quad \alpha eu = 2.989 \cdot 10^3$

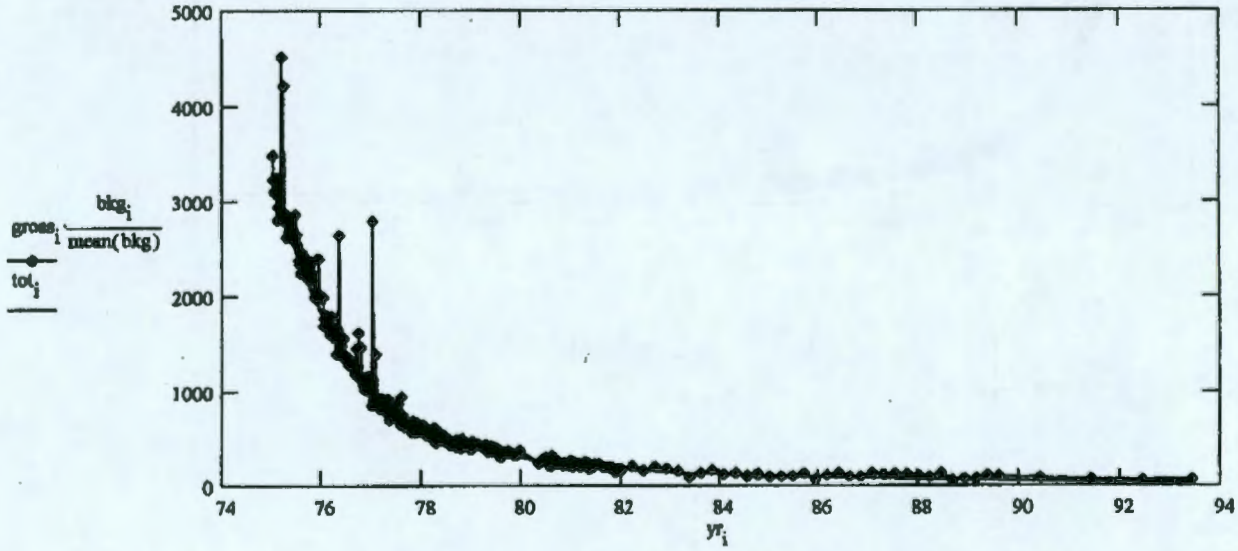
$Co_i := \alpha co \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Co_i + Eu_i$

$\frac{\alpha eu}{\alpha co} = 7.728$

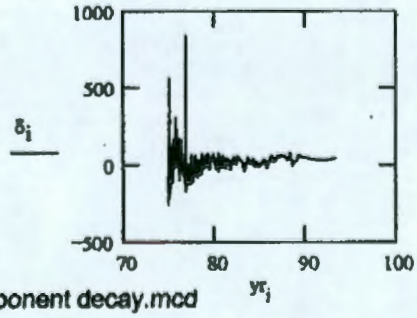
$\frac{Eu_N}{Co_N} = 2.427 \cdot 10^{-4}$

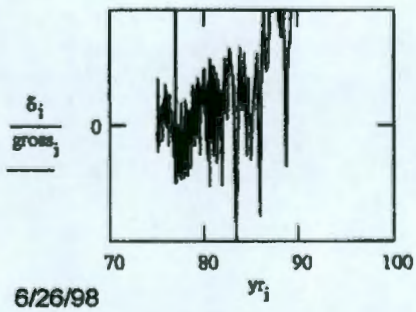
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





Borehole 21-03-07

Contamination (Cs-137) from 2-10 feet is Tank Farms Activity

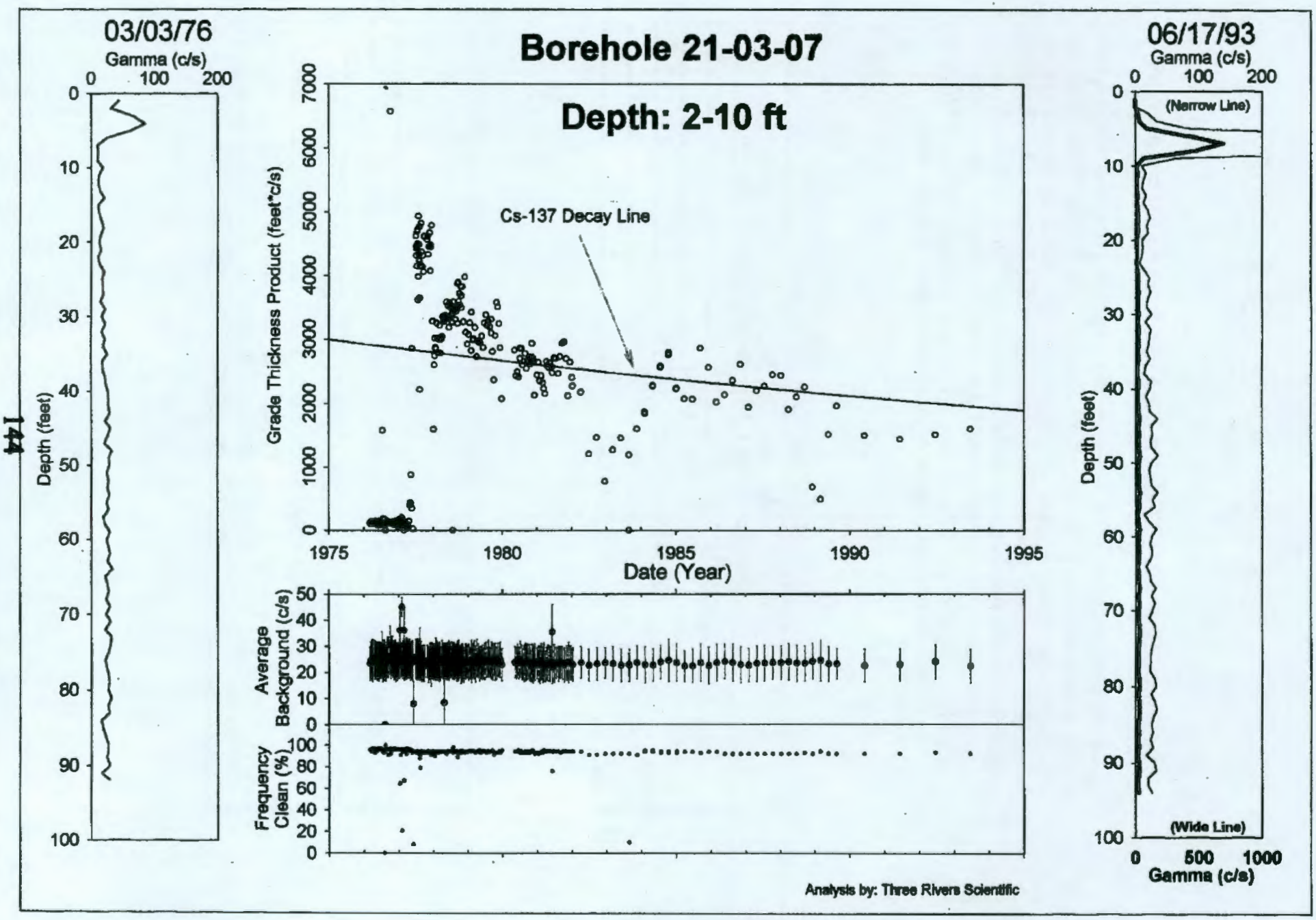
Grade thickness product over 2 to 10 feet increased April 27, 1977, from this time, the interval is decreasing consistent with a least squares fit for Cs-137 (HPGe identified) and Ru-106 (hypothesis) from April 27, 1977 to June 17, 1993. However, the rapid change character is indicative of tank farms activity such as transfer line proximity. The least square fit results in gross gamma contribution ratio of Cs-137 to Ru-106 of 0.30 as of July 1, 1977. Even if no Ru-106 is present, it was added for relative comparison that might be useful for other studies as a possibility. Note readings between 6/29/82 & 11/16/83 are artificially low due to incomplete logging of entire interval.

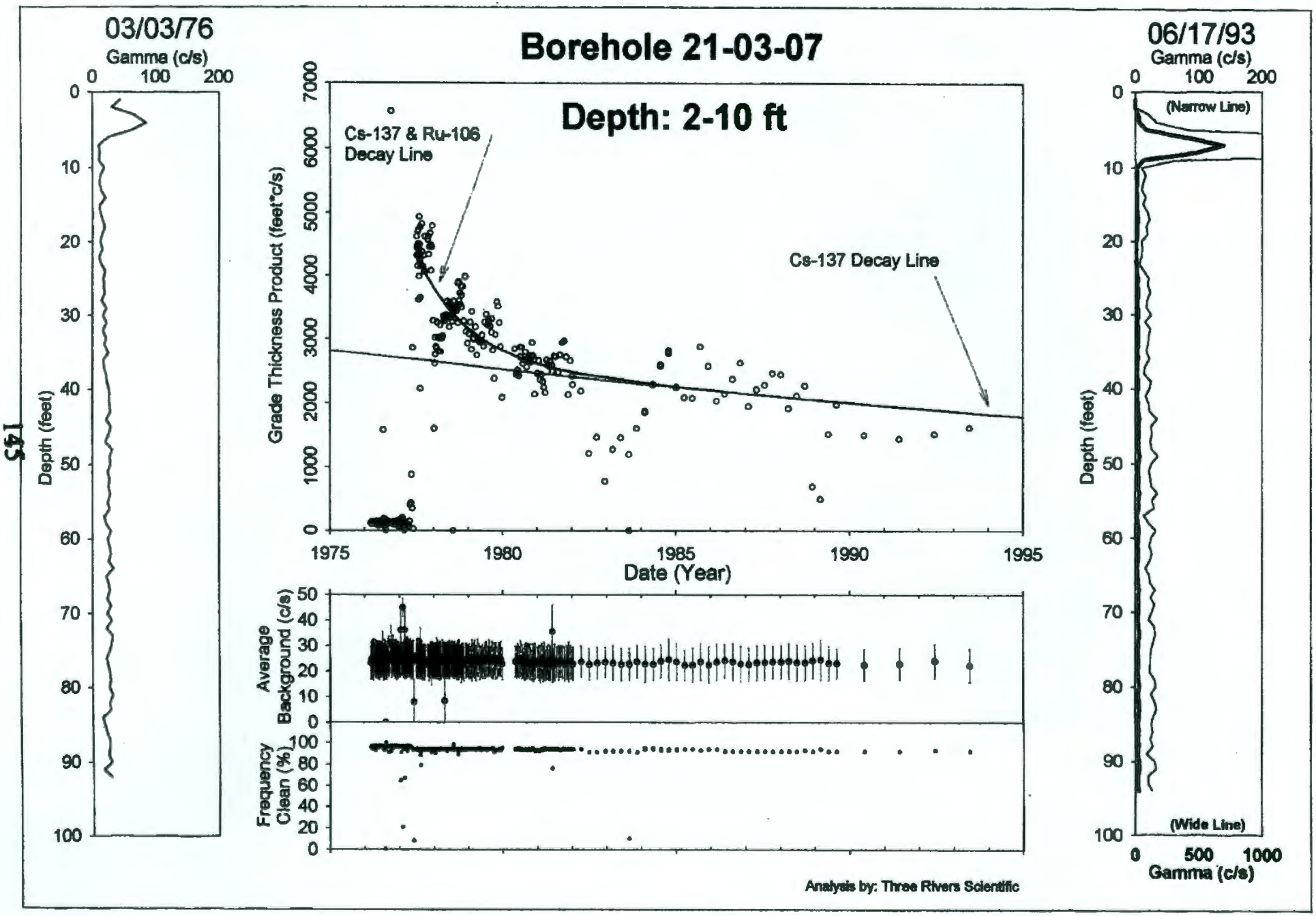
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI & 03: Neutron
Borehole Depth :	95 ft
Survey Depth :	95 ft
First Survey Date :	3/3/1976
Last Survey Date :	6/17/1993
Number Surveys :	271

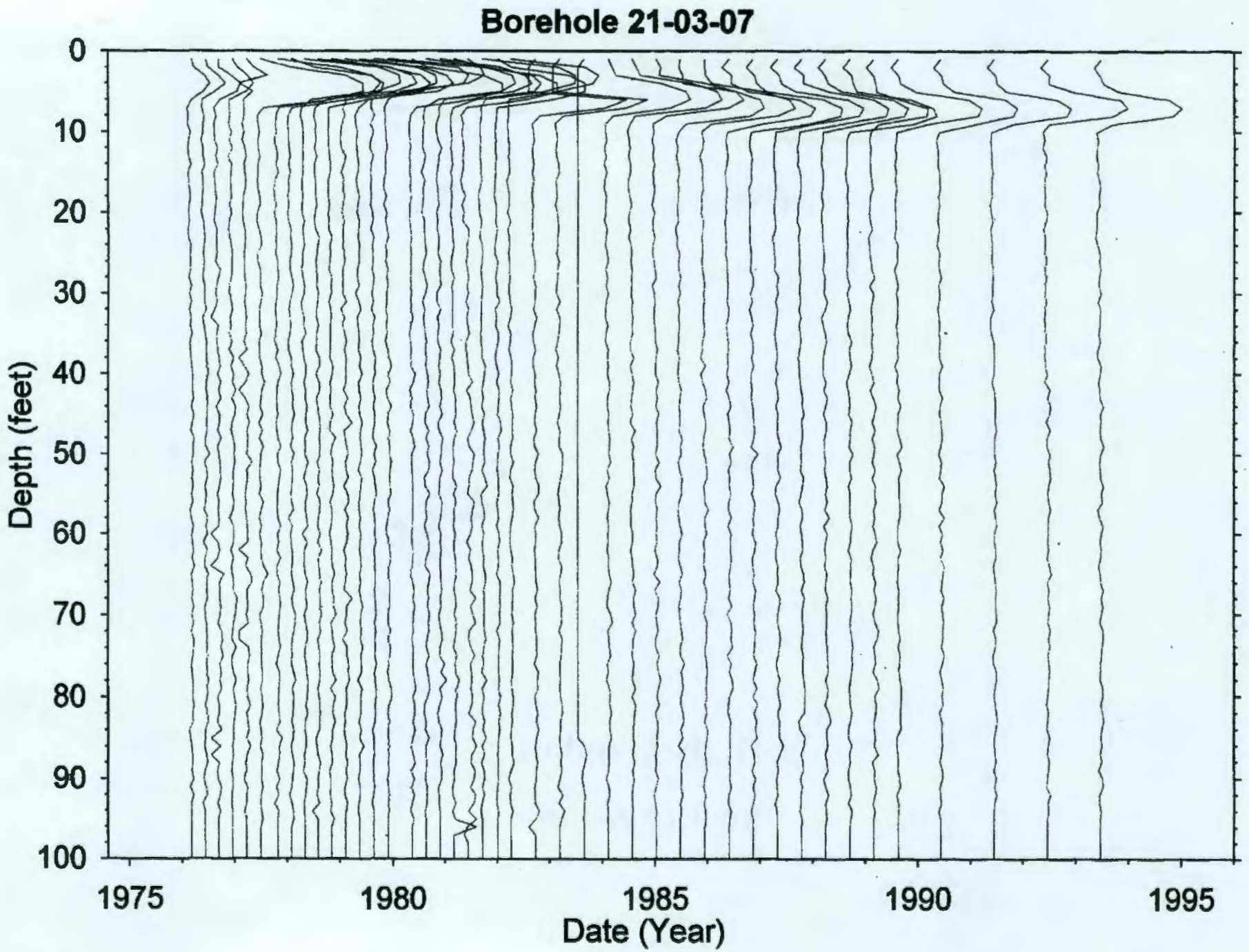
Analysis Notes

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 :	2-10 Tank Farms Activity	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


03/03/76
Gamma (c/s)
0 100 200
Depth (feet)
Borehole 21-03-07
Depth: 2-10 ft
Cs-137 Decay Line
Grade Thickness Product (feet*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/17/93
Gamma (c/s)
(Narrow Line)
(Wide Line)
Gamma (c/s)
Analysis by: Three Rivers Scientific



HNF-3531 -REV0


Borehole 21-03-07
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-03-07

Total # Surveys 275

Probe Type 04 1 14

neutron surveys 3

GR Surveys 271

Log Date: 3-3-76 1st

6-17-93 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Co Eu U

Max Survey Depth 95

near surface

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
	An event occurred between 4-27-77 & 4-20-77		
	& higher still after 7-1-77		
	From 6-29-82	thru 11-16-83	not complete logging

BackGnd.Txt

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

2-10

Analysis Notes

near surface major increase 4-27-77 & 6-29-82 no log of near surface (only bottom of interval)

Least squares fit for Co + Eu cannot fit data

Least square for Rn & Cs looks good $\left.\frac{CsGR}{RnGR}\right|_{77} = .30$

7-1-77

Analyst Name Ryan Randall

S/W ver TFG ROSS2.2

filein := "two.txt"

Well 21-03-07

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

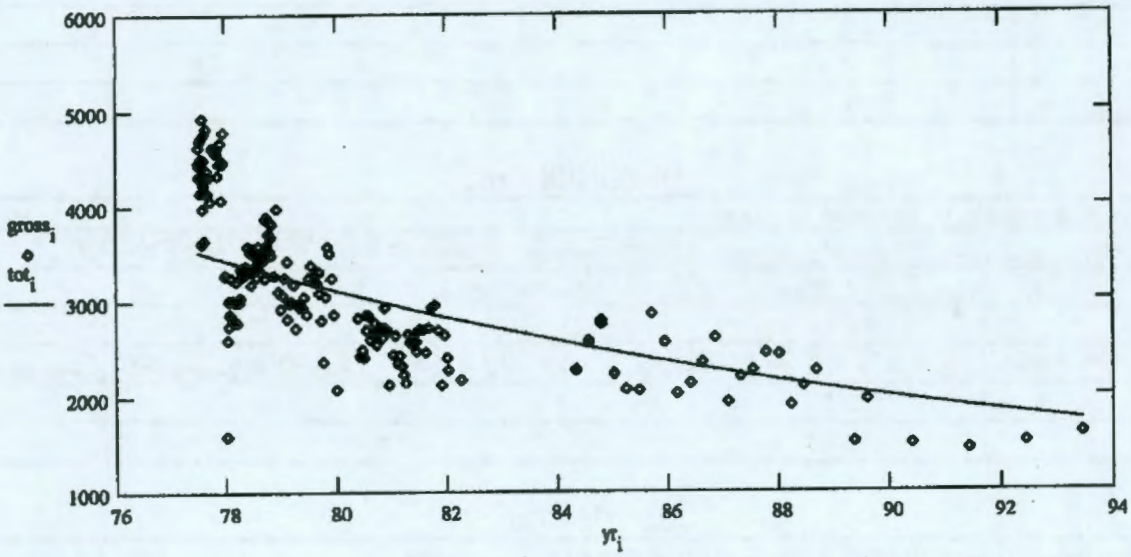
$N := last(yr)$ $\quad N = 189$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 8.5$

$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 00$ $\quad acs := 2000$ $\quad aeu := 2000$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



$acs := 2800$ $\quad aeu := 10000$

$\tau eu := 1$

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

Given

$ssq(acs, aeu) = 0$ $\quad 1 = 1$

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

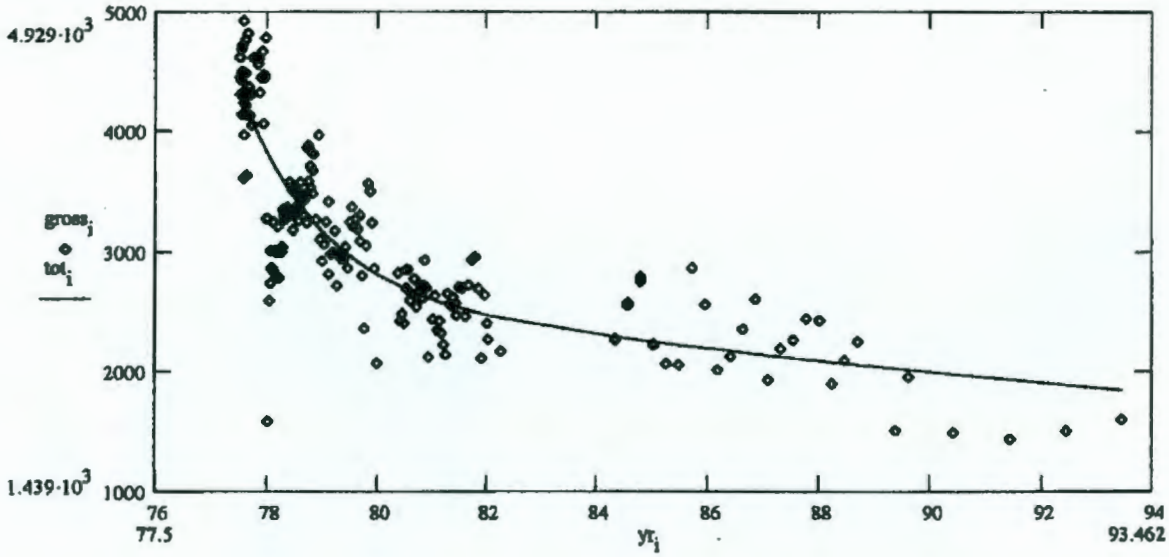
$\alpha cs = 2.831 \cdot 10^3$ $\quad \alpha eu = 9.418 \cdot 10^3$

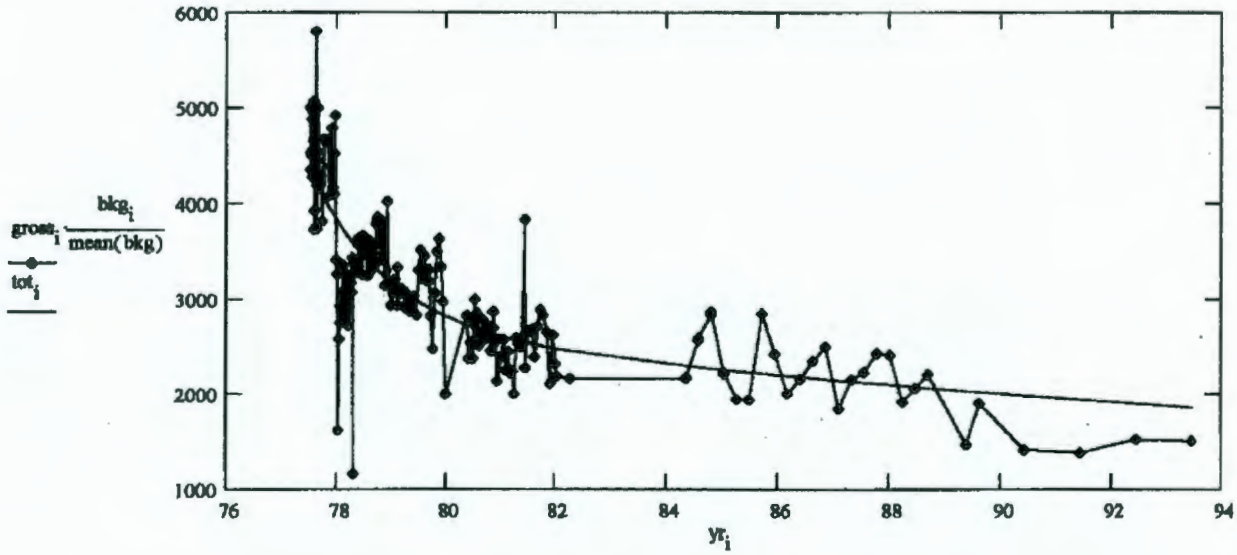
$\frac{\alpha cs}{\alpha eu} = 0.301$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Cs_i + Eu_i$

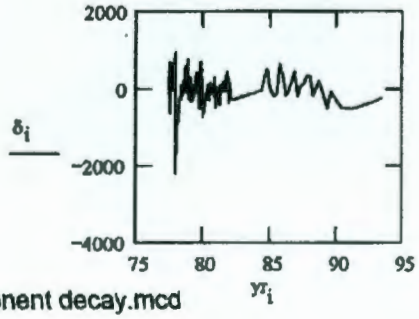
$\frac{Eu_N}{Cs_N} = 1.408 \cdot 10^{-5}$

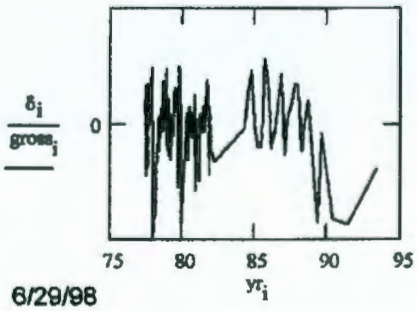
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





Borehole 21-03-11

No Gamma Ray Emitting Contamination was identified.

No significant levels of gamma ray contamination are present above the survey probe detection threshold between 1976 and 1993 in the vadose zone from 2 to 100 feet.

Gross Gamma Survey Information

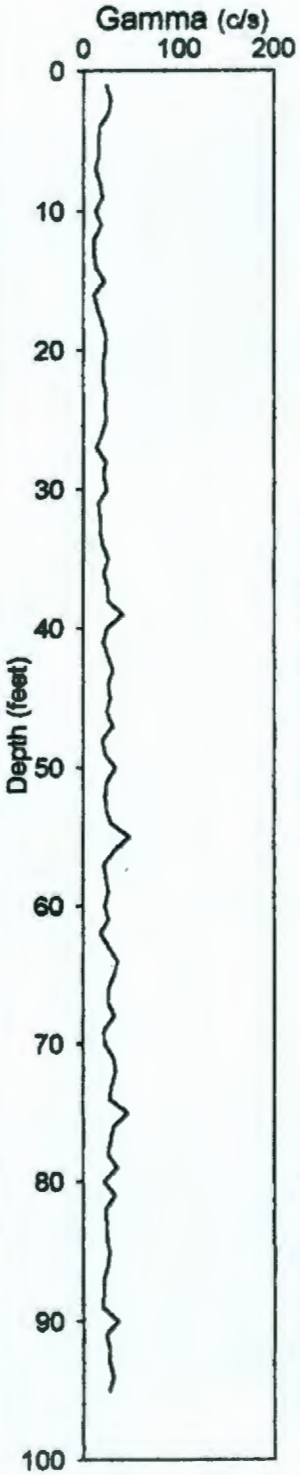
Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	3/2/1976
Last Survey Date :	10/5/1993
Number Surveys :	154

Analysis Notes

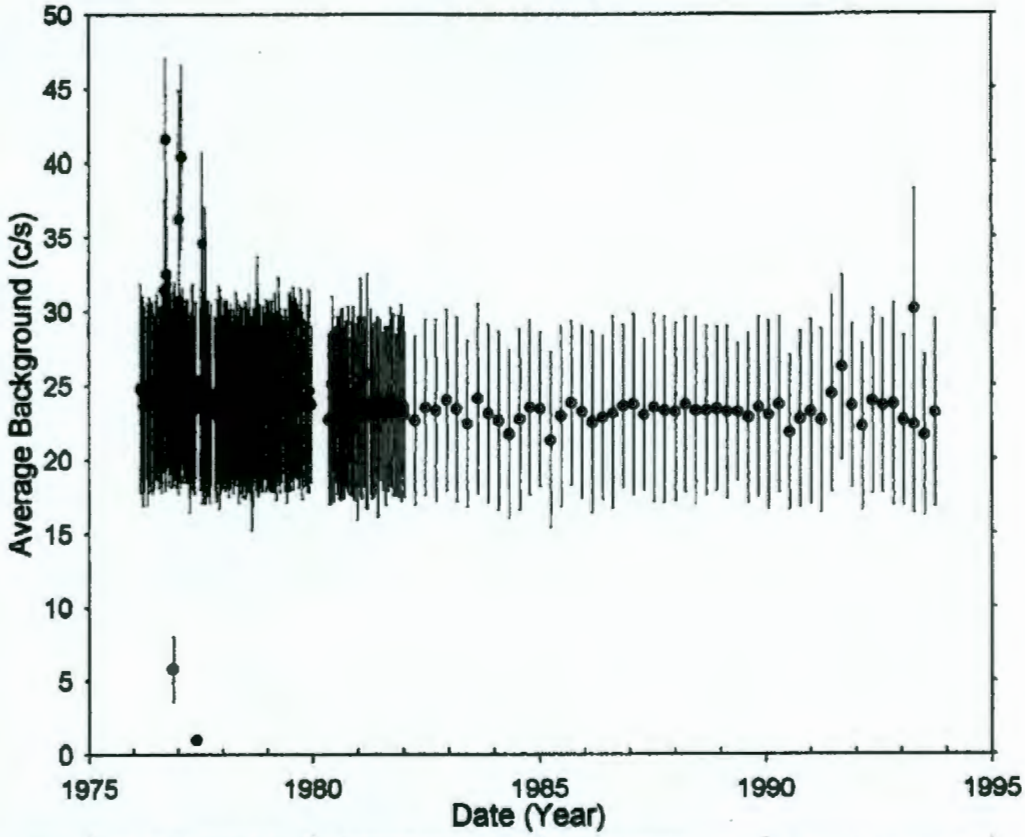
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

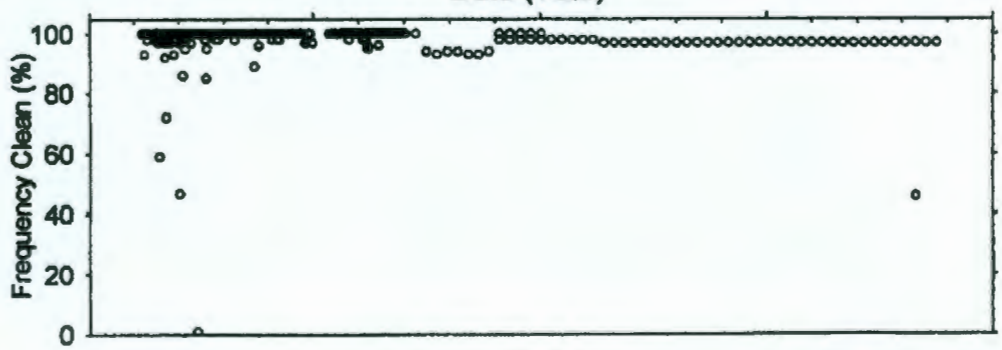
Borehole 21-03-11

Oldest Survey
3/02/1976

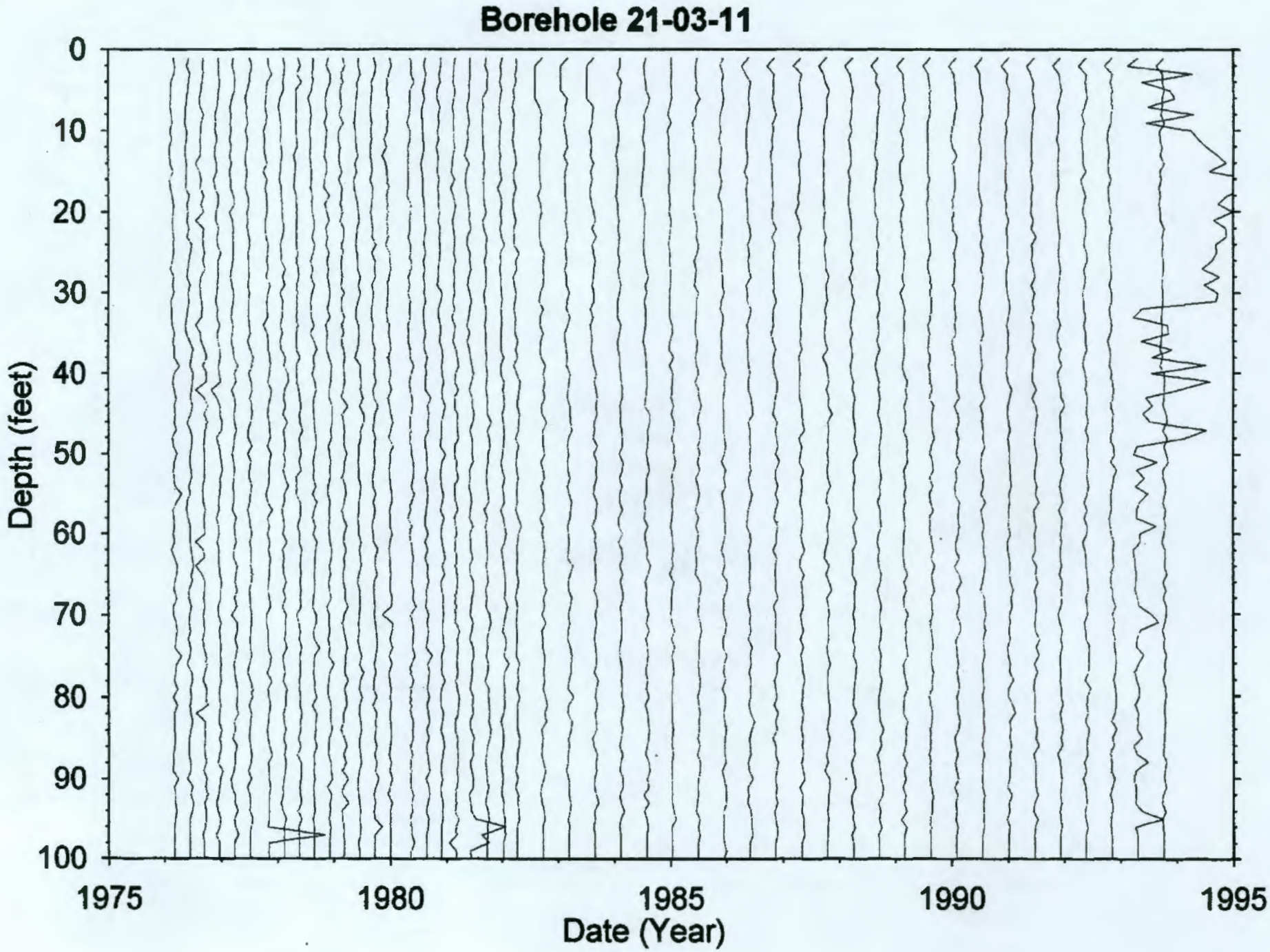


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-03-11
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

BX

Dry Well Survey Analysis - Notes

Borehole 21-03-11 Total # Surveys 284 Probe Type 04 3 14

neutron surveys 3 # GR Surveys

Log Date: 3-2-76 1st 10-5-93 Last Presentation Plot Dates
(If different from 1st & Last)

Contamination Zone Depth(s): None

Isotope from Spectral Survey: Cs low @ surf Co low @ 210' Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			nothing in >50 above

BackGnd.Txt

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

2-10 start

Analysis Notes

Analyst Name R3 S/W ver TFGROSS22

Borehole 21-03-12

Contamination (Cs-137) from 15-35 feet appears Stable

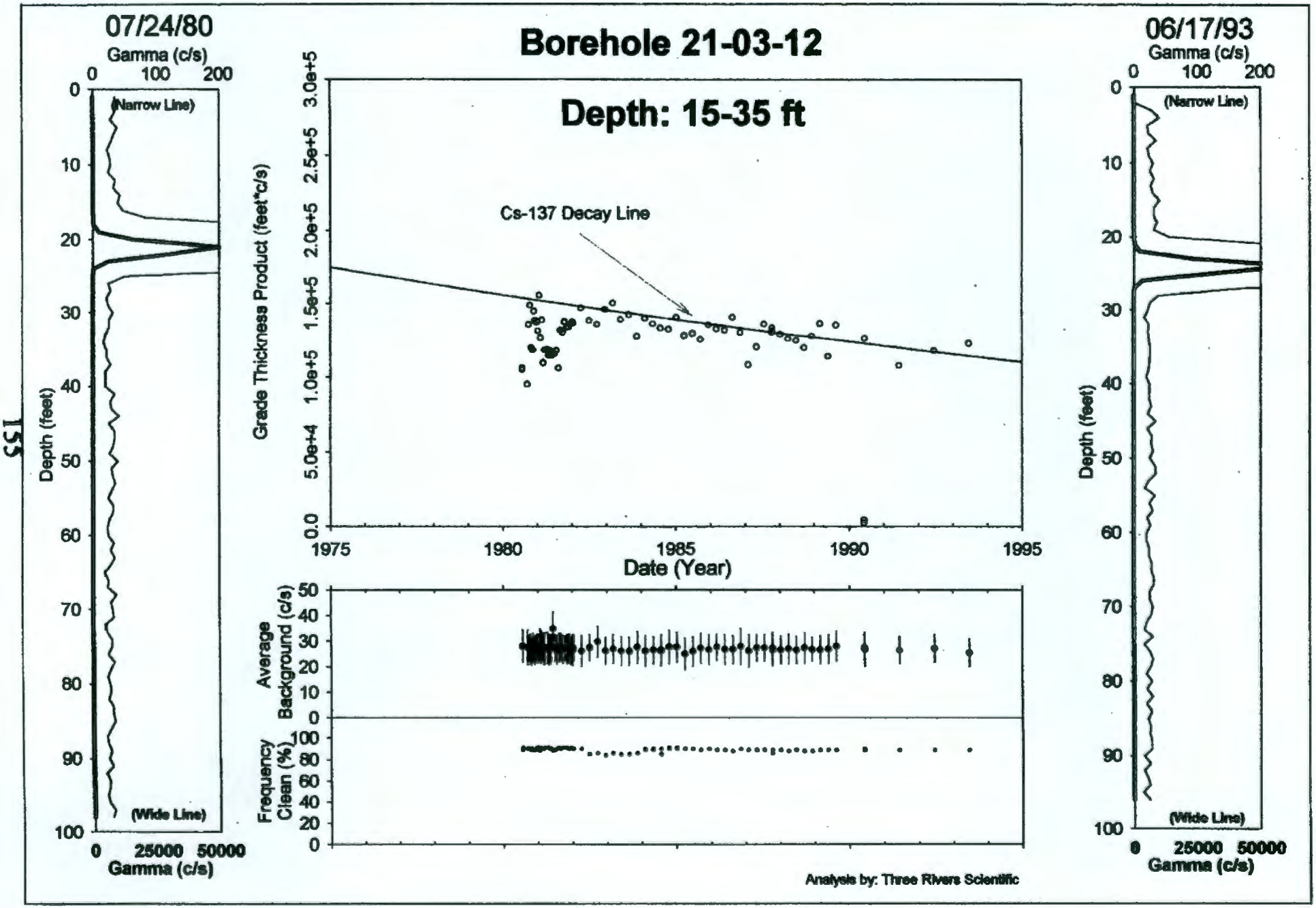
Grade thickness product from 15 to 35 feet is decreasing consistent with Cs-137 from 1983 to 1993. However, there is some question of exceeding high count rate limits for this interval, particularly prior to 1983.

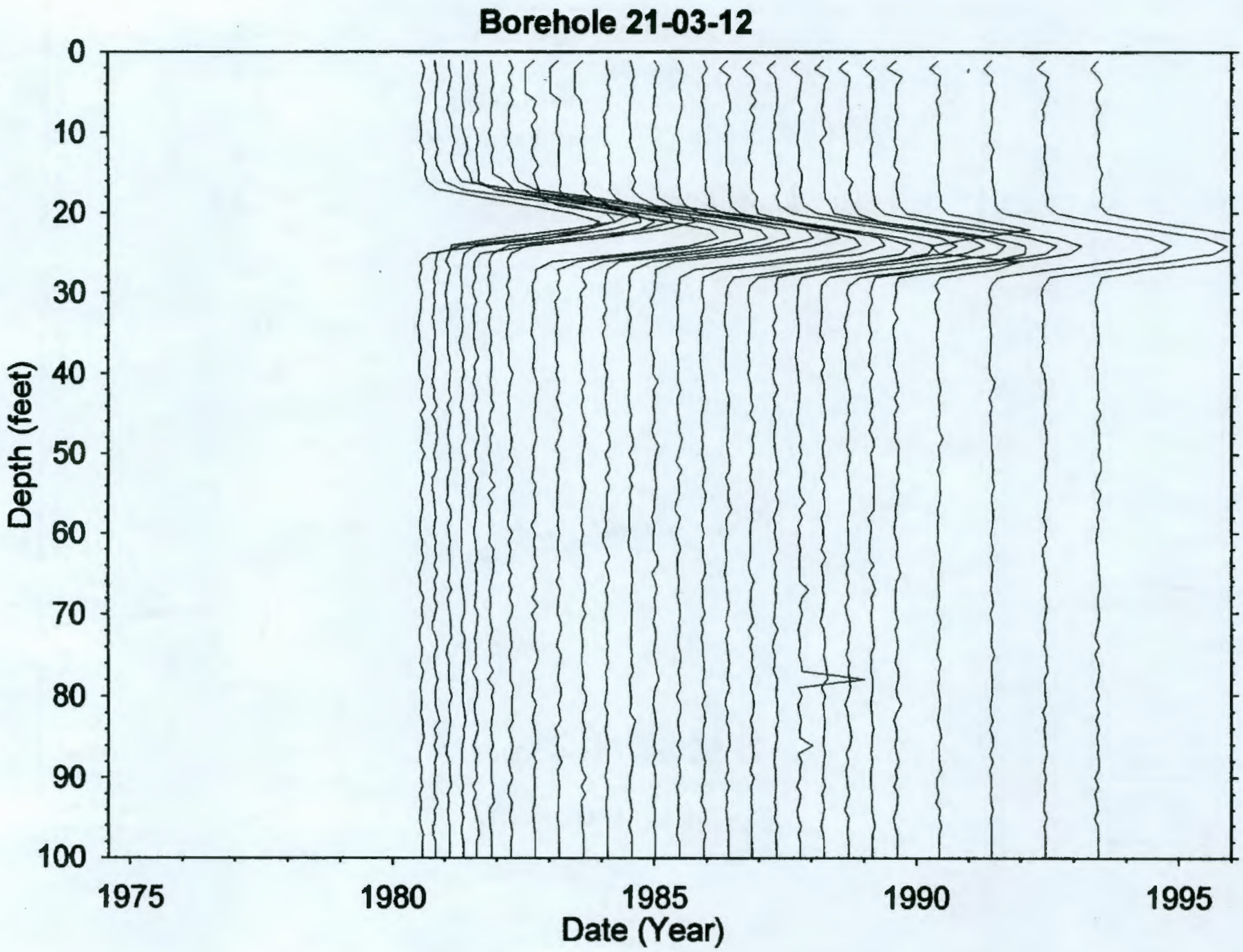
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI & 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980
Last Survey Date :	6/17/1993
Number Surveys :	80

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 :	15-35 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


Borehole 21-03-12
Depth: 15-35 ft
07/24/80
06/17/93
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 25000 50000
Gamma (c/s)
Grade Thickness Product (feet*c/s)
0.0 5.0e+4 1.0e+5 1.5e+5 2.0e+5 2.5e+5 3.0e+5
Cs-137 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-03-12
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-03-12

Total # Surveys 101

neutron surveys 3

Probe Type 04 (80) 14 (18)

GR Surveys 80

Log Date: 7-24-80 1st 6-17-93 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 15-35

Isotope from Spectral Survey: Cs

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Only one zone

BackGnd.Txt

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

15-35 start

Analysis Notes

at 40K c/s dead time is excessive for 04, kent look at it

Analyst Name R3

S/W ver TFGROSS 2.2

Borehole 21-04-01

Contamination (Cs-137) from 2-20 feet is Stable

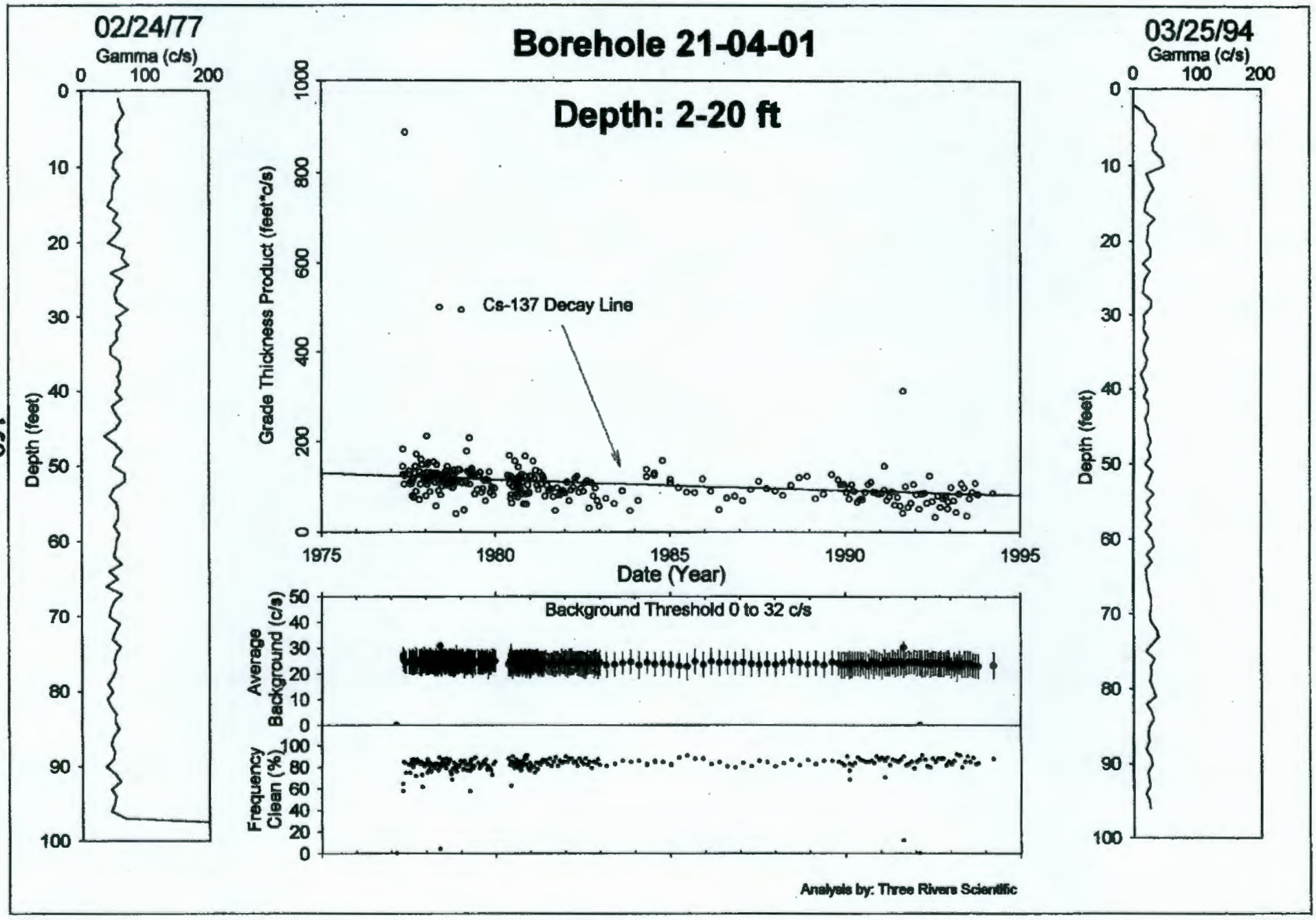
Grade thickness product from 2 to 20 feet is decreasing consistent with
Cs-137 (HPGe identified) decay from 1977 to 1994.
The levels are near threshold.

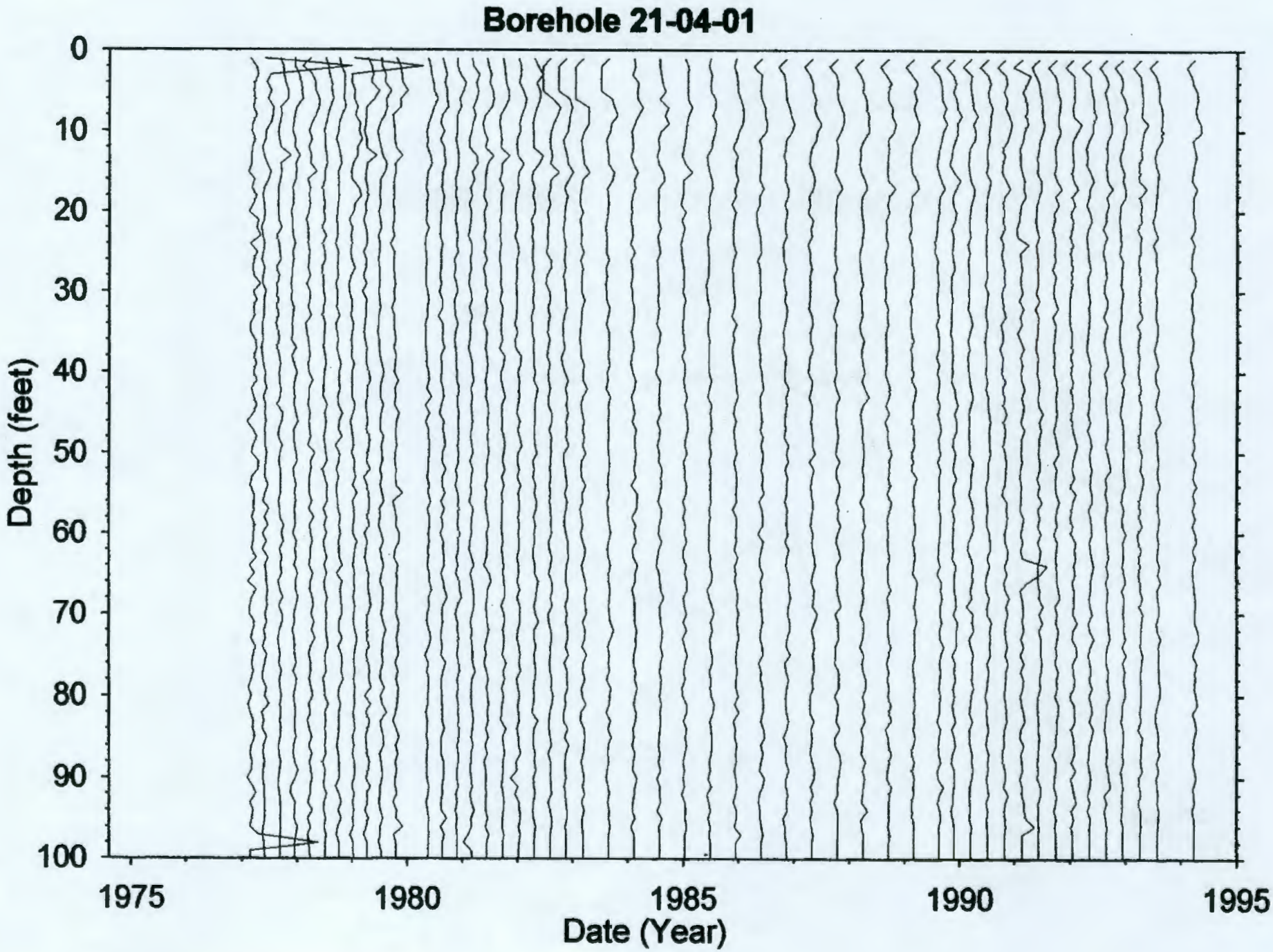
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	2/24/1977
Last Survey Date :	3/25/1994
Number Surveys :	273

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<32	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-20 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


Borehole 21-04-01
Depth: 2-20 ft
02/24/77
Gamma (c/s)
0 100 200
Depth (feet)
0 10 20 30 40 50 60 70 80 90 100
03/25/94
Gamma (c/s)
0 100 200
Depth (feet)
0 10 20 30 40 50 60 70 80 90 100
Grade Thickness Product (feet*c/s)
0 200 400 600 800 1000
Cs-137 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Background Threshold 0 to 32 c/s
Average Background (c/s)
0 10 20 30 40 50
Frequency Clean (%)
0 20 40 60 80 100
Analysis by: Three Rivers Scientific


Borehole 21-04-01
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-04-01 Total # Surveys 277 Probe Type 04 02 14

neutron surveys 2 # GR Surveys 273

Log Date: 2-24-77 1st 3-25-94 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs near surface (2 gram) Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Need to see lower threshold 32

BackGnd.Txt

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

2-15 start

Analysis Notes

2-15' discarded 2-20' used. Recalculated for key $0 \le x \le 32$ PM in order to help push state at threshold

Analyst Name R³ S/W ver TFGROSS 2.2

Borehole 21-04-03

Contamination (Cs-137 & Eu-154) from 0-12 feet is Tank Farm Activity early, stable late

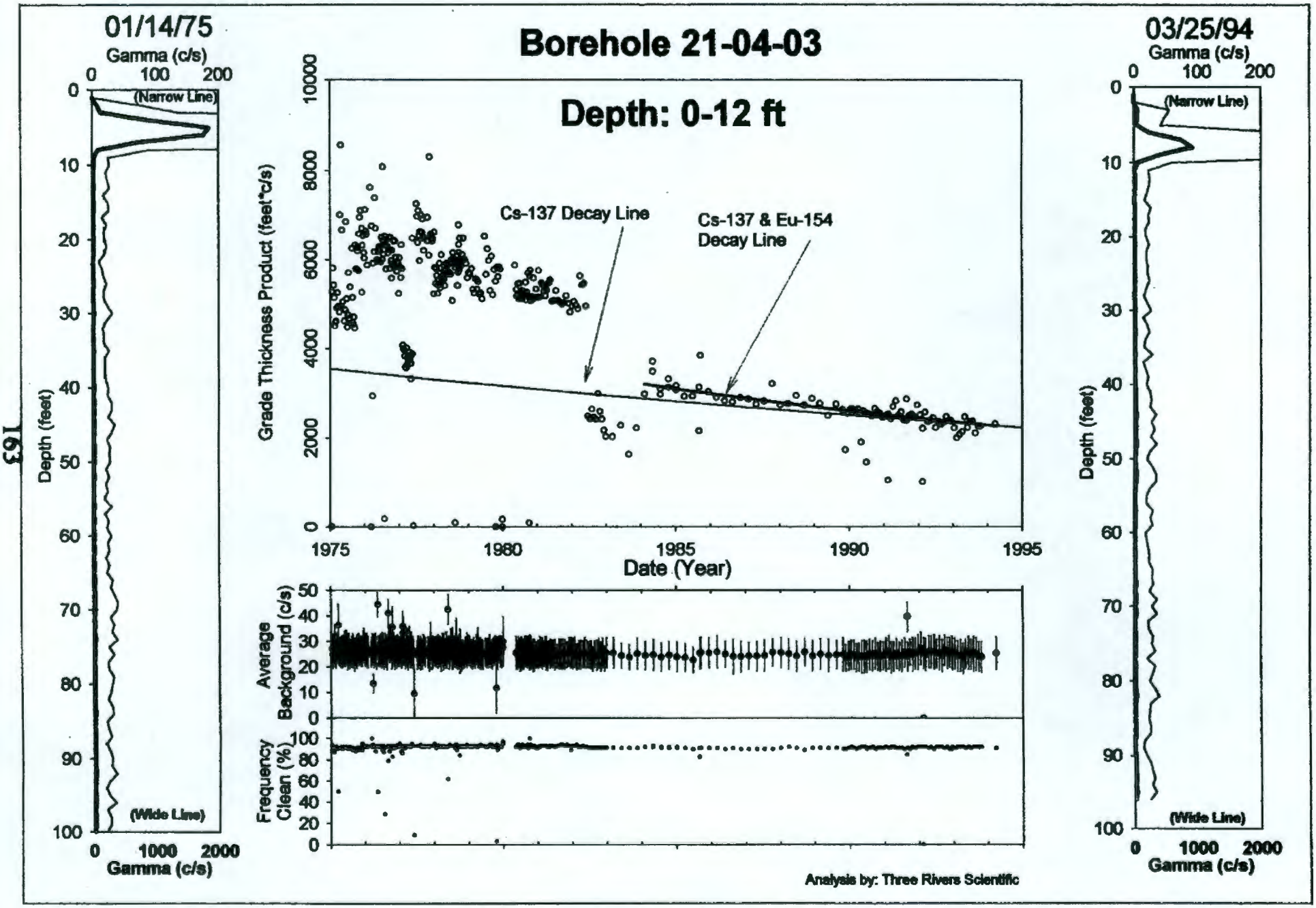
Grade thickness product over 0 to 12 feet exhibits changing behavior from Jan 14, 1975 until Jun 1, 1982. Also from Jun 1, 1982 until Feb 8, 1984 readings are artificially low due to incomplete logging of entire depth interval. From Feb 8, 1984 until Mar 25, 1994 the interval is decreasing consistent with a least squares fit for Cs-137 (identified from HPGe detector) and Eu-154 (identified from HPGe detector). Note the Co-60 identified from HPGe data is too low to observe with gross gamma response. The least square fit results in gross gamma contribution ratio of Cs-137 to Eu-154 of 6.0 as of Mar 25, 1994.

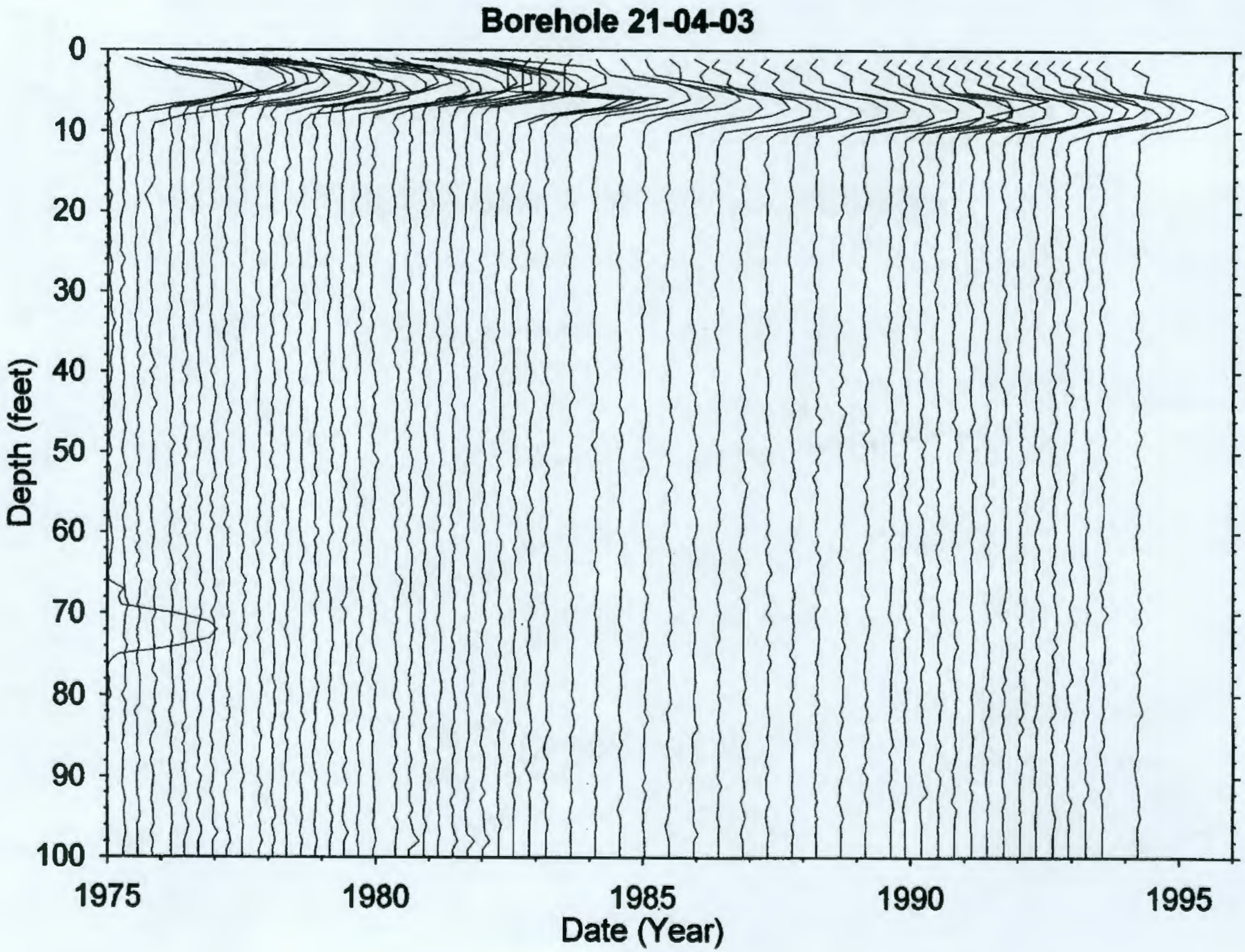
Gross Gamma Survey Information

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 :	1/14/1975
Last Survey Date :	3/25/1994
Number Surveys :	389

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 :	0-12 Tank Farm Activity early, Stable late	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


Borehole 21-04-03
Depth: 0-12 ft
01/14/75
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
03/25/94
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Cs-137 & Eu-154 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-04-03
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-04-03 | Total # Surveys 394 | Probe Type 04 14 02

neutron surveys 3 | # GR Surveys 389

Log Date: 1-14-75 1st | 3-25-94 Last | Presentation Plot Dates 1-20-75 (If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey: Cs Eu Co some near surface | Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			From 6-22-82 to 2-8-84 incomplete logging of top interval

BackGnd.Txt

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

2-20 start

Analysis Notes

Eu should be see a great bump in!

Analyst Name Rene Rawlas | S/W ver TFGRDS2.2

filein := "two.txt"

Well 21-04-03

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

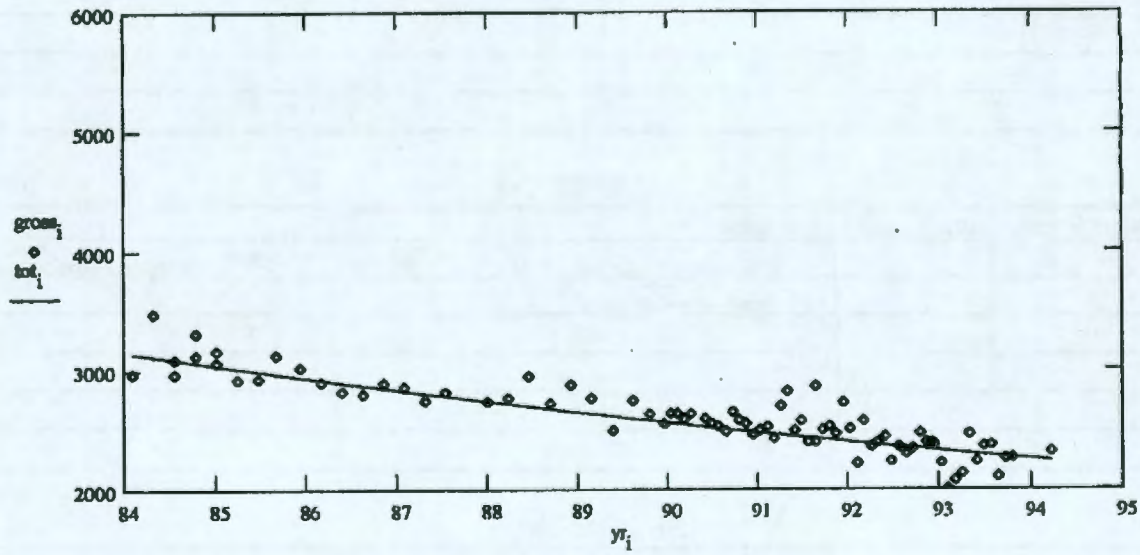
$N := \mathrm{last}(yr)$ $\quad N = 82$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 8.5$

$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 00$ $\quad acs := 3000$ $\quad aeu := 1500$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}} \cdot 1$ $\quad tot_i := Cs_i + Eu_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aeu) = 0$ $\quad 1 = 1$

$\begin{bmatrix} \alpha cs \\ \alpha eu \end{bmatrix} := \mathrm{Minerr}(acs, aeu)$ $\quad \alpha cs = 3.029 \cdot 10^3$ $\quad \alpha eu = 1.568 \cdot 10^3$

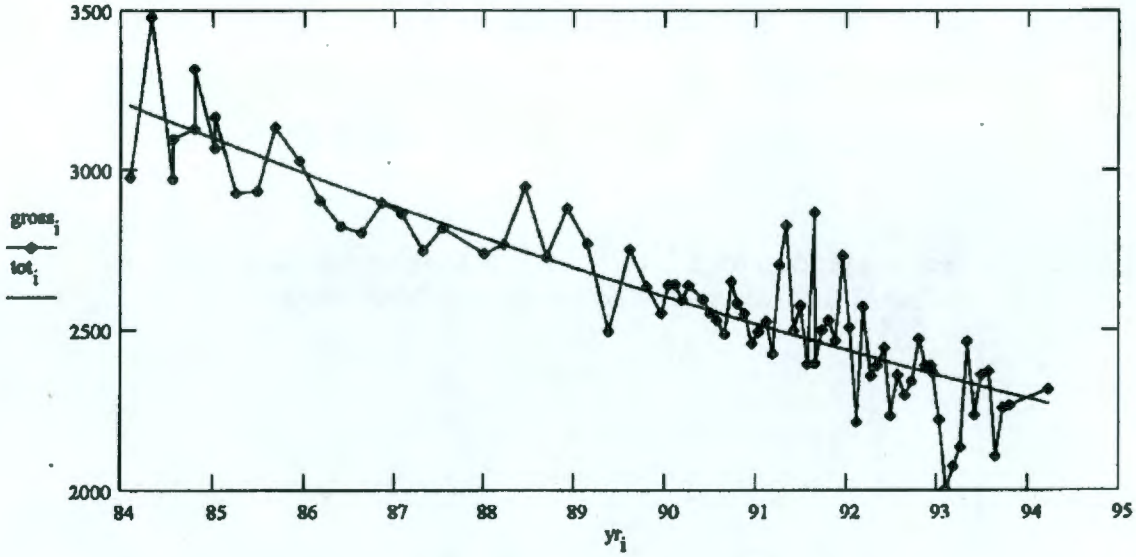
$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha eu \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau eu}}$ $\quad tot_i := Cs_i + Eu_i$

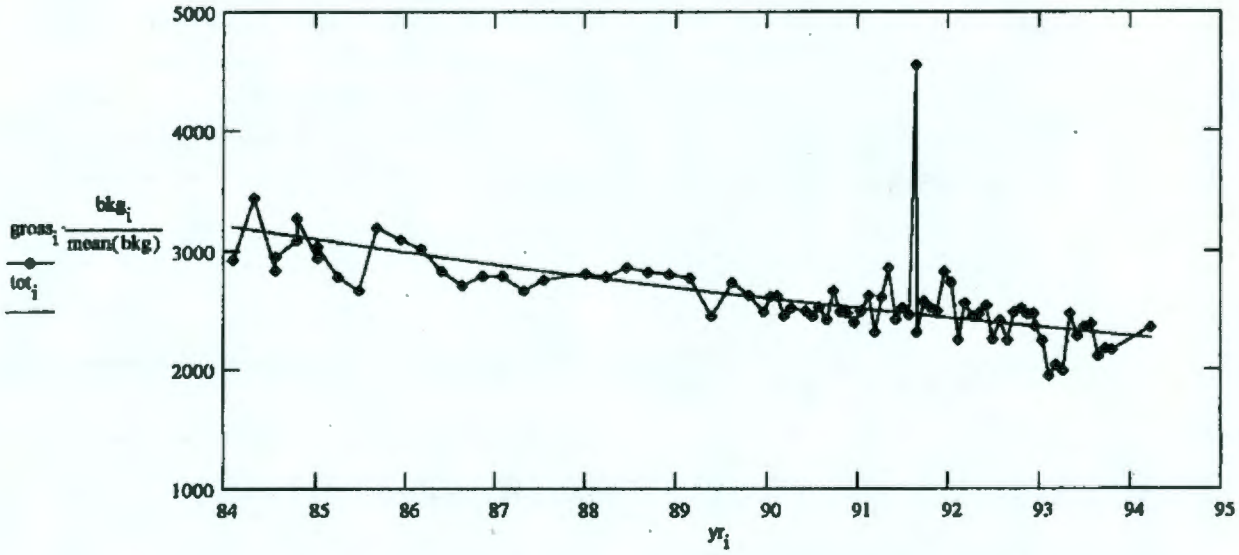
$\frac{\alpha cs}{\alpha eu} = 1.933$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

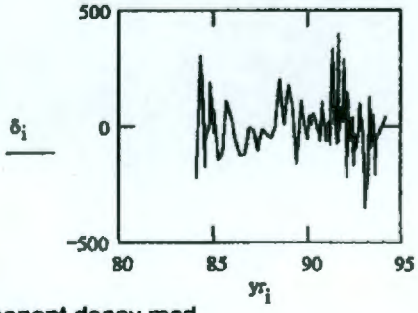
$\frac{Eu_N}{Cs_N} = 0.168$

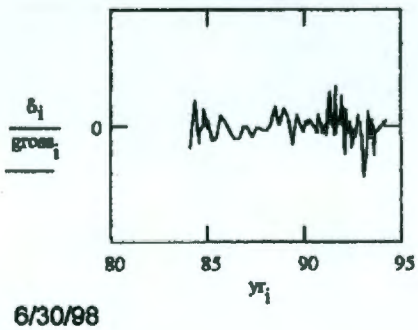
$\frac{Cs_N}{Eu_N} = 5.961$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





Borehole 21-04-04

Contamination (Cs-137) from 2-25 feet is Stable

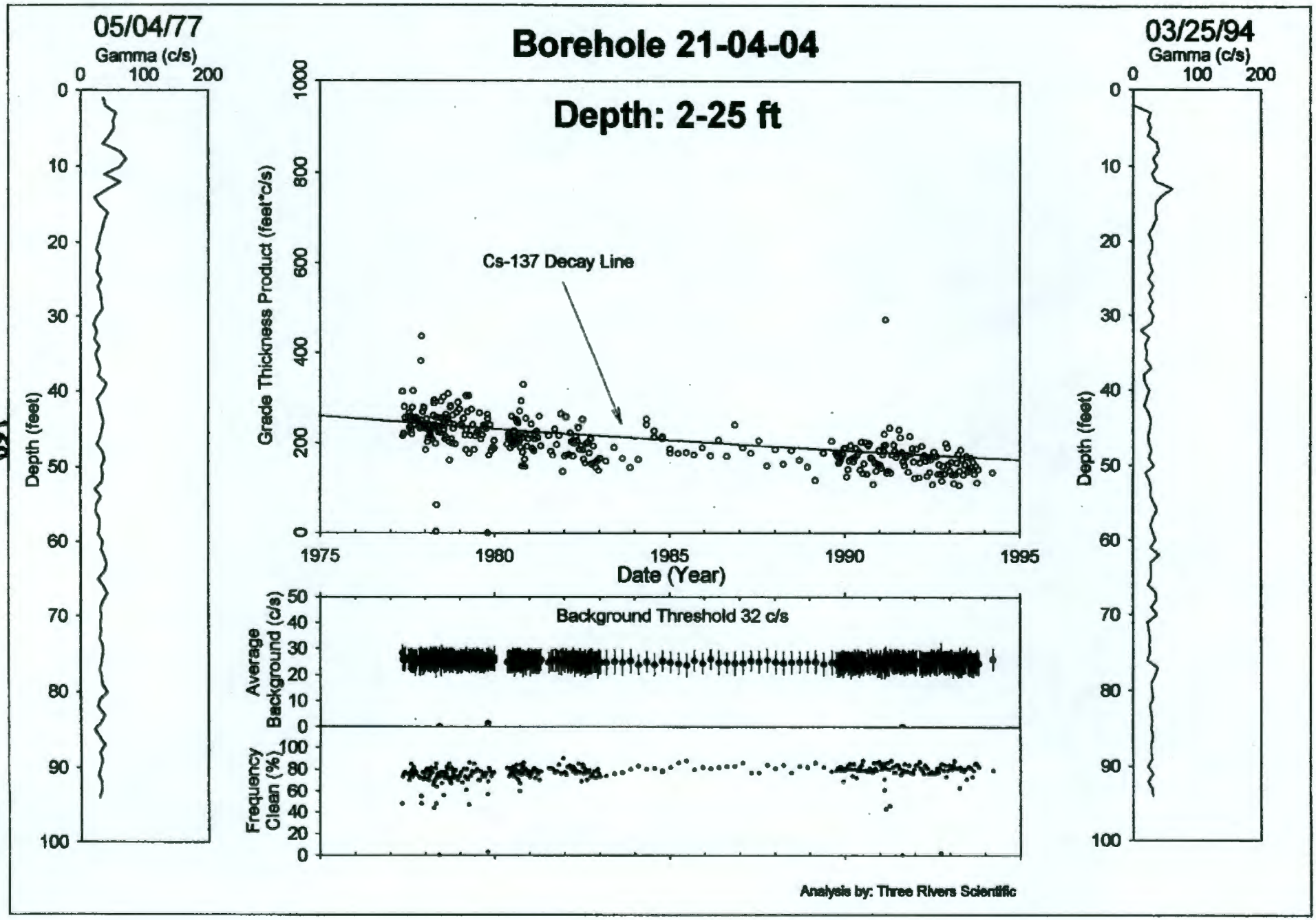
Grade thickness product from 2 to 25 feet is decreasing consistent with Cs-137 (HPGe identified) decay from 1977 to 1994.

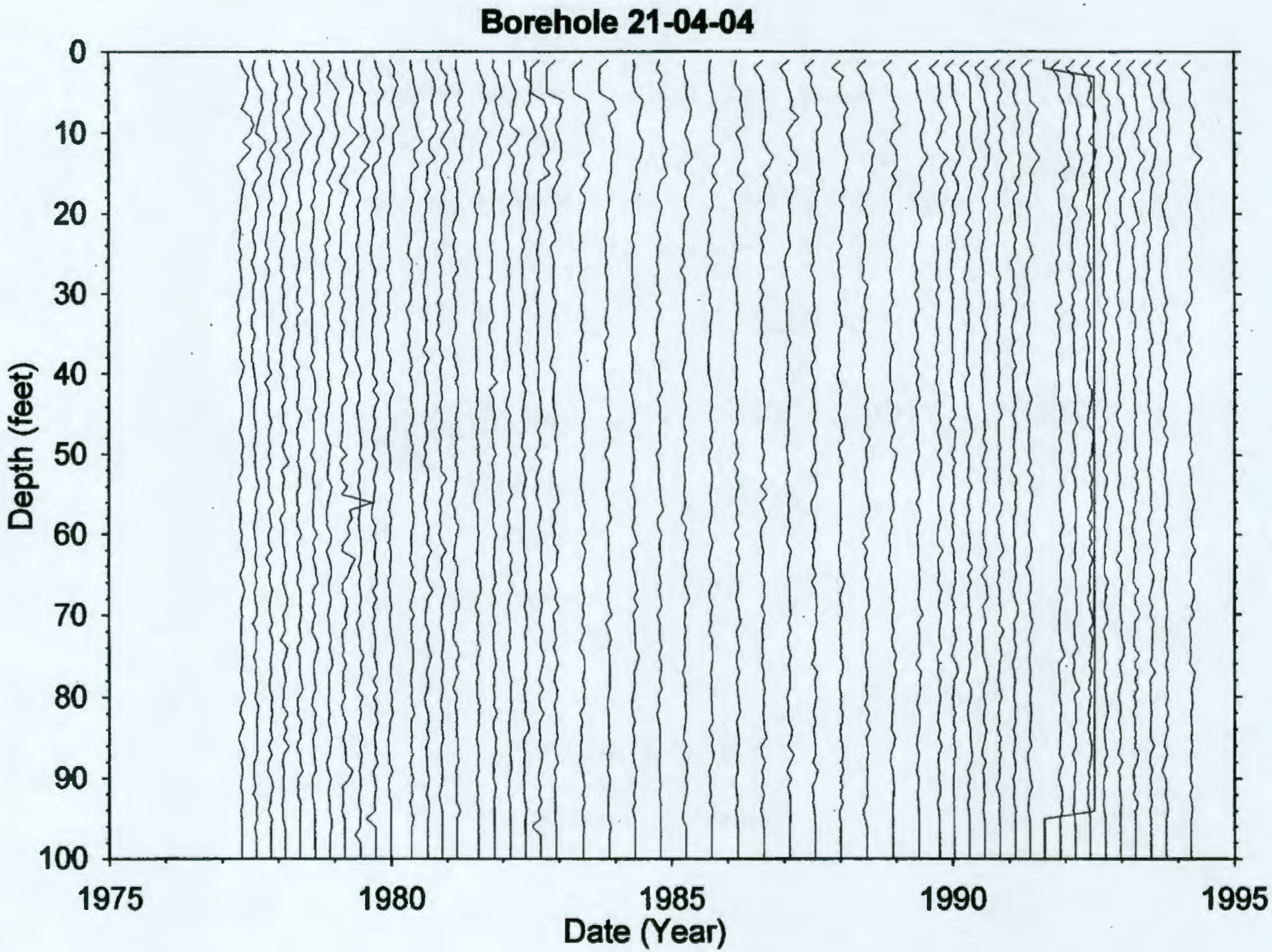
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	14: Shielded NaI, 02: Red GM, 03: Neutron
Borehole Depth :	96 ft
Survey Depth :	96 ft
First Survey Date :	5/4/1977
Last Survey Date :	3/25/1994
Number Surveys :	338

Analysis Notes

Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<32	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	2-25 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


05/04/77
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-04-04
Depth: 2-25 ft
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Date (Year)
1975
1980
1985
1990
1995
Background Threshold 32 c/s
Average Background (c/s)
Frequency Clean (%)
03/25/94
Gamma (c/s)
Depth (feet)
Analysis by: Three Rivers Scientific


Borehole 21-04-04
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-04-04

Total # Surveys 342

Probe Type D4 14 02

neutron surveys 2

GR Surveys 335

Log Date: 5-4-77 1st

3-25-94 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): 2-25 ft Cs

Isotope from Spectral Survey: Cs

Max Survey Depth 96

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

2-25 above

Analysis Notes

Set threshold @ 32 c/s

Analyst Name Bruce Randall

S/W ver TFGRDS 2.2

Borehole 21-04-06

Contamination (Cs-137) from 0-10 feet is Tank Farm Activity
Contamination (Cs-137) from 8-20 feet is **UNSTABLE**, Stable late

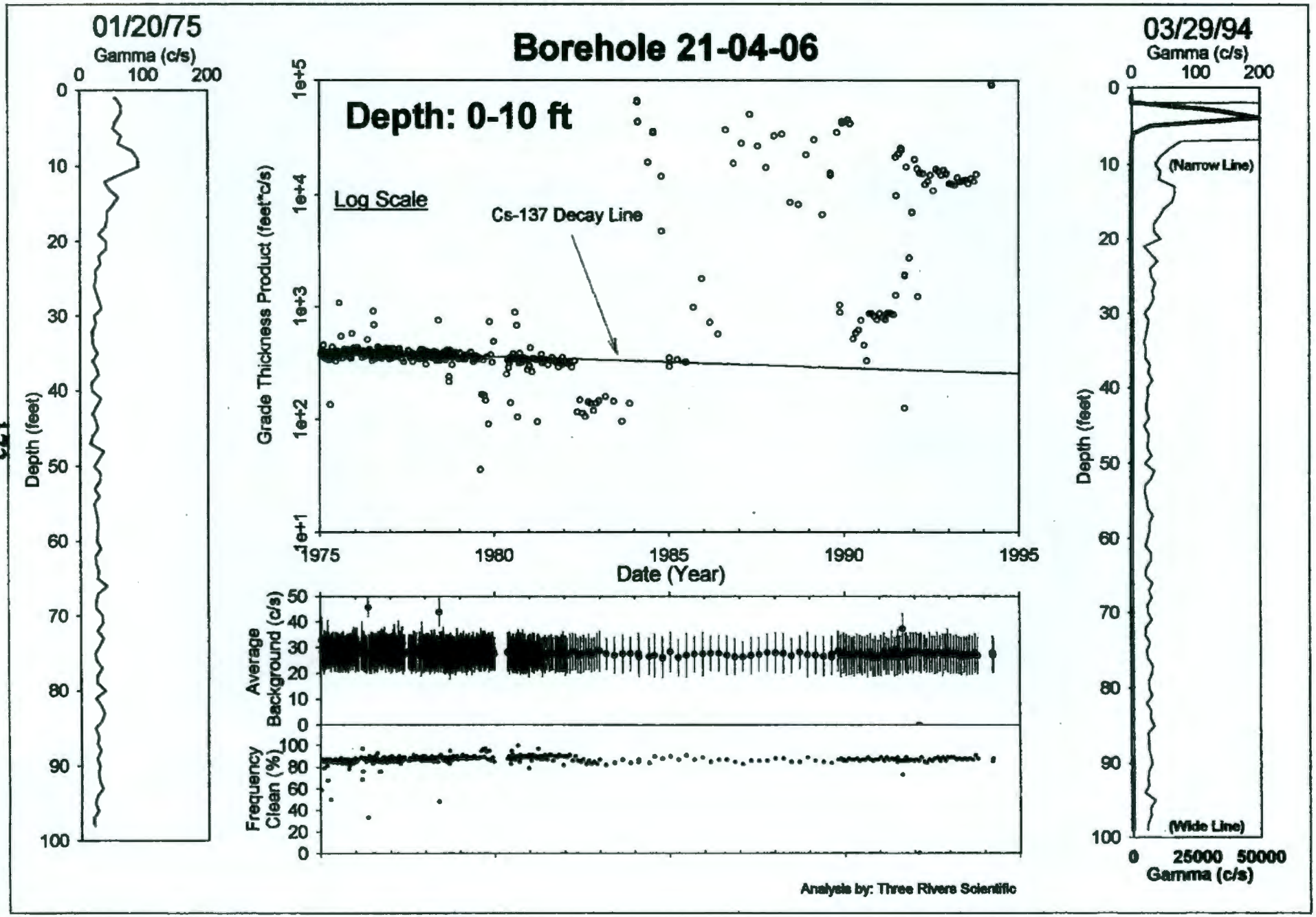
Grade thickness product over 0 to 10 feet demonstrates radical changes indicative of tank farm activities. The higher readings from mid 1984 to last readings may be affected by high count rate limitations, but are still significantly higher than from 1975 to 1982. The grade thickness product over 8 to 20 feet also shows some changes that may be caused by the upper interval. However, since 1985 this interval shows a decrease consistent with the natural decay of Cs-137.

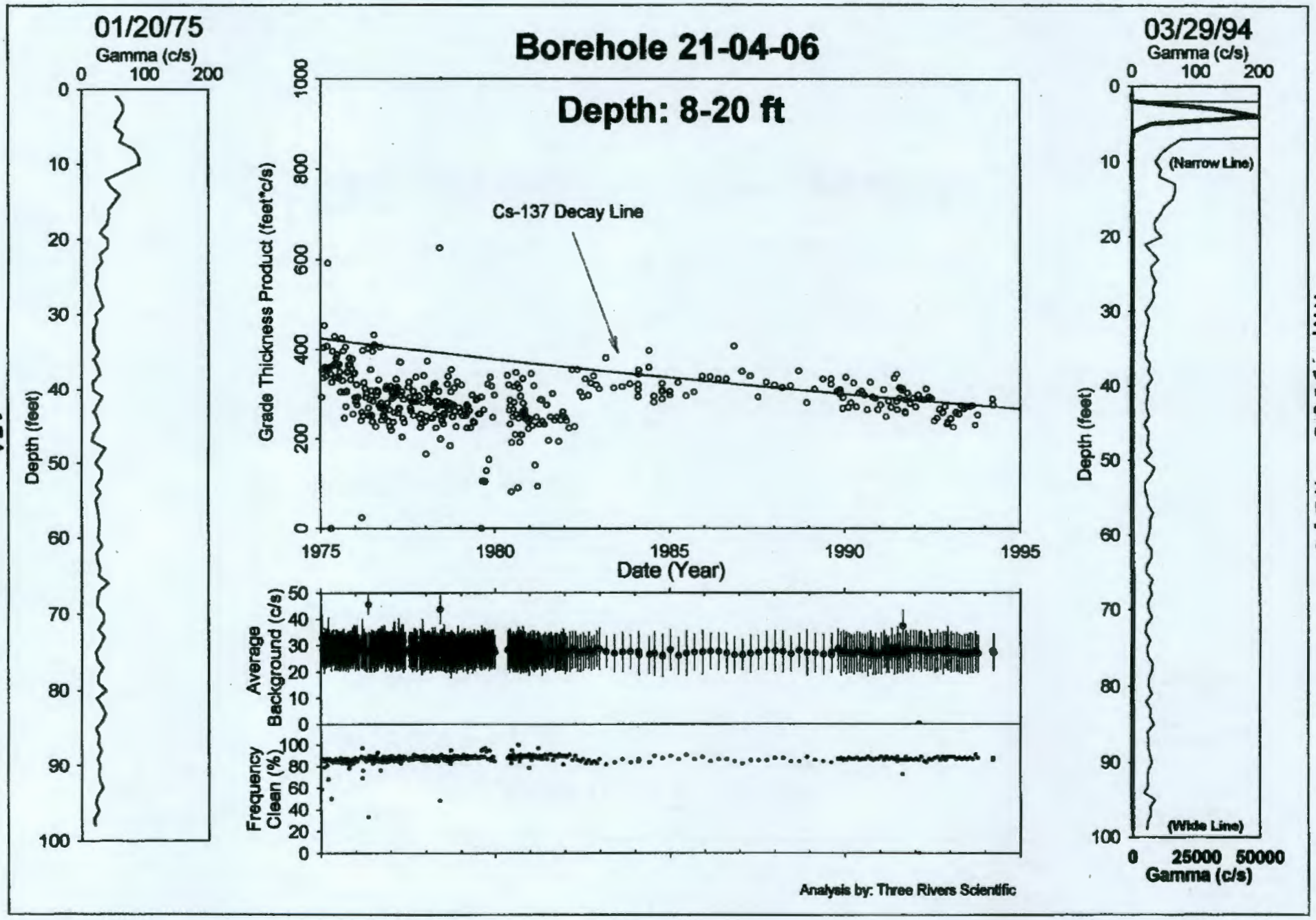
Gross Gamma Survey Information

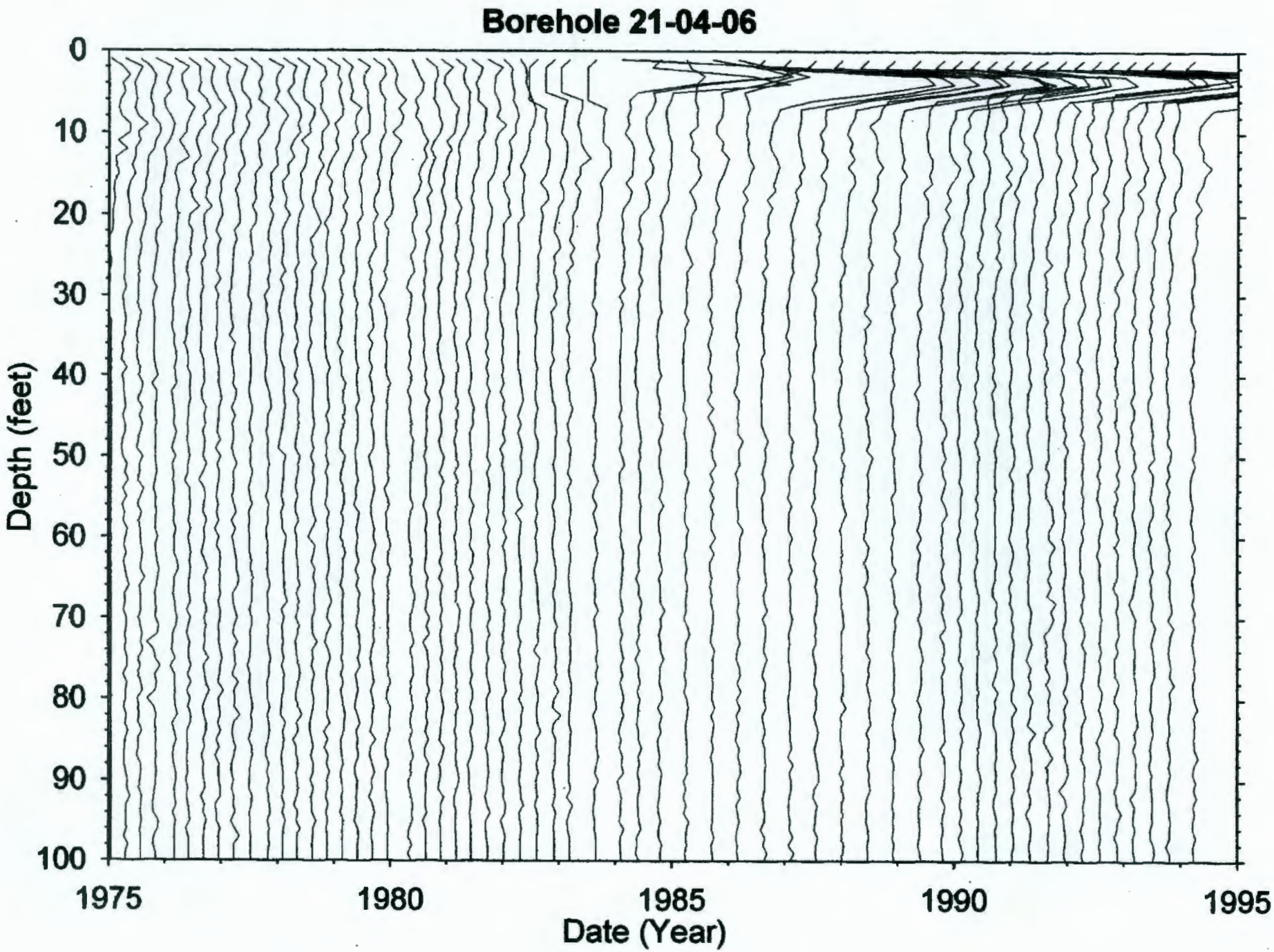
Probe Type :	04: NaI
Other Probe Types :	14: shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	3/29/1994
Number Surveys :	392

Analysis Notes

Survey Dates Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<bkg<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	0-10 Tank Farm Activity, 8-20 **UNSTABLE** Early	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


Borehole 21-04-06
Depth: 0-10 ft
Log Scale
Cs-137 Decay Line
01/20/75
Gamma (c/s)
Depth (feet)
03/29/94
Gamma (c/s)
(Narrow Line)
(Wide Line)
Grade Thickness Product (feet*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-04-06
Depth: 8-20 ft
01/20/75
Gamma (c/s)
0 100 200
Depth (feet)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Date (Year)
1975 1980 1985 1990 1995
Average Background (c/s)
Frequency Clean (%)
03/29/94
Gamma (c/s)
(Narrow Line)
(Wide Line)
0 25000 50000
Gamma (c/s)
Analysis by: Three Rivers Scientific


Borehole 21-04-06
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-04-06

Total # Surveys 397

Probe Type 04 1 14

neutron surveys 4

GR Surveys 393

Log Date: 1-14-75 1st

3-29-94 Last

Presentation Plot Dates 1-20-75
(If different from 1st & Last)

Contamination Zone Depth(s): 0-5 & 5-15

Isotope from Spectral Survey: Cs & Eu → too low in 95

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

Dead time or problem but still equal & real increase late in time 1st plot only 30 pt

Analyst Name Brent Randall

S/W ver TFBROSE 2.2

Borehole 21-04-08

Contamination (Cs-137) from 0-14 feet is Stable
Contamination (Co-60) from 59-65 feet is Stable
Contamination (Co-60) from 80-100 feet is Stable

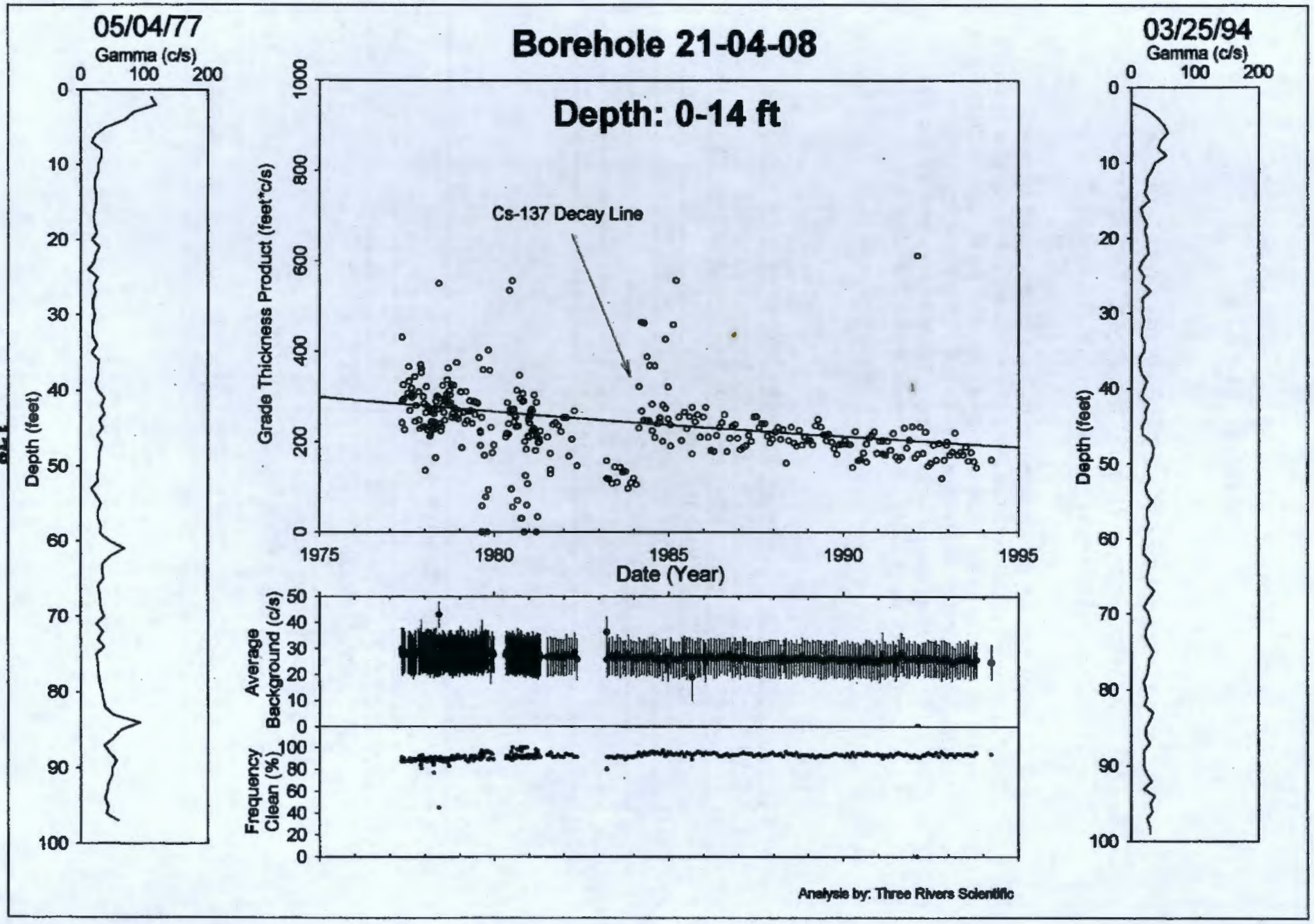
Grade thickness product from 0 to 14 feet is decreasing consistent with Cs-137 (HPGe identified), even though the logging system was not designed to operate near the surface or bottom of the well. Also, during 1983, the top 2 feet of the well was not logged. Grade thickness product from 59 to 65 feet is decreasing consistent with Co-60 (HPGe identified), and at very low levels. Grade thickness product from 80 to 100 feet is decreasing consistent with Co-60 (HPGe identified).

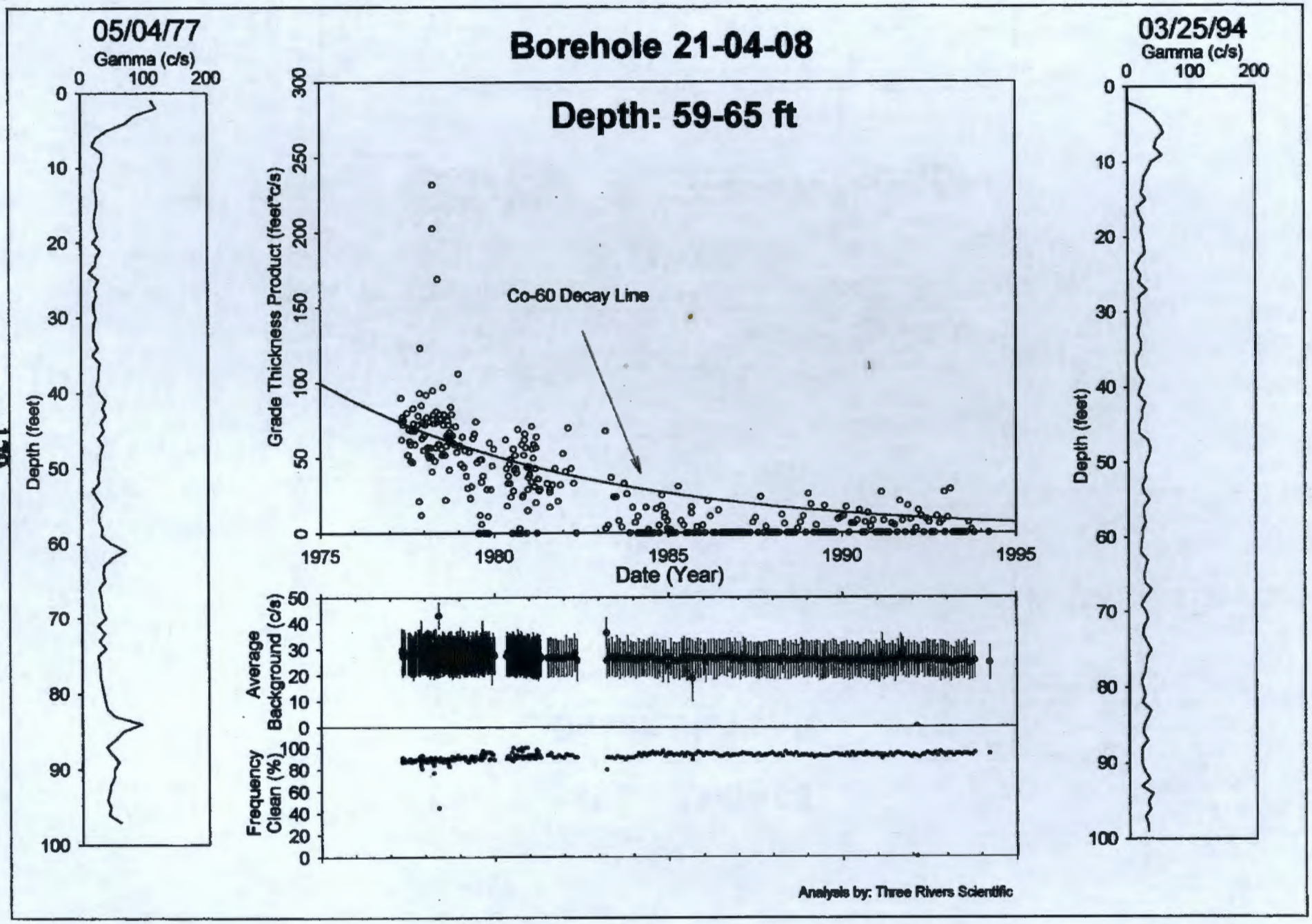
Gross Gamma Survey Information

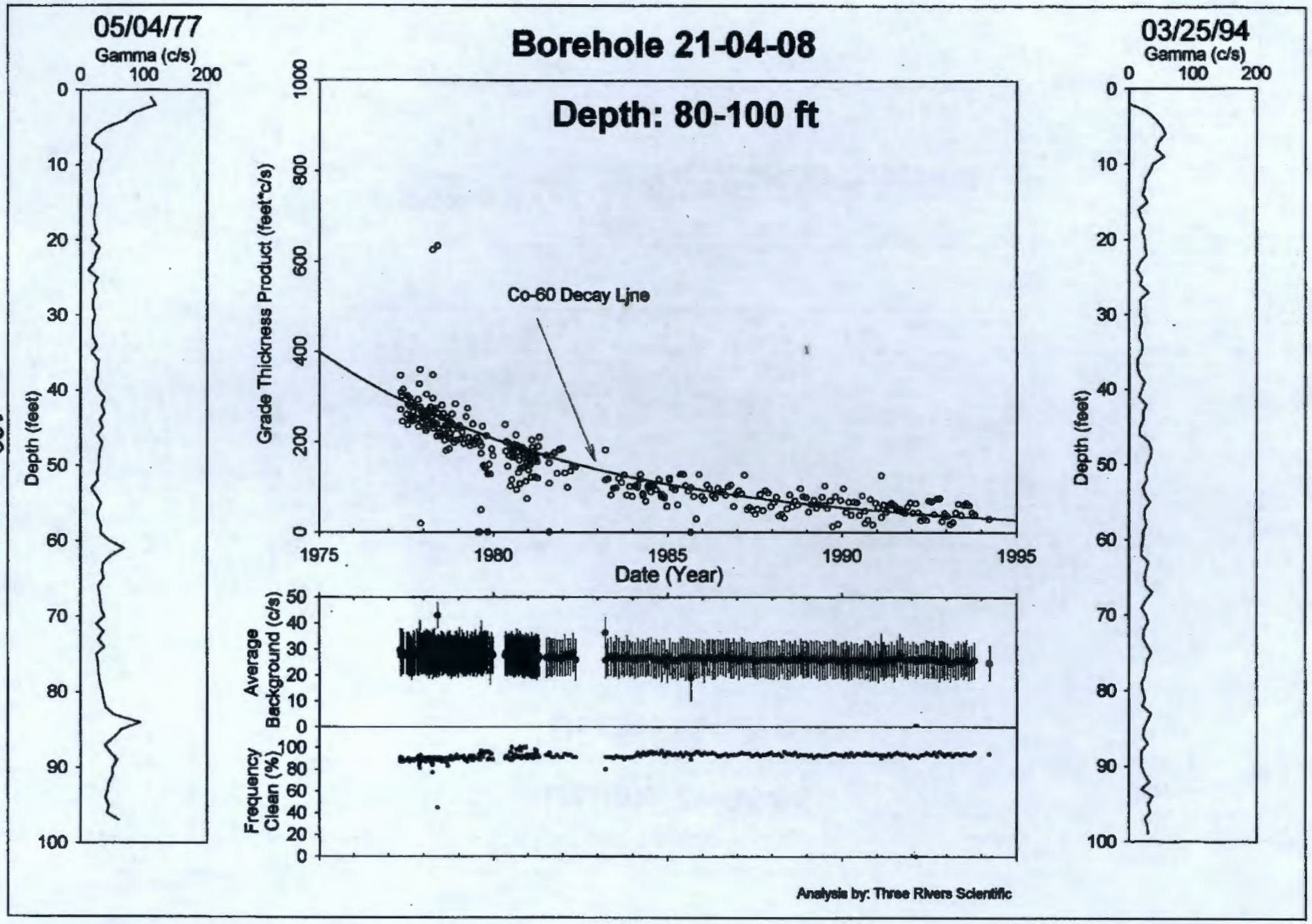
Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	5/4/1977
Last Survey Date :	3/25/1994
Number Surveys :	346

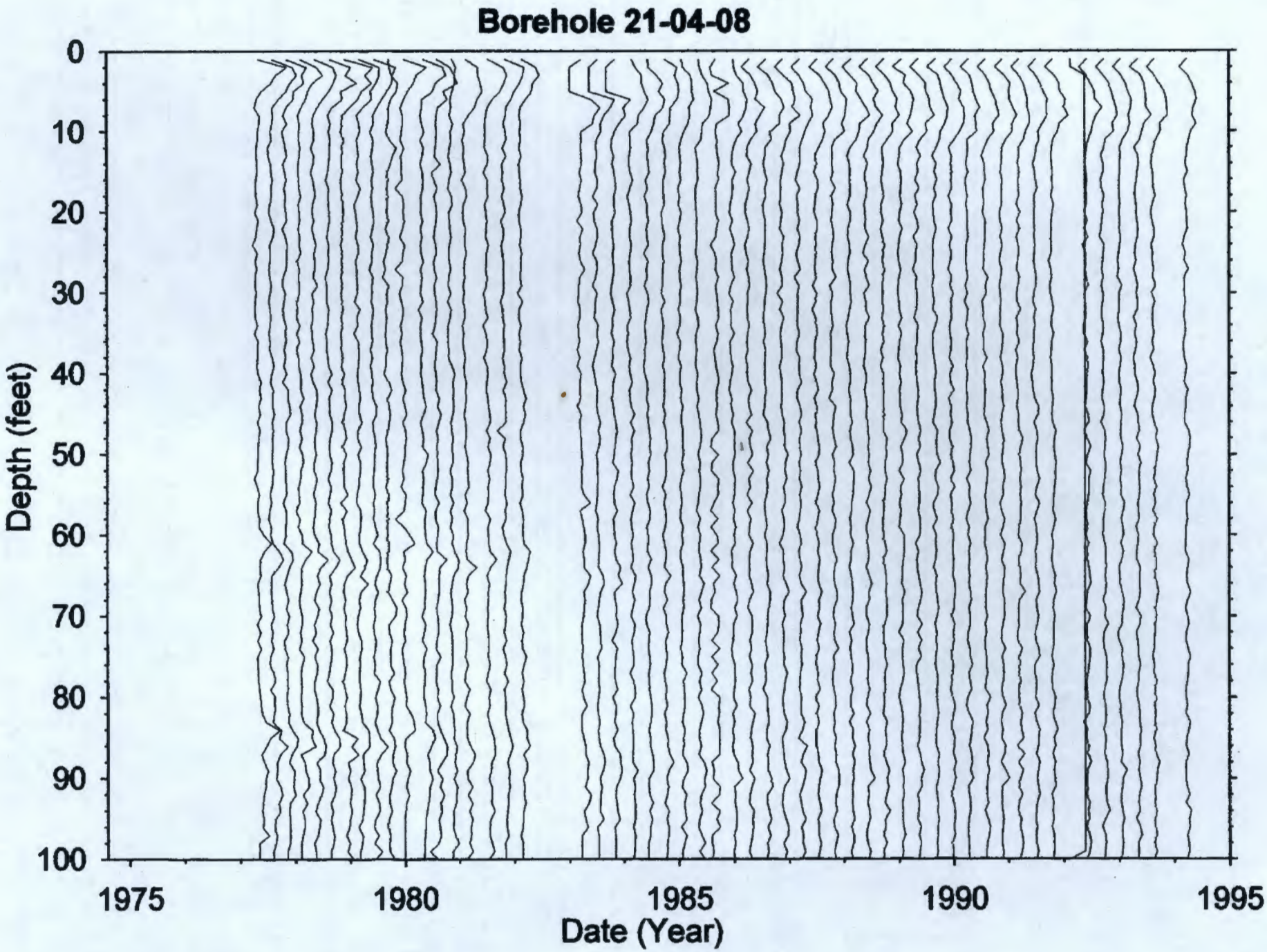
Analysis Notes

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 :	0-14, 59-65, & 80-100 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


05/04/77
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-04-08
Depth: 0-14 ft
Cs-137 Decay Line
Grade Thickness Product (feet*c/s)
Date (Year)
1975
1980
1985
1990
1995
Average Background (c/s)
Frequency Clean (%)
03/25/94
Analysis by: Three Rivers Scientific


Borehole 21-04-08
Depth: 59-65 ft
05/04/77
Gamma (c/s)
0
100
200
Depth (feet)
Grade Thickness Product (feet*c/s)
Co-60 Decay Line
1975
1980
1985
1990
1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
03/25/94
Analysis by: Three Rivers Scientific


Borehole 21-04-08
Depth: 80-100 ft
05/04/77
Gamma (c/s)
0
100
200
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
Grade Thickness Product (feet*c/s)
0
200
400
600
800
1000
Co-60 Decay Line
1975
1980
1985
1990
1995
Date (Year)
Average Background (c/s)
0
10
20
30
40
50
Frequency Clean (%)
0
20
40
60
80
100
03/25/94
Gamma (c/s)
0
100
200
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
Analysis by: Three Rivers Scientific


Borehole 21-04-08
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-04-08

Total # Surveys 351

neutron surveys 3

Probe Type 04 02 14

GR Surveys 346

Log Date: 5-4-77 1st 3-25-94 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 0-14 60 85

Isotope from Spectral Survey: Cs and Co Daughs

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Co early is clearly visible

BackGnd.Txt

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

Analysis Notes

Very low levels of Eu40

Analyst Name [illegible]

S/W ver TFGROSS2.2

Borehole 21-04-11

Contamination (Cs-137) from 2-17 feet is Stable late
Contamination (Co-60) from 60-95 feet is Stable

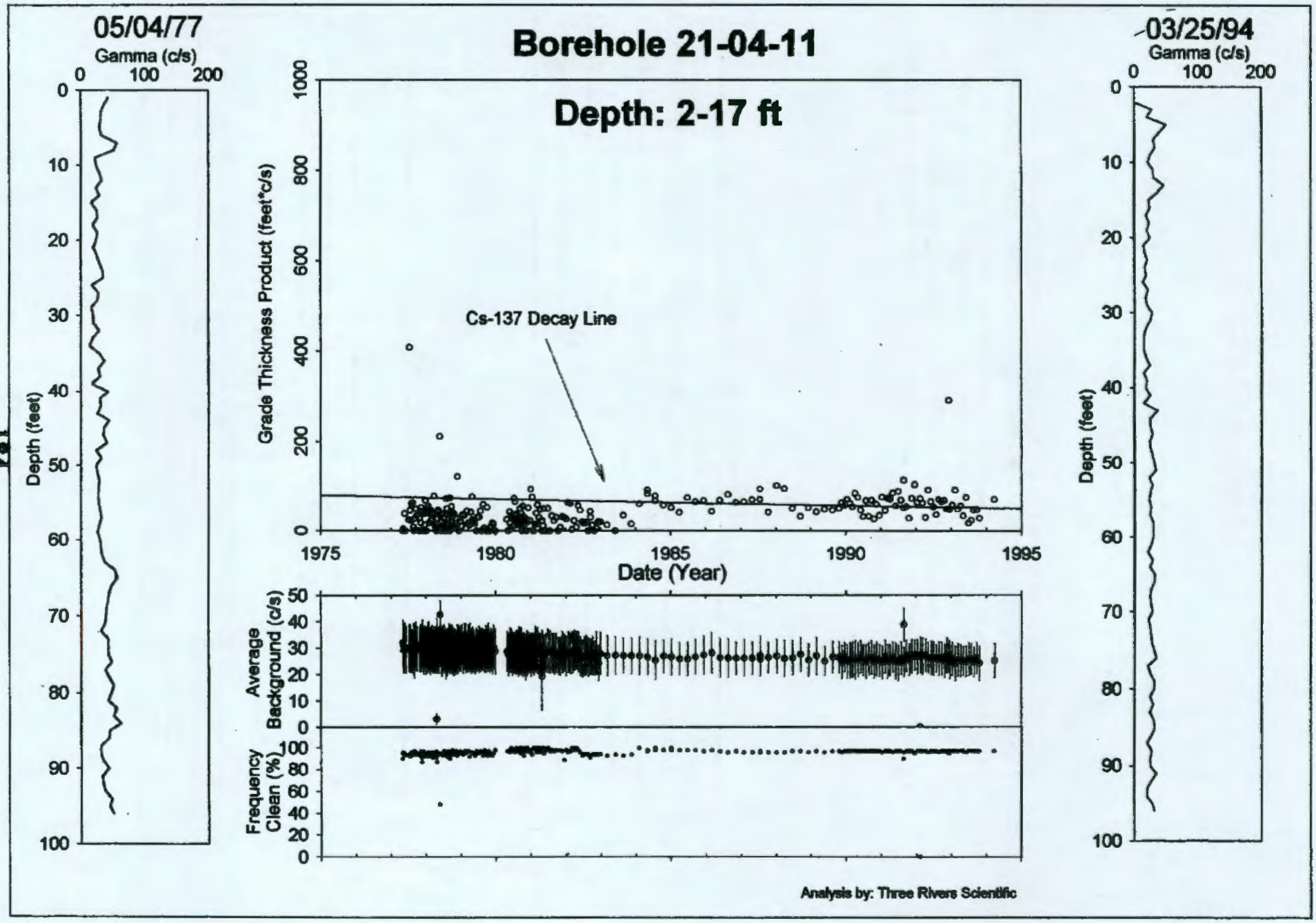
Grade thickness product from 2 to 17 feet is decreasing consistent with Cs-137 (HPGe identified). Due to system limitations near the surface and very low contamination levels, the grade thickness product was computed for the larger interval. Prior to 1984, the historical trend is undetermined, but stable from 1984 to 1994. Grade thickness product from 60 to 95 feet is decreasing consistent with Co-60 (HPGe identified). Again, the low levels of Co-60 required the wider intervals, thus, no statement of downward movement is possible.

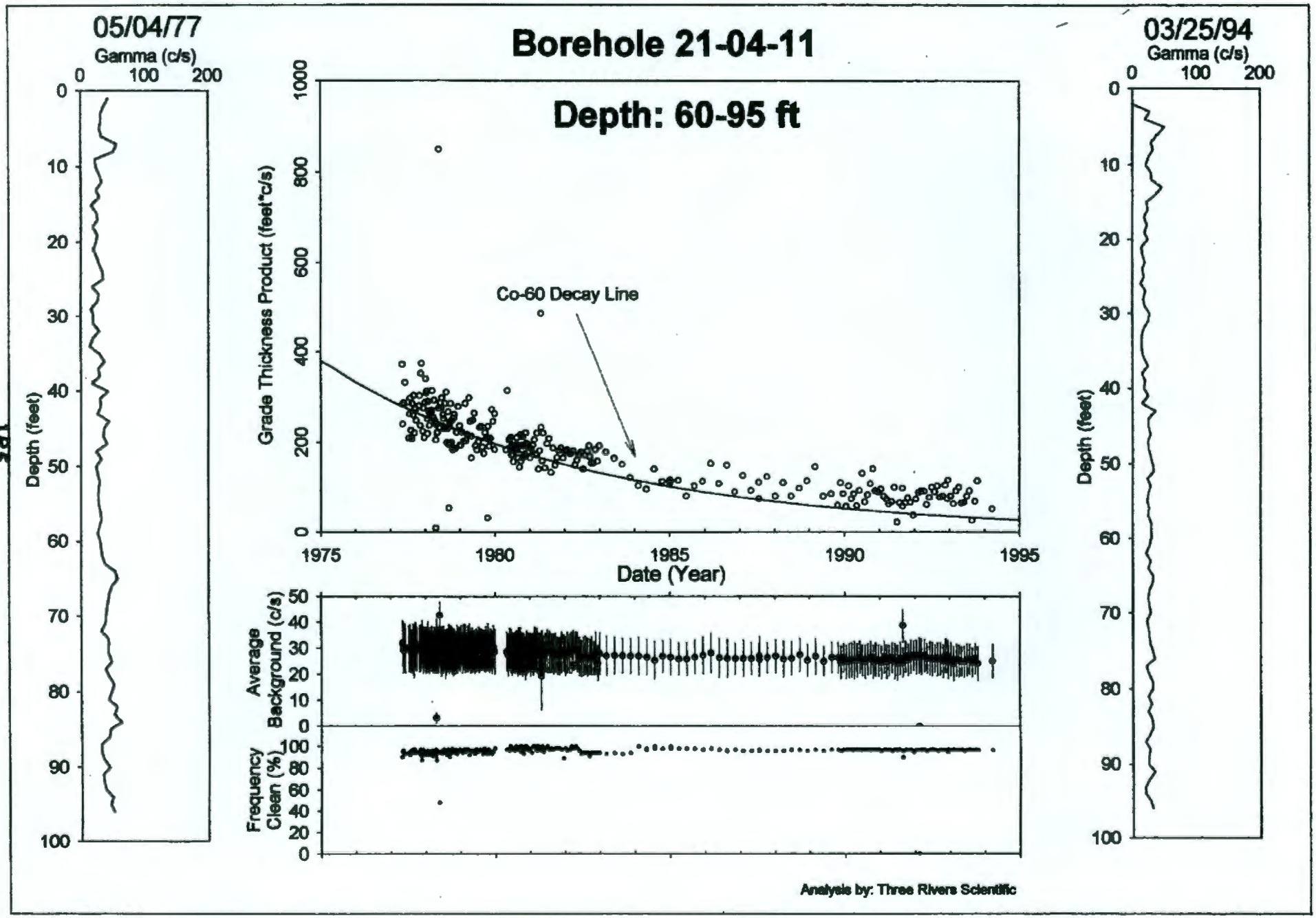
Gross Gamma Survey Information

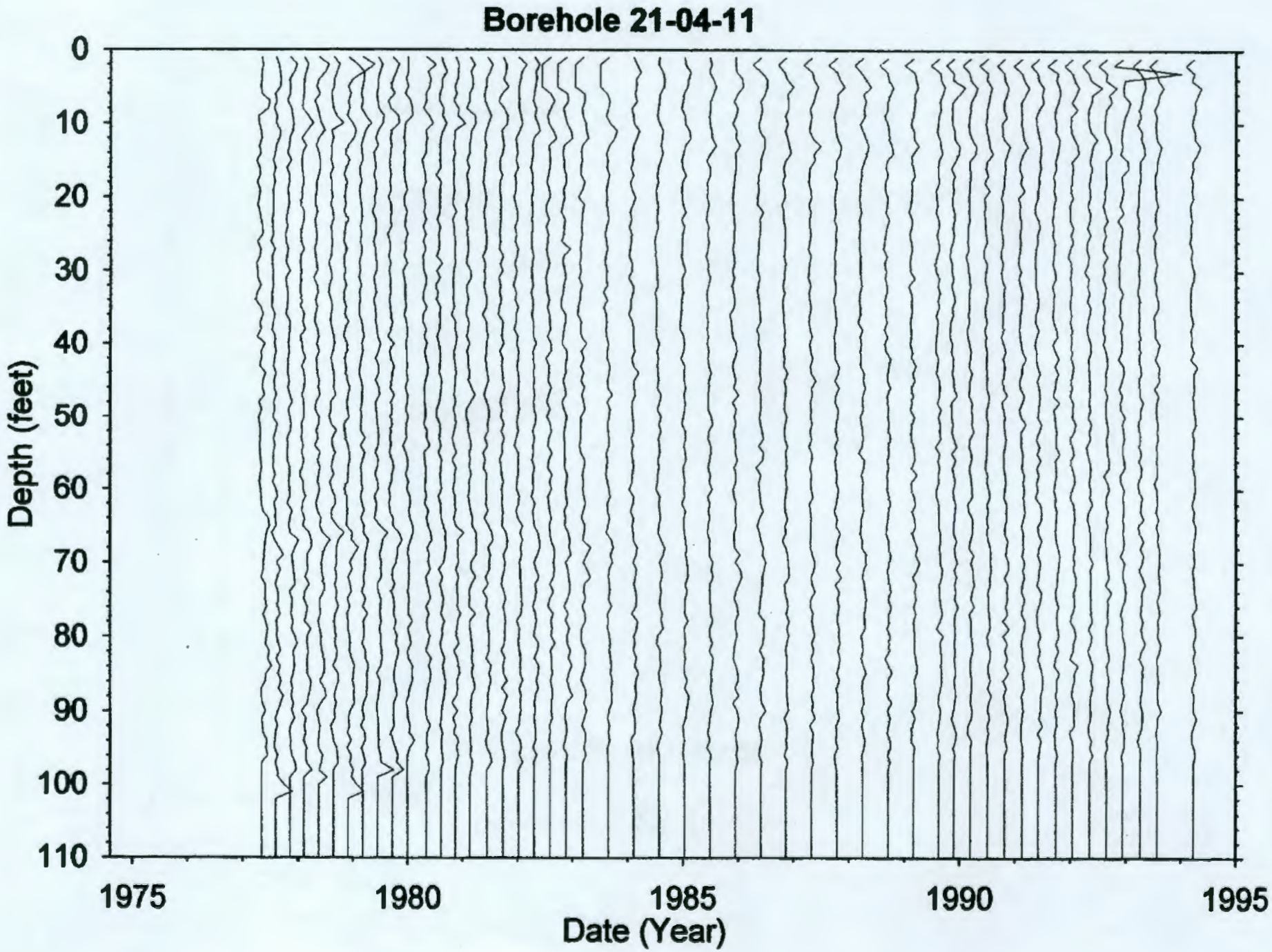
Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	5/4/1977
Last Survey Date :	3/25/1994
Number Surveys :	275

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 :	2-17 Stable late, 60-95 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


05/04/77
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-04-11
Depth: 2-17 ft
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Date (Year)
1975
1980
1985
1990
1995
Average Background (c/s)
Frequency Clean (%)
03/25/94
Analysis by: Three Rivers Scientific


05/04/77
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-04-11
Depth: 60-95 ft
Grade Thickness Product (feet*c/s)
Co-60 Decay Line
1975
1980
1985
1990
1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
03/25/94
Analysis by: Three Rivers Scientific


Borehole 21-04-11
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-04-11 BX

Total # Surveys 279

neutron surveys 2

Probe Type 04 02 14

GR Surveys 275

Log Date: 5-4-77 1st

3-25-94 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs and Co only

Max Survey Depth _____

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Cam all Co early but not late

BackGnd.Txt

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

Analysis Notes

Very low levels thru wider intervals

Analyst Name [illegible]

S/W ver TFG Rev 2.2

Borehole 21-05-02

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 1994 in the vadose zone from 2 to 100 feet.

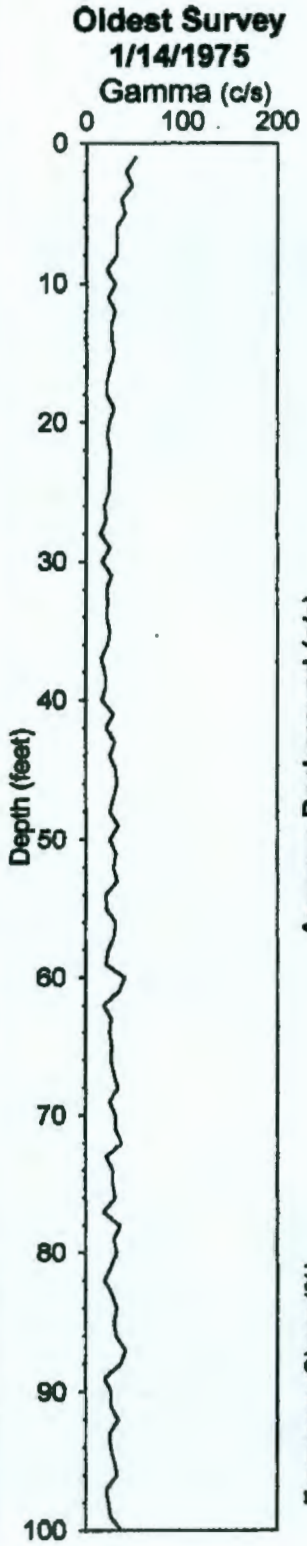
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	362

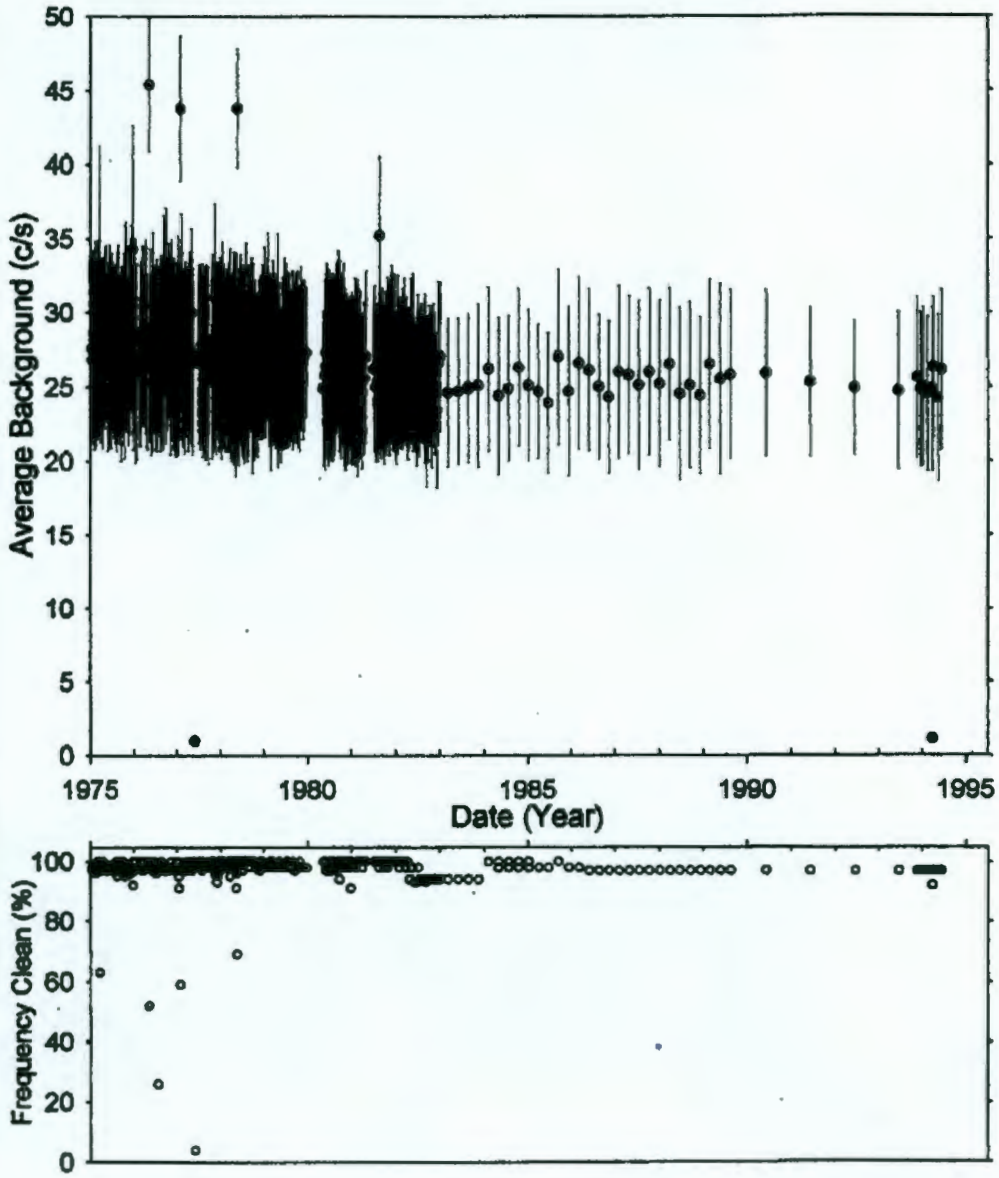
Analysis Notes

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	

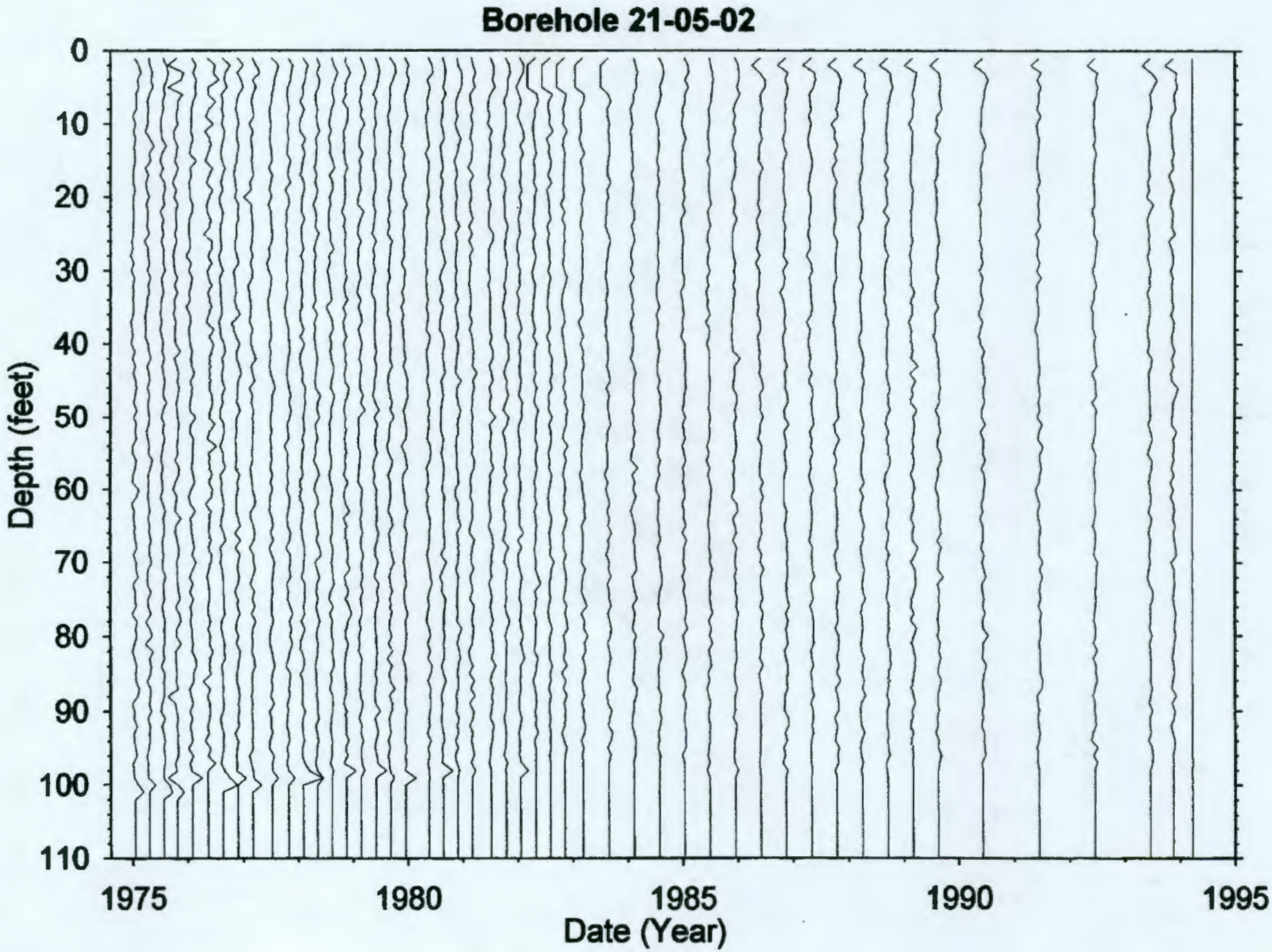
Borehole 21-05-02



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-05-02
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-05-02 Total # Surveys 367 Probe Type 04 02

neutron surveys 4 # GR Surveys 362

Log Date: 1-14-75 1st 6-13-94 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs near surface Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			no real above atm threshold

BackGnd.Txt

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

Analysis Notes

The threshold for this well & Cs is higher than other

Analyst Name [signature] S/W ver IFGRPS2.2

Borehole 21-05-03

Contamination (Cs-137) from 2-20 feet is Undetermined

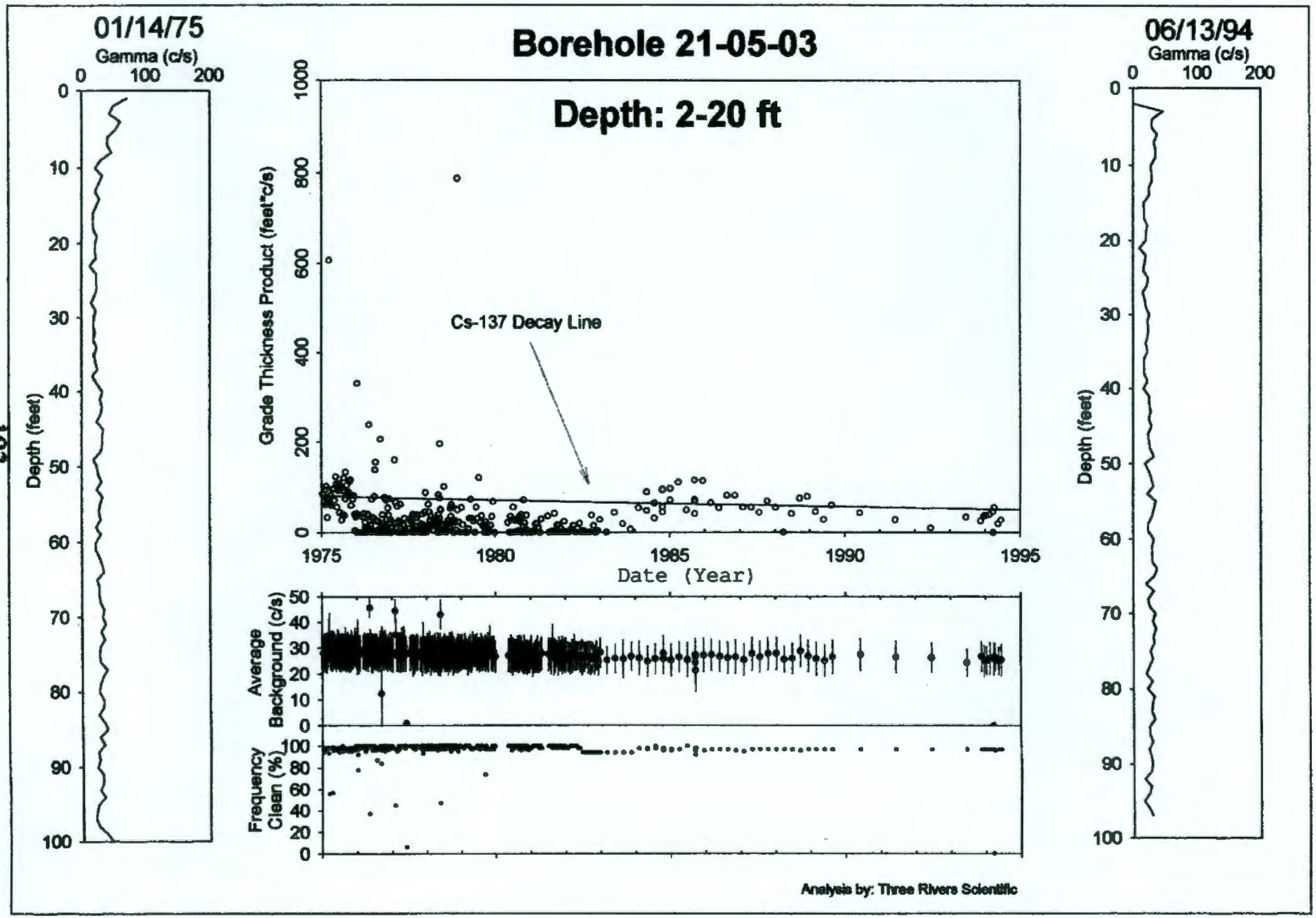
Grade thickness product from 2 to 20 feet is near threshold and the stability cannot be determined.

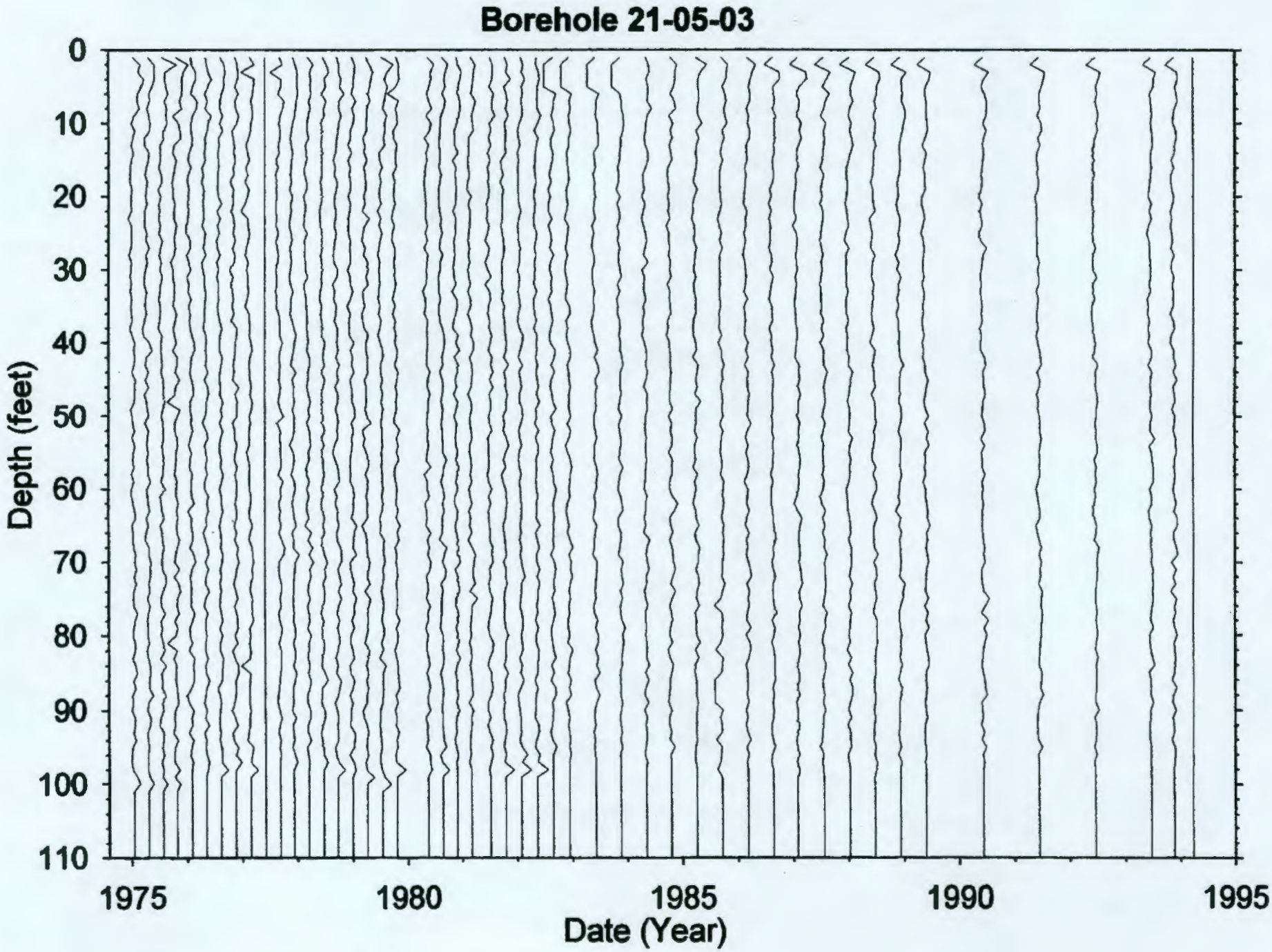
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	348

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 21-05-03
Depth: 2-20 ft
01/14/75
Gamma (c/s)
0 100 200
Depth (feet)
06/13/94
Gamma (c/s)
0 100 200
Depth (feet)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-05-03
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-05-03

Total # Surveys 356

Probe Type 04 02

neutron surveys 7

GR Surveys 348

Log Date: 1-14-75 1st

6-13-94 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): None

Isotope from Spectral Survey: Cs low & surface

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			intermittent near surface

BackGnd.Txt

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

Analysis Notes

Cs-137 & also higher throughout for near surface int contamination above shallow low levels

Analyst Name [illegible]

S/W ver TFGRDS 22

Borehole 21-05-05

Contamination (Co-60) from 60-80 feet is Undetermined

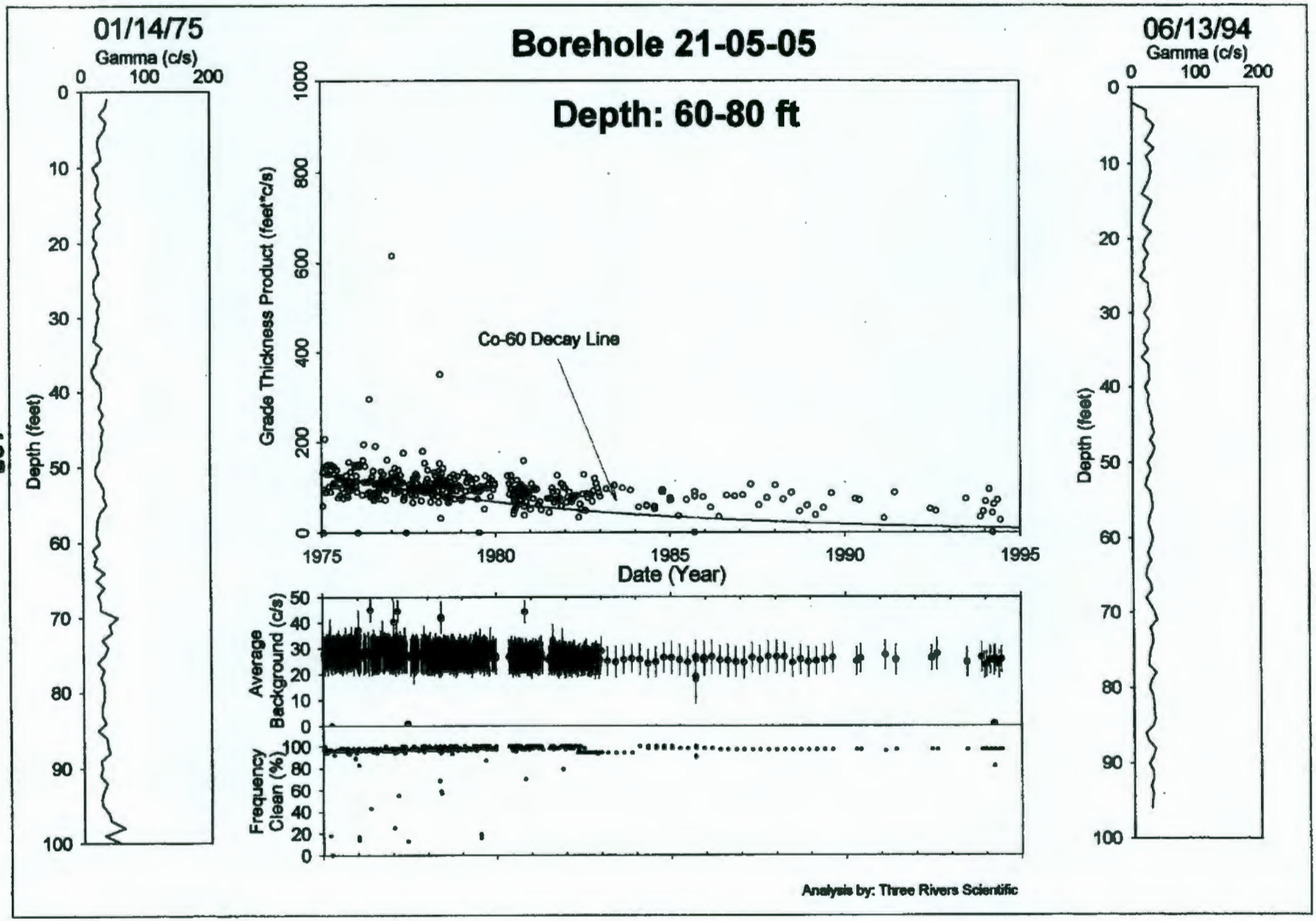
Grade thickness product from 60 to 80 feet appears to decrease slower than Co-60 (HPGe identified), but the levels are at threshold and over the history drop below threshold for the gross gamma instrumentation.

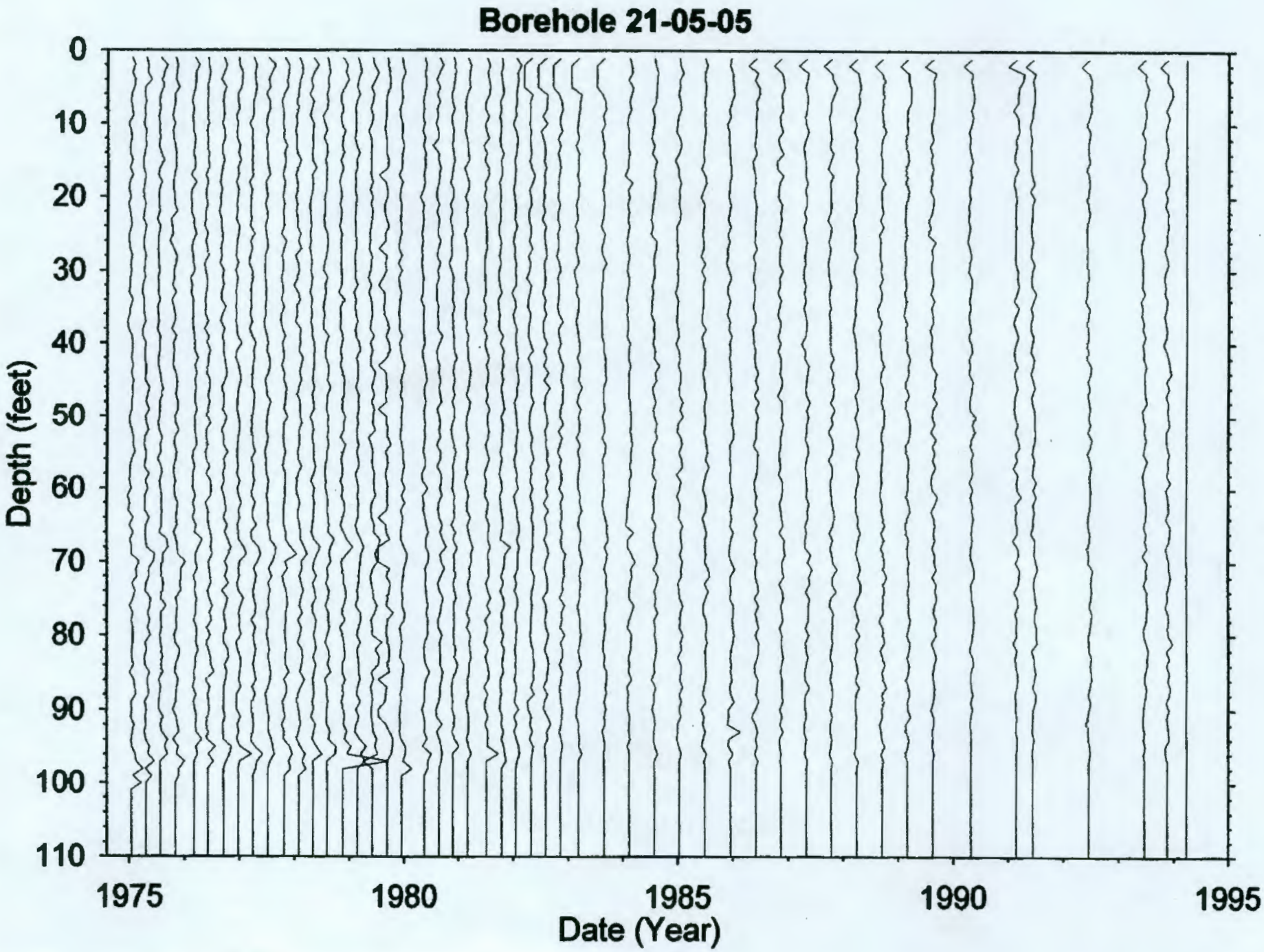
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	375

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 :	60-80 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


Borehole 21-05-05
Depth: 60-80 ft
01/14/75
Gamma (c/s)
0
100
200
Depth (feet)
06/13/94
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Co-60 Decay Line
Date (Year)
1975
1980
1985
1990
1995
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-05-05
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-05-05

Total # Surveys 380

Probe Type 04 02

neutron surveys 4

GR Surveys 375

Log Date: 1-14-75 1st

6-13-94 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): 70'

Isotope from Spectral Survey: Cs surface & 100 Co 70'

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			bottom & surface no shown
			last Co @ 70 shown

BackGnd.Txt

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

Analysis Notes

Undetermined due to background contraction

Analyst Name Russel Randall

S/W ver TFERCSS2.2

Borehole 21-05-06

Contamination (Cs-137) from 2-15 feet is Stable late
Contamination (Co-60) from 60-95 feet is Undetermined

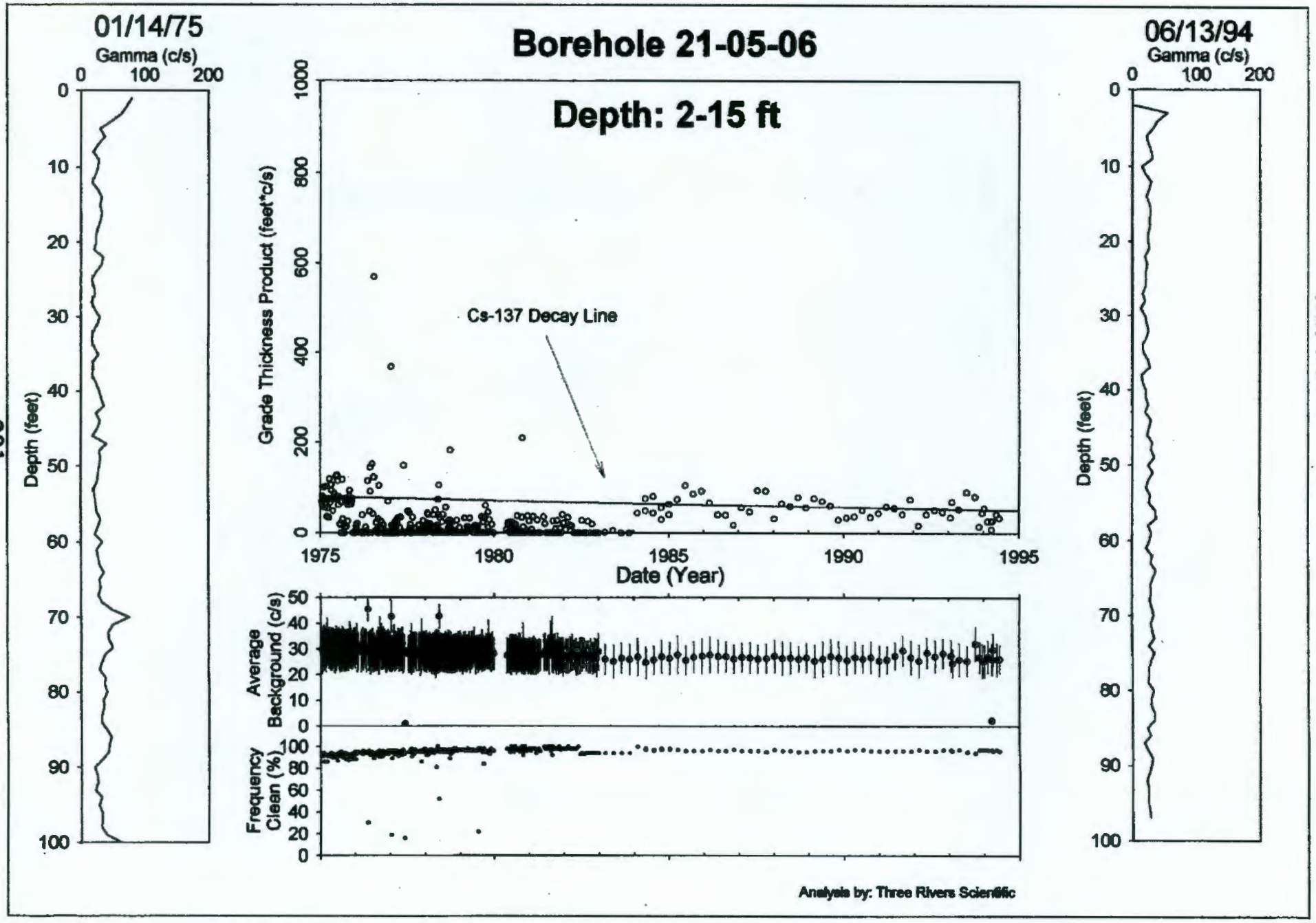
Grade thickness product from 2 to 15 feet is decreasing consistent with Cs-137 (HPGe identified), from 1984 to 1994. However, due to system limitations near the surface, no conclusion can be stated for the history before 1984. Grade thickness product from 60 to 80 feet appears to decrease slower than Co-60 (HPGe identified), but the levels are at threshold and over the history drop below threshold for the gross gamma instrumentation. Note that the larger interval was used for the two intervals (one at 70 and other at 87 feet) in order to assist the low threshold, thus no statement can be made concerning downward movement.

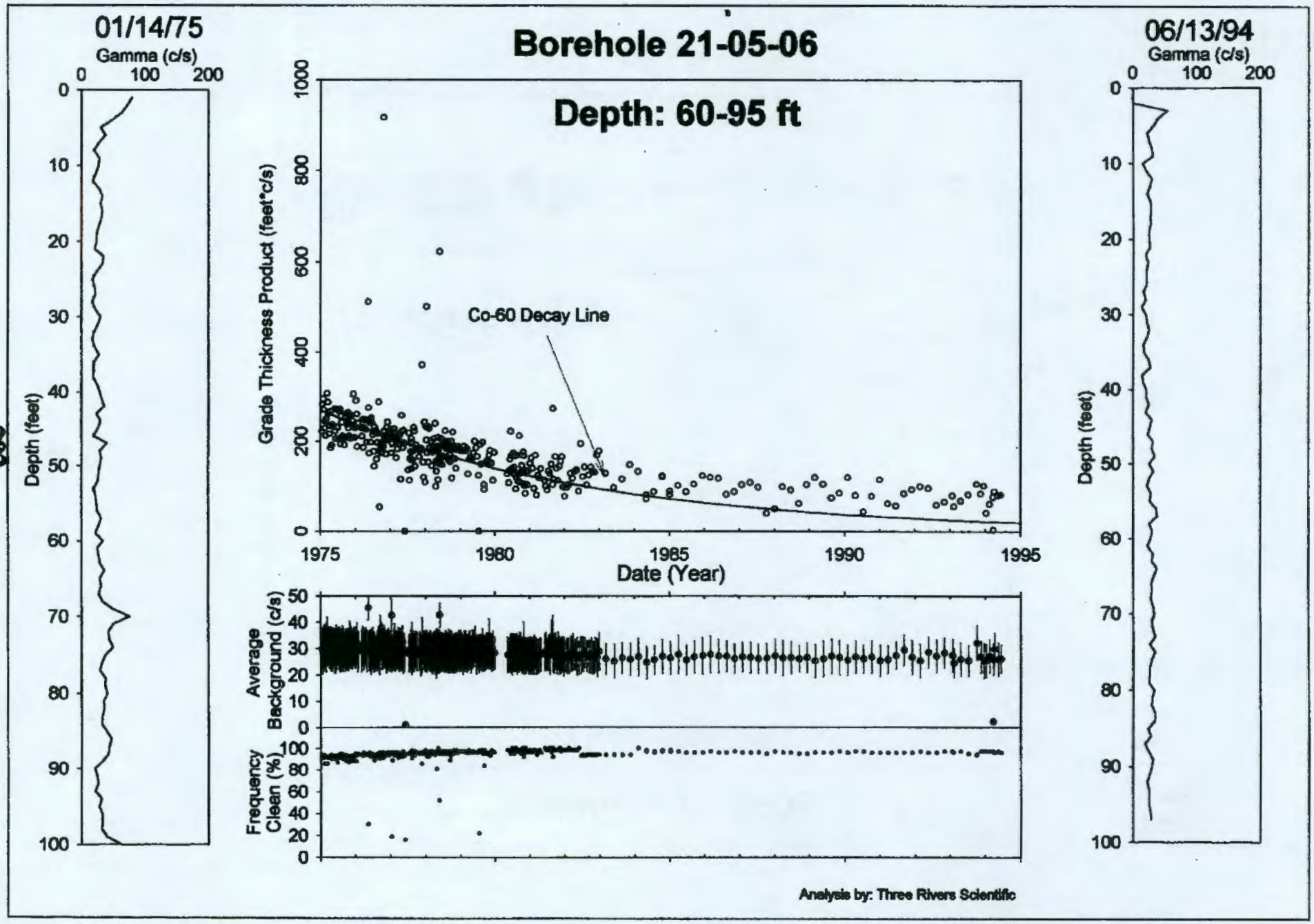
Gross Gamma Survey Information

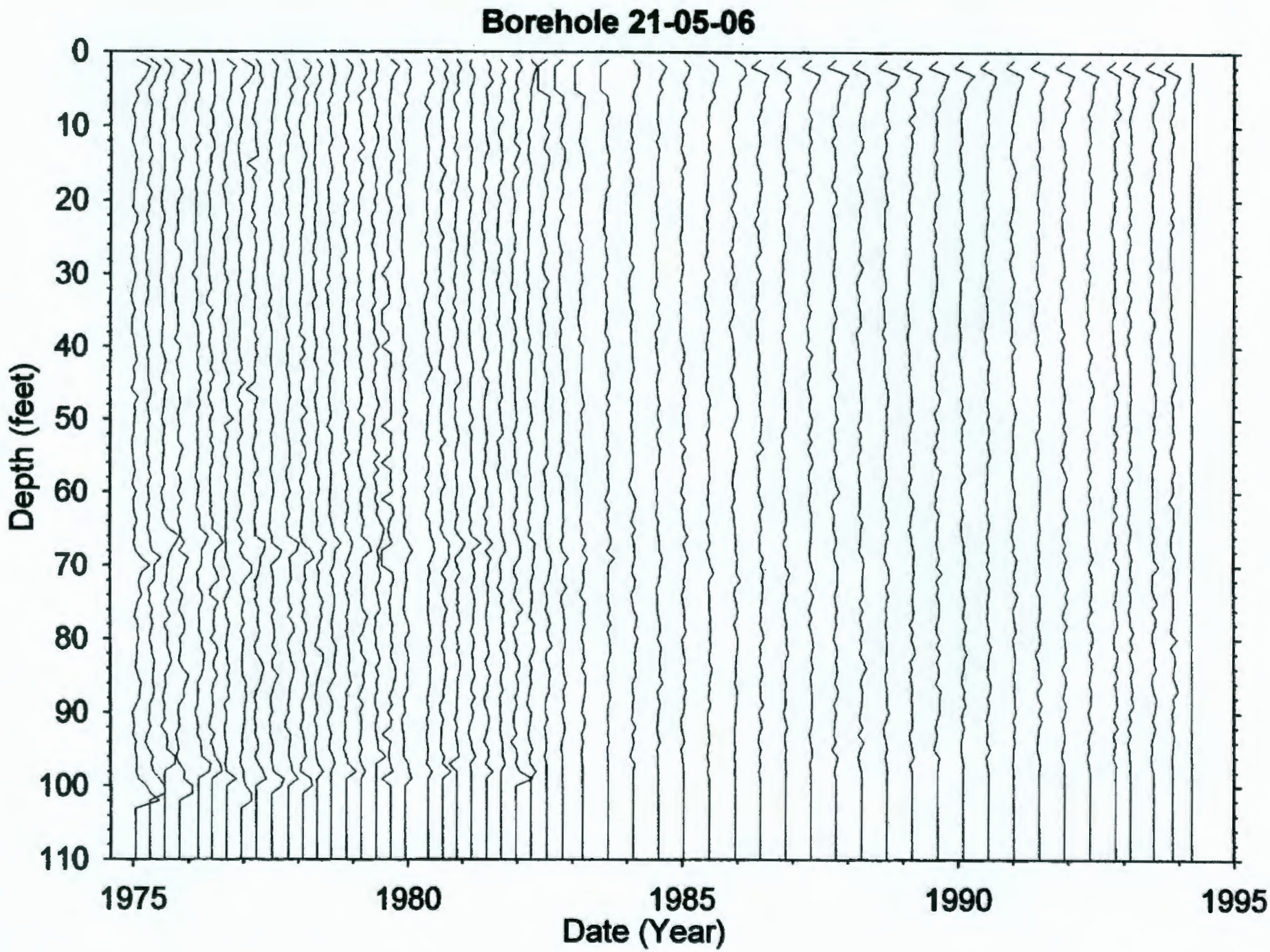
Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 14: Shielded NaI, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	370

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 :	2-15 Stable late 60-80 Undetermined	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	


01/14/75
Gamma (c/s)
0 100 200
Depth (feet)
Borehole 21-05-06
Depth: 2-15 ft
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/13/94
Gamma (c/s)
0 100 200
Depth (feet)
Analysis by: Three Rivers Scientific


01/14/75
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-05-06
Depth: 60-95 ft
Grade Thickness Product (feet*c/s)
Co-60 Decay Line
1975
1980
1985
1990
1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/13/94
Gamma (c/s)
Depth (feet)
Analysis by: Three Rivers Scientific


Borehole 21-05-06
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX 21-05-06 Total # Surveys 377 Probe Type 04 14 02

neutron surveys 5 # GR Surveys 370

Log Date: 1-14-75 1st 6-13-94 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 70 & 83 but very low

Isotope from Spectral Survey: Cs and Co 80-90 Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			60 & 83 but low add together
			i.e. 60-95

BackGnd.Txt

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

Analysis Notes

Surface is excavated

Analyst Name [signature] S/W ver TFGROSS2.2

Borehole 21-05-10

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 1994 in the vadose zone from 2 to 98 feet.

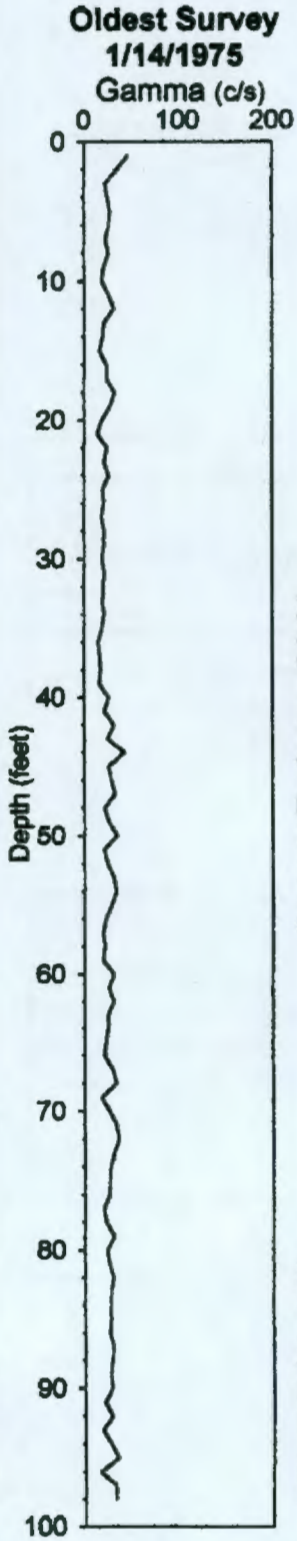
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	98 ft
Survey Depth :	98 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	372

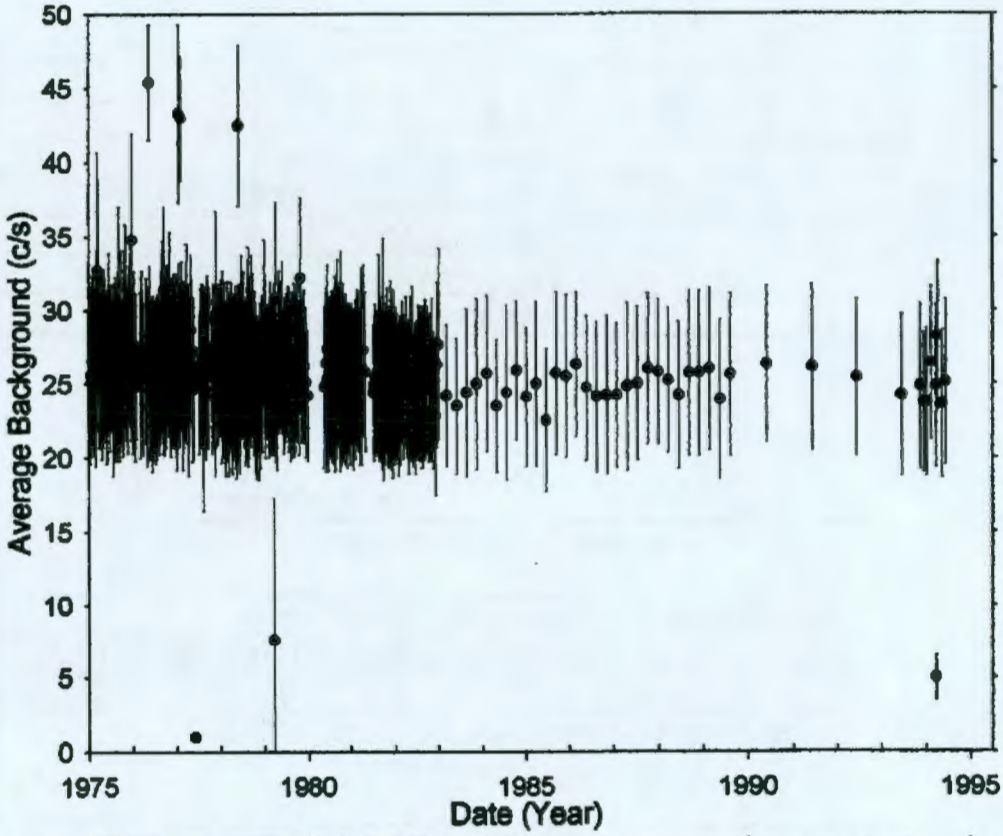
Analysis Notes

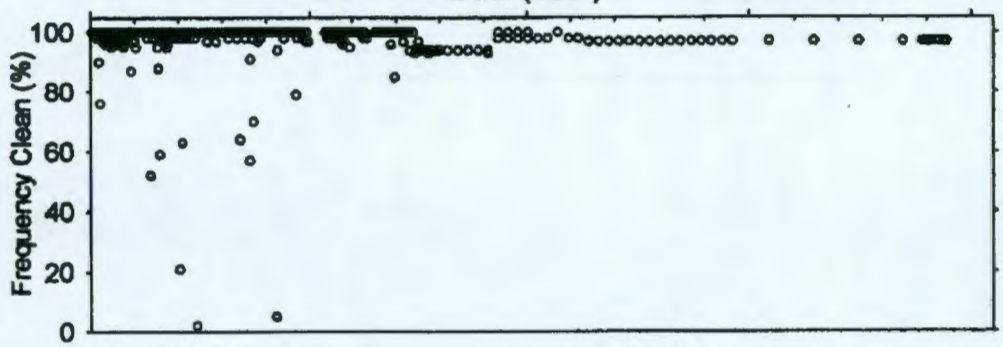
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-05-10

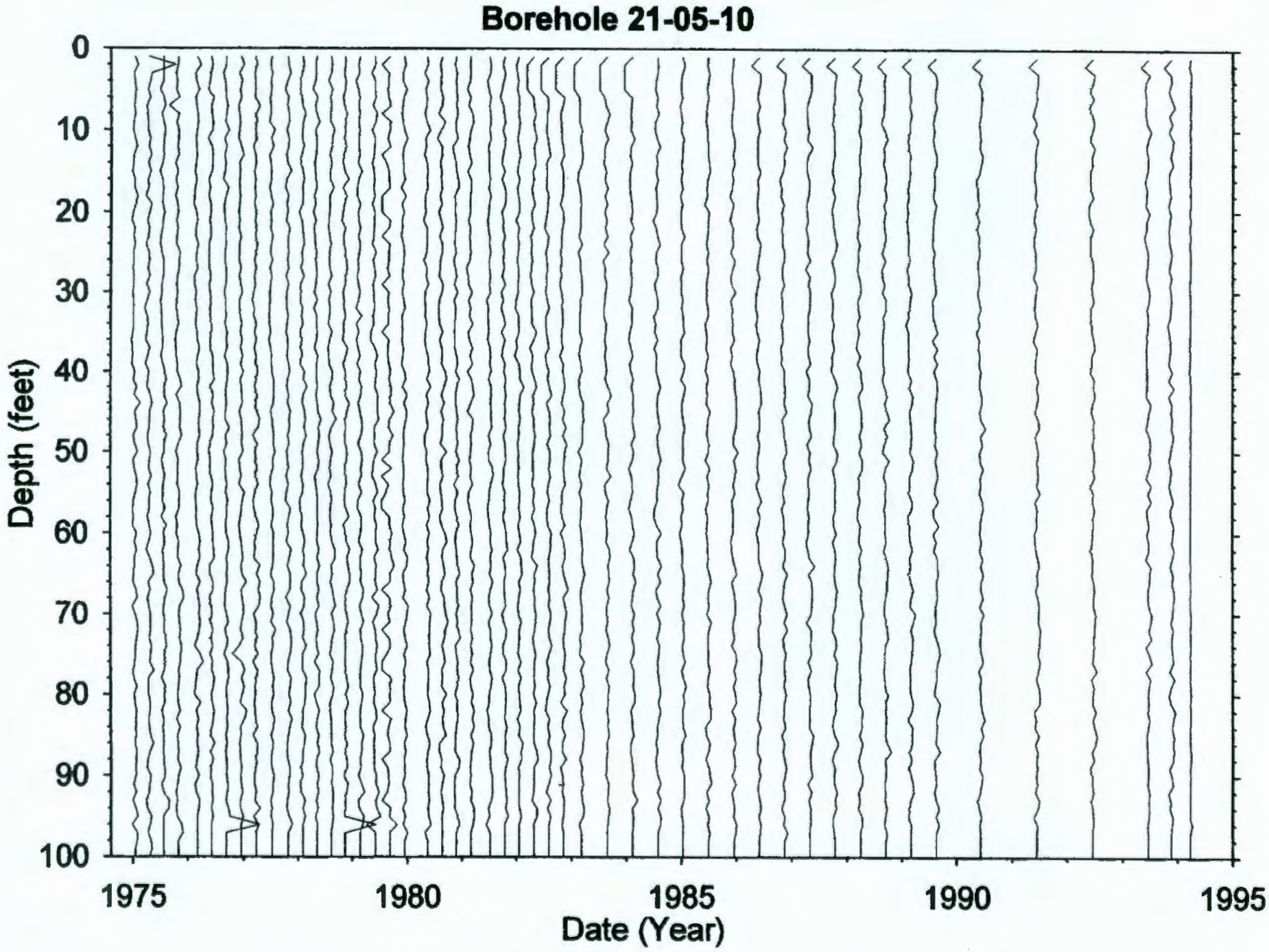


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-05-10
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-05-10

Total # Surveys 379

Probe Type 04

neutron surveys 7

GR Surveys 372

Log Date: 1-14-75 1st

6-13-94 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): None

Isotope from Spectral Survey: Co low & surface

Max Survey Depth 98

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Clean

BackGnd.Txt

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

Analysis Notes

Clean

Analyst Name [illegible]

S/W ver TF6R0052.2

Borehole 21-05-12

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 1994 in the vadose zone from 2 to 98 feet.

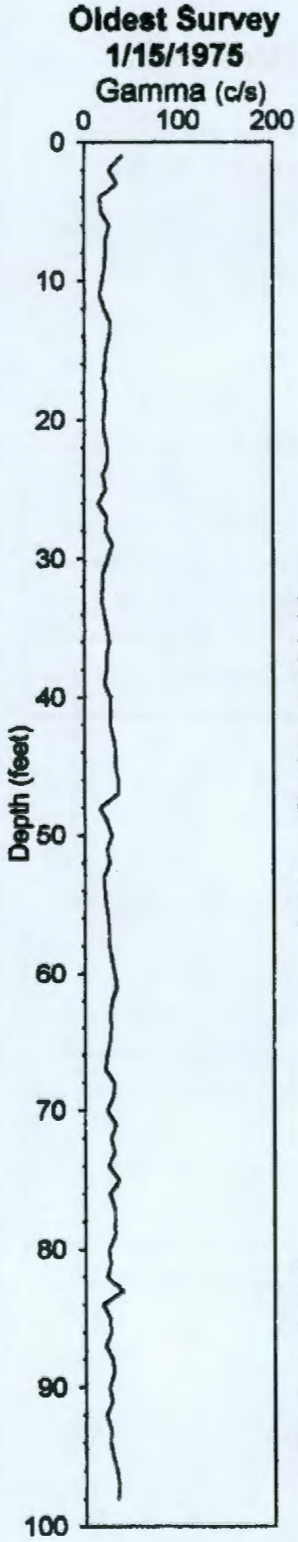
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	6/13/1994
Number Surveys :	381

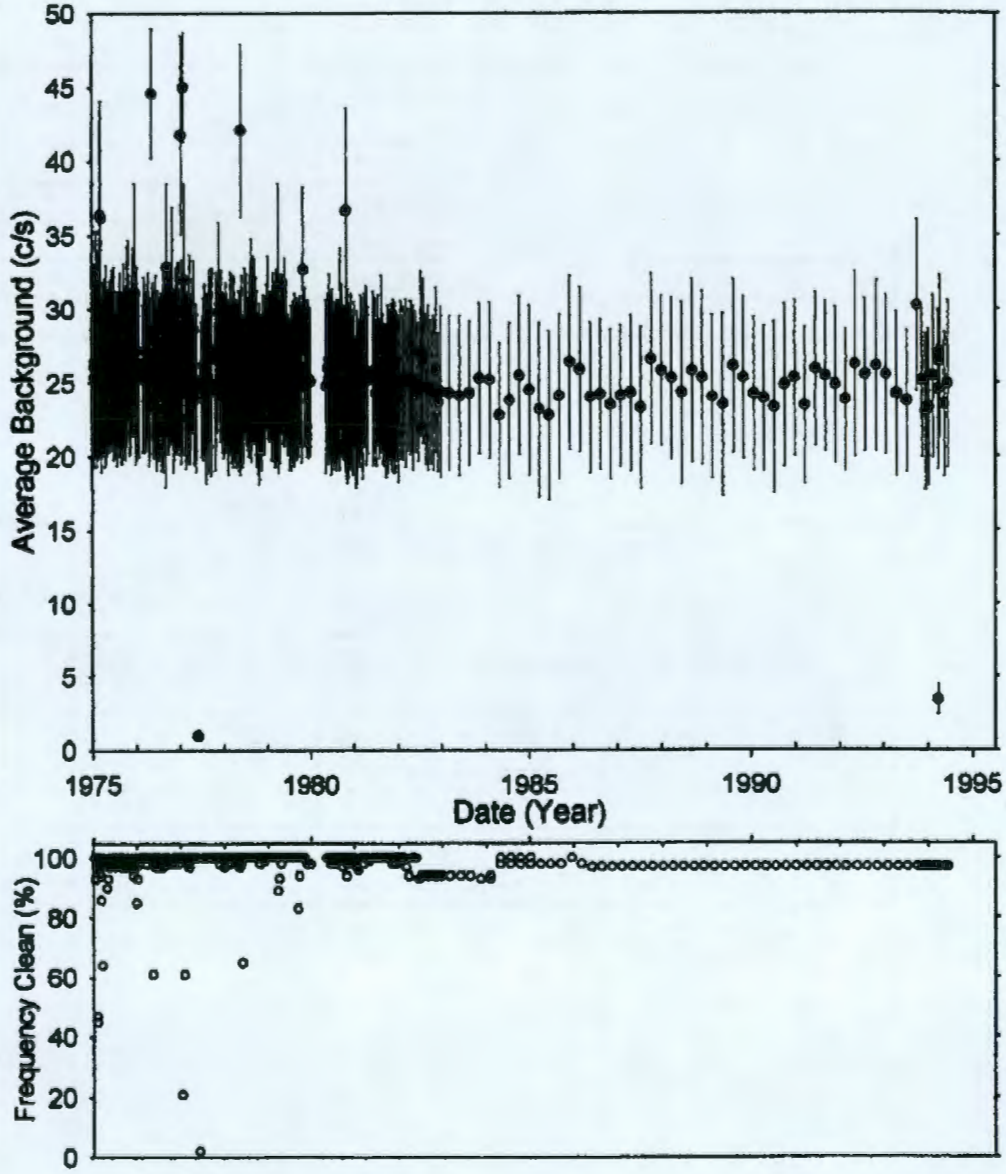
Analysis Notes

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	

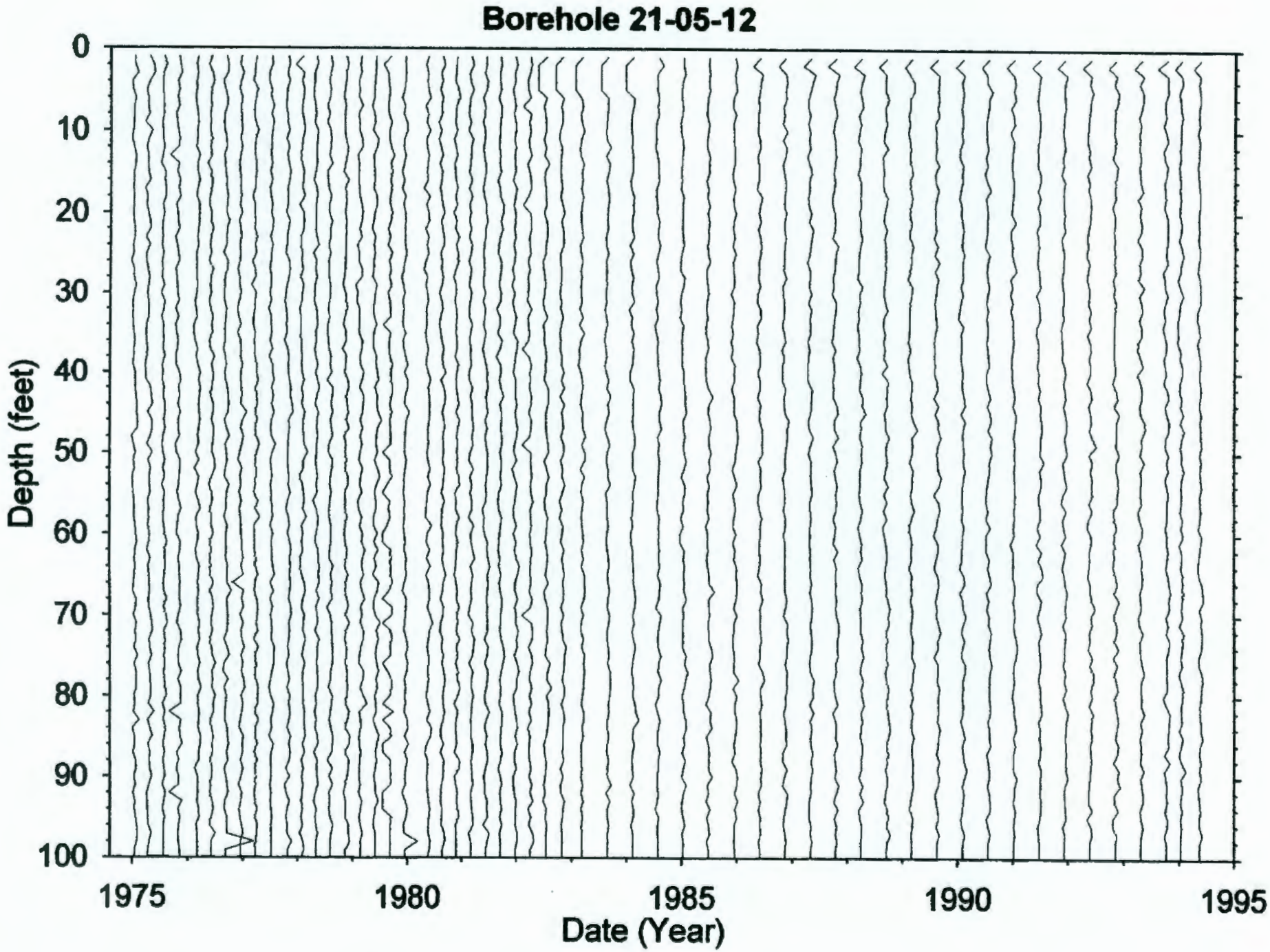
Borehole 21-05-12



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-05-12
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-05-12 Total # Surveys 386 Probe Type 04

neutron surveys 5 # GR Surveys 381

Log Date: 1-15-95 1st 6-13-94 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): None

Isotope from Spectral Survey: Cs low & surface Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Clean

BackGnd.Txt

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

Analysis Notes

Clean

Analyst Name Rame S/W ver IFGR0552 2

Borehole 21-06-01

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.

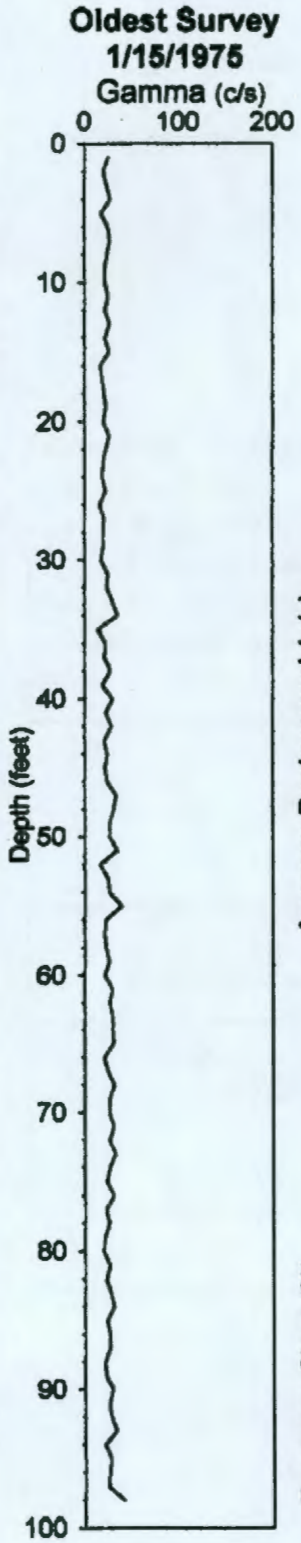
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	10/5/1993
Number Surveys :	331

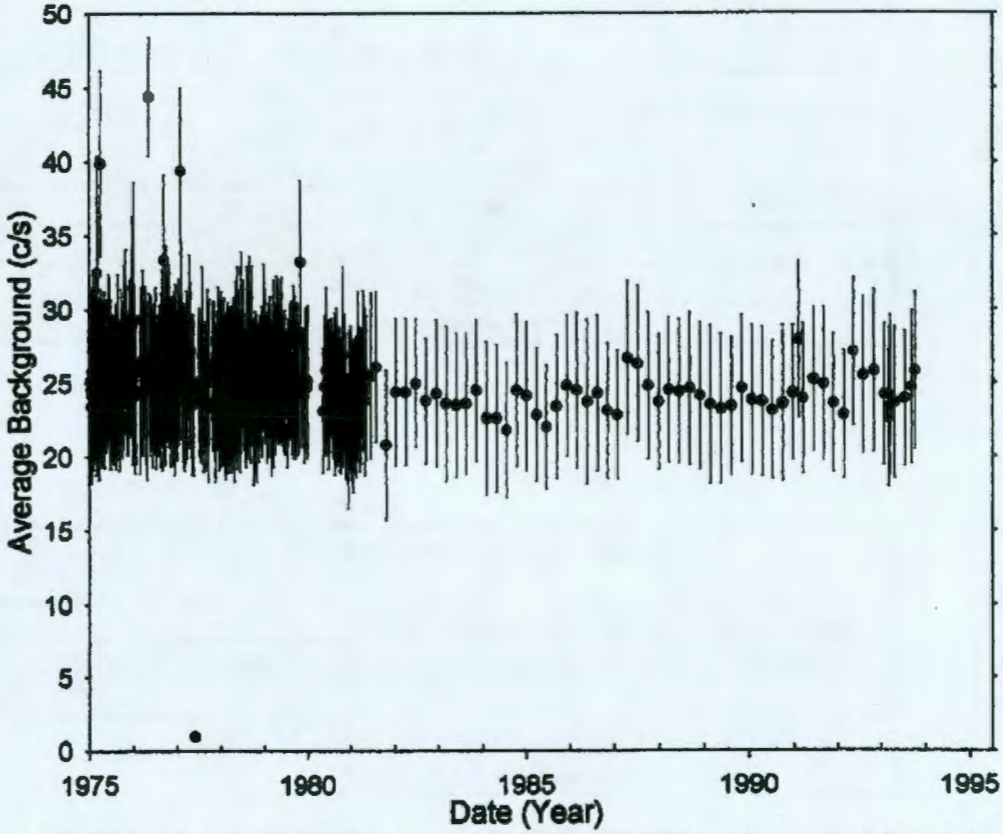
Analysis Notes

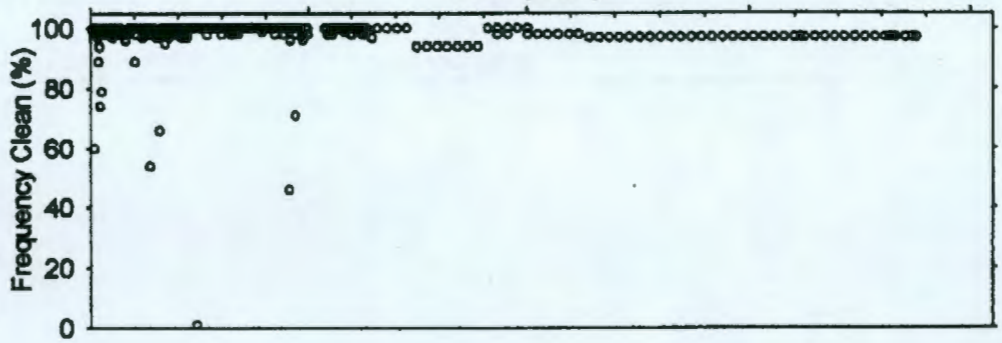
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	NONE	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	

Borehole 21-06-01

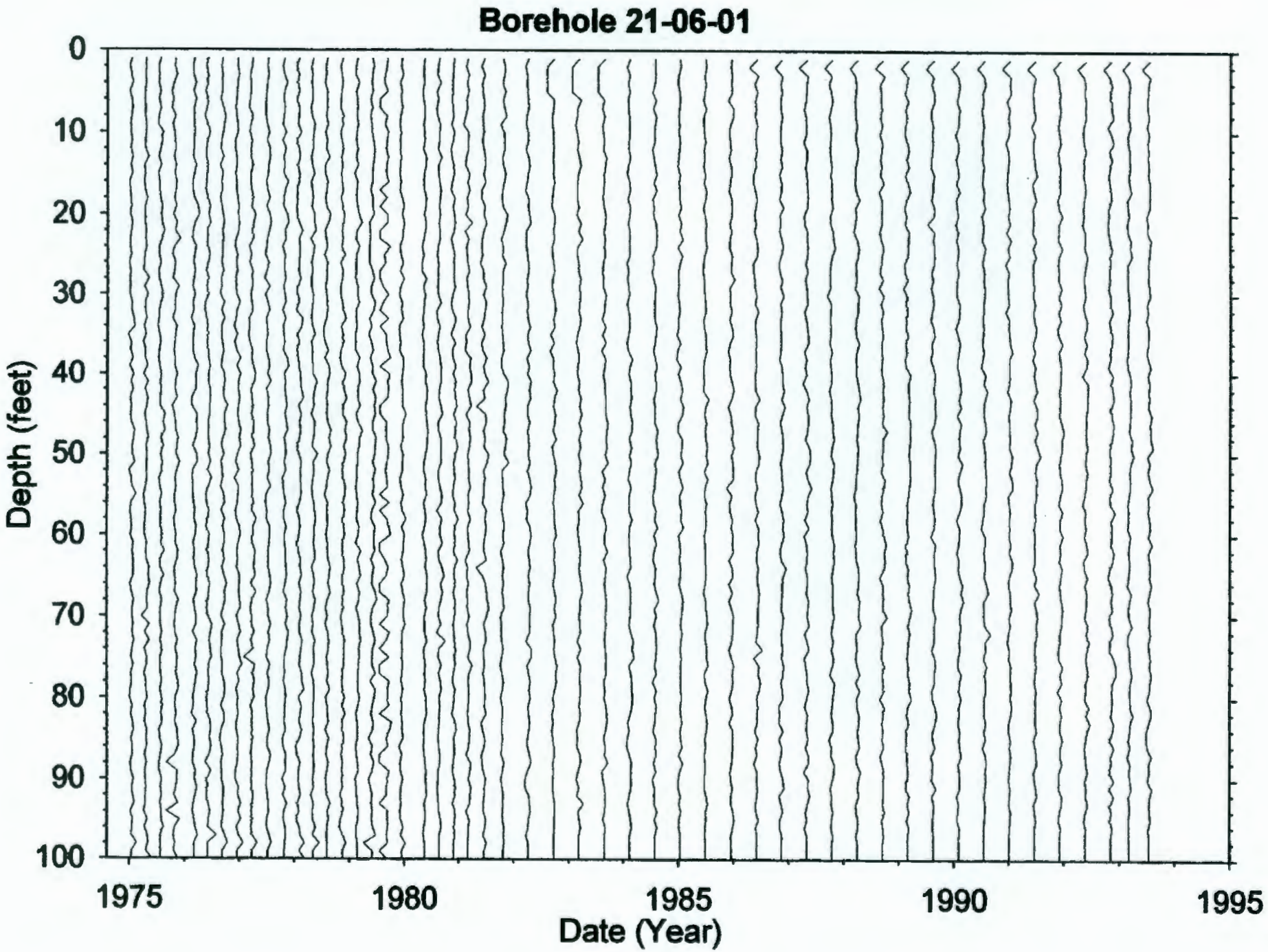


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-06-01
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BK

Borehole 21-06-01

Total # Surveys 336

neutron surveys 4

Probe Type D4 02

GR Surveys 331

Log Date: 1-15-75 1st

10-5-93 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): None

Isotope from Spectral Survey: Cs @ ~MDL

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Clean

BackGnd.Txt

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

Analysis Notes

Clean

Analyst Name Rame

S/W ver TFGROSS2.2

Borehole 21-06-02

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.

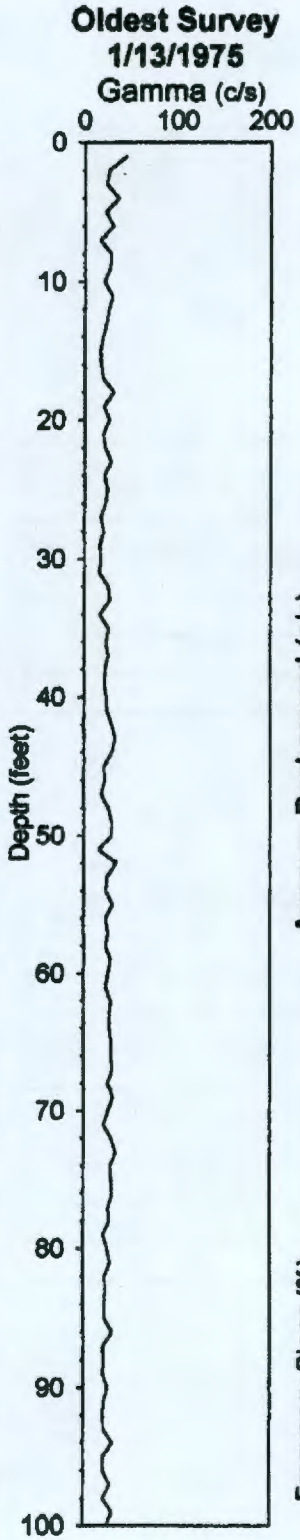
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	02: Red GM, 03: Neutron
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/13/1975
Last Survey Date :	10/5/1993
Number Surveys :	334

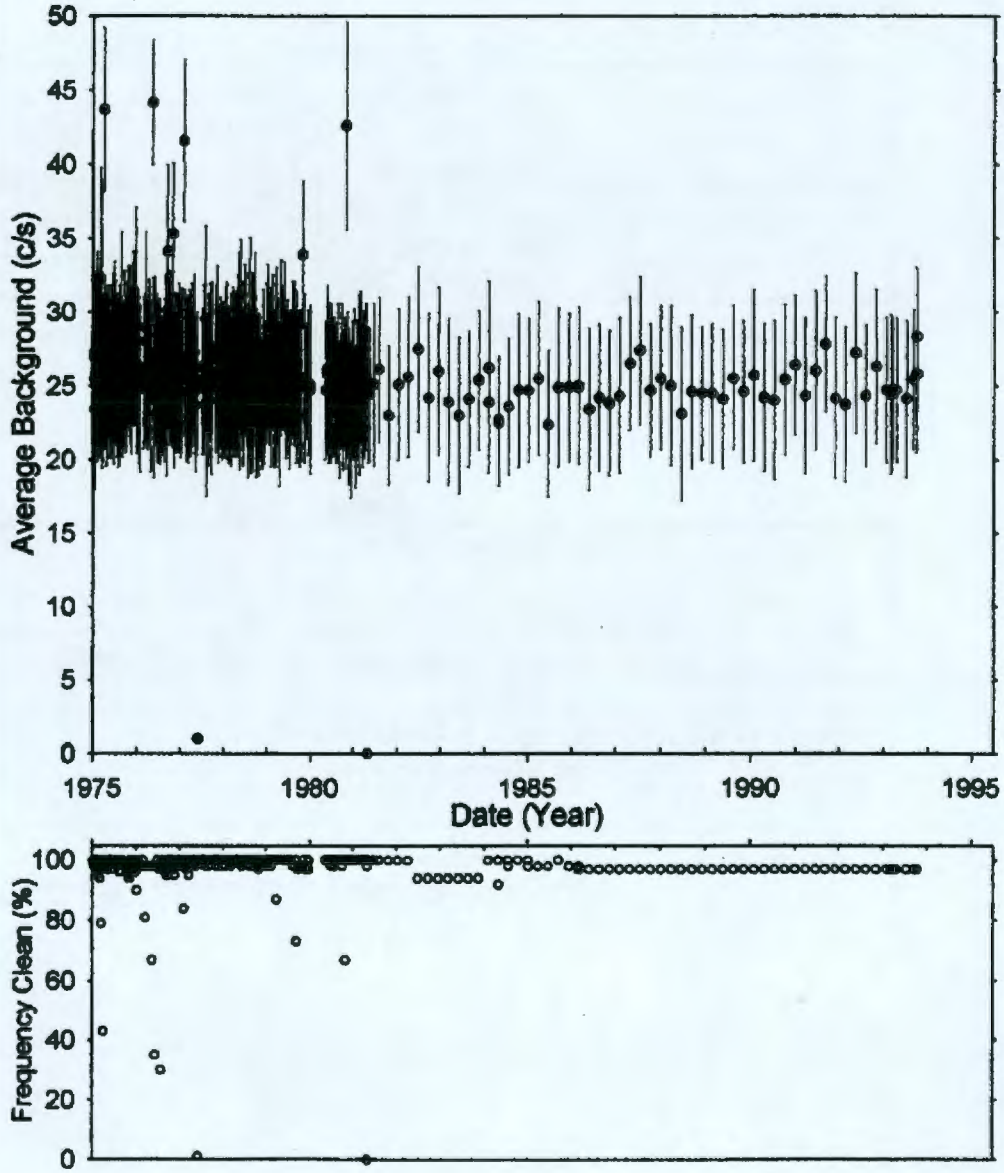
Analysis Notes

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	

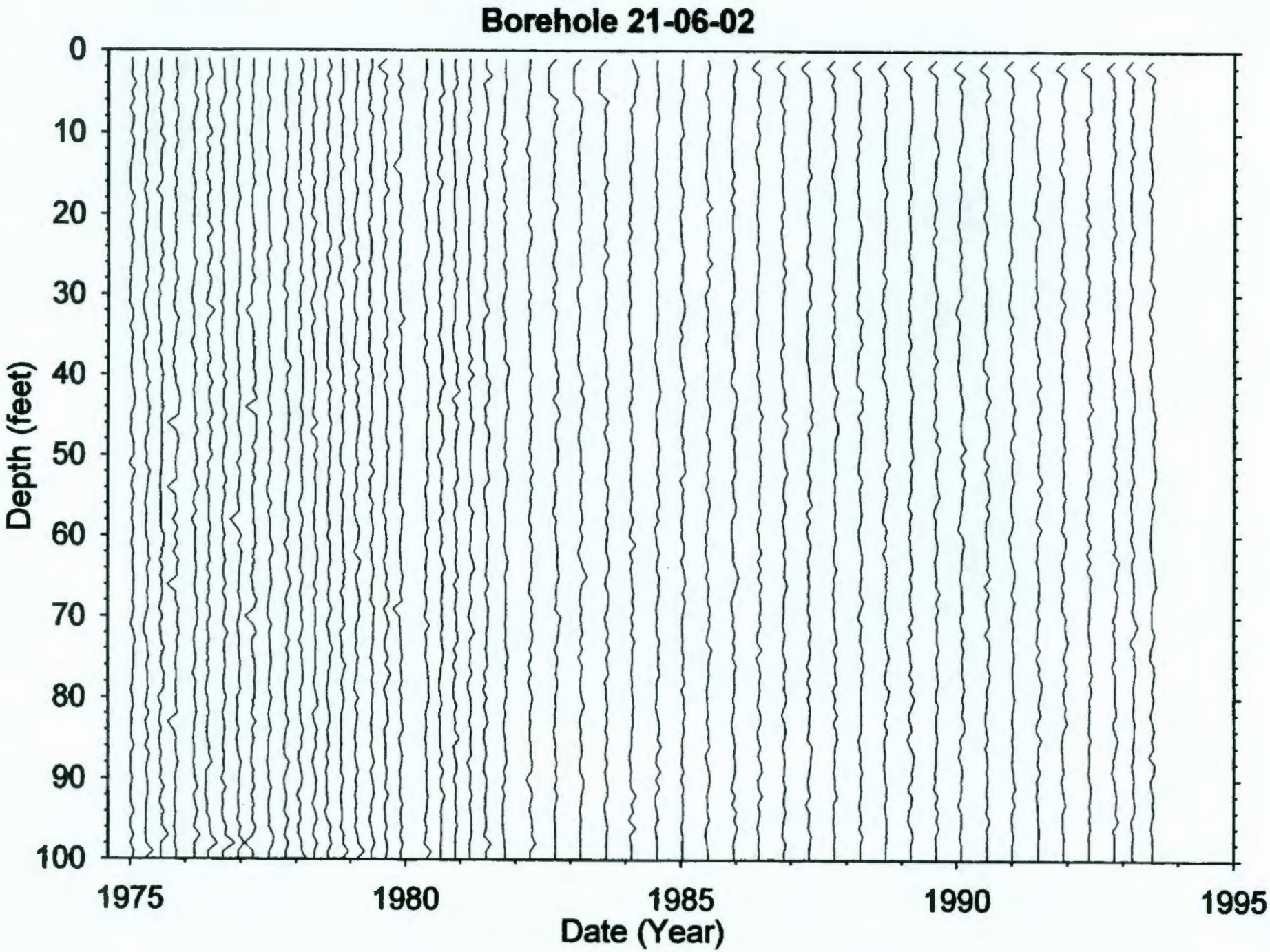
Borehole 21-06-02



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-06-02
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-06-02

Log Date: 1-13-75 1st

Total # Surveys 341

neutron surveys 4

10-5-93 Last

Probe Type D4 14 02 (1 2)

GR Surveys 334

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs very low & ave.

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			Clean

BackGnd.Txt

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

Analysis Notes

Clean

Analyst Name [signature]

S/W ver YFGROSE 2-2

Borehole 21-06-05

Contamination (Cs-137) from 32-44 feet is Stable
Contamination (U-238/235 & Sb-125) from 44-60 feet is Stable

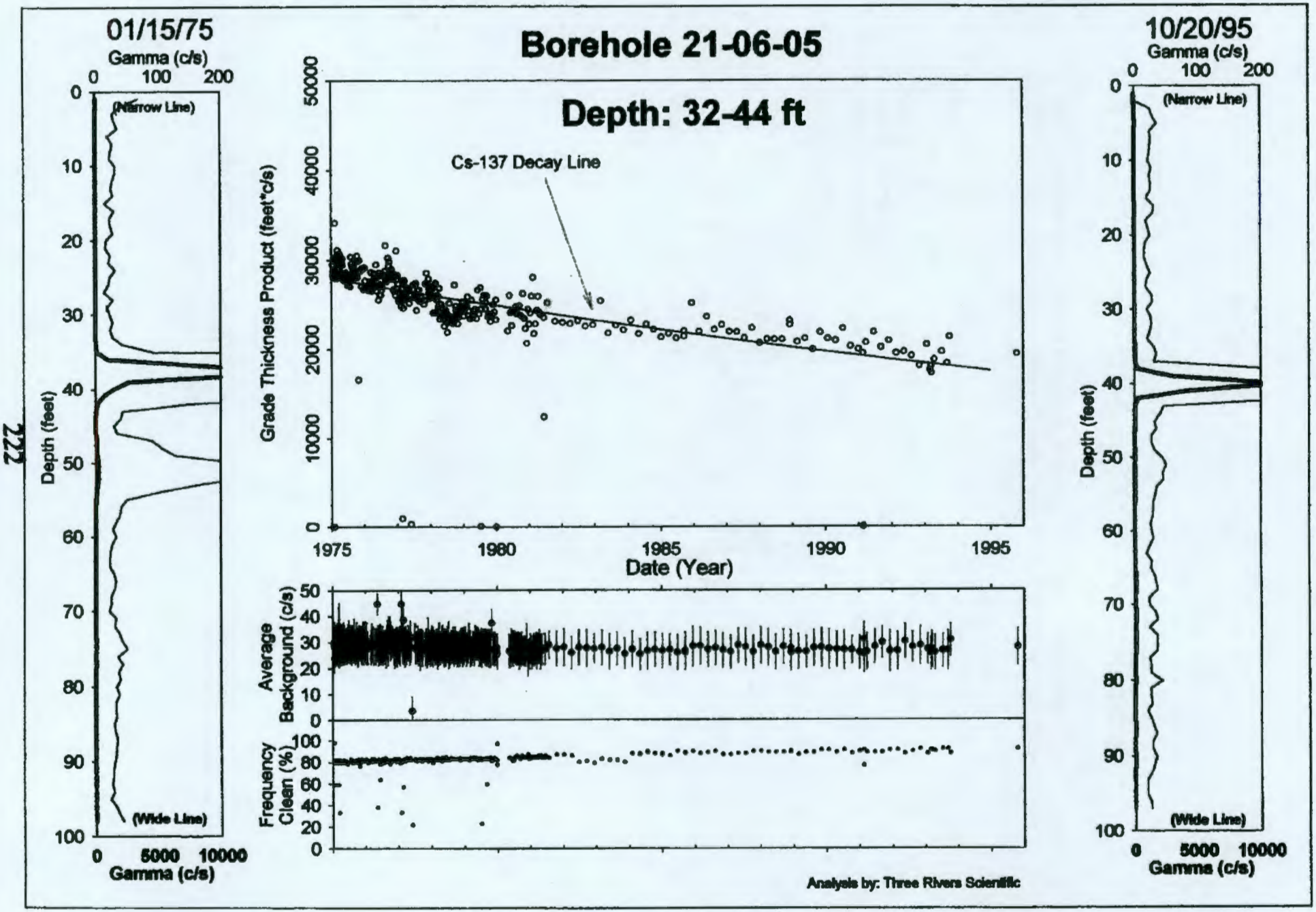
Grade thickness product from 32 to 44 feet is decreasing consistent with Cs-137 (HPGe identified) from 1975 to 1993. Note that Sb-125 is HPGe identified, but at low levels for this interval.
Grade thickness product from 44 to 60 feet is decreasing consistent with a least squares fit for U-238/235 (HPGe identified) and Sb-125 (hypothesis) from 1975 to 1993. The least squares fit results in gross gamma contribution ratio of U-238/235 to Sb-125 of 0.07 as of Jan 1975. Special note, the HPGe did identify Sb-125 at shallower depths than 44-60, but the Sb-125 in 44-60 feet decayed to level below detection. Likewise, the levels in the 32-44 feet were completely masked by the strong Cs-137 signal.

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 :	10/20/1995
Number Surveys :	344

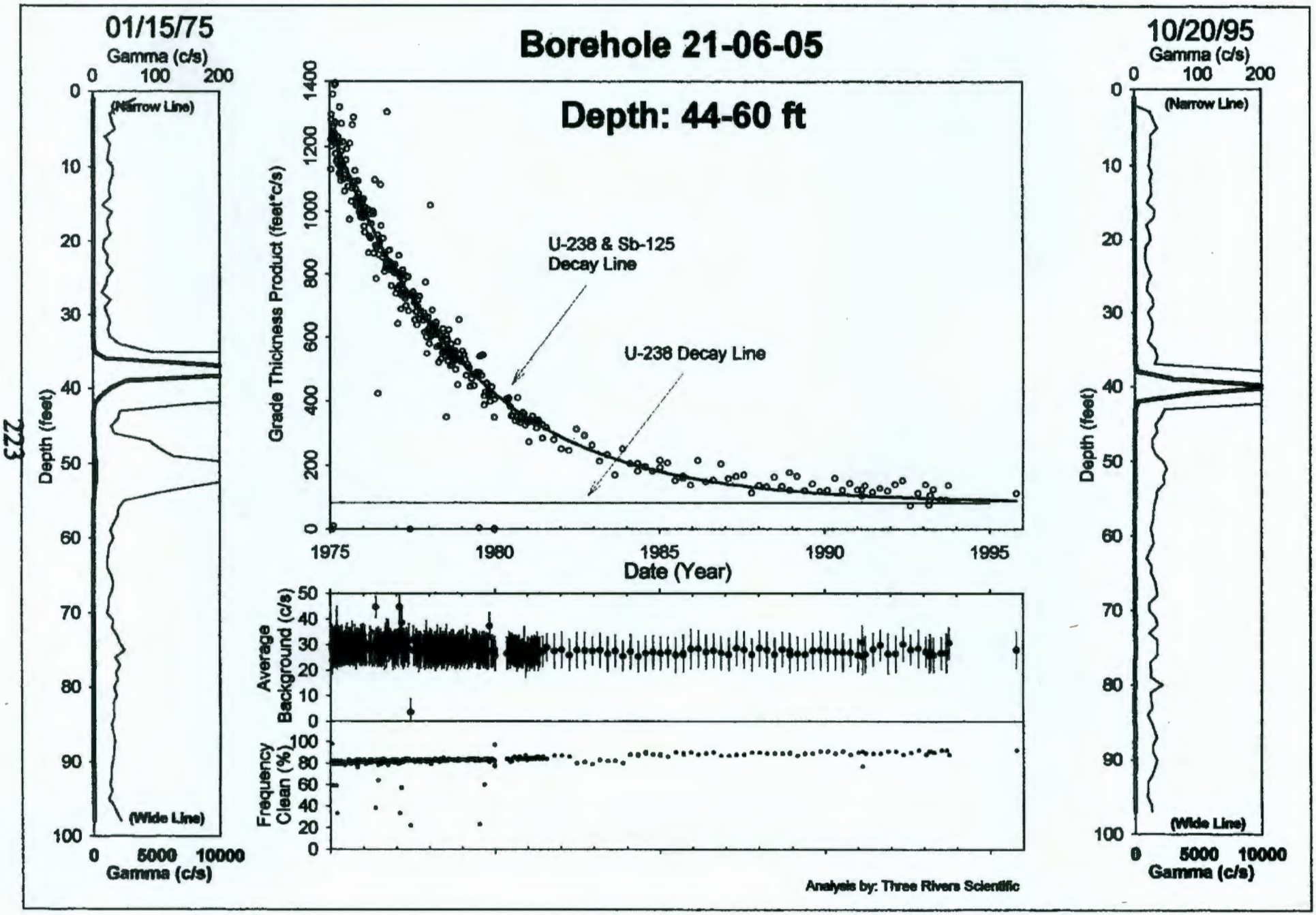
Analysis Notes

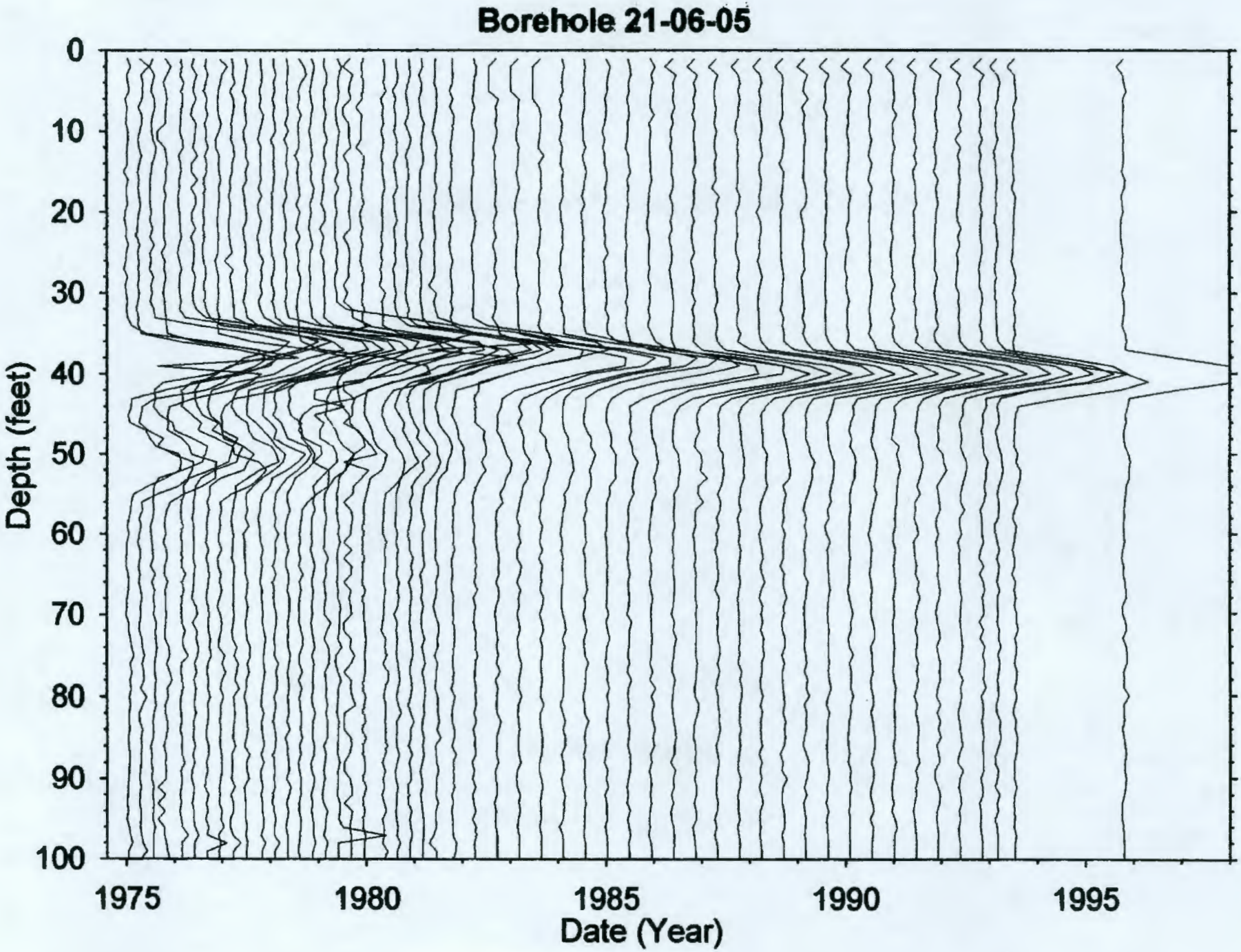
Number Surveys Rejected :	0	
Lower Threshold for Bad Survey Values :	<= 0	
Method Used to Compute Background :	Threshold 0<val<50	
Depth(s) where Contamination Identified in Gross Gamma Surveys :	32-44 & 44-60 Stable	
Analyst Name :	R.R. Randall	
Company Name :	Three Rivers Scientific	



222

HNF-3531 -REV0


Borehole 21-06-05
Depth: 44-60 ft
01/15/75
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
U-238 & Sb-125
Decay Line
U-238 Decay Line
Date (Year)
Average
Background (c/s)
Frequency
Clean (%)
10/20/95
Analysis by: Three Rivers Scientific


Borehole 21-06-05
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

BX

Borehole 21-06-05

Total # Surveys 353

Probe Type 04 14 02

neutron surveys 7

GR Surveys 344

Log Date: 1-15-75 1st

10-20-95 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs Sb K's

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

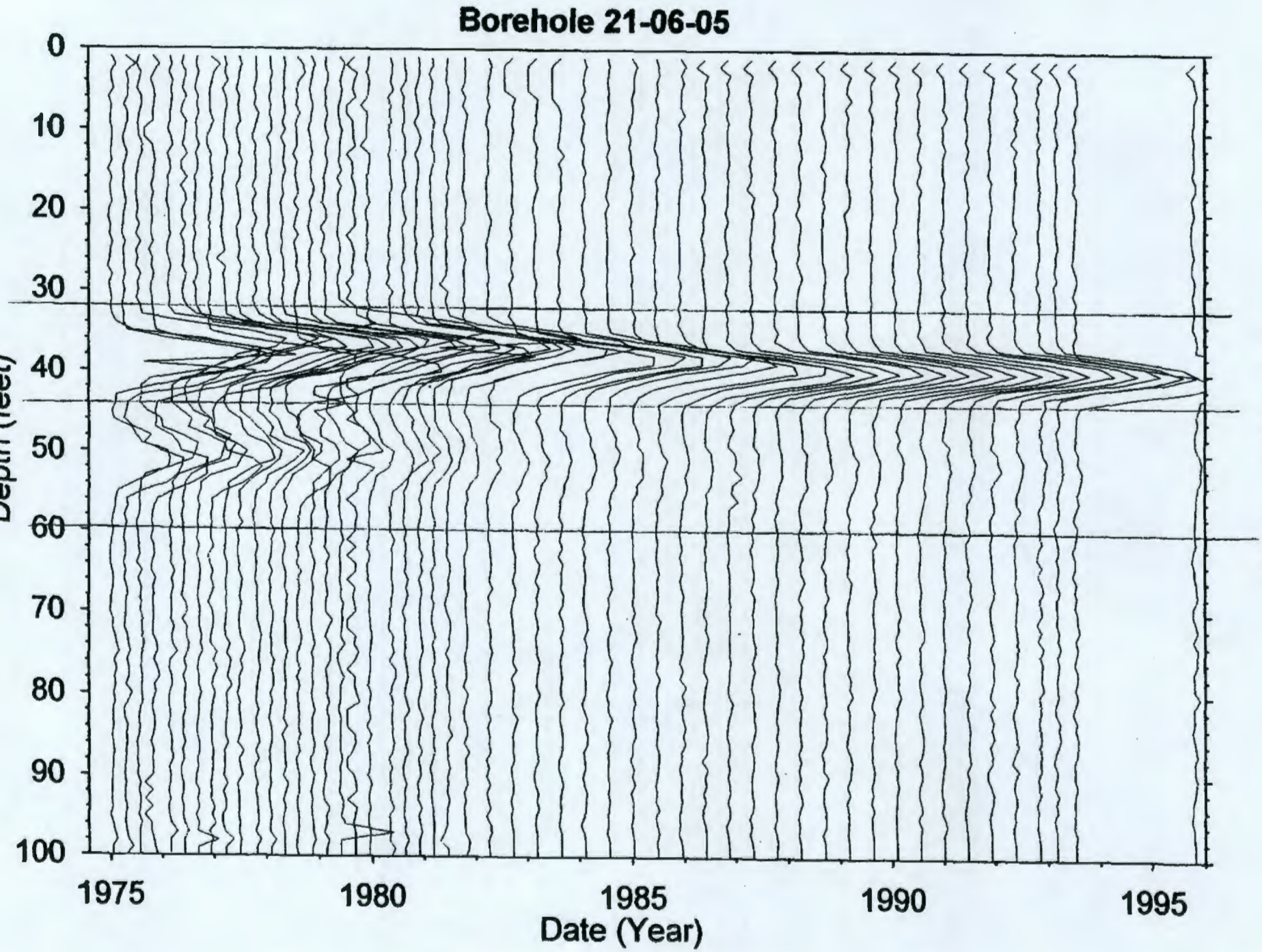
Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment

Analysis Notes

may need depth shift for Co/K zone

Analyst Name Rocco

S/W ver TFGR0992-2


Borehole 21-06-05
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

filein := "two.txt"

Well 21-06-05

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

$N := last(yr)$ $\quad N = 331$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$ $\quad \tau eu := 2.77$

$\tau co := 5.27$ $\quad \tau cs := 3\cdot 10^{9}$ $\quad aco := 00$ $\quad acs := 90$

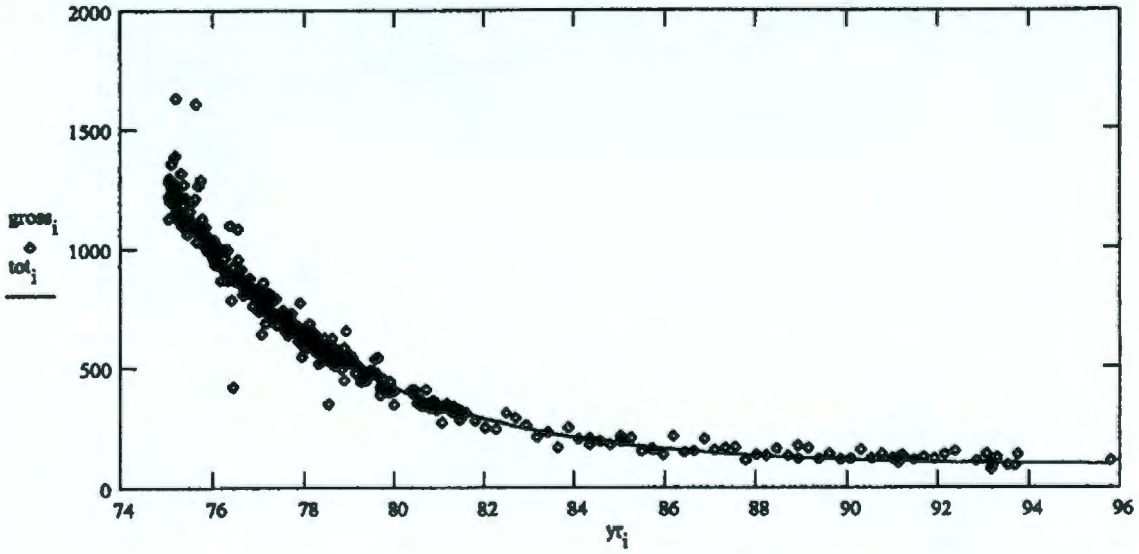
Eu variables are
Ru-106 $\quad aeu := 1150$

$Cs_i := acs\cdot e^{-(yr_i-75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco\cdot e^{-(yr_i-75)\cdot\frac{\ln(2)}{\tau co}}$ $\quad Eu_i := aeu\cdot e^{-(yr_i-75)\cdot\frac{\ln(2)}{\tau eu}}\cdot 1$ $\quad tot_i := Cs_i + Eu_i$

$gross_i := net_i$

Cs variables are U238

This data edited for spurious points



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

Given

$ssq(acs,aeu)=0$ $\quad 1=1$

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

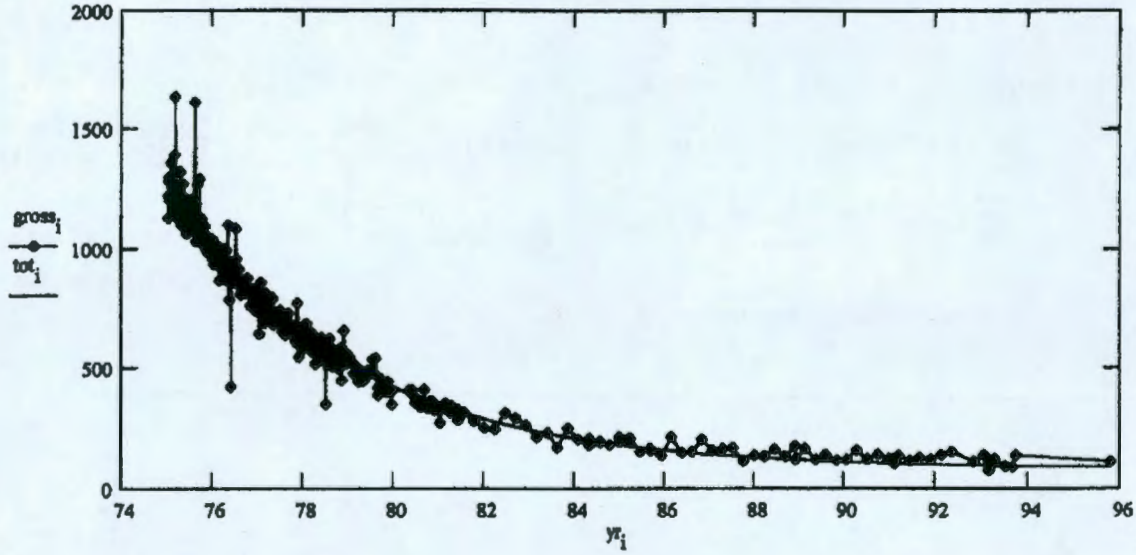
$\alpha cs = 83.878$ U-238 $\quad \alpha eu = 1.19\cdot 10^{3}$ Sb-125

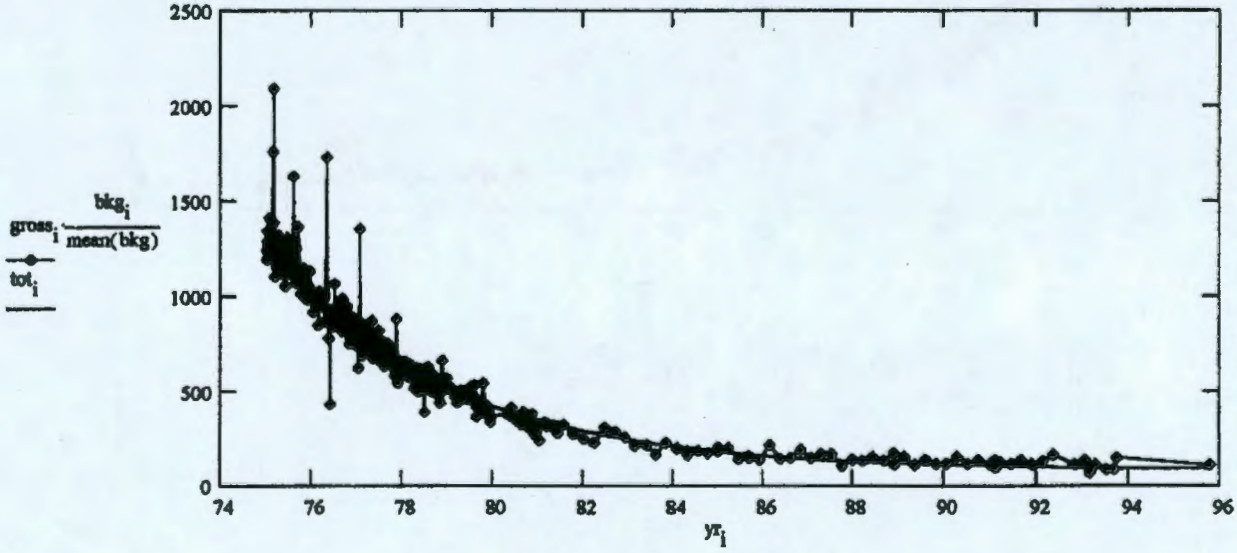
$$Cs_i := \alpha cs\cdot e^{-(yr_i-75)\cdot\frac{\ln(2)}{\tau cs}} \quad Eu_i := \alpha eu\cdot e^{-(yr_i-75)\cdot\frac{\ln(2)}{\tau eu}} \quad tot_i := Cs_i + Eu_i$$

$$\frac{\alpha cs}{\alpha eu} = 0.07$$

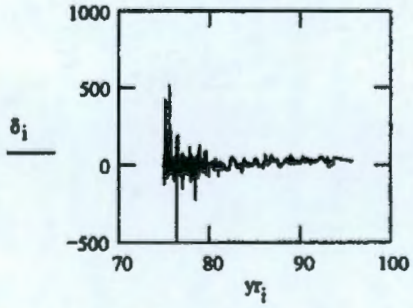
$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

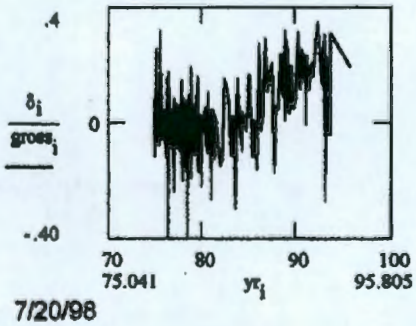
$$\frac{Eu_N}{Cs_N} = 0.078$$





$\delta_i := gross_i - tot_i$ $\qquad$ $\delta n_i := gross_i \cdot \frac{bkg_i}{mean(bkg)} - tot_i$





Borehole 21-06-10

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 10 to 100 feet. There are some activities from 0 to 10 feet, but most likely surface phenomena, thus the classification of clean.

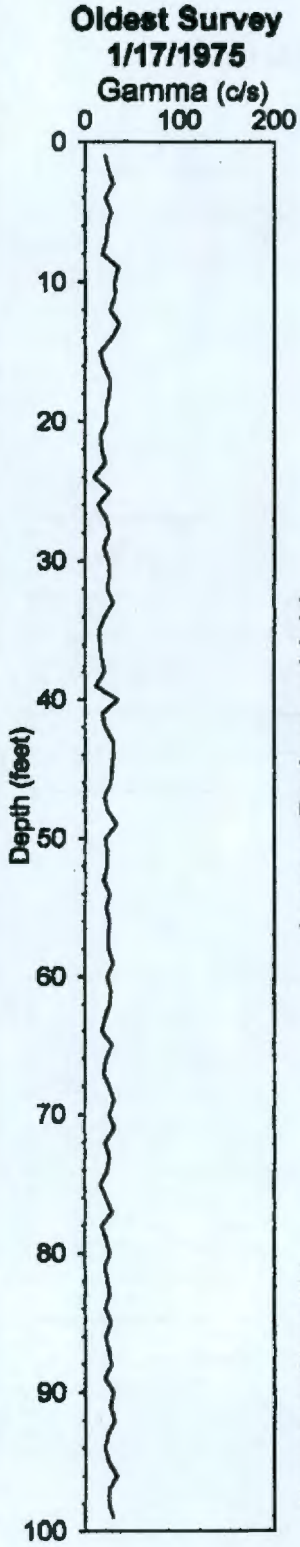
Gross Gamma Survey Information

Probe Type :	04: NaI
Other Probe Types :	03: Neutron
Borehole Depth :	103 ft
Survey Depth :	103 ft
First Survey Date :	1/17/1975
Last Survey Date :	10/20/1995
Number Surveys :	341

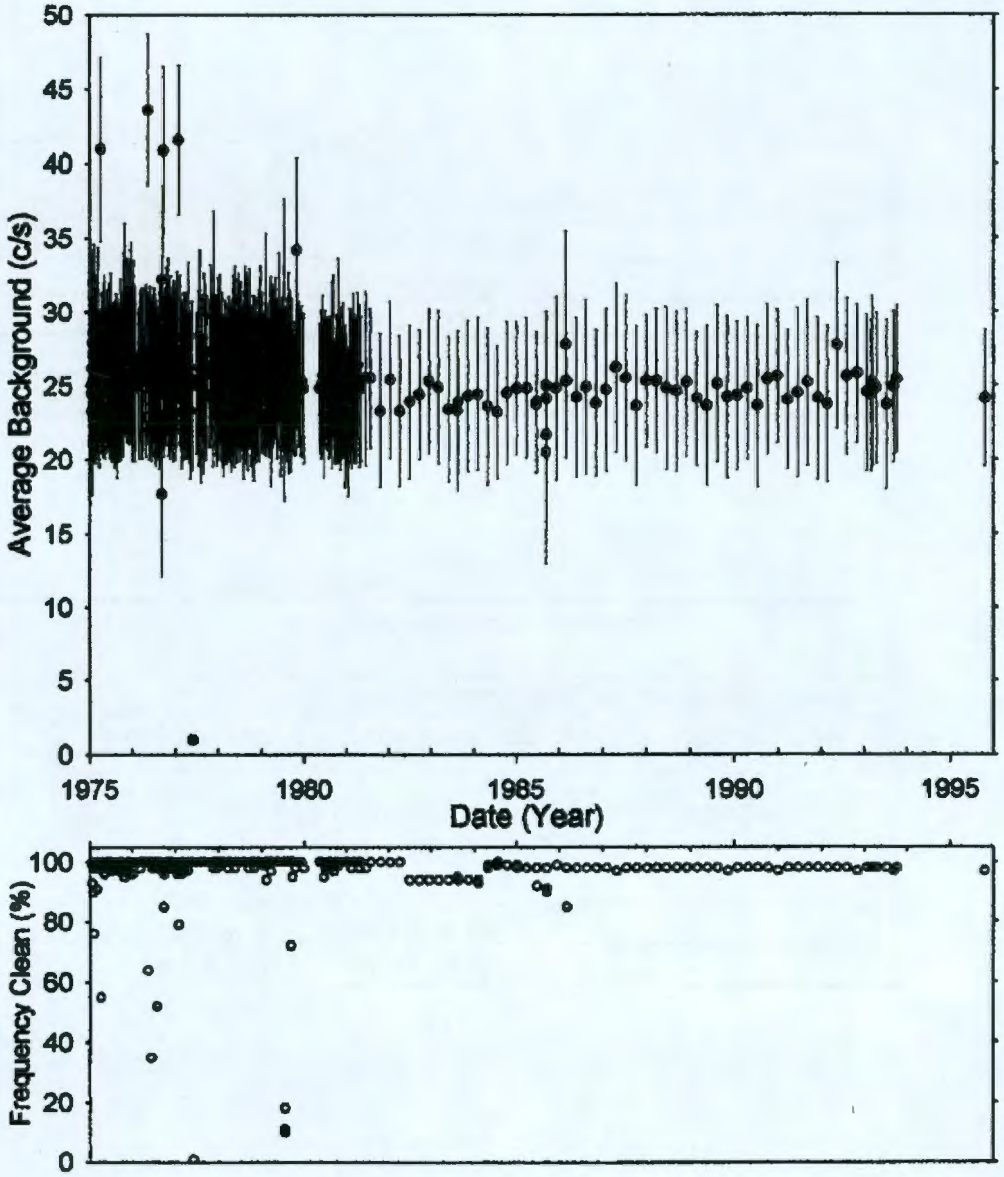
Analysis Notes

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	

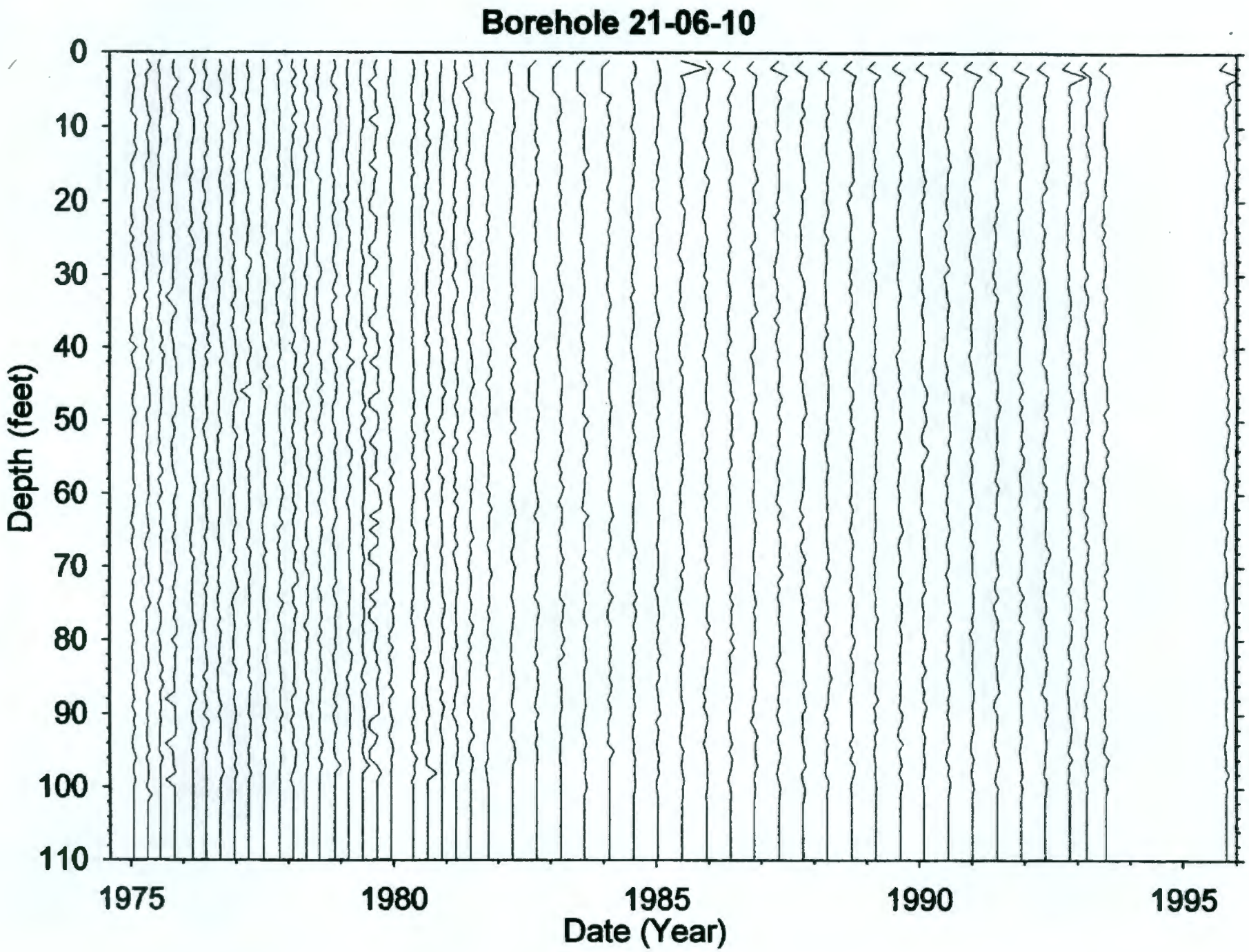
Borehole 21-06-10



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-06-10
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole 21-06-10 | Total # Surveys 345 | Probe Type 04

neutron surveys 4 | # GR Surveys 341

Log Date: 1-17-75 1st | 10-20-95 Last | Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs [illegible] [illegible] | Max Survey Depth 103

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			83-85 non surface

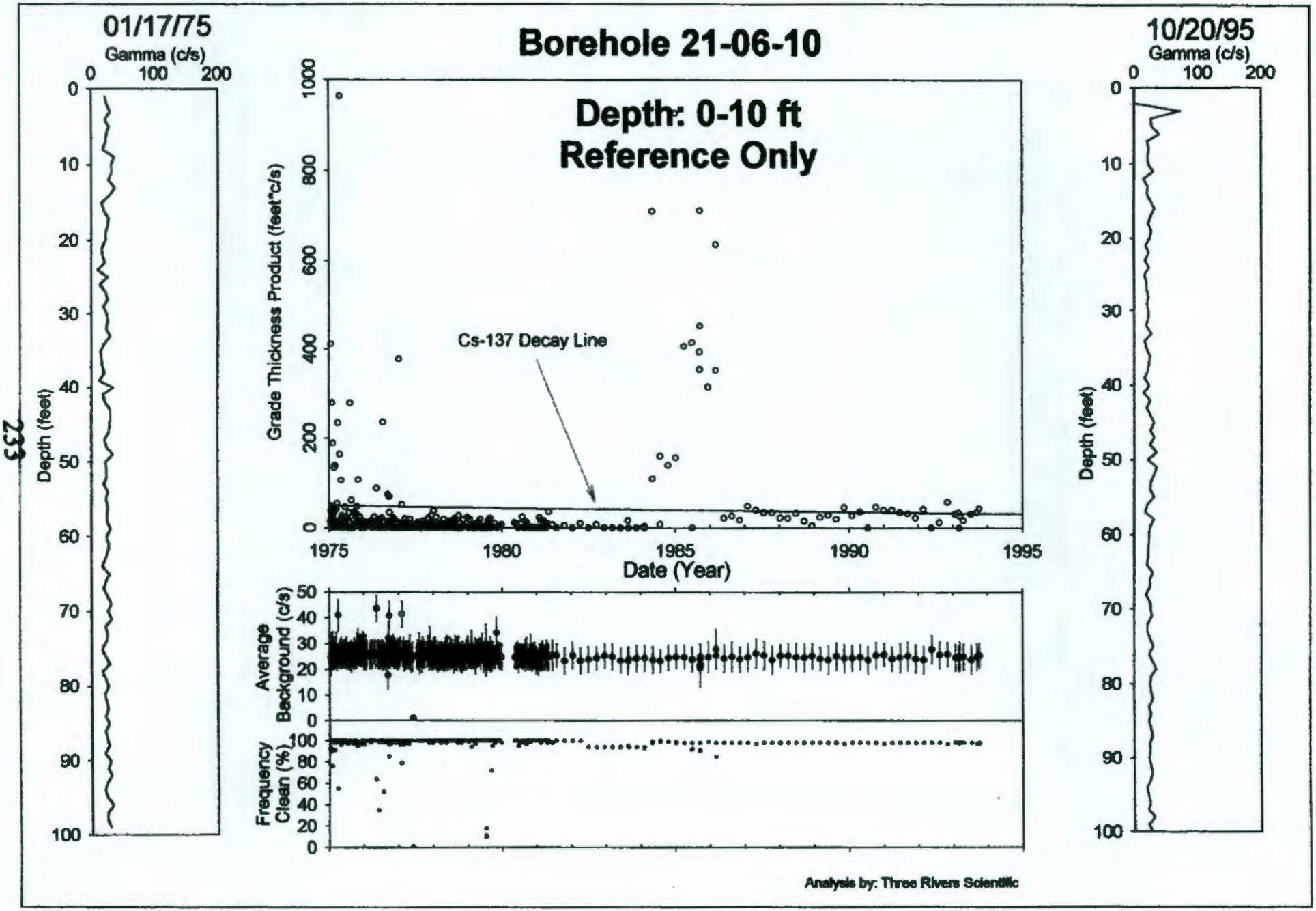
BackGnd.Txt

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

Analysis Notes

Plotted peak 8-10' but left for reference only
classed as Clean

Analyst Name [illegible] | S/W ver TFGROSS2.2



233

HNF-3531 -REV 0

Borehole 21-07-03

Contamination (Co-60) from 62-68 feet and 82-100 feet is Stable

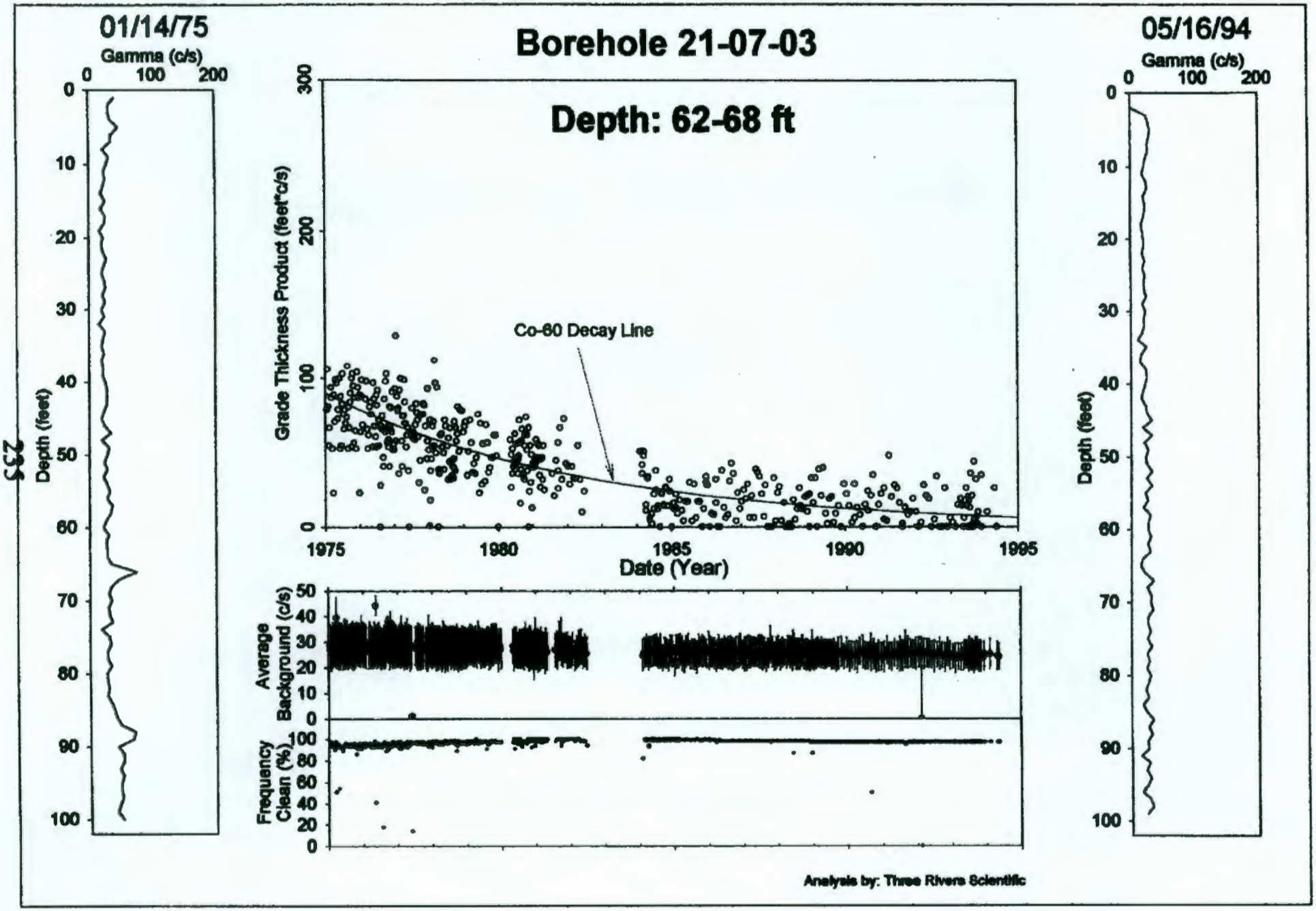
Grade Thickness Product for two radioactive zones (62-68 and 82-100 feet) is decreasing within the gross gamma sensitivity at a rate consistent with the decay of Cobalt-60 (identified from HPGe detector).

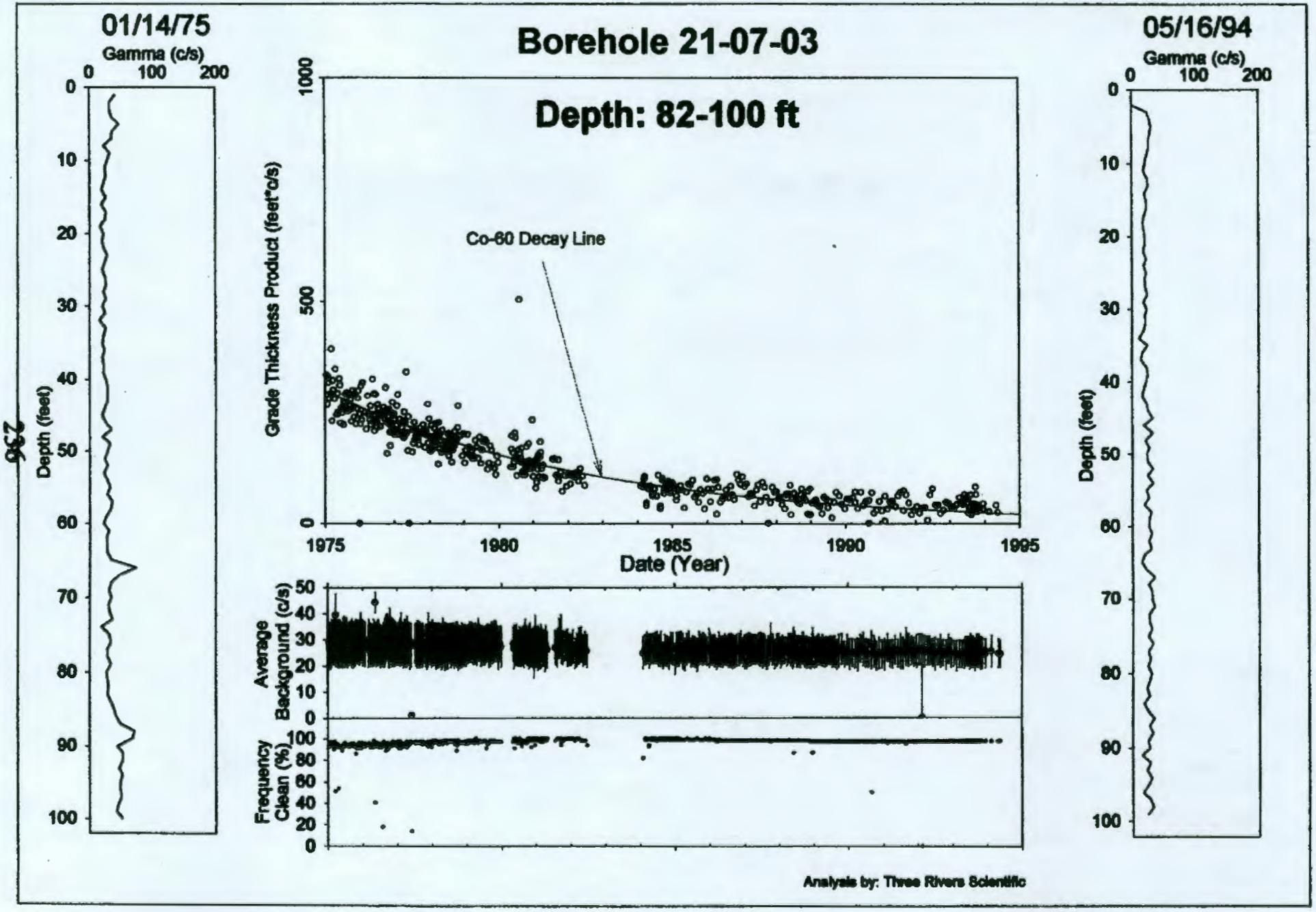
Gross Gamma Survey Information

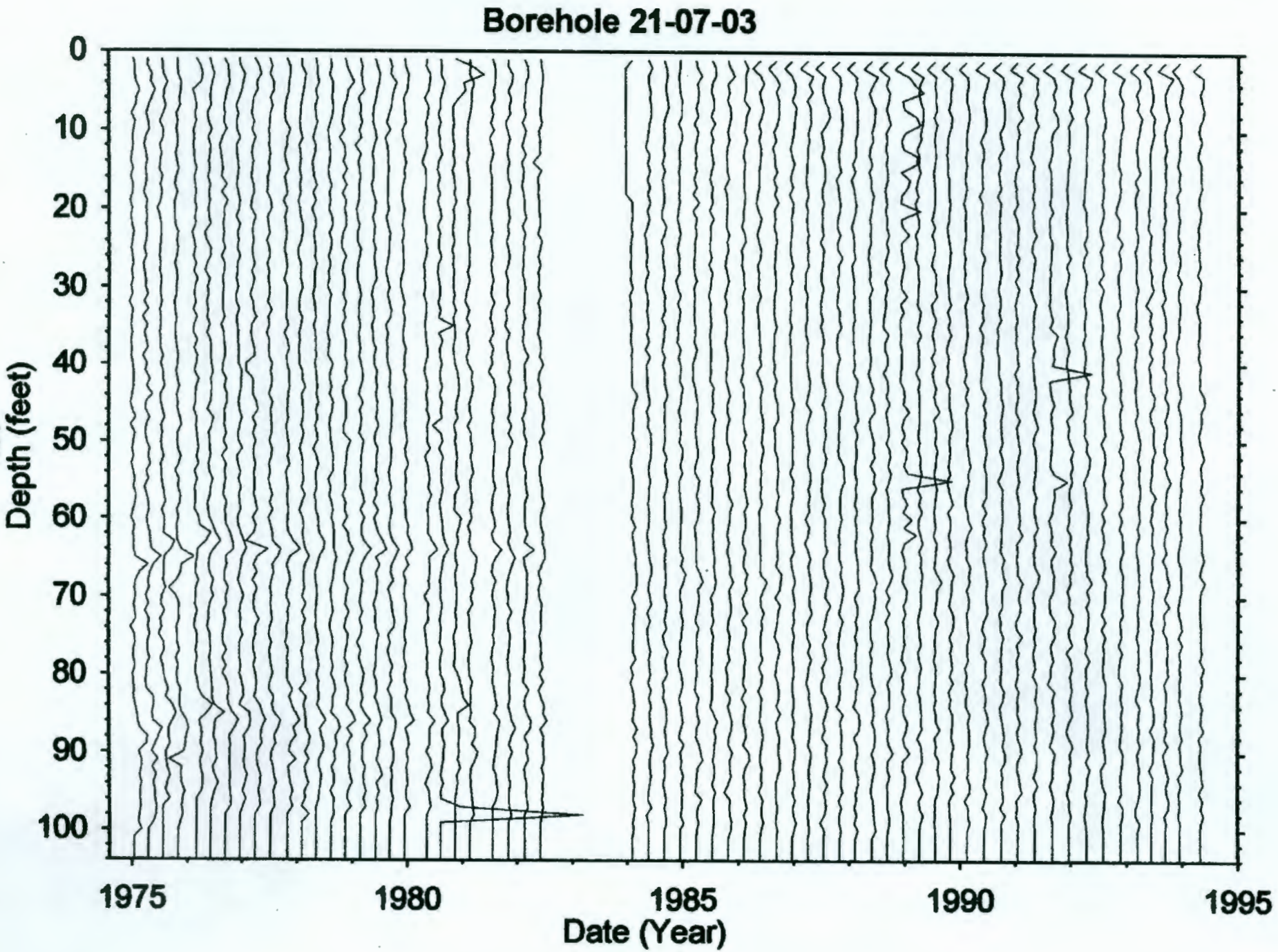
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/16/1994
Number Surveys :	495

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	45 to 60 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**62-68 feet is Stable** **82-100 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


01/14/75
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-07-03
Depth: 62-68 ft
Grade Thickness Product (feet*c/s)
Co-60 Decay Line
Date (Year)
1975
1980
1985
1990
1995
Average Background (c/s)
Frequency Clean (%)
05/16/94
Analysis by: Three Rivers Scientific


01/14/75
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-07-03
Depth: 82-100 ft
Co-60 Decay Line
Grade Thickness Product (feet*c/s)
Date (Year)
1975
1980
1985
1990
1995
Average Background (c/s)
Frequency Clean (%)
05/16/94
Analysis by: Three Rivers Scientific


Borehole 21-07-03
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-07-03)

Total # Surveys 500

Probe Type 07

neutron surveys 3

GR Surveys ~~595~~ 495

Log Date: 75-01-14 1st

94-05-16 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0 TO 20 FT) < 5 pCi/g

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
75-04-22	21	50	
76-07-27	61	75	
77-06-01	83	98	
84-02-01	18	100	
90-08-30	49	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-20	HI-BKG	100	
76-05-12	HI-BKG	100	
88-06-02	TOOL PROB	170	
88-12-21	TOOL PROB	98	
92-02-13	HI-BKG	100	TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-03-21	AVG BKG	99	51%	39.4	
75-04-22	% CLEAN	~~48~~ 7	54%	28.8	
75-12-24	LENGTH	170	96%	28.0	
76-05-12	AVG BKG	97	41%	44.3	
76-07-27	% CLEAN	79	18%	27.0	
77-06-01	AVG BKG	97	14%	1.0	
92-02-13	AVG BKG	94	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
TWO LOW LEVEL RADIATION ZONES IDENTIFIED

Analyst Name Randall Price

S/W ver TFGROSS V2.20

Borehole 21-07-06

Contamination (Cs-137) from 20-34, 34-53, and 53-99 feet is Stable

Grade Thickness Product in the two lower radioactive zones (20-34 and 53-99 feet) is decreasing at rate consistent with the decay of Cesium-137 from July 1980 through May 1994 for the intermediate sensitivity probe (01 Green GM).

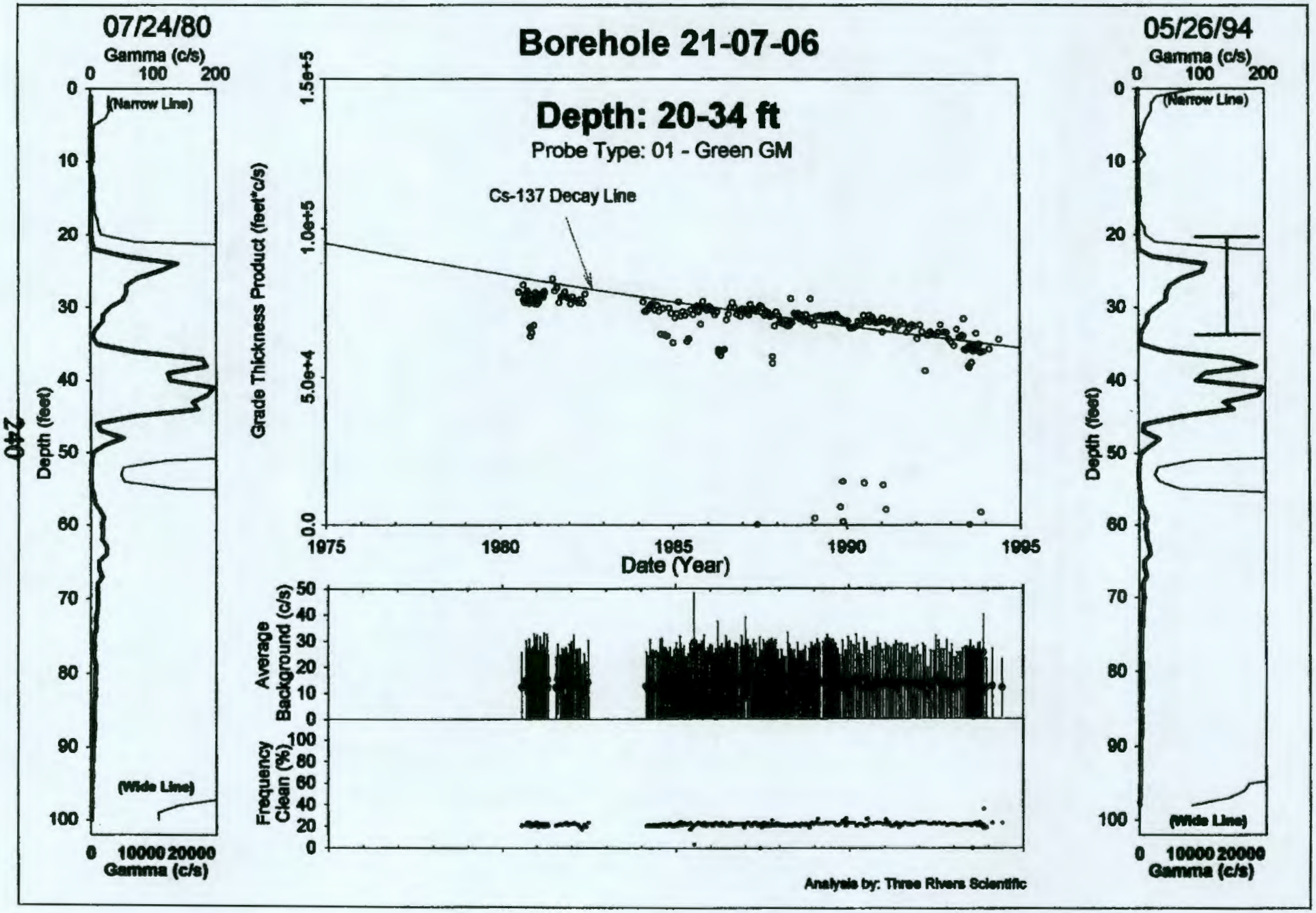
For the high radioactive zone (34-53 feet) the Green GM probe (01) was unable to confirm the stability, whereas the Red GM probe (02) was run during the same time interval and confirmed that the radioactive zone is decreasing at a rate consistent with the decay of Cesium-137.

Gross Gamma Survey Information

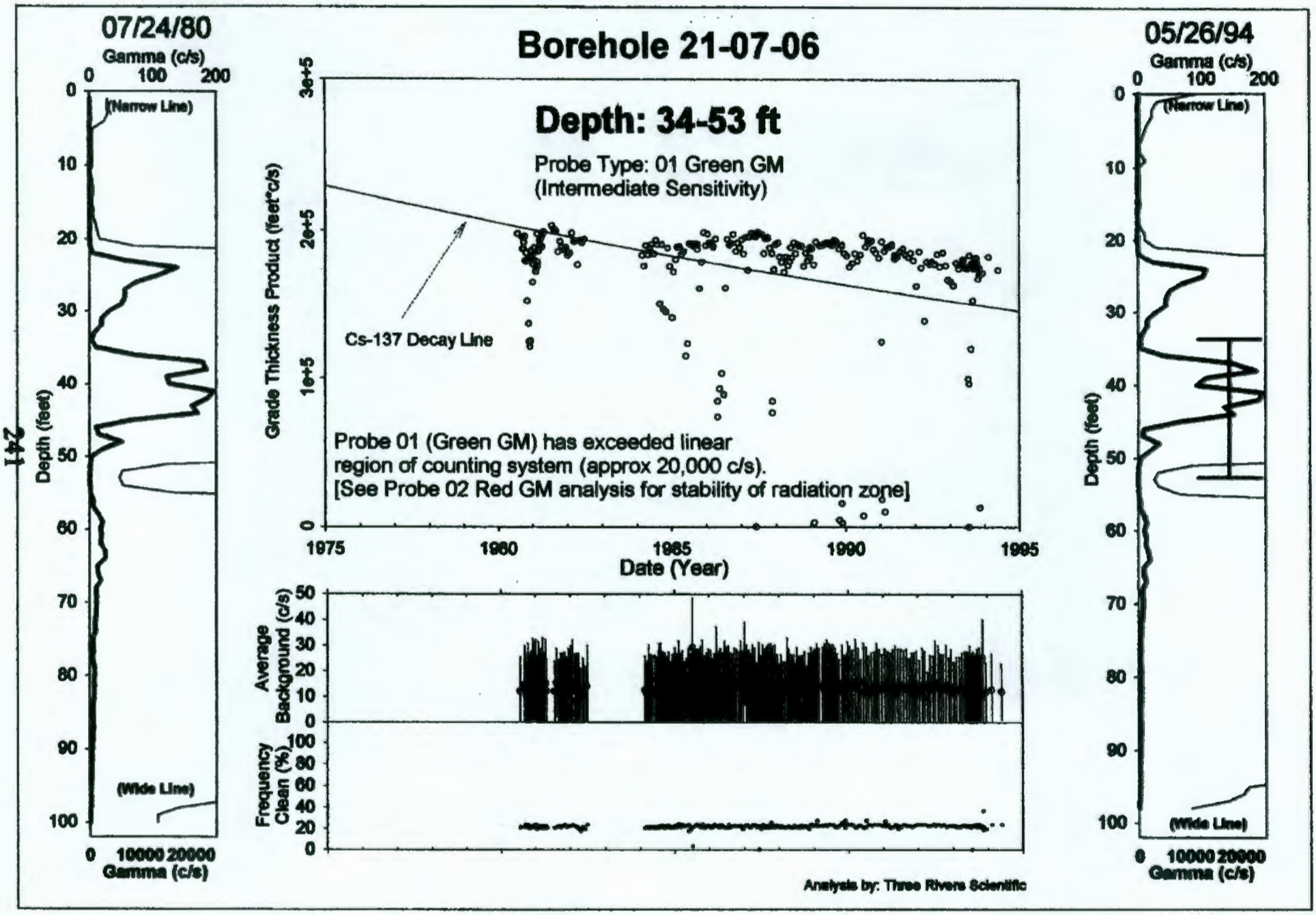
Probe Type :	01: Green GM (Intermediate Sensitivity) 02: Red GM (Lowest Sensitivity) 14: Shielded NaI (Saturated)
Other Probe Types :	04: Sodium Iodide Scintillator (Saturated) 03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980 (Type 01) 5/05/1980 (Type 02) 1/11/1980 (Type 14)
Last Survey Date :	5/26/1994 (Type 01) 5/26/1994 (Type 02) 9/02/1980 (Type 14)
Number Surveys :	274 (Type 01) 283 (Type 02) 32 (Type 14)

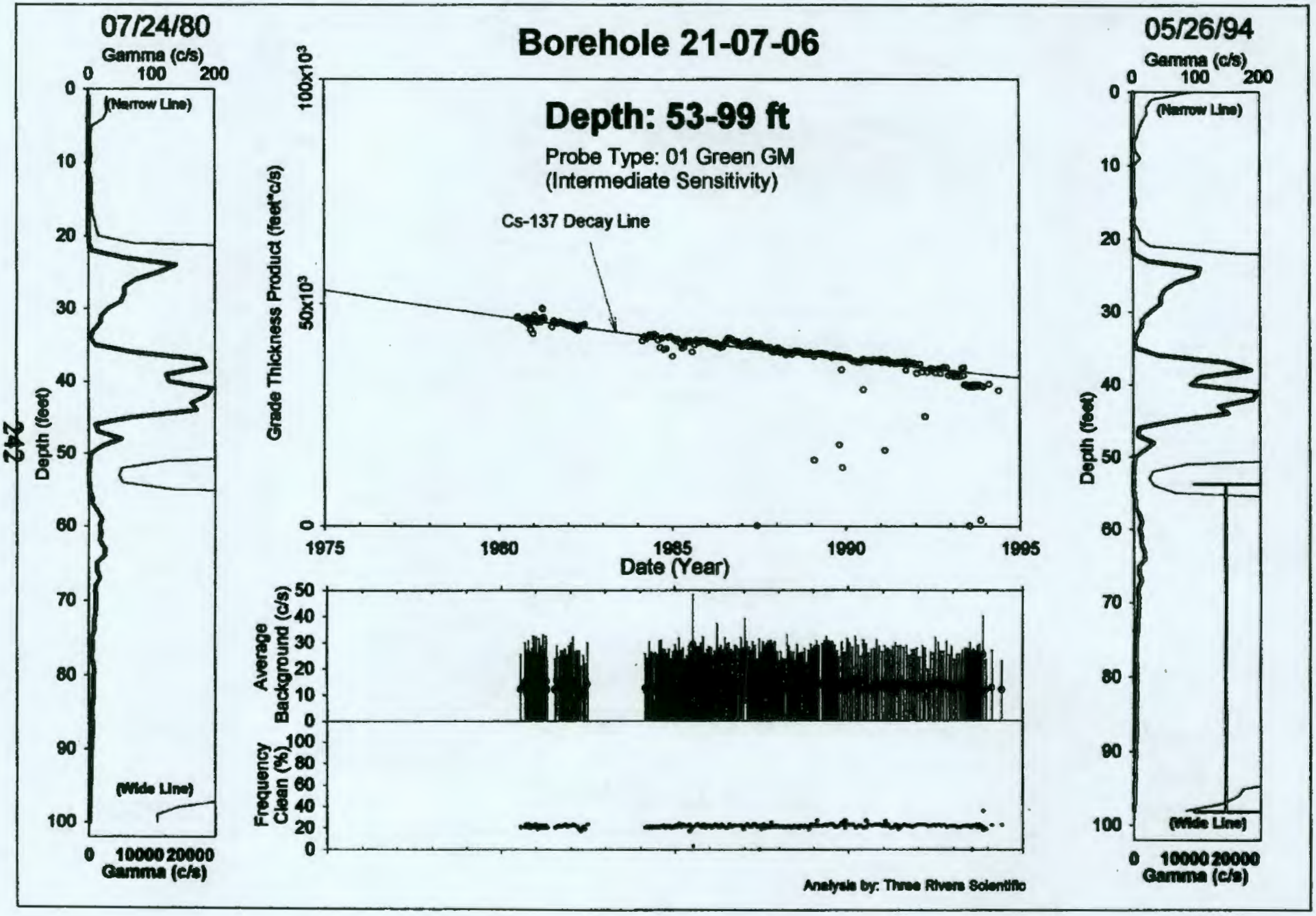
Analysis Notes

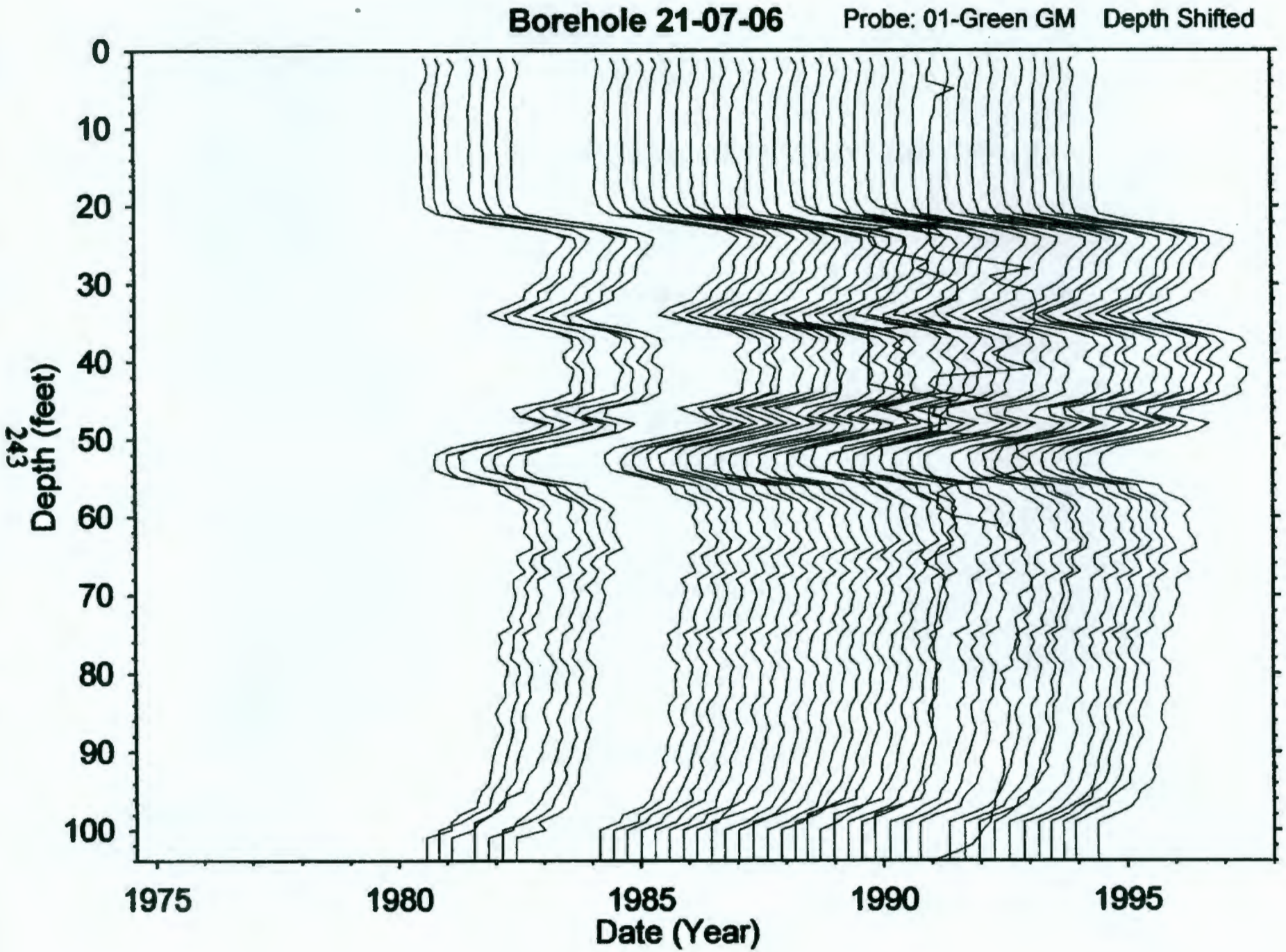
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 10)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**20-34 feet is Stable** **34-53 feet is Stable** **53-99 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

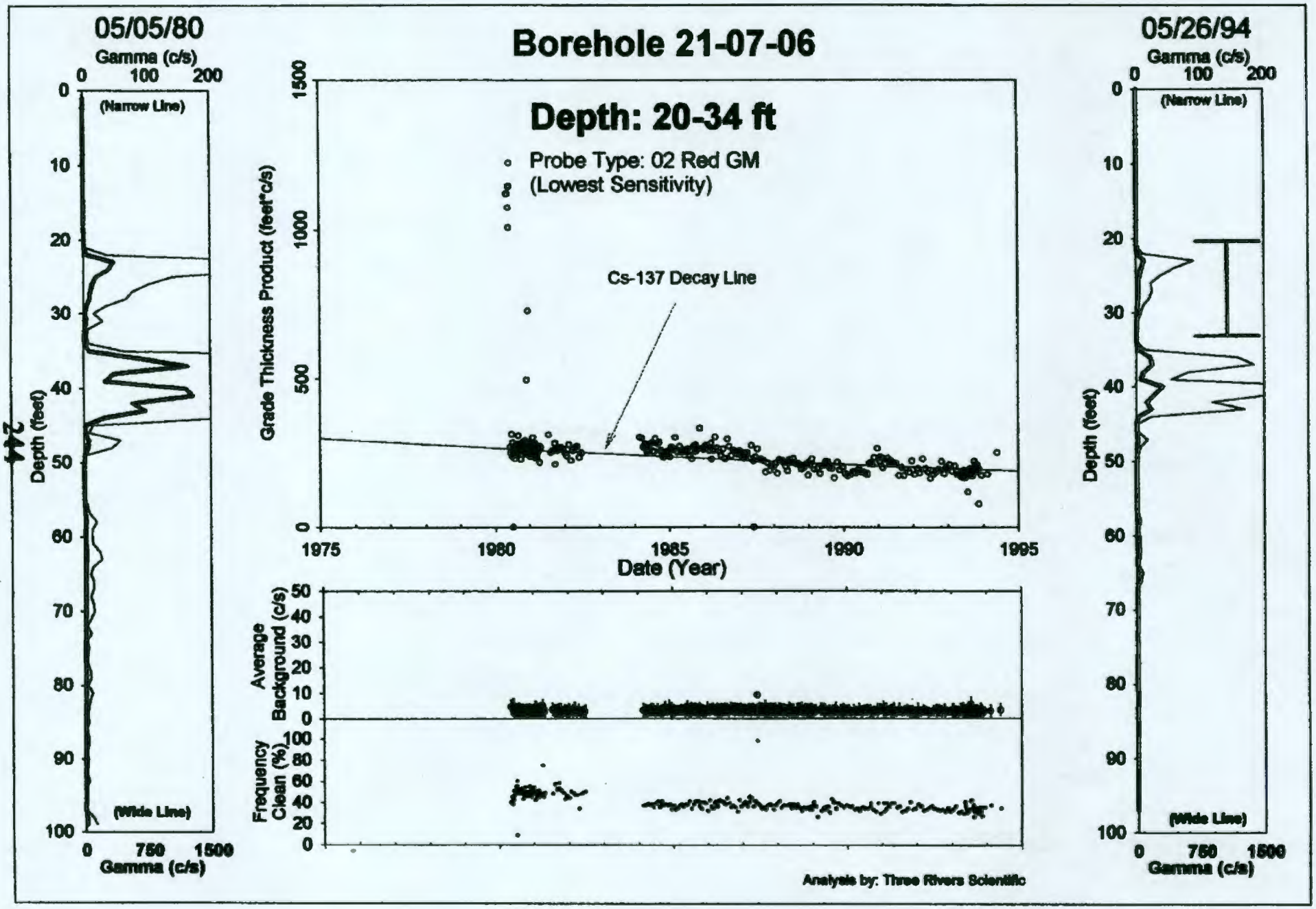


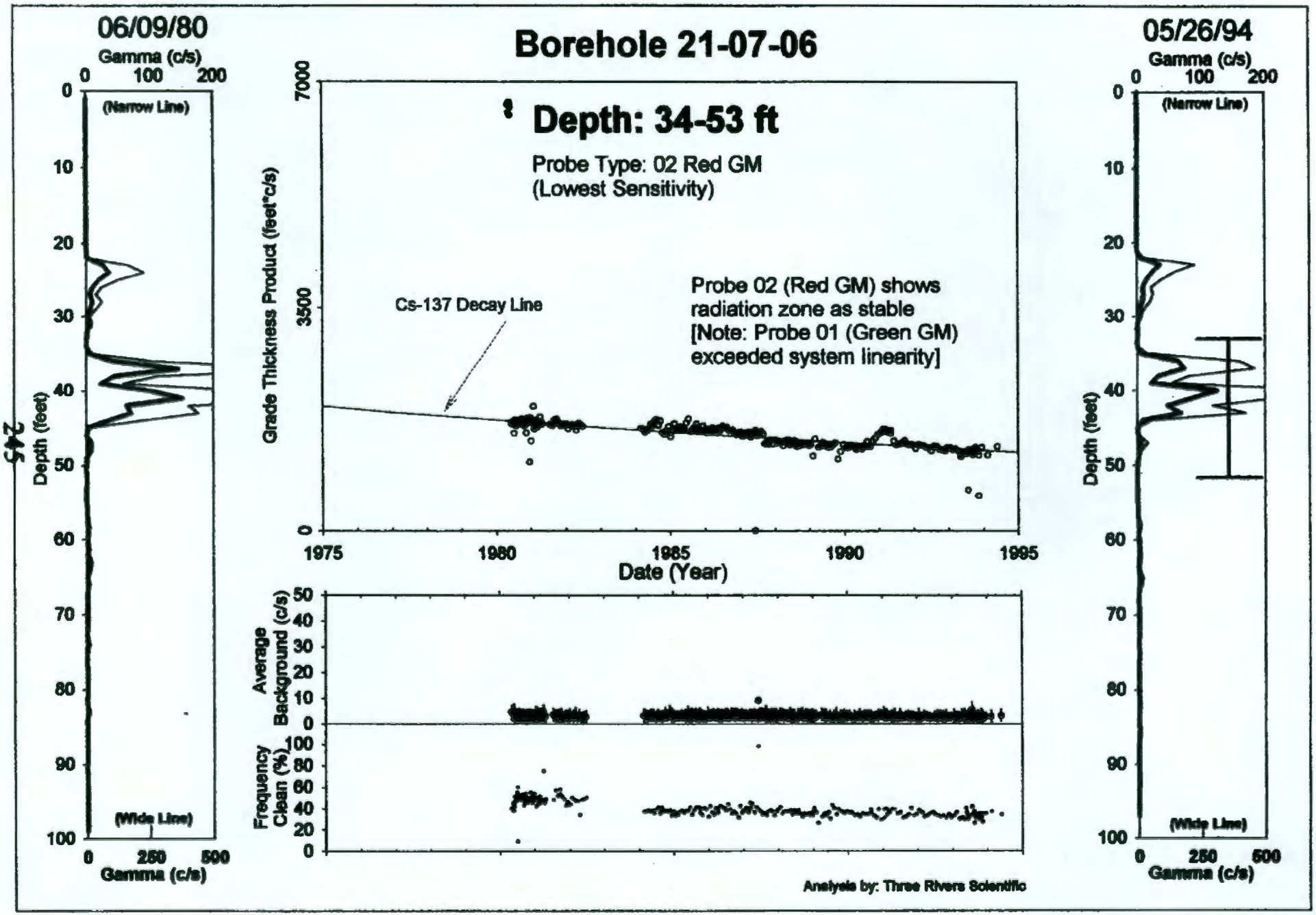
HNF-3531 -REV0

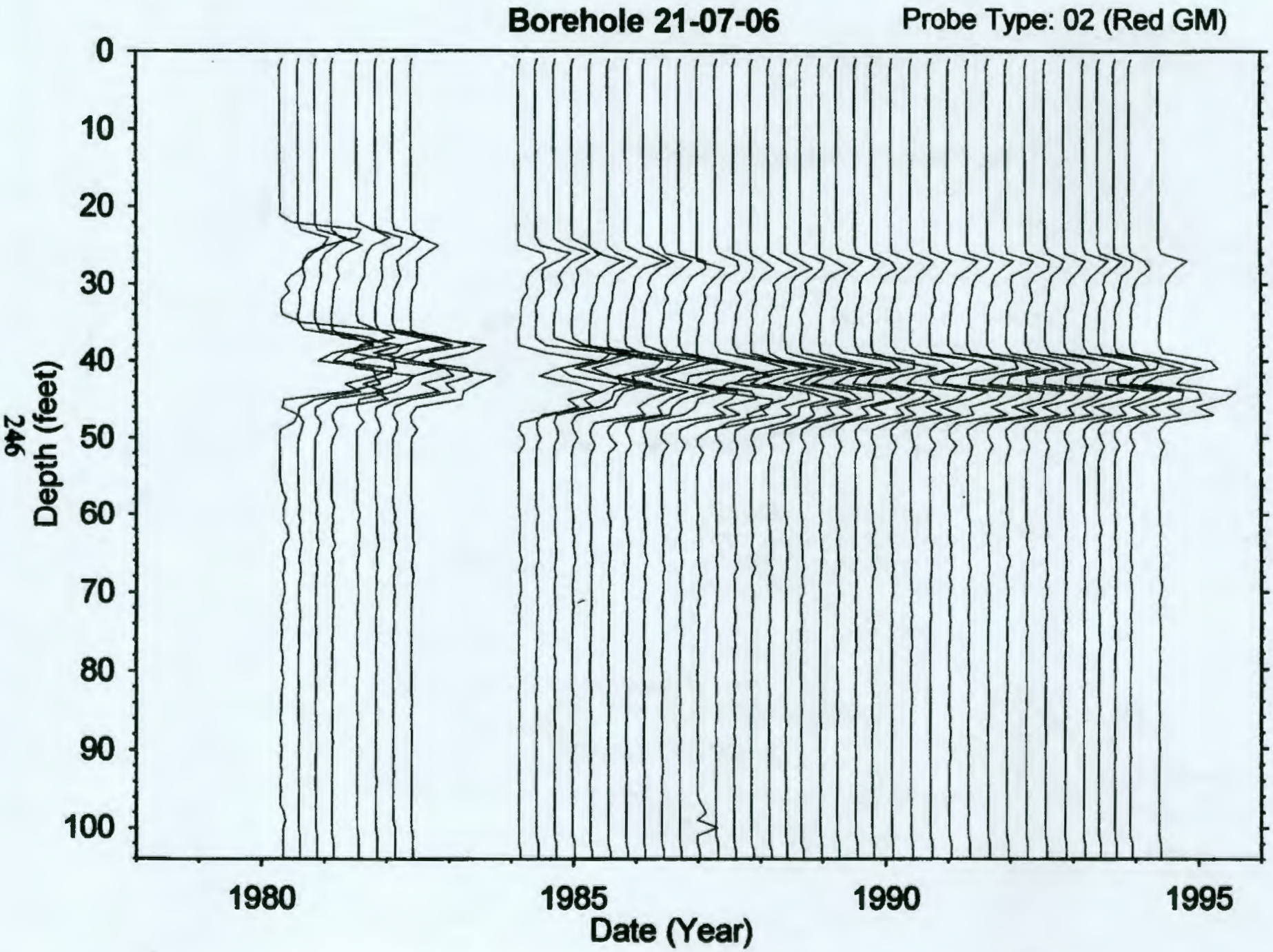

Borehole 21-07-06
07/24/80
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 10000 20000
Gamma (c/s)
Depth: 34-53 ft
Probe Type: 01 Green GM
(Intermediate Sensitivity)
Cs-137 Decay Line
Grade Thickness Product (feet*c/s)
Probe 01 (Green GM) has exceeded linear
region of counting system (approx 20,000 c/s).
[See Probe 02 Red GM analysis for stability of radiation zone]
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific
05/26/94
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 10000 20000
Gamma (c/s)


Borehole 21-07-06
Depth: 53-99 ft
Probe Type: 01 Green GM
(Intermediate Sensitivity)
Cs-137 Decay Line
07/24/80
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
05/26/94
Analysis by: Three Rivers Scientific


Borehole 21-07-06
Probe: 01-Green GM
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)


Borehole 21-07-06
Depth: 20-34 ft
Probe Type: 02 Red GM
(Lowest Sensitivity)
Cs-137 Decay Line
05/05/80
05/26/94
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Grade Thickness Product (feet*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


06/09/80
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
0 250 500
Gamma (c/s)
Depth (feet)
Borehole 21-07-06
Depth: 34-53 ft
Probe Type: 02 Red GM
(Lowest Sensitivity)
Cs-137 Decay Line
Probe 02 (Red GM) shows radiation zone as stable
[Note: Probe 01 (Green GM) exceeded system linearity]
Grade Thickness Product (feet*c/s)
7000
3500
0
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific
05/26/94
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
0 250 500
Gamma (c/s)
Depth (feet)


Borehole 21-07-06
Probe Type: 02 (Red GM)
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

01 (274) 80-07-24 → 94-05-2
02 (283) 80-05-05 → 94-05-2
04 (4) 89-03-17 → 92-07-2
14 (32) 90-01-11 → 90-07-0
SATURATED

Borehole BX (21-07-06)

Total # Surveys 598

neutron surveys 4

Probe Type 01

GR Surveys 274

Log Date: 80-07-24 1st

94-05-26 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (FULL WELL LENGTH)

Max Survey Depth 102

BA 1/2

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
85-07-12B	21	100	
87-02-02	14	100	
89-10-23	11	100	
93-07-14	101	101	
93-11-11	22	100	
89-03-17	53	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
87-06-05A	TOOL FAIL	102	
89-02-02	TOOL FAIL	100	
89-10-23	TOOL FAIL	100	
89-11-22A	TOOL FAIL	100	
90-07-02	TOOL FAIL	100	
91-01-17A	TOOL FAIL	100	
91-02-15	BAD SURVEY	100	
93-07-14	WRONG HOLE		
93-11-11	TOOL FAIL		
PROBE 02 - RED GAM			
90-07-07A	TOOL FAIL		
87-06-05A	TOOL FAIL		
93-07-21	TOOL FAIL		
93-11-04	TOOL FAIL		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
82-04-19	AVG BKG	76	17%	8.9	
85-07-12	% CLEAN	102	3%	25.3	
87-06-05	AVG BKG	102	0%	0.0	
93-07-14	AVG BKG	101	0%	0.0	
93-11-11A	AVG BKG	101	36%	25.3	
87-06-05	% CLEAN	102	98%	9.0	
91-09-24	AVG BKG	101	0%	0.0	
80-05-29	AVG BKG	101	0%	1.0	

Analysis Notes

NO SURVEYS REJECTED
3 RADIATION ZONES ~~FOUND~~ SELECTED FOR ANALYSIS

Analyst Name Randall Reid

S/W ver TFCROSS.V2.20

Borehole 21-08-02

Contamination (Cs-137) from 0 to 14 feet is Tank Farm Activity

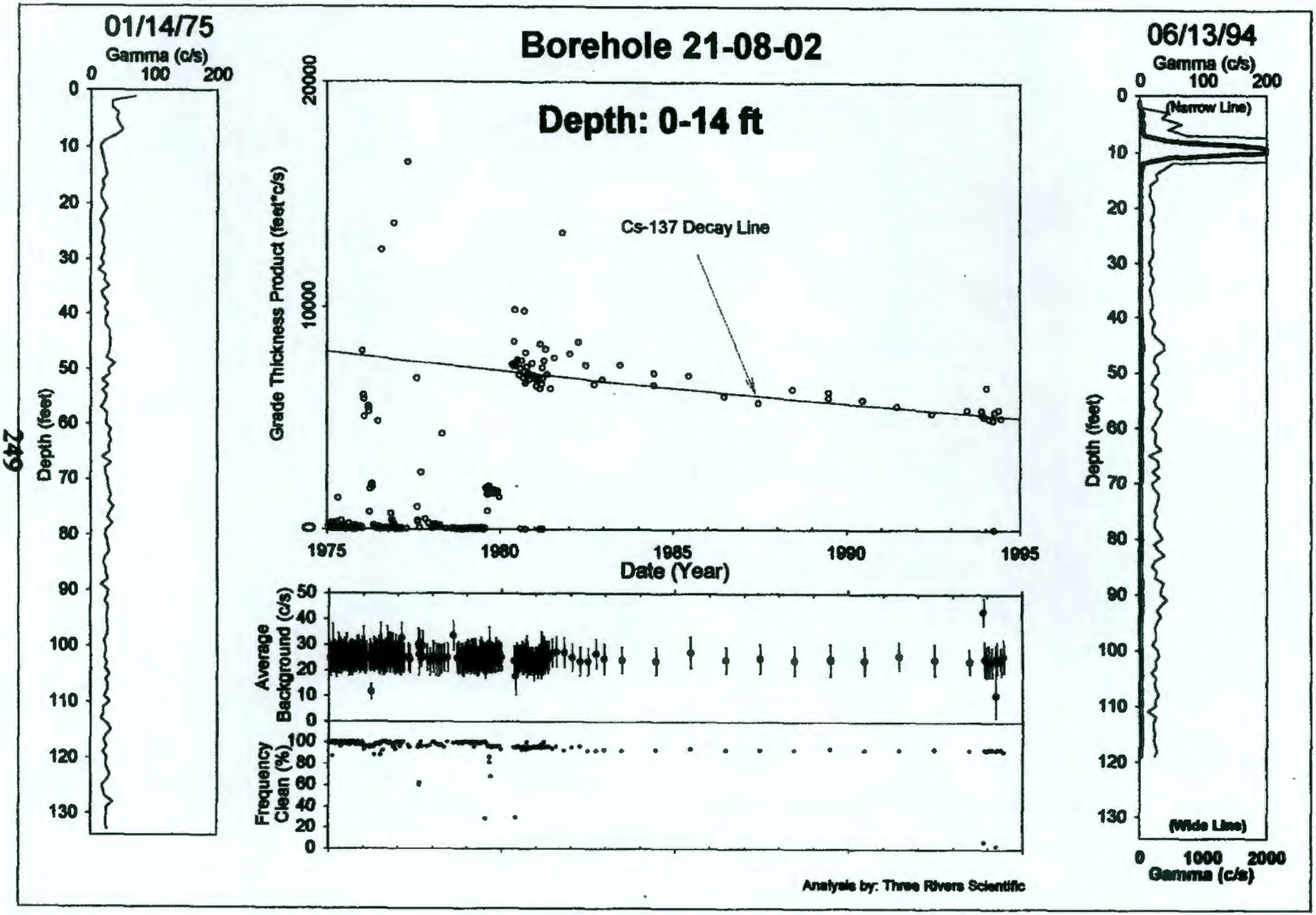
Grade Thickness Product from 0 to 14 feet is erratic from 1975 through 1979, and is categorized as Tank Farm Activity. Grade Thickness Produce from 1980 through 1994 the is decreasing at a rate consistent with the decay of Cesium-137 (identified from HPGe detector).

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	130 ft
Survey Depth :	130 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	228

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 :	**0-14 feet is TF Activity**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



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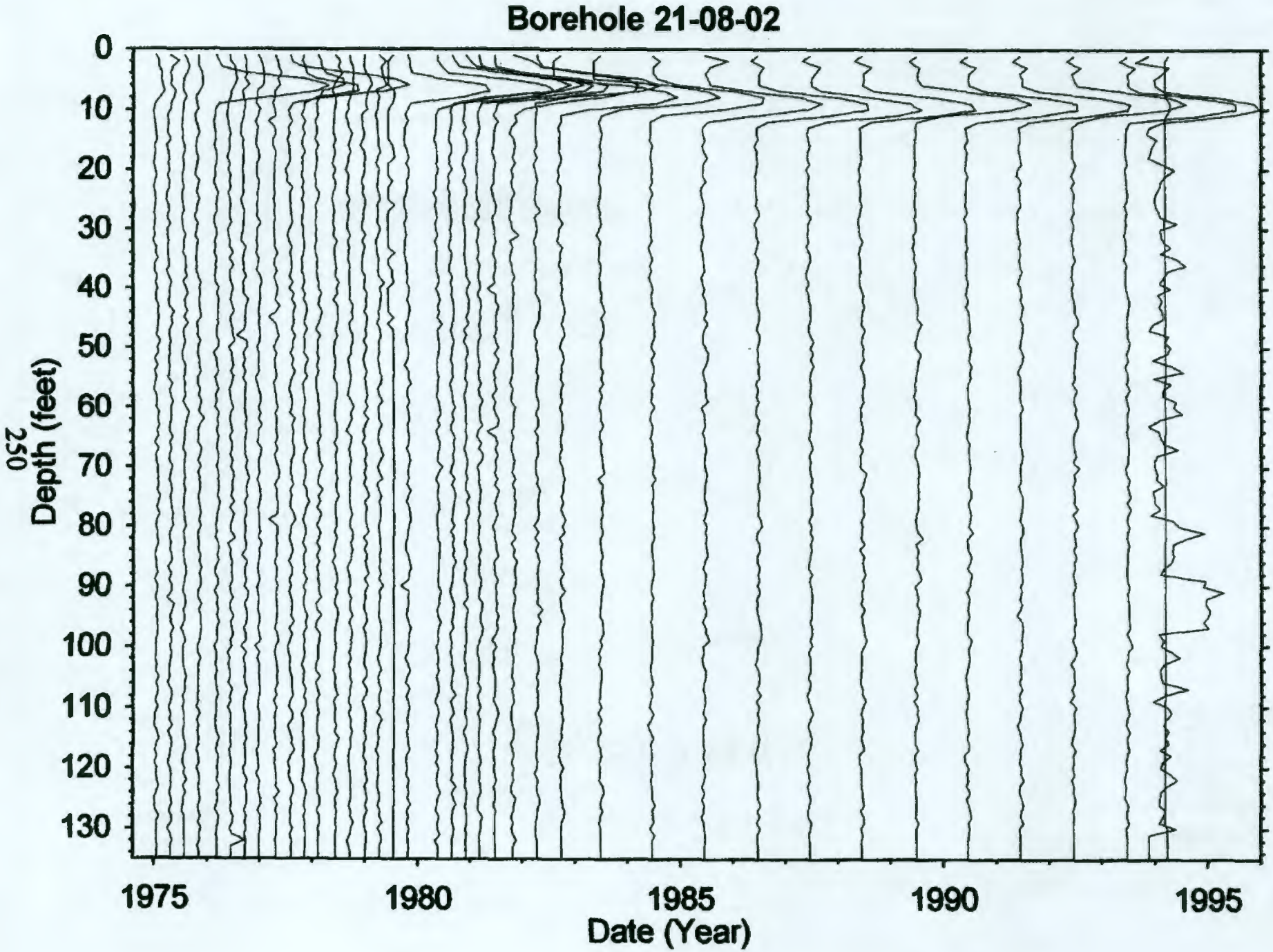
HNF-3531 -REV0


Borehole 21-08-02
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-08-02)

Total # Surveys 237

Probe Type 04

neutron surveys 3

GR Surveys 228

Log Date: 75-01-14 1st

94-06-13 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs-137 (0-11 FT) MAX 100 pCi/g

Max Survey Depth 130

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
76-04-27	11	130	
77-08-12	34	100	
79-07-11	33	60	
79-09-04	36	120	
80-05-29	88	130	
94-03-24	125	130	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
77-08-10	HI-BKG	130	
93-11-17	HI-BKG	130	TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-10-21	LENGTH	46	93%	27.0	
76-05-12	% CLEAN	96	45%	45.3	
77-06-01	AVG BKG	98	7%	11.4	
77-11-16	LENGTH	45	95%	26.1	
78-05-09	AVG BKG	98	94	11.5	
79-07-11	% CLEAN	124	29%	28.7	
93-11-17	% CLEAN	100	11%	16.3	
94-03-24	AVG BKG	100	95%	2.3	

Analysis Notes

RADIATION ZONE FIRST APPEARED 76-01-07 (NOT CONTINUOUS)
RADIATION ZONE CONSTANT - AFTER 79-08-23

Analyst Name Randall Price

S/W ver TPGROSS V2.20

Borehole 21-08-04

Contamination (Cs-137 & Eu-154) from 0 to 12 feet appears Stable

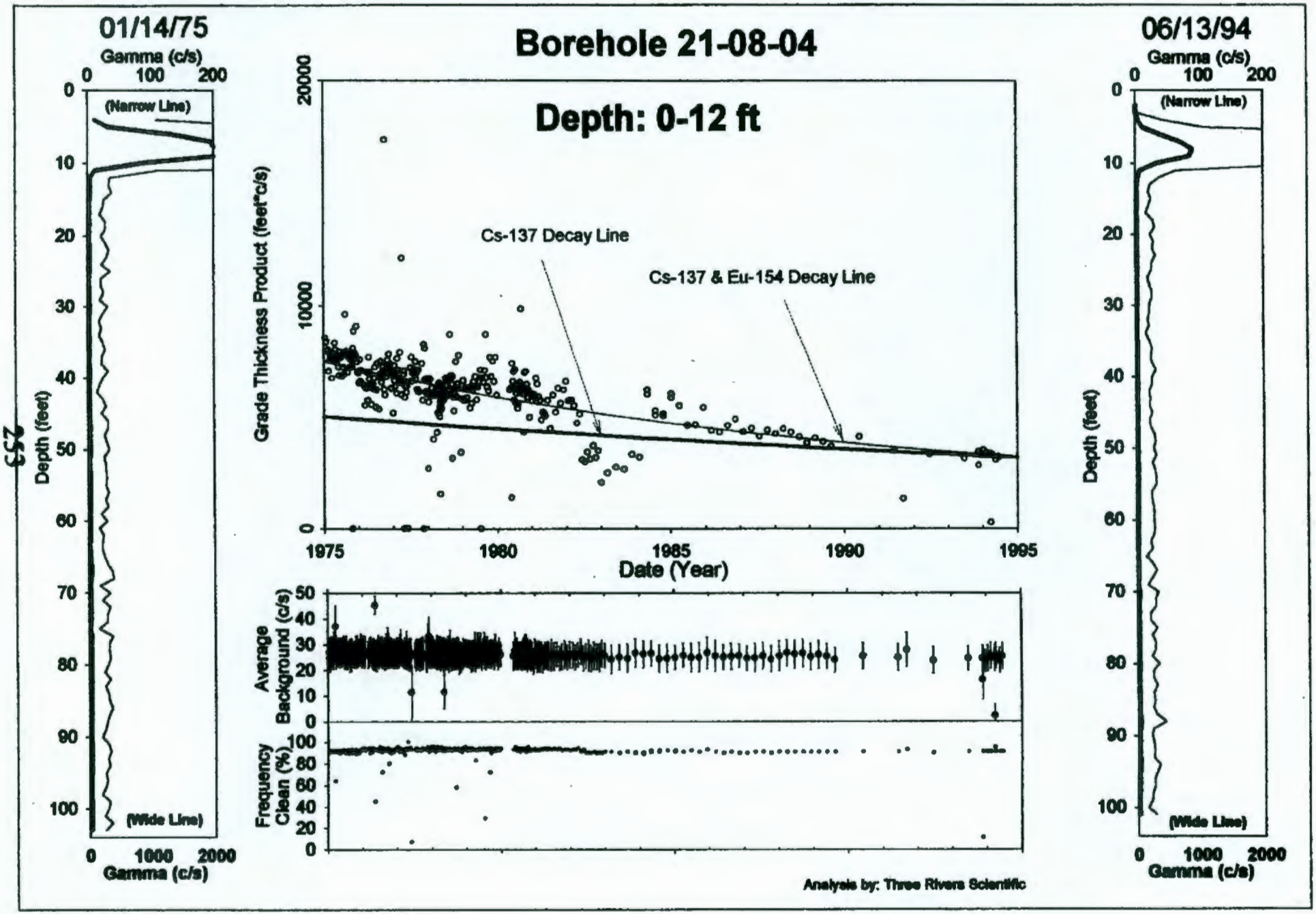
Grade Thickness Product from 0 to 12 feet is decreasing within log acquisition procedures, consistent with a least squares fit for Cesium-137 and Europium-154 (both identified from HPGe detector) between January 1975 and June 1994. The radiation zone was partially logged from May 1982 through February 1984, as shown on the stack plot. The least squares fit results in a gross gamma contribution ratio of 0.28 for Eu-154 to Cs-137 on June 1994.

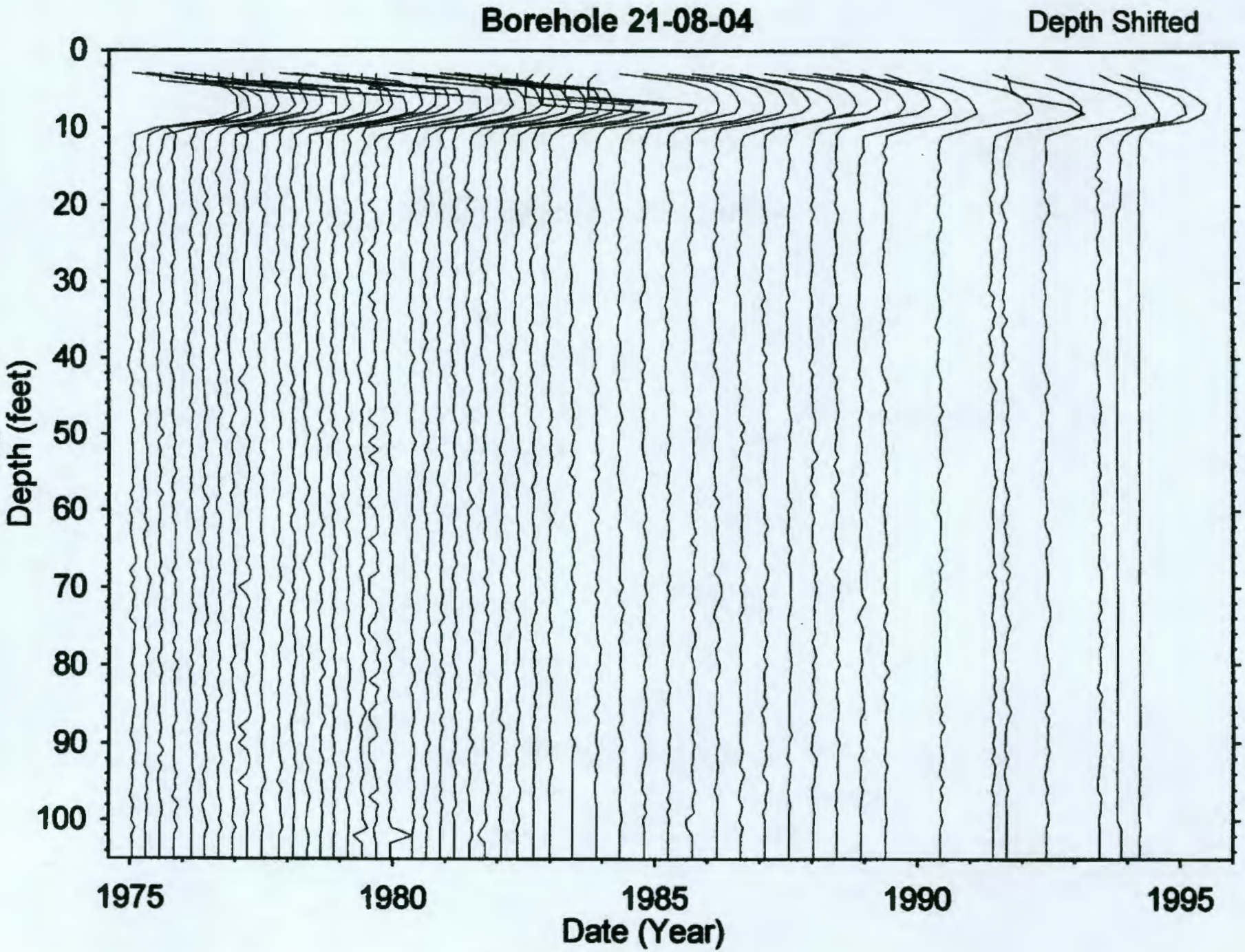
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (5 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	341

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 :	**0-12 feet appears Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


Borehole 21-08-04
Depth: 0-12 ft
01/14/75
06/13/94
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Cs-137 & Eu-154 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-08-04
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-04-04)

Total # Surveys ~~8~~ 346

Probe Type 64

neutron surveys 5

GR Surveys 341

Log Date: 75-01-14 1st

94-06-13 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0 TO 25 FT) <30 pCi/g
CO-60 5 FT < 0.3 pCi/g

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
77-06-01	91	100	
78-09-13	35	90	
79-07-11	95	120	
79-09-04	22	100	
93-11-17	82	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-20	HI-BKG	100	
75-10-21A	BAD SURVEY	45	NO PEAK AT 10 FT
76-07-27	BAD SURVEY	120	TOP PEAK 710 FT
76-10-06A	BAD SURVEY	105	TOP PEAK 710 FT
77-04-20A	BAD SURVEY	80	NO PEAK
77-06-01	BAD SURVEY	100	NO PEAK - WRONG WELL

77-11-16 - BAD
78-09-13 BAD
79-07-11A BAD
82-06-15 TO 84-02-08 [PEAK TRUNCATED]
91-09-09 BAD
94-03-24 BAD

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-10-21	LENGTH	46	93%	27.0	
76-05-12	AVG-BKG	76	45%	45.3	
76-07-27	LENGTH	125	72%	26.8	
77-06-01	AVG-BKG	98	7%	11.4	
77-11-16	LENGTH	45	95%	26.1	
78-05-09	LENGTH	124	29%	28.7	
93-11-17	AVG-BKG	100	11%	16.3	
94-03-24	AVG-BKG	100	95%	2.3	

Analysis Notes

NO SURVEYS REJECTED
DEPTH SHIFT ON TRAILING EDGE
DECREASE IN GTP IS NOT CONSISTENT WITH HPGE EXPECTED RESULTS EU/CS = 0.28 RATIO OF GROSS GAMMA

Analyst Name Randall Price

S/W ver TRGROSS V2.20

filein := "two.txt"

Well 21-08-04

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

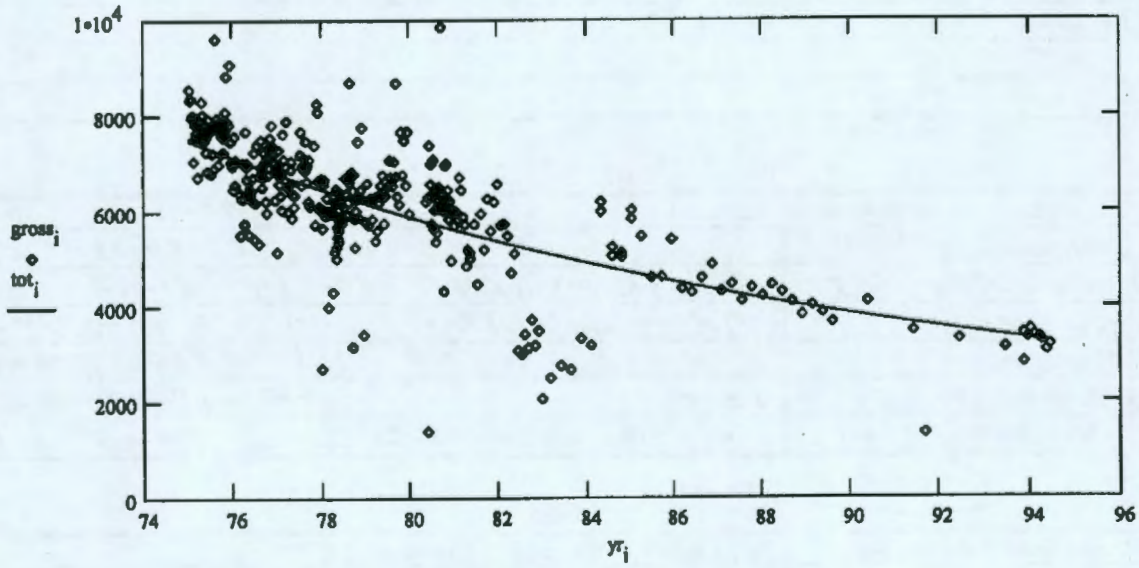
$N := last(yr)$ $\quad N = 330$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau cs := 30.17$ $\quad acs := 4000$

2nd Isotope is Eu-154 (8.5 yrs) $\quad \tau 2 := 8.5$ $\quad a2 := 3500$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}}$ $\quad tot_i := Cs_i + X2_i$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(acs, a2) = 0$ $\quad 1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := \mathrm{Minerr}(acs, a2)$$

$\alpha cs = 4 \cdot 10^3$ $\quad \alpha 2 = 3.5 \cdot 10^3$

$\frac{\alpha cs}{\alpha 2} = 1.143$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}}$ $\quad tot_i := Cs_i + X2_i$

$\boxed{\frac{X2_N}{Cs_N} = 0.28}$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

Borehole 21-08-05

Contamination (Cs-137) from 0 to 35 feet is Stable
Contamination (Co-60) from 62 to 72 feet is Stable

Surveillance logging activities were not designed to monitor low contamination levels and monitor contamination at the surface.

The upper radioactive zone (0 to 35 feet) indicates that a short lived radionuclide, such as Ru-106, may have been present from 1975 to 1976. Ru-106 was identified (hypothesis) in the adjacent borehole, 21-08-06.
Grade Thickness Product from 0 to 35 feet is decreasing within counting system limitation at a rate consistent with Cesium-137 (identified from HPGe detector) between January 1975 and June 1994.

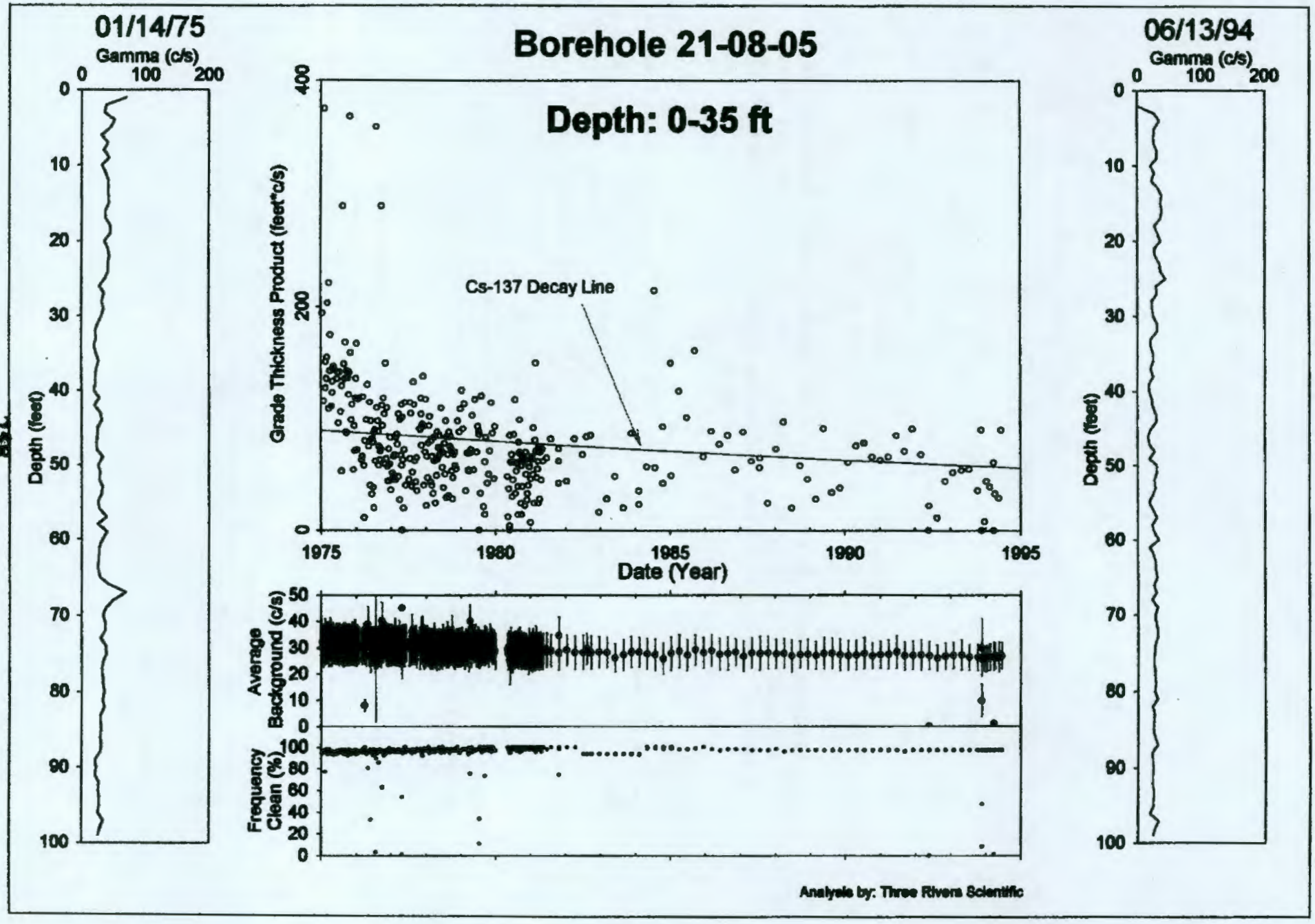
Grade Thickness Product from 62 to 72 feet is decreasing within counting system limitation at a rate consistent with Cobalt-60 (identified from HPGe detector) between January 1975 and June 1994. After 1984 the concentration of Co-60 is at and below the sensitivity threshold.

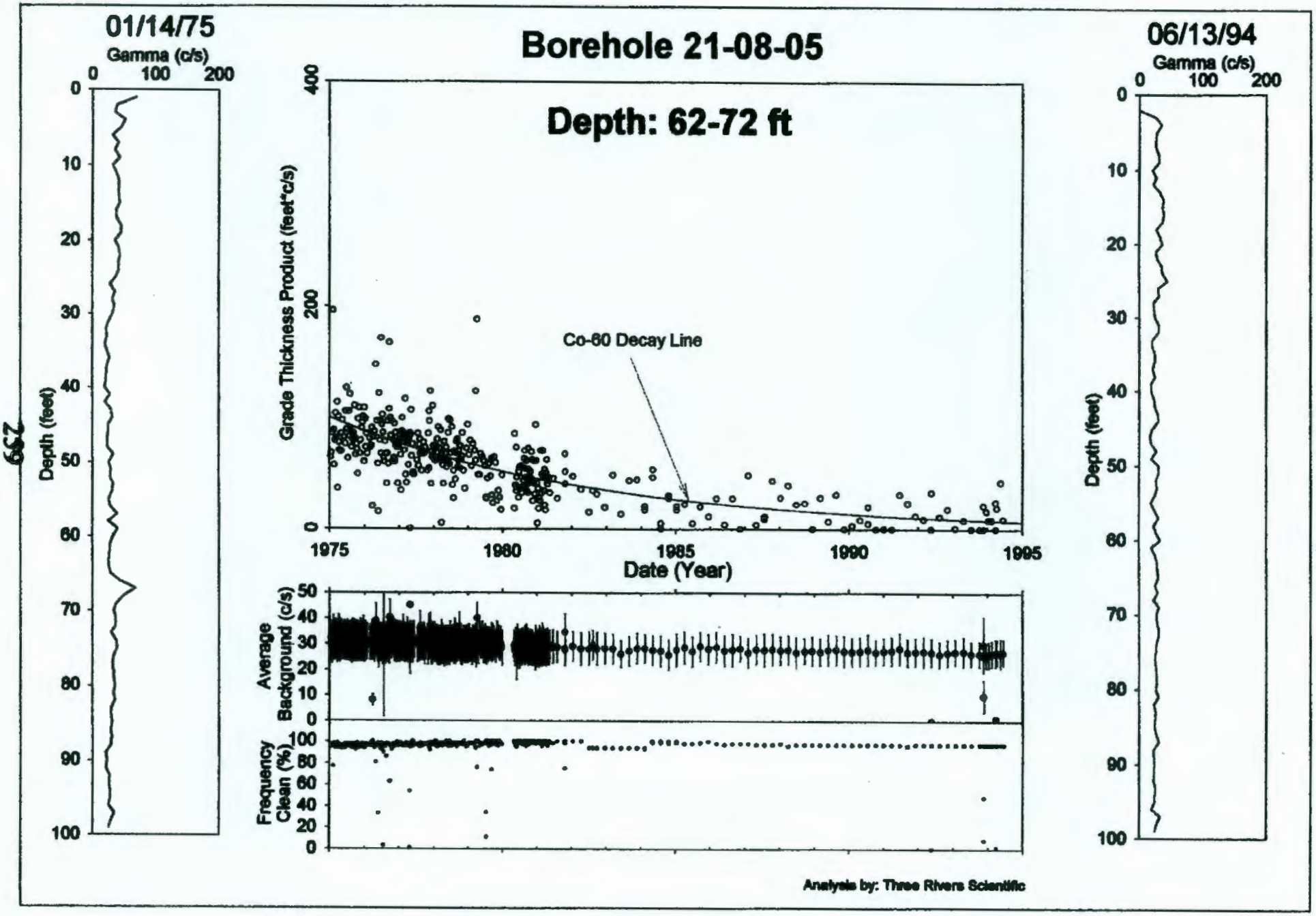
Gross Gamma Survey Information

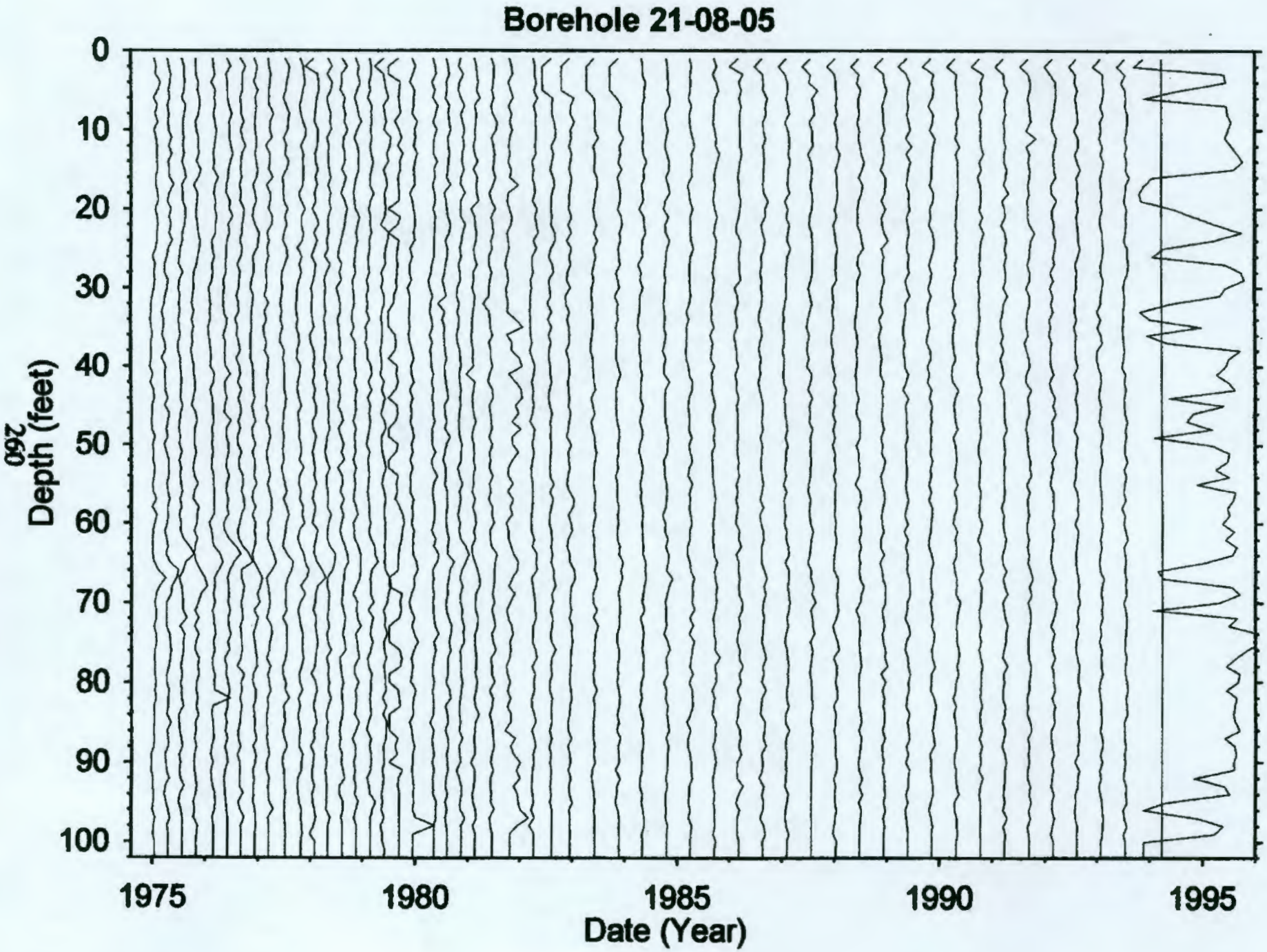
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	360

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 :	**0-35 feet is Stable** **62-72 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


01/14/75
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-08-05
Depth: 0-35 ft
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Date (Year)
1975
1980
1985
1990
1995
Average Background (c/s)
Frequency Clean (%)
06/13/94
Analysis by: Three Rivers Scientific


Borehole 21-08-05
Depth: 62-72 ft
01/14/75
Gamma (c/s)
0 100 200
Depth (feet)
06/13/94
Gamma (c/s)
0 100 200
Depth (feet)
Grade Thickness Product (feet*c/s)
Co-60 Decay Line
Date (Year)
1975 1980 1985 1990 1995
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific



HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole BX(21-08-05) Total # Surveys 363 Probe Type 04

neutron surveys 3 # GR Surveys 360

Log Date: 75-01-14 1st 94-06-13 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): LOW ZONE (65-72 FT)

Isotope from Spectral Survey: CS-137 (0-40FT) < 5 pCi/g Max Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
76-05-26	139	170	93-11-17B (51 GAPS)
76-07-20B	38	50	94-03-24 (98 GAPS)
77-04-20A,B	93	100	
79-07-11A,B	53	60	
79-09-04	24	95	
92-05-18	99	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-02-06	HI-BKG	100	HIGH TOOL SENSITIVITY
76-07-20	TOOL PROB	60	TOOL FAILURE
76-08-18		100	POSSIBLE TOOL MALFUNCTION
76-09-22	HI-BKG	100	HI-TOOL SENSITIVITY?
81-10-21	HI-BKG	100	
93-11-17A	TOOL FAIL	100	TOOL FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-24	AVG BKG	96	100%	8.0	
76-07-20	LENGTH	52	3%	30.0	
77-04-20	% CLEAN	97	1%	45.0	
79-07-11	LENGTH	47	34%	30.9	
92-05-18	AVG BKG	99	0%	0.0	
93-11-17	% CLEAN	99	8%	29.9	
94-03-24	AVG BKG	99	1%	1.0	

Analysis Notes

NO SURVEYS REJECTED
LOW ACTIVITY ZONE 62-72FT SEEN FROM 1975 TO 1982
LOW LEVEL CS-137 AT SURFACE TO 40FT NOT EASILY SEEN
IN CROSS & SURVEILLANCE LOGS

Analyst Name Randall Price S/W ver T-BGROSS V2.20

Borehole 21-08-06

Contamination (Ru-106) from 43 to 52 feet is Stable

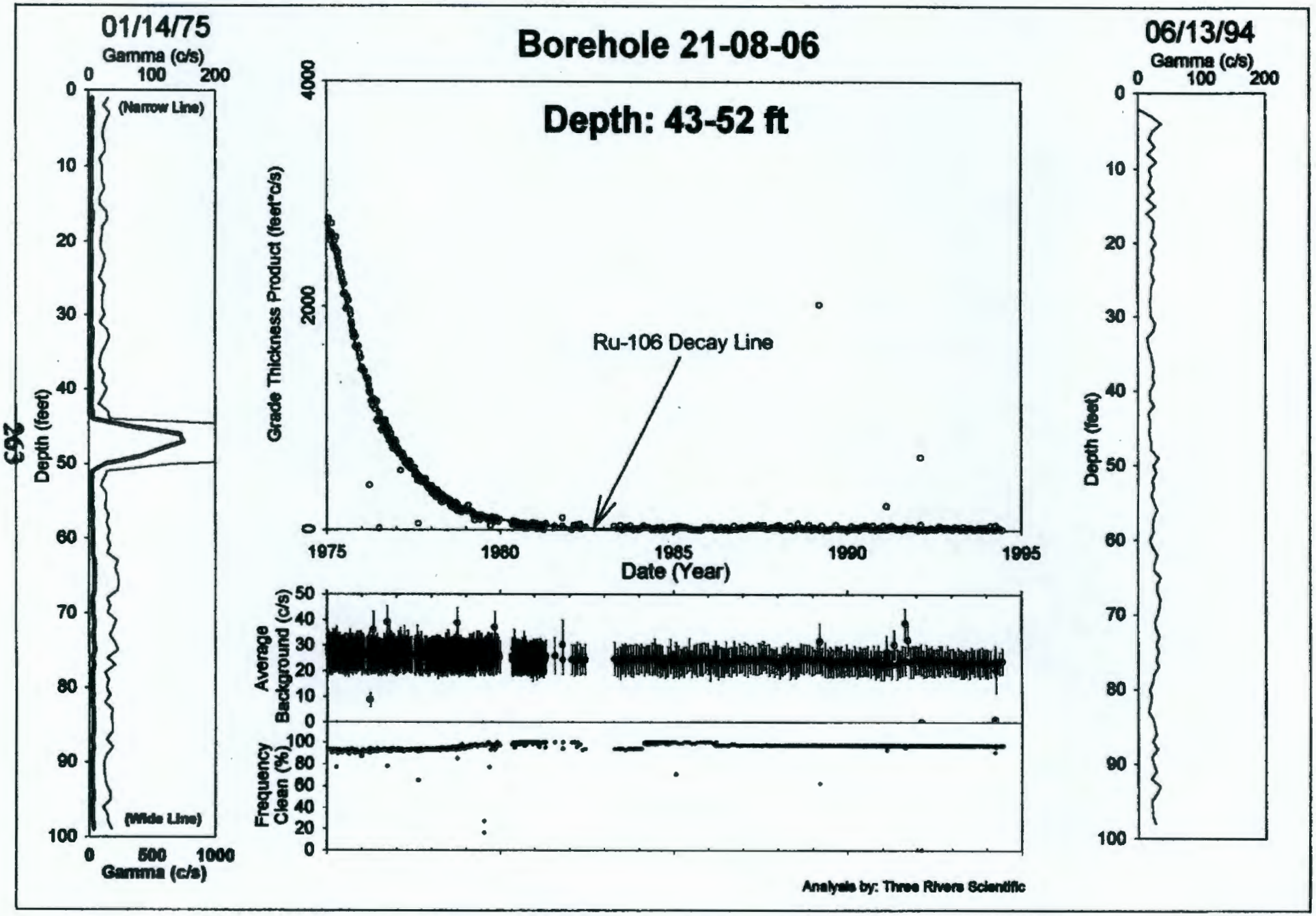
Grade Thickness Product from 43 to 52 feet is decreasing at a rate consistent with Ruthenium-106 (hypothesis) half-life between January 1975 and June 1981.

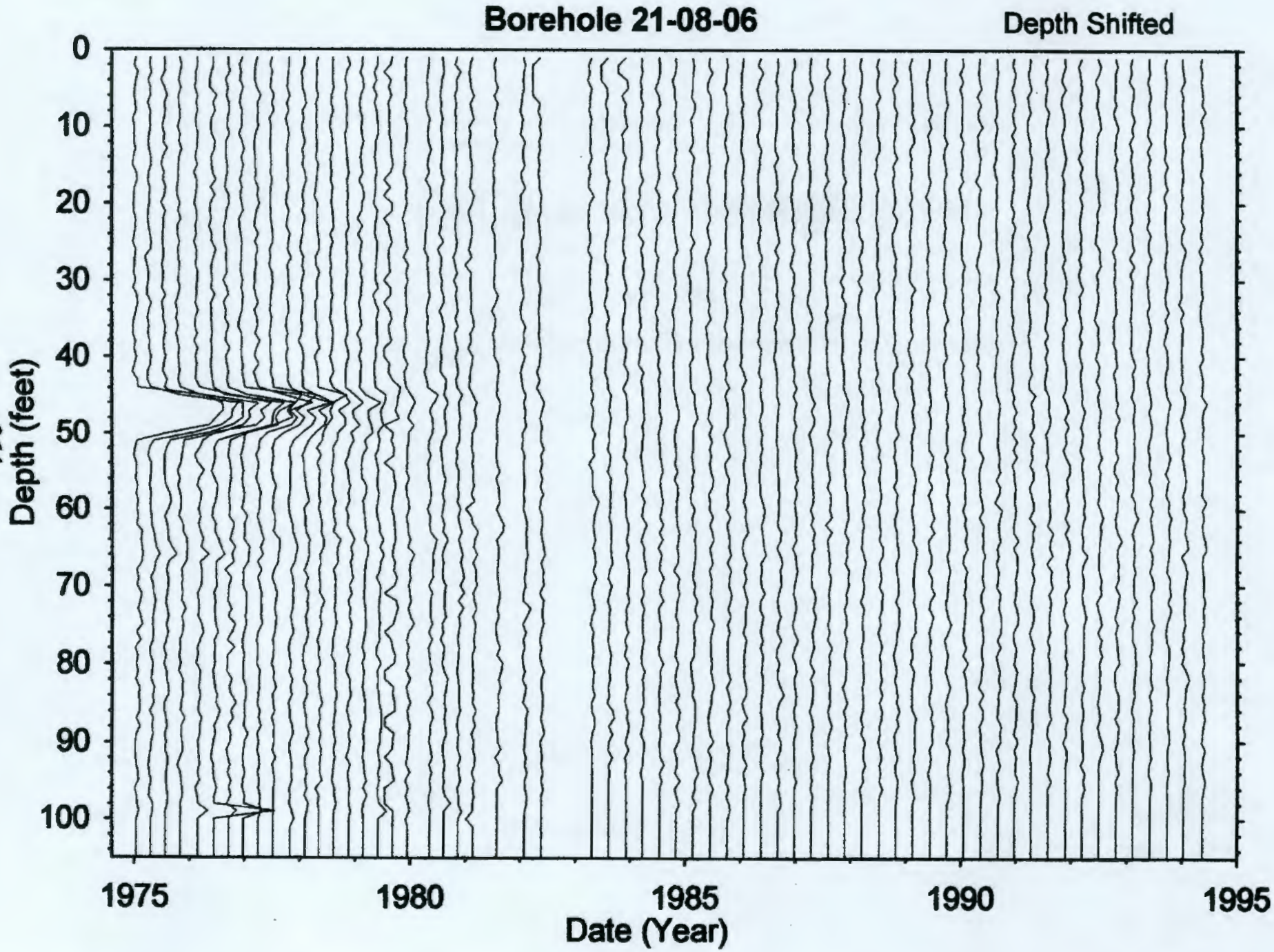
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	458

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 :	**43-52 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


Borehole 21-08-06
Depth: 43-52 ft
01/14/75
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
06/13/94
Gamma (c/s)
Depth (feet)
Grade Thickness Product (feet*c/s)
Ru-106 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-08-06
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-08-06)

Total # Surveys 461

Probe Type 04

neutron surveys 3

GR Surveys 458

Log Date: 75-01-14 1st

94-06-13 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0-15FT) <1 pCi/g

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
77-08-12	27	80	
78-07-11A,B	35	40	
79-09-04	21	100	
85-01-22	29	102	
94-03-24	8	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-03-24		100	RAD ZONE MISSING
77-08-12B		90	REDUCED RAD ZONE
89-03-15A		100	TOOL NOISE
92-02-13	HI-CPS	100	TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-24	AVG BKG	96	94%	8.7	
76-09-22	"	97	78%	39.0	
78-09-26	"	97	85%	38	
78-07-11A,B	% CLEAN	42	76%	25.4	
91-08-27	AVG BKG	98	95%	38.5	
92-02-13	AVG BKG	98	0%	0.0	
94-03-24	AVG BKG	98	91%	1.1	

Analysis Notes

NO SURVEYS REJECTED
SHORT LIVED RADIATION ZONE

Analyst Name Randall Rice

S/W ver T&Gross V2.20

Borehole 21-08-07

Contamination (Cs-137) from 0-12 feet is Tank Farm Activity, Contamination (Cs-137 & Co-60) from 30-42, & 42-54 feet is Stable

Grade Thickness Product from 0 to 12 feet is erratic from 1975 through 1979, and is categorized as Tank Farm activity. Grade Thickness Product from 1980 through 1994 is decreasing at a rate consistent with Cs-137 (identified from HPGe detector).

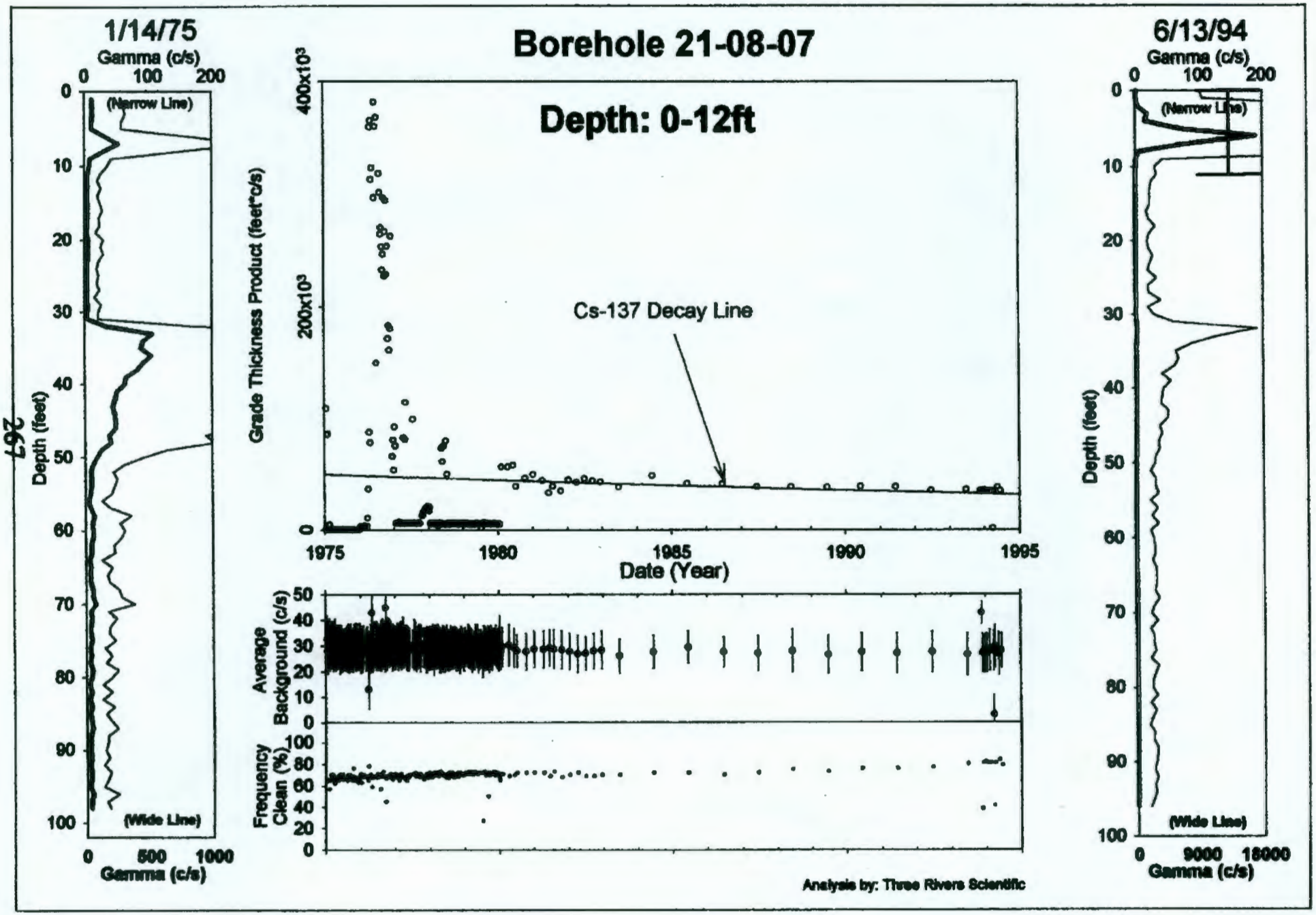
The main radioactive interval was evaluated as two radioactive zones to identify if downward movement had occurred. Grade Thickness Products from 30 to 42 and 42 to 54 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Cobalt-60 (identified from HPGe detector) between January 1975 and June 1994. The least squares fit results in a gross gamma contribution ratio for Co-60 to Cs-137 of 1.8 and 8.6, respectively, on June 1994.

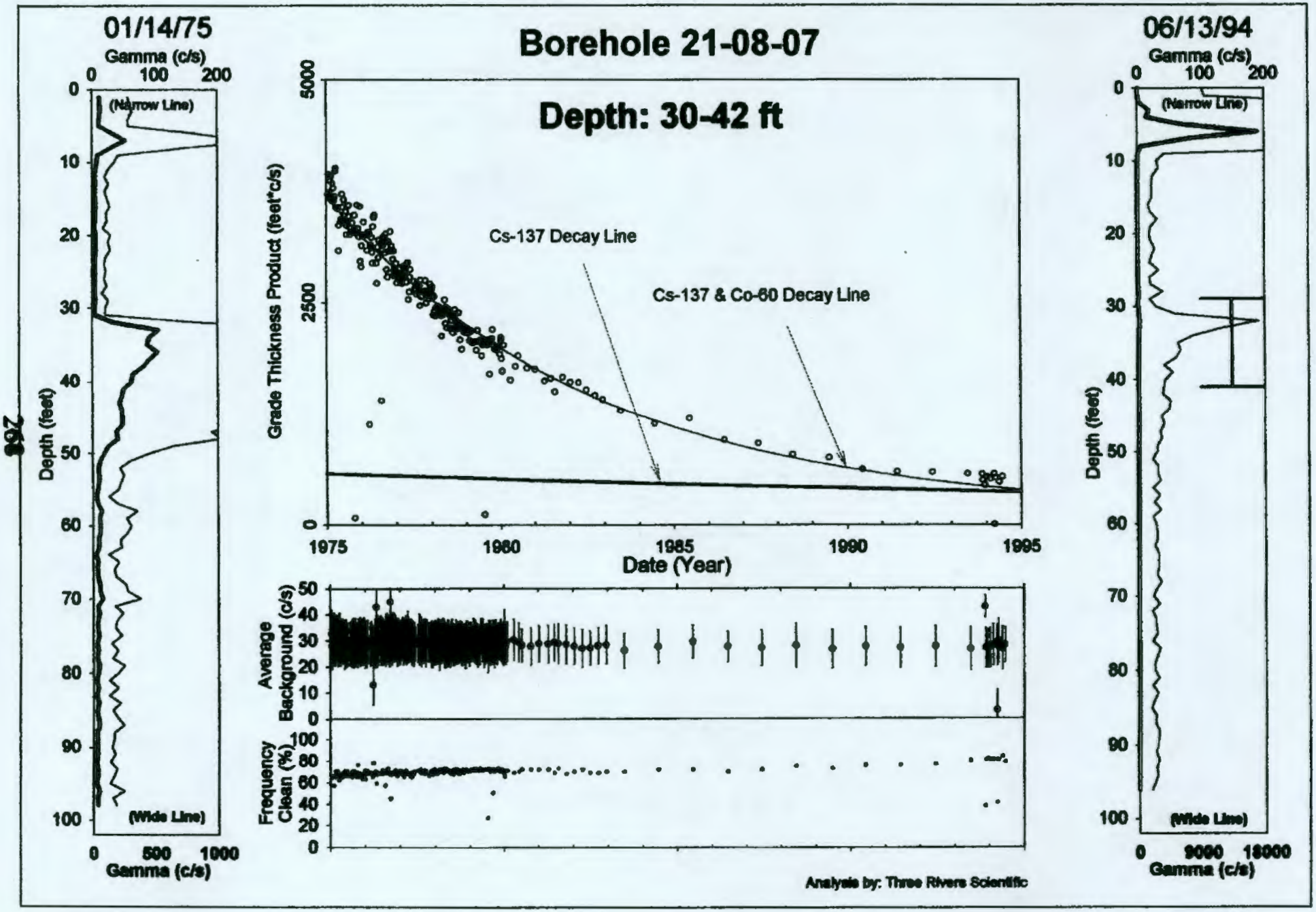
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	250

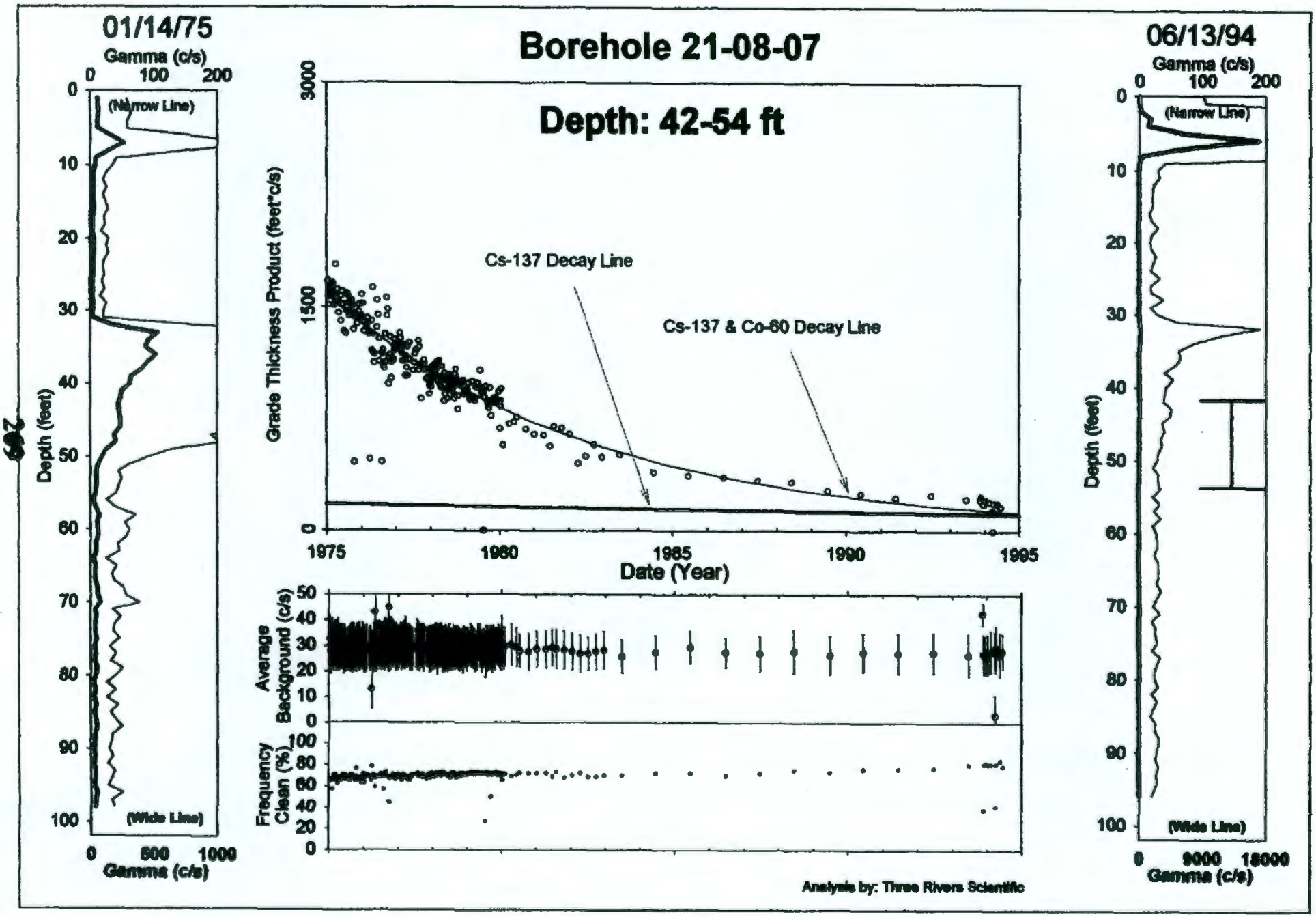
Analysis Notes

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 :	**0-12 feet is Stable** **30-42 feet is Stable** **44-54 feet are Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

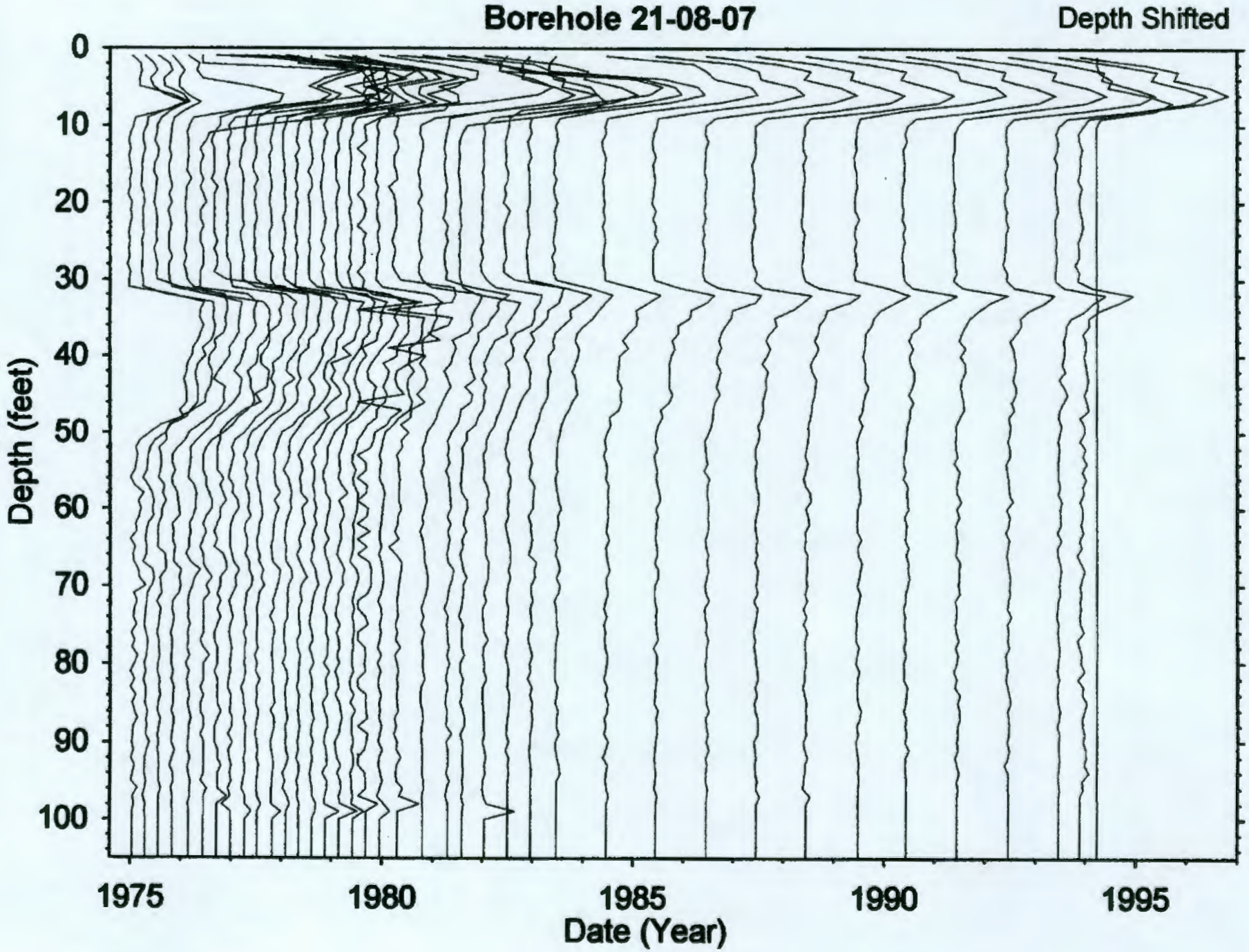

1/14/75
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 500 1000
Gamma (c/s)
Borehole 21-08-07
Depth: 0-12ft
Grade Thickness Product (feet*c/s)
400x10³
200x10³
0
Cs-137 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific
6/13/94
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 9000 18000
Gamma (c/s)



HNF-3531 -REV0



HNF-3531 -REV0


Borehole 21-08-07
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-08-07)

Total # Surveys 253

Probe Type 04

neutron surveys 3

GR Surveys 250

Log Date: 75-01-14 1st

94-06-13 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: _____

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
79-07-11	78		
79-09-04	22		
94-03-24	54		

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-10-15	DEPTH ERROR	140	
76-03-24	BAD SURVEY	100	
76-07-27	DEPTH ERROR	120	TOOL DID NOT STOP RECORDING AT TOP
79-07-11	BAD SURVEY	120	
82-06-30 TO	83-06-22	STOP RECORDING AT SURFACE (TOP)	
94-03-24	BAD SURVEY		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-10-15	LENGTH	139	75%	27.2	
76-03-24	AVG-BKG	77	78%	13.1	
76-04-24	AVG BKG	98	59%	42.9	
76-09-22	AVG BKG	98	45%	44.9	
79-07-11	% CLEAN	117	27%	23.9	
93-11-17	AVG BKG	99	38%	42.7	
94-03-24	AVG BKG	99	41%	30.1	

Analysis Notes

NO SURVEYS REJECTED

Analyst Name Randall Price

S/W ver TF GROSS V2020

filein := "two30-42.txt"

Well 21-08-07

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

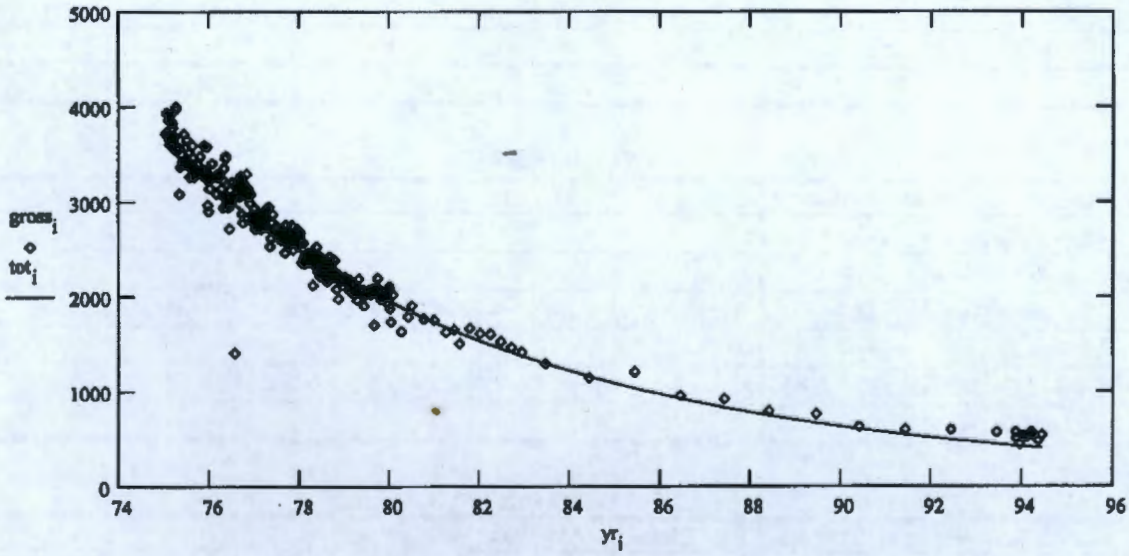
$N := \mathrm{last}(yr)$ $\quad N = 245$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 3400$ $\quad acs := 220$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad tot_i := Cs_i + Co_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aco) = 0$ $\quad 1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha co \end{bmatrix} := \mathrm{Minerr}(acs, aco)$$

$\alpha cs = 228.235$ $\quad \alpha co = 3.459 \cdot 10^3$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad tot_i := Cs_i + Co_i$

$\frac{\alpha cs}{\alpha co} = 0.066$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

$\frac{Co_N}{Cs_N} = 1.803$

filein := "two42-54.txt"

Well 21-08-07

$A := READPRN(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

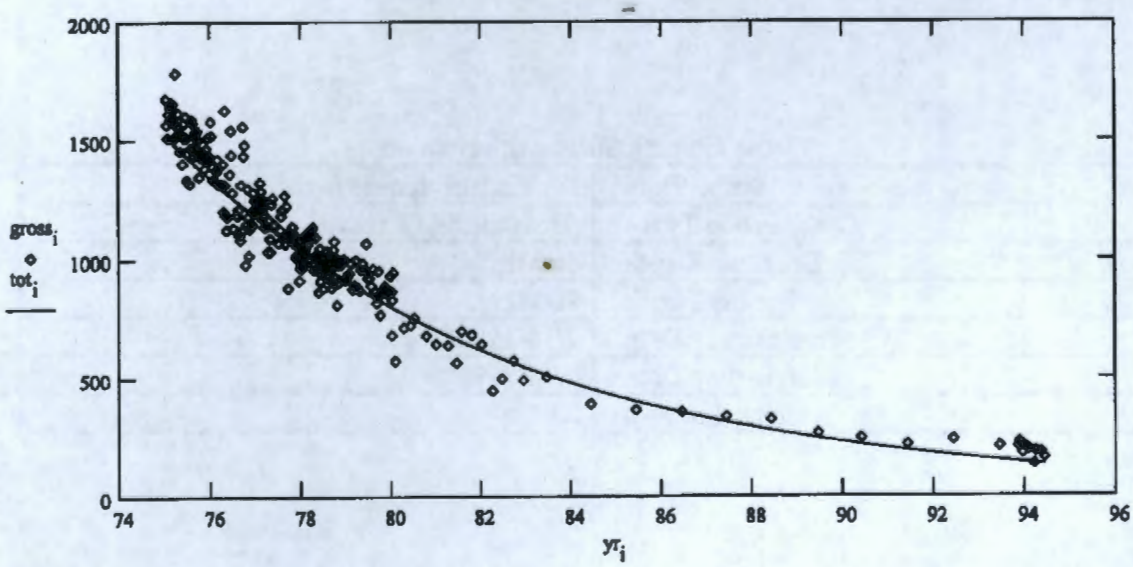
$N := last(yr)$ $\quad N = 244$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 1500$ $\quad acs := 30$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad tot_i := Cs_i + Co_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aco) = 0$ $\quad 1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha co \end{bmatrix} := Minerr(acs, aco)$$

$\alpha cs = 21.068$ $\quad \alpha co = 1.567 \cdot 10^3$

$\frac{\alpha cs}{\alpha co} = 0.013$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad tot_i := Cs_i + Co_i$

$\frac{Co_N}{Cs_N} = 8.62$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad WRITEPRN("twop.txt") := out$

Borehole 21-08-10

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.

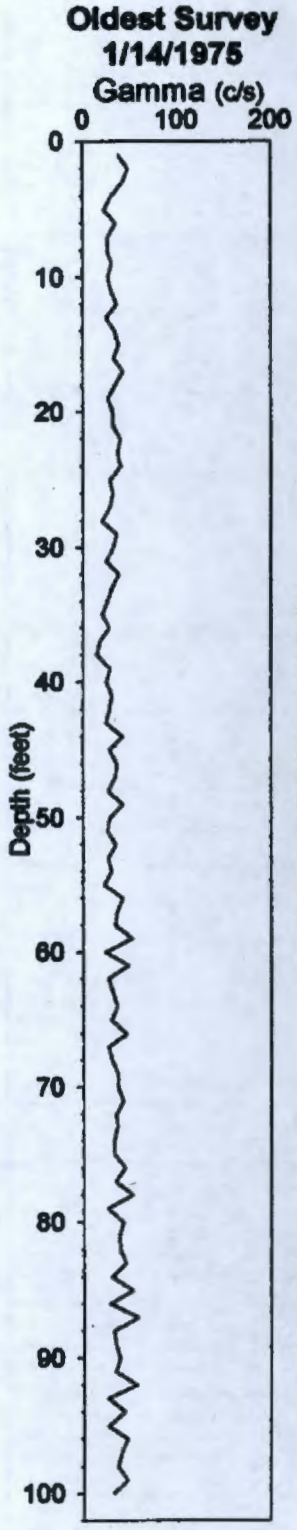
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	229

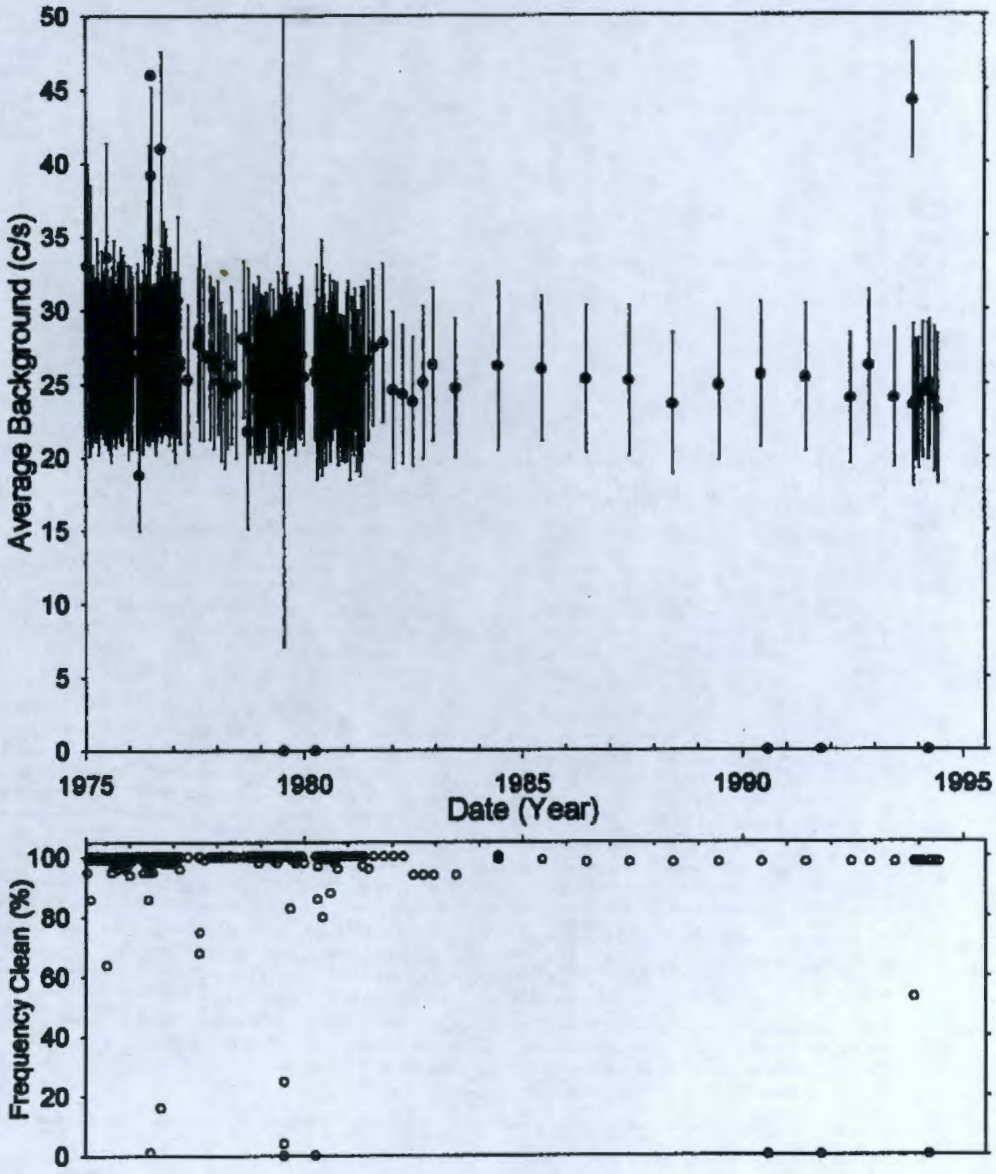
Analysis Notes

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

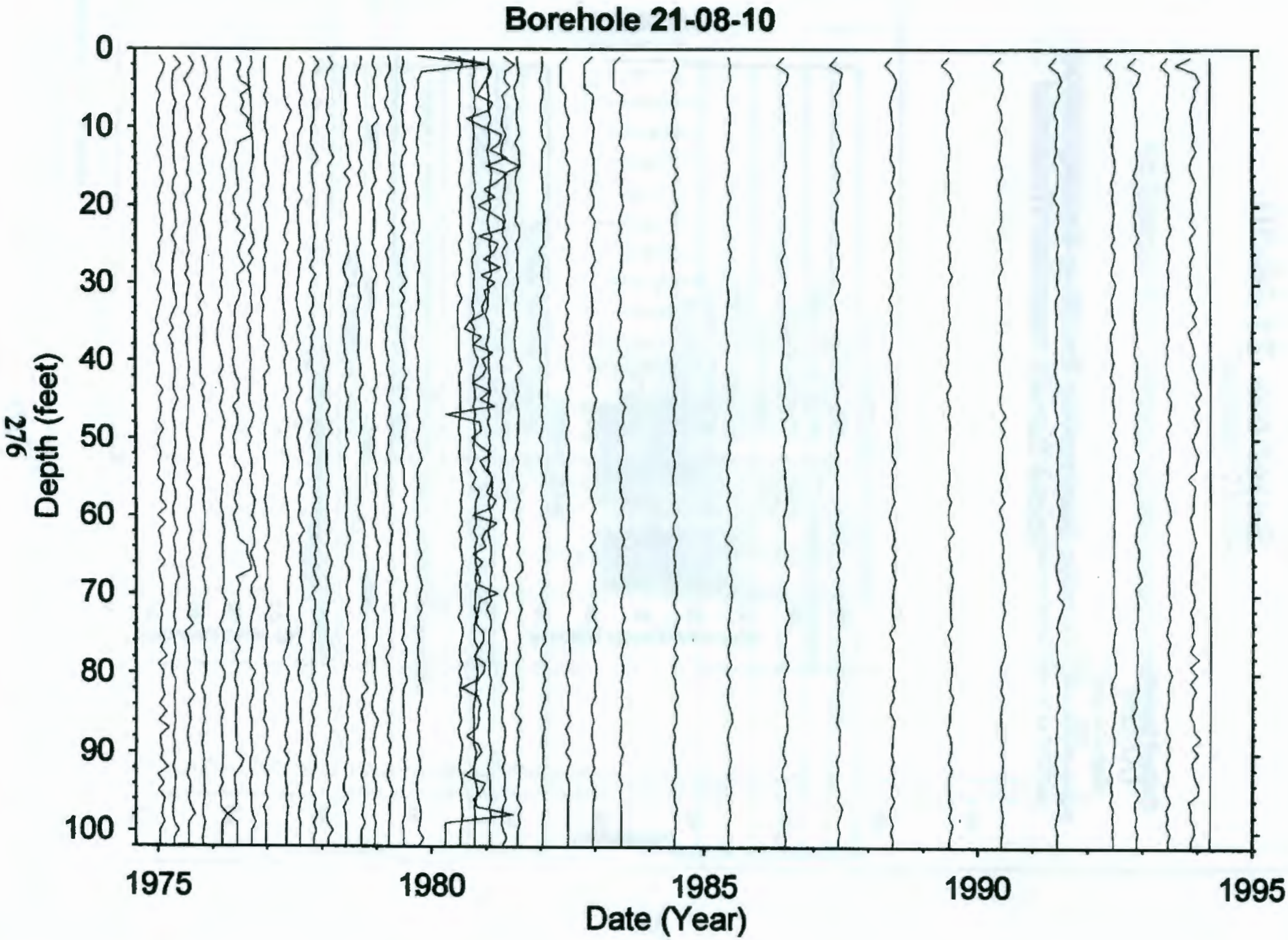
Borehole 21-08-10



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-08-10
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-08-10)

Total # Surveys 232

Probe Type 04

neutron surveys 3

GR Surveys 229

Log Date: 75-01-14 1st

94-06-13 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0.35 FT) <5 pCi/g

Max Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
77-09-12	22	90	
79-07-11	77	90	
79-09-04	16	95	
80-05-29	18	100	
94-03-24	100	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-02-11	HI-BKG	102	
75-06-25	HI-CPS	100	
76-06-30	HI-BKG	95	
76-09-22	HI-BKG	100	
77-08-10	HI-CPS	100	TOOL FAIL
79-07-11	TOOL FAIL	95	
80-03-31	HI-CPS	100	
93-11-17	HI-BKG	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-06-18	LENGTH	31	100%	27.8	
76-06-30	AVG-BKG	95	1%	46.0	
76-09-22	% CLEAN	98	16%	41.0	
79-07-11	LENGTH	39	25%	23.6	
80-07-31	% CLEAN	98	0%	0.0	
80-08-05	LENGTH	26	88%	27.7	
93-11-17	AVG-BKG	100	53%	44.2	
94-03-24	AVG BKG	100	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED

NO RADIATION ZONE FOUND ABOVE DETECTION THRESHOLD

Analyst Name Randall Pierce

S/W ver TFGROSS V2.20

Borehole 21-08-12

Contamination (Cs-137) from 2 to 10 feet is Tank Farm Activity

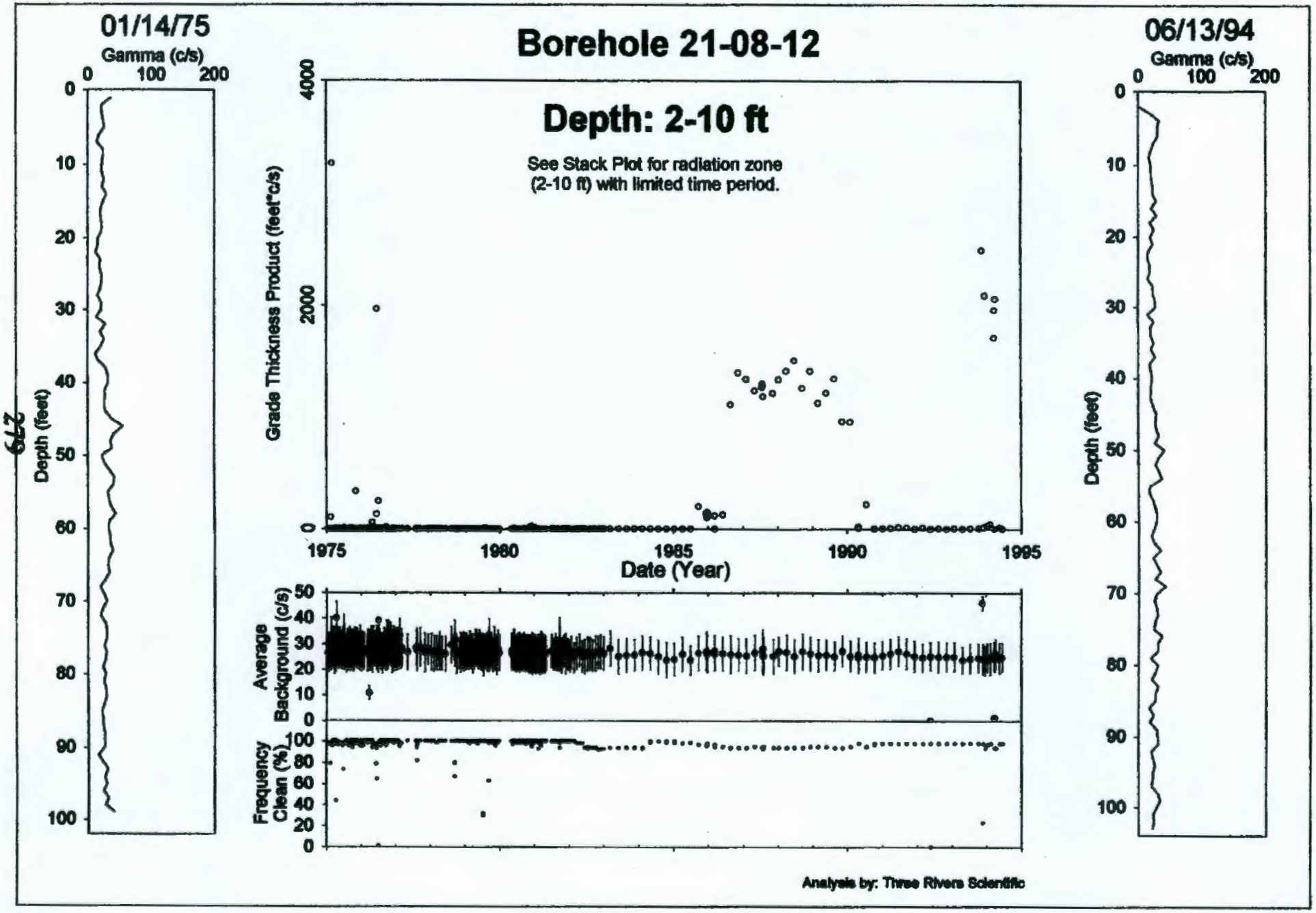
Grade Thickness Product from 2 to 10 feet is generally zero (0) with time intervals of erratic activity, indicating the possible Tank Farm activity. The radionuclide identified from the HPGe detector survey is Cesium-137.

Gross Gamma Survey Information

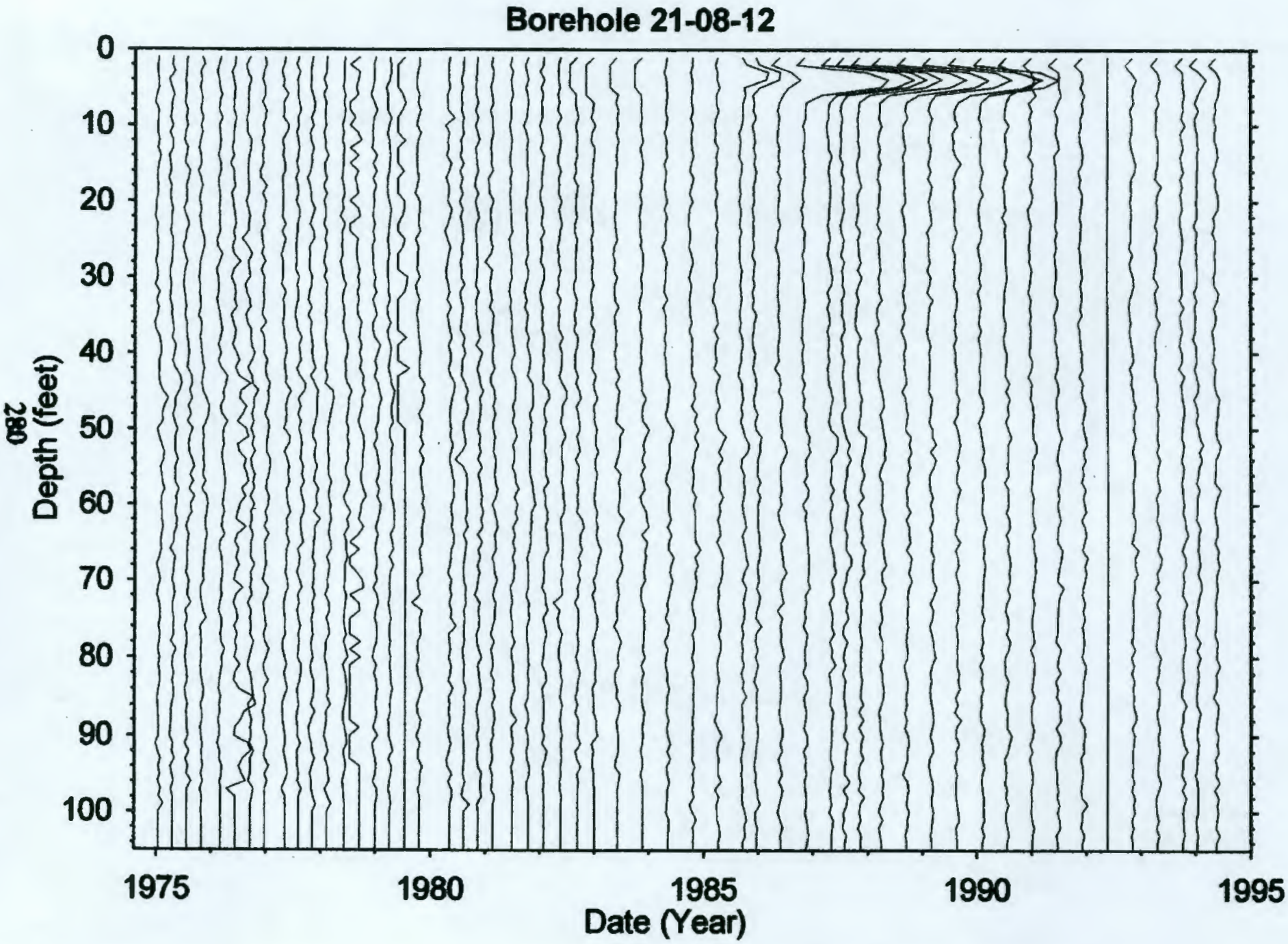
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	6/13/1994
Number Surveys :	226

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 :	**2-10 feet is TF Activity**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



HNF-3531 -REV 0



HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole BY(21-08-12)

Total # Surveys 329

Probe Type 04

neutron surveys 3

GR Surveys 226

Log Date: 75-01-14 1st

94-06-13 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (3-20FT) <3P CI/G

CO-60 (50-70FT) <1P CI/G

Max Survey Depth 104FT

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
77-08-12	14	90	
78-09-13A,B	30	95	
79-07-11 A,B	52	50	
79-09-04	35	95	
92-05-18	103	104	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-02-11	HI-BKG	100	
75-04-09	HI-BKG	100	
75-06-25	HI-BKG	100	
76-06-15B	TOOL FAIL	100	
76-06-30	HI-BKG		
86-08-20	TO 90-01-31		HI-CPS AT SURFACE (4FT)
93-11-17	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	% CLEAN	99	44%	40.1	
76-03-23	AVG BKG	97	100%	10.8	
76-06-30	% CLEAN	94	1%	39.0	
79-07-11A,B	% CLEAN	49	32%	23.9	
80-12-01	LENGTH	40	95%	26.8	
92-05-16	AVG BKG	103	0%	0.0	
93-11-17	AVG BKG	103	23%	46.0	

Analysis Notes

NO SURVEYS REJECTED
HIGH GAMMA ZONE (2-10FT) 86-90 HAS LIMITED TIME INTERVAL

Analyst Name Randall Rued

S/W ver TFGROSS V2.20

Borehole 21-09-02

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 1994 in the vadose zone from 2 to 100 feet.

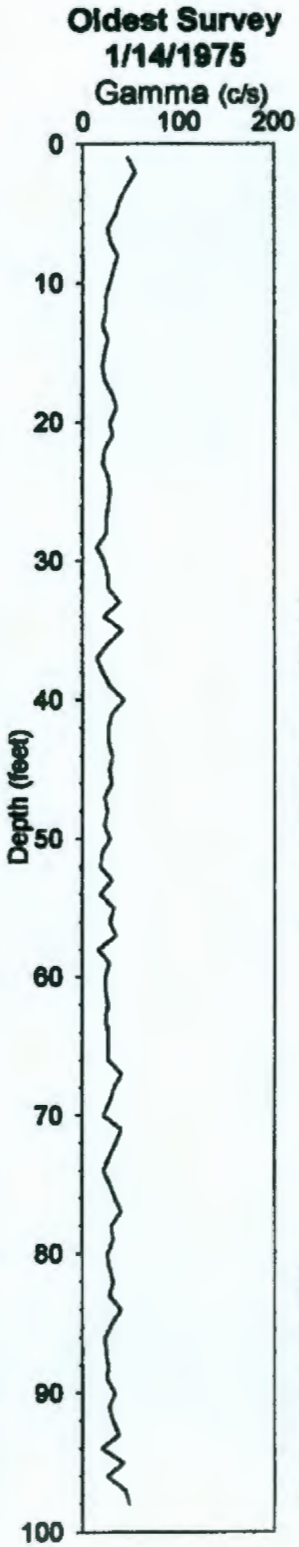
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	378

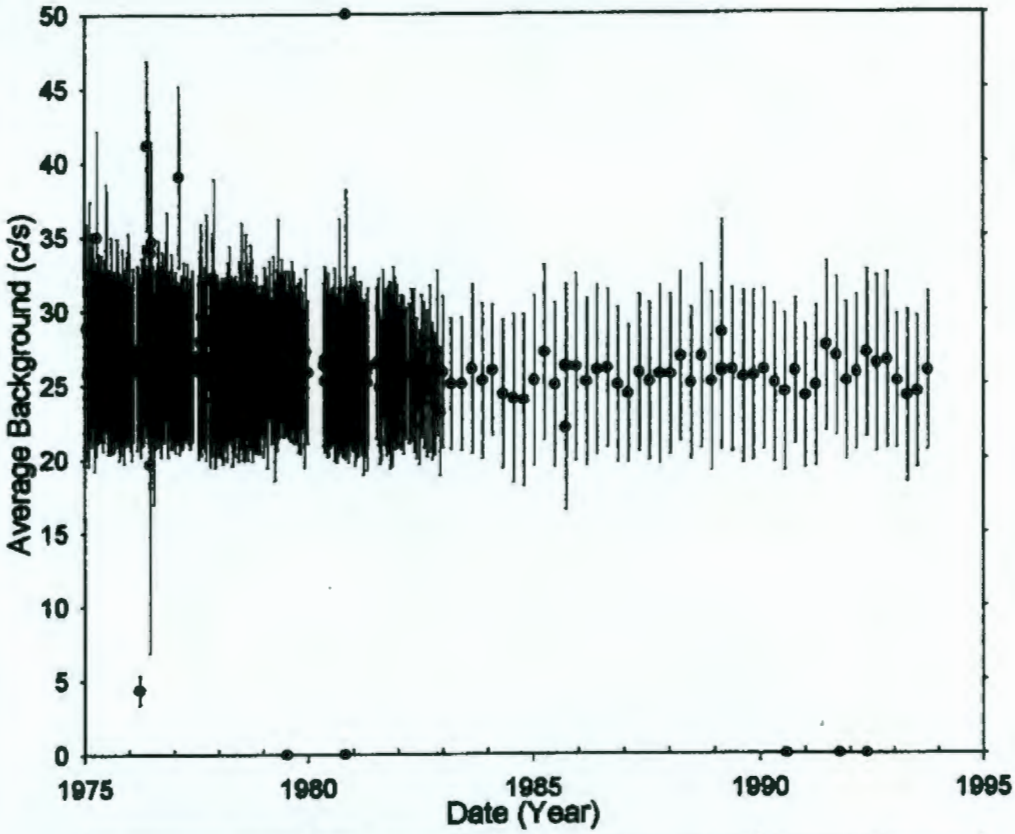
Analysis Notes

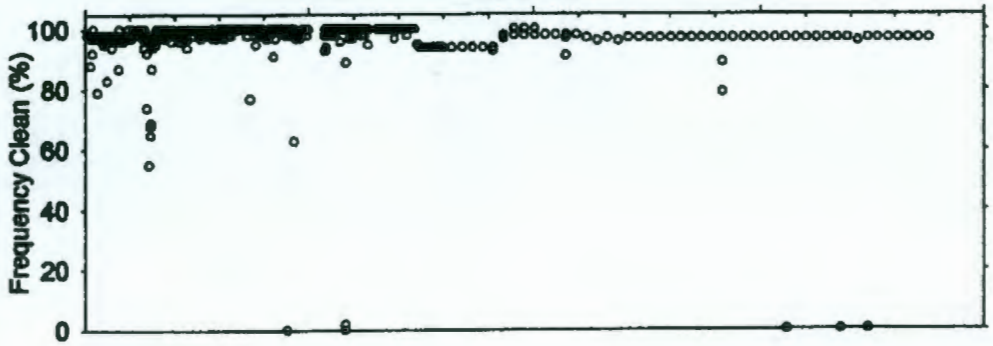
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**No Contamination**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-09-02

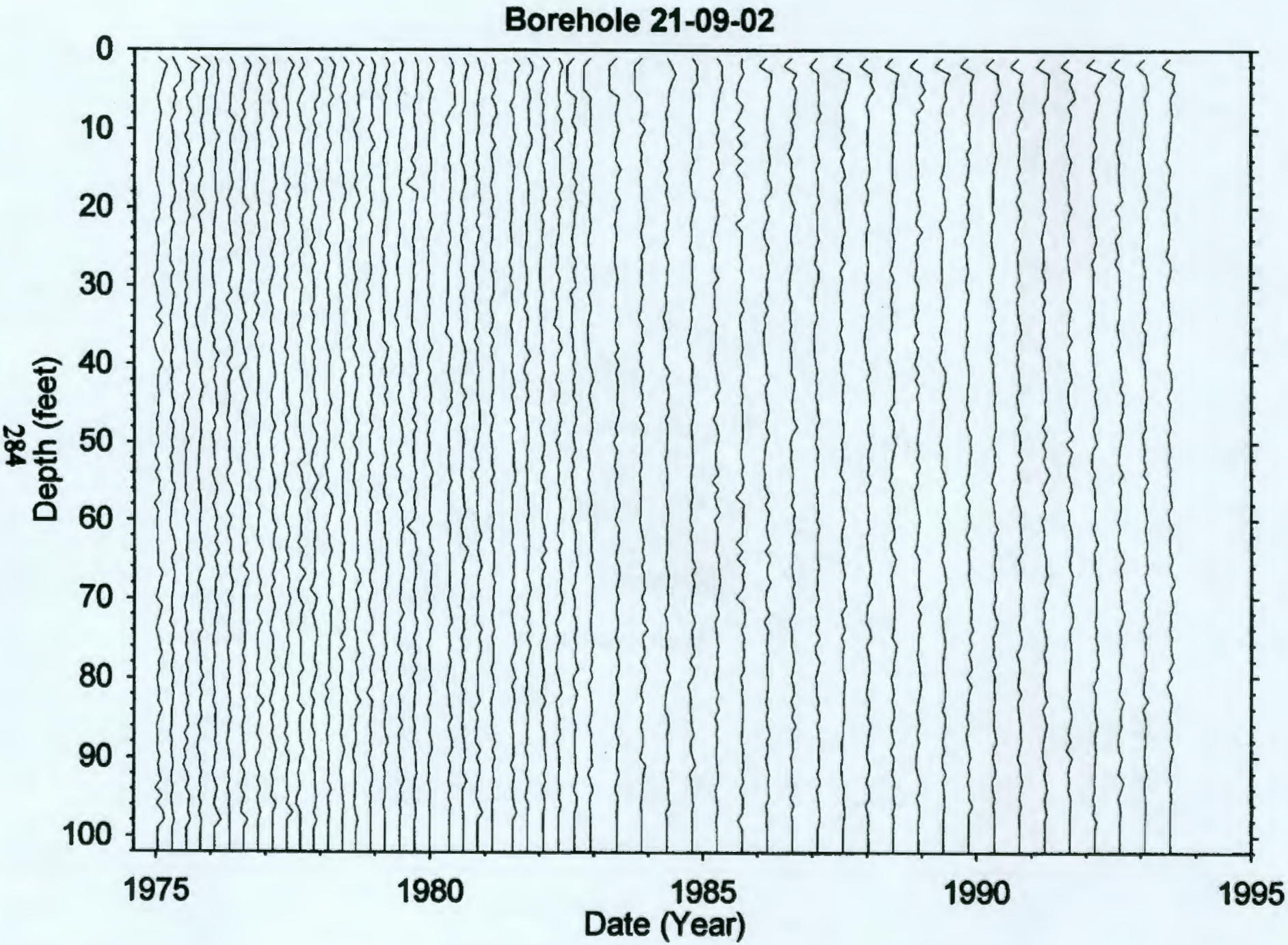


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific



HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole BX(21-09-02)

Total # Surveys 381

Probe Type 04

neutron surveys 3

GR Surveys 378

Log Date: 75-01-14 1st

93-10-05 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0 TO 25FT) <10pCi/g) Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
75-10-01	9	98	
76-06-15	14	98	
78-09-13	22	100	
79-07-11	43	90	
79-09-04	34	95	
85-09-18	7	100	
92-05-18	97	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-06-09	HI-BKG	98	
76-06-15B	HI-BKG	95	
76-06-23	TOOL FAIL	100	
79-07-11A	TOOL FAIL	95	
80-10-28A,B	HI-BKG	98	
89-02-27A,B	TOOL FAIL	100	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-23	AVGBKG	96	100%	4.4	
76-05-19	"	97	74%	46.2	
76-07-19	LONGTH	33	100%	25.5	
79-07-11	AVGBKG	91	0%	0.0	
80-10-28A	"	95	0%	0.0	
80-10-28B	"	97	2%	50.0	
92-05-18	"	97	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED

Analyst Name Randall Rice

S/W ver TFGRAPH V2.20

Borehole 21-09-04

Contamination (Cs-137) from 5 to 14 feet is Tank Farm Activity

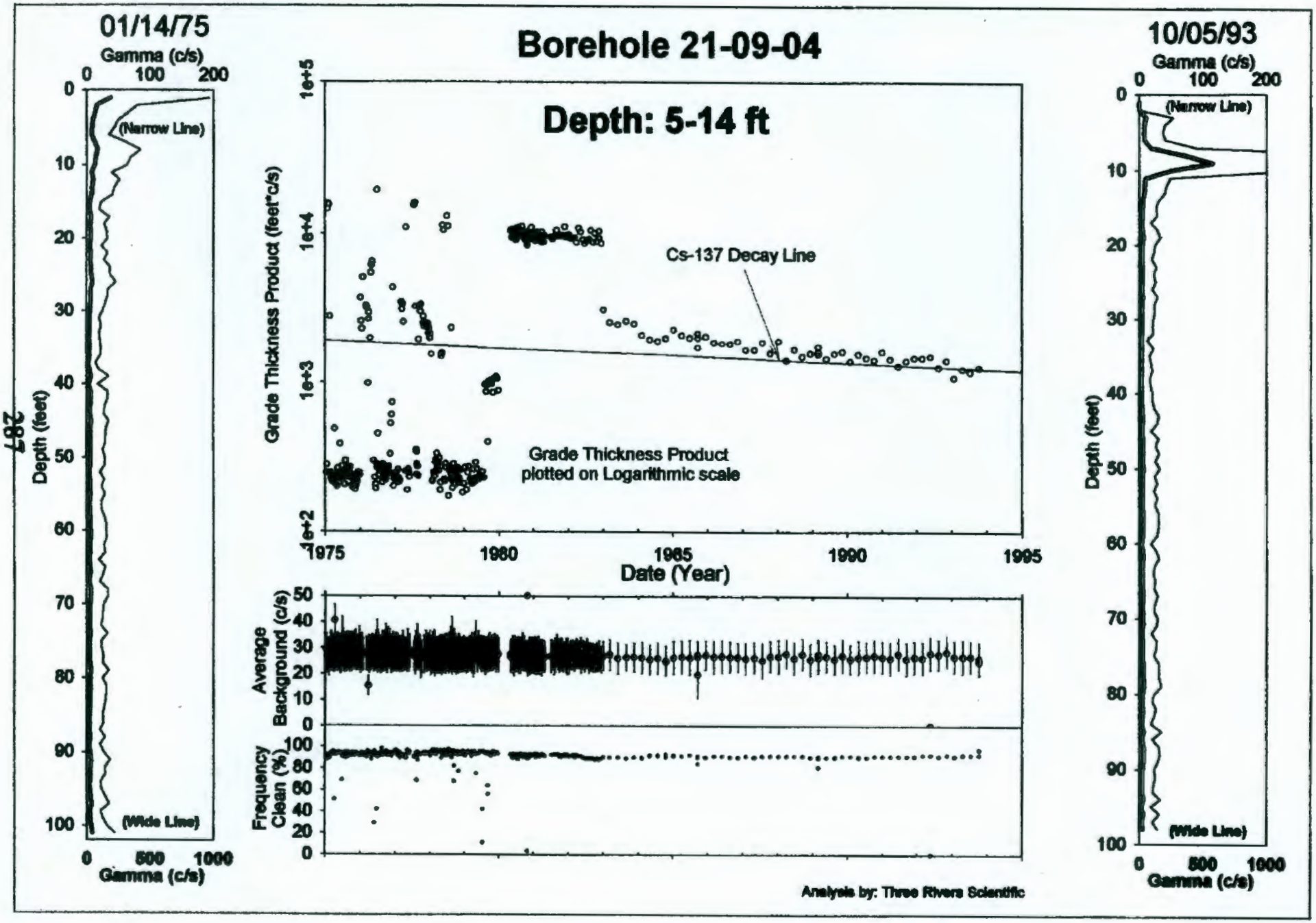
Grade Thickness Product from 5 to 14 feet is erratic from 1975 through 1984, and is categorized as Tank Farm activity. Grade Thickness Product from 1984 through 1994 is decreasing at a rate that is slightly greater than the decay of Cs-137 (identified from HPGe detector).

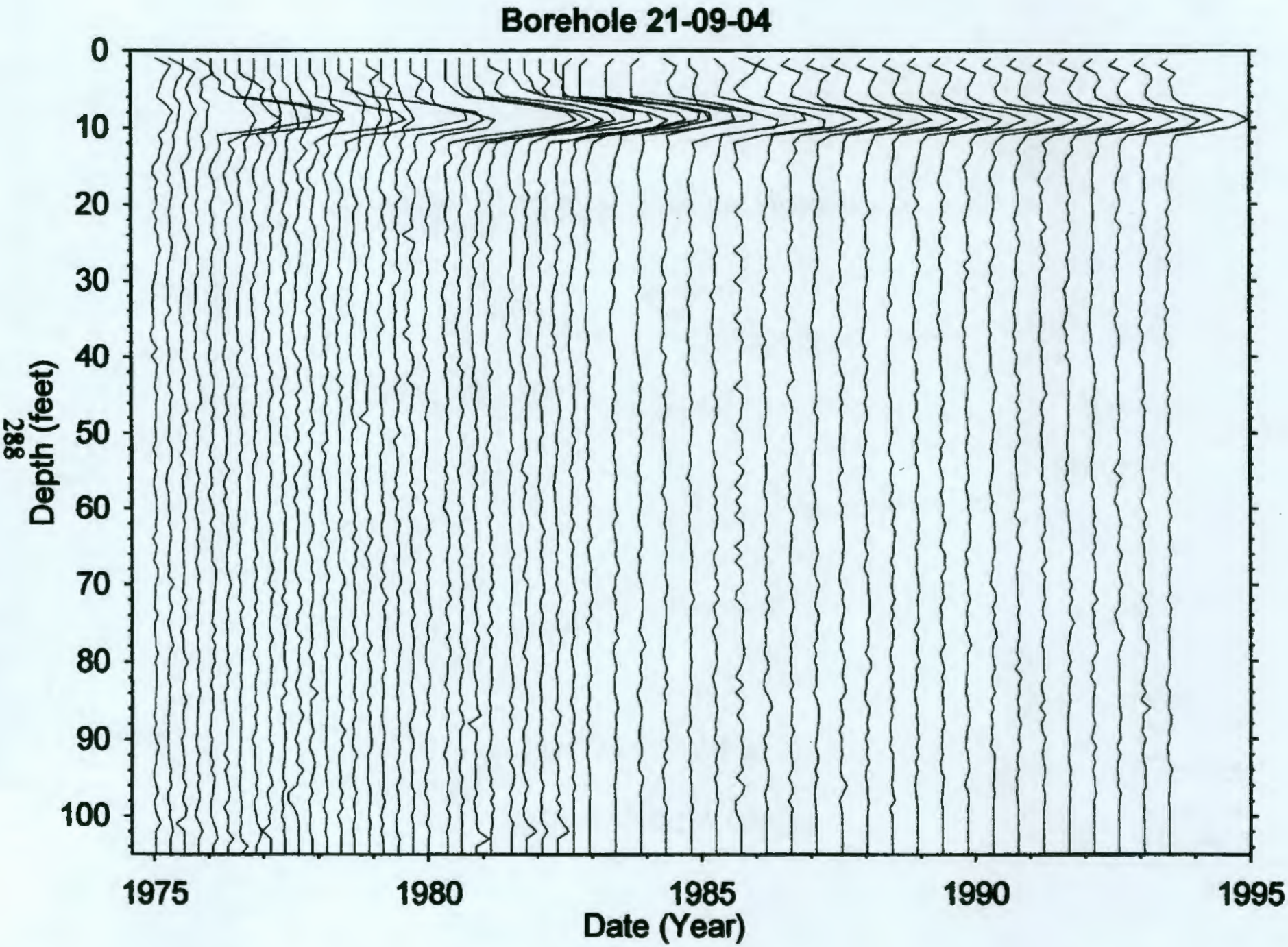
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	01/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	381

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 :	**5-14 feet is TF Activity**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


Borehole 21-09-04
Depth: 5-14 ft
01/14/75
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Grade Thickness Product
plotted on Logarithmic scale
Date (Year)
Average Background (c/s)
Frequency Clean (%)
10/05/93
Analysis by: Three Rivers Scientific


Borehole 21-09-04
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-09-04)

Total # Surveys 385

Probe Type 64

neutron surveys 4

GR Surveys 381

Log Date: 75-01-14 1st

93-10-05 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (8FT ≈ 20 pCi/g)

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
76-05-26	65	90	79-07-11 A,B (24 GAPS
77-08-12	24	90	79-09-04 A,B (44 GAPS)
78-09-13A	32	100	92-05-18 98 GAPS
78-11-02	17	98	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI-BKG	100	
75-06-25	HI-BKG	98	
(76-01-07	(FD) 76-03	-04) RAD	ZONE NEAR SURFACE
76-06-23	TOOL FAIL	100	
(77-03-08	(FD) 78-07	-11) RAD	ZONE NEAR SURFACE
80-10-28	HI-BKG	100	HIGH BKG CPS

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	AVG-BKG	100	51%	40.5	
76-03-23	"	98	95%	15.4	
76-05-26	% CLEAN	93	29%	27.6	
76-06-23	"	100	42%	33.3	
79-07-11	% CLEAN	45	11%	27.4	
80-10-28	AVG BKG	99	3%	50.0	
92-05-18	"	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
RADIATION ZONE MAY BE ~~FOU~~ SHOWING ACTIVITY FROM A NEAR SURFACE TRANSFER LINE (ASSUMED)

Analyst Name Randall Price

S/W ver TFGROSS V2.20

Borehole 21-09-08

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 1994 in the vadose zone from 2 to 100 feet.

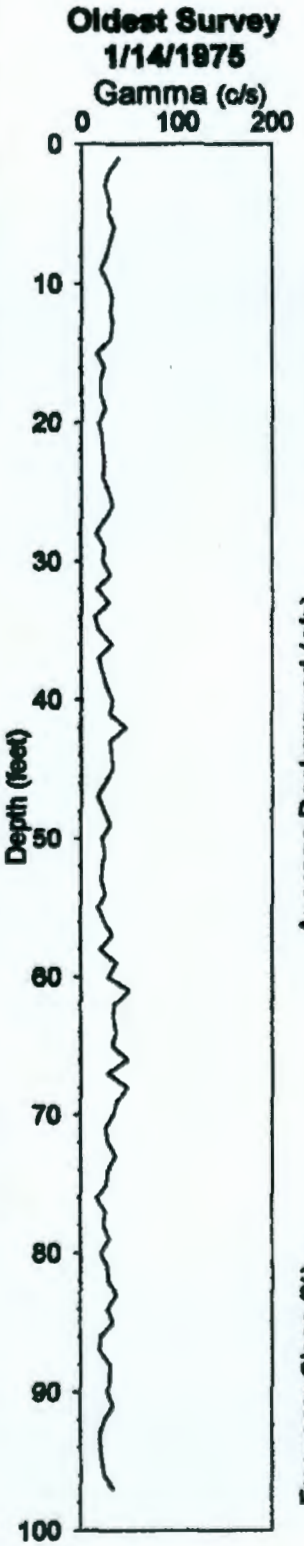
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	367

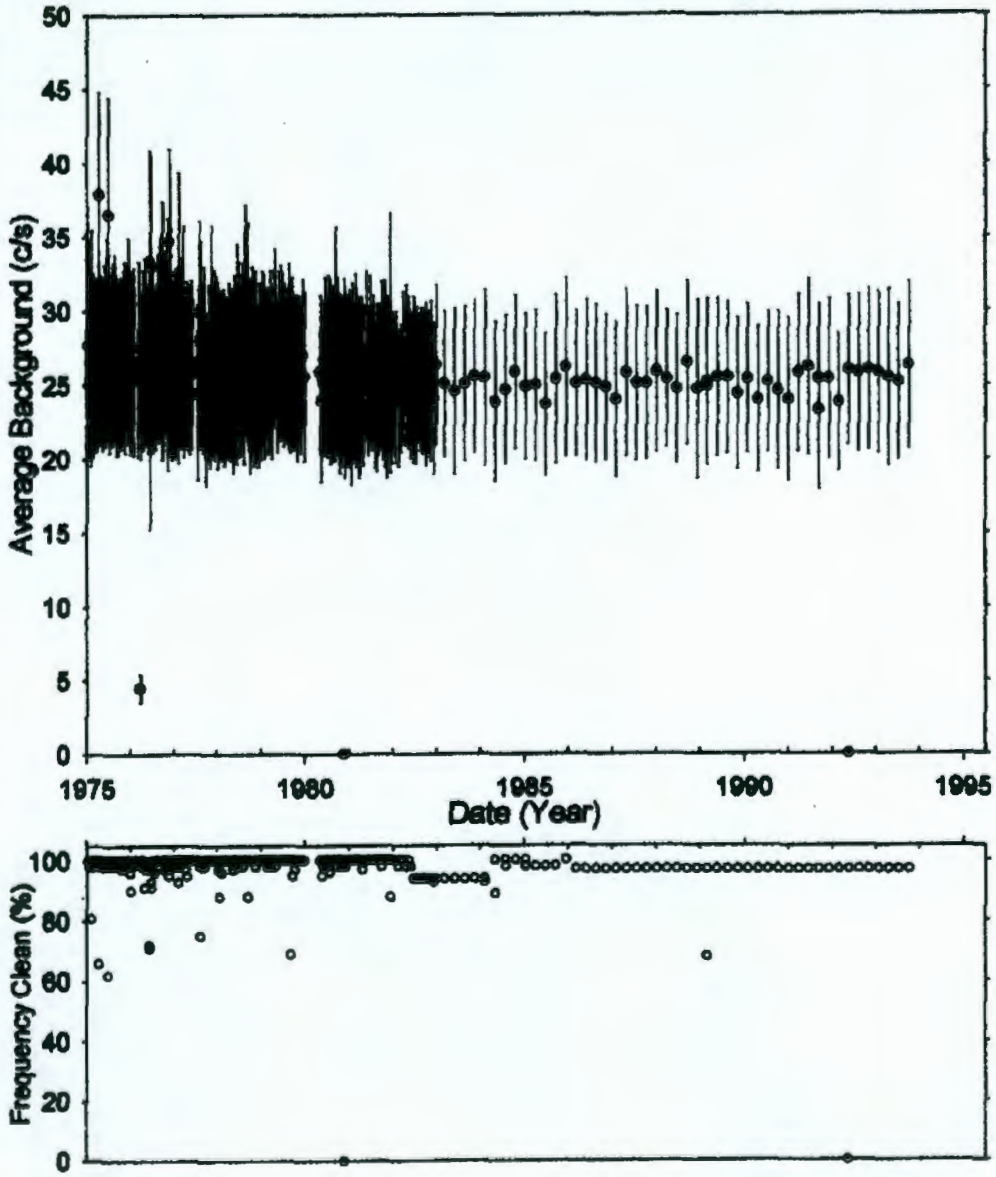
Analysis Notes

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

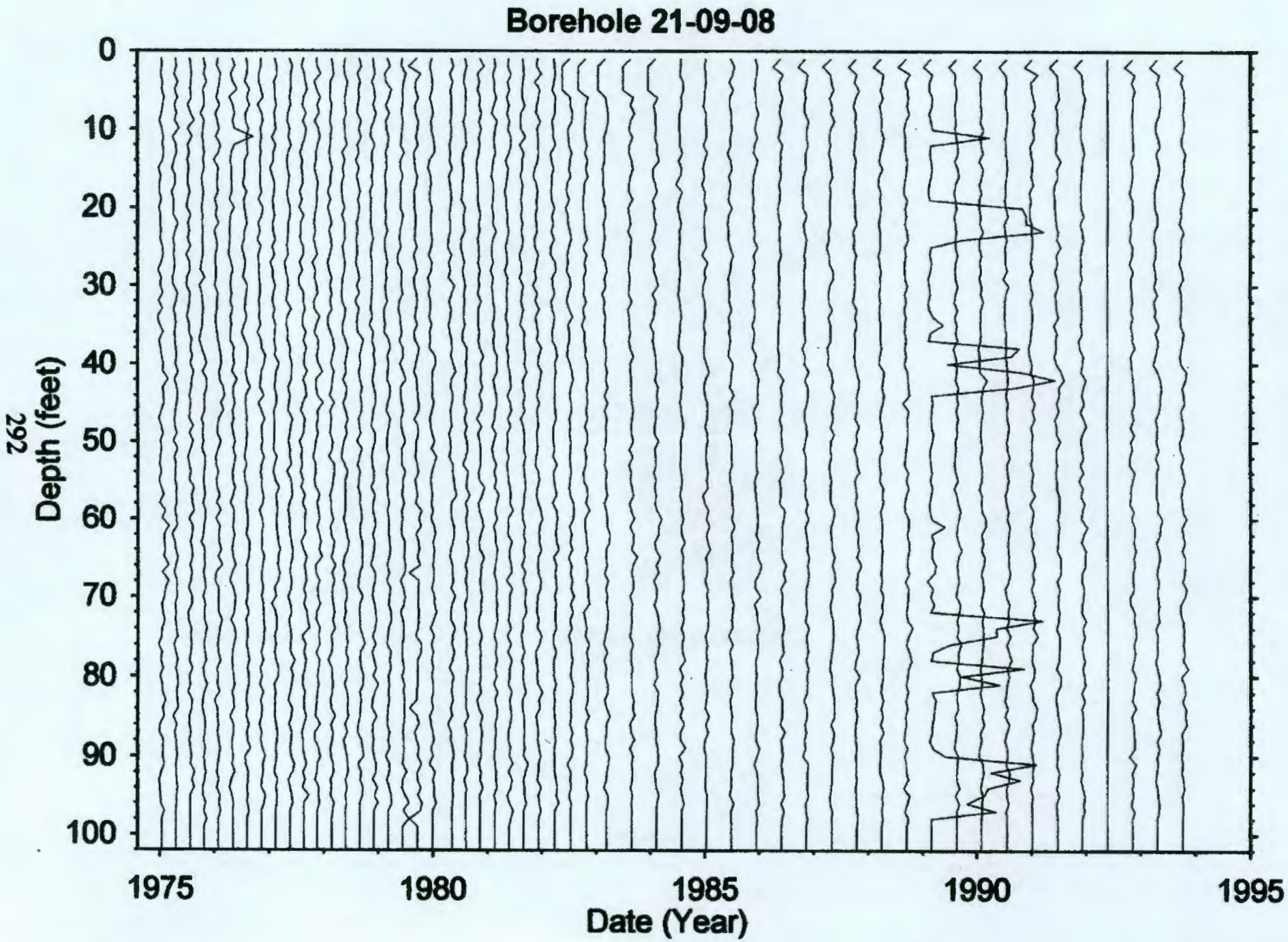
Borehole 21-09-08



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-09-08
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-09-08)

Total # Surveys 370

Probe Type 04

neutron surveys 3

GR Surveys 367

Log Date: 75-01-14 1st

93-10-05 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0 TO 15 FT) < 5 pCi/g

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
77-08-12	22	95	
79-09-04	29	98	
84-05-02	10	100	
92-05-18A	97	98	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI-BKG	98	POSSIBLE TOOL NOISE
75-06-25	HIGH-BKG	98	"
76-06-15A,B	TOOL FAIL	98,95	TOOL FAILURE
80-11-19	HI-CPS	100	TOOL FAILURE
89-02-27A	TOOL NOISE	98	TOOL INTERMITTENT FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	% CLEAN	98	66%	37.9	
75-06-25	"	96	62%	36.5	
76-03-24	AVG BKG	95	100%	4.5	
76-11-23	"	97	95%	34.7	
80-11-19	% CLEAN	99	0%	0.0	
82-05-18	"	97	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION zone above detection threshold present

Analyst Name Randall Ruiz

S/W ver TAGROSS v2.20

Borehole 21-09-12

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 1994 in the vadose zone from 2 to 100 feet.

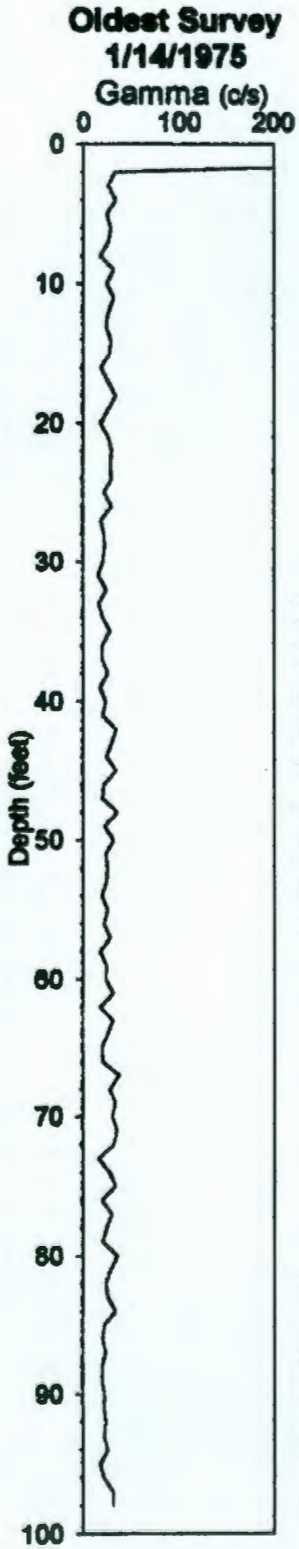
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	10/05/1993
Number Surveys :	306

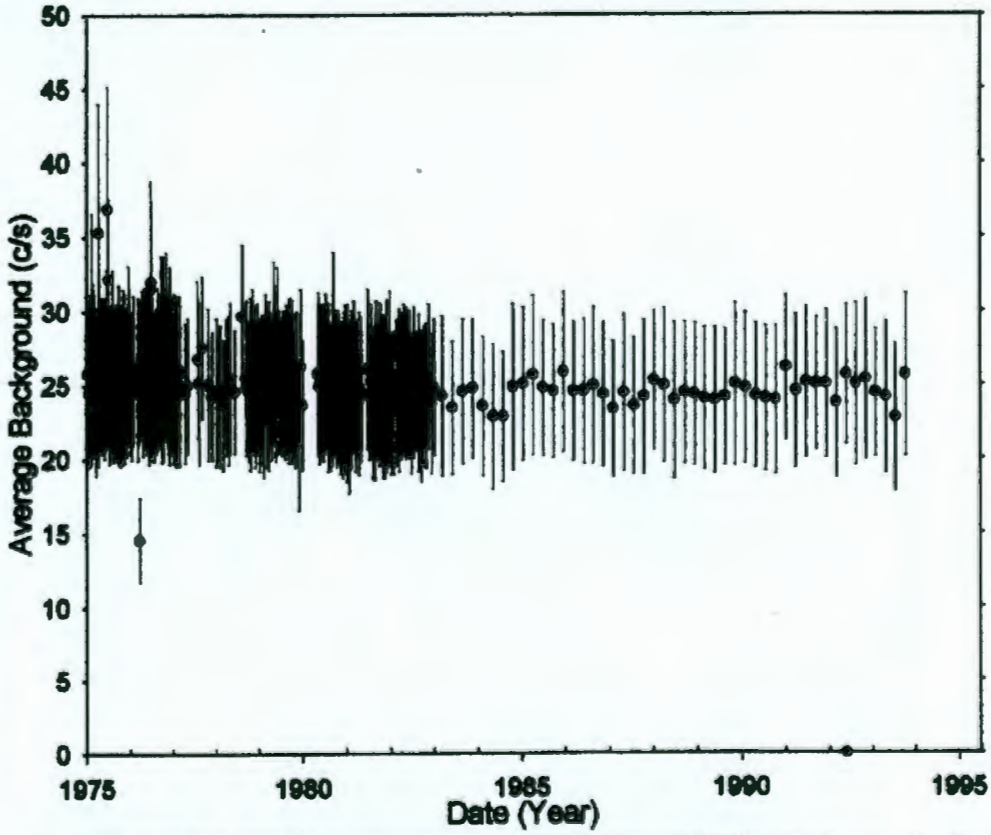
Analysis Notes

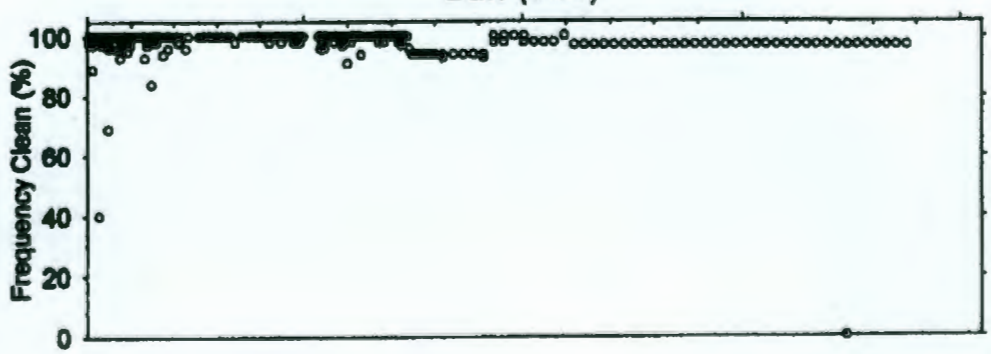
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**No Contamination**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-09-12

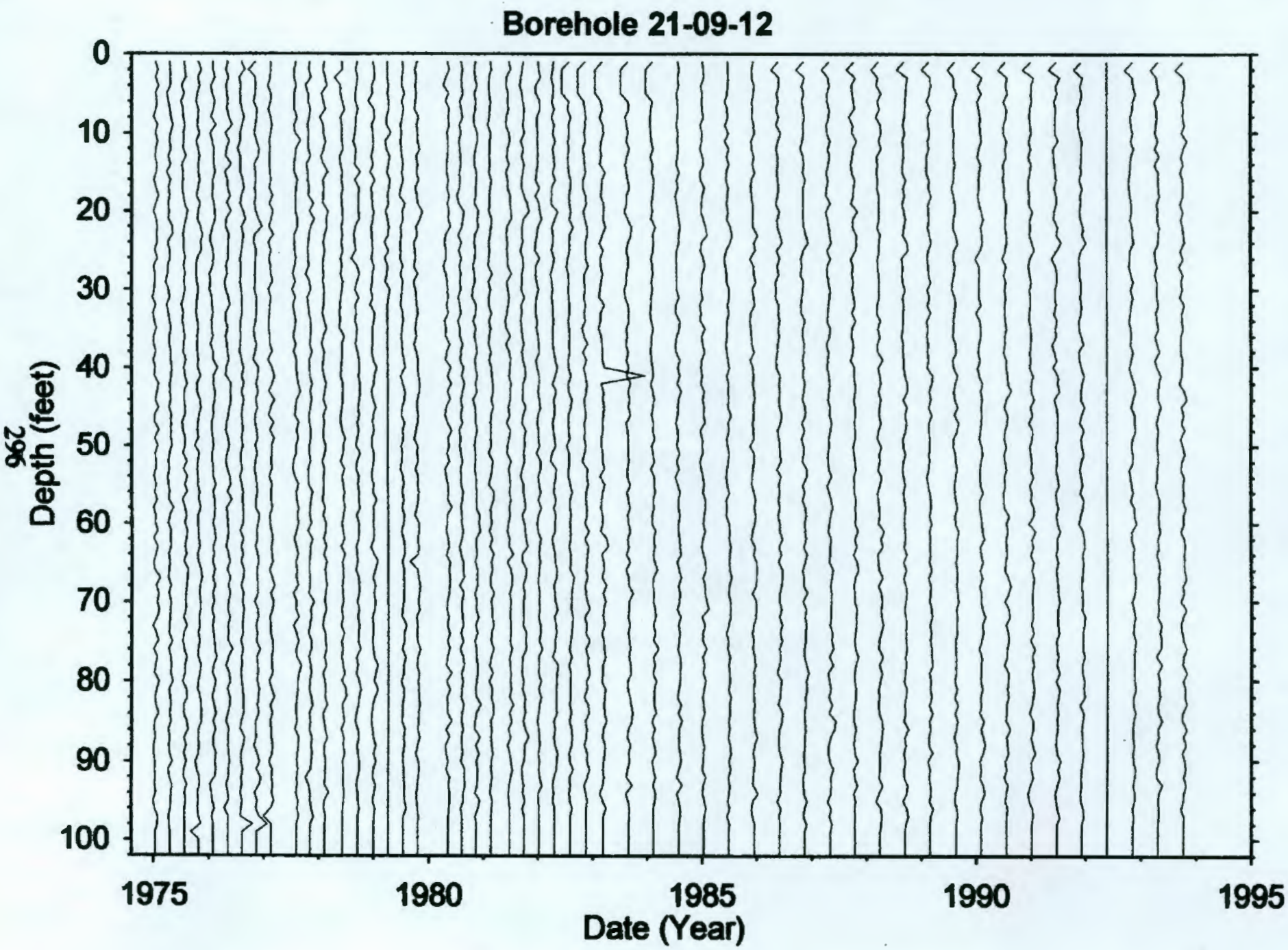


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-09-12
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-09-12)

Total # Surveys 309

Probe Type 04

neutron surveys 3

GR Surveys 306

Log Date: 75-01-14 1st

93-10-05 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0.0035 CT) < 2p Ci/g

Max Survey Depth 100 FT

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
92-05-18	97	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-04-09	HI-BKG	98	
75-06-25	HI-BKG	98	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-04-09	AVG BKG	97	40%	35.3	
75-06-25	% CLEAN	96	69%	36.9	
75-10-29	LENGTH	31	96%	26.0	
76-03-23A	AVG BKG	95	100%	14.6	
92-05-18	AVG BKG	97	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE IDENTIFIED above detection threshold

Analyst Name Randall Price

S/W ver TFGROSS V2.70

Borehole 21-10-01

Contamination (Cs-137) from 0 to 10 feet is Tank Farm Activity
Contamination (Cs-137 & Co-60) from 38 to 52 feet is Stable

Grade Thickness Product from 0 to 10 feet is somewhat erratic from 1975 through 1985 and is categorized as Tank Farm activity. Grade Thickness Product from 1986 through 1994 is decreasing at a rate consistent with Cs-137 (identified from HPGe detector) within the logging system sensitivity.

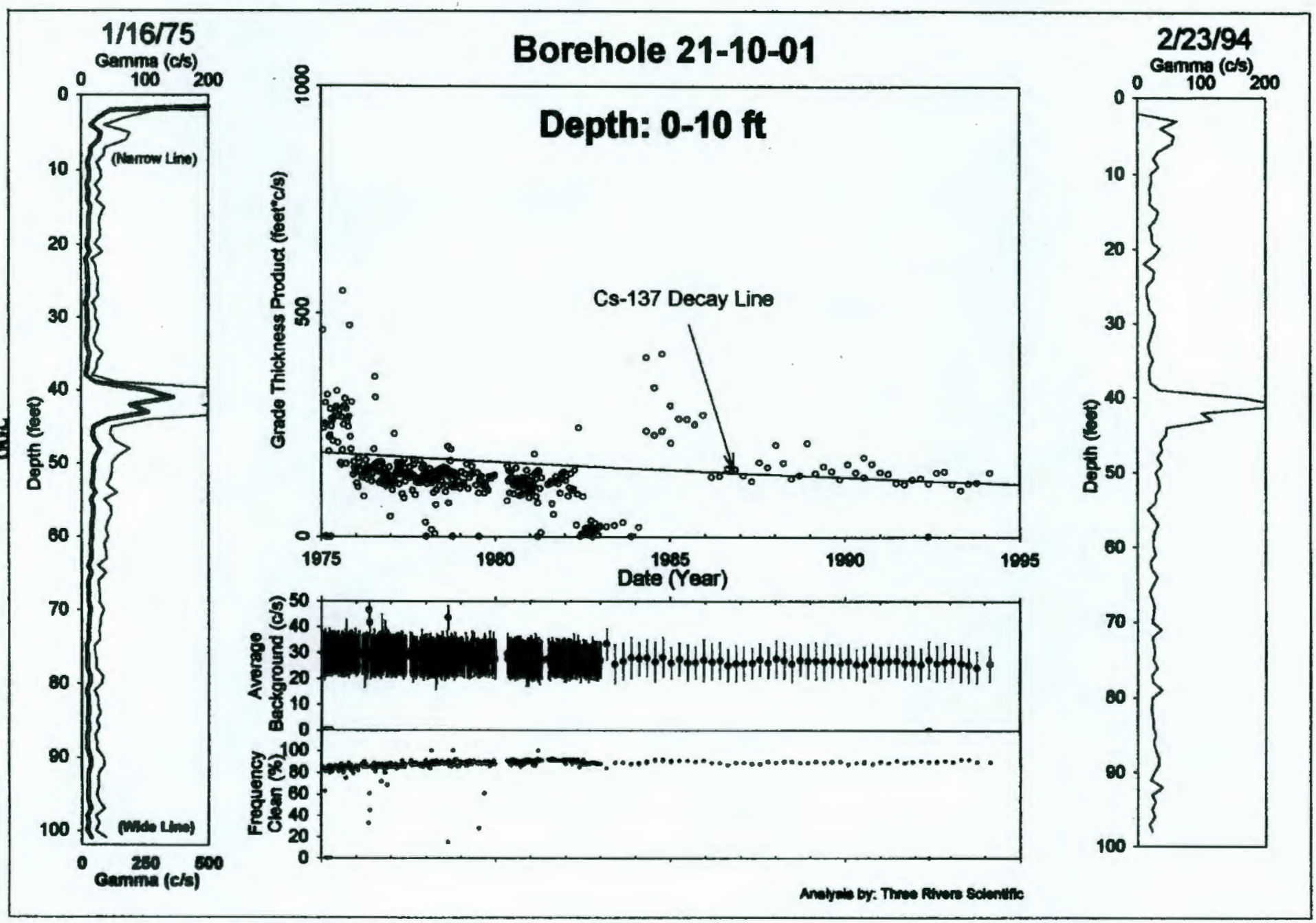
Grade Thickness Product from 38 to 52 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Cobalt-60 (both identified from HPGe detector) between January 1975 and February 1994. The least squares fit results in a gross gamma contribution ratio of 0.05 for Co-60 to Cs-137 on February 1994.

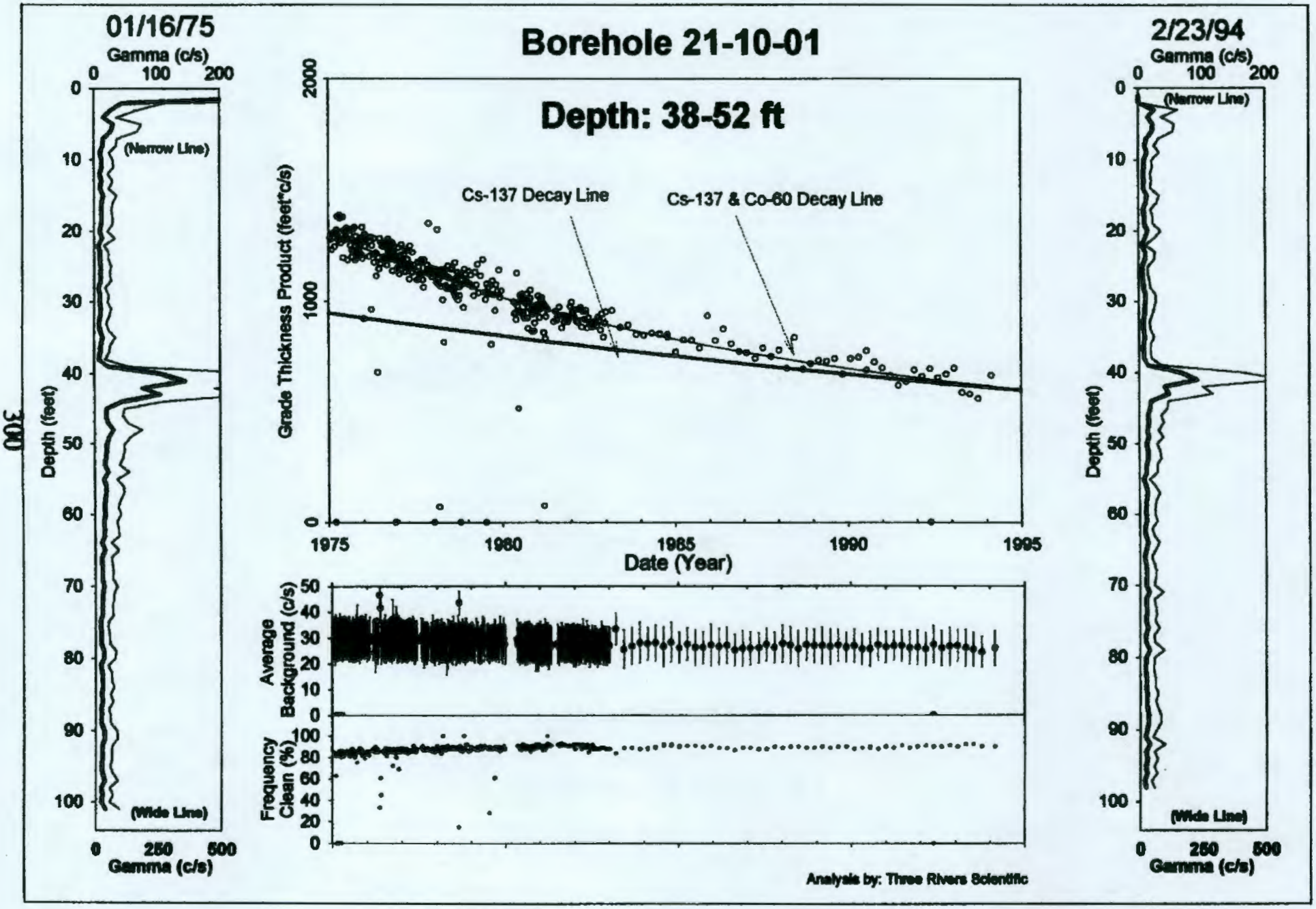
Gross Gamma Survey Information

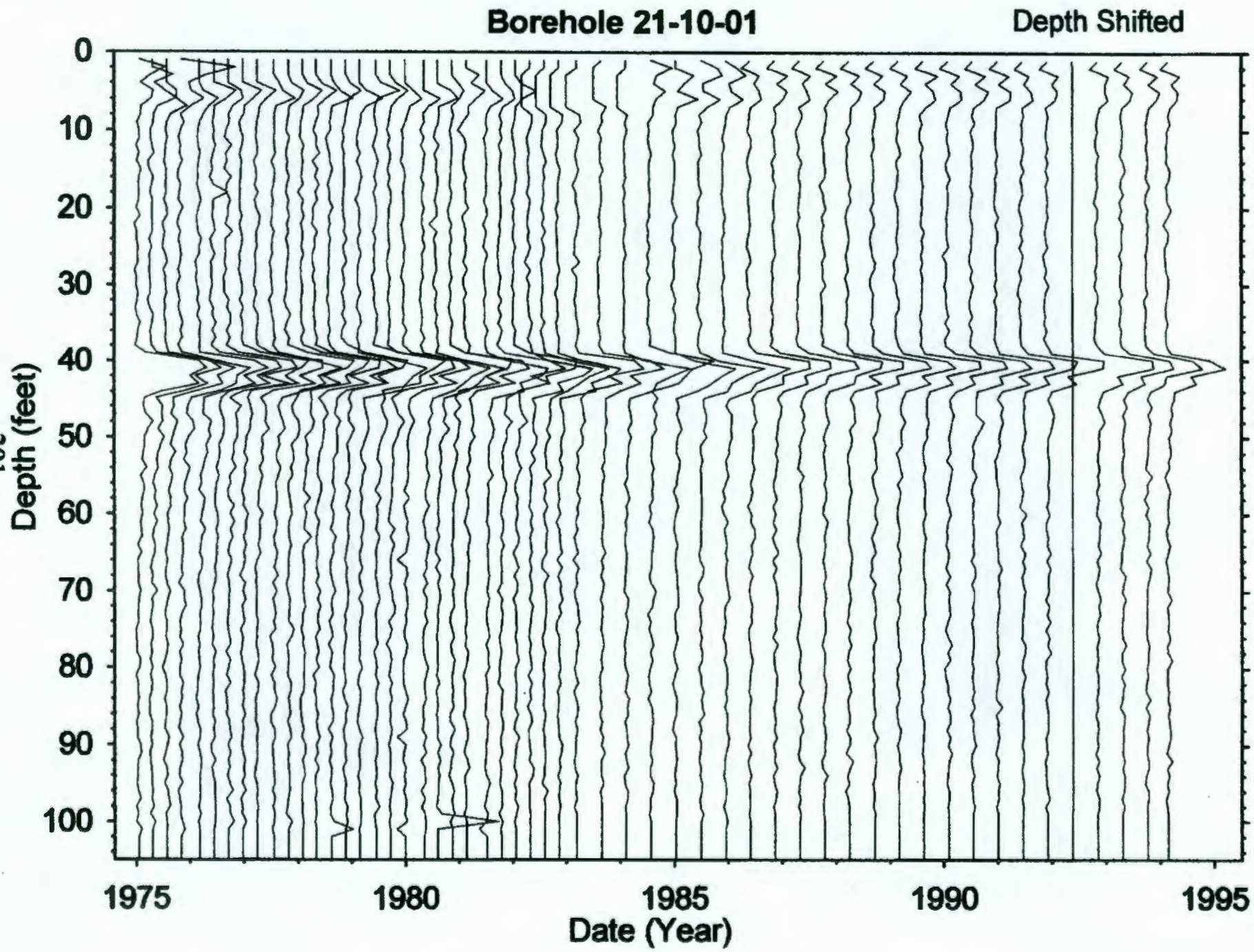
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/16/1975
Last Survey Date :	2/23/1994
Number Surveys :	369

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** **38-52 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


Borehole 21-10-01
Depth: 0-10 ft
1/16/75
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 250 500
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
2/23/94
Gamma (c/s)
0 100 200
Depth (feet)
Analysis by: Three Rivers Scientific


Borehole 21-10-01
Depth: 38-52 ft
01/16/75
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 250 500
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Cs-137 & Co-60 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
2/23/94
Analysis by: Three Rivers Scientific


Borehole 21-10-01
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-10-11) Total # Surveys 373 Probe Type 4

neutron surveys 4 # GR Surveys 369

Log Date: 75-01-16 1st 94-02-23 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 & Co-60 Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
76-05-26	131	170	
79-07-11	40	60	
79-09-04	31	95	
92-05-18	98	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-02-13		100	TOOL FAIL
75-03-05		100	TOOL FAIL
75-03-11	LONG SURVEY	170	RECORDING ERROR
75-04-08		100	TOOL FAIL
76-05-26	LONG SURVEY	170	RECORDING ERROR
76-11-23B		102	BAD SURVEY
78-01-04B		90	BAD DEPTHS
78-02-28		100	WRONG WELL

78-08-22 TOOL NOISE
78-10-10A (40FT) SHORT LOC
79-07-11A (60) SHORT LOC
81-03-23 100 WRONG WELL
92-05-18 100 WRONG WELL

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
75-01-15	AVG BKG	99	0%	0.0	
75-02-13	"	98	0%	0.0	
75-03-05	"	98	0%	0.0	
75-04-08	"	99	0%	0.0	
76-05-12	%CLEAN	96	33%	46.5	
76-09-22	AVG BKG	97	72%	37	
79-08-22	% CLEAN	97	15%	43.5	
92-05-18	AVG BKG	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
Co/Cs = 1:17 of GROSS COUNTS ON 2-1994 (CONSISTENT W/SCALS 1997)

Analyst Name Randall Ruth S/W ver TGROSS V2.20

filein := "two.txt"

A := READPRN(filein)

Well 21-10-01

$yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

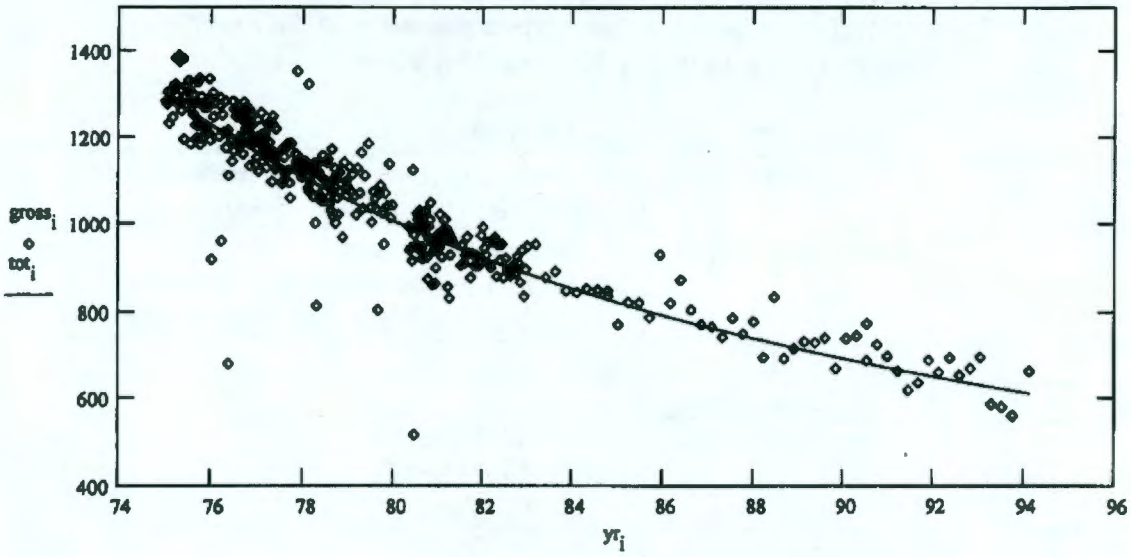
$N := last(yr)$ $N = 356$ $i := 0..N$ $k := 0..300$ $j := 0..299$

$\tau co := 5.27$ $\tau cs := 30.17$ $aco := 400$ $acs := 900$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $tot_i := Cs_i + Co_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aco) = 0$ $1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha co \end{bmatrix} := Minerr(acs, aco)$$

$\alpha cs = 905.409$ $\alpha co = 407.919$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $Eu_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $tot_i := Cs_i + Co_i$

$\frac{\alpha cs}{\alpha co} = 2.22$

$\frac{Co_N}{Cs_N} = 0.055$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out

Borehole 21-10-03

Contamination (Cs-137) from 0 to 96 feet is Stable

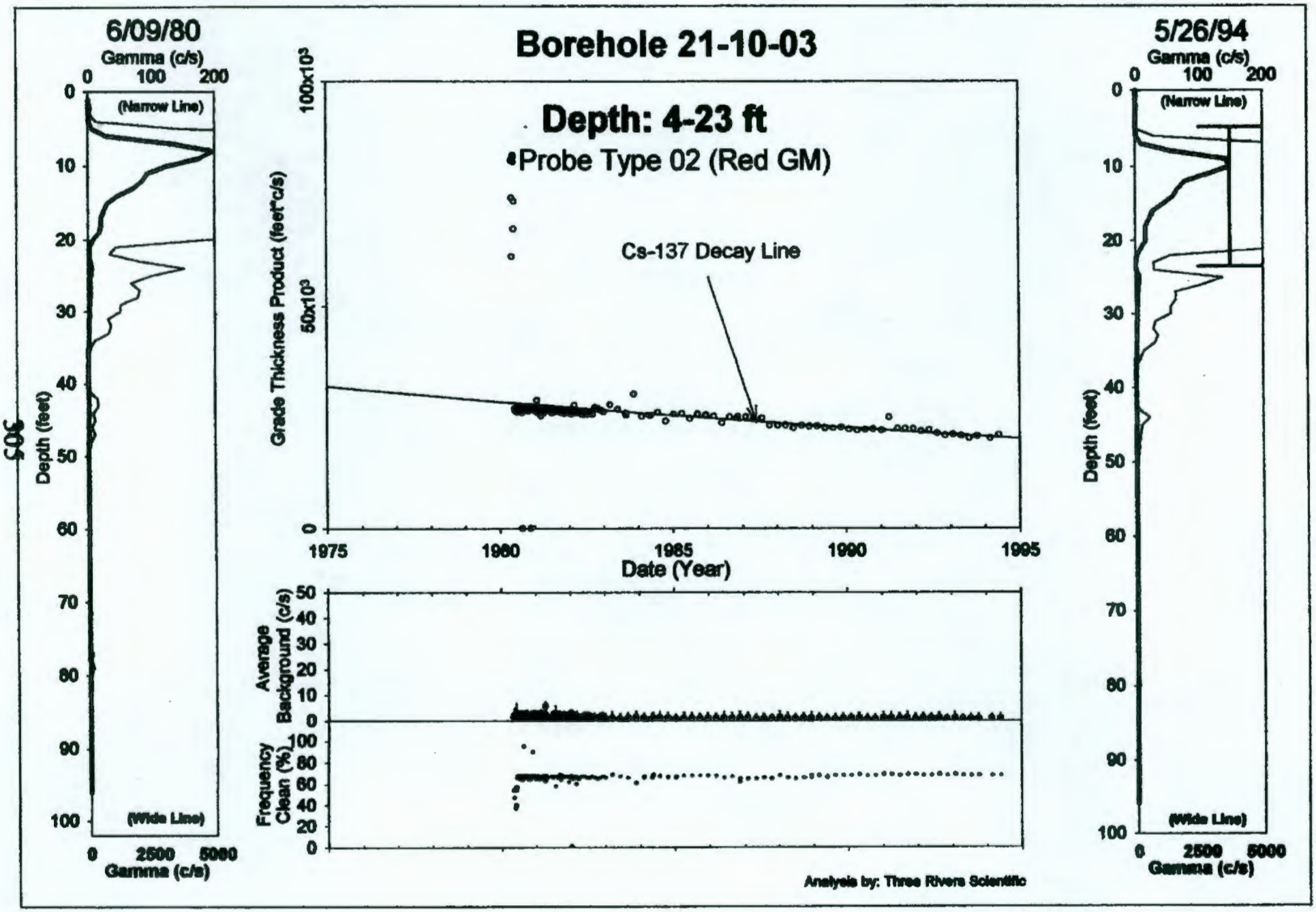
The surveillance logs were analyzed as six radioactive zones to identify if downward movement had occurred. The NaI and Green GM probe types were not designed to monitor high contamination levels (greater than 40,000 and 20,000 c/s, respectively). The radiation zone (0-23 feet) exceeded the count rate capabilities of the Green GM. . The Red GM probe (0-23 and 23-41 feet) showed that the Grade Thickness Product was decreasing at a rate consistent with Cs-137 between July 1980 and May 1994. The lower five radiation zones (23-41, 41-57, 57-72, 72-88, and 88-96 feet) have Grade Thickness Products (Green GM) that are decreasing at a rate consistent with the decay of Cesium-137 between July 1980 and May 1994.

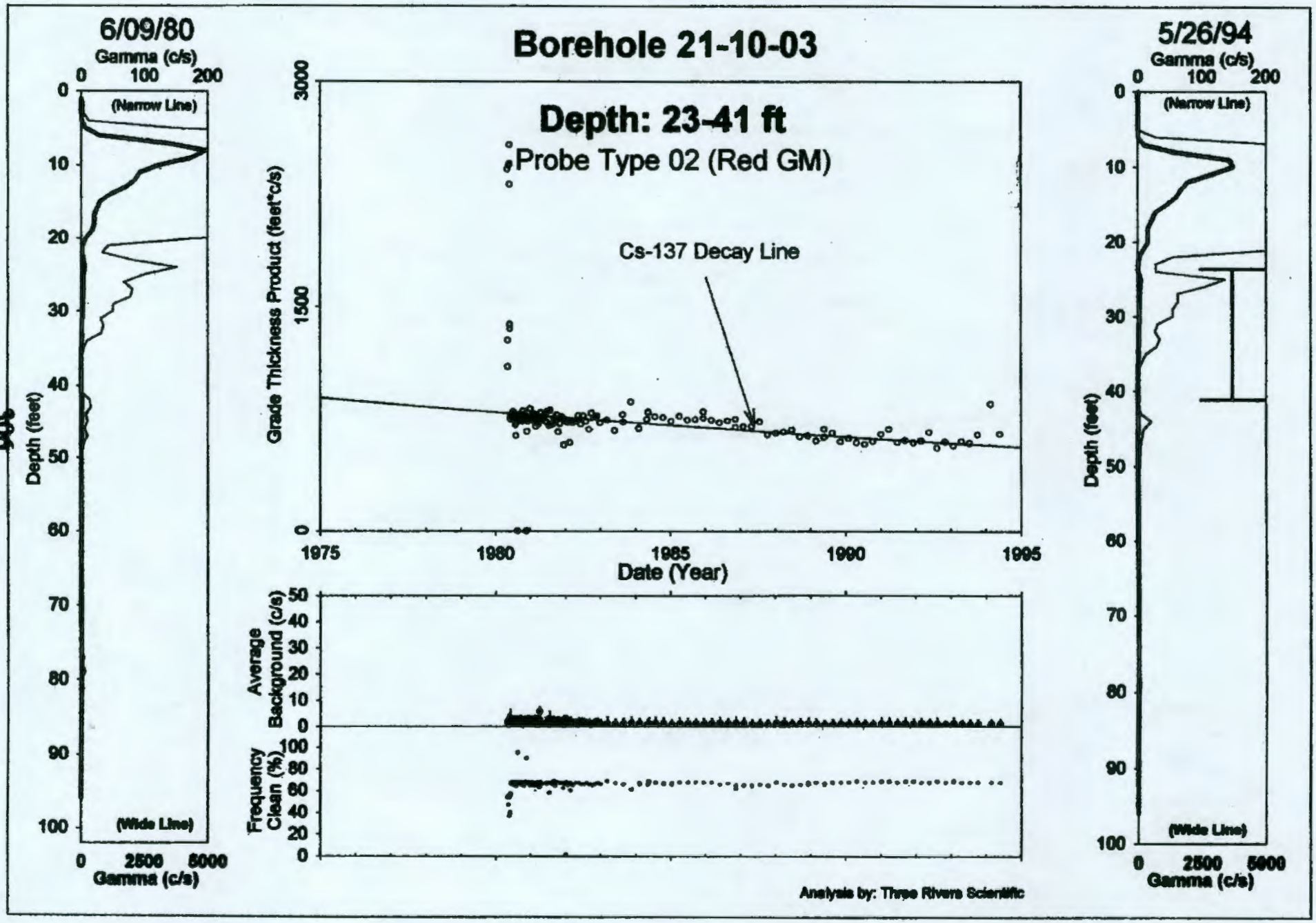
Gross Gamma Survey Information

Probe Type :	01: Green GM (Intermediate Sensitivity) 02: Red GM (Lowest Sensitivity)
Other Probe Types :	03: Neutron (4 surveys) 04: Sodium Iodide Scintillator (saturated) 14: Shielded NaI (saturated, limited time)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980 (Type 01) 5/05/1980 (Type 02) 1/11/1980 (Type 14)
Last Survey Date :	5/26/1994 (Type 01) 5/26/1994 (Type 02) 9/02/1980 (Type 14)
Number Surveys :	133 (Type 01) 155 (Type 02) 32 (Type 14)

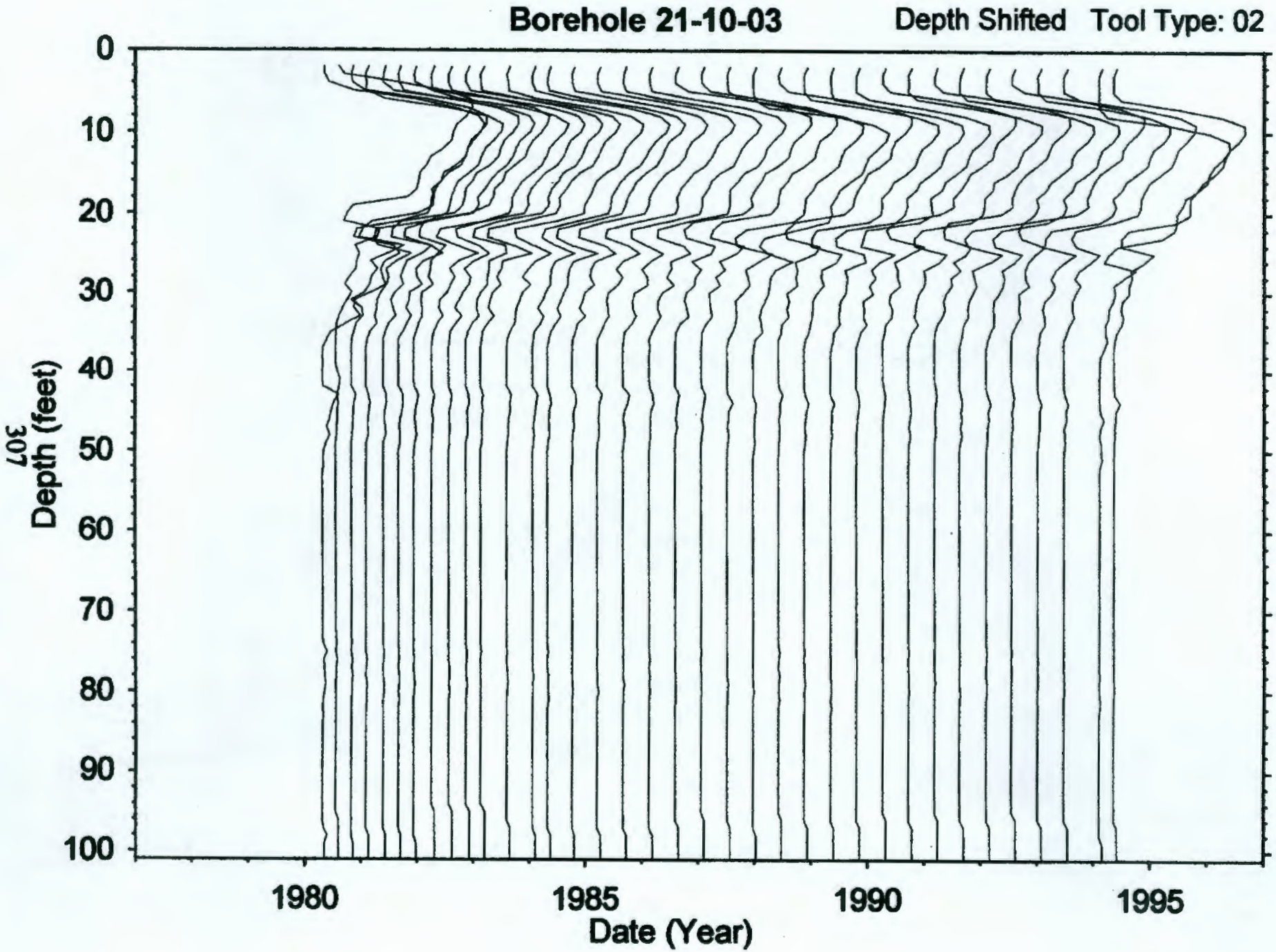
Analysis Notes

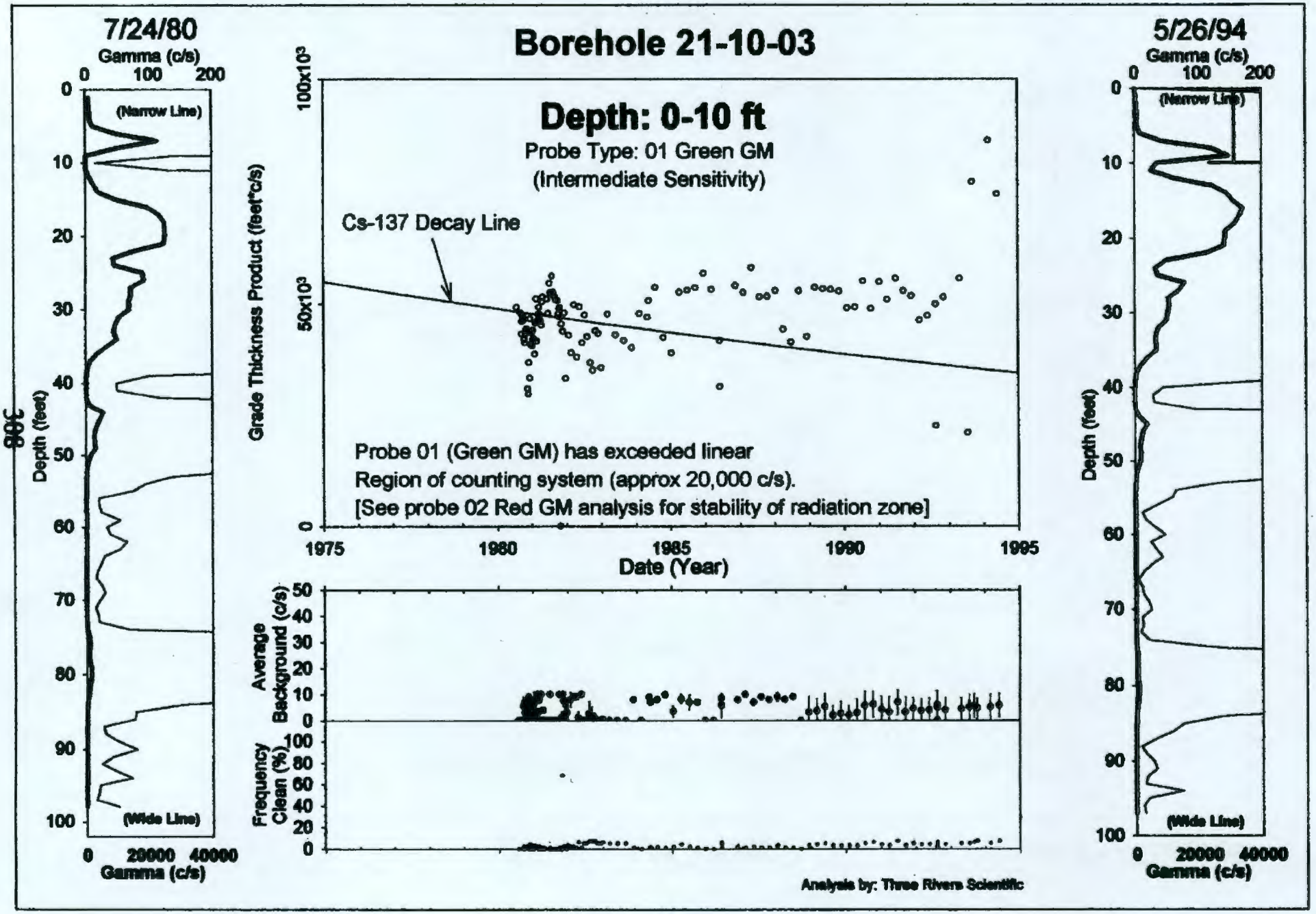
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 10)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**0-23, 23-41, 41-57, 57-72, 72-88, 88-95 feet are Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

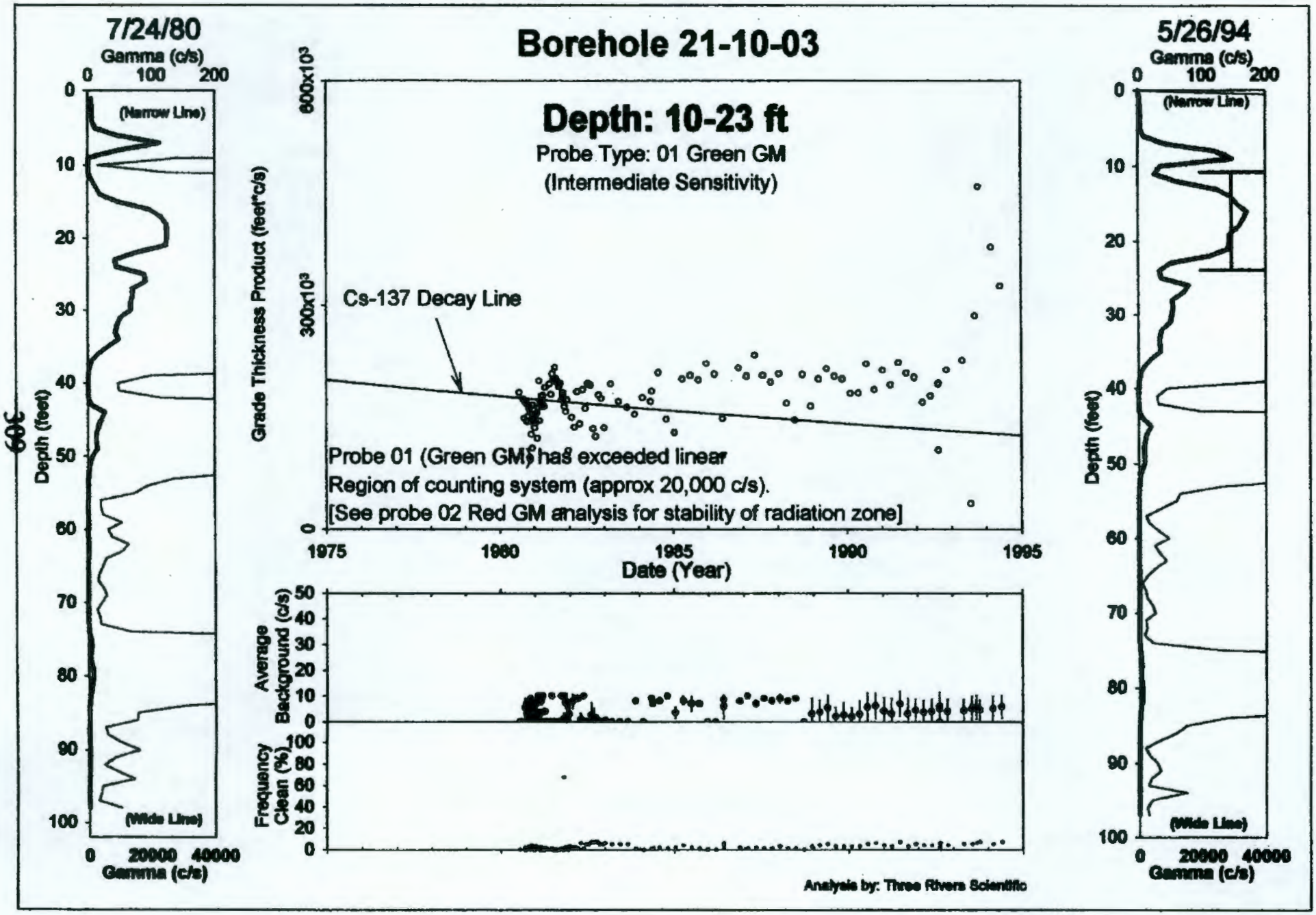

Borehole 21-10-03
Depth: 4-23 ft
Probe Type 02 (Red GM)
Cs-137 Decay Line
6/09/80
5/26/94
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Grade Thickness Product (feet*c/s)
100x10³
50x10³
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific



HNF-3531 -REV0

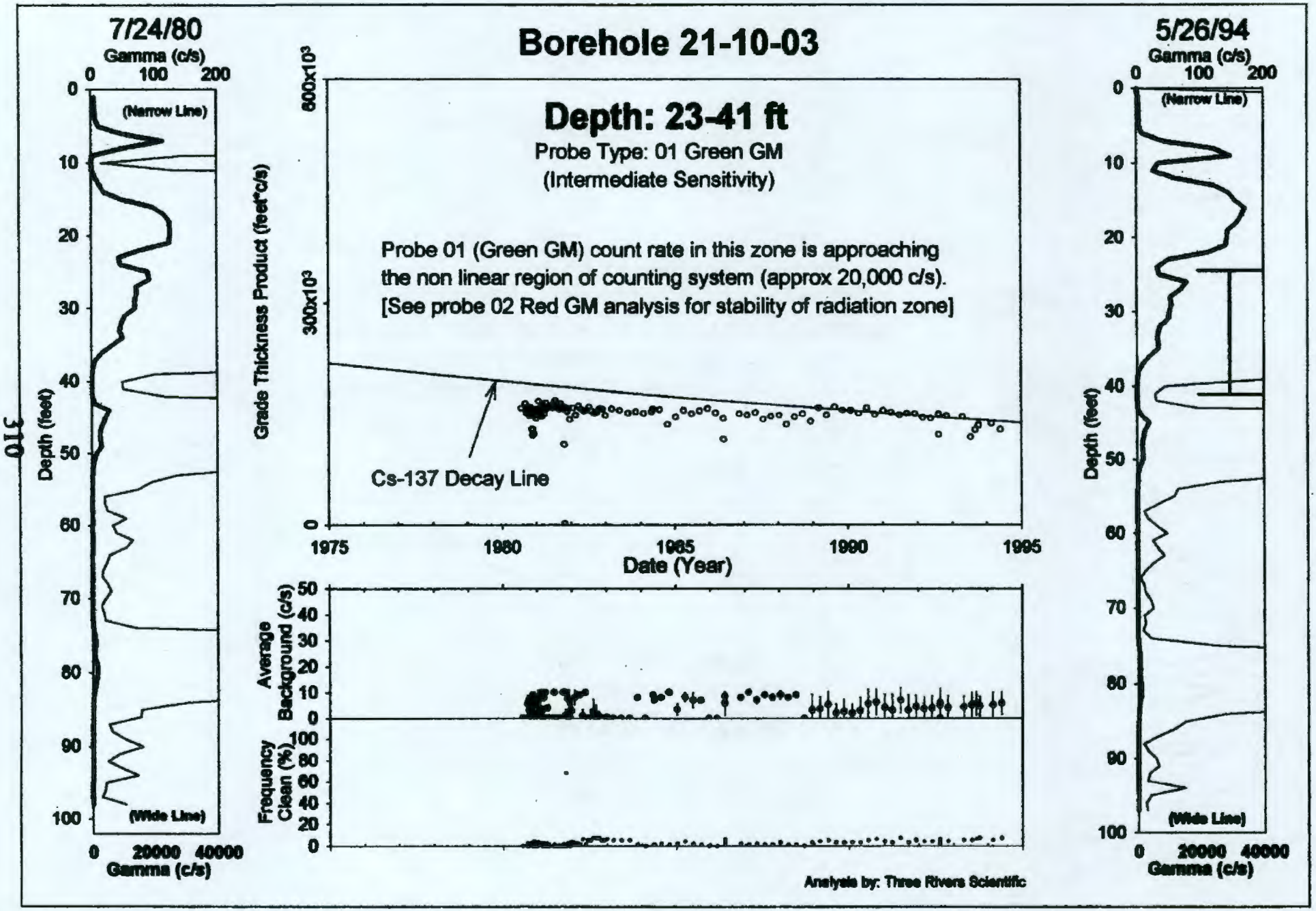

Borehole 21-10-03
Depth Shifted
Tool Type: 02
0
10
20
30
40
50
60
70
80
90
100
Depth (feet)
1980
1985
1990
1995
Date (Year)

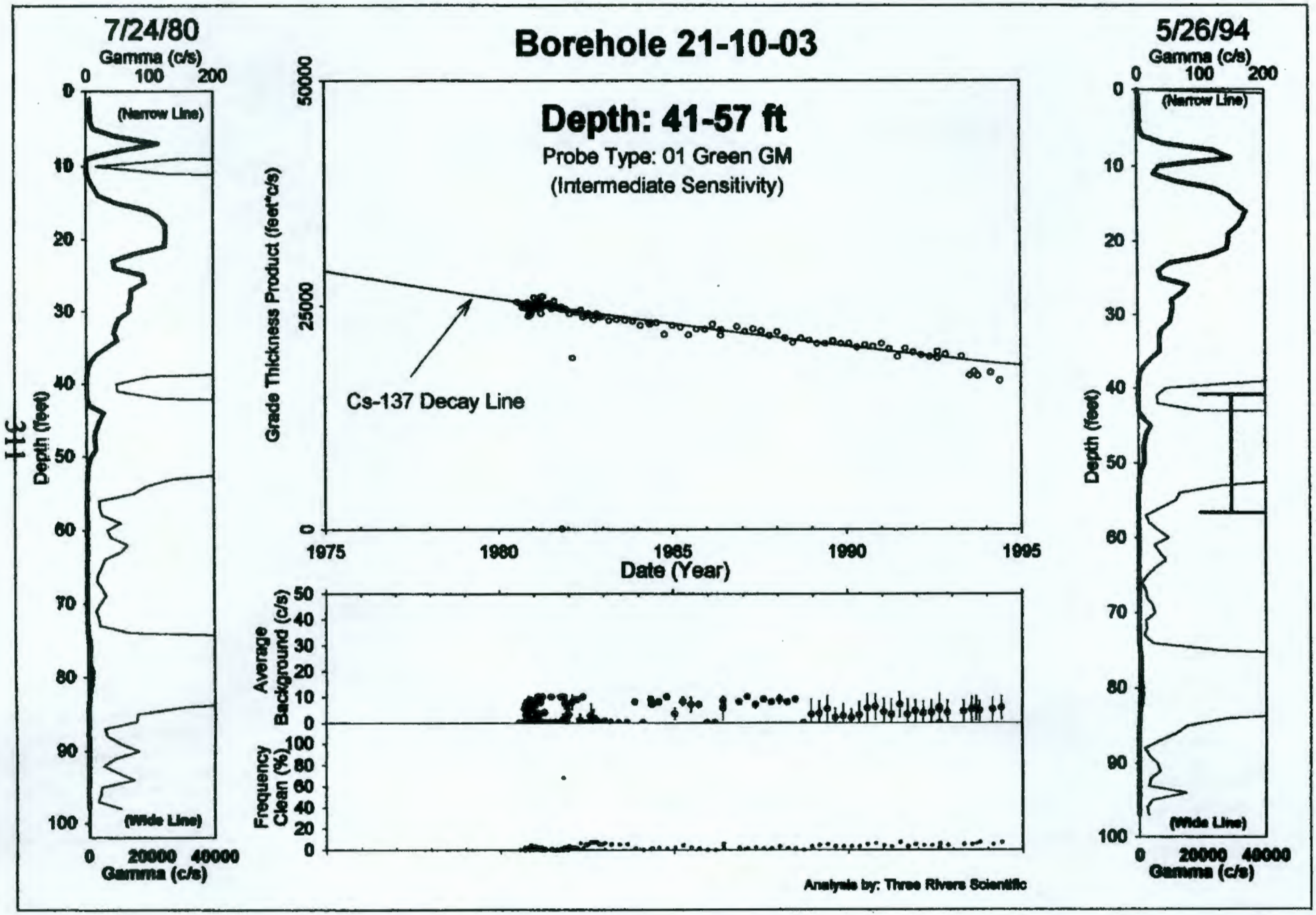

7/24/80
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 20000 40000
Gamma (c/s)
Borehole 21-10-03
Depth: 0-10 ft
Probe Type: 01 Green GM
(Intermediate Sensitivity)
Cs-137 Decay Line
Grade Thickness Product (feet*c/s)
100x10³
50x10³
Probe 01 (Green GM) has exceeded linear
Region of counting system (approx 20,000 c/s).
[See probe 02 Red GM analysis for stability of radiation zone]
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific
5/26/94
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 20000 40000
Gamma (c/s)



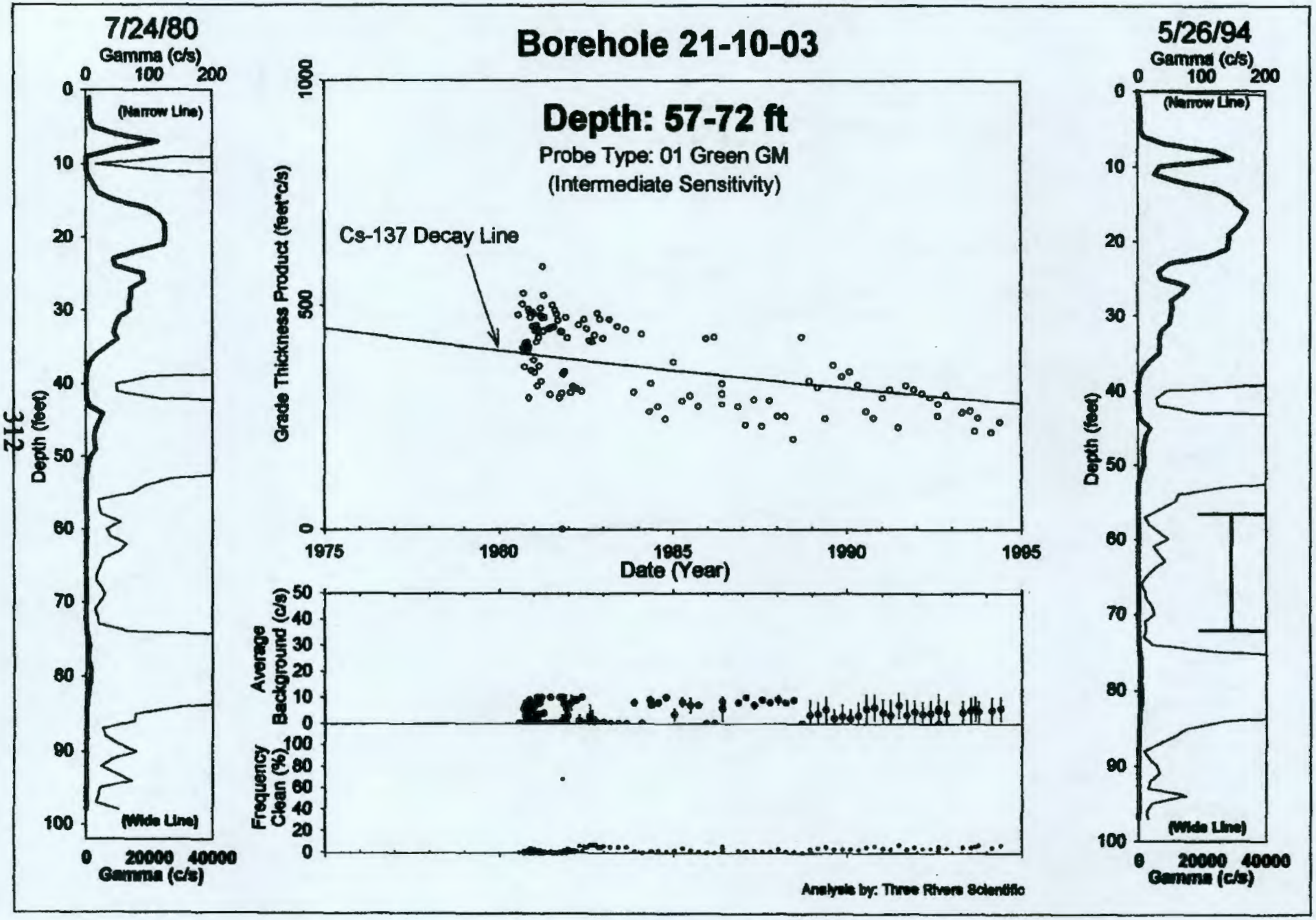
60C

HNF-3531 -REV0

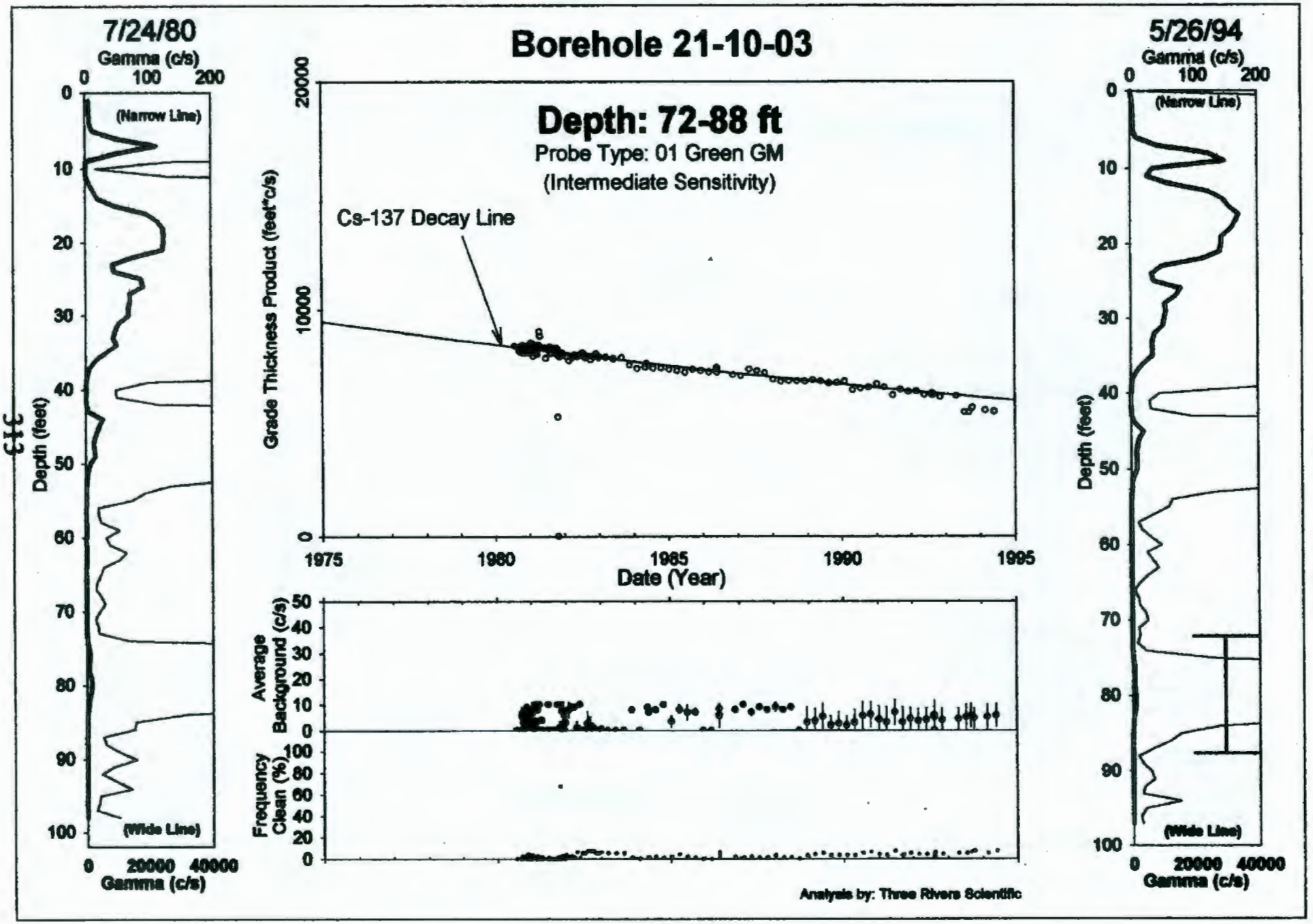

Borehole 21-10-03
Depth: 23-41 ft
Probe Type: 01 Green GM
(Intermediate Sensitivity)
Probe 01 (Green GM) count rate in this zone is approaching the non linear region of counting system (approx 20,000 c/s).
[See probe 02 Red GM analysis for stability of radiation zone]
Cs-137 Decay Line
Grade Thickness Product (feet*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
7/24/80
5/26/94
Gamma (c/s)
Depth (feet)
(Narrow Line)
(Wide Line)
Analysis by: Three Rivers Scientific



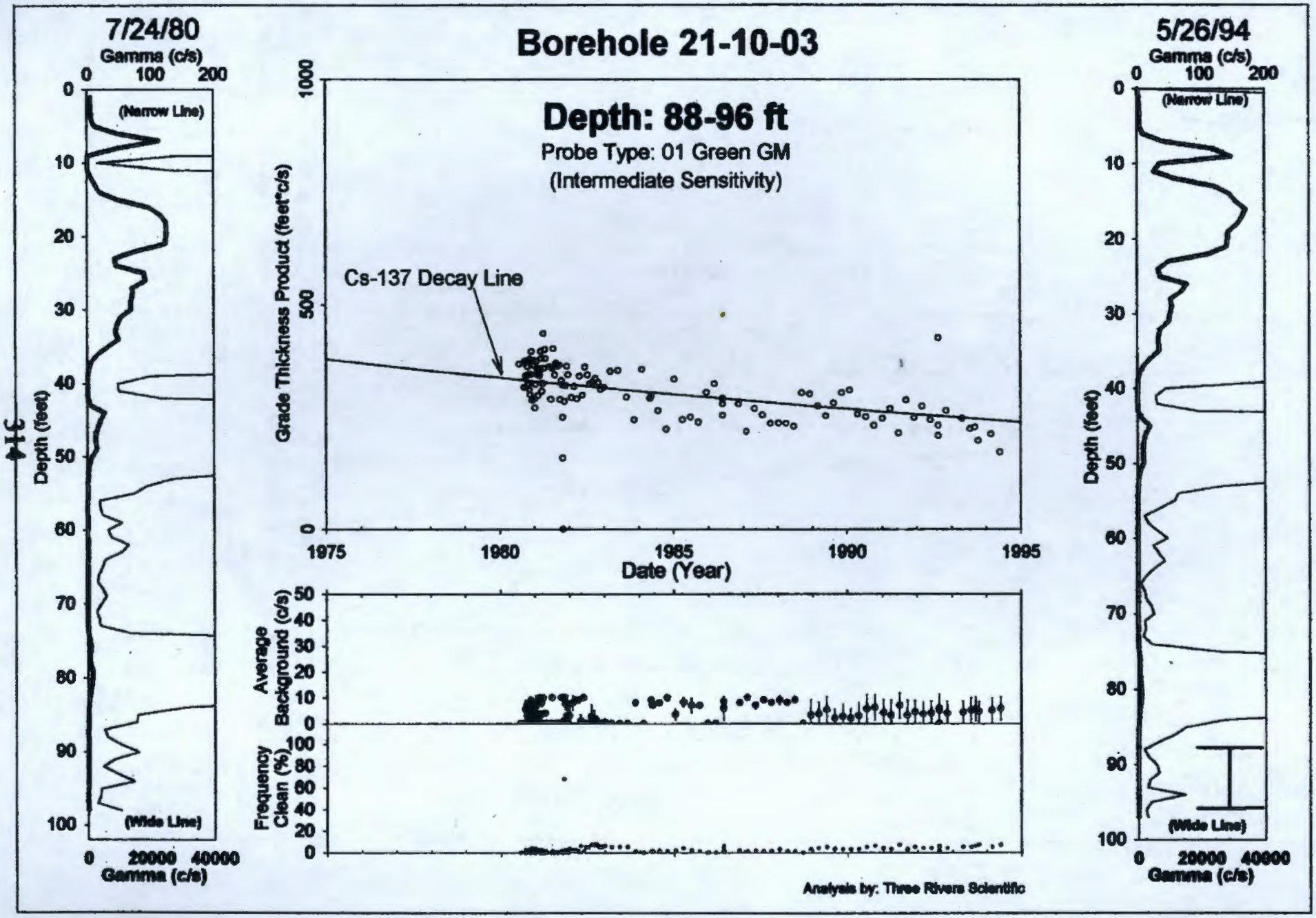
HNF-3531 -REV0


Borehole 21-10-03
Depth: 57-72 ft
Probe Type: 01 Green GM
(Intermediate Sensitivity)
Cs-137 Decay Line
Grade Thickness Product (feet*c/s)
Date (Year)
7/24/80
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
5/26/94
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific

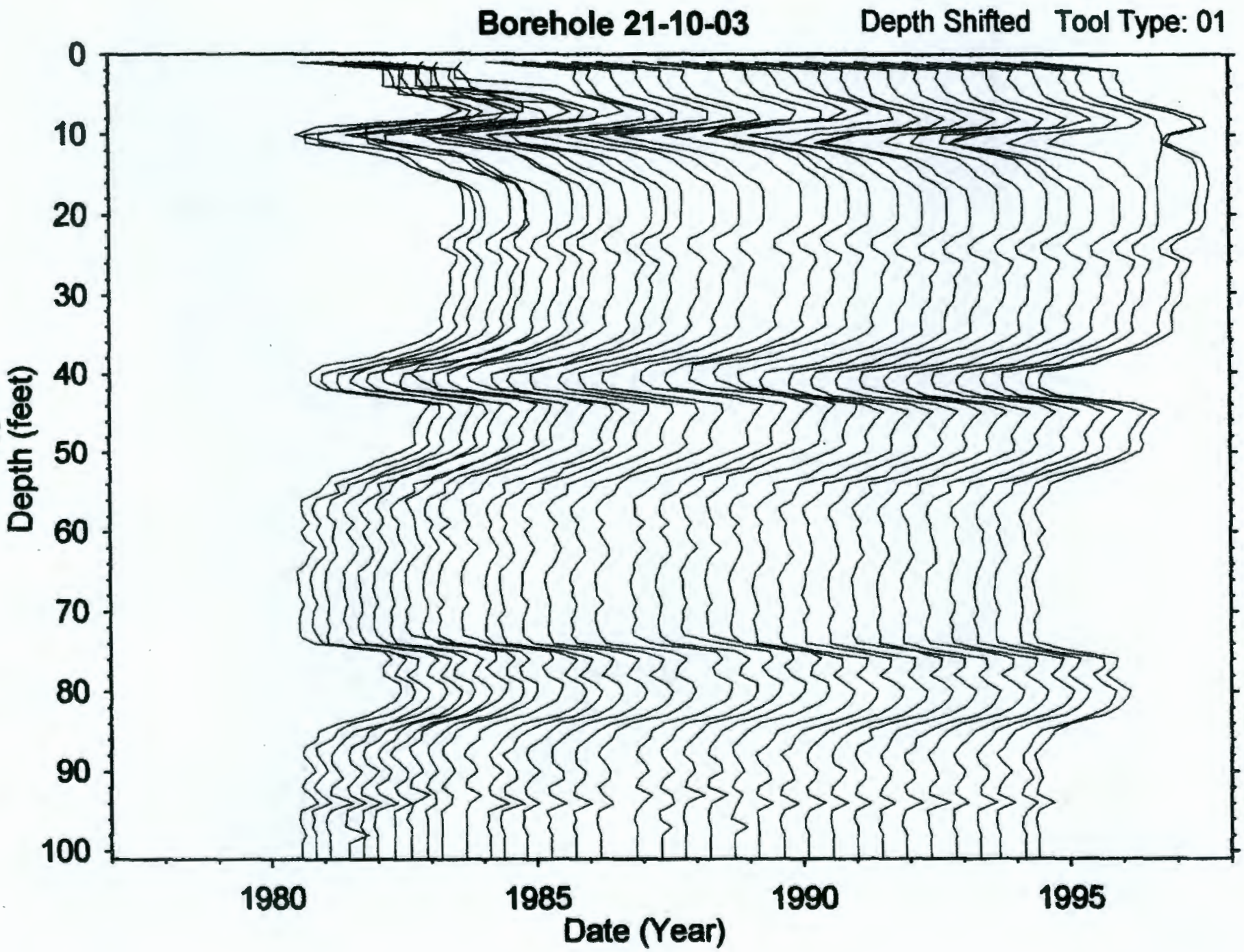
Borehole 21-10-03



HNF-3531 -REV0



HNF-3531 -REV0


Borehole 21-10-03
Depth Shifted Tool Type: 01
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

#01 (133) 80-07-24 → 94-05-
02(155) 80-05-05 → 94-05-
04(6) 91-09-09 → 94-05-16
14(32) 80-11-11 → 80-09-02

Borehole BX (21-10-03)

Total # Surveys 330

neutron surveys 154

94-05-26 Last

Probe Type 01

GR Surveys 133

Presentation Plot Dates _____ (If different from 1st & Last)

Log Date: 80-07-24 1st

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs-137 FULL HOLE
Co-60 (< 1p Ci/g)

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
81-10-26B	40	100	
87-05-01A	11	106	
93-07-12	99	100	
93-07-14	99	100	
80-05-27	26	100	& 80-06-02 (18 GAPS)
82-02-22	9	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
81-09-15A	SHORT SURVEY	40	PROBE TYPE 04
81-10-26C	BAD SURVEY	100	192-05-18 WRONG TOOL
87-05-01A	DEPTH ERROR	102	PROBE TYPE 14
92-08-11	TOOL NOISE	100	80-03-31B (DEPTH ERROR - TOOL FAIL
93-07-12	WRONG HOLE	100	
93-07-14	WRONG HOLE	100	
80-05-12A	TOOL NOISE		
80-11-18A	BAD SURVEY	50	
82-01-04A	WRONG TOOL	102	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
81-09-15A	LENGTH	31	45%	24.1	
81-10-26C	AVG-BKG	98	77%	4.6	
87-05-01A	AVG-BKG	100	10%	0.7	
93-07-12	AVG-BKG	99	100%	0.0	
93-07-14	AVG-BKG	99	100%	0.0	
80-08-18	LENGTH	23	95%	1.0	
80-11-18	LENGTH	62	93%	1.5	
82-01-04	AVG-BKG	99	28%	24.7	
80-03-31A	AVG-BKG	97	17%	0.0	

Analysis Notes

SURVEYS THAT WONT DEPTH SHIFT: 86-08-22/87-05-01A/

Analyst Name Randall Price S/W ver TFGROSS. V2.20

Borehole 21-10-05

Contamination (Cs-137) from 31-52, 52-62 and 74-85 feet is Stable

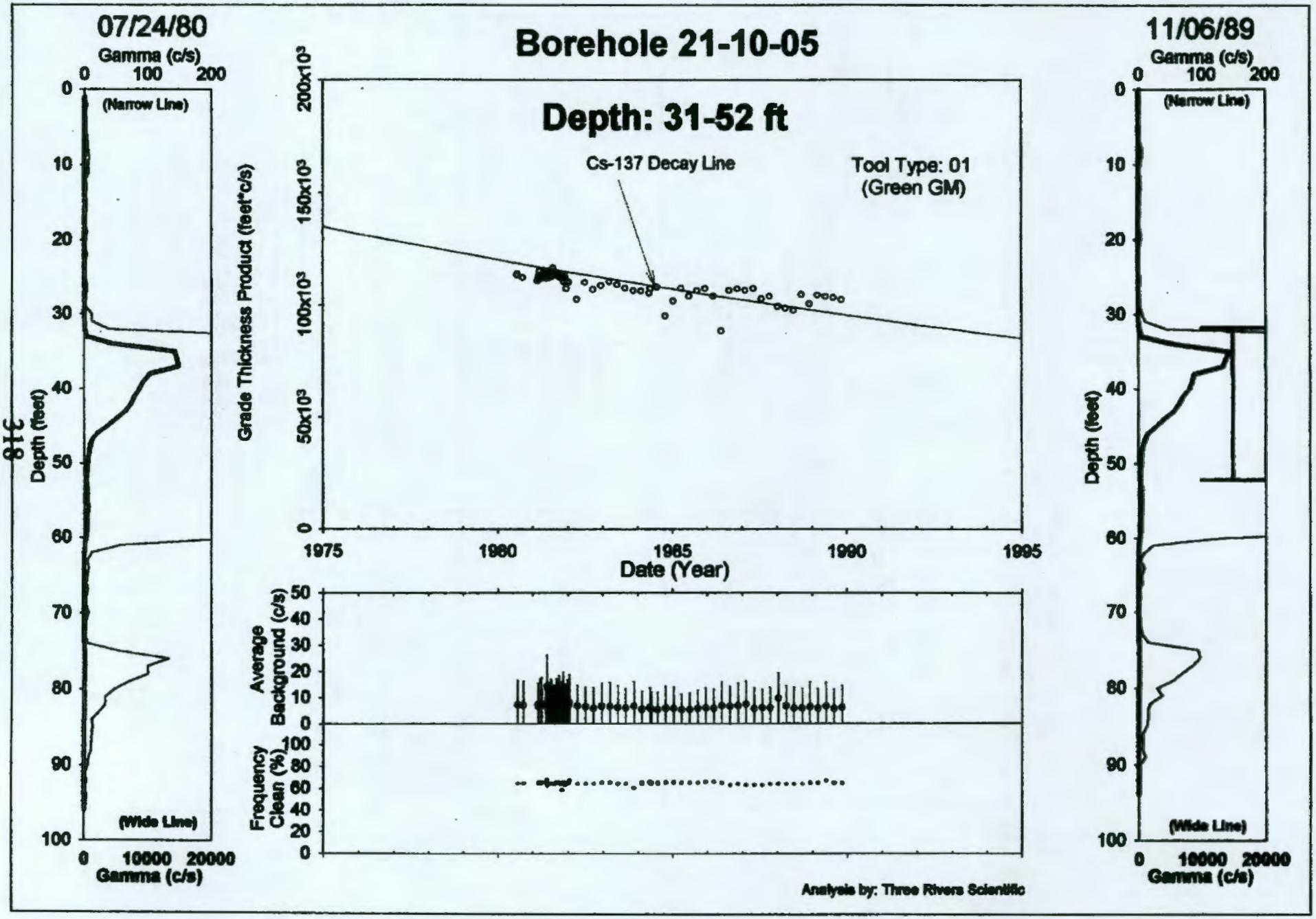
Grade Thickness Product in three contamination zones (i.e. 31-52, 52-62, and 74-85 feet) is decreasing at a rate consistent with Cesium-137 decay between July 1980 and November 1989.

Gross Gamma Survey Information

Probe Type :	01: Green GM (Intermediate Sensitivity)
Other Probe Types :	02: Red GM (Lowest Sensitivity) 04: Sodium Iodide Scintillator (Saturated) 14: Shielded NaI (limited time)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980 (Type 01) 1/14/1980 (Type 02) 1/11/1980 (Type 04) 7/24/1980 (Type 14)
Last Survey Date :	11/06/1989 (Type 01) 7/22/1981 (Type 02) 12/16/1980 (Type 04) 5/05/1981 (Type 14)
Number Surveys :	74 (Type 01) 36 (Type 02) 32 (Type 04) 39 (Type 14)

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= -1
Method Used to Compute Background :	Threshold (0< val < 10)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**31-52 ft is Stable** **74-85 ft is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



HNF-3531 -REV0

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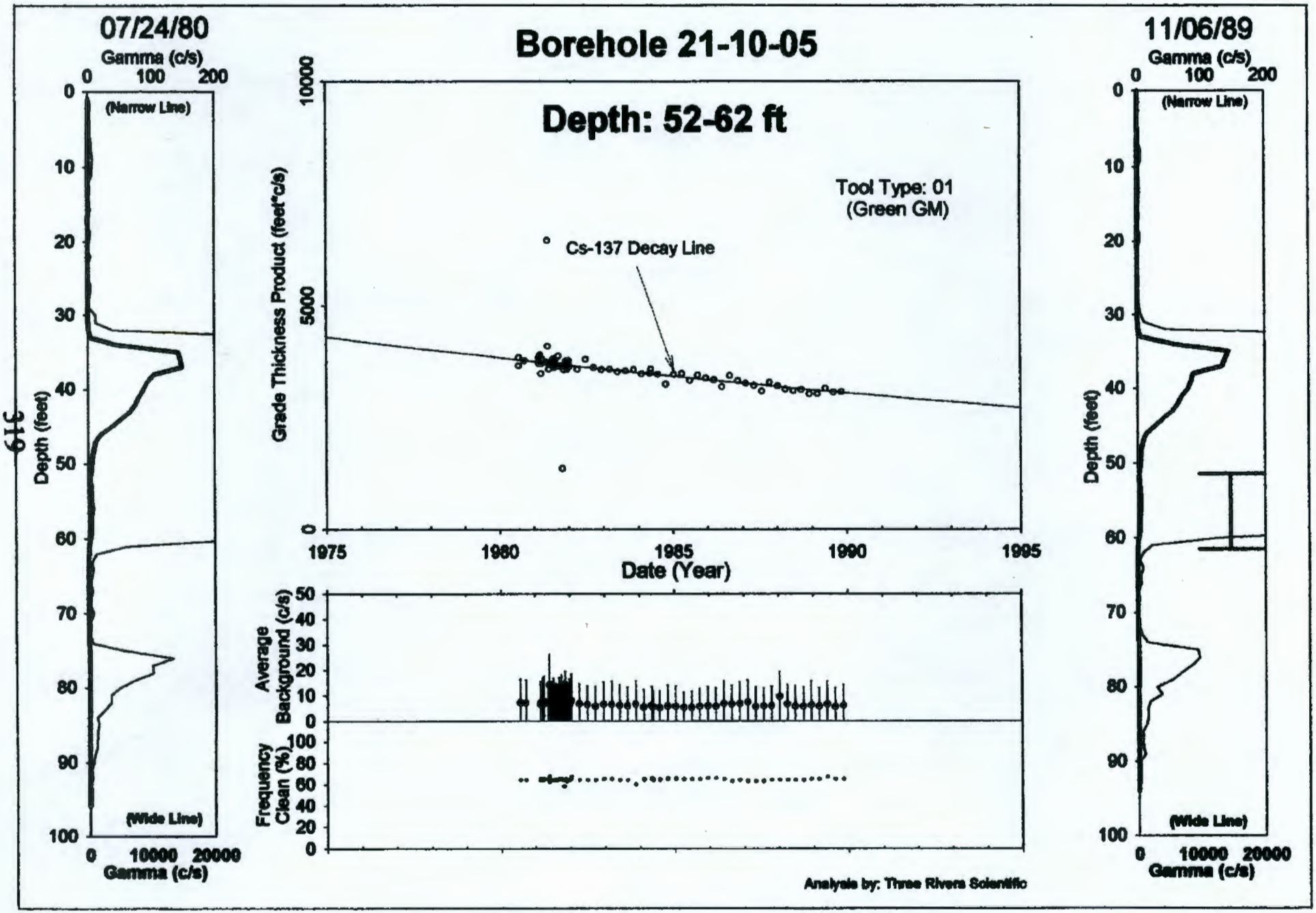
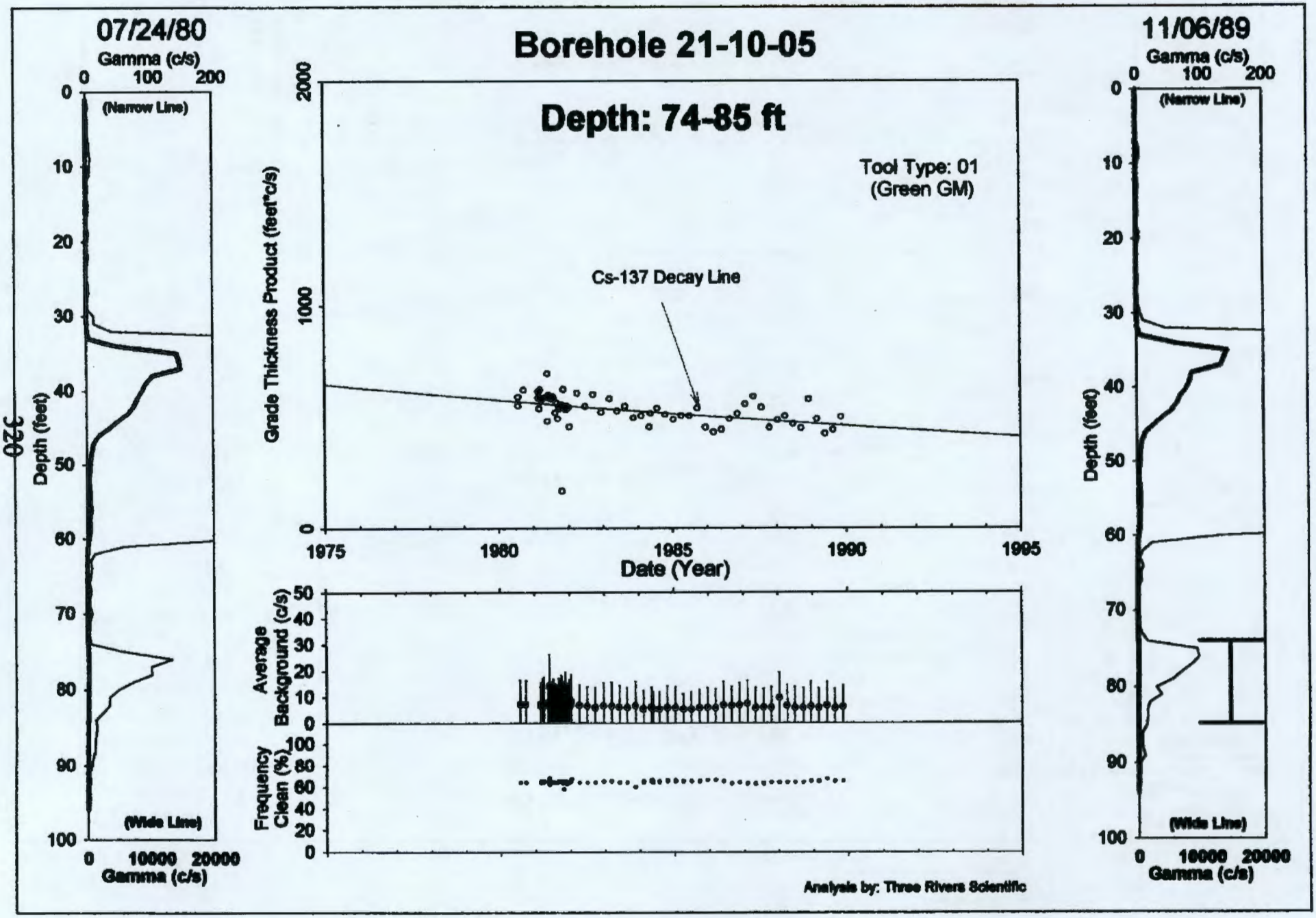
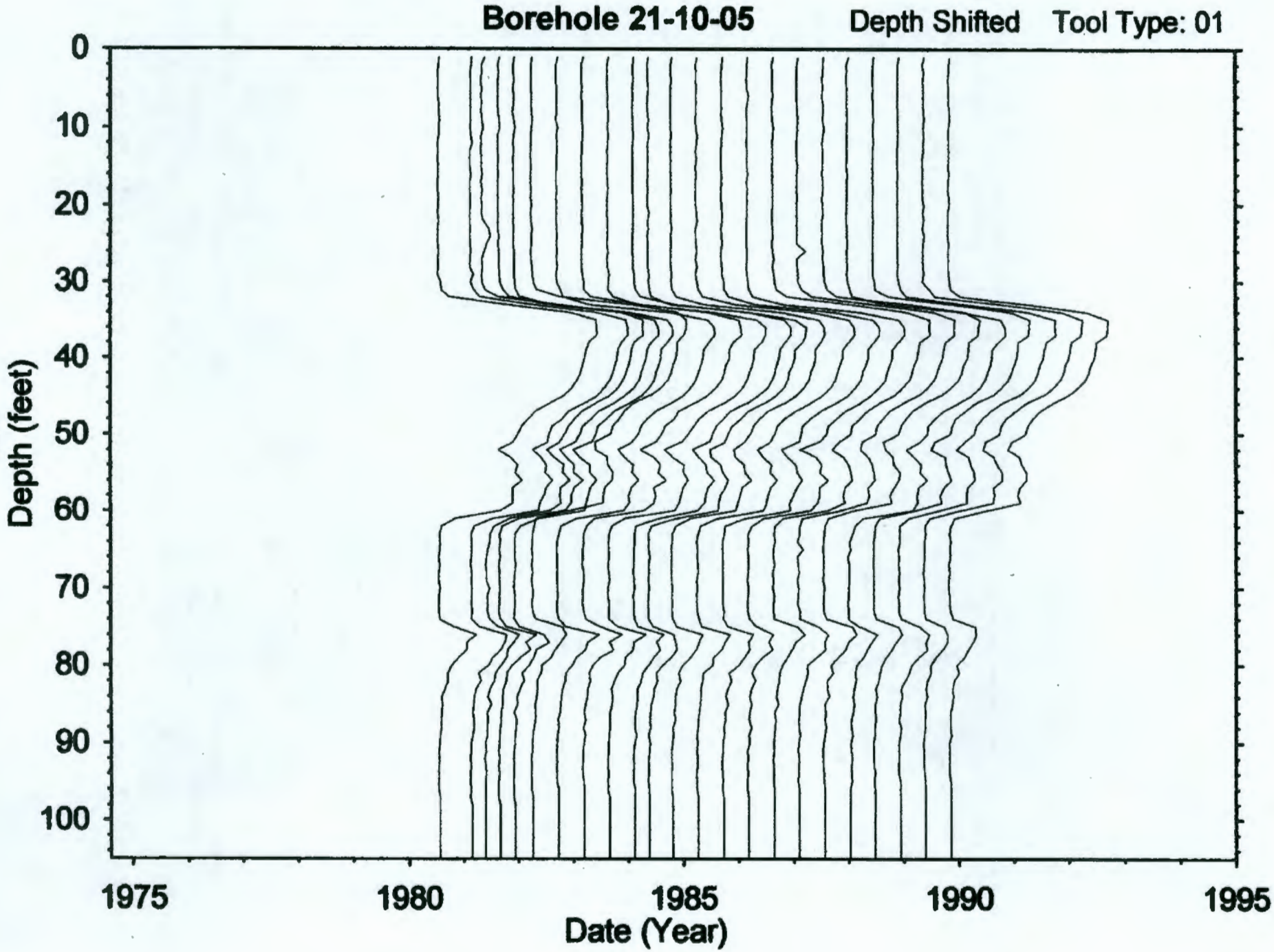

Borehole 21-10-05
Depth: 52-62 ft
07/24/80
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Tool Type: 01
(Green GM)
Cs-137 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
11/06/89
Analysis by: Three Rivers Scientific


Borehole 21-10-05
Depth: 74-85 ft
Tool Type: 01
(Green GM)
Cs-137 Decay Line
Grade Thickness Product (feet*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
07/24/80
11/06/89
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Analysis by: Three Rivers Scientific


Borehole 21-10-05
Depth Shifted
Tool Type: 01
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

01 (74) 80-07-24 = 87-11-0
02 (36) 80-01-14 → 81-07-2
04 (32) 80-01-11 → 80-12-
14 (39) 80-07-24 → 81-05-

Borehole BX(21-10-05

Total # Surveys 181

Probe Type 01

neutron surveys 0

GR Surveys 14

Log Date: 80-07-24 1st

87-11-06 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (FULL WELL) + Co-60 <1 pCi/g

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
81-10-26	9	85	
81-12-07	9	85	
82-09-20	10	100	
80-05-27	24	96	
80-06-02A	42	96	
06-02B	44	96	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
81-05-27	SEVERE DEPTH	110	SEVERE DEPTH ERROR
81-10-12	DEPTH	40	OFF DEPTH (SHORT SURVEY
81-11-26A	DEPTH	85	"
81-12-07	DEPTH	85	"
80-06-02A,B	BAD SURVEY	100	WRONG HOLE
80-03-31A,B	TOOL BAD	100	TOOL MALFUNCTION
88-09-14	TOOL BAD	102	"
80-09-16	DEPTH	110	OFF DEPTH (LONG SURVEY)

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
81-10-12A	DEPTH	42	73%	9.1	
80-06-02	% CLEAN	96	54%	1.2	
80-03-31	AVG BKG	96	0%	0.0	
88-09-14	% CLEAN	99	97%	29.0	WRONG BOREHOLE

Analysis Notes

NO SURVEYS REJECTED
VARIATIONS IN GTP MAY BE RESULT OF TOOL CHANGES
TIME LAPSE OF PROBE TYPES 02, 04, 14 LIMIT USEFULNESS OF THESE SURVEYS
RED GM TOOL (02) HAD 6 MONTH WITH ONE TOOL THEN CHANGED TO LESS SENSITIVE TOOL JUN 80
NAI TOOL (04) WAS SATURATED AT 60 KCPS (10X MULTIPLIER TO 3/20/80)
SHIELDED NAI (14) SURVEY PROFILE CLOSER MATCH TO (01) TOOL TYPE

Analyst Name Randall Reid

S/W ver TPGROSS V2.20

Borehole 21-10-07

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 1994 in the vadose zone from 2 to 100 feet.

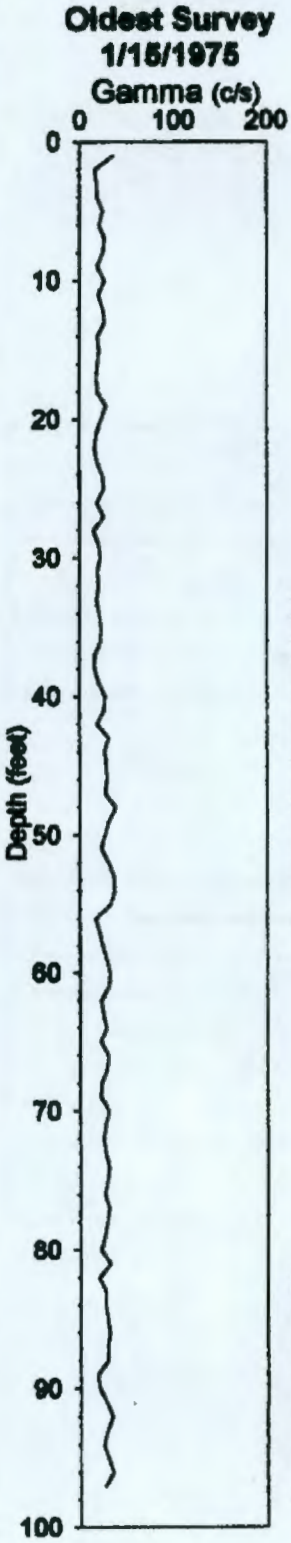
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	395

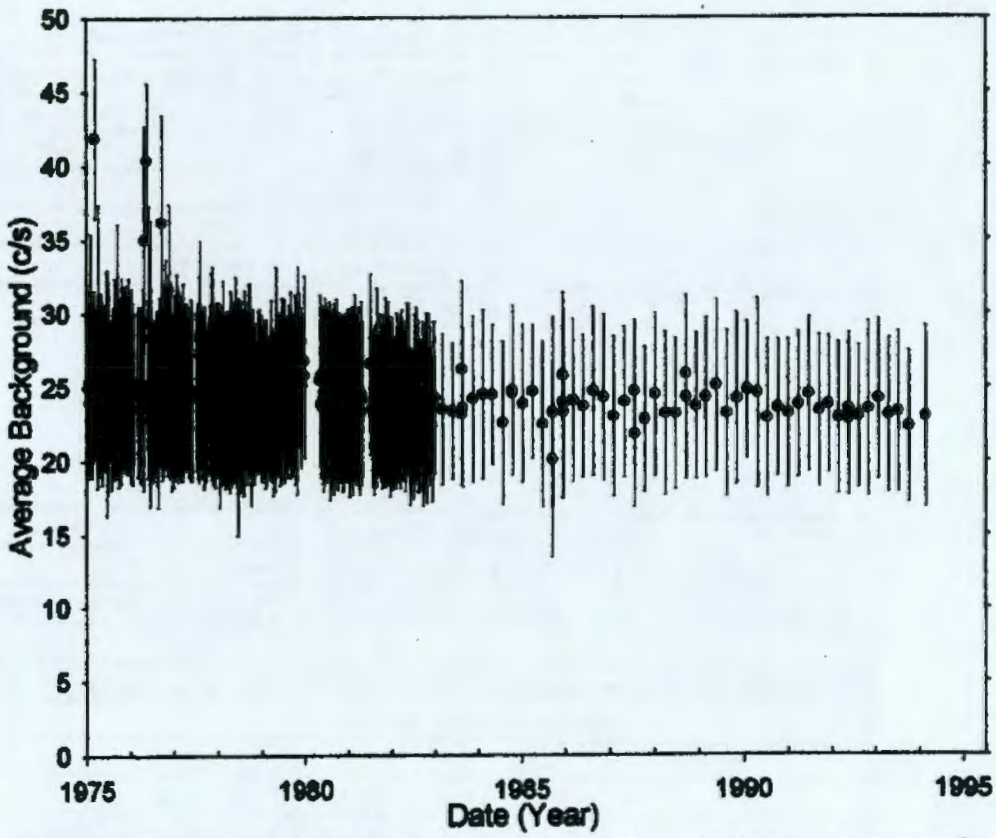
Analysis Notes

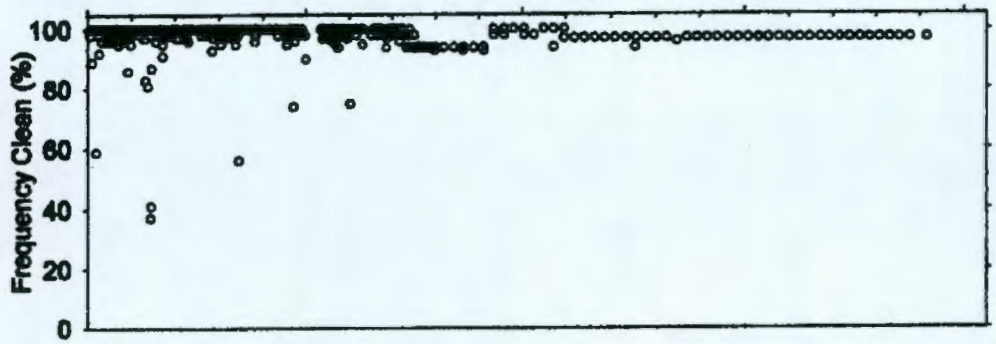
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**No Contamination**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-10-07

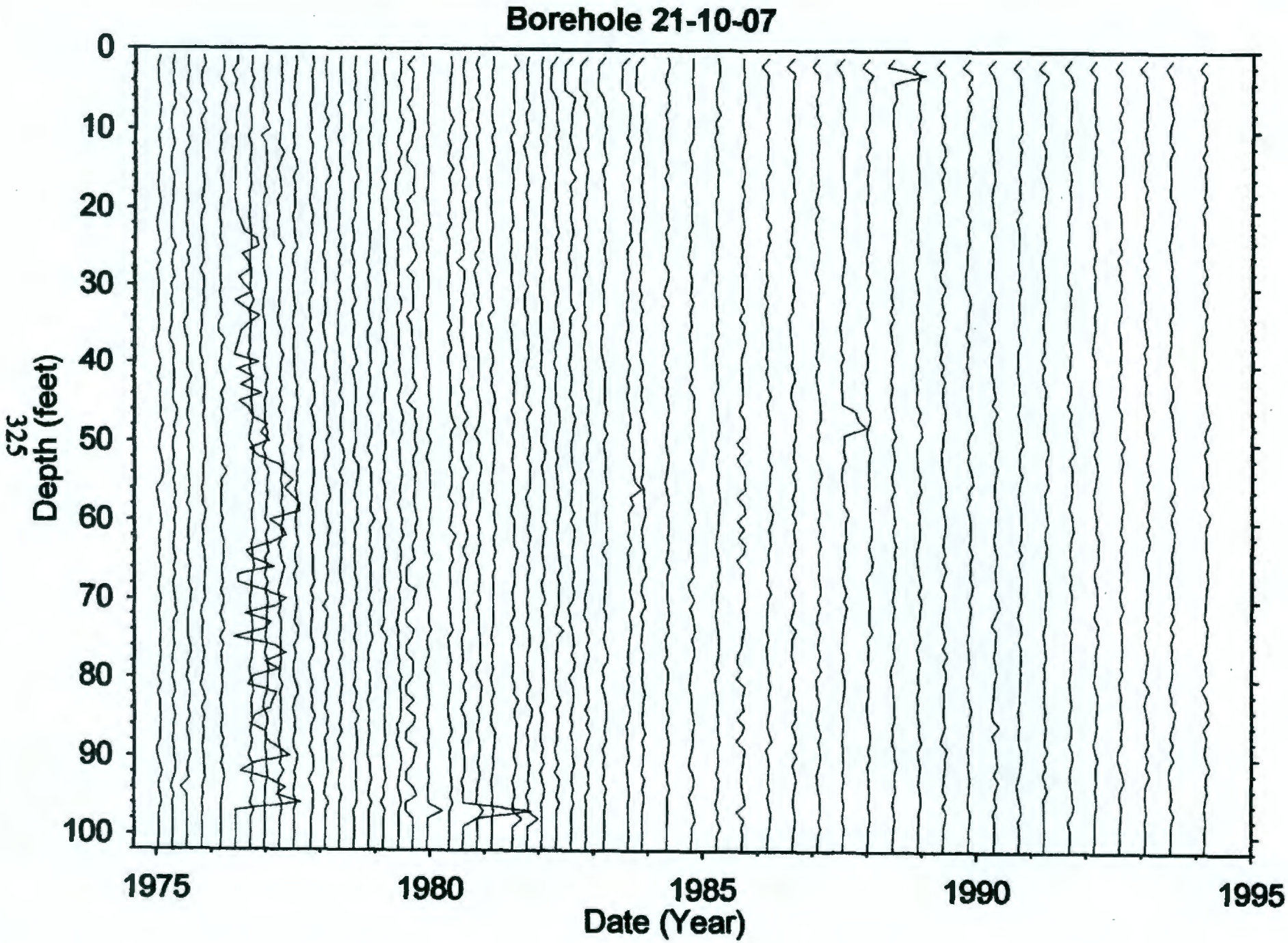


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-10-07
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-10-07

Total # Surveys 399

Probe Type 04

neutron surveys 4

GR Surveys 395

Log Date: 75-01-15 1st

94-02-23 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (<2pCi/g) AT SURFACE

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
75-12-03	13	98	
79-09-04	25	96	
81-01-06	12	45	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
75-03-11	HI BKG	100	
76-06-09	HI CPS	100	HIGH SENSITIVITY TOOL
76-06-15	TOOL MALFUNCTION	98	PROBABLE TOOL FAILURE
78-06-13A	HI-CPS	100	POSSIBLE TOOL NOISE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-03-11	AVG BKG	98	59%	41.9	
75-12-10	LENGTH	31	100%	26.9	
76-05-19	AVG BKG	97	81%	40.4	
76-06-09	% CLEAN	96	37%	29.4	
76-06-15	% CLEAN	94	41%	22.8	
77-02-09	LENGTH	42	100%	27.0	
81-01-06	LENGTH	49	75%	24.8	

Analysis Notes

NO SURVEYS REJECTED

NO RADIATION ZONE ABOVE DETECTION THRESHOLD

Analyst Name Rondall Price

S/W ver TPGROSS V2.20

Borehole 21-10-11

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 1994 in the vadose zone from 2 to 100 feet.

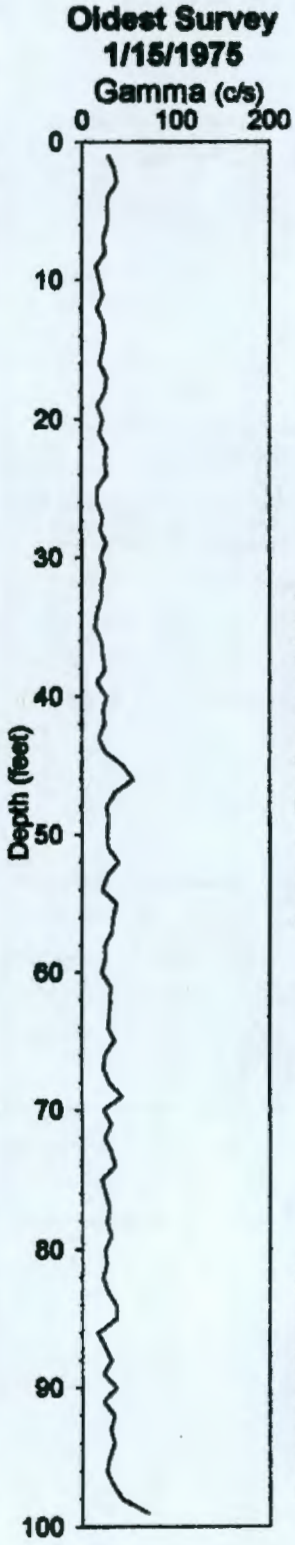
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	363

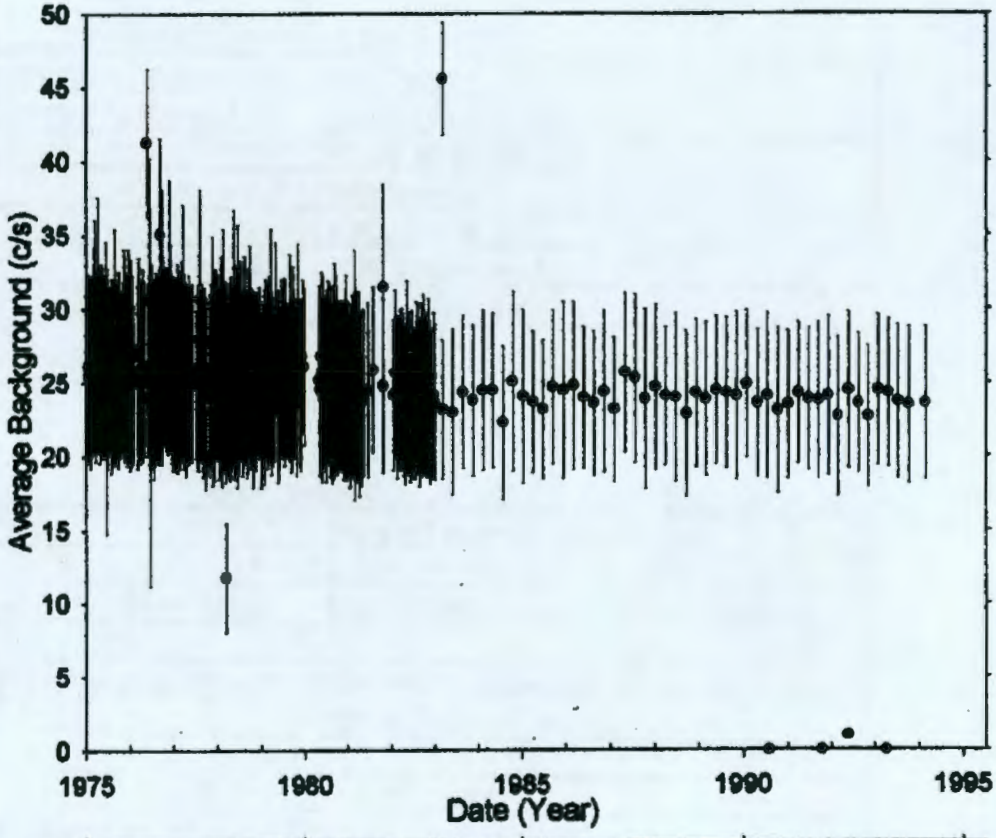
Analysis Notes

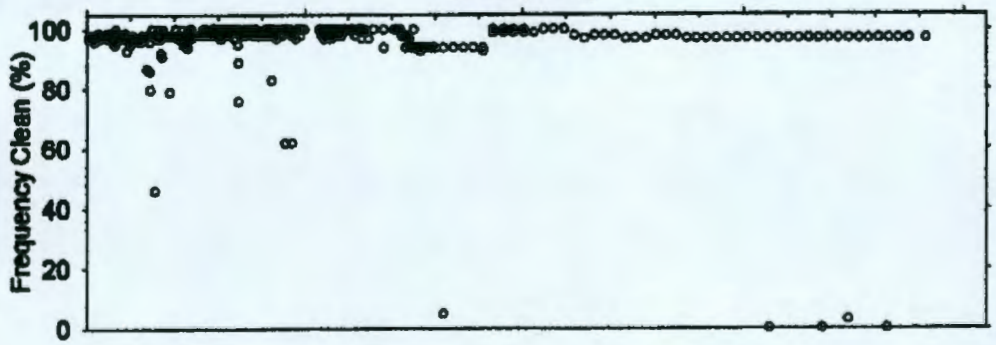
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**No Contamination**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-10-11

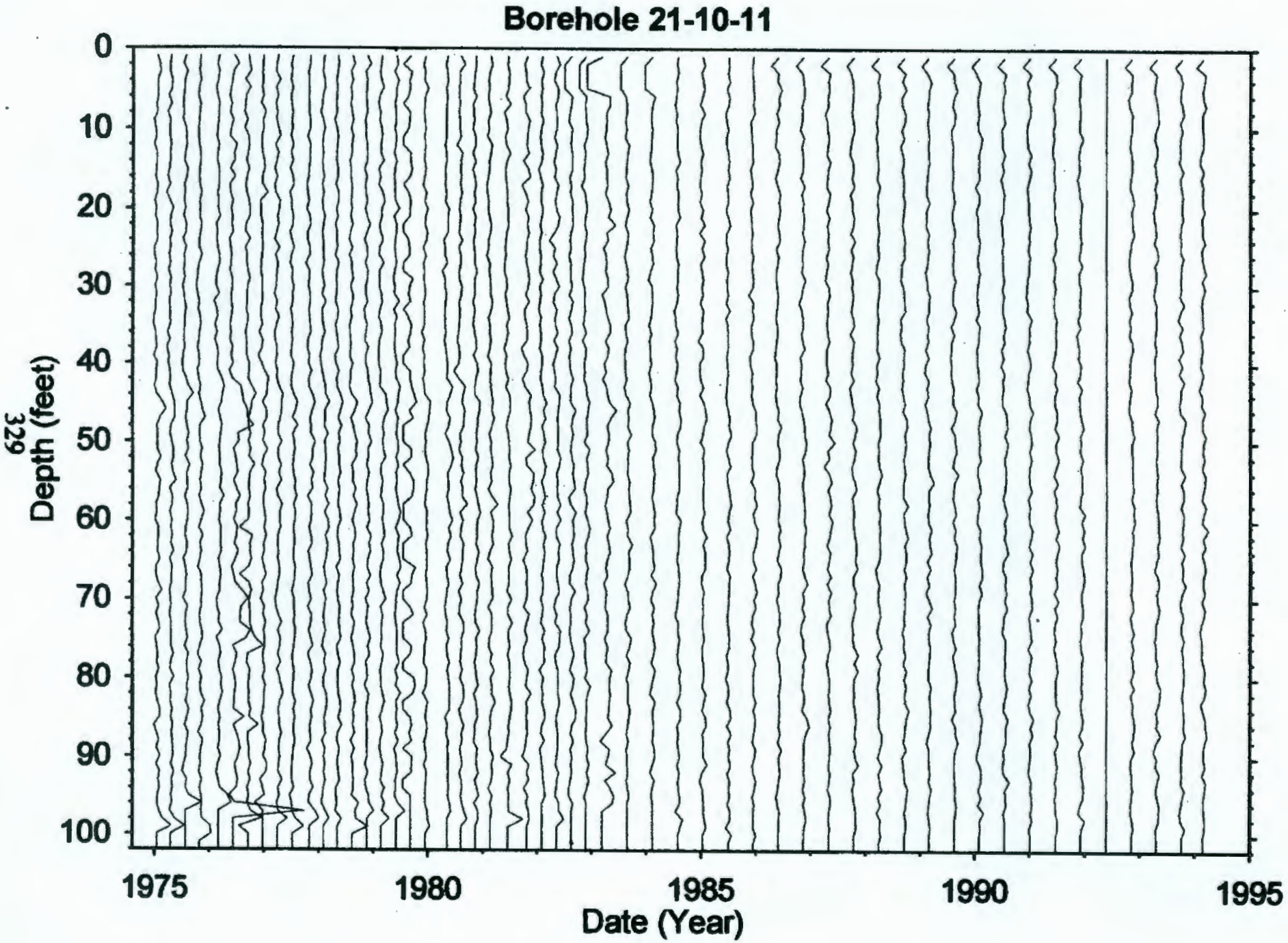


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-10-11
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole BX(21-10-11)

Total # Surveys 367

Probe Type 04

neutron surveys 4

GR Surveys 363

Log Date: 75-01-15st

94-02-23 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 SURFACE ONLY (TO 25FT) < 1PCi/g

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
76-07-20	32	60	
79-07-11	18	50	
79-09-04	35	95	
92-05-18	96	100	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
76-06-15	HI-PKCPS	95	PROBABLE TOOL MAL FUNCTION
76-11-23A	HI-CPS	100	HIGH TOOL CPS
78-06-15A	HI-CPS	100	HIGH TOOL CPS
78-06-15B	HI-CPS	100	"
79-03-20	HI-CPS	98	HIGH TOOL CPS
83-03-09	HI-CPS	100	HIGH TOOL CPS

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
76-05-19	AVG-BKG	96	87%	41.3	
76-07-20	%CLEAN	60	46%	24.4	
76-08-24	LENGTH	132	100%	25.4	
~~78-09-04~~					
78-03-14	AVG-BKG	97	100%	11.8	
79-07-11	LENGTH	48	62%	27.7	
~~83-03-09~~	%CLEAN	96	5%	45.6	
92-05-18	%CLEAN	96	3%	1.0	

Analysis Notes

NO SURVEYS REJECTED

NO RADIATION ZONES ABOVE DETECTION THRESHOLD IDENTIFIED

Analyst Name Randall Price

S/W ver TFGROSS V2.20

Borehole 21-11-03

Contamination (Cs-137) from 0 to 10 feet is Undetermined
Contamination (Cs-137) from 34 to 44 feet is Undetermined
Contamination (Cs-137) from 44 to 62 feet is Stable
Contamination (Cs-137) from 62 to 70 feet is Stable
Contamination (Cs-137) from 70 to 94 feet is Stable

Surveillance logging activities were not designed to monitor high contamination levels with count rates exceeding 40,000 c/s (34-44 feet) and monitor contamination at the surface (0-10 feet).

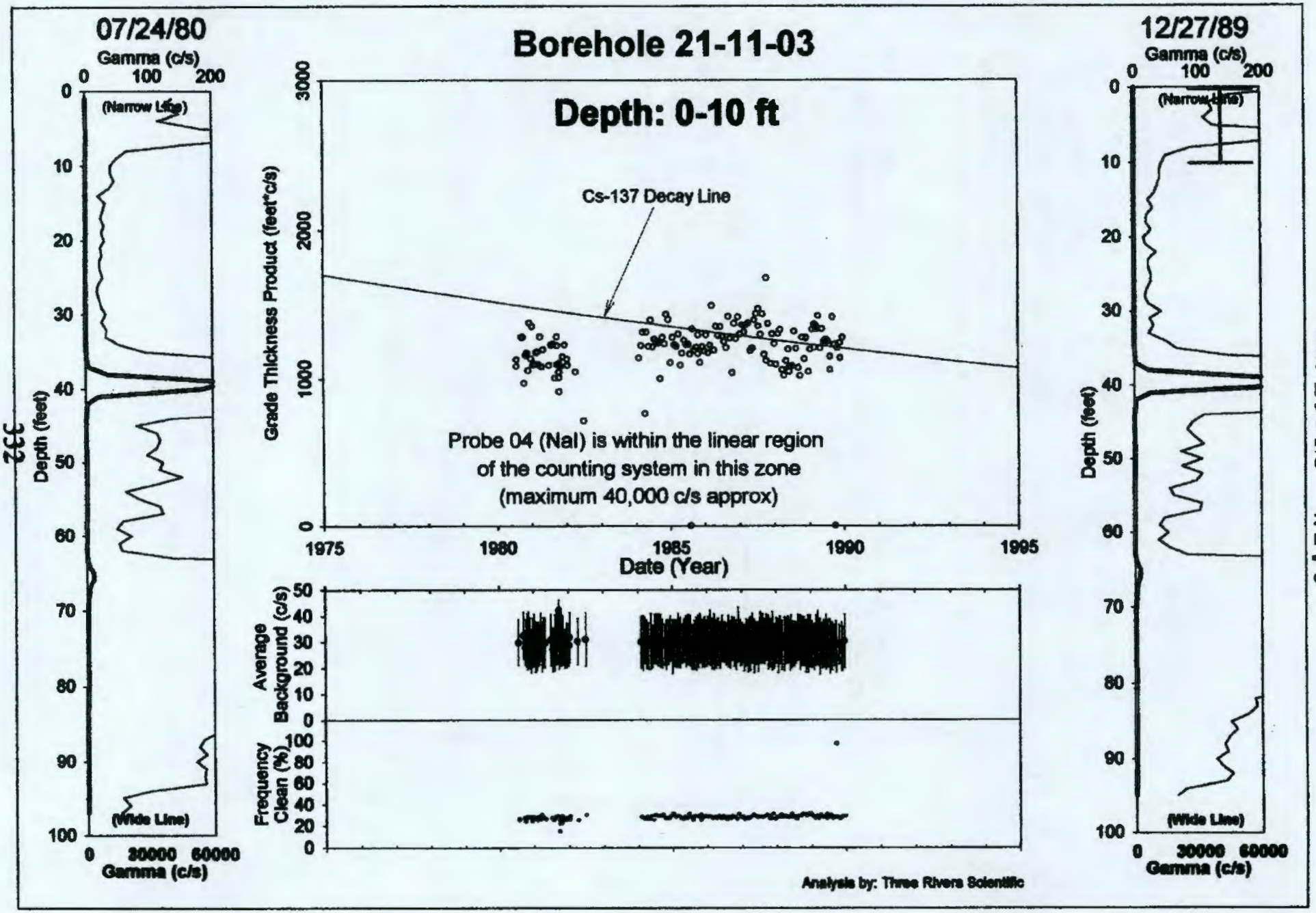
Grade Thickness Product from 44-62, 62-70, and 70-94 feet is decreasing at a rate consistent with Cesium-137 (identified from HPGe detector) between July 1980 and December 1989.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	14: Shielded NaI (21 surveys; 1980, 81, 89)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980
Last Survey Date :	12/19/1989
Number Surveys :	176

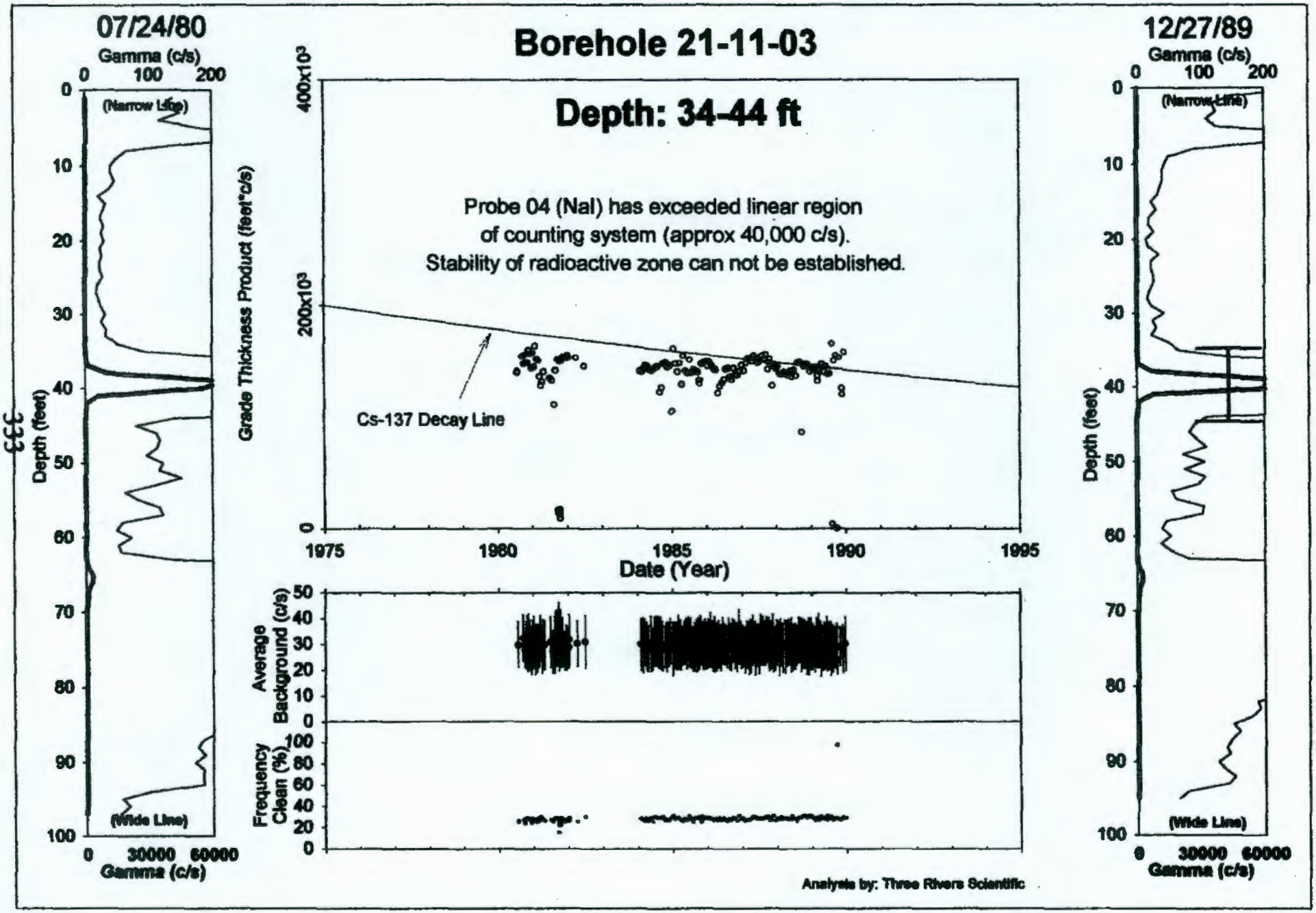
Analysis Notes

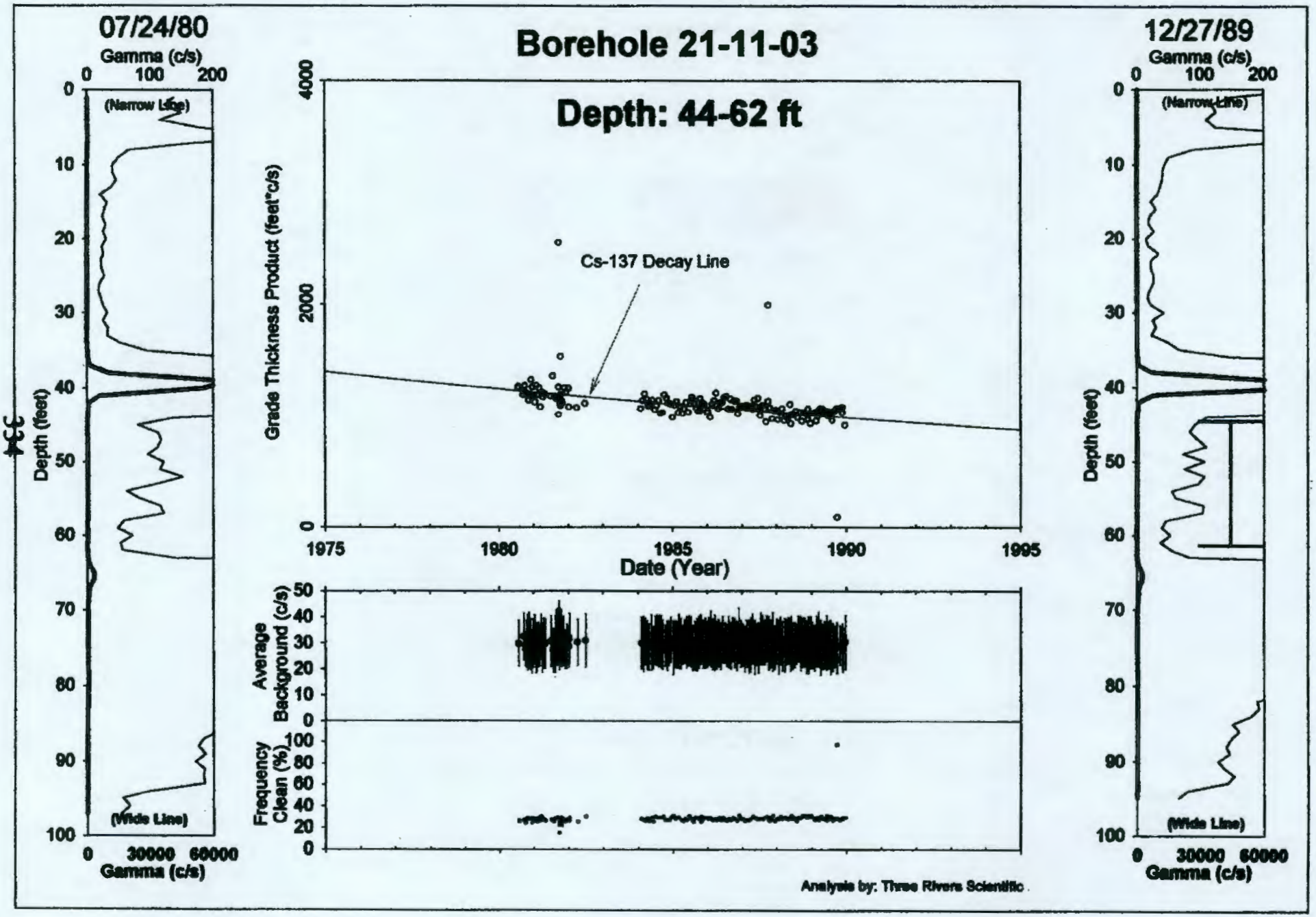
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**0-10 feet is Undetermined** **34-44 feet is Undetermined** **44-62, 62-70, 70-94 ft Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



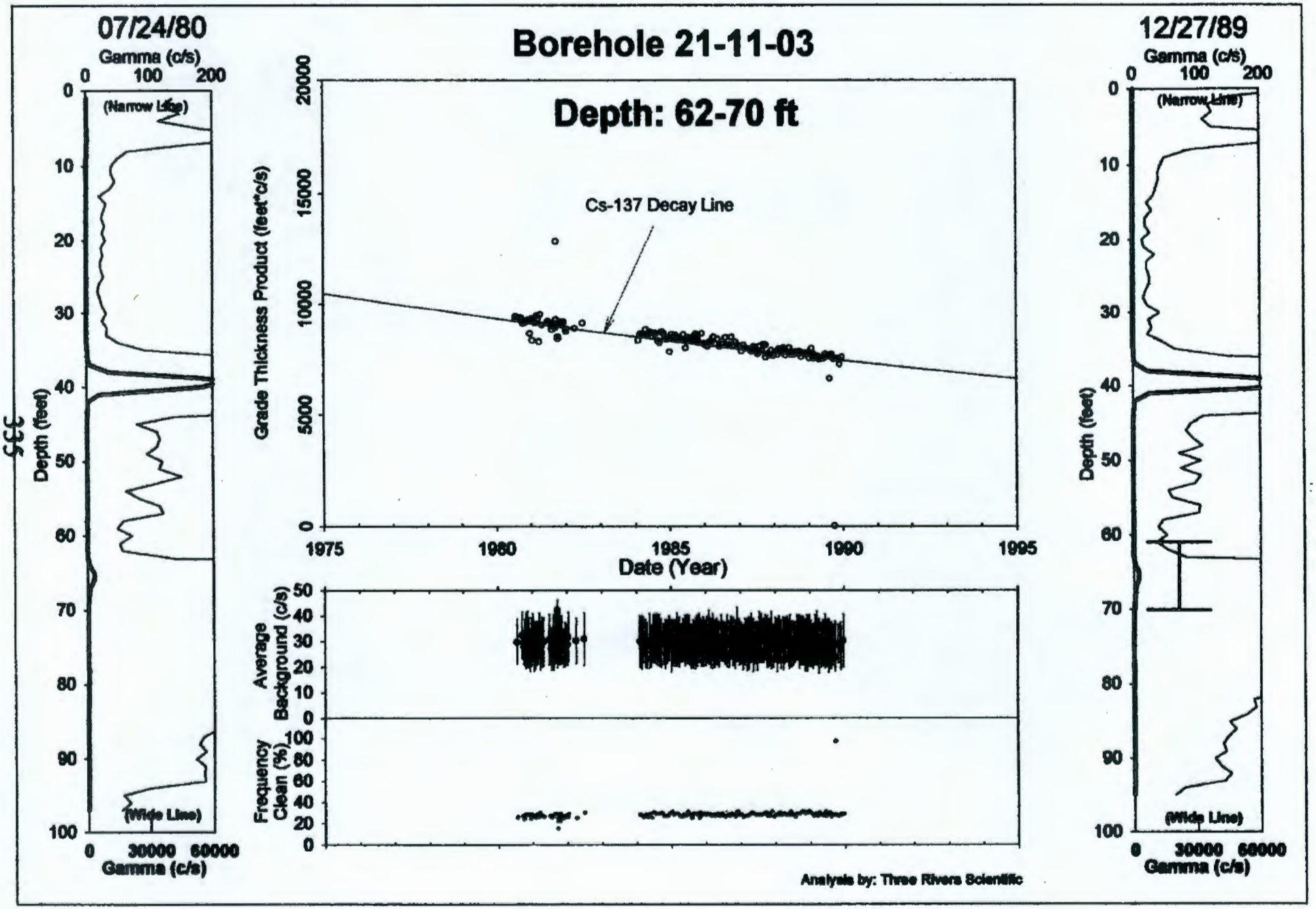
HNF-3531 -REV0

ZCC

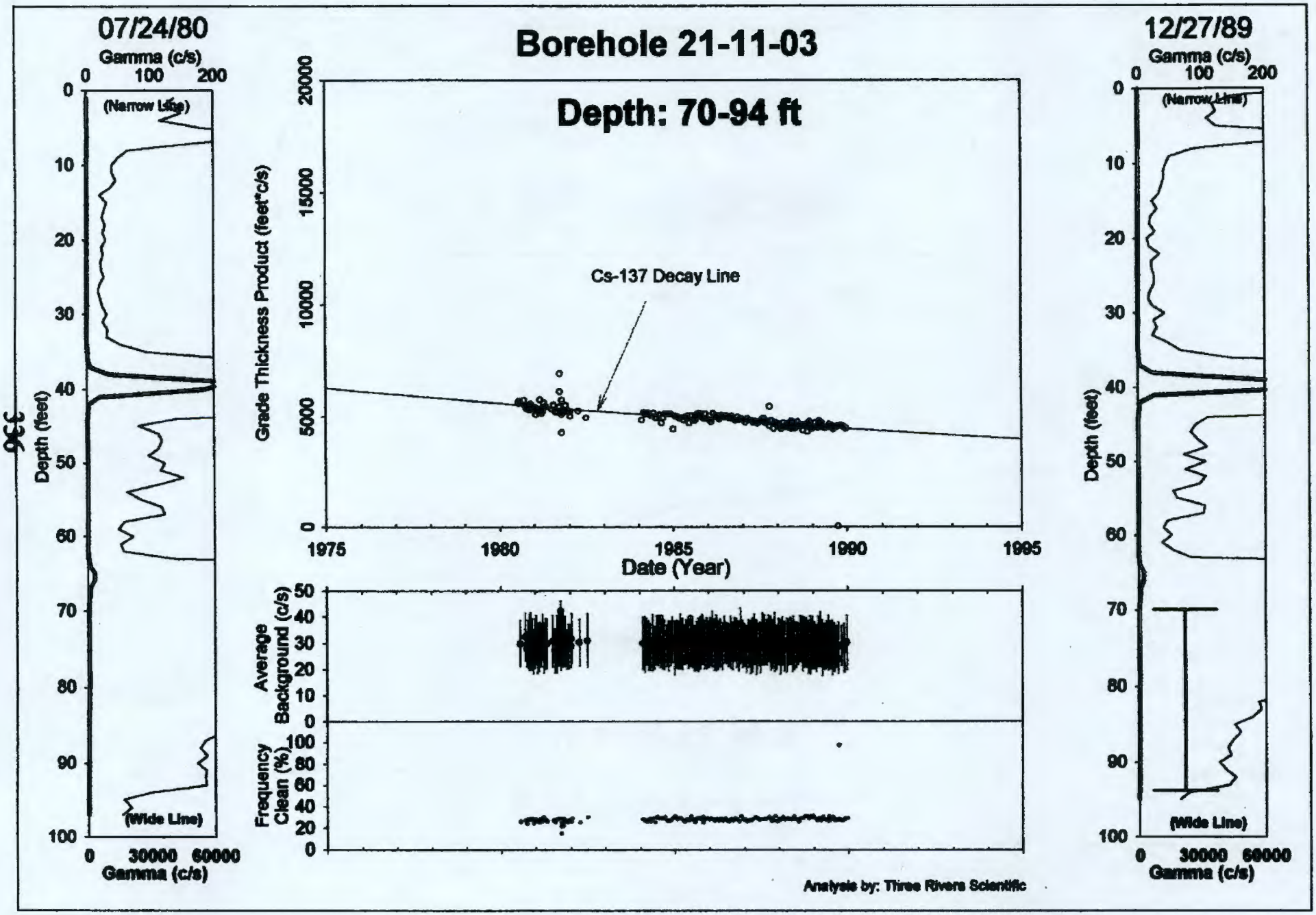

Borehole 21-11-03
Depth: 34-44 ft
Probe 04 (NaI) has exceeded linear region
of counting system (approx 40,000 c/s).
Stability of radioactive zone can not be established.
Cs-137 Decay Line
07/24/80
12/27/89
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Grade Thickness Product (feet*c/s)
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific



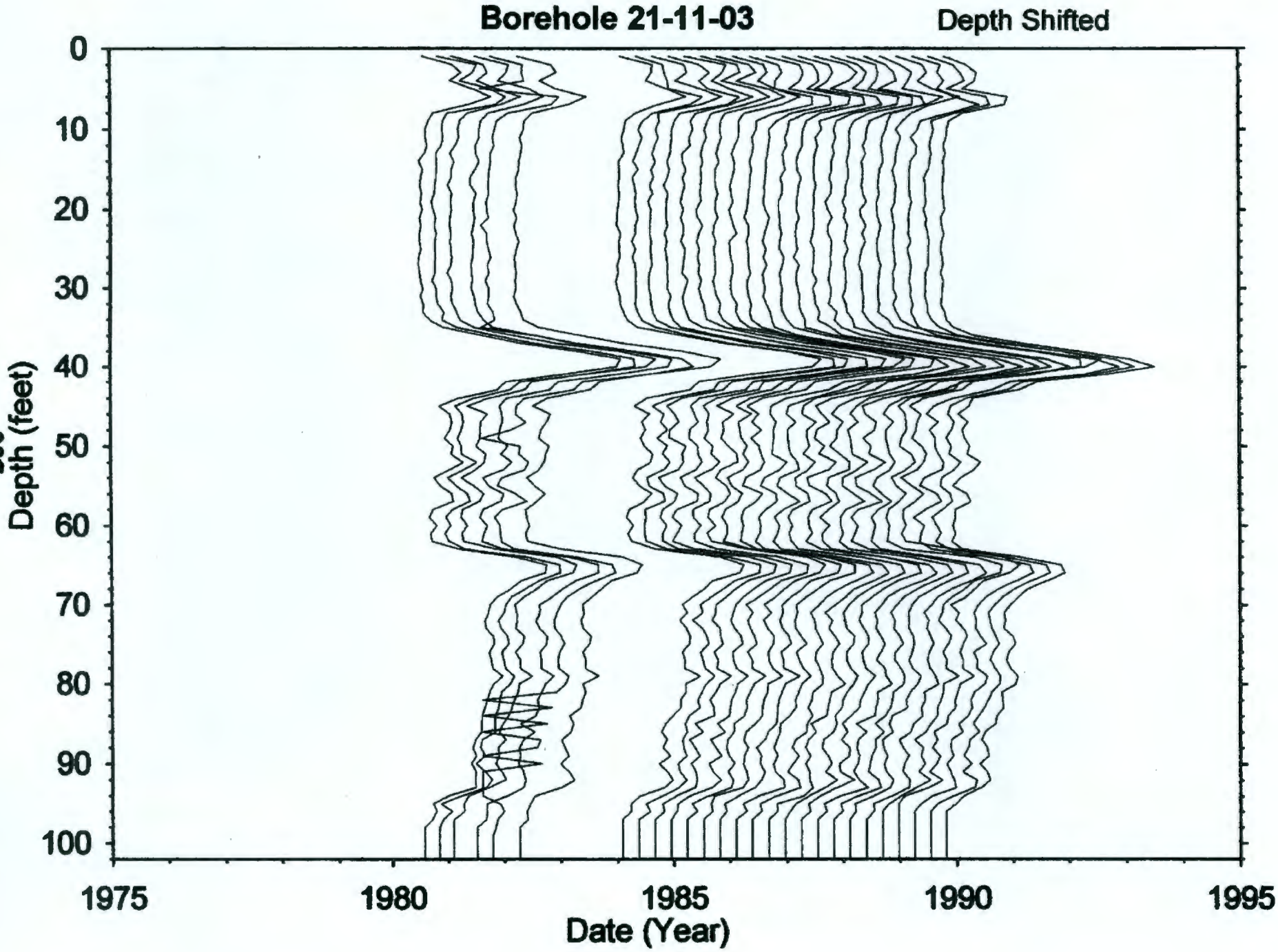
HNF-3531 -REV0



HNF-3531 -REV0



HNF-3531 -REV0


Borehole 21-11-03
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

14 = 80-01-10 → 89-08-
(21)

Borehole BX(21-11-03

Total # Surveys 97

Probe Type 04, 14

neutron surveys 0

GR Surveys 176, 21

Log Date: 80-07-24 1st

89-12-19 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
81-10-13	12	100	
95-07-30	13	98	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
89-09-22	NO PEAKS	100	WRONG BOREHOLE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
81-09-22	HI-BKG	97	15%	42.3	
89-09-22	80 CLEAN	98	97%	23.8	

Analysis Notes

ZONE 34-44 FT EXCEED LINEAR REGION OF SYS

Analyst Name Randall Rice

S/W ver TFGROSS V2.2

Borehole 21-11-04

Contamination (Cs-137) from 35 to 46 ft is Stable

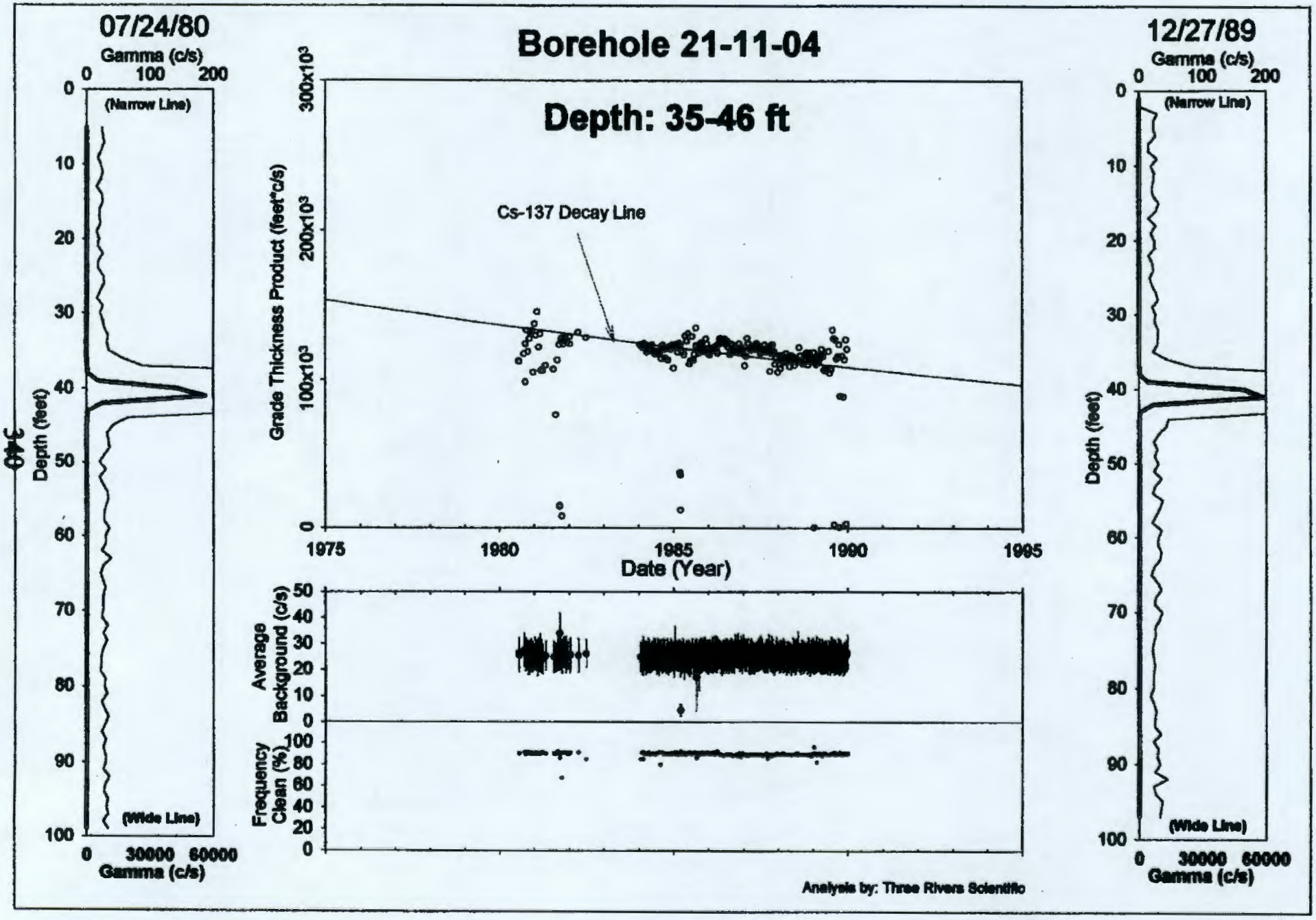
Surveillance logging activities were not designed to monitor high contamination levels with count rates exceeding 40,000 c/s. Grade Thickness Product from 35 to 46 feet is decreasing within counting system limitations at a rate consistent with Cesium-137 decay between July 1980 and December 1989.

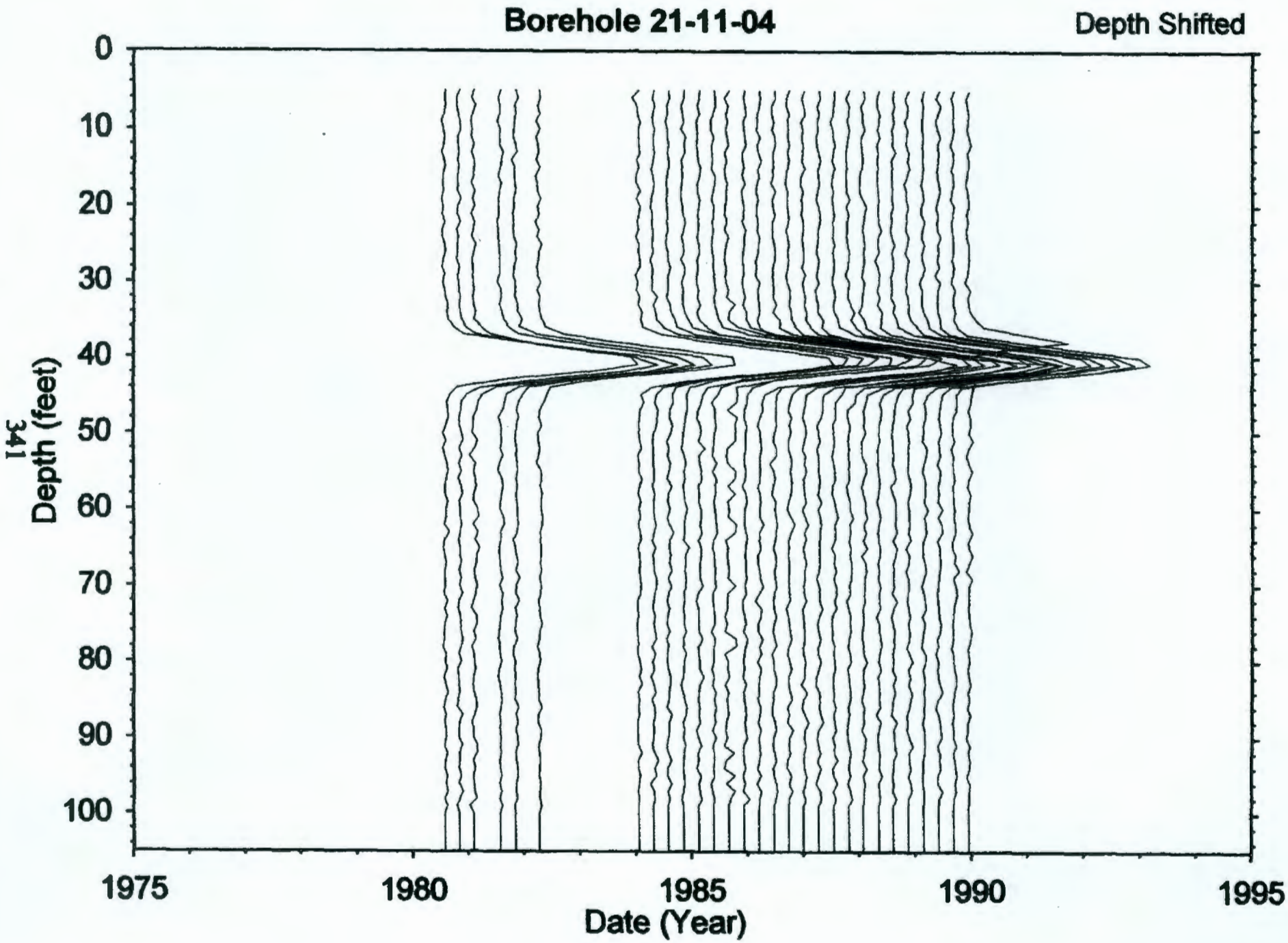
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	14: Shielded NaI (22 surveys; 1980, 85, 89)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	7/24/1980
Last Survey Date :	12/27/1989
Number Surveys :	218

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 :	**35-46 ft is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


Borehole 21-11-04
Depth: 35-46 ft
07/24/80
12/27/89
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 30000 60000
Gamma (c/s)
Grade Thickness Product (feet*c/s)
300x10³
200x10³
100x10³
Cs-137 Decay Line
1975 1980 1985 1990 1995
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific


Borehole 21-11-04
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-11-04)

Total # Surveys 240

Probe Type 64, 14 PAGE 14 (80-01-10 TO 89-

neutron surveys 0

GR Surveys 218

Log Date: 80-07-24 1st

89-12-27 Last

Presentation Plot Dates _____
(If different from 1st & Last)

Contamination Zone Depth(s): 30-46FT

Isotope from Spectral Survey: CS-137 CO-60

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
81-10-13	24	98	
84-08-15	10	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
89-01-10	NO RAD ZONE	98	PEAK MISSING
89-08-09A	BAD PEAK	98	POORLY DEFINED RAD ZONE
89-10-02	BAD PEAK	98	"
89-12-13A	BAD PEAK	98	"

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
81-10-13	% CLEAN	96	67%	24.9	
85-03-12B	AVG BKG	96	92%	4.5	
85-06-26	AVG BKG	98	86%	17.1	

Analysis Notes

Analyst Name _____ S/W ver _____.

Borehole 21-11-05

Contamination (Cs-137) from 40 to 46 ft is Undetermined

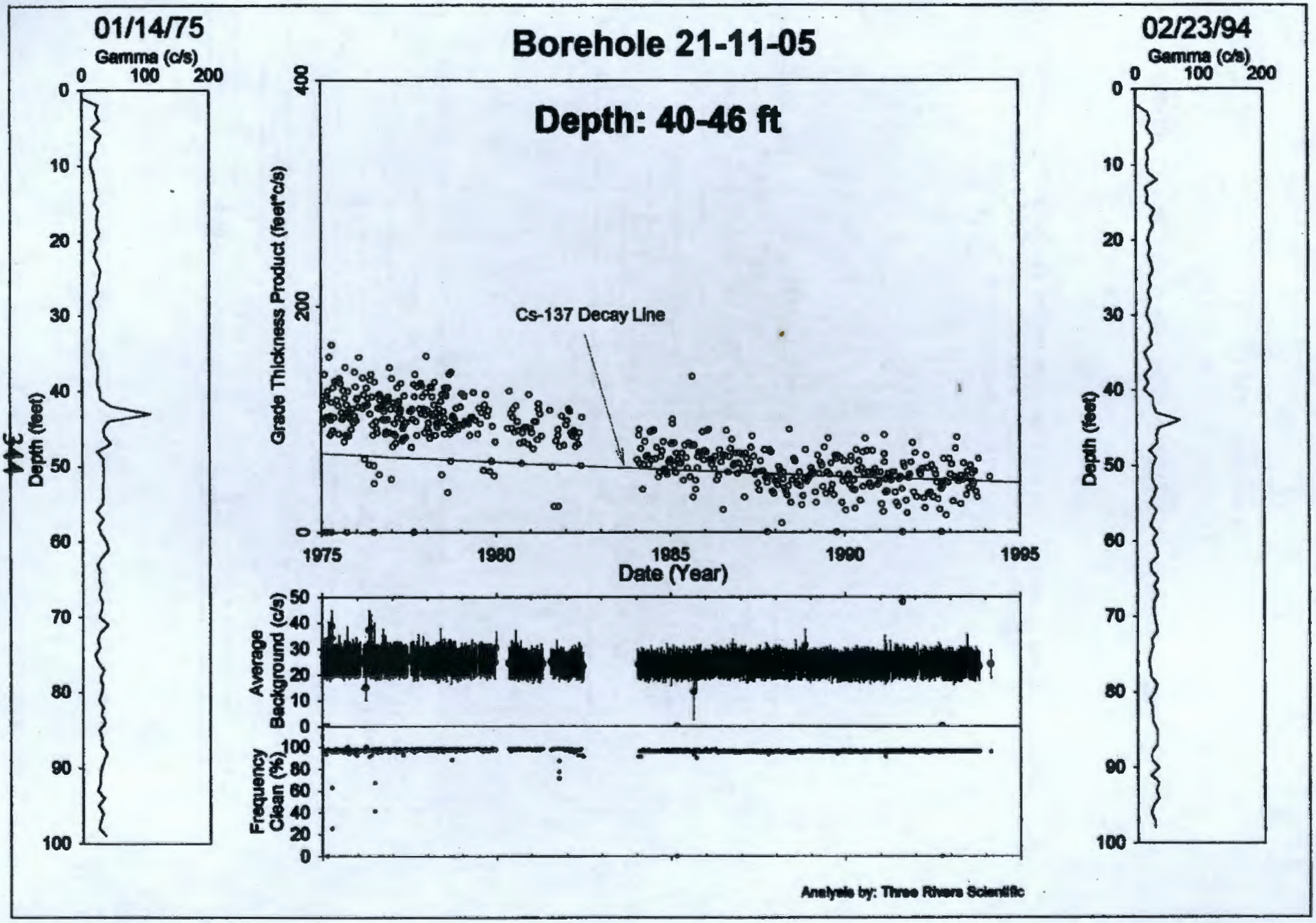
Grade Thickness Product from 40 to 46 feet is decreasing at a rate that appears to be greater than the decay rate of Cesium-137 (identified from HPGe detector) between January 1975 and February 1994.

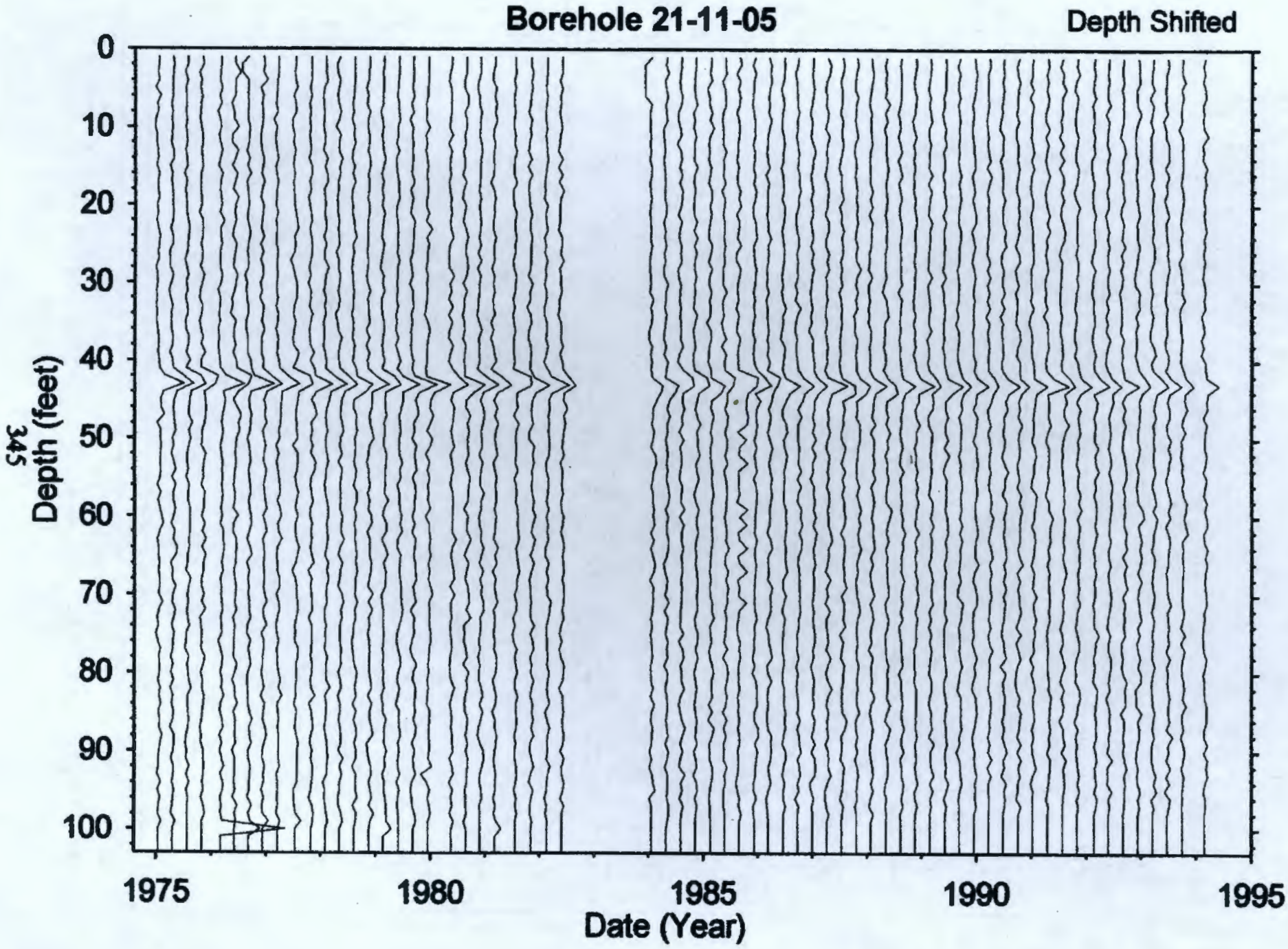
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	2/23/1994
Number Surveys :	558

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	50 to 90 ft
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**40-46 feet is Undetermined**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


01/14/75
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-11-05
Depth: 40-46 ft
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Date (Year)
1975
1980
1985
1990
1995
Average Background (c/s)
Frequency Clean (%)
02/23/94
Analysis by: Three Rivers Scientific


Borehole 21-11-05
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BK (21-11-05)

Total # Surveys 362

Probe Type 04

neutron surveys 4

GR Surveys 358

Log Date: 75-01-14 1st

94-02-23 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 42 FT

Isotope from Spectral Survey: CS-137

Max Survey Depth 100 FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
81-10-13A	11	98	
81-10-13B	24	98	
81-10-13C	22	98	
85-09-23	8	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-02-13	HI-CPS	100	TOOL MALFUNCTION
75-04-08	HI-CPS	100	POSSIBLE TOOL MALFUNCTION
75-04-09	HI-CPS	100	TOOL MALFUNCTION
76-06-22	HI-CPS	100	TOOL FAILURE
76-06-24	HI-CPS	100	TOOL MALFUNCTION
85-02-26	TOOL FAIL	100	TOOL FAILURE
92-09-29	TOOL FAIL	100	TOOL FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-02-13	AVG BKG	98	0%	0.0	
75-04-09	AVG BKG	99	25%	38.8	
76-06-22	% CLEAN	96	41%	30.6	
76-03-24	AVG BKG	96	100%	15.0	
81-10-13	% CLEAN	97	71%	22.7	
85-02-26	AVG BKG	99	0%	0.0	
85-08-26	AVG BKG	99	93%	13.2	
91-08-21	AVG BKG	98	97%	48.0	
92-09-29	AVG BKG	98	0%	0.0	

Analysis Notes

BKG (50-90 FT)

Analyst Name Randall Reid

S/W ver TF-GROSS V2.20

Borehole 21-11-07

Contamination (Cs-137 & Co-60) from 35 to 45 feet is Stable

Surveillance logging activities were not designed to monitor low contamination levels.

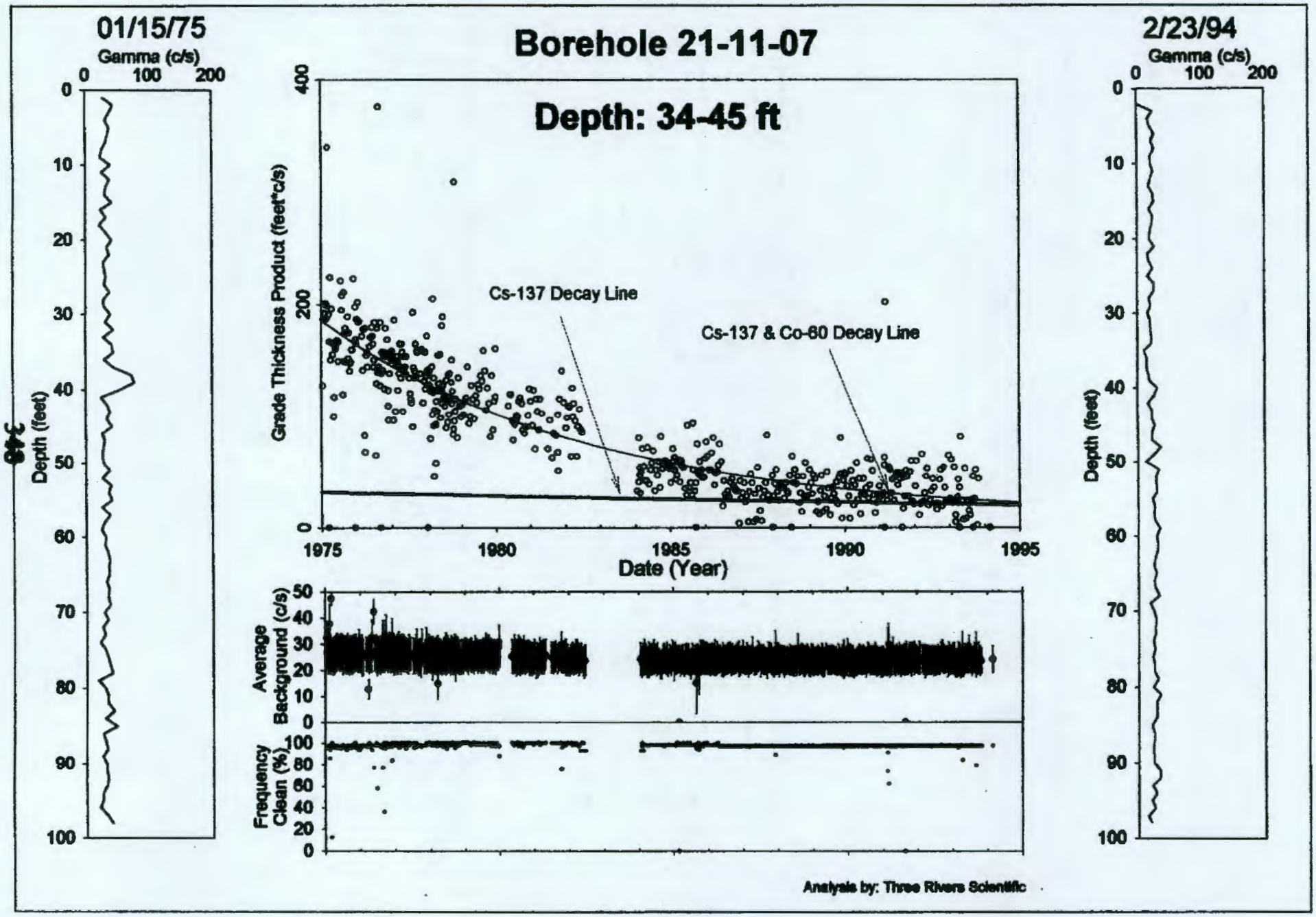
Grade Thickness Product from 35 to 45 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Cobalt-60 (both identified from HPGe detector) between January 1975 and February 1994. The least squares fit results in a gross gamma contribution ratio for Co-60 to Cs-137 of 1.3on February 1994.

Gross Gamma Survey Information

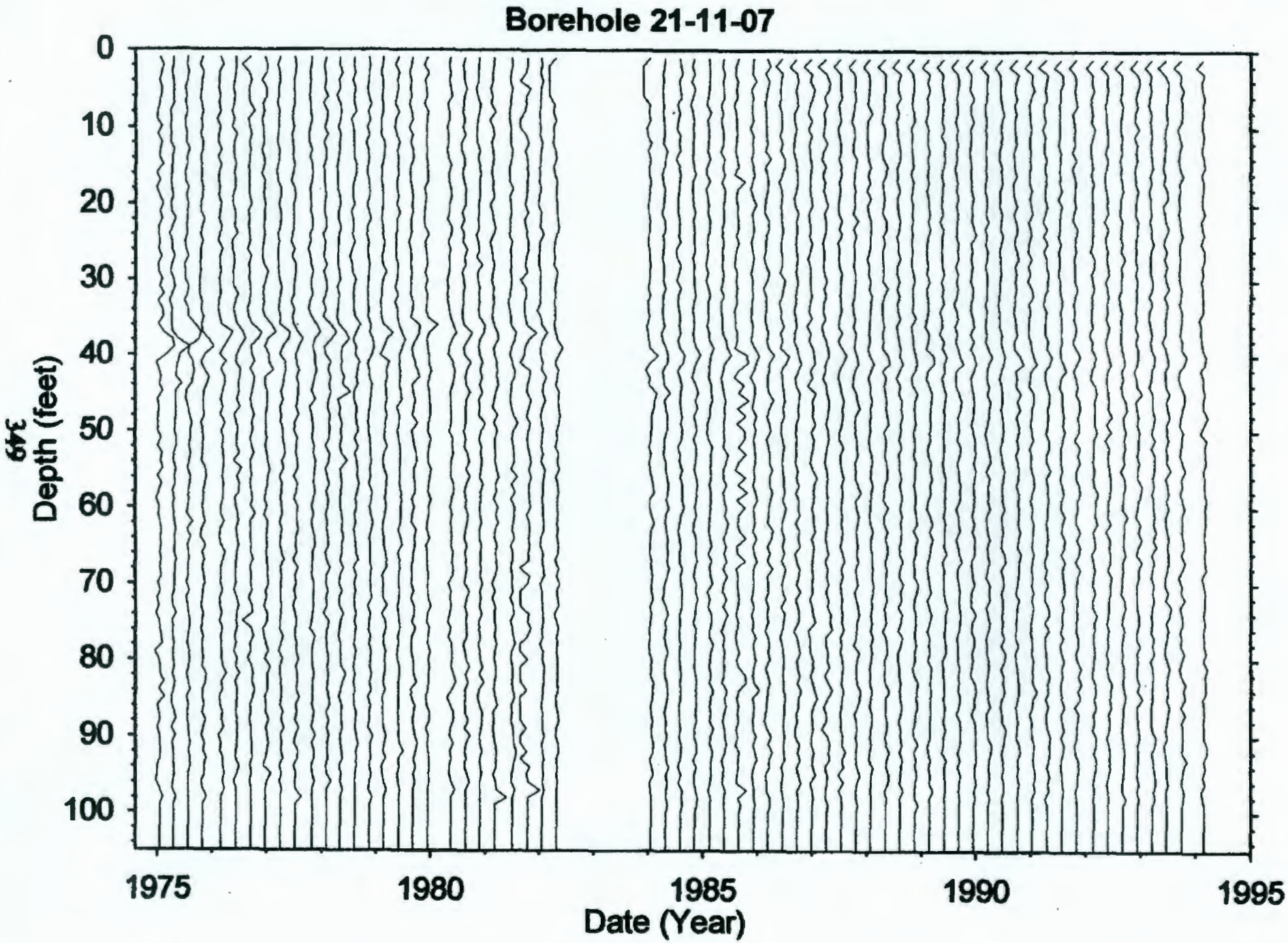
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	561

Analysis Notes

Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	5 to 35 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**35-45 ft is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



HNF-3531 -REV0


Borehole 21-11-07
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-11-07)

Total # Surveys 565

Probe Type 04

neutron surveys 4

GR Surveys 561

Log Date: 75-01-15 1st

94-02-23 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 40FT (35-45FT)

Isotope from Spectral Survey: CS-137 (<5 pCi/g @ 0 & 40') CO-60 @ 44FT < 0.1 pCi/gm

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
76-09-02	8	40	BAD SURVEY
81-08-13	21	98	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-03-05	HI CPS	100	
76-06-23	MALFUNCTN	100	TOOL PROBABLY MALFUNCTION
76-09-02A	TOOL FAIL	40	TOOL MALFUNCTION
76-11-23A	MALFUNCTION	102	PROBABLE TOOL MALFUNCTION
79-12-26	HI-CPS	98	POSSIBLE TOOL MALFUNCTION
85-02-26	TOOL FAIL	100	TOOL MALFUNCTION
87-11-30	HI-CPS	100	TOOL MALFUNCTION
91-02-19 (91-02-20A) 91-03-05)			– TOOL MALFUNCTION
91-08-21	HI-CPS		TOOL MALFUNCTION

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-03-05	% CLEAN	98	12%	47.4	
76-03-24	AVG BKG	95	98%	12.7	
76-05-19	AVG BKG	96	77%	42.4	
85-02-26	% CLEAN	99	0%	0.0	
85-08-26	AVG BKG	99	95%	15.1	
91-08-21	% CLEAN	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
BACKGROUND 5-35FT

Analyst Name Randall Price

S/W ver TFGROSS V2.20

filein := "two.txt"

Well 21-11-07

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

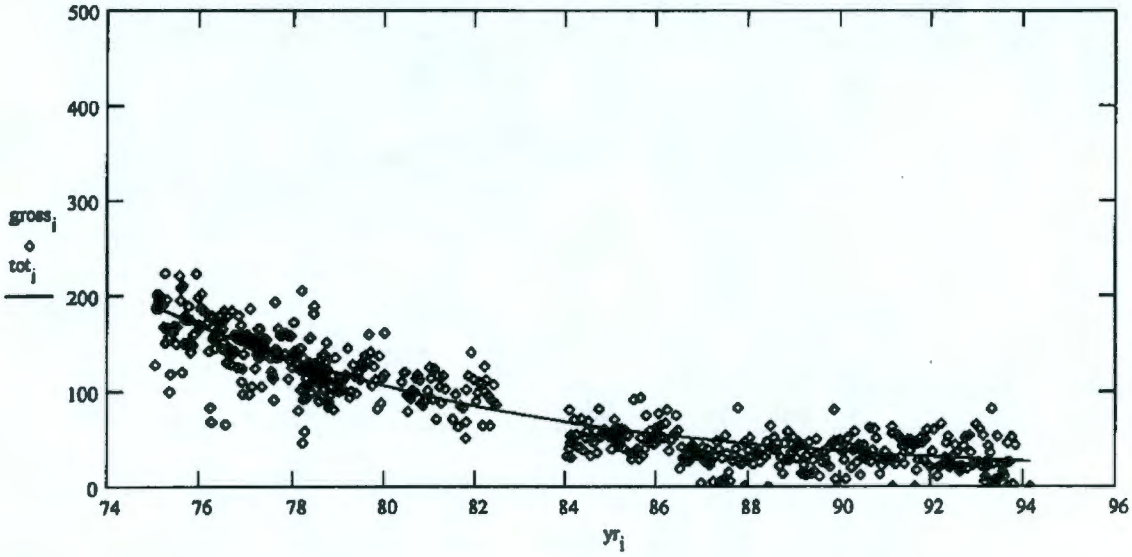
$N := last(yr)$ $\quad N = 550$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau co := 5.27$ $\quad \tau cs := 30.17$ $\quad aco := 170$ $\quad acs := 20$

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad tot_i := Cs_i + Co_i$

$gross_i := net_i$

This data edited for spurious points



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

Given

$ssq(acs, aco) = 0$ $\quad 1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha co \end{bmatrix} := \mathrm{Minerr}(acs, aco)$$

$\alpha cs = 15.785$ $\quad \alpha co = 170.204$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $\quad Eu_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}}$ $\quad tot_i := Cs_i + Co_i$

$\frac{\alpha cs}{\alpha co} = 0.093$

$\frac{Co_N}{Cs_N} = 1.347$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

Borehole 21-11-10

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 1994 in the vadose zone from 2 to 100 feet.

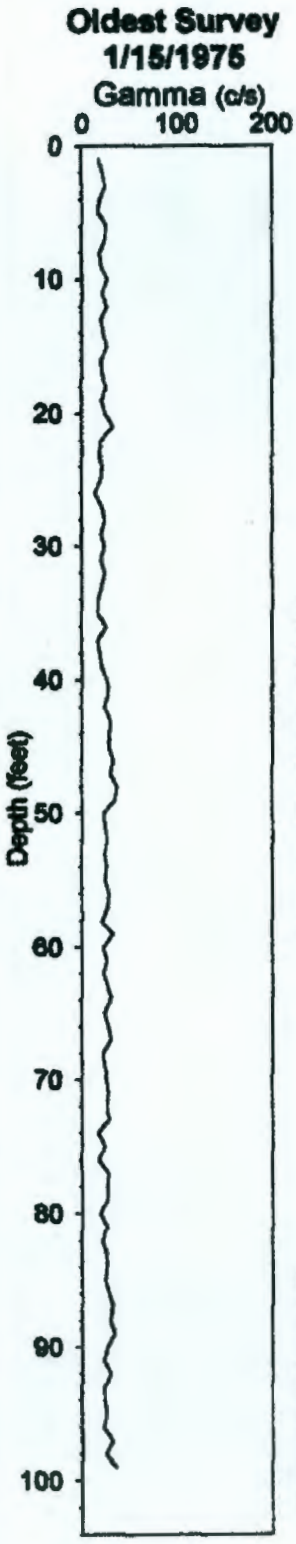
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	554

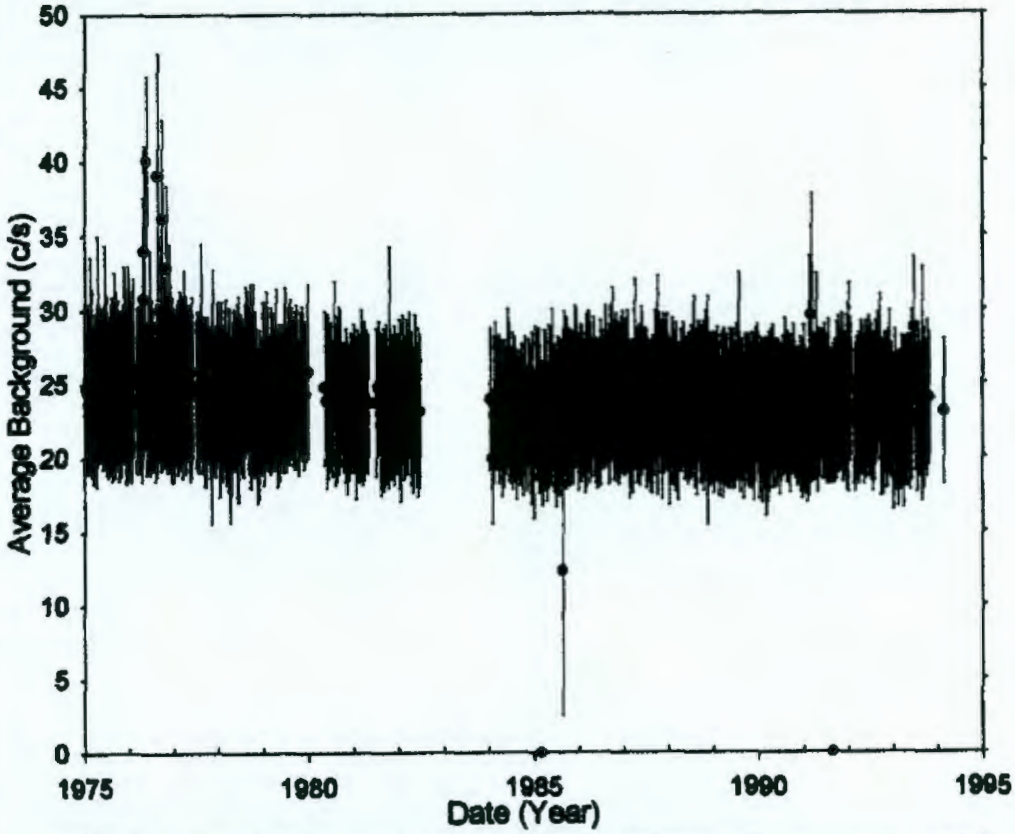
Analysis Notes

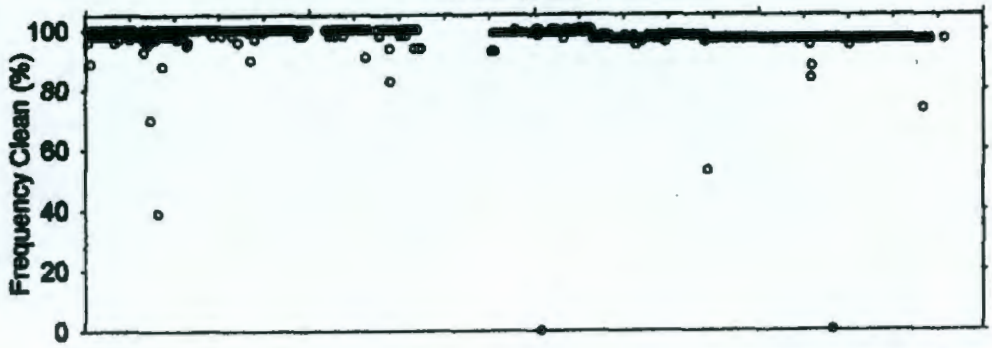
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**No Contamination**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-11-10

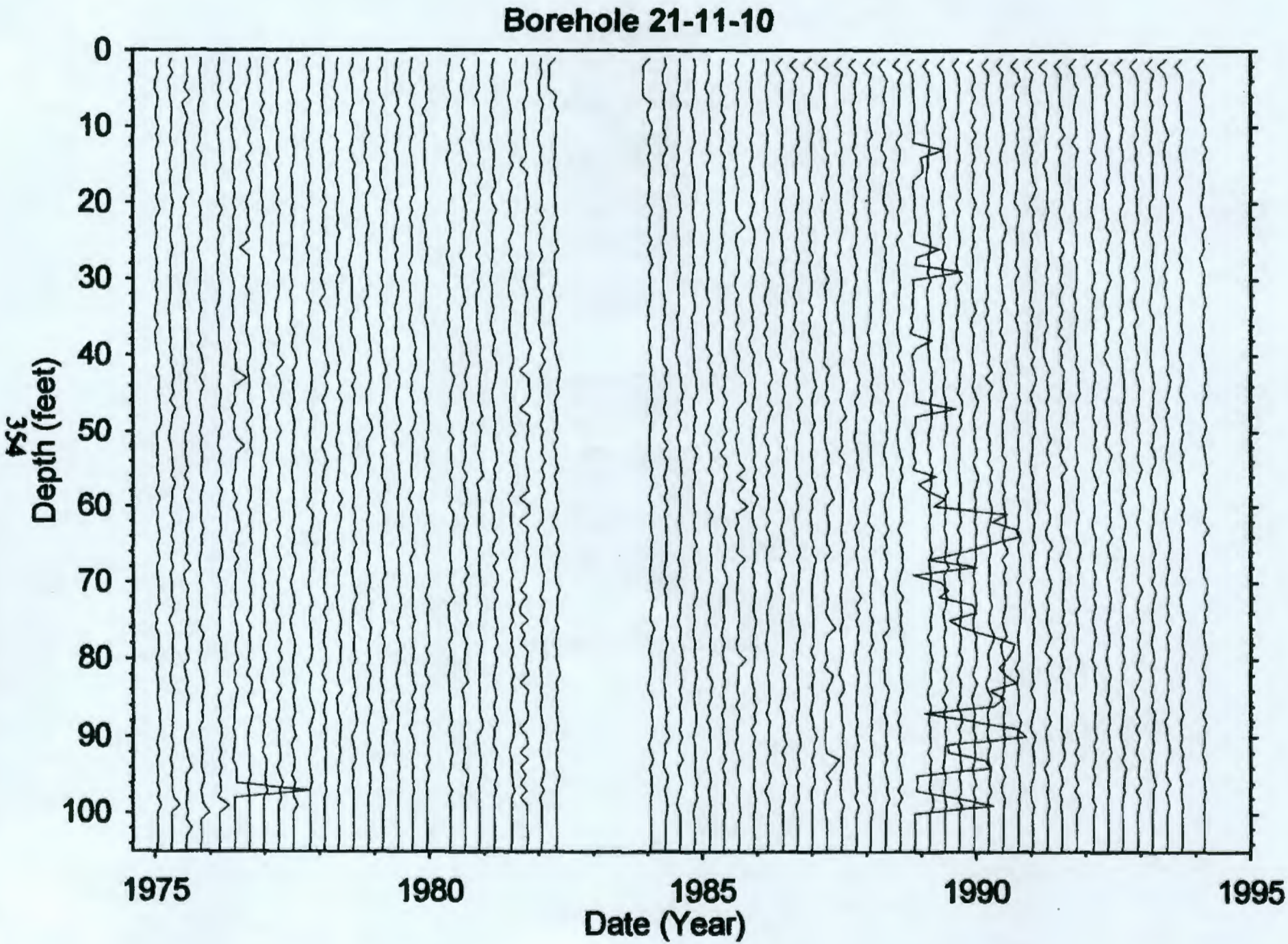


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-11-10
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-11-10)

Total # Surveys 558

Probe Type 04

neutron surveys 4

GR Surveys 554

Log Date: 75-01-15 1st

94-02-23 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 SURFACE ONLY

Max Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	9	98	
81-10-13	16	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
76-06-15	HIGH CPS	98	PROBABLE TOOL MALFUNCTION
76-08-18	HI-BKG	100	HIGH AVG BKG
85-02-26	TOOL FAIL	100	TOOL FAILURE
88-11-14A	TOOL FAIL	100	TOOL FAILURE PROBABLE
88-11-14C	TOOL FAIL	100	"
91-08-21	HI-BKG	100	HIGH AVG BKG
93-09-01	HIGH BKG	100	PROBABLE TOOL FAILURE

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
76-05-19	HI-BKG	97	95%	40.1	
76-08-18	HI-BKG	98	39%	39.1	
81-03-30	SHORT SURVEY	12	91%	23.9	
85-02-26	HI-BKG	100	0%	0.0	
91-08-21	HI-BKG	99	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE IDENTIFIED

Analyst Name Randall Reid

S/W ver TF-GROSS V2.20

Borehole 21-11-11

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 1994 in the vadose zone from 2 to 100 feet.

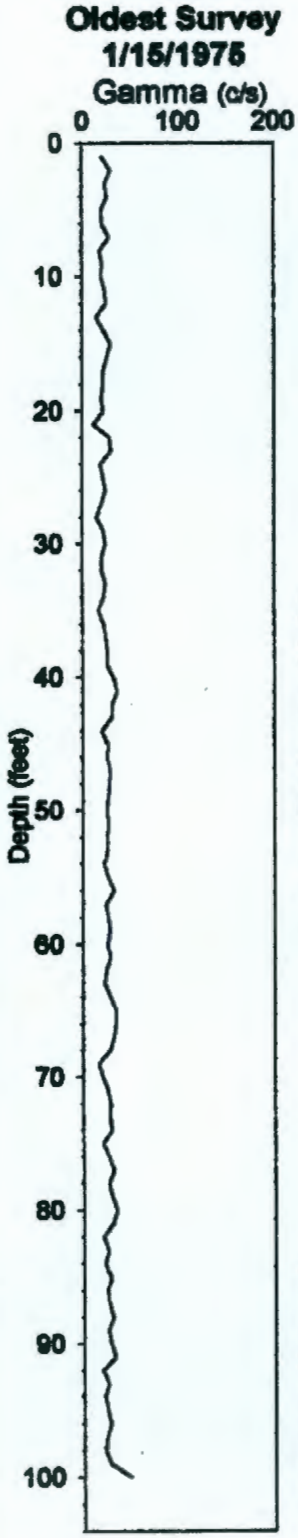
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/15/1975
Last Survey Date :	2/23/1994
Number Surveys :	554

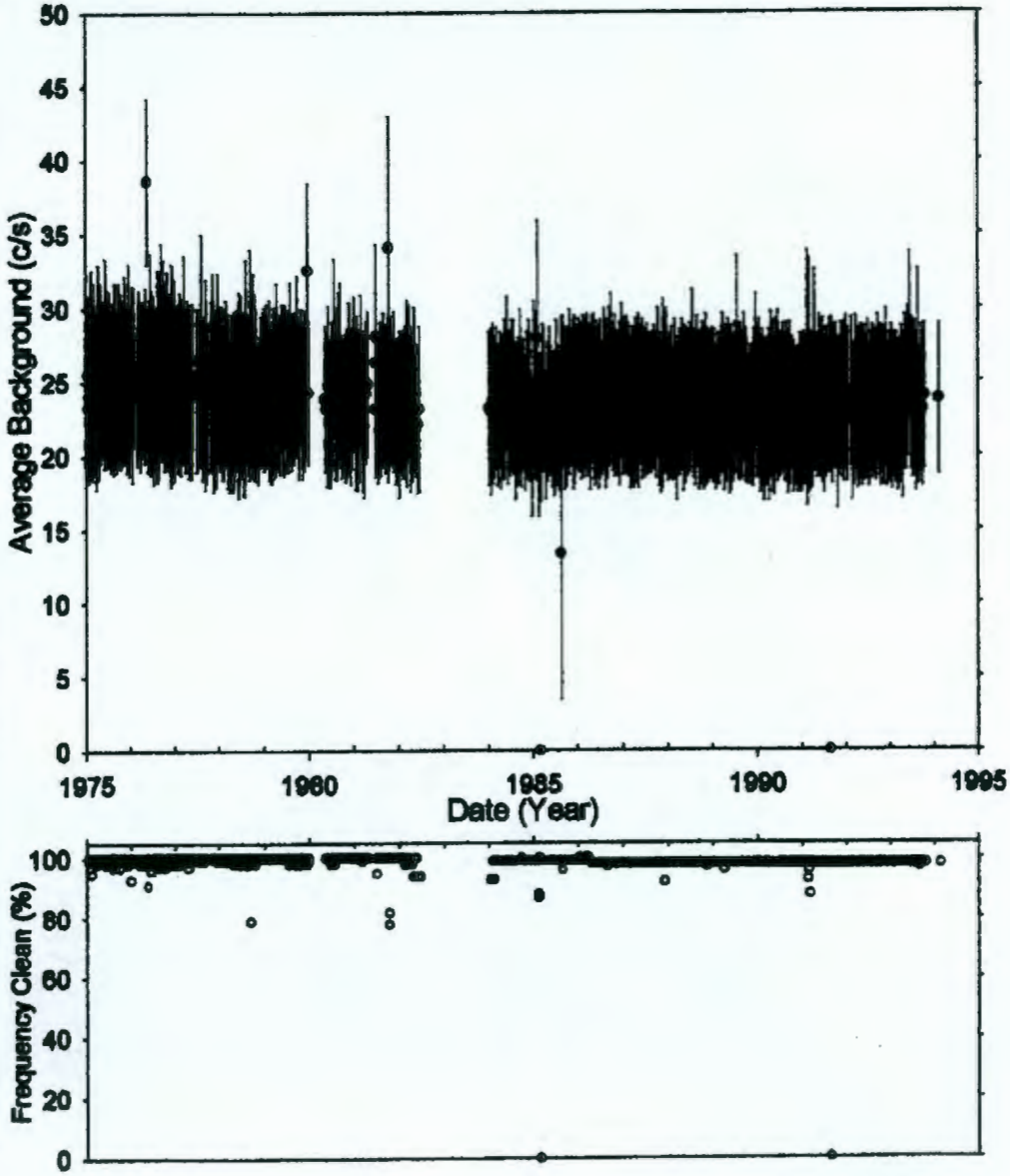
Analysis Notes

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

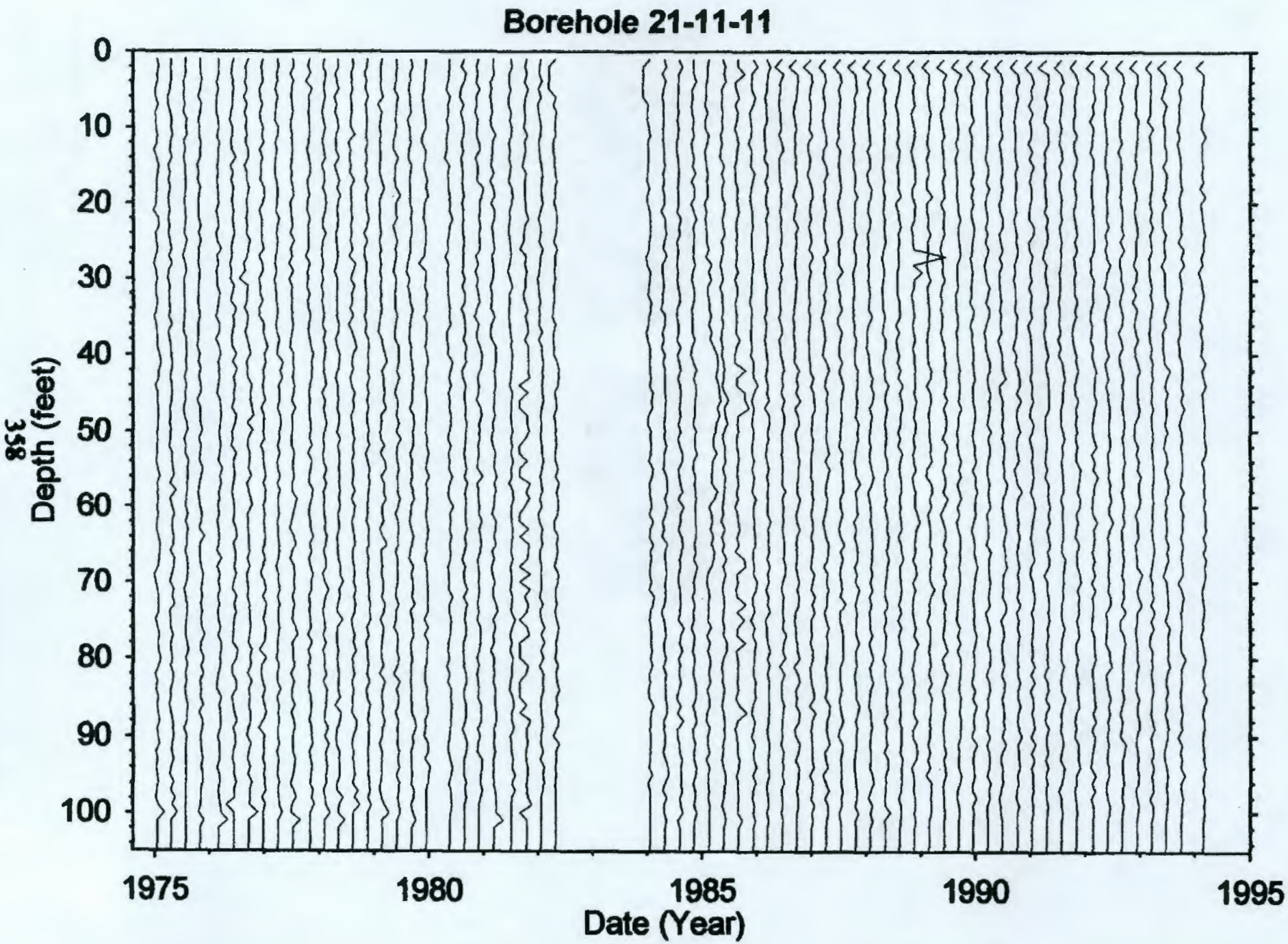
Borehole 21-11-11



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-11-11
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-11-11)

Total # Surveys 558

Probe Type 04

neutron surveys 4

GR Surveys 554

Log Date: 75-01-15 1st

94-02-23 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (SURFACE ONLY)

Max Survey Depth 100 FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
75-12-30	6	95	
78-09-13	20	95	
81-10-13	22	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
81-10-15	HI-BKG	100	
85-02-26	TOOL-FAILE	100	TOOL MALFUNCTION
91-03-05	SURVEY DIAL	100	POSSIBLE WRONG HOLE ID
91-08-21	HI-BKG	100	HI AVG TOOL COUNTS

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
76-05-19	HI-BKG	99	91%	38.6	
79-12-26	HI-BKG	99	100%	32.6	
81-10-13	% CLEAN	100	78%	24.0	
81-10-15	~~HI~~-BKG	94	92%	34.1	
85-02-26	ACTIVITY	101	0%	0.0	
85-08-26	AVG BKG	101	96%	13.4	
91-08-21	AVG CNTS	100	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE IDENTIFIED ON TF SURVEYS

Analyst Name Randall Rutt

S/W ver TFGROSS V2.20

Borehole 21-12-02

Contamination (Cs-137) from 0 to 6 feet is Tank Farm Activity
Contamination (Cs-137) from 6 to 20 ft is Undetermined

Grade Thickness Product from 0 to 6 feet is erratic from 1975 to 1986 and is categorized as Tank Farm activity. Surveillance logging activities were not designed to monitor low contamination levels or contamination near the surface. Grade Thickness Product from 1986 through 1995 is decreasing at a rate consistent with Cs-137 (identified from HPGe detector).

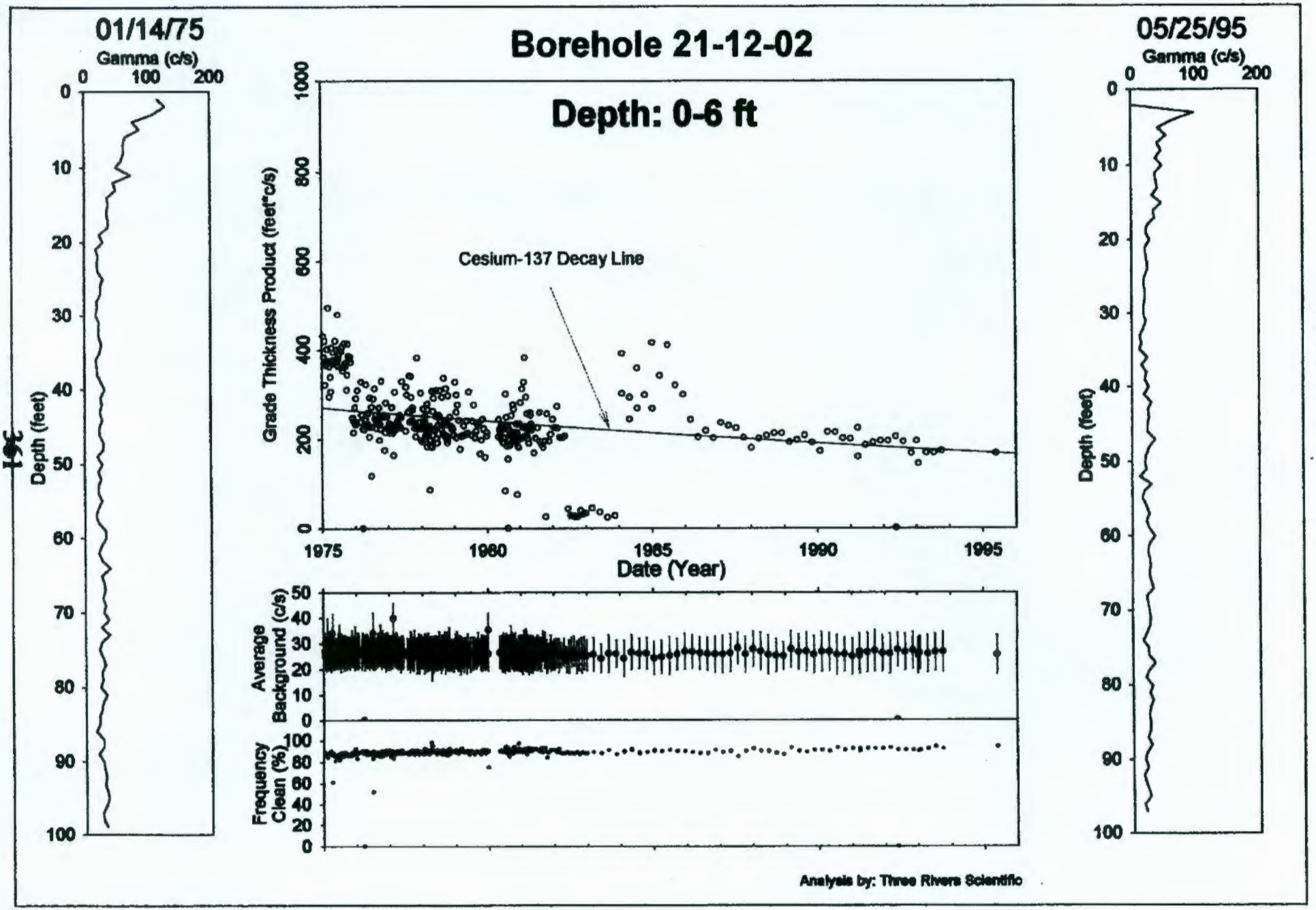
The radioactive zone from 6 to 20 feet has three time intervals that warrant discussion. (1) From 1975 to 1976 the Grade Thickness Product appears to be decreasing at a high rate which may indicate a short lived radionuclide, possibly Ru-106. (2) From 1976 to 1982 the Grade Thickness Produce is decreasing within counting statistics at a rate consistent with Cesium-137, then a step increase appears to have occurred. (3) From 1982 through 1994 the Grade Thickness Produce is decreasing within counting statistics at a rate consistent with Cesium-137 (identified from HPGe detector).

Gross Gamma Survey Information

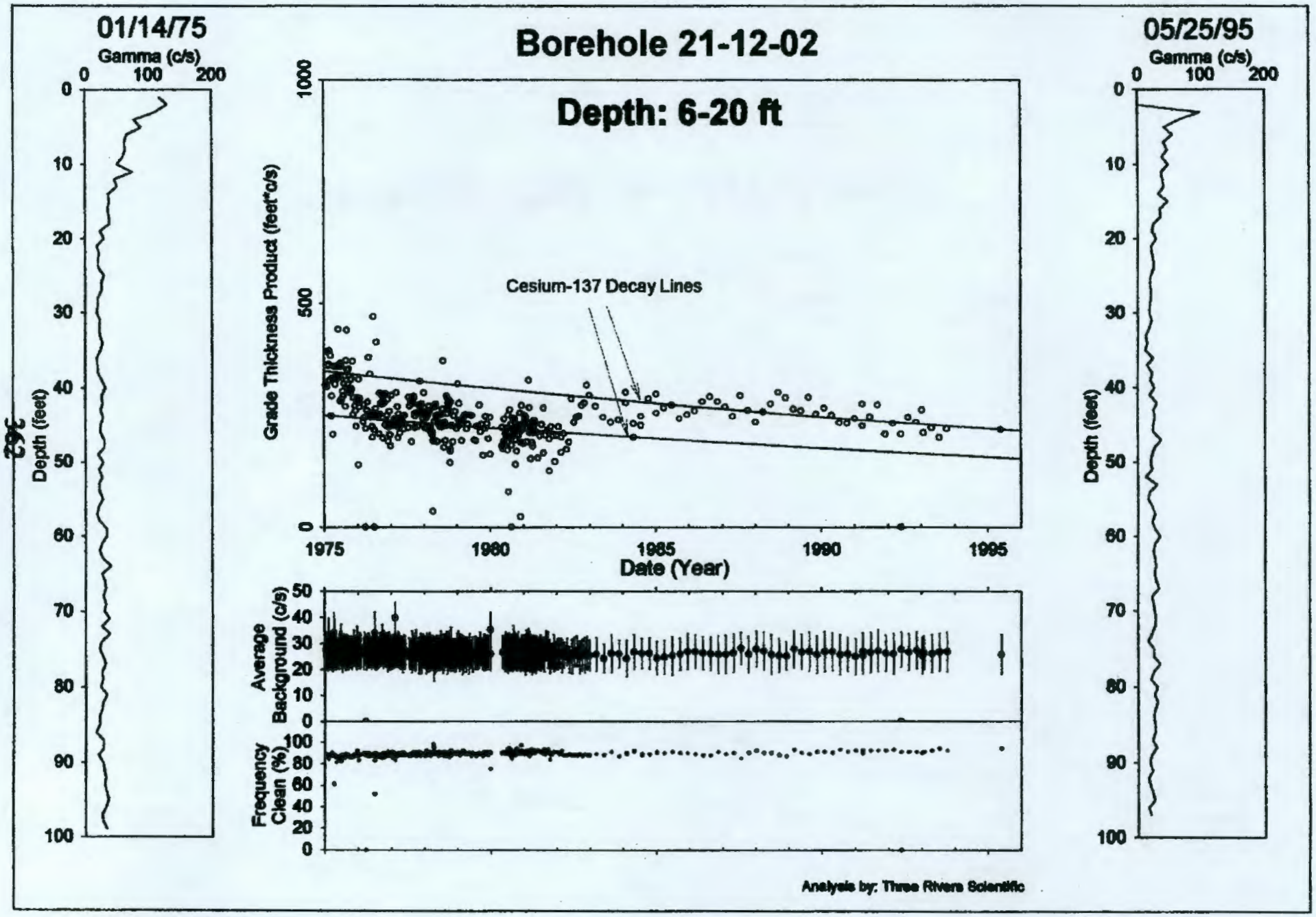
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (3 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	361

Analysis Notes

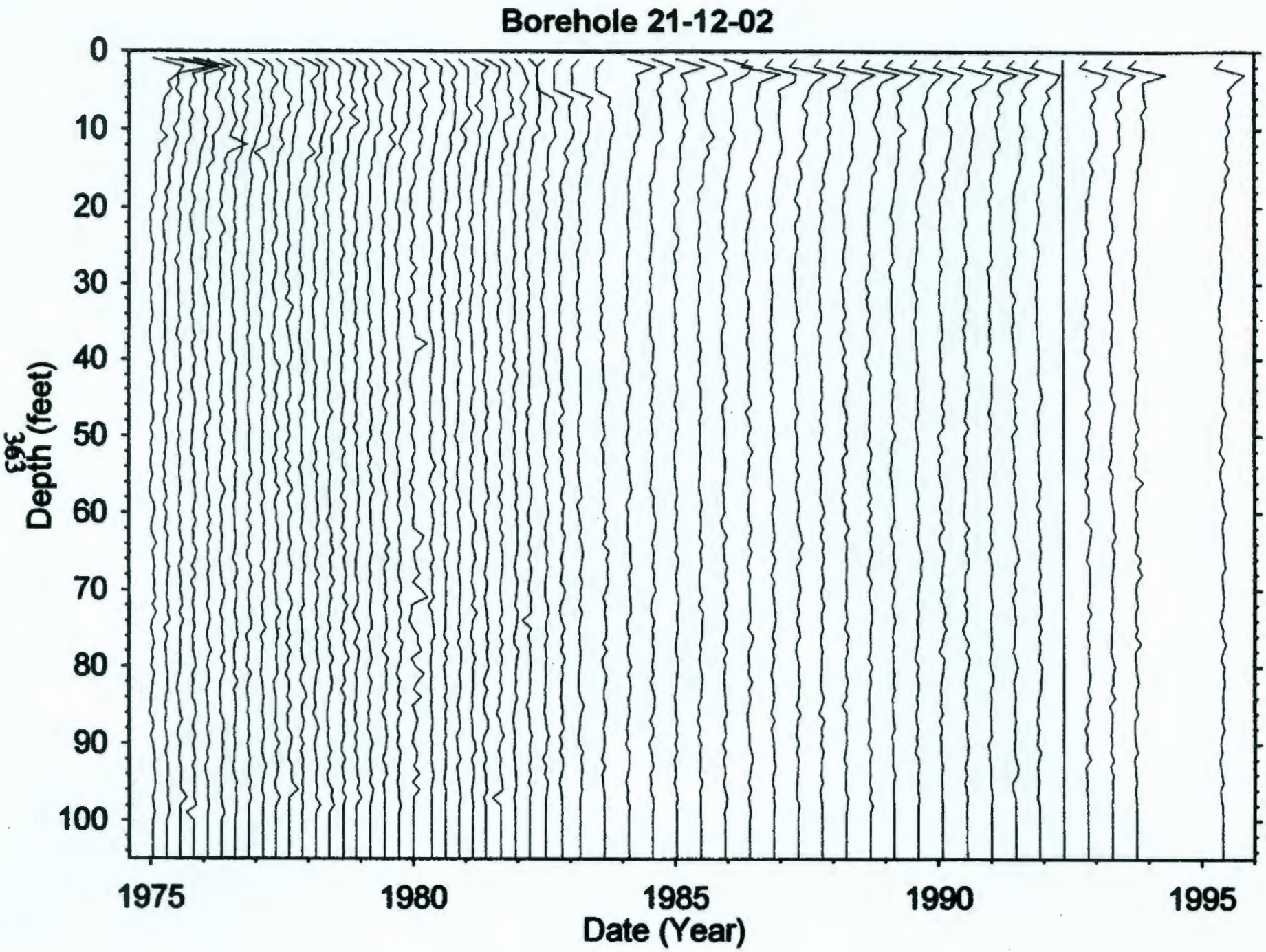
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	20 to 95 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**0-6 ft is TF Activity** **6-20 feet is Undetermined**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



HNF-3531 -REV0



HNF-3531 -REV0


Borehole 21-12-02
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-12-02)

Total # Surveys 364

Probe Type 04

neutron surveys 3

GR Surveys 361

Log Date: 75-01-14 1st

95-05-25 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): SURFACE TO 20 FT

Isotope from Spectral Survey: CS-137 (Co-60 @ 42FT < .2 pCi/g) Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
76-01-07	8	98	
76-03-24	96	98	
81-10-13	13	100	
92-05-18	97	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
			1982-02-08 LOG PROCEDURE CHANGES, TO INCLUDE SURVEY TO TOP OF WELL

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-04-09	% CLEAN	98	61%	34.0	HIGH BKG
76-03-24	BAD SURVEY	96	0%	0.0	
76-06-30	% CLEAN	93	52%	33.9	
77-02-10	HI BKG	97	83%	35.7	
79-12-26	% CLEAN	96	75%	35.2	
92-05-18	BAD SURVEY	97	0%	0.0	

Analysis Notes

LOW LEVEL CONTAMINATION FROM SURFACE (0FT) TO 20FT.
MAX CS-137 = 20 pCi/g @ 2FT
DEPTH ZONE 0-6FT & 6 TO 20FT
BACKGROUND 20-95FT

Analyst Name Randall Price S/W ver TFGROSS V.2.20

Borehole 21-12-05

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.

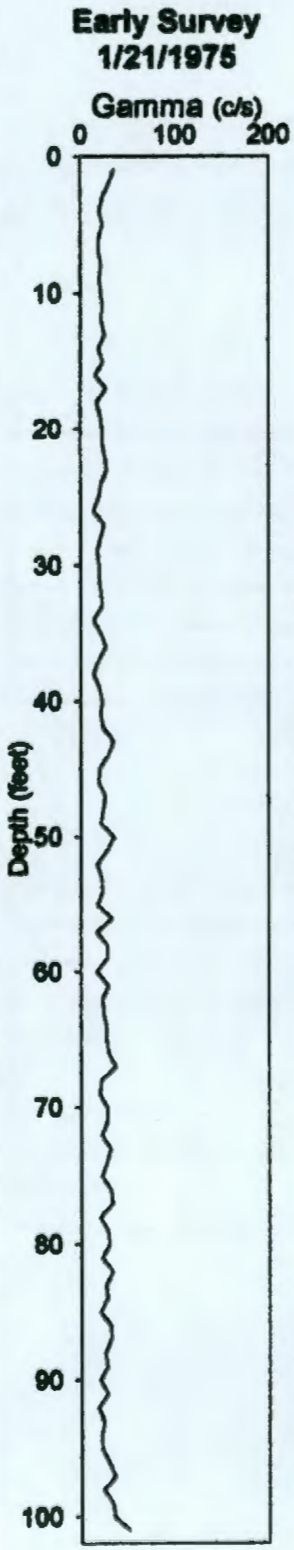
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	344

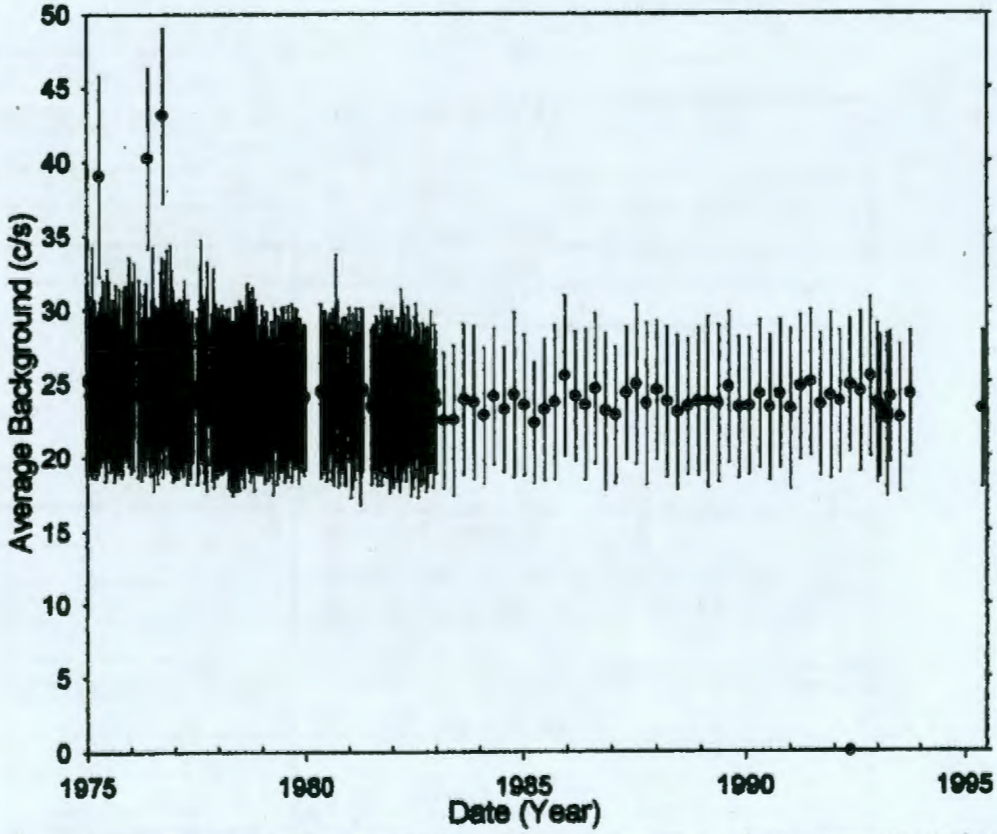
Analysis Notes

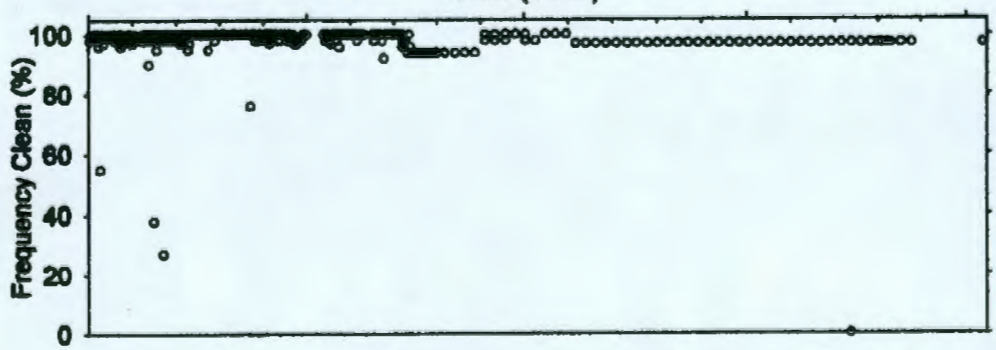
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**No Contamination**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-12-05

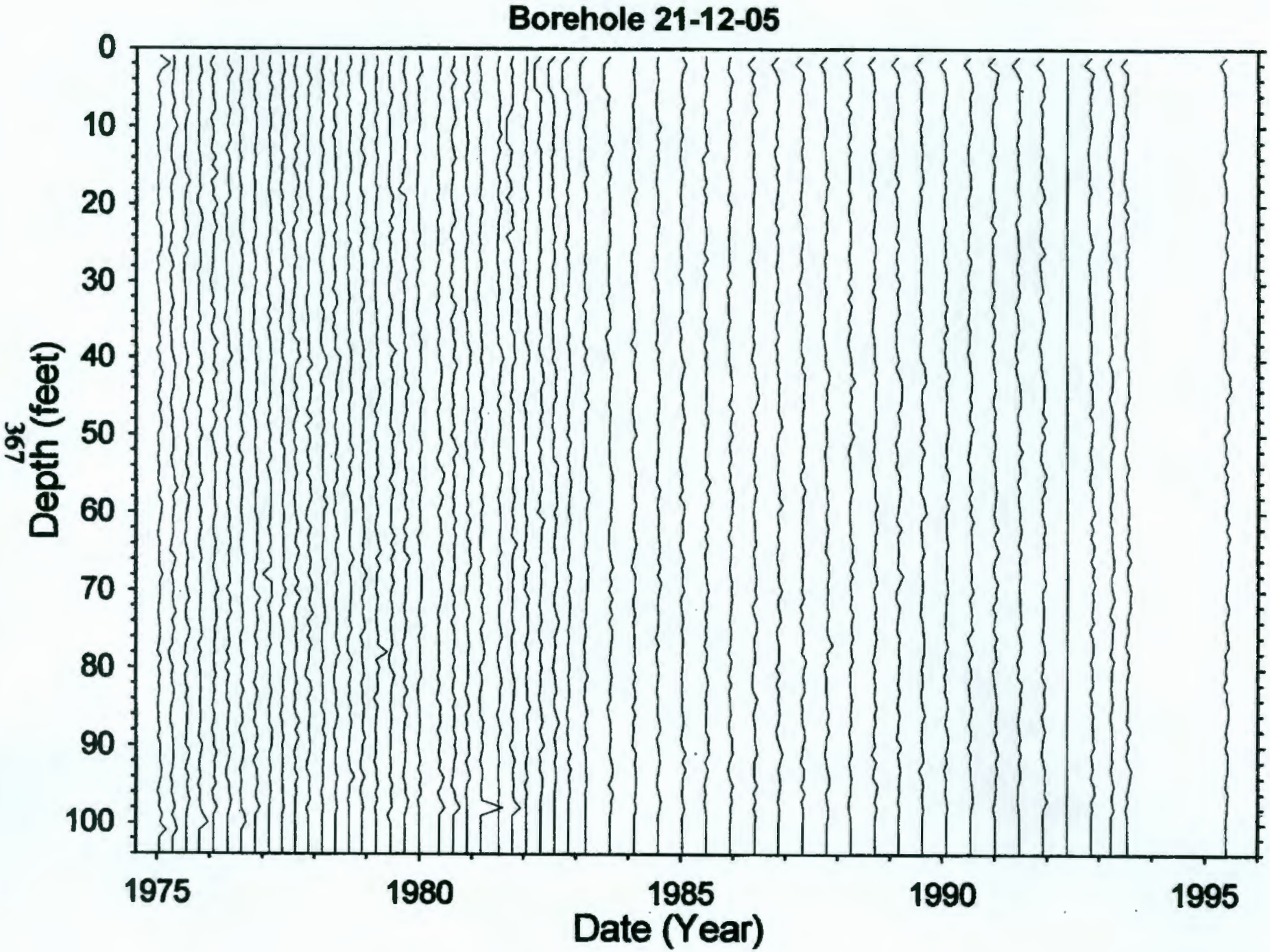


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-12-05
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-12-05)

Total # Surveys 348

Probe Type 04

neutron surveys 4

GR Surveys 344

Log Date: 75-01-14 1st

95-05-25 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): NONE (CLEAN

Isotope from Spectral Survey: CS-137 AT SURFACE

Max Survey Depth 97 FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	22	97	
81-10-13	7	100	
92-05-18	98	98	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-04-09	HIGH BKG	~98	
76-06-30	HIGH CPS	~95	
76-09-22	HIGH BKG	~95	

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-04-09	% CLEAN	99	55%	39.1	
76-06-30	% CLEAN	94	38%	28.5	
76-09-22	% CLEAN	97	27%	43.2	
78-09-13	% CLEAN	95	76%	26.2	
92-05-18	% CLEAN	98	0%	0.0	

Analysis Notes

NO HIGH CPS ZONE IDENTIFIED/CONFIRMED ON HI-ZONES FILE
NO SURVEYS REJECTED
'CLEAN'

Analyst Name Randall Price

S/W ver TF GROSS V2.20

Borehole 21-12-07

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.

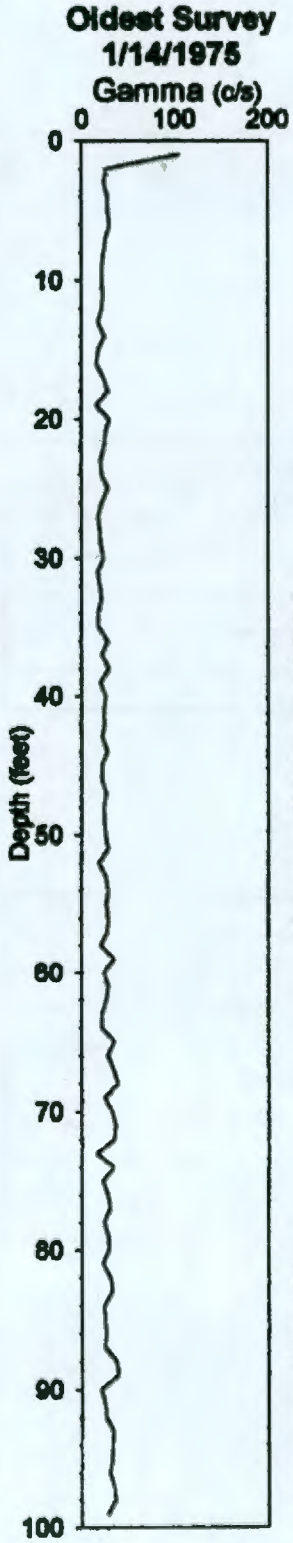
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	359

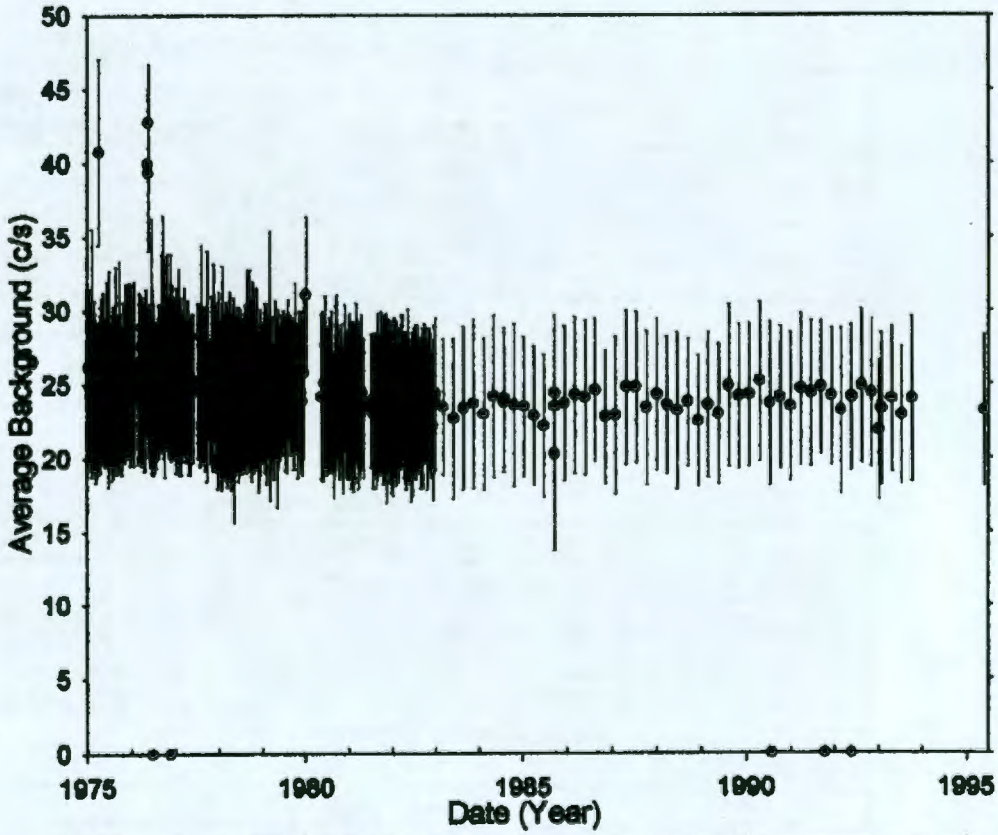
Analysis Notes

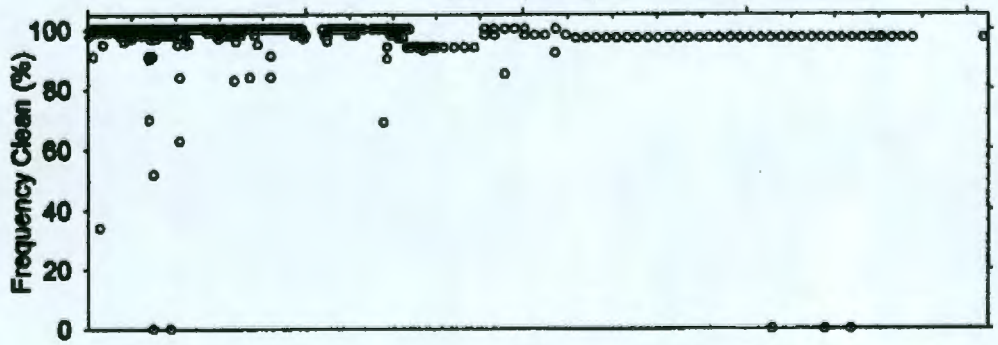
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**No Contamination**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

Borehole 21-12-07

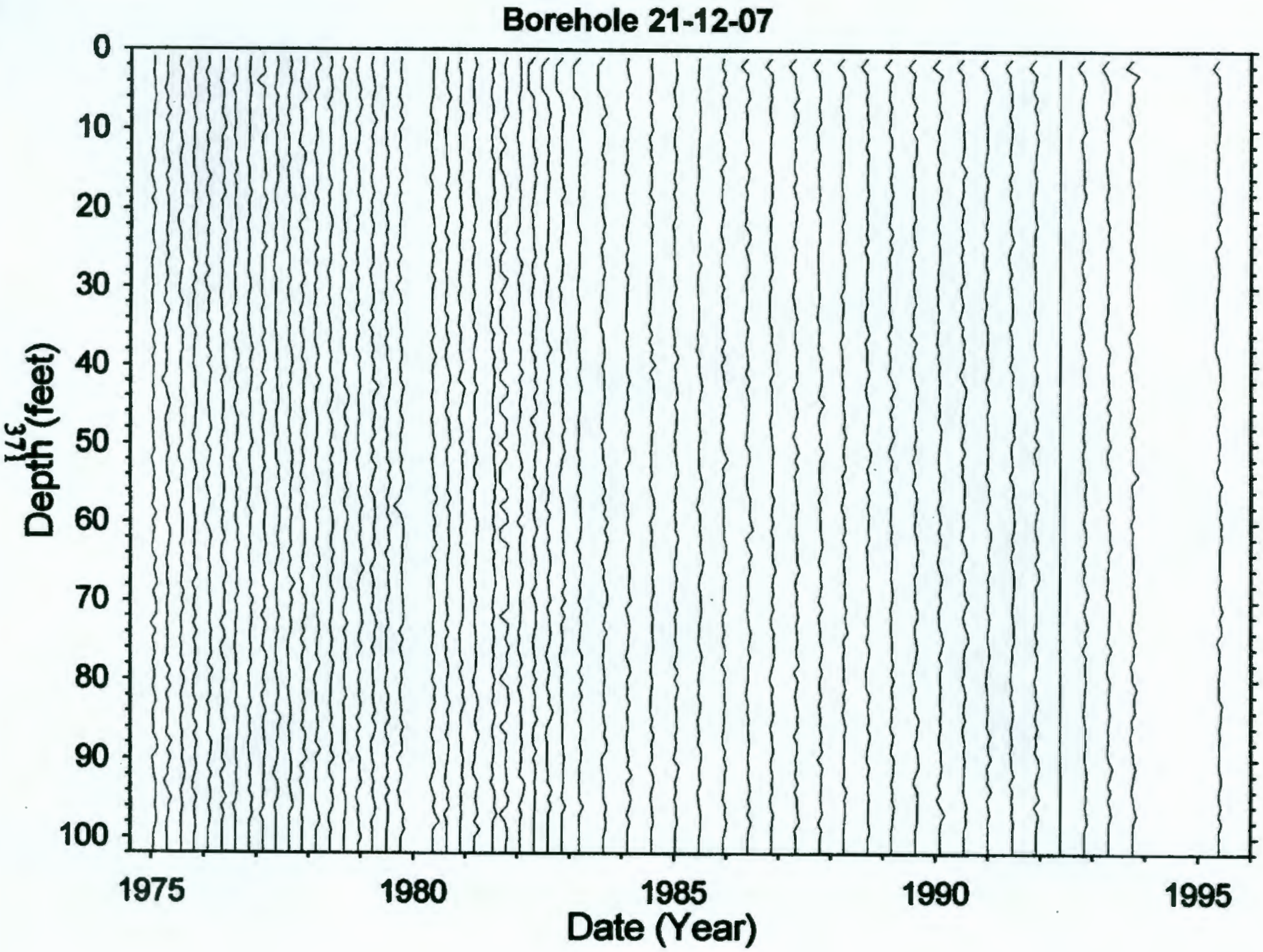


No Gamma-Ray Emitting Contamination Above Survey Detection Threshold





Analysis by: Three Rivers Scientific


Borehole 21-12-07
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-12-07) Total # Surveys 363 Probe Type 04

neutron surveys 4 # GR Surveys 359

Log Date: 75-01-14 1st 95-05-25 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 AT SURFACE Max Survey Depth 100'

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	15	295	
81-10-13	31	102	
84-07-25	14	100	
92-05-18	98	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-04-09	HI-CPS	100	
76-06-30A	HI-CPS	100	TOOL READING HIGH
76-06-30C	HI-CPS	140	TOOL MALFUNCTION
77-02-03A	HI-CPS 80'	100	MAYBE WRONG HOLE OR TOOL MALFUNCTION
77-02-03C	HI-CPS 20'	40'	TOOL MALFUNCTION
78-05-03A	HI-CPS 80'	100	
79-03-05A	HI-CPS 80'	100	PROBABLY TOOL MALFUNCTION
81-11-09	" 80'	100	"

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-04-09	BKG	99	34%	40.8	
75-07-02A	DEPTH	46	100%	28.5	
76-03-17	DEPTH	196	99%	26.2	
76-06-30A	% CLEAN	95	0%	0.0	
77-01-19	DEPTH	143	95%	25.7	
77-02-09	DEPTH	36	63%	27.6	
81-10-13	% CLEAN	100	69%	23.8	
92-05-18	% CLEAN	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONE IDENTIFIED ABOVE DETECTION THRESHOLD
'CLEAN'

Analyst Name Randall Ruiz S/W ver TFCROSS V2.20

Borehole 21-12-10

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 1994 in the vadose zone from 2 to 100 feet.

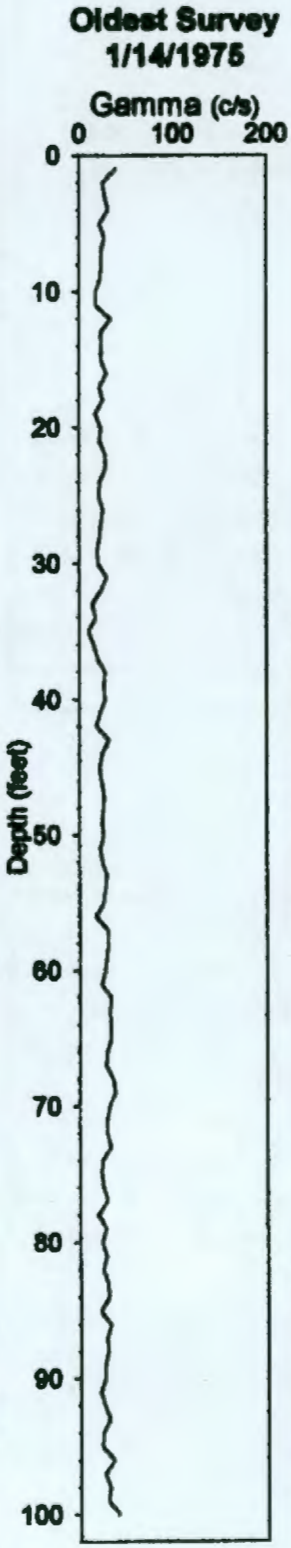
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	355

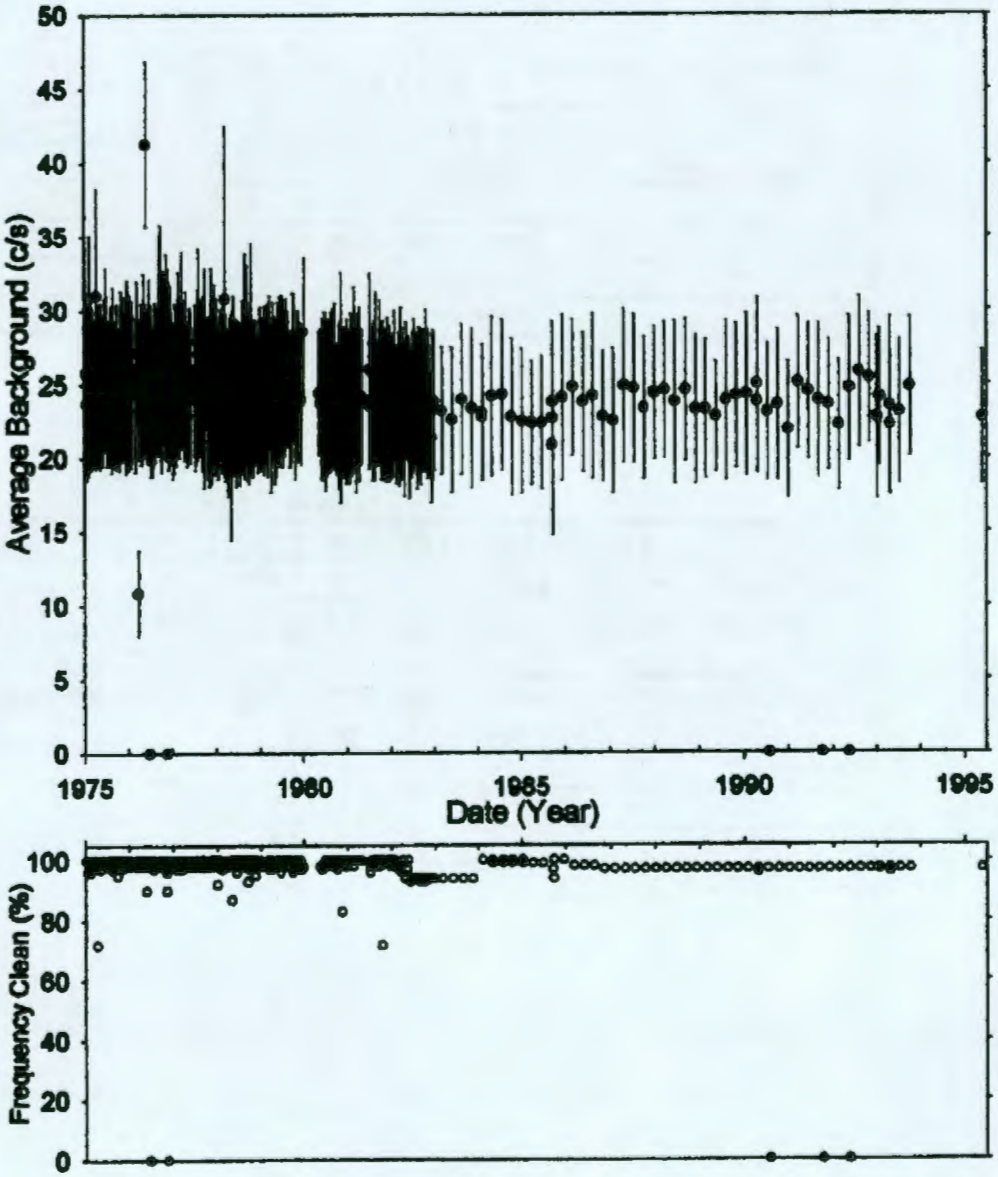
Analysis Notes

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

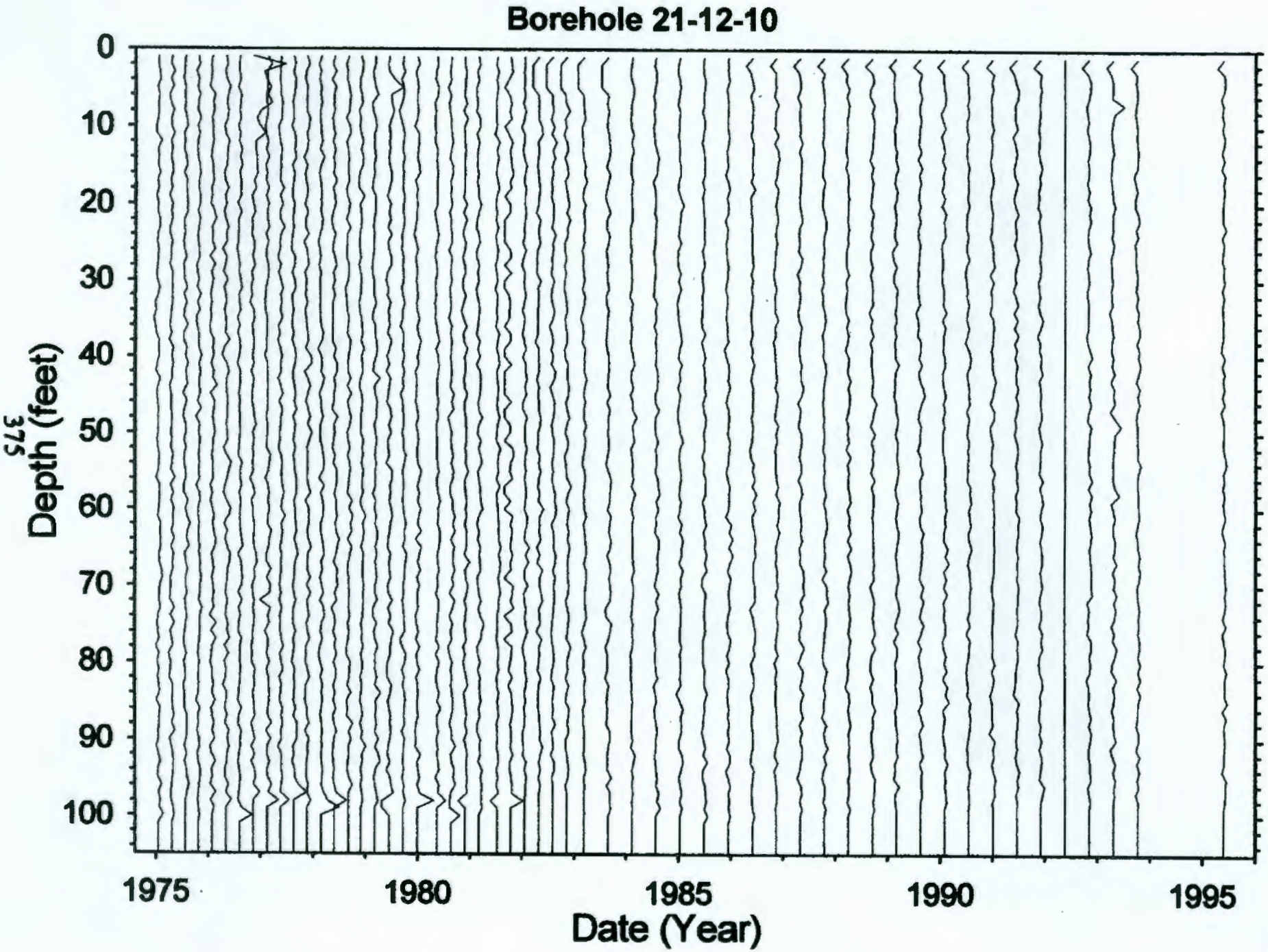
Borehole 21-12-10



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-12-10
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-12-10

Total # Surveys 360

Probe Type 04

neutron surveys 5

GR Surveys 355

Log Date: 75-01-14 1st

95-05-25 Last

Presentation Plot Dates SAME (If different from 1st & Last)

Contamination Zone Depth(s):

Isotope from Spectral Survey:

Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
81-10-13	26	~100	
92-05-18	98	~100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
76-06-23A	HI-CPS	~100	PROBE TOOL MALFUNCTION
76-06-30	ABOVE AVG CPS	100	HIGHER CPS THAN NORMAL

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
75-04-09	LOW % CLEAN	100	72%	31.0	
76-03-24	LOW BKG	98	98	10.9	
76-06-23A	BAD SURVEY	98	0%	0.0	
76-06-30	BAD SURVEY	94	0%	0.0	
81-10-13	LOW % CLEAN	98	72%	23.8	
92-05-18	LOW BKG	98	0%	0.0	

Analysis Notes

NO CONSISTANT INTERVAL (TIME RANGE) OF CPS >50 CPS
LOW LEVEL ACTIVITY ZONE (CS-137) AT SURFACE (0-25FT)
WAS NOT IDENTIFIED ABOVE NATURAL FORMATION CHARACTER
(40-100 FT) THUS CLASSIFIED AS 'CLEAN' FOR TF SURVEYS

NO SURVEYS REJECTED.

Analyst Name Randall Price

S/W ver TFGROSS V2.20

Borehole 21-12-12

Contamination (Cs-137) at 4-10 ft is Stable

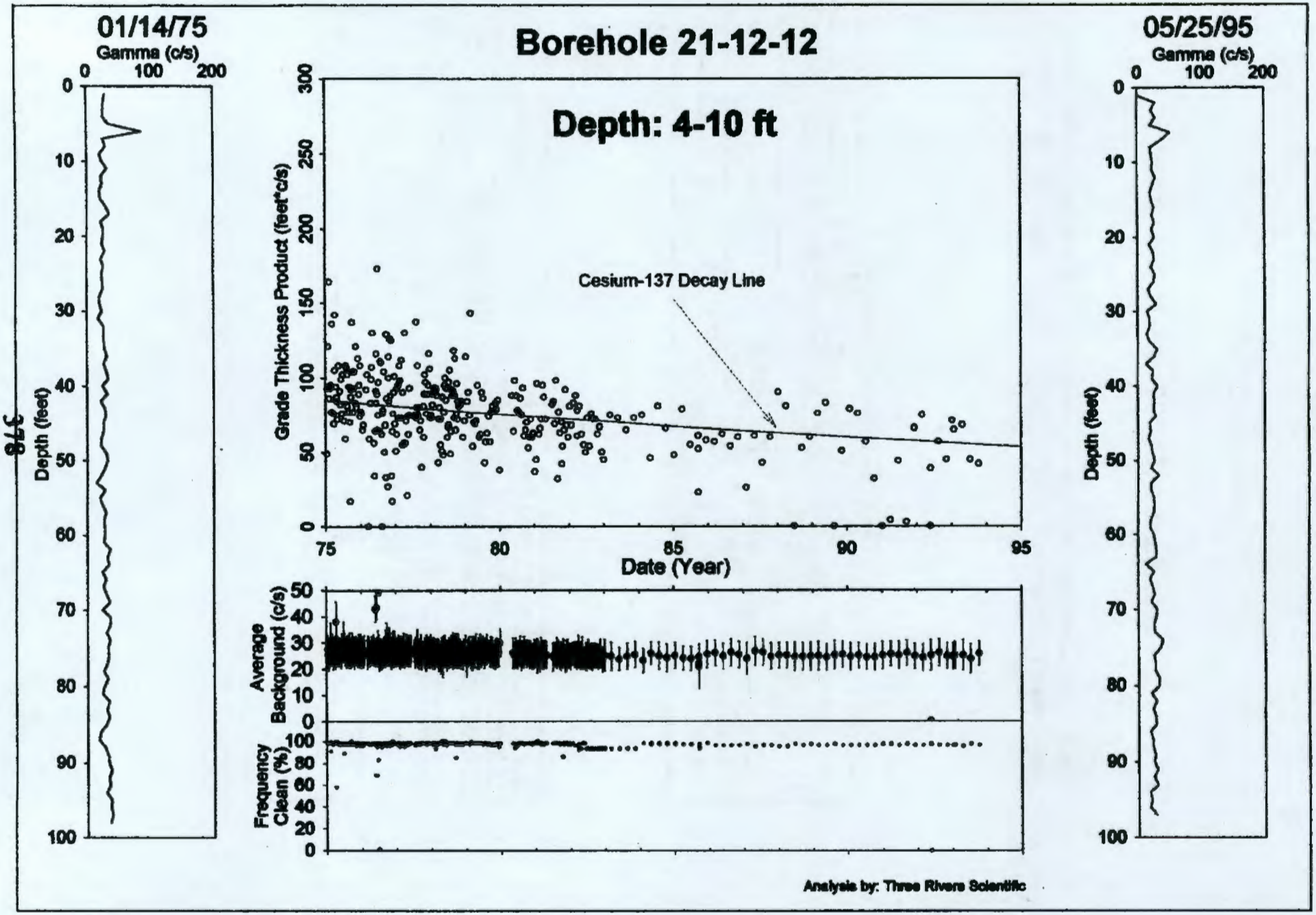
Grade Thickness Product between 4-10 feet appears to be decreasing at a rate consistent with Cesium-137 (identified from HPGe detector) between January 1975 and May1995.

Gross Gamma Survey Information

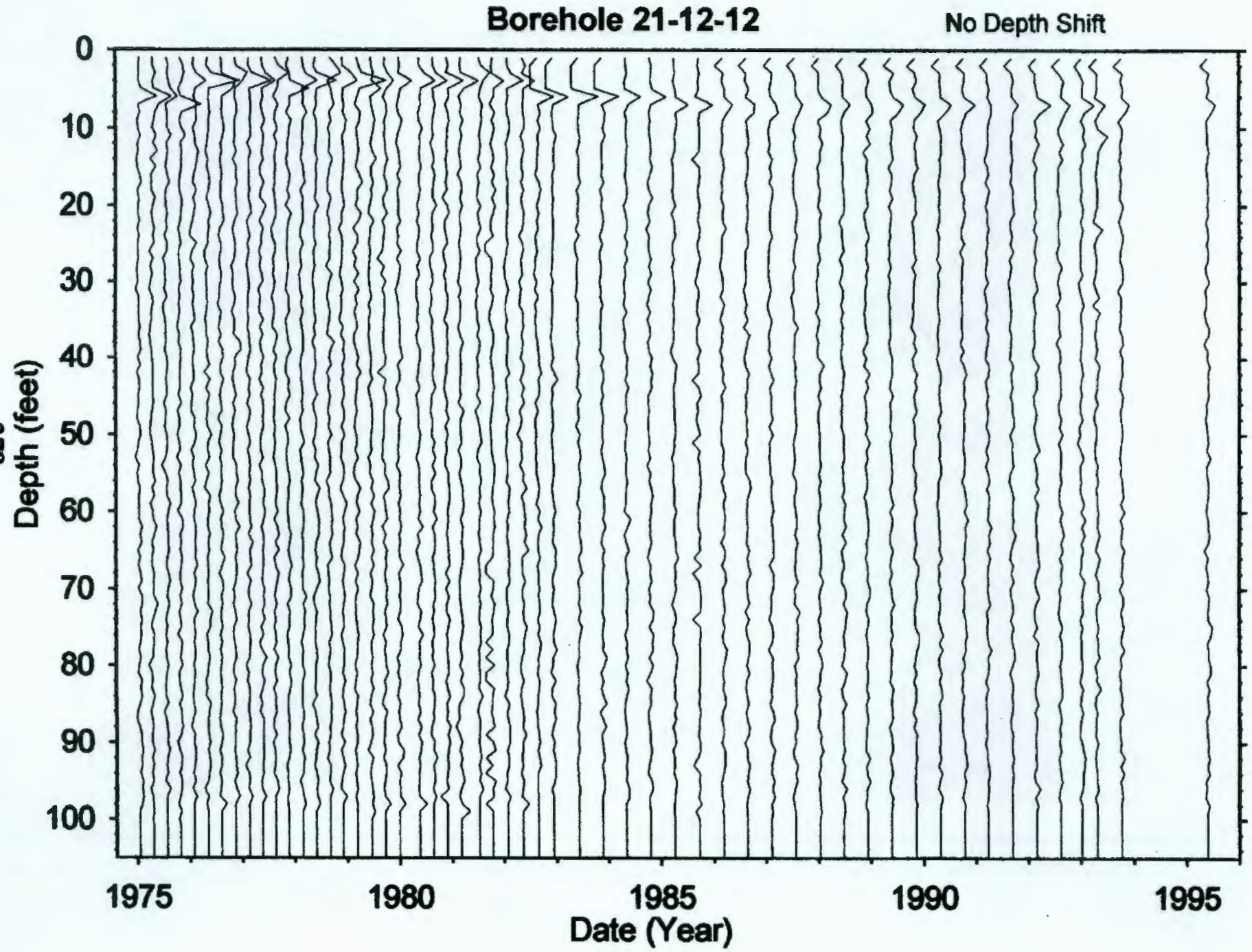
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (4 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/14/1975
Last Survey Date :	5/25/1995
Number Surveys :	335

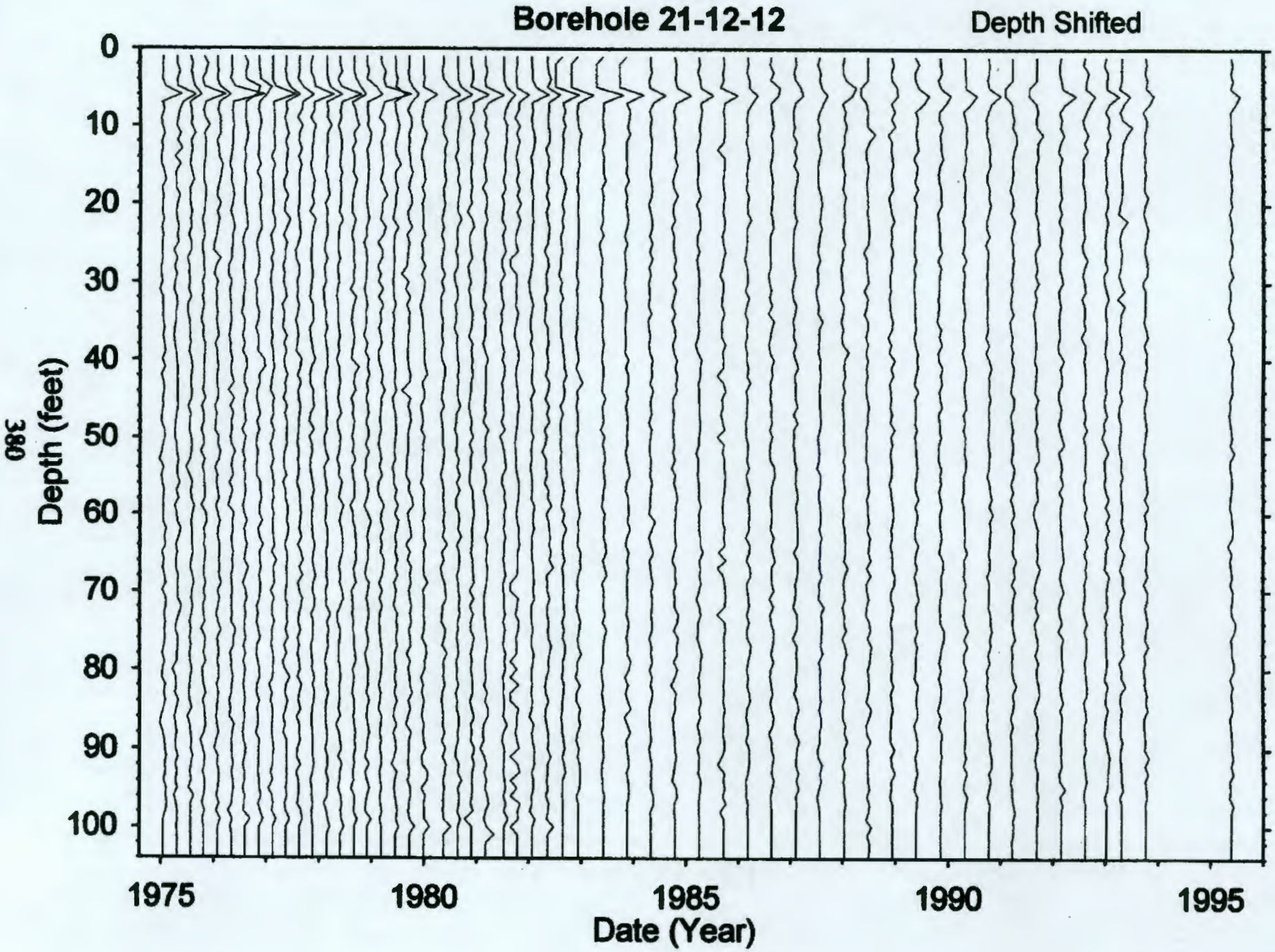
Analysis Notes

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 :	**4-10 ft. is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



HNF-3531 -REV0


Borehole 21-12-12
No Depth Shift
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)


Borehole 21-12-12
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-12-12)

Total # Surveys ~~340~~ 339

Probe Type 04

neutron surveys 4

GR Surveys 335

Log Date: 75-01-14 1st

95-05-25 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 7FT (2-28FT FROM SGLS)

Isotope from Spectral Survey: CS-137

Max Survey Depth 100FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
78-09-13	13	98	
81-10-13	13	102	
92-05-18	98	100	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
75-04-09		100	TOOL RESPONSE > AVERAGE
76-06-23	HIZONE 19-29'	100	POSSIBLE TOOL MALFUNCTION OR WRONG HOLE
76-06-30		100	TOOL RESPONSE > NORM

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
76-06-30	HIGHCPS	94	1%	49.0	
92-05-18	HIGH GAPS	98	0%	0.0	

Analysis Notes

NO SURVEYS REJECTED
DEPTH SHIFTED USING SHIFTAUTO V1.0 (MAR 13,98)
BKG COMPUTED (<= 50 CPS)
RAD ZONE ANALYSIS 4-10FT
ZONE AT 6FT IS STABLE (LOW ACTIVITY 30pCi/g MAX FROM SGLS)

Analyst Name Randall Price

S/W ver TF GROSS V2.20 JAN 8,98

Borehole 21-27-01

Contamination (Sb-125 & U-235/238) from 68 to 78 feet is Stable

Grade Thickness Product for the radioactive zone (68-78 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 and Uranium-235/238 (both identified from HPGe detector) between January 1979 and March 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to U-235/238 of 0.5 on March 1993.

Gross Gamma Survey Information

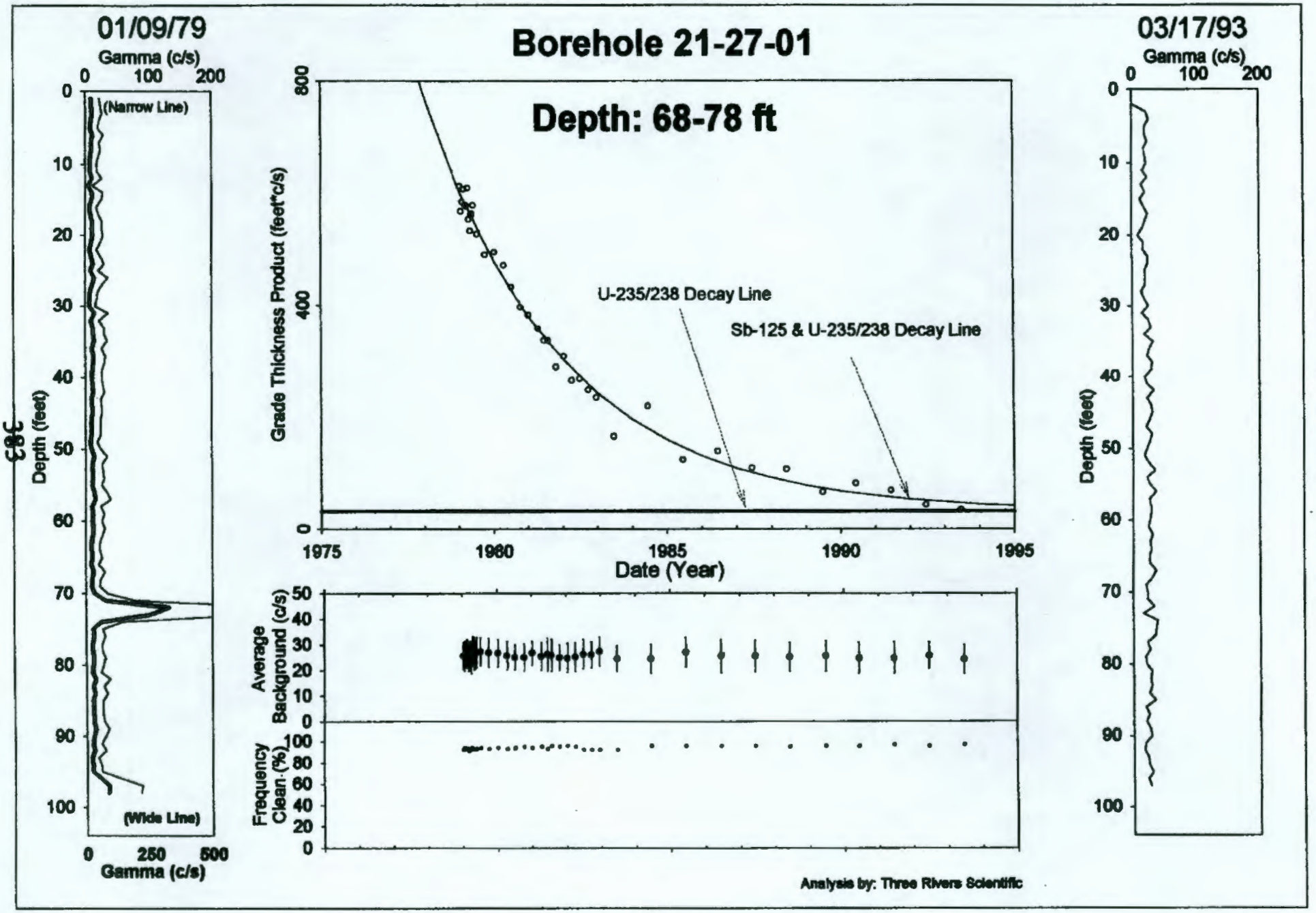
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1979
Last Survey Date :	3/17/1993
Number Surveys :	38

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 :	**68-78 ft is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific

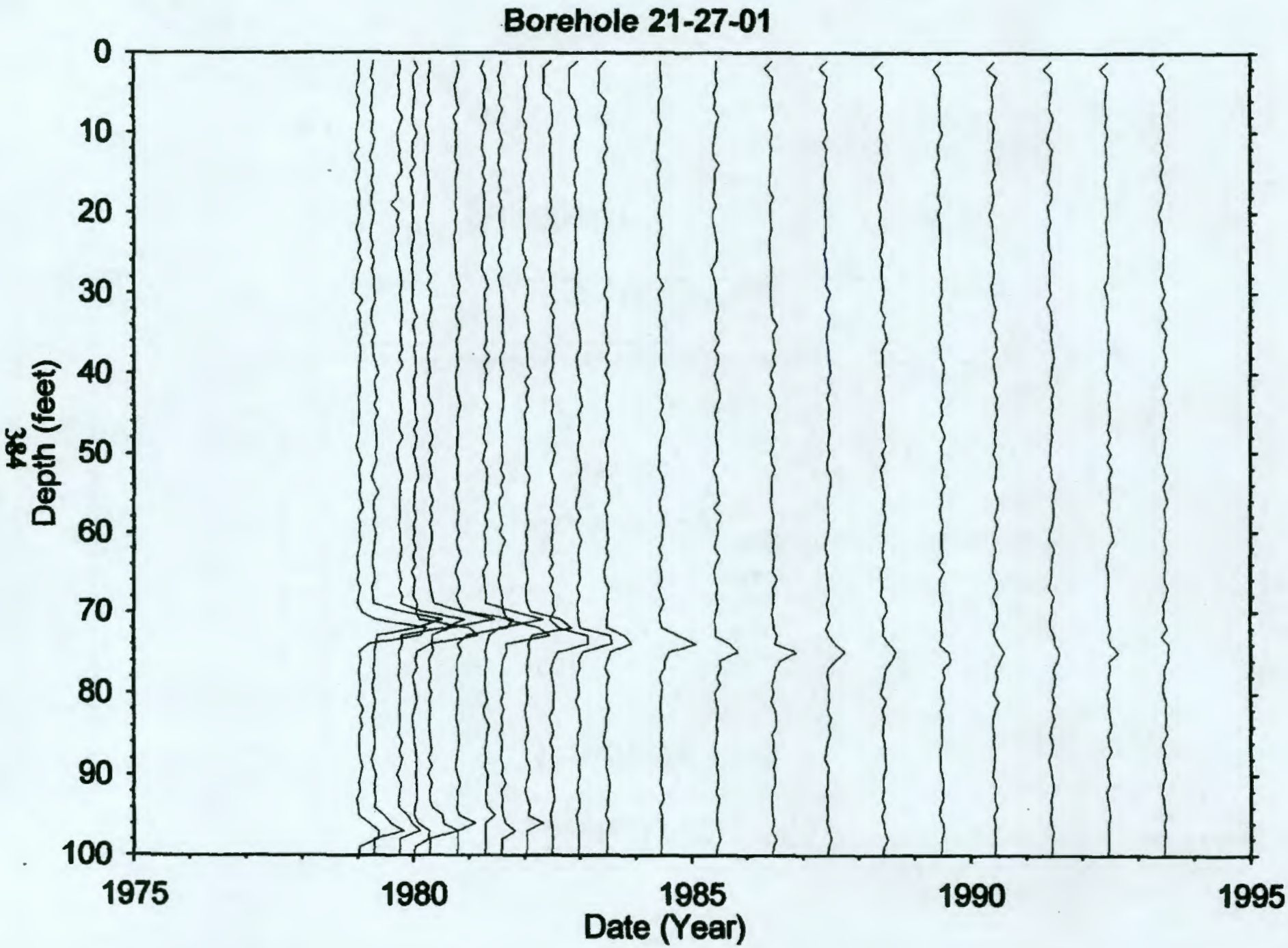
Borehole 21-27-01

Depth: 68-78 ft



C8C

HNF-3531 -REV0


Borehole 21-27-01
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-27-01) Total # Surveys 40 Probe Type 4

neutron surveys 2 # GR Surveys 38

Log Date: 79-01-09 1st 93-03-17 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 (0-20cm) < 2 pCi/g Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
NO SURVEYS WITH >5 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
79-03-05	TOOL PROBS	100	APPEARS TO HAVE 2 RADIATION ZONES

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
NO UNUSUAL SURVEYS IDENTIFIED					

Analysis Notes

NO SURVEYS REJECTED
SHORT LIVED RADIONUCLIDES (SB-125)

Analyst Name Randall Pinto S/W ver TGROSS V2.20

Well 21-27-01

filein := "two68-78.txt"

A := READPRN(filein) yr := $A^{<1>}$ net := $A^{<7>}$ bkg := $A^{<6>}$ max := $A^{<4>}$

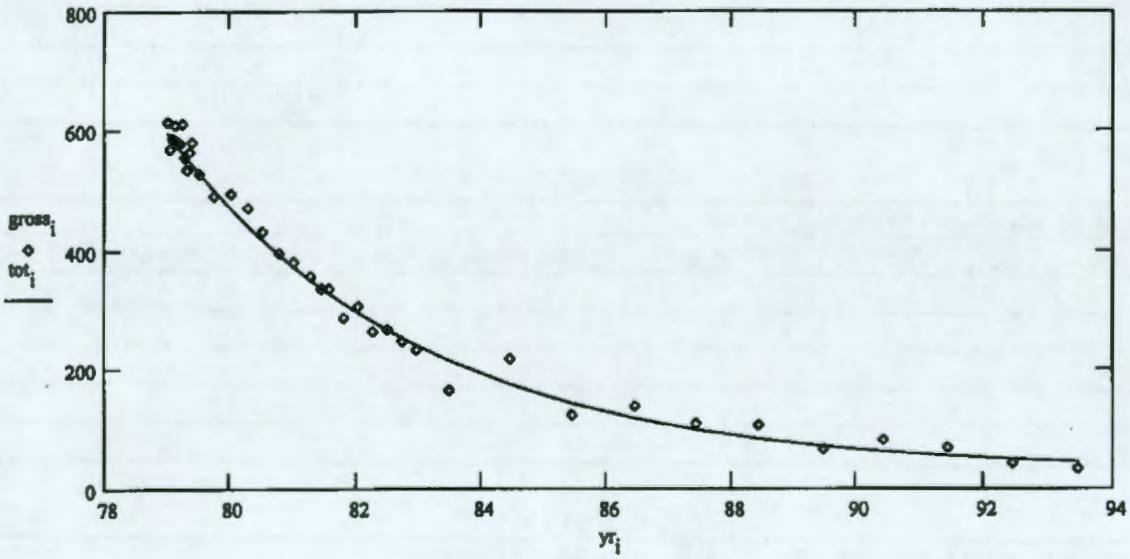
N := last(yr) N = 37 i := 0..N k := 0..300 j := 0..299

1st Isotope is U (4.5 e6 yrs) $\tau co := 4.5 \cdot 10^9$ aco := 30

2nd Isotope is Sb-125 (2.77 yrs) $\tau 2 := 2.77$ a2 := 1550

$$Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

ssq(aco, a2)=0 1=1

$$\begin{bmatrix} \alpha co \\ \alpha 2 \end{bmatrix} := Minerr(aco, a2)$$

$\alpha co = 30.656$ $\alpha 2 = 1.572 \cdot 10^3$

$$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$\frac{\alpha co}{\alpha 2} = 0.019$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out Ratio Sb/U $\frac{X2_N}{Co_N} = 0.505$

Borehole 21-27-02

Contamination (Sb-125 & U-235/238) from 68 to 78 feet is Stable

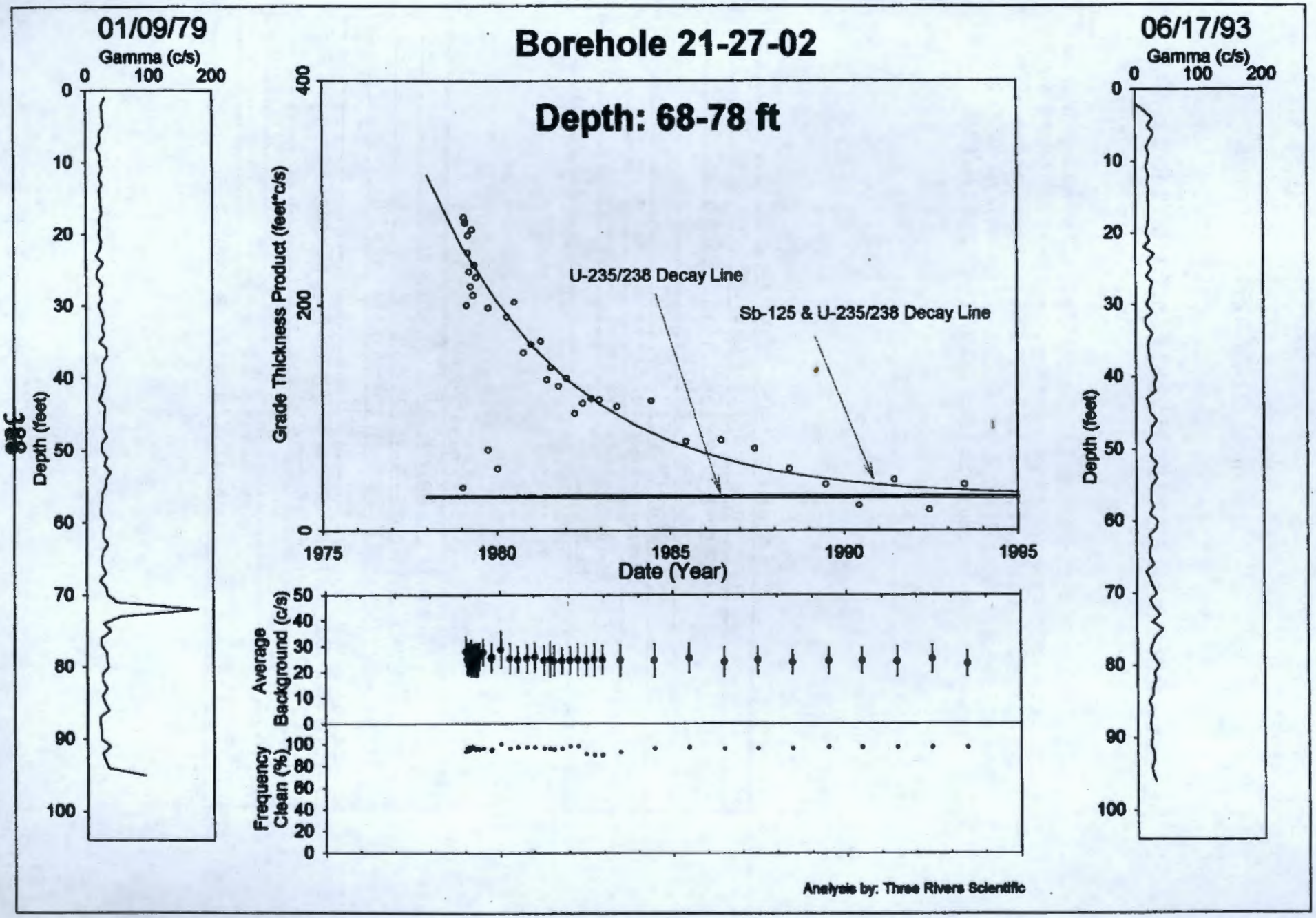
Grade Thickness Product for the radioactive zone (68-78 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 and Uranium-235/238 (both identified from HPGe detector) between January 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to U-235/238 of 0.2 on June 1993.

Gross Gamma Survey Information

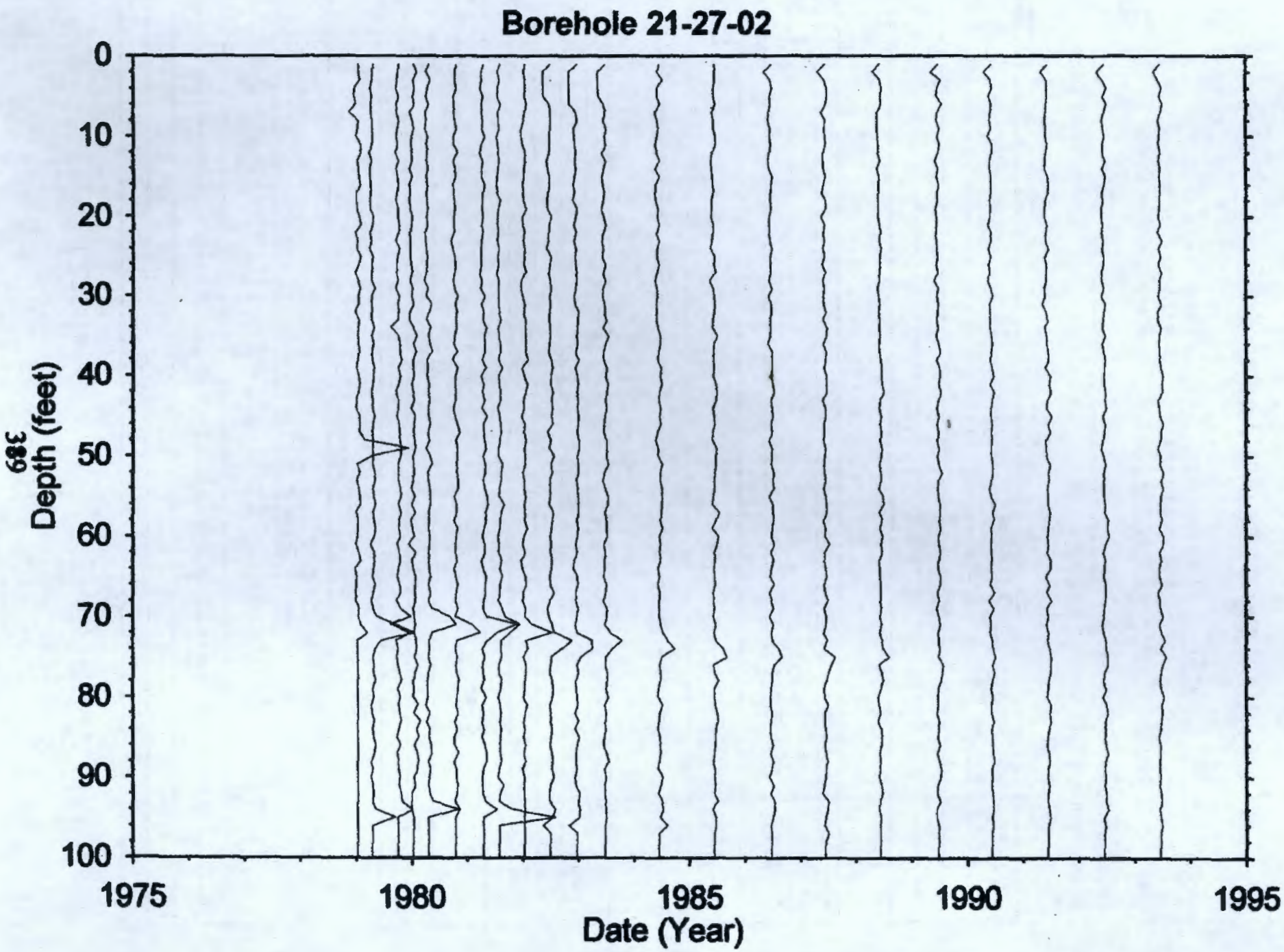
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1979
Last Survey Date :	6/17/1993
Number Surveys :	41

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 :	**68-78 ft is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



HNF-3531 -REV0



HNF-3531 -REV0

Dry Well Survey Analysis - Notes

Borehole BX(21-27-02) Total # Surveys 43 Probe Type 04

neutron surveys 2 # GR Surveys 41

Log Date: 79-01-09 1st 93-06-17 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS-137 Max Survey Depth 100

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
NO SURVEYS WITH >7 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
79-01-09	BAD SURVEY	55 FT	SHORT SURVEY
79-01-09	BAD SURVEY	80	4

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
79-01-09	LENGTH	53	96%	27.5	

Analysis Notes

NO SURVEYS REJECTED
SHORT LIVED RADIATION ZONE 2 TO 2 FT
ASSUMED TO BE Sb-125 BASED ON OTHER HPGe LOGS IN ADJACENT WELLS.

Analyst Name Randall Pruett S/W ver TAGROSS V2.20

filein := "two68-78.txt"

Well 21-27-02

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

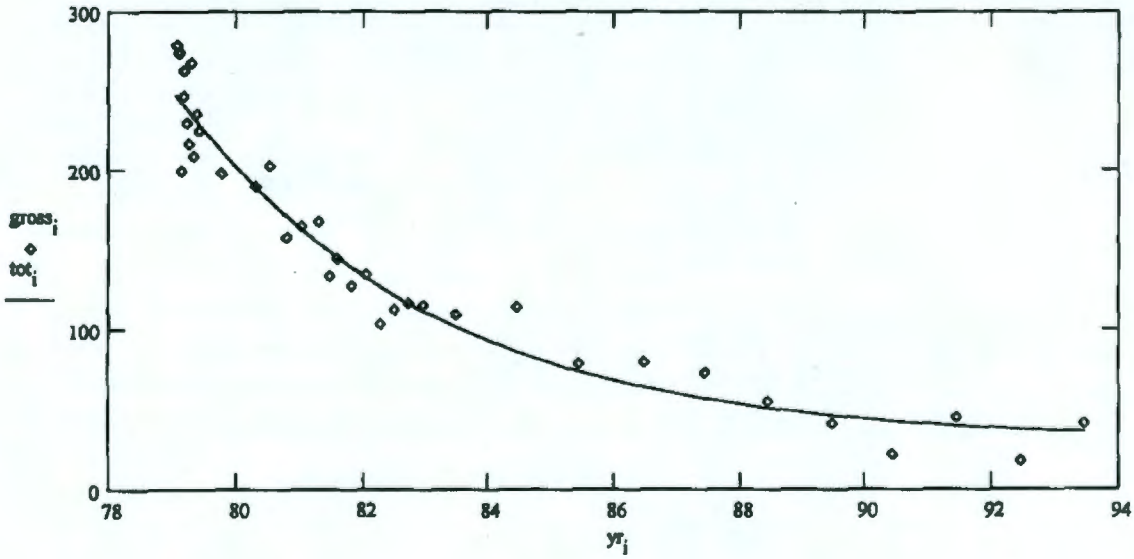
$N := last(yr)$ $\quad N = 36$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

1st Isotope is U (4.5 e6 yrs) $\quad \tau co := 4500000$ $\quad aco := 30$

2nd Isotope is Sb-125 (2.77 yrs) $\tau 2 := 2.77$ $\quad a2 := 600$

$$Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(aco, a2) = 0 \qquad 1 = 1$

$$\begin{bmatrix} \alpha co \\ \alpha 2 \end{bmatrix} := \mathrm{Minerr}(aco, a2)$$

U $\quad \alpha co = 30.229$ $\qquad$ Sb $\quad \alpha 2 = 607.599$

$$\frac{\alpha co}{\alpha 2} = 0.05$$

$$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$out^{<0>} := yr \qquad out^{<1>} := tot \qquad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

Ratio U/Sb $\quad \frac{Co_N}{X2_N} = 5.048$

Borehole 21-27-06

No Gamma-Ray Emitting Contamination was identified

No significant levels of gamma-ray contamination is present above the survey probe detection threshold between 1979 and 1993 in the vadose zone from 2 to 100 feet.

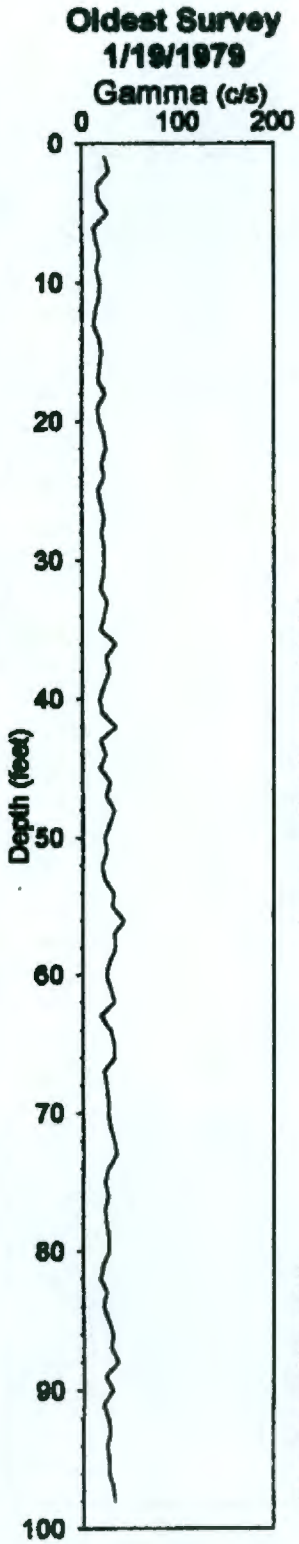
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	100 ft
Survey Depth :	100 ft
First Survey Date :	1/09/1979
Last Survey Date :	6/17/1993
Number Surveys :	41

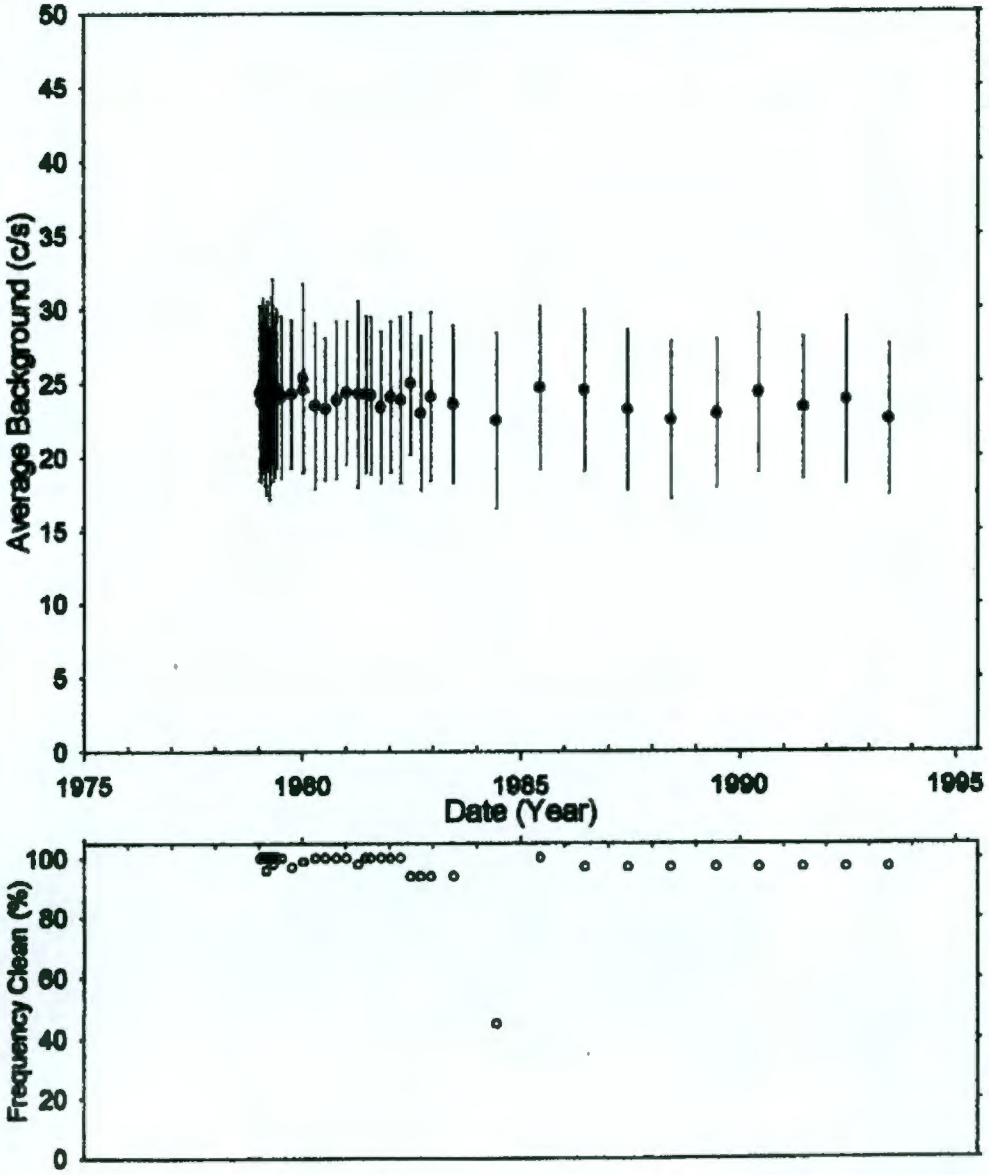
Analysis Notes

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

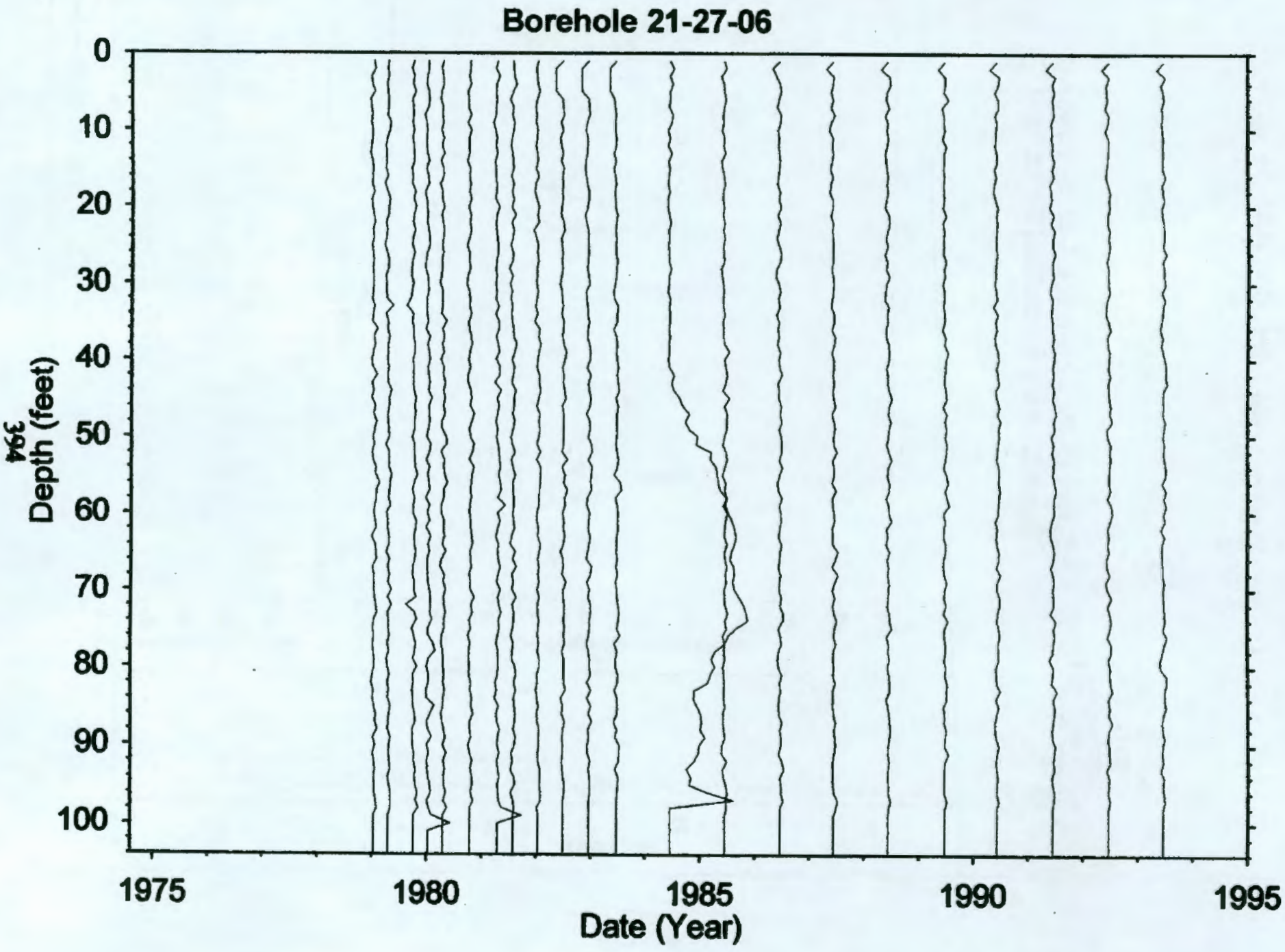
Borehole 21-27-06



No Gamma-Ray Emitting Contamination Above Survey Detection Threshold



Analysis by: Three Rivers Scientific


Borehole 21-27-06
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-27-06) Total # Surveys 43 Probe Type 4

neutron surveys 2 # GR Surveys 41

Log Date: 79-01-09 1st 93-06-17 Last Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs-137 Max Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
NO SURVEYS W/ > 5 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
84-06-12A	TOOL FAIL		
NO			

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
84-06-12A	% CLEAN	97	45%	225	

Analysis Notes

NO SURVEYS REJECTED
NO RADIATION ZONES ABOVE DETECTION THRESHOLD

Analyst Name Randall Price S/W ver TFGROSS V2.20

Borehole 21-27-07

Contamination (Sb-125 & U-235/238) from 68 to 84 feet and 90 to 118 feet is Stable

Grade Thickness Product for the two radioactive zones (68-84 and 90-118 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to U-235/238 of 0.5 and 0.04, respectively, on June 1993.

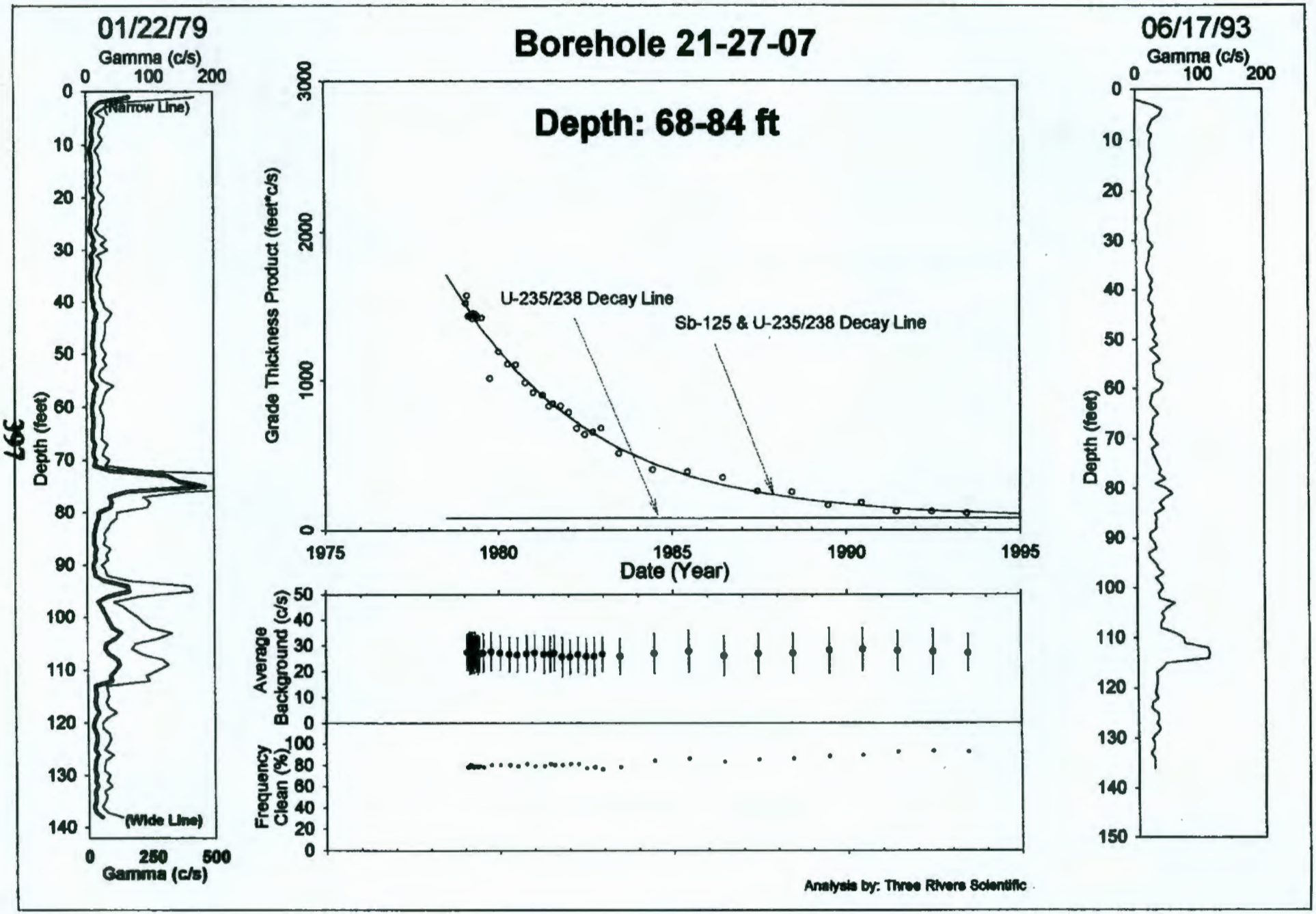
The majority of U-235/238 in the lower radioactive zone (90-118 feet) is concentrated in the lowest portion from 108 to 118 feet.

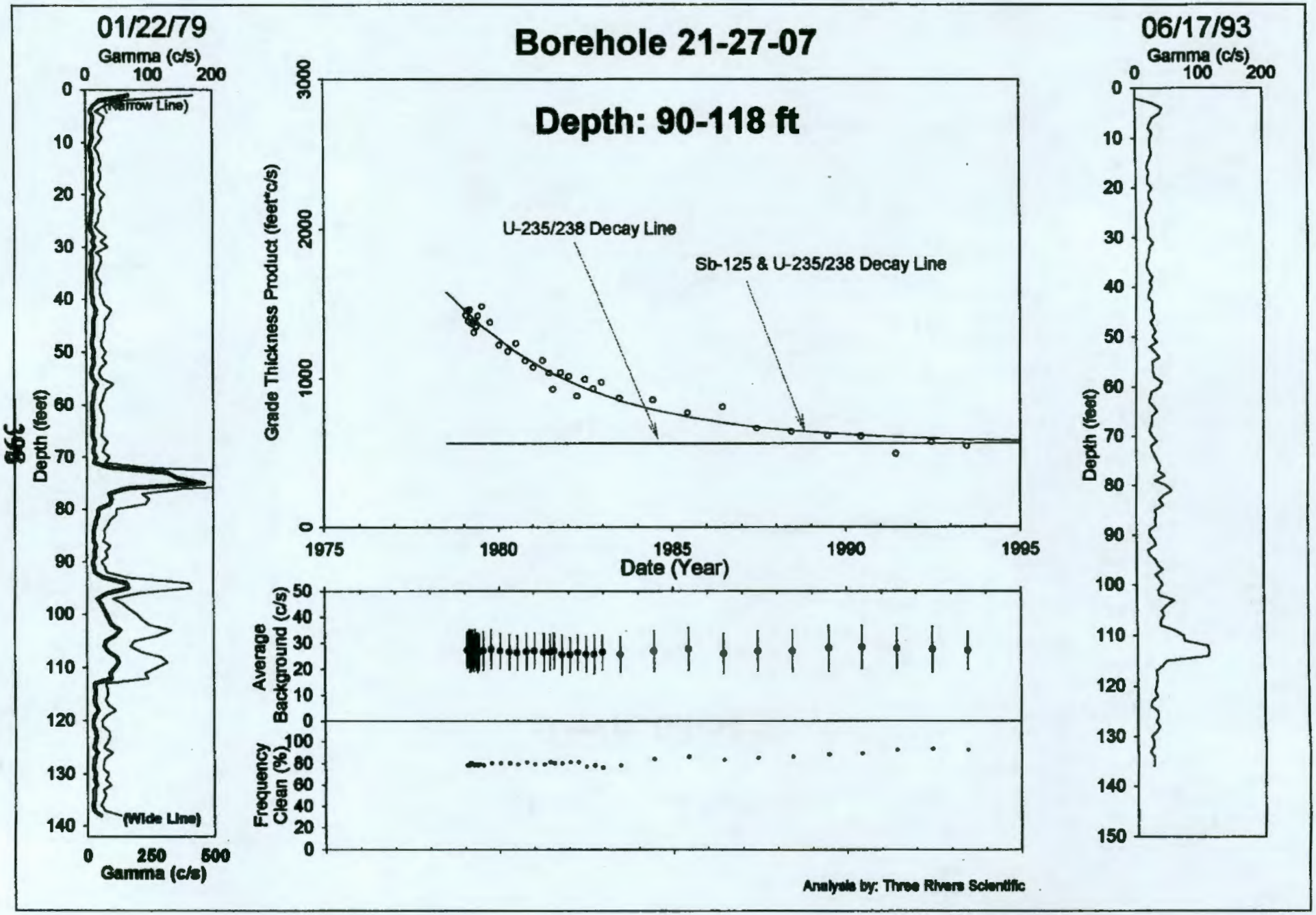
Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	138 ft
Survey Depth :	138 ft
First Survey Date :	1/22/1979
Last Survey Date :	6/17/1993
Number Surveys :	37

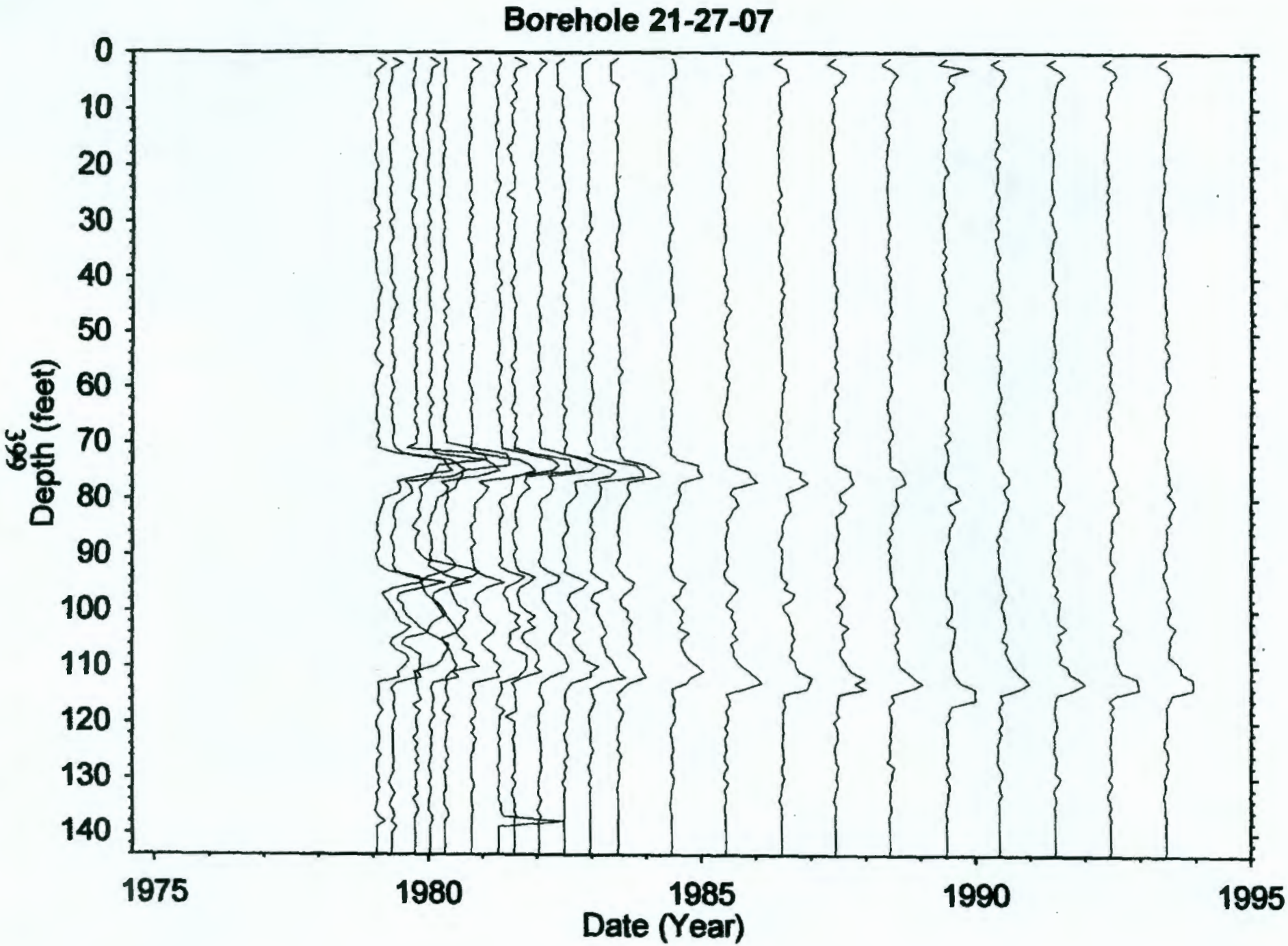
Analysis Notes

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 :	**68-84 feet is Stable** **90-118 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


Borehole 21-27-07
Depth: 68-84 ft
01/22/79
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
06/17/93
Gamma (c/s)
Depth (feet)
Grade Thickness Product (feet*c/s)
U-235/238 Decay Line
Sb-125 & U-235/238 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific



HNF-3531 -REV0


Borehole 21-27-07
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-27-07

Total # Surveys 39

Probe Type 04

neutron surveys 2

GR Surveys 37

Log Date: 79-01-22 1st

93-06-17 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs, SB-125, U

Max Survey Depth ~~150~~ 1240 RKP

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
NO SURVEYS WITH 7 6 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
NO BAD SURVEYS			

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
NO SURVEYS DEVIATED FLOW NORTH					

Analysis Notes

NO SURVEYS REJECTED

Analyst Name Randall Ruiz

S/W ver TFGROSS V2.20

filein := "two68-084.txt" **Well 21-27-07**

A := READPRN(filein) $yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

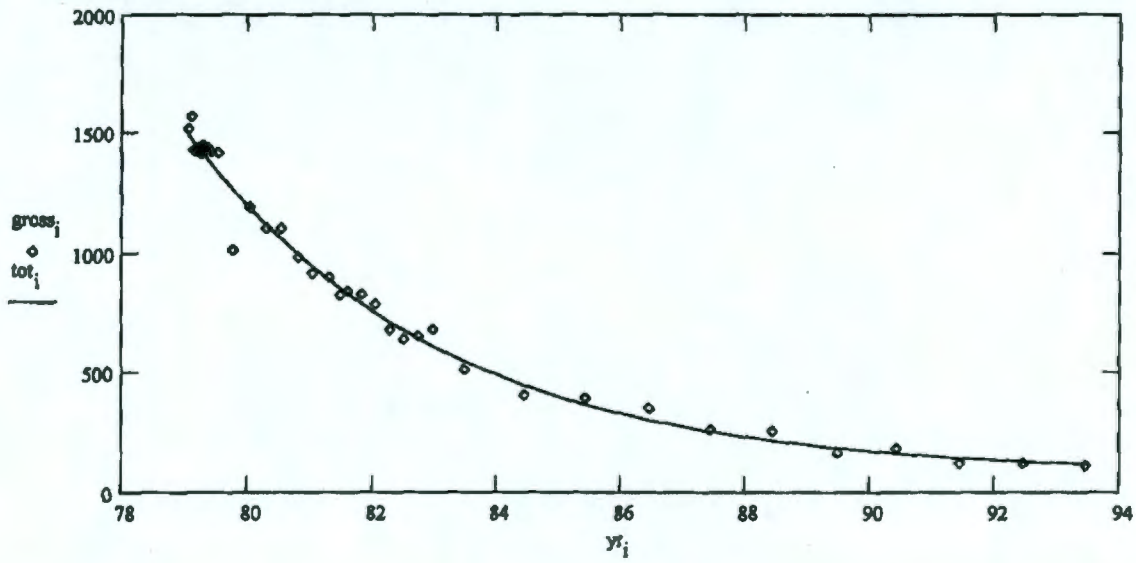
N := last(yr) N = 36 i := 0..N k := 0..300 j := 0..299

1st Isotope is U (4.5 e6 yrs) $\tau co := 4500000$ aco := 80

2nd Isotope is Sb-125 (2.77 yrs) $\tau 2 := 2.77$ a2 := 3900

$$Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

ssq(aco, a2)=0 I=1

$$\begin{bmatrix} \alpha co \\ \alpha 2 \end{bmatrix} := Minerr(aco, a2)$$

U Sb

$\alpha co = 82.557$ $\alpha 2 = 3.911 \cdot 10^3$

$$\frac{\alpha co}{\alpha 2} = 0.021$$

$$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out

Ratio U/Sb $\frac{Co_N}{X2_N} = 2.142$

filein := "two90-118.txt" **Well 21-27-07**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

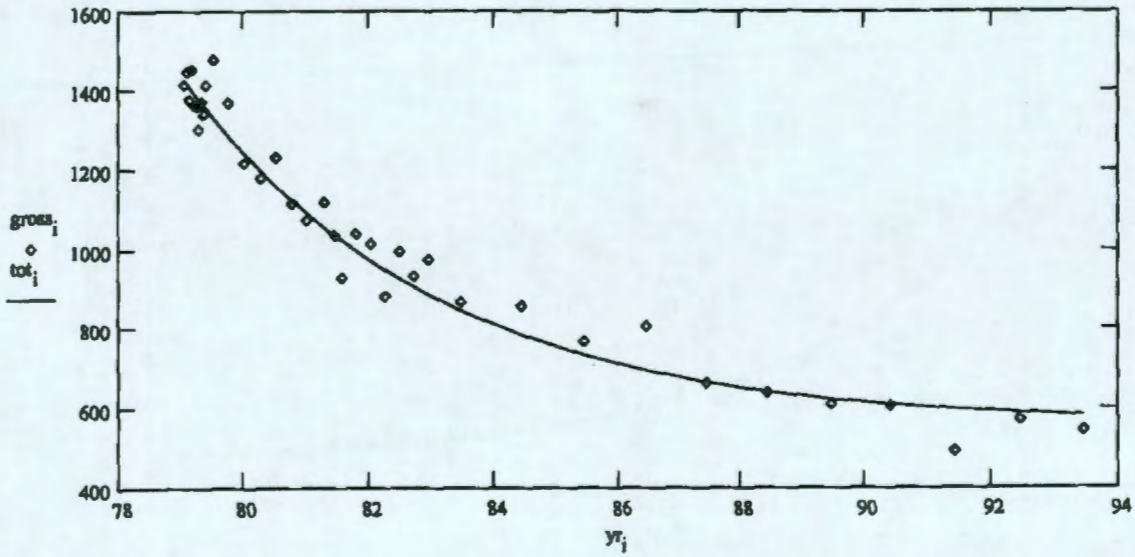
$N := last(yr)$ $\quad N = 36$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

1st Isotope is U (4.5 e6 yrs) $\quad \tau co := 4500000$ $\quad aco := 560$

2nd Isotope is Sb-125 (2.77 yrs) $\tau 2 := 2.77$ $\quad a2 := 2400$

$$Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(aco, a2) = 0 \qquad 1 = 1$

$$\begin{bmatrix} \alpha co \\ \alpha 2 \end{bmatrix} := \mathrm{Minerr}(aco, a2)$$

U $\quad \alpha co = 566.072$ $\qquad$ Sb $\quad \alpha 2 = 2.426 \cdot 10^3$

$$\frac{\alpha co}{\alpha 2} = 0.233$$

$$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$out^{<0>} := yr \qquad out^{<1>} := tot \qquad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

Ratio U/Sb $\quad \frac{Co_N}{X2_N} = 23.682$

Borehole 21-27-08

Contamination (Sb-125) from 40 to 86 feet is Stable
Contamination (Co-60&Sb-125&U-235/238) from 92 to 116 feet is Stable
Contamination (U-235/238) from 130 to 146 feet is Stable

Grade Thickness Product for the radioactive zone (40-86 feet) is decreasing at a rate consistent with the decay of Antimony-125 (identified from HPGe detector) between April 1979 and June 1993.

Grade Thickness Product for the radioactive zone (92-116 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Antimony-125 (hypothesis), Cobalt-60 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Co-60:Sb-125:U-235/238 is 182:43:1097 on June 1993.

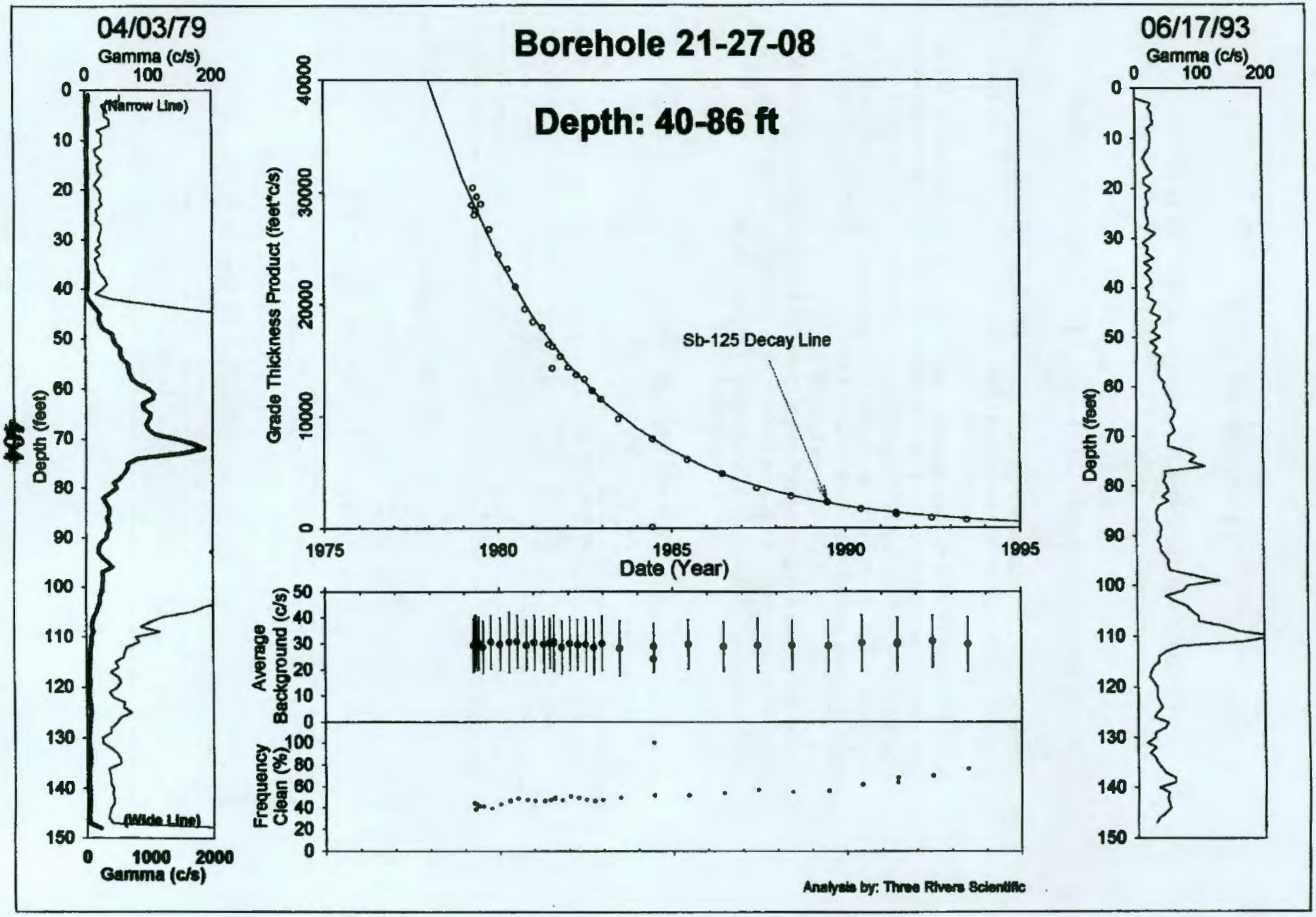
Grade Thickness Product of the radioactive zone (130-146 feet) appears to be stable, within the measurement counting uncertainty, with Uranium-235/238 (identified form HPGe detector). Surveillance logging activities were not designed to monitor low contamination levels.

Gross Gamma Survey Information

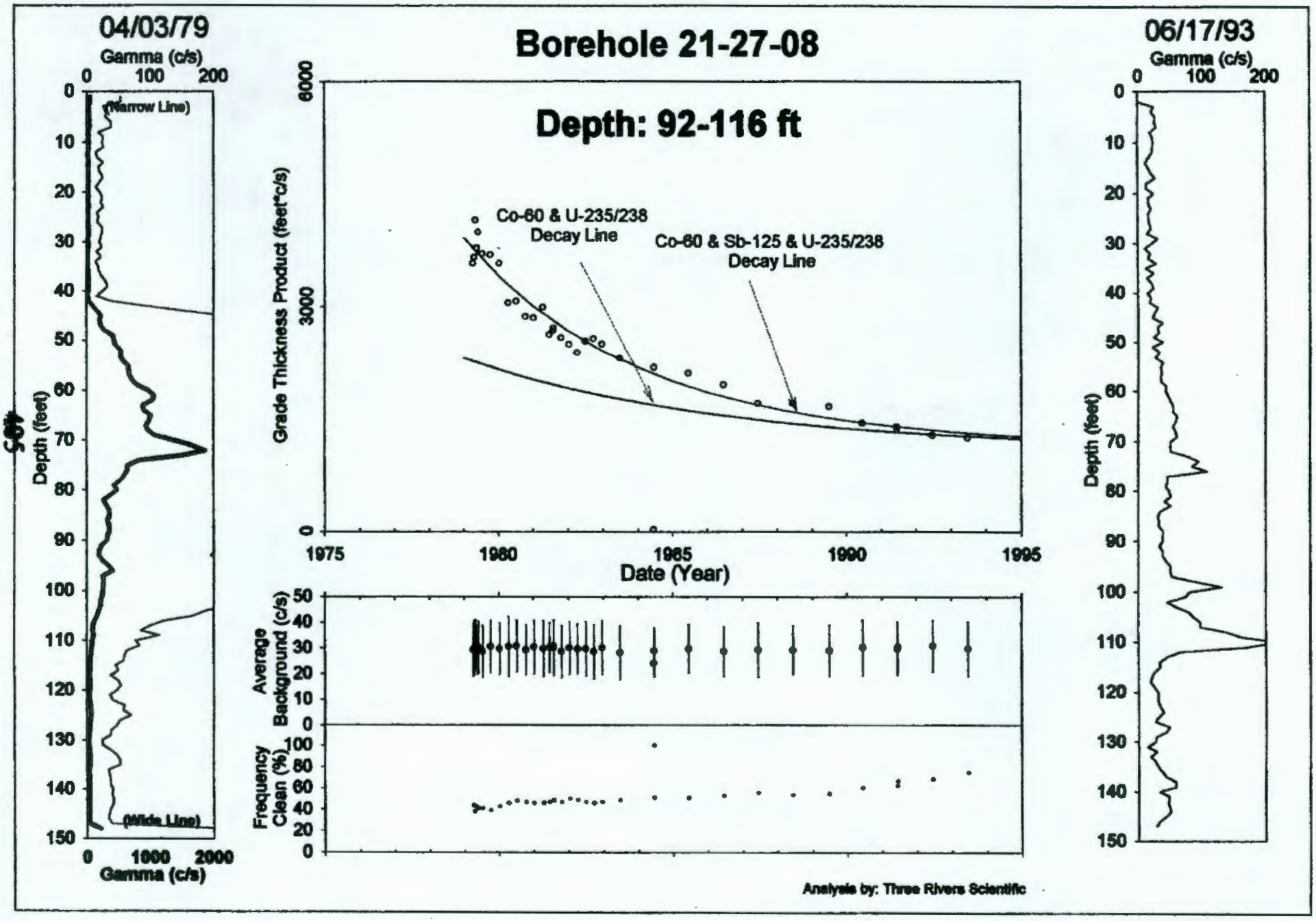
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	4/30/1979
Last Survey Date :	6/17/1993
Number Surveys :	35

Analysis Notes

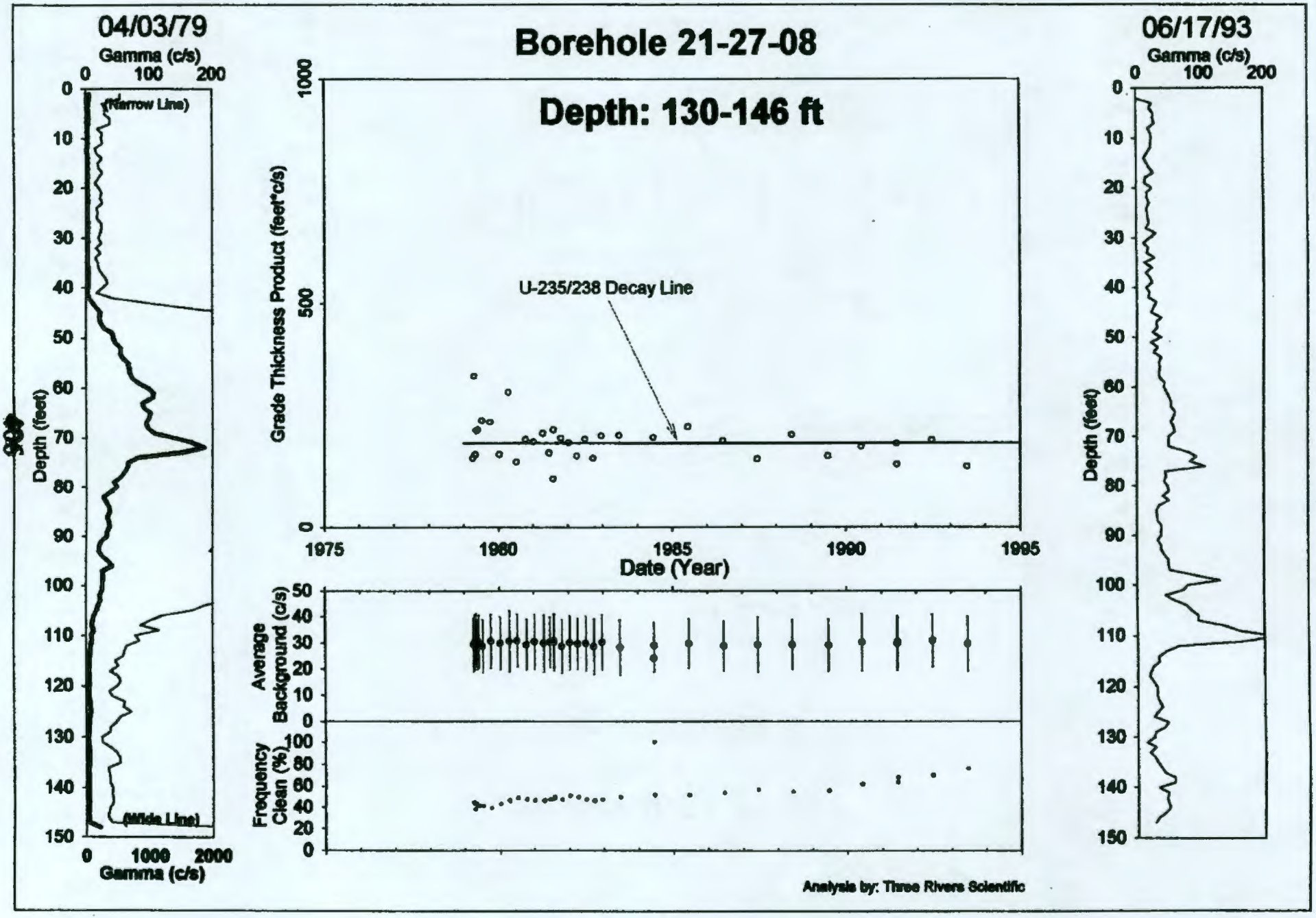
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**40-86 feet is Stable** **92-116 feet is Stable** **130-146 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



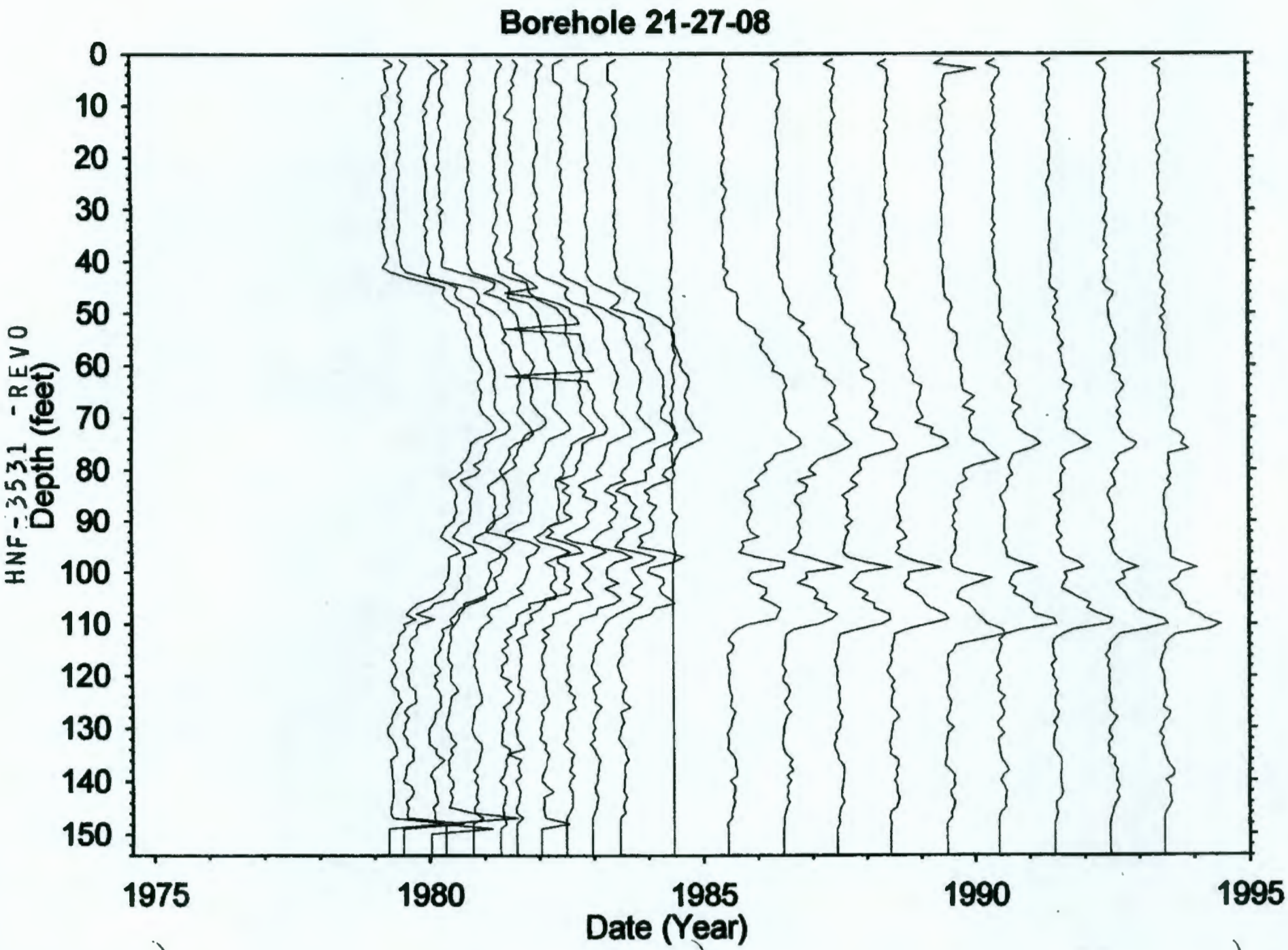
HNF-3531 -REV0



HNF-3531 -REV0



HNF-3531 -REV0



HNF-3531-REV0

Dry Well Survey Analysis - Notes

Borehole BX(21-27-08

Log Date: 79-04-03 1st

Total # Surveys 37

neutron surveys 2

93-06-17 Last

Probe Type 04

GR Surveys 35

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: CS, Co, EU, SB, U

Max Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
NO SURVEYS WITH > 6 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
84-06-12	PROBABLY WRONG WELL		

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
84-06-12	% CLEAN	97	100%	2400	

Analysis Notes

NO SURVEYS REJECTED

Analyst Name Randall Bud

S/W ver TFGRAPH V 2.20

filein := "two92-116.txt"

Well 21-27-08

A := READPRN(filein)

$yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

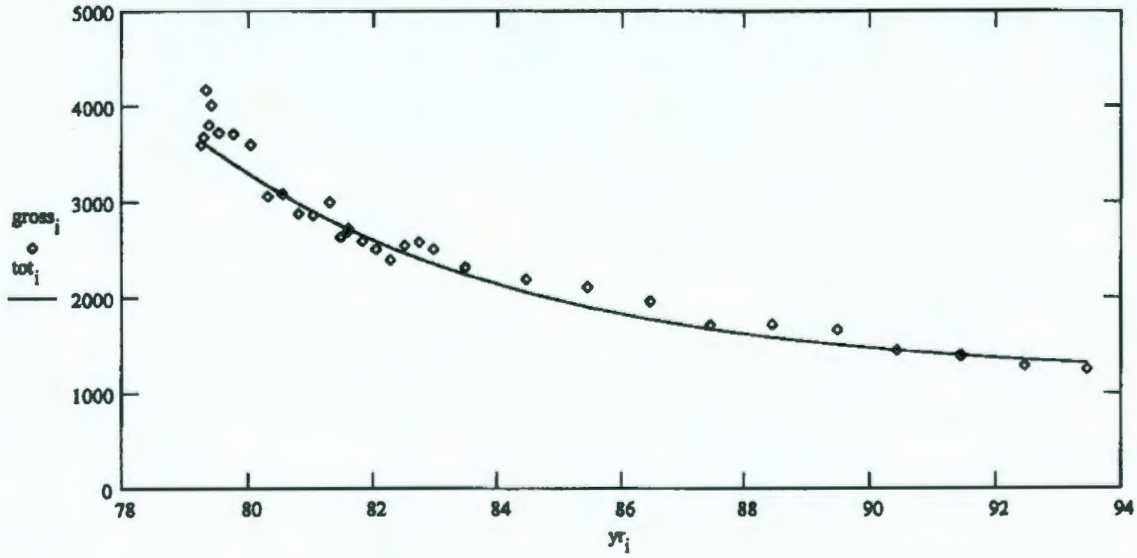
$N := last(yr)$ $N = 33$ $i := 0..N$ $k := 0..300$ $j := 0..299$

$\tau cs := 5.27$ $acs := 2000$

2nd Isotope is Sb-125 (2.77 yrs) $\tau 2 := 2.77$ $a2 := 4030$ $B := 1100$ B is Uranium

$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}}$ $tot_i := Cs_i + X2_i + B$

$gross_i := net_i$ This data edited for spurious points



$$ssq(a1, a3, a5) := \sum_i \left[gross_i - \left[a1 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} + a3 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} + a5 \right] \right]^2$$

Given

$ssq(acs, a2, B) = 0$ $1 = 1$ $B = B$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \\ bk \end{bmatrix} := Minerr(acs, a2, B)$$

Co $\alpha cs = 2.072 \cdot 10^3$ Sb $\alpha 2 = 4.39 \cdot 10^3$ U $bk = 1.097 \cdot 10^3$

$\frac{\alpha cs}{\alpha 2} = 0.472$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}}$ $X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}}$ $tot_i := Cs_i + X2_i + B$

Sb $\frac{X2_N}{Cs_N} = 0.237$ Sb $X2_N = 43.262$ Co $Cs_N = 182.74$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out

filein := "two130-146.txt" **Well 21-27-08**

A := READPRN(filein) $\quad yr := A^{<1>} \quad net := A^{<7>} \quad bkg := A^{<6>} \quad max := A^{<4>}$

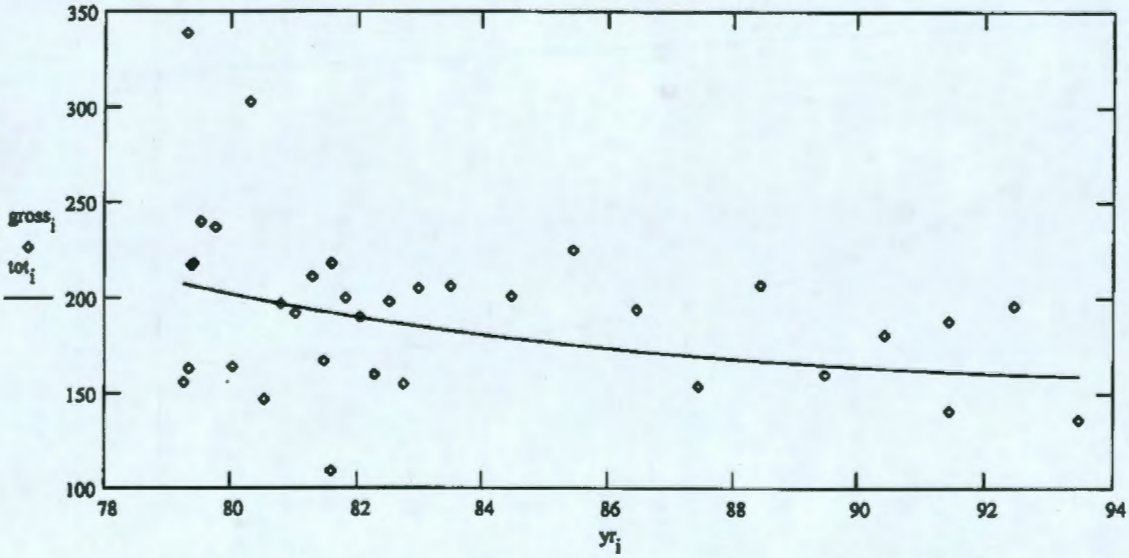
$N := last(yr) \quad N = 33 \quad i := 0..N \quad k := 0..300 \quad j := 0..299$

1st Isotope is Co (5.27 yrs) $\quad \tau co := 5.27 \quad aco := 100$

2nd Isotope is U (4.5 e6 yrs) $\quad \tau 2 := 4500000 \quad a2 := 150$

$$Co_i := aco \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(aco, a2) = 0 \qquad 1 = 1$

$$\begin{bmatrix} \alpha co \\ \alpha 2 \end{bmatrix} := Minerr(aco, a2)$$

$\alpha co = 99.729 \qquad \alpha 2 = 156.799$

$$\frac{\alpha co}{\alpha 2} = 0.636$$

$$Co_i := \alpha co \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau co}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$out^{<0>} := yr \qquad out^{<1>} := tot \qquad WRITEPRN("twop.txt") := out$

Ratio Co/U $\quad \frac{Co_N}{X2_N} = 0.056$

Borehole 21-27-09

Five Zones of Radioactive Contamination Established
70 to 91 feet (Cs-137 & Sb-125) is Stable
91 to 101 feet (Cs-137 & Sb-125) is Stable
101 to 107 feet (Cs-137 & Sb-125) is Stable
107 to 116 feet (Cs-137 & U-235/238) is Stable
116 to 124 feet (Cs-137 & Sb-125 & U-235/238) is Stable

Grade Thickness Product from 70 to 91 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 and Cesium-137 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 1.8 on June 1993.

Grade Thickness Product from 91 to 101 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 (hypothesis) and Cesium-137 (identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.6 on June 1993.

Grade Thickness Product from 101 to 107 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 (hypothesis) and Cesium-137 (identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.09 on June 1993.

Grade Thickness Product from 107 to 116 feet is decreasing at a rate consistent with a least squares fit for Cesium-137 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for U-235/238 to Cs-137 of 4.6 on June 1993.

Grade Thickness Product from 116 to 124 feet is decreasing at a rate consistent with a least squares fit for Antimony-125 (hypothesis), Cesium-137 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for U-235/238:Cs-137:Sb-125 of 171:143:5 on June 1993.

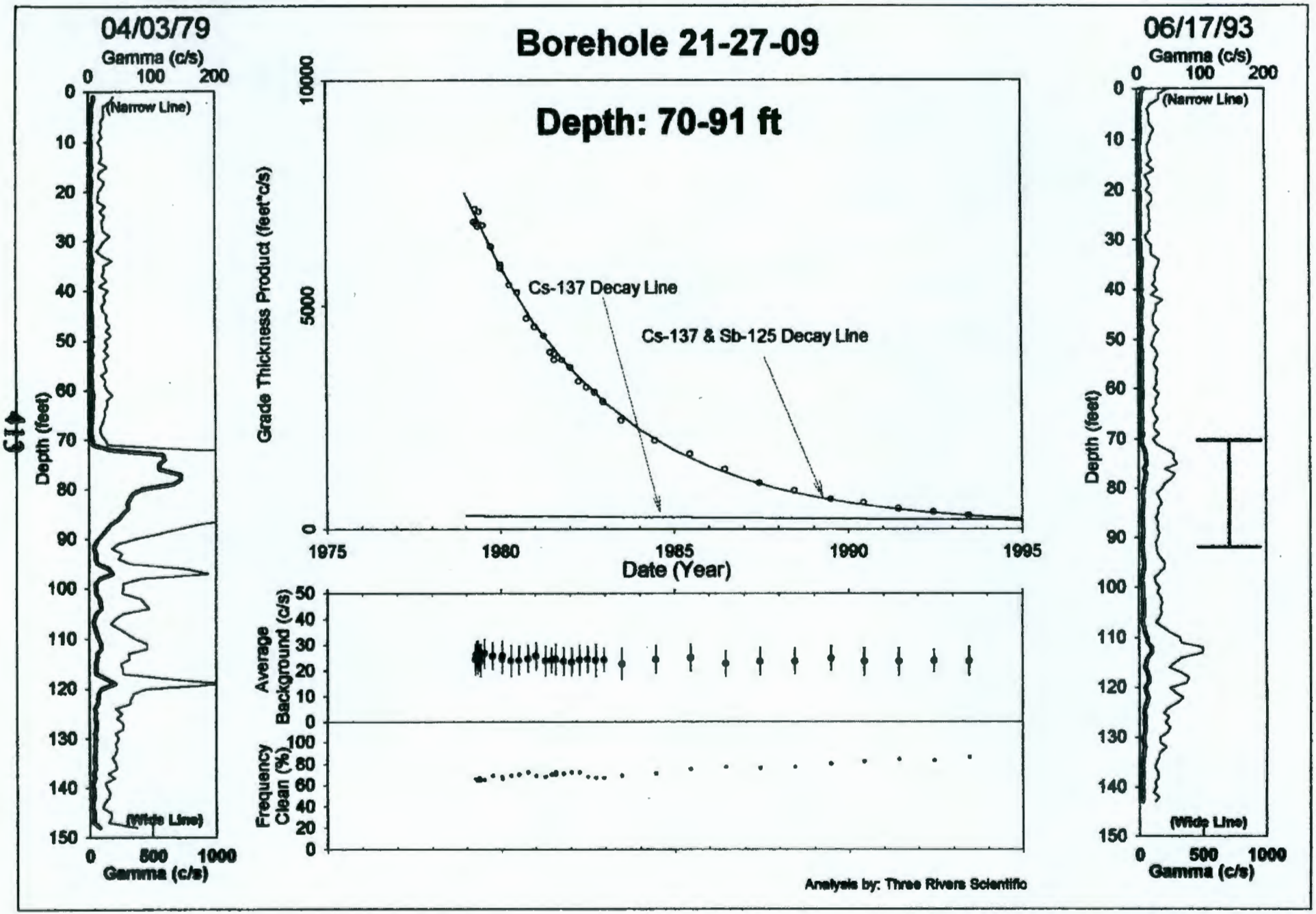
Borehole 21-27-09

Gross Gamma Survey Information

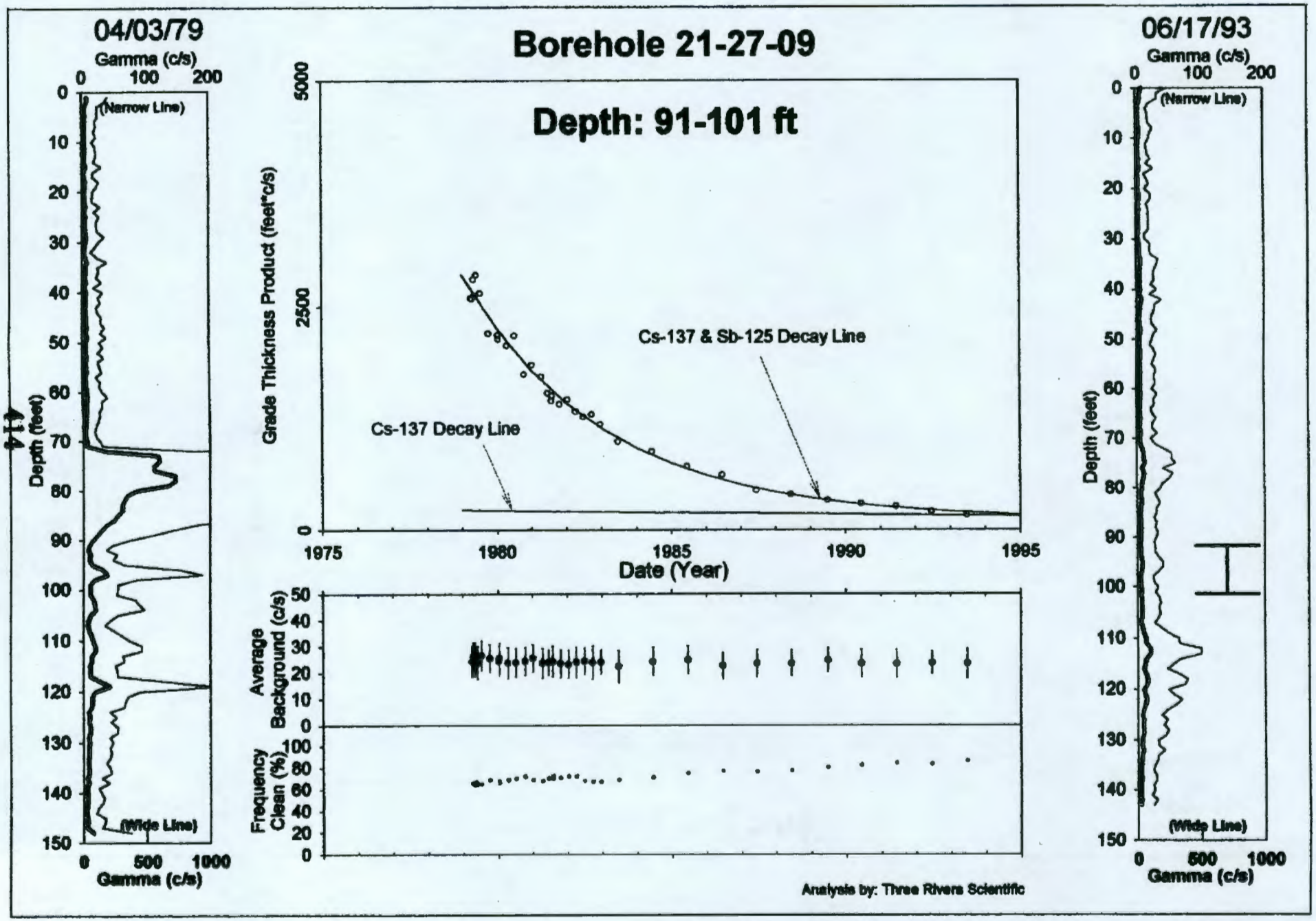
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	4/03/1979
Last Survey Date :	6/17/1993
Number Surveys :	34

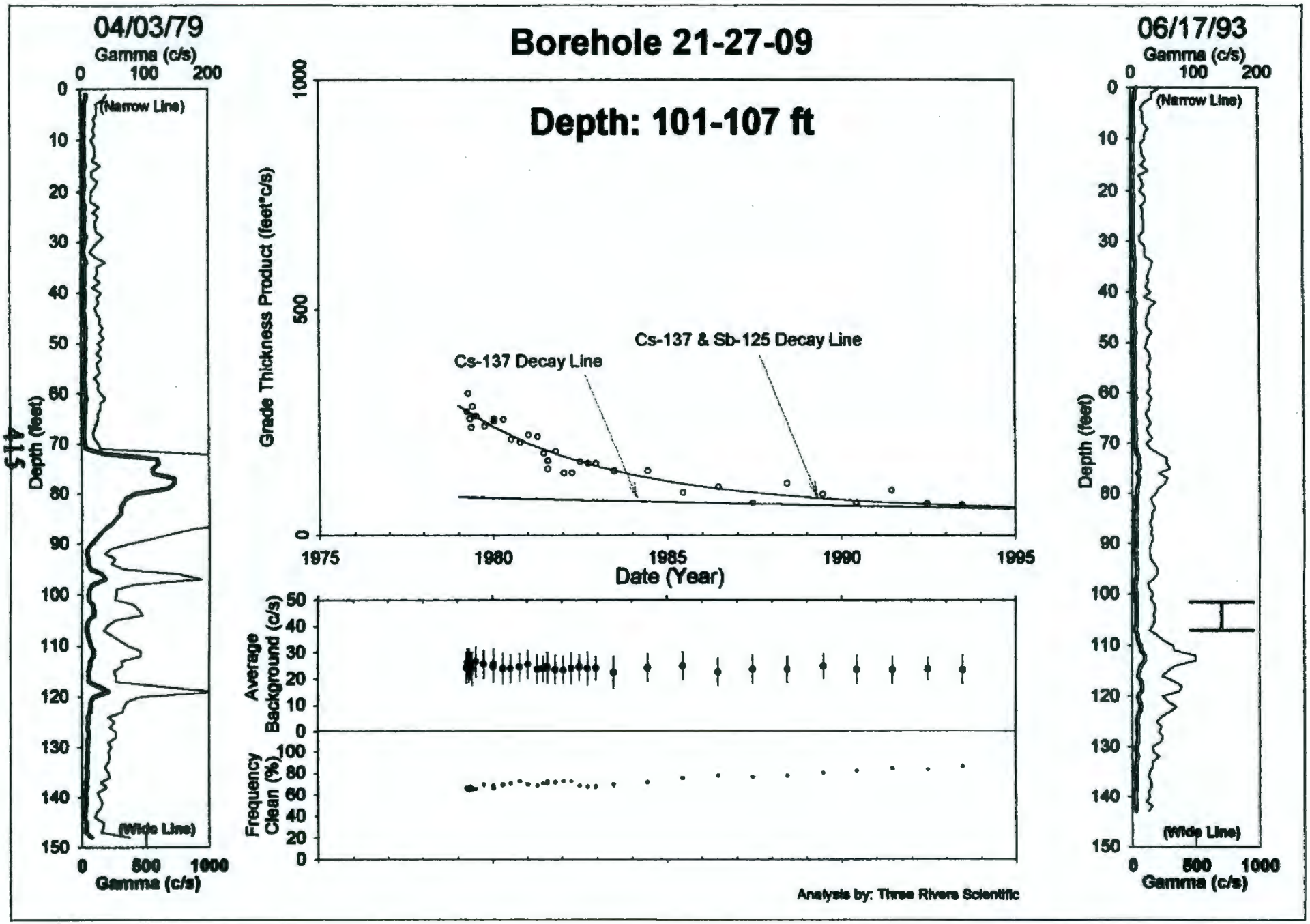
Analysis Notes

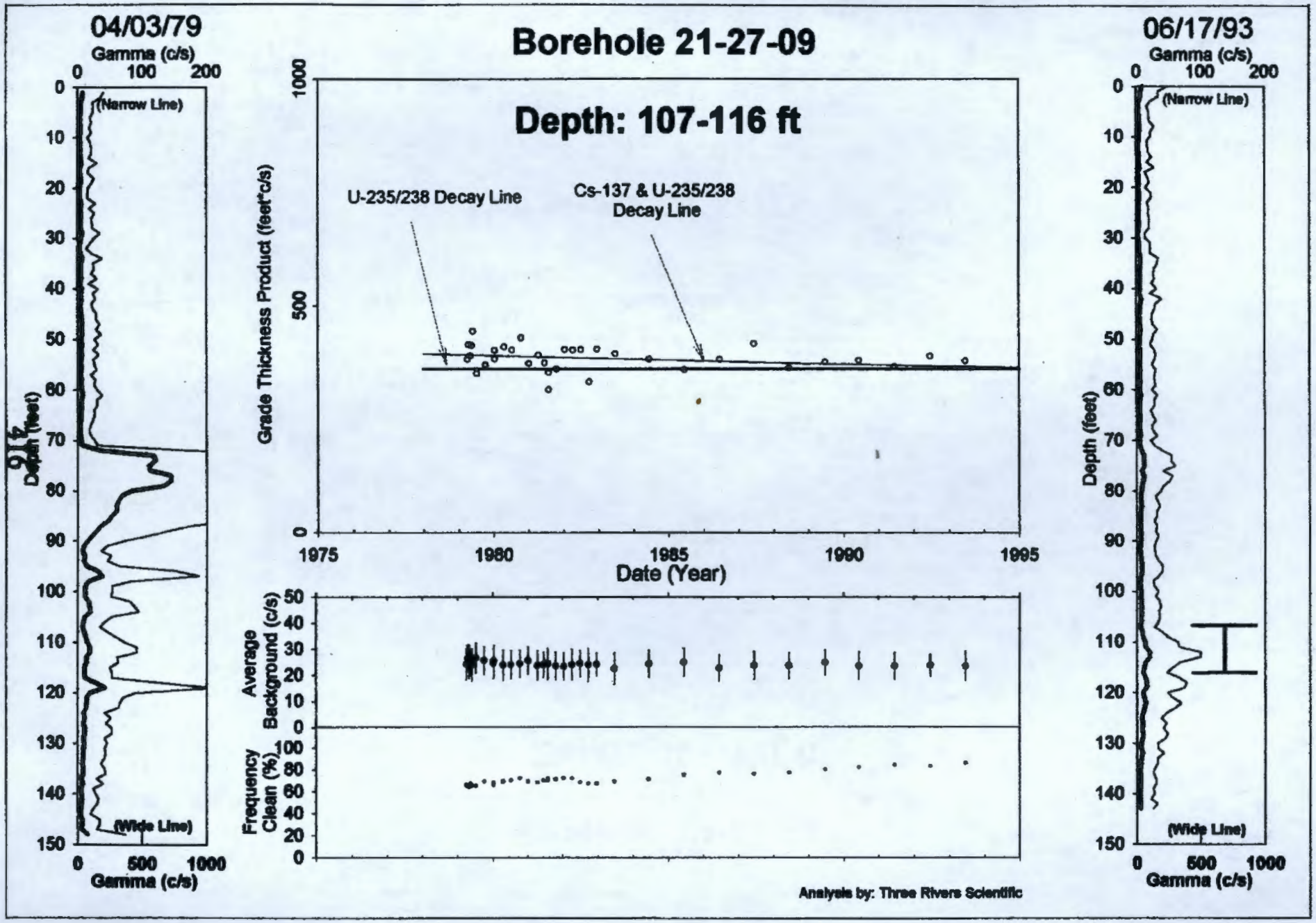
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	Threshold (0< val < 50)
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**70-91 feet is Stable** **91-101 feet is Stable** **101-107 feet is Stable** **107-116 feet is Stable** **116-124 feet is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



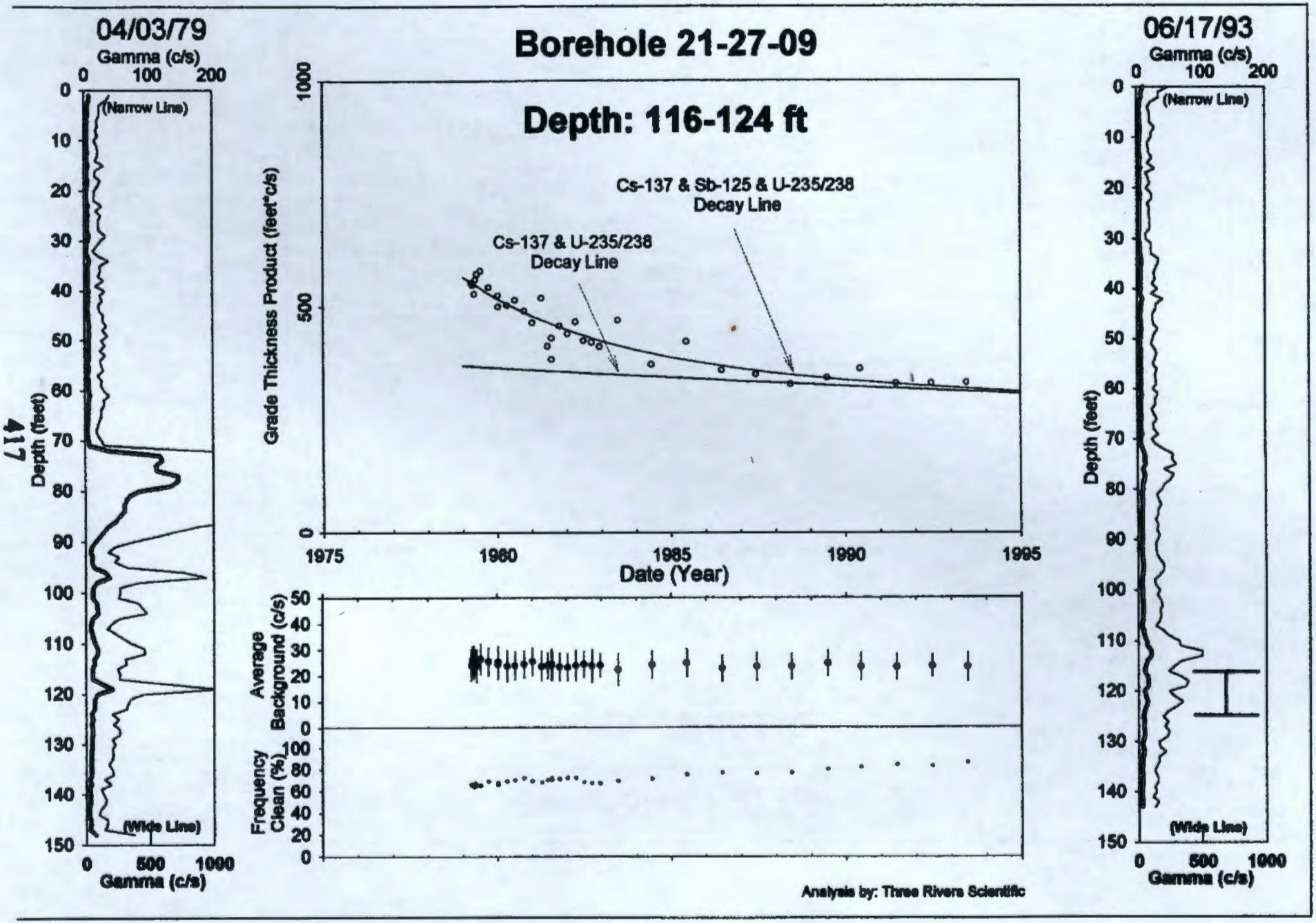
HNF-3531 -REV0


Borehole 21-27-09
Depth: 91-101 ft
04/03/79
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Cs-137 & Sb-125 Decay Line
Cs-137 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/17/93
Analysis by: Three Rivers Scientific

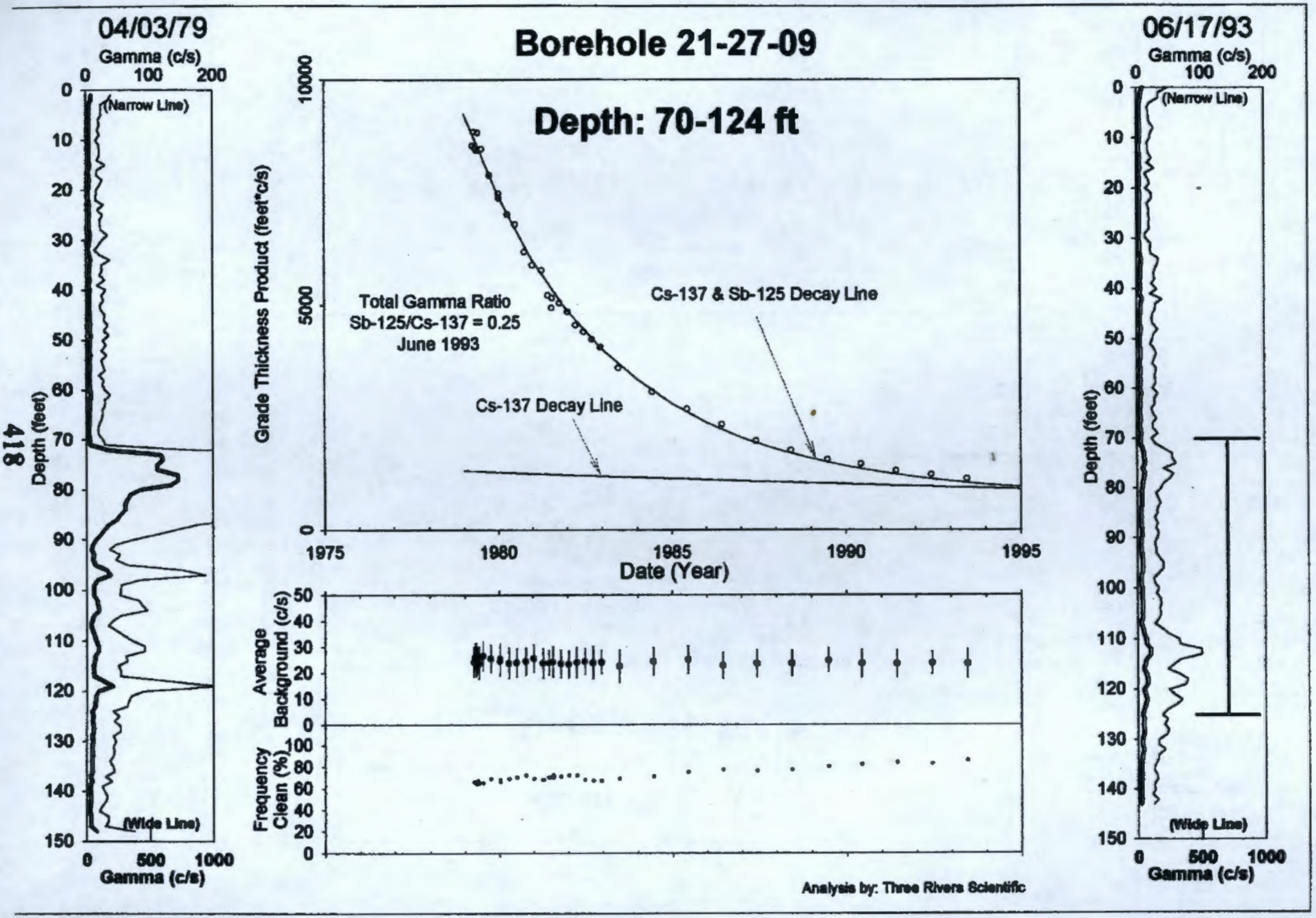

Borehole 21-27-09
Depth: 101-107 ft
04/03/79
06/17/93
Gamma (c/s)
(Narrow Line)
(Wide Line)
Depth (feet)
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Cs-137 & Sb-125 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
Analysis by: Three Rivers Scientific



HNF-3531 -REV0

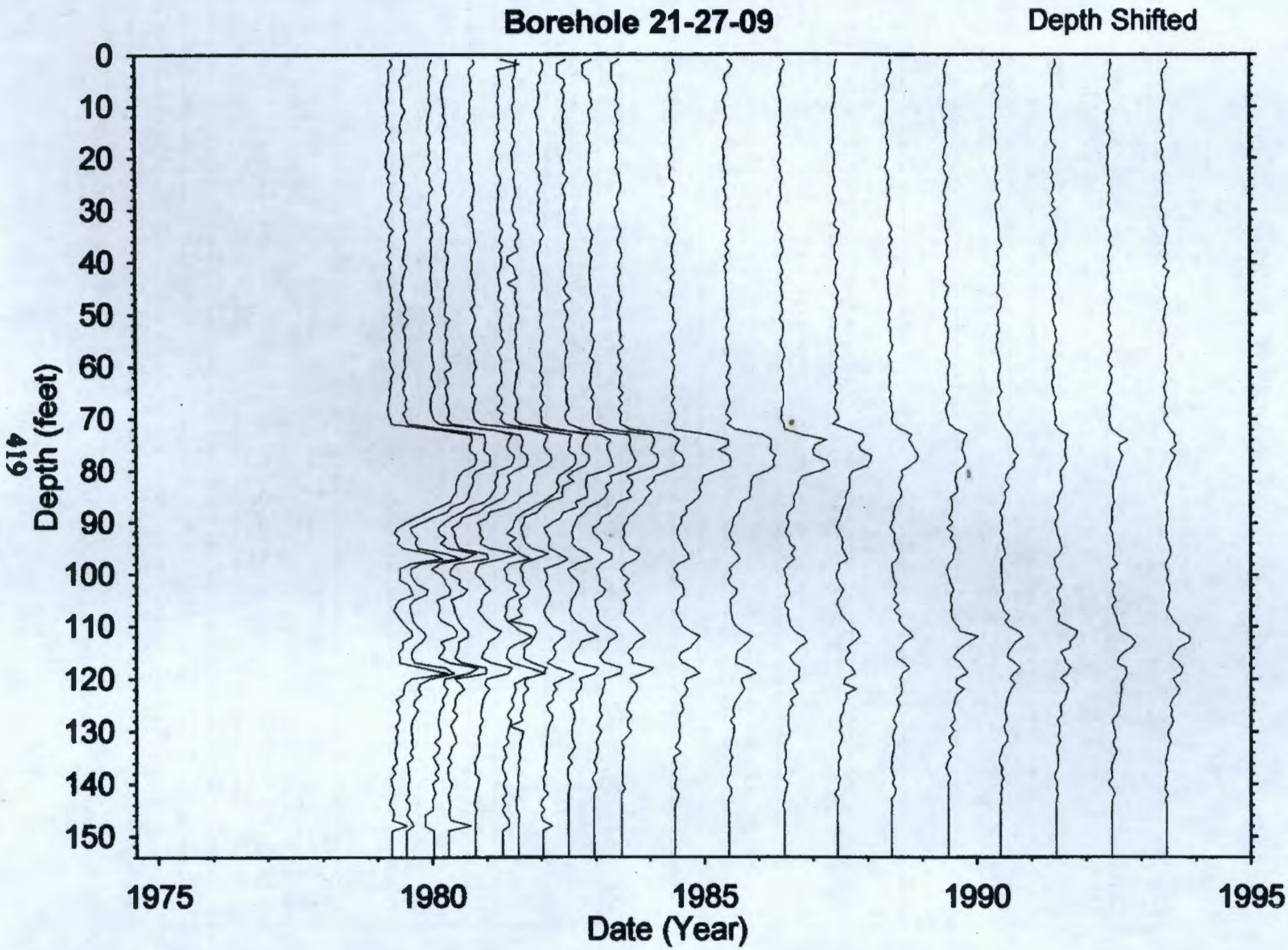


HNF-3531 -REV0



418

HNF-3531 -REV0


Borehole 21-27-09
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX (21-27-09)

Total # Surveys 36

Probe Type 04

neutron surveys 2

GR Surveys 34

Log Date: 79-04-03 1st

93-06-17 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): 64-122 FT

Isotope from Spectral Survey: CS, Sb, U

Max Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
NO SURVEYS WITH 76 GAPS			

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment
NO BAD SURVEYS			

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
NO SURVEYS WITH ABNORMAL AVG BKG OR % CLEAN					

Analysis Notes

NO SURVEYS REJECTED
SURVEYS SHIFTED W/ SHF-AUTO AND DETAIL ZONE ANALYSIS
PERFORMED THEN COMPARED TO COMPOSITE ZONE (70-124 FT)
(DETAIL ZONES 70-91, 91-101, 101-107, 107-116, 116-124 FT)
CONCLUSION: Sb-125 DID NOT MIGRATE AS DEEP AS Cs-137
RATIO Sb/Cs DECREASES FROM 1.8 (UPPER ZONE) TO 0.01 (LOWER ZONE)
INDICATING LARGER PENETRATION DEPTH FOR Cs RELATIVE TO Sb

Analyst Name Randall Reid

S/W ver TFGROSS V2.20

needs to be heard

filein := "Ab-070-091.txt"

Well 21-27-09

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

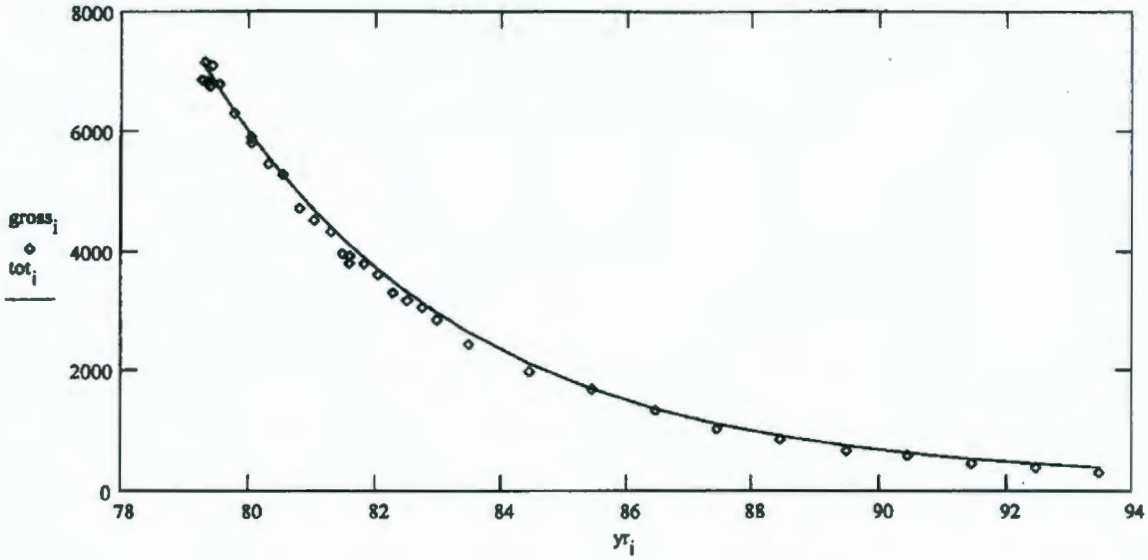
$N := last(yr)$ $\quad N = 33$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau cs := 30.17$ $\quad acs := 300$

2nd Isotope is Sb-125 (2.77 yrs) $\quad \tau 2 := 2.77$ $\quad a2 := 20000$

$Cs_i := acs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad X2_i := a2 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau 2}}$ $\quad tot_i := Cs_i + X2_i$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(acs, a2) = 0$ $\quad l = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := \mathrm{Minerr}(acs, a2)$$

$\alpha cs = 166.337$ $\quad \alpha 2 = 2.003 \cdot 10^4$

$\frac{\alpha cs}{\alpha 2} = 8.306 \cdot 10^{-3}$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $\quad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau 2}}$ $\quad tot_i := Cs_i + X2_i$

$\frac{X2_N}{Cs_N} = 1.813$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

filein := "Ab-091-101.txt"

Well 21-27-09

$A := READPRN(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

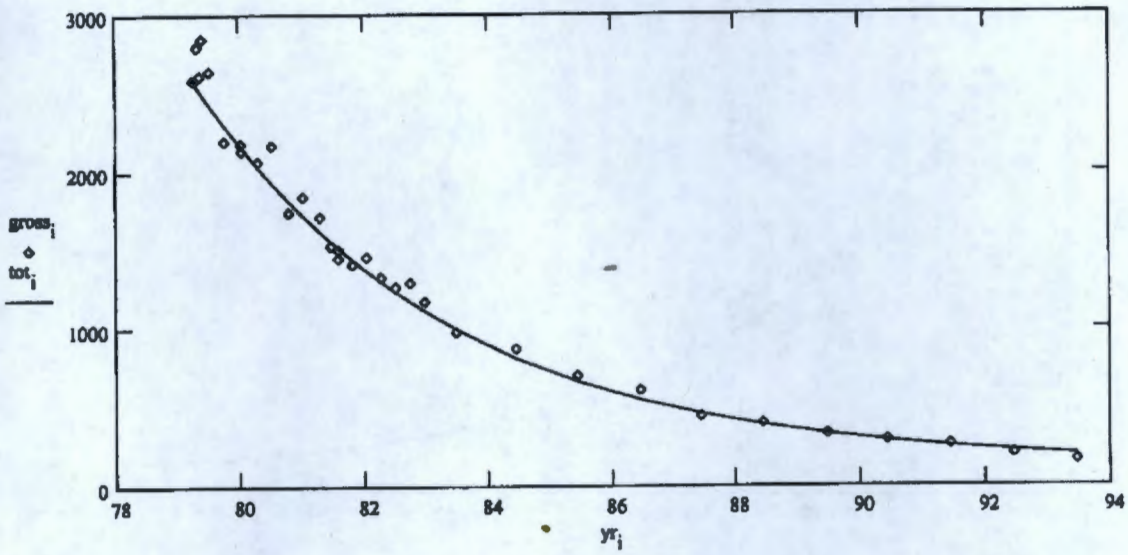
$N := last(yr)$ $\quad N = 33$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau cs := 30.17$ $\quad acs := 200$

2nd Isotope is Sb-125 (2.77 yrs) $\quad \tau 2 := 2.77$ $\quad a2 := 7000$

$$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(acs, a2) = 0$ $\quad 1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := Minerr(acs, a2)$$

$\alpha cs = 189.428$ $\quad \alpha 2 = 7.295 \cdot 10^3$

$$\frac{\alpha cs}{\alpha 2} = 0.026$$

$$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$$\frac{X2_N}{Cs_N} = 0.58$$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad WRITEPRN("twop.txt") := out$

filein := "Ab-101-107.txt"

Well 21-27-09

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

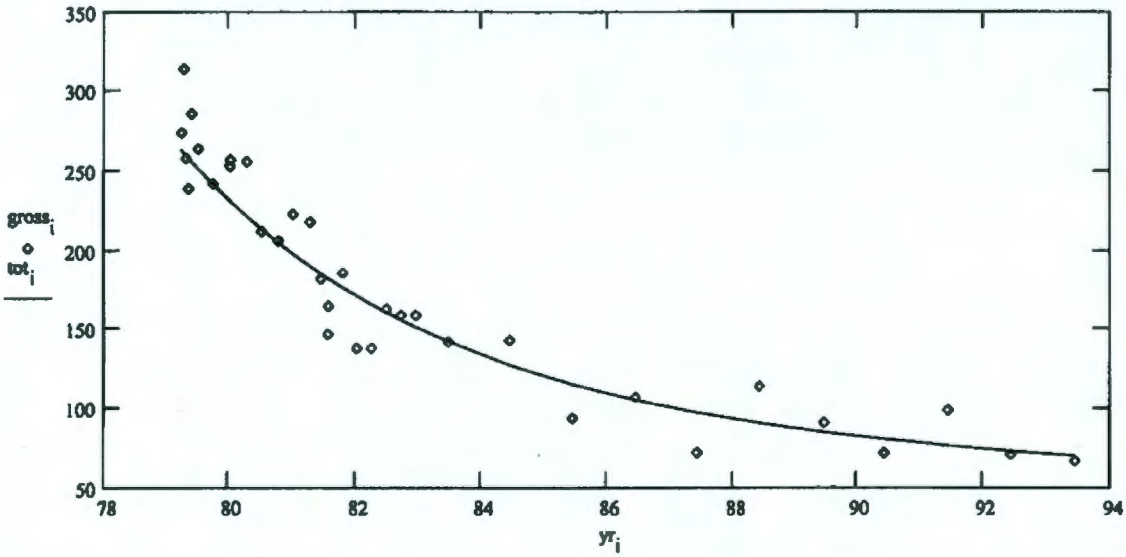
$N := last(yr)$ $\quad N = 33$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau cs := 30.17$ $\quad acs := 100$

2nd Isotope is Sb-125 (2.77 yrs) $\quad \tau 2 := 2.77$ $\quad a2 := 500$

$$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(acs, a2) = 0$ $\quad 1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := \mathrm{Minerr}(acs, a2)$$

$\alpha cs = 93.113$ $\quad$ Sb-125 $\alpha 2 = 552.88$

$$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$\frac{\alpha cs}{\alpha 2} = 0.168$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

$\frac{X2_N}{Cs_N} = 0.089$

Well 21-27-09

filein := "Ab-107-116.txt"

A := READPRN(filein)

$yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

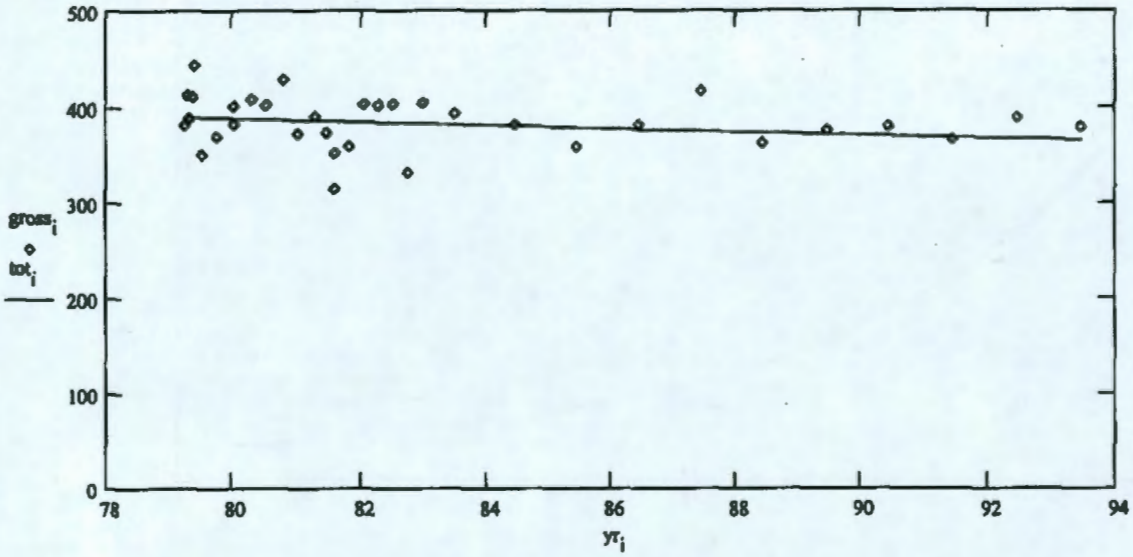
$N := last(yr)$ $N = 33$ $i := 0..N$ $k := 0..300$ $j := 0..299$

$\tau cs := 30.17$ $acs := 100$

2nd isotope is U (4.5 E9 yrs) $\tau 2 := 4.55 \cdot 10^9$ $a2 := 300$

$Cs_i := acs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $X2_i := a2 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau 2}}$ $tot_i := Cs_i + X2_i$

$gross_i := net_i$ *This data edited for spurious points*



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

Given

$ssq(acs, a2) = 0$ $1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := Minerr(acs, a2)$$

$\alpha cs = 100.651$ $\alpha 2 = 301.399$

$\frac{\alpha cs}{\alpha 2} = 0.334$

$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau cs}}$ $X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau 2}}$ $tot_i := Cs_i + X2_i$

$\frac{X2_N}{Cs_N} = 4.576$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out

filein := "Ab-116-124.txt"

Well 21-27-09

A := READPRN(filein)

$yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

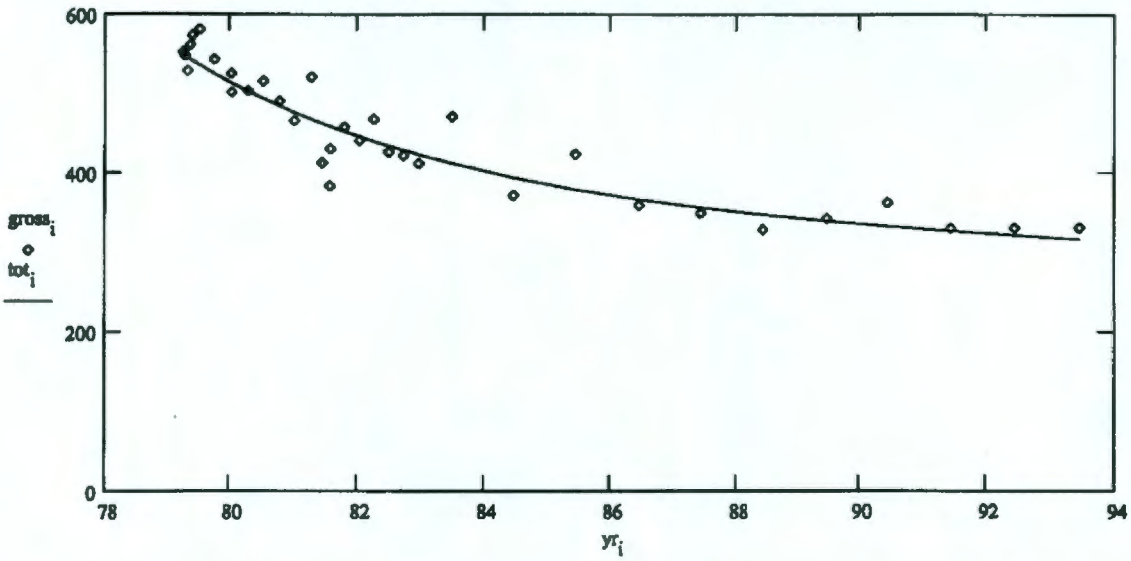
N := last(yr) N = 33 i := 0..N k := 0..300 j := 0..299

τcs := 30.17 acs := 217

2nd Isotope is Sb-125 (2.77 yrs) τ2 := 2.77 a2 := 530 B := 170 B is Uranium

$$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i + B$$

$gross_i := net_i$ This data edited for spurious points



$$ssq(a1, a3, a5) := \sum_i \left[gross_i - \left[a1 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} + a3 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} + a5 \right] \right]^2$$

Given

ssq(acs, a2, B)=0 1=1 B=B

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \\ bk \end{bmatrix} := Minerr(acs, a2, B)$$

$\alpha cs = 218.629$ Sb $\alpha 2 = 537.142$ $bk = 171.423$

$$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i + B$$

$\frac{\alpha cs}{\alpha 2} = 0.407$

$\frac{X2_N}{Cs_N} = 0.037$

Sb $X2_N = 5.293$ $Cs_N = 143.053$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out

Well 21-27-09

filein := "Ab-070-124.txt" (COMBINED)

A := READPRN(filein)

$yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

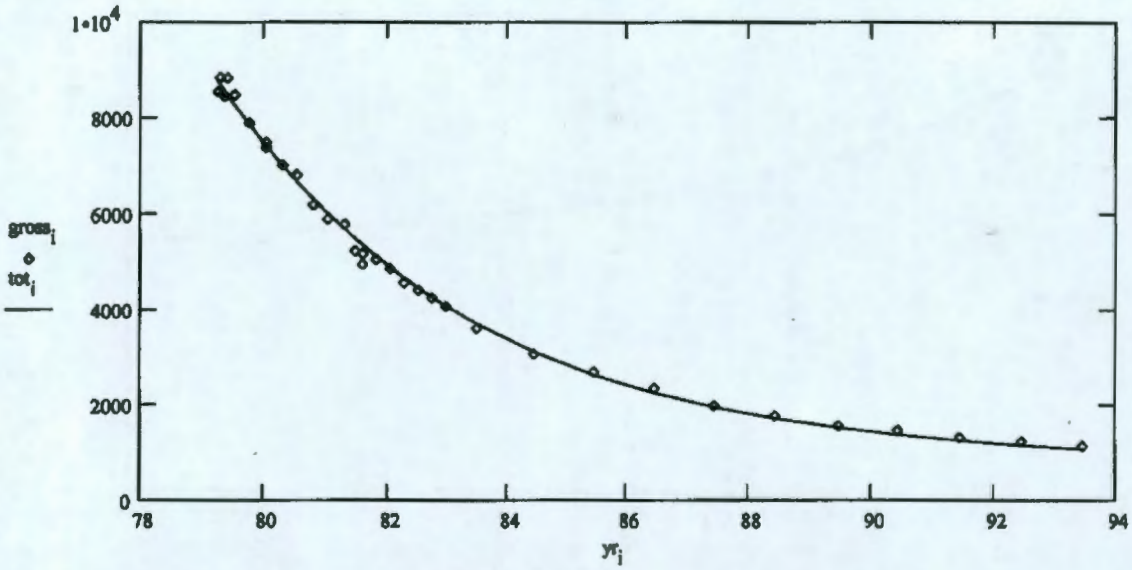
$N := last(yr)$ $N = 33$ $i := 0..N$ $k := 0..300$ $j := 0..299$

$\tau cs := 30.17$ $acs := 1300$

2nd isotope is Sb-125 (2.77 yrs) $\tau 2 := 2.77$ $a2 := 22000$

$$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(acs, a2) = 0$ $l = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := Minerr(acs, a2)$$

$\alpha cs = 1.29 \cdot 10^3$ $\alpha 2 = 2.196 \cdot 10^4$

$$\frac{\alpha cs}{\alpha 2} = 0.059$$

$$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$$\boxed{\frac{X2_N}{Cs_N} = 0.256}$$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out

Borehole 21-27-10

Contamination (Cs-137&Sb-125) from 70 to 102 ft is Stable
Contamination (Cs-137&U-235/238) from 118 to 135 ft is Stable

Grade Thickness Product for the radioactive zone (70-102 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Cesium-137 and Antimony-125 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Sb-125 to Cs-137 of 0.55 on June 1993.

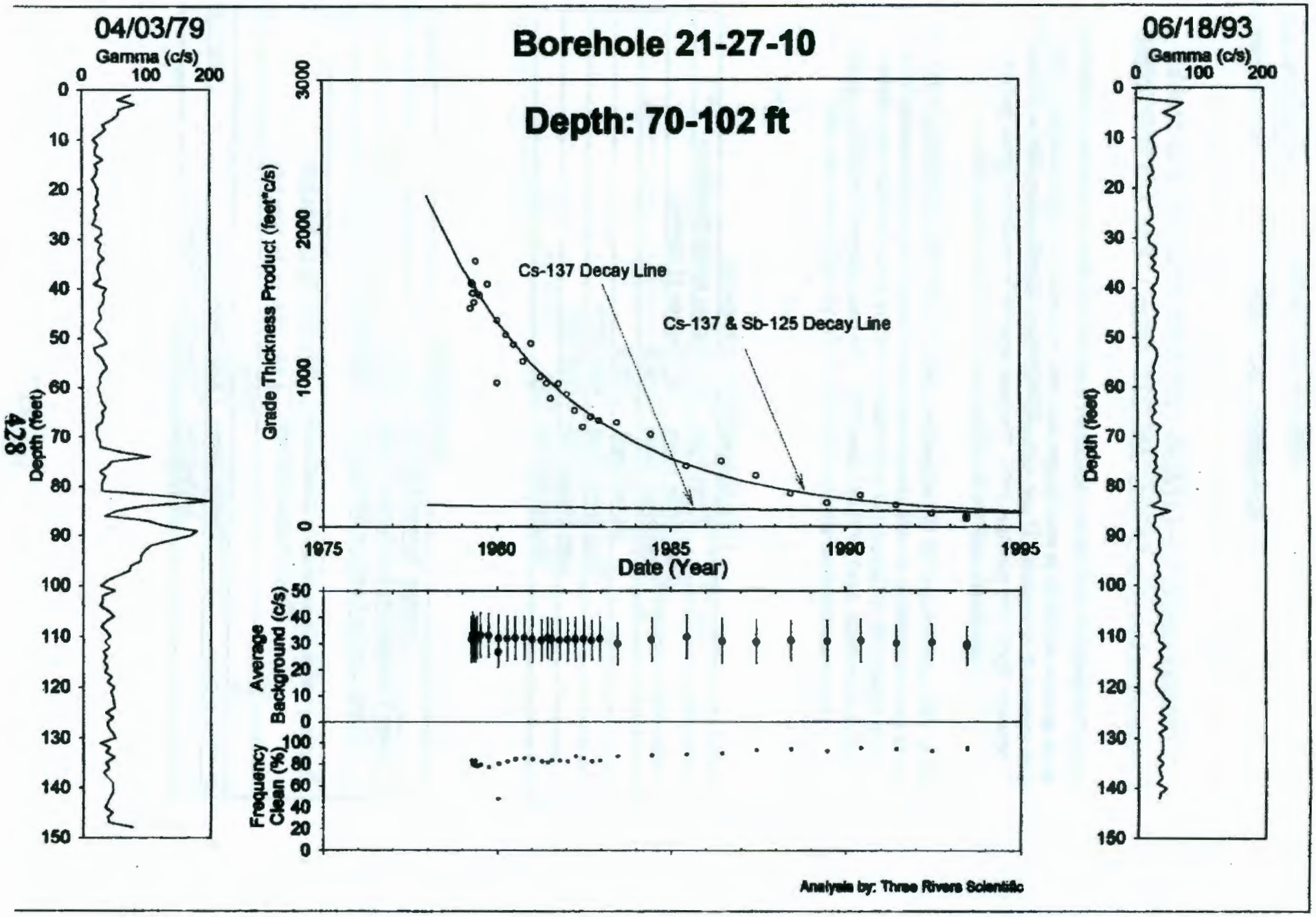
Grade Thickness Product for the radioactive zone (118-135 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Cesium-137 and Uranium-235/238 (both identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for U-235/238 to Cs-137 of 0.35 on June 1993.

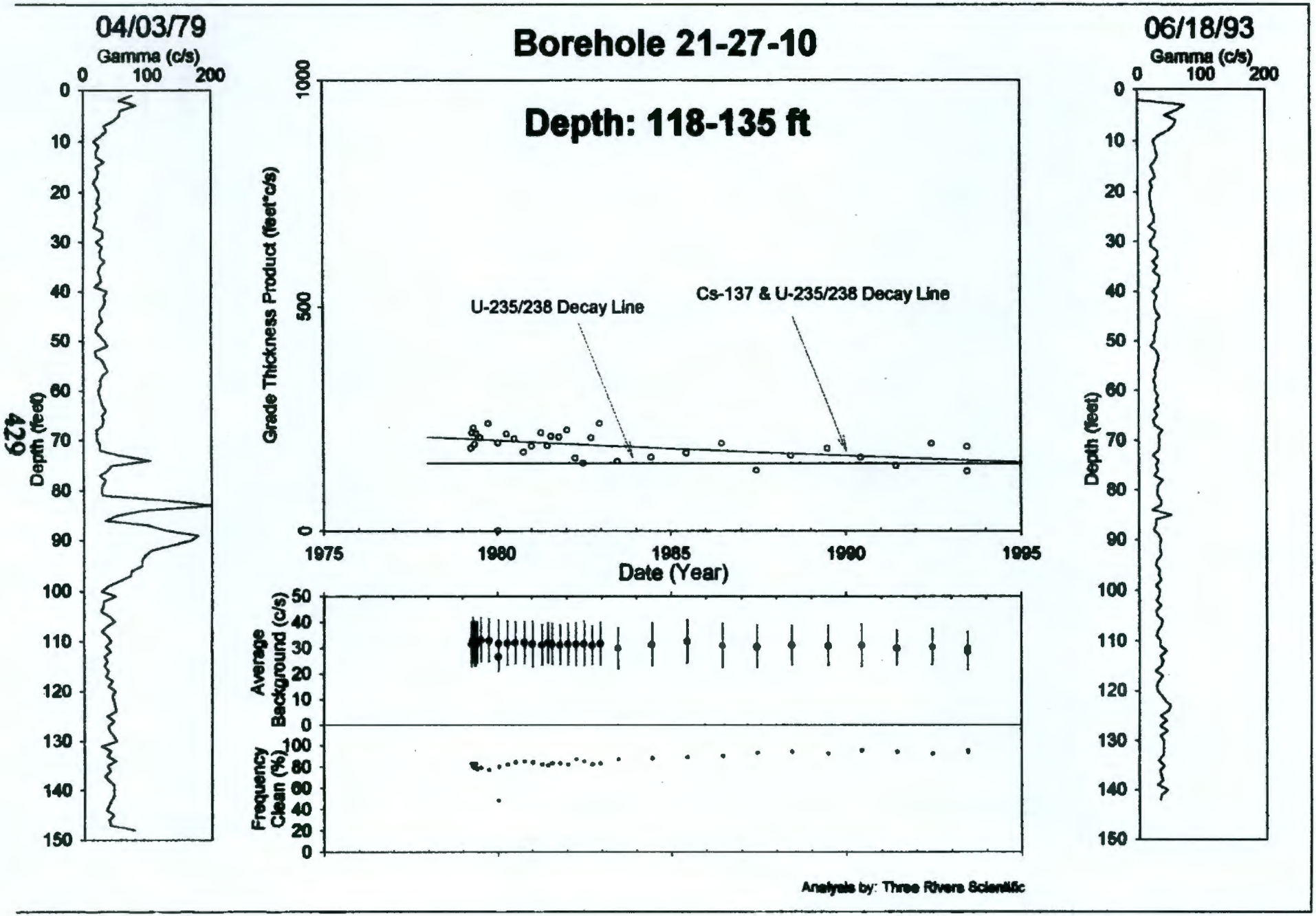
Gross Gamma Survey Information

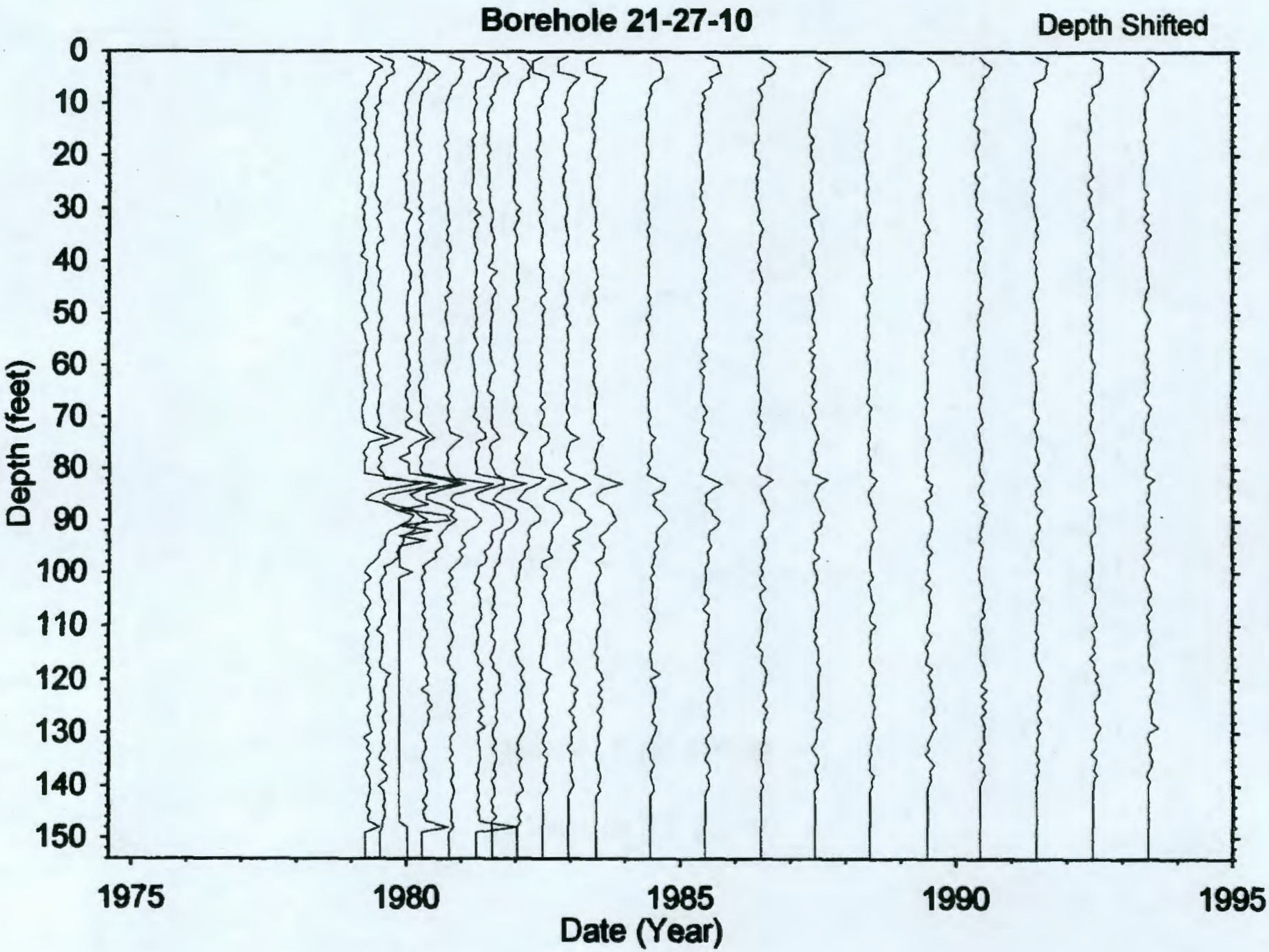
Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	150 ft
Survey Depth :	150 ft
First Survey Date :	4/03/1979
Last Survey Date :	6/18/1993
Number Surveys :	35

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 :	**70-102 ft is Stable** **118-135 ft is Stable**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific


04/03/79
Gamma (c/s)
0 100 200
Depth (feet)
Borehole 21-27-10
Depth: 70-102 ft
Grade Thickness Product (feet*c/s)
Cs-137 Decay Line
Cs-137 & Sb-125 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/18/93
Gamma (c/s)
Depth (feet)
Analysis by: Three Rivers Scientific


04/03/79
Gamma (c/s)
0
100
200
Depth (feet)
Borehole 21-27-10
Depth: 118-135 ft
Grade Thickness Product (feet*c/s)
U-235/238 Decay Line
Cs-137 & U-235/238 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/18/93
Analysis by: Three Rivers Scientific


Borehole 21-27-10
Depth Shifted
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
1975
1980
1985
1990
1995
Date (Year)

Dry Well Survey Analysis - Notes

Borehole BX(21-27-10)

Total # Surveys 37

Probe Type 04

neutron surveys 2

GR Surveys 35

Log Date: 79-04-03 1st

93-06-18 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): SHORT LIVED ISOTOPE (70-100FT & 120-135)

Isotope from Spectral Survey: Cs, Eu, U, Sb

Max Survey Depth 150

GAPS.Txt

Survey Date	num. Gaps	approx #Sampl's	Comment
90-01-08	56	145	

HI-ZONES.Txt

Survey Date	Reason Selected	approx #Samp's	Comment

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq. Clean	Avg. Bkg	Comment
90-01-08	%CLEAN	150	48%	26.8	

Analysis Notes

NO SURVEYS REJECTED
BROAD ZONE ANALYZED (70-102FT)

Analyst Name Randall Price

S/W ver THROSS V2.20

filein := "two118-135.txt" **Well 21-27-10**

$A := READPRN(filein)$ $yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

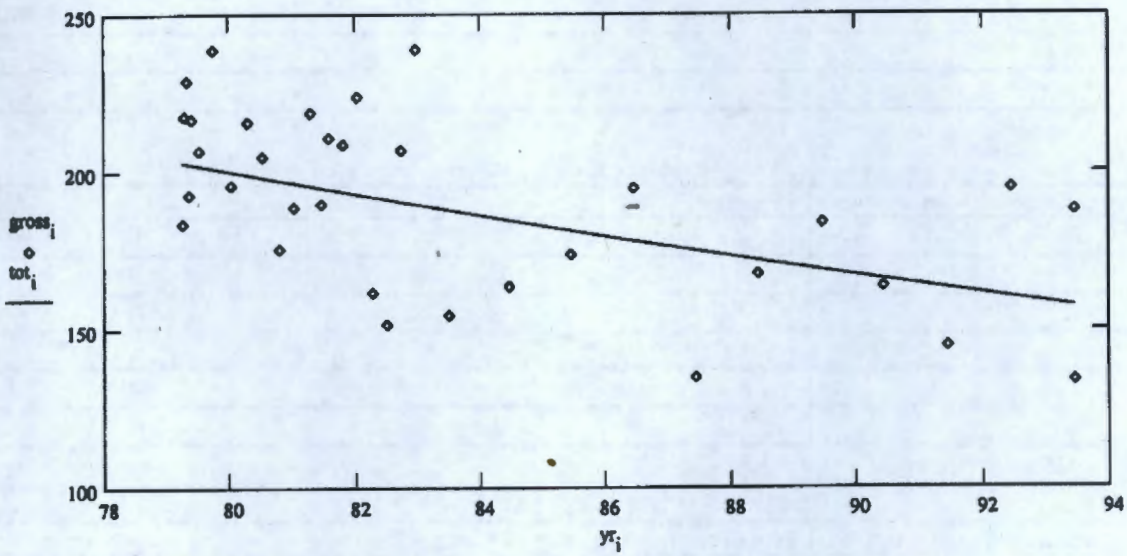
$N := last(yr)$ $N = 32$ $i := 0..N$ $k := 0..300$ $j := 0..299$

$\tau cs := 30.17$ $acs := 180$

2nd Isotope is U-235/238 (4.5e9 yrs) $\tau 2 := 4.5 \cdot 10^9$ $a2 := 40$

$$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(acs, a2) = 0$ $1 = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := Minerr(acs, a2)$$

$\alpha cs = 181.528$ $\alpha 2 = 41.26$

$$\frac{\alpha cs}{\alpha 2} = 4.4$$

$$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$$\frac{X2_N}{Cs_N} = 0.347$$

$out^{<0>} := yr$ $out^{<1>} := tot$ $WRITEPRN(\text{"twop.txt"}) := out$

filein := "two70-102.txt" **Well 21-27-10**

$A := READPRN(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

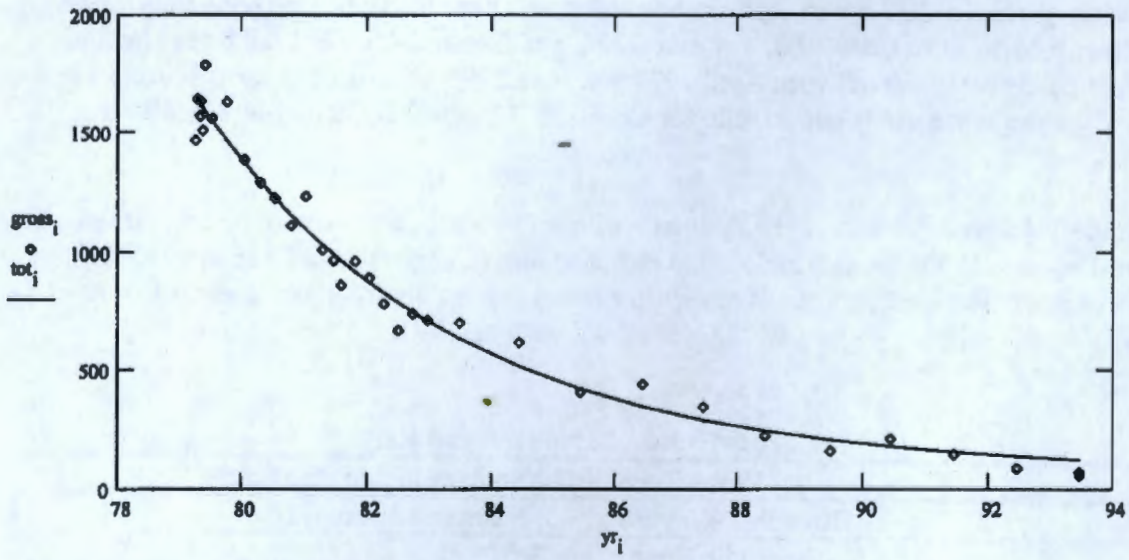
$N := last(yr)$ $\quad N = 33$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau cs := 30.17$ $\quad acs := 122$

2nd Isotope is Sb-125 (2.77 yrs) $\quad \tau 2 := 2.77$ $\quad a2 := 4470$

$$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(acs, a2) = 0$ $\quad l = 1$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \end{bmatrix} := Minerr(acs, a2)$$

Sb

$\alpha cs = 122$ $\quad \alpha 2 = 4.47 \cdot 10^3$

$$\frac{\alpha cs}{\alpha 2} = 0.027$$

$$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i$$

Sb $\frac{X2_N}{Cs_N} = 0.552$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad WRITEPRN("twop.txt") := out$

Borehole 21-27-11

Contamination (Co-60 & Sb-125 & U-235/238) from 66 to 110 feet is Stable
Stability of Contamination (Co-60 & U-235/238) from 110 to 138 feet is Undetermined

Grade Thickness Product for the radioactive zone (66-110 feet) is decreasing within the gross gamma sensitivity to each isotope and relative intensity at a rate consistent with a least squares fit of Cobalt-60, Antimony-125, and Uranium-235/238 (all three identified from HPGe detector) between April 1979 and June 1993. The least squares fit results in a gross gamma contribution ratio for Co-60:Sb-125:U-235/238 of 144:818:890 on June 1993.

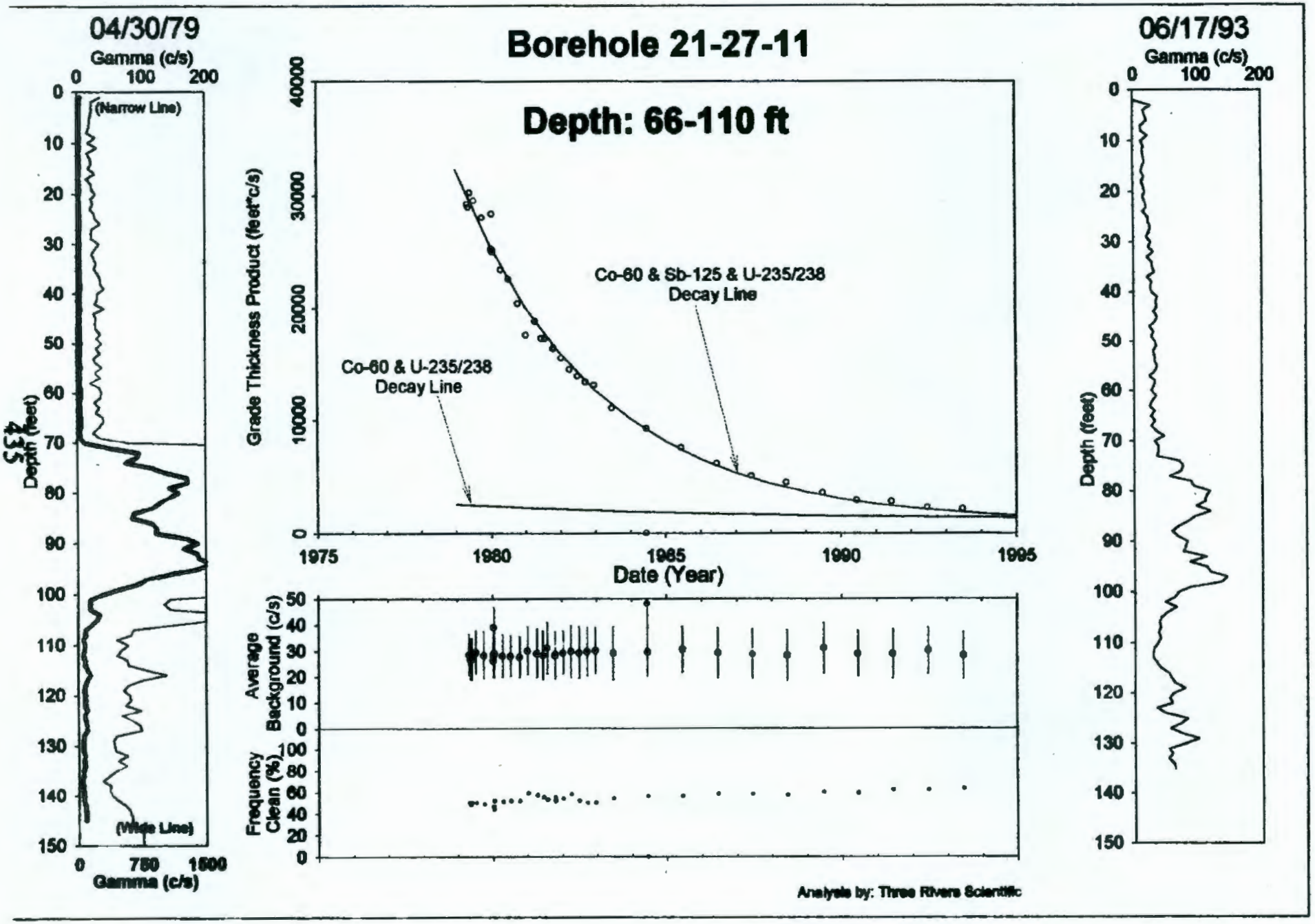
Grade Thickness Product of the radioactive zone (110-138 feet) can not be established. A least squares fit for the HPGe detected radionuclides (Cobalt-60 and Uranium-235/238) is presented. The least squares fit results in a gross gamma contribution ratio for Co-60 to U-235/238 of 0.2 on June 1993.

Gross Gamma Survey Information

Probe Type :	04: Sodium Iodide Scintillator
Other Probe Types :	03: Neutron (2 surveys)
Borehole Depth :	138 ft
Survey Depth :	138 ft
First Survey Date :	4/30/1979
Last Survey Date :	6/17/1993
Number Surveys :	36

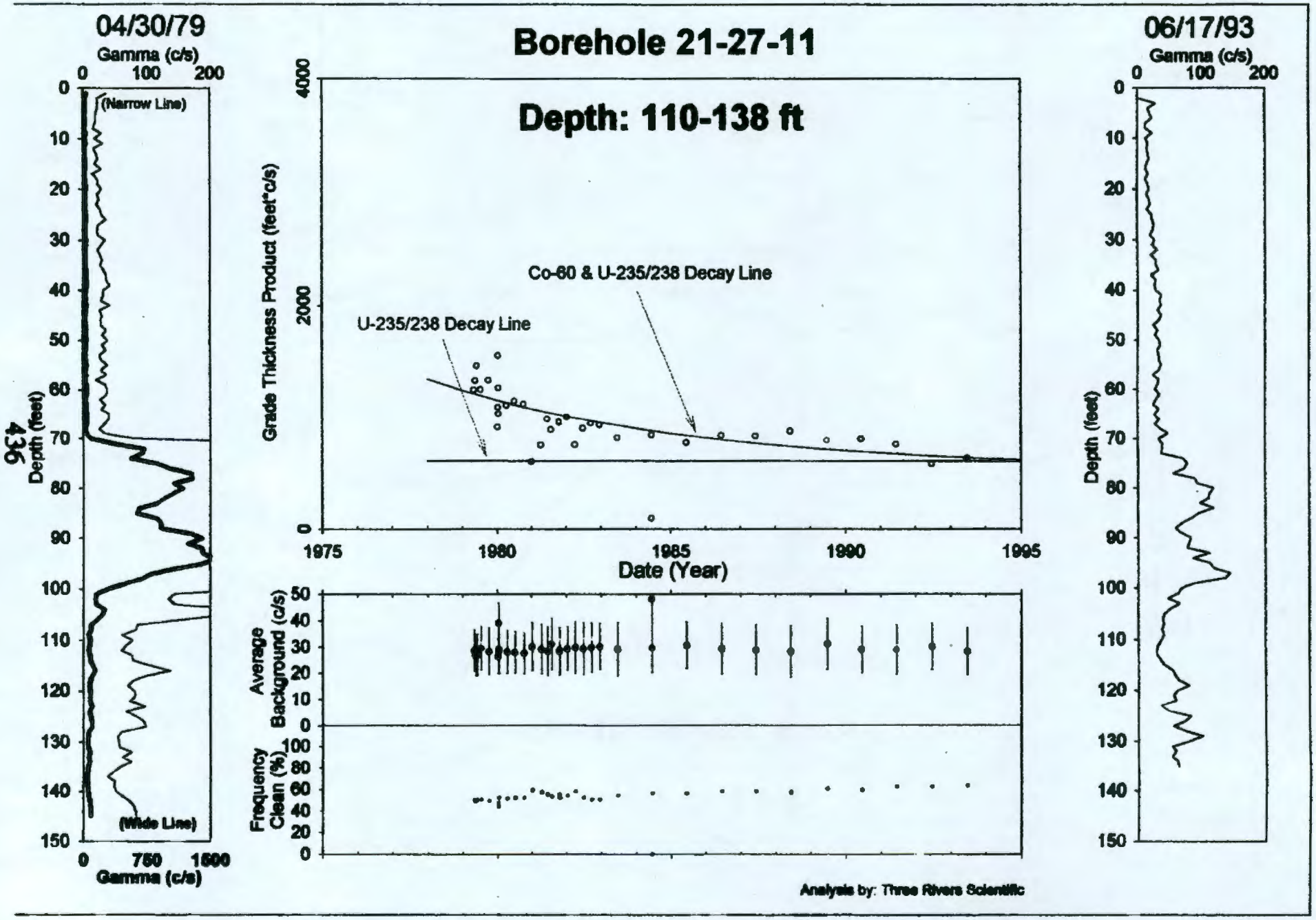
Analysis Notes

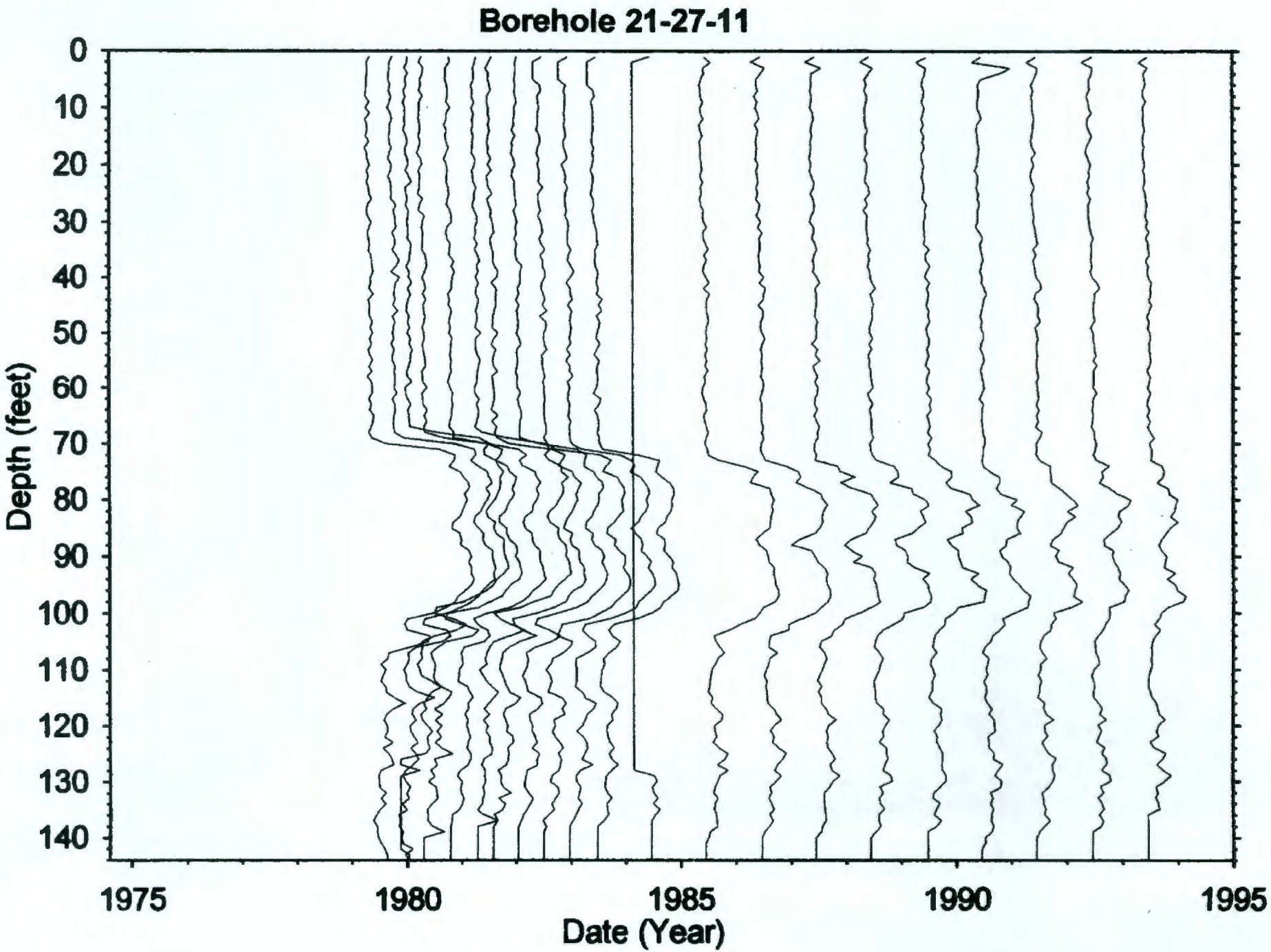
Number Surveys Rejected :	0
Lower Threshold for Bad Survey Values :	<= 0
Method Used to Compute Background :	40 to 60 feet
Depth(s) where Contamination Identified in Gross Gamma Surveys :	**66-110 feet is Stable** **110-138 feet Undetermined**
Analyst Name :	R.K. Price
Analysis By :	Three Rivers Scientific



435

HNF-3531 -REV0


Borehole 21-27-11
Depth: 110-138 ft
04/30/79
Gamma (c/s)
0 100 200
(Narrow Line)
(Wide Line)
Depth (feet)
0 750 1500
Gamma (c/s)
Grade Thickness Product (feet*c/s)
Co-60 & U-235/238 Decay Line
U-235/238 Decay Line
Date (Year)
Average Background (c/s)
Frequency Clean (%)
06/17/93
Analysis by: Three Rivers Scientific


Borehole 21-27-11
Depth (feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
1975
1980
1985
1990
1995
Date (Year)

filein := "two110-138.txt" **Well 21-27-11**

$A := \mathrm{READPRN}(filein)$ $\quad yr := A^{<1>}$ $\quad net := A^{<7>}$ $\quad bkg := A^{<6>}$ $\quad max := A^{<4>}$

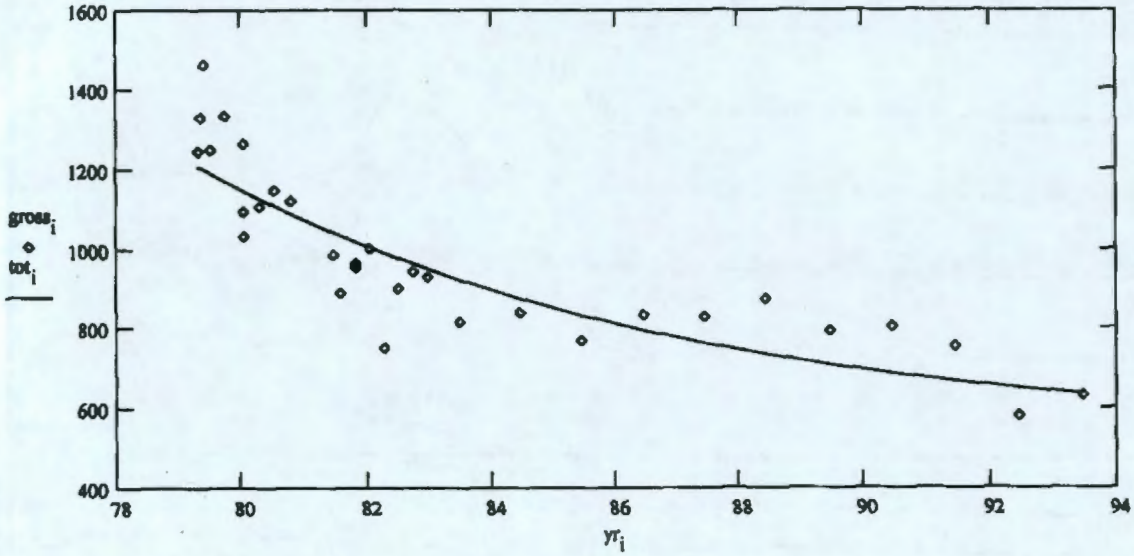
$N := last(yr)$ $\quad N = 30$ $\quad i := 0..N$ $\quad k := 0..300$ $\quad j := 0..299$

$\tau co := 5.27$ $\quad aco := 1200$

2nd Isotope is U (4.5 E6 yrs) $\quad \tau 2 := 4500000$ $\quad a2 := 530$

$$Co_i := aco \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$gross_i := net_i$ This data edited for spurious points



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

Given

$ssq(aco, a2) = 0$ $\quad 1 = 1$

$$\begin{bmatrix} \alpha co \\ \alpha 2 \end{bmatrix} := \mathrm{Minerr}(aco, a2)$$

$\alpha co = 1.21 \cdot 10^3$ $\quad \alpha 2 = 533.806$

$$\frac{\alpha co}{\alpha 2} = 2.267$$

$$Co_i := \alpha co \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau co}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\cdot\frac{\ln(2)}{\tau 2}} \qquad tot_i := Co_i + X2_i$$

$$\boxed{\frac{Co_N}{X2_N} = 0.2}$$

$out^{<0>} := yr$ $\quad out^{<1>} := tot$ $\quad \mathrm{WRITEPRN}(\text{"twop.txt"}) := out$

Well 21-27-11

filein := "two66-110.txt"

A := READPRN(filein)

$yr := A^{<1>}$ $net := A^{<7>}$ $bkg := A^{<6>}$ $max := A^{<4>}$

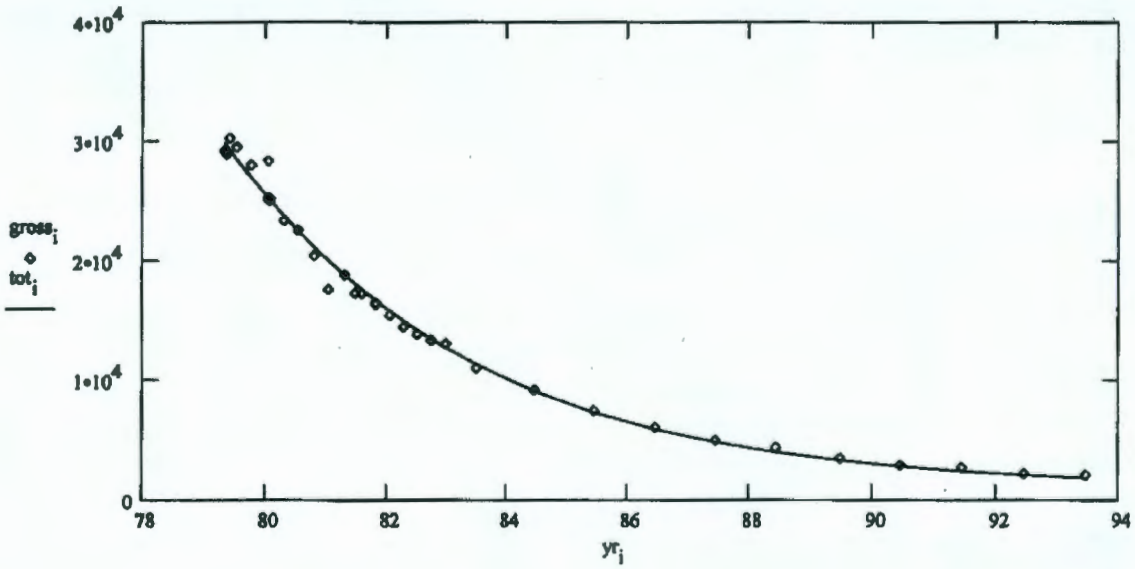
$N := last(yr)$ $N = 34$ $i := 0..N$ $k := 0..300$ $j := 0..299$

1st Isotope is Co-60 (5.27 yrs) $\tau cs := 5.27$ $acs := 1660$

2nd Isotope is Sb-125 (2.77 yrs) $\tau 2 := 2.77$ $a2 := 83000$ $B := 888$ B is Uranium

$$Cs_i := acs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := a2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i + B$$

$gross_i := net_i$ This data edited for spurious points



$$ssq(a1, a3, a5) := \sum_i \left[gross_i - \left[a1 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} + a3 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} + a5 \right] \right]^2$$

Given

$ssq(acs, a2, B) = 0$ $1 = 1$ $2 = 2$

$$\begin{bmatrix} \alpha cs \\ \alpha 2 \\ bk \end{bmatrix} := Minerr(acs, a2, B)$$

Co $\alpha cs = 1.631 \cdot 10^3$ Sb $\alpha 2 = 8.301 \cdot 10^4$ U $bk = 890.279$

$$Cs_i := \alpha cs \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau cs}} \qquad X2_i := \alpha 2 \cdot e^{-(yr_i - 75)\frac{\ln(2)}{\tau 2}} \qquad tot_i := Cs_i + X2_i + B$$

$\frac{\alpha cs}{\alpha 2} = 0.02$

$\frac{X2_N}{Cs_N} = 5.686$

Sb $X2_N = 817.994$

Co $Cs_N = 143.856$

$out^{<0>} := yr$ $out^{<1>} := tot$ WRITEPRN("twop.txt") := out

Dry Well Survey Analysis - Notes

Borehole BX(21-27-11)

Total # Surveys 38

Probe Type 04

neutron surveys 2

GR Surveys 36

Log Date: 74-11-30 1st

93-06-17 Last

Presentation Plot Dates _____ (If different from 1st & Last)

Contamination Zone Depth(s): _____

Isotope from Spectral Survey: Cs, (Co, Sb) U

Max Survey Depth 138

25-75FT 70-100FT 70-137FT

GAPS.Txt

Survey Date	num. Gaps	num. Samples	Comment
80-01-08	16	145	
84-06-12	128	140	

HI-ZONES.Txt

Survey Date	Reason Selected	num. Samples	Comment
84-06-12	BAD SURVEY	140	(RAPID DECAY FROM 1980 TO 1990)

BackGnd.Txt

Survey Date	Reason Selected	num. Samples	Feq.Clean	Avg.Bkg	Comment
84-06-12	AVG BICC	137	0%	48.0	

Analysis Notes

RATIO Co/Sb @ 6/93 = 0.57/1 OF CURRENT EMISSIONS

NO SURVEYS REJECTED

Analyst Name Randall Ruc

S/W ver TKGROSS V.2.20