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Pacific Northwest
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Borehole Data Package for Well 299-E33-44 at Single-Shell Tank Waste Management Area B-BX-BY

D. G. Horton
S. M. Narbutovskih

March 1999

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Acknowledgment

The analyses of particle size distribution, moisture content, pH, electrical conductivity, cation exchange capacity, calcium carbonate content, and alkalinity were done in the Applied Geology and Geochemistry Group laboratory, Pacific Northwest National Laboratory, Richland, Washington. The work was supervised by Jeff Serne. His laboratory also produced the 1:1 water:sediment extracts for major cation and anion analyses. The cation analyses were done at the Chemical Analysis Laboratory at the University of Georgia in Athens, Georgia. The anion analyses were done in the Pacific Northwest National Laboratory interfacial geochemistry laboratory. Mr. Serne provided interpretations of all the physical and chemical data from sediment samples, and those interpretations are incorporated into this report. His contribution is very much appreciated.

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1.0 Introduction

One new Resource Conservation and Recovery Act (RCRA) groundwater monitoring well was installed during September 1998 at the single-shell tank farm Waste Management Area (WMA) B-BX-BY in 1998 in fulfillment of Tri-Party Agreement (Ecology 1996) milestone M-24-40. The well is 299-E33-44 and is located east of the BY single-shell tank farm. The well is a new upgradient monitoring well drilled in support of the groundwater assessment program at WMA B-BX-BY. The locations of all wells in the monitoring network at WMA B-BX-BY are shown on Figure 1.

The groundwater monitoring plan for single-shell tanks (Caggiano and Goodwin 1991) describes the hydrogeology of the 200 East Area and WMA B-BX-BY. An Interim Change Notice to the groundwater monitoring plan provides justification for the new well. The new well was constructed to the specifications and requirements described in Washington Administrative Code (WAC) 173-160 and WAC-173-303.

This document is a compilation of information on the drilling and construction, well development, pump installation, and sediment testing and analyses applicable to well 299-E33-44. Appendix A contains copies of the geologist's log, the Well Construction Summary Report, and Well Summary Sheet (as-built diagram); Appendix B contains results of laboratory analyses completed on samples of sediment from the well; and Appendix C contains geophysical logs. An aquifer test (slug test) was done in the well after well completion. Results from the aquifer test will be published elsewhere. Additional documentation concerning well construction is on file with Bechtel Hanford, Inc., Richland, Washington.

English units are used in this report because they are used by drillers to measure and report depths and well construction details. The conversion is made by multiplying feet by 0.3048 to obtain meters or multiplying inches by 2.54 to obtain centimeters.

2.0 Well 299-E33-44

2.1 Drilling and Sampling

Well 299-E33-44 was drilled using a cable tool rig and a drive barrel from 0 to 247 ft below ground surface (bgs) and cable tool rig and hard tool from 247 to 255 ft bgs. The well was drilled to a total depth of 255 ft bgs during September 1998. Temporary 8 5/8-in.-outside-diameter, carbon steel casing was used from ground surface to 247.8 ft bgs. Approximately 45 gal of water was added to the borehole during hard tool drilling in basalt from 247 to 255 ft bgs. Static water level was 239.36 ft bgs on September 26, 1998.

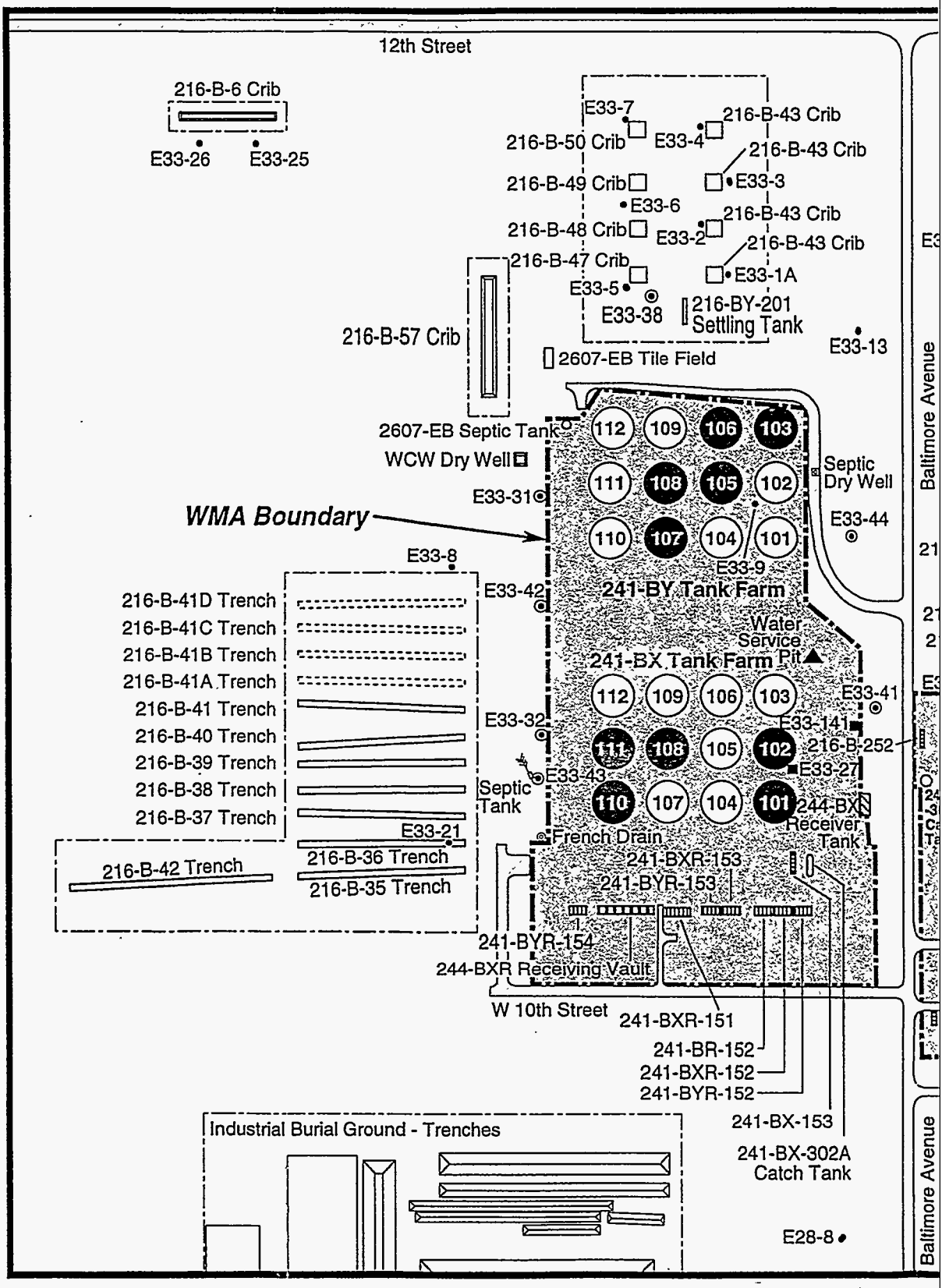
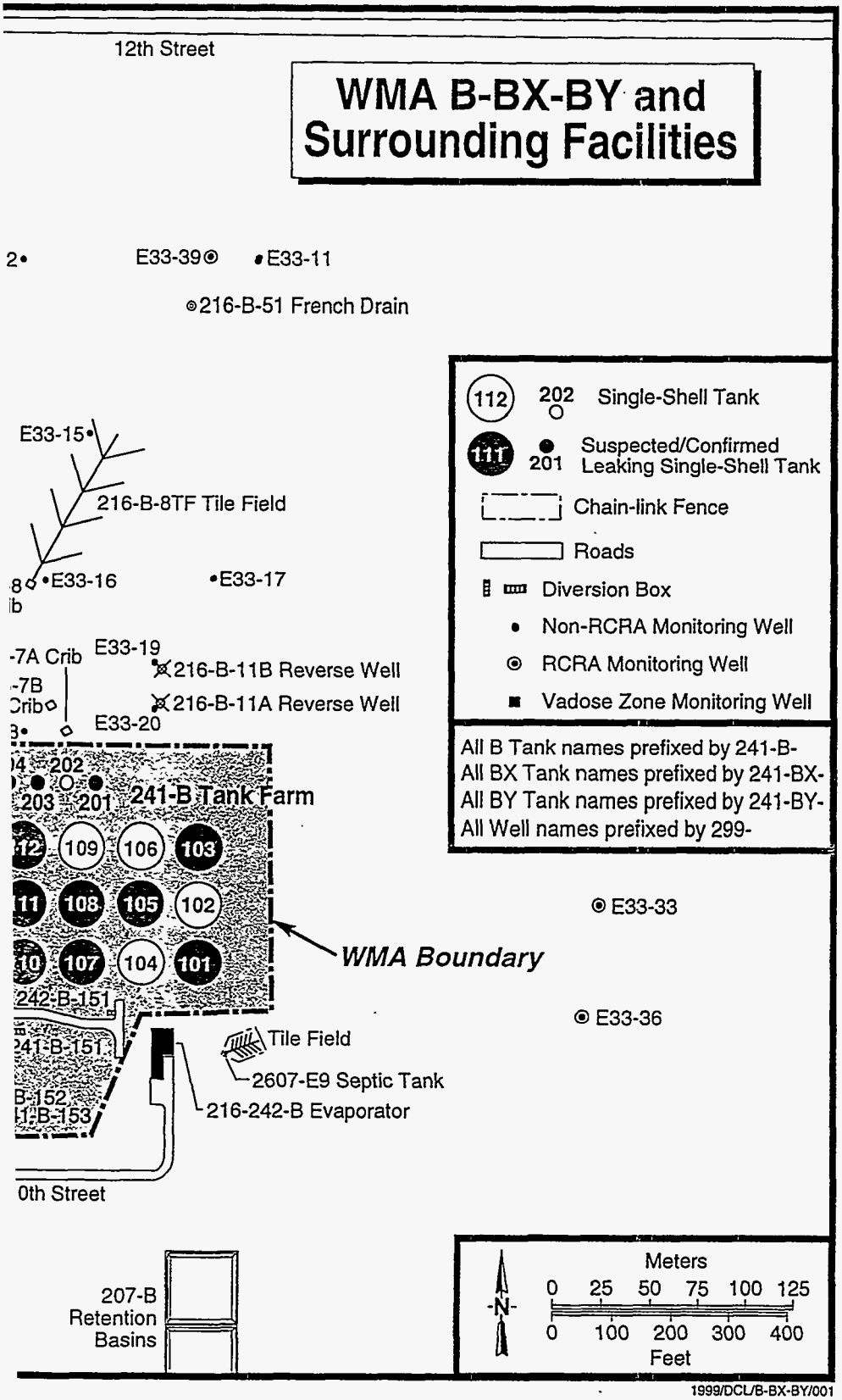


Figure 1. Map of Waste Management Area B-BX-BY an
Monitoring Network



cation of Wells in the Groundwater

Sediments encountered during drilling are part of the Hanford formation and were predominantly sandy gravel and sand with minor silty sand and silty, sandy gravel from the surface to about 163 ft bgs; silt and sandy silt from 163 to about 174 ft bgs; gravelly sand and silty, sandy gravel from 174 to 247 ft bgs; and basalt from 247 ft to total depth. A geologist's log is included in Appendix A.

Grab samples were collected at 5-ft intervals from the surface to 230 ft bgs for analysis of leachable ions, pH, electrical conductivity, cation exchange capacity, and moisture and calcium carbonate contents. Additional grab samples were collected at 70, 125, 230, 231, 234, 236, 241, 243, and 245 ft bgs for analysis of particle size distribution. One split spoon sample was collected from 208 to 210.5 ft bgs (100% of recovery) for determination of particle size distribution, moisture content and hydraulic properties. Samples also were collected every foot from 230 ft to 246 ft bgs for analysis of residual contaminants left from a falling water table. Results from all available laboratory analyses are in Appendix B. At depths from which samples were not collected for other purposes, sediment samples were collected for geologic description and archive at approximately 5-ft intervals throughout the entire borehole.

The particle size data show that the sediment at 70 to 74 ft bgs is very fine grained (predominantly very fine sand, silt and clay), the sediment at 125 ft bgs is coarser sand, and the sample from near 240 ft bgs is a mixture of gravel, sand, and silt. There is a thin layer of cemented material at 166 ft depth that appears to be sulfate rich (possibly gypsum). The moisture contents seem to correlate with particle size with the finer grained material having higher moisture content.

The water extract nitrate data for depths 80 to 105 ft and 140 to 175 ft seem higher than natural sediment, suggesting that the vadose zone in this area may have been impacted by liquid discharges. Sulfate is higher than expected in many of the same samples. The cation exchange capacity seems to show a positive correlation with particle size distribution as is expected. The mix of divalent and monovalent cations is within the range expected for natural sediments.

The borehole and drill cuttings were monitored regularly for organic vapors and radionuclide contaminants. No contamination was found.

A gross gamma-ray log, using a sodium iodide detector, and a neutron moisture log were obtained for lithologic purposes on September 23, 1998. A high resolution, spectral gamma-ray log was obtained on September 24, 1998, for identification of man-made radionuclides. All geophysical logs were run from 0 to 254 ft bgs. The spectral gamma-ray log identified cesium-137 near the surface (0.5 to 3 ft) with a maximum activity of 3 pCi/g and cesium-137 at intermittent depths throughout the borehole at activities <0.3 pCi/g. No other man-made radionuclides were identified. All geophysical logs are in Appendix C.

2.2 Well Completion

The permanent casing and screen were installed in well 299-E33-44 during September 1998. A 4-in.-inner-diameter, stainless steel, wire wrap (0.01 in. slot) screen was set from 253.0 to 238.0 ft bgs. The

permanent casing is 4-in.-inner-diameter stainless steel from 238.0 ft bgs to 1.94 ft above ground surface. Centralizers were placed above and below the screen and every 40 ft from the screen to the surface. The bottom of the screen has a 4-in. end cap.

The sand pack is 20 to 40 mesh silica sand from 253.9 to 227.2 ft bgs. The annular seal is 0.25 in. bentonite pellets from 227.2 to 199 ft bgs, medium bentonite chunks from 199 to 9.8 ft bgs, and Portland cement from 9.8 ft to the surface. A 4 ft by 4 ft by 6 in. concrete pad was placed around the well at the surface. A protective casing with locking cap, four protective steel posts, an a brass marker stamped with the well number were set into the concrete pad. The Well Construction Summary Report and the Well Summary Sheet (as-built) are in Appendix A.

The vertical and horizontal coordinates of the well were surveyed in December 1998. The horizontal position of the well was determined by Global Positioning System observations referenced to horizontal control stations established by the U.S. Army Corps of Engineers. The coordinates are Washington Coordinate System, South Zone, NAD83/91 datum. Vertical datum is NAVD 1988 and is based on existing bench marks established by the U.S. Army Corps of Engineers. Survey data are included in Table 1.

Table 1. Survey Data for Well 299-E33-44

Well Name	Easting (m)	Northing (m)	Elevation (m)	
299-E33-44	573,706.411	137,469.1635		Center of casing
			196.7733	"X" on casing rim
	573,706.420	137,469.4315	196.0284	Brass cap

2.3 Well Development and Pump Installation

Well 299-E33-44 was developed on October 1, 1988. A 2 hp Grundfos pump was used to remove about 300 gal of formation water from the well at 4 gal/min. The final turbidity was 3.23 NTU.

A dedicated Hydrostar sampling pump was installed in well 299-E33-44 on October 17, 1998. The sampling pump intake is at 251.4 ft depth relative to the brass cap (see Table 1).

3.0 References

Caggiano, J. A., and S. M. Goodwin. 1991. *Interim Status Groundwater Monitoring Plan for the Single-Shell Tanks.* WHC-SD-EN-AP-012, Rev. 1. Westinghouse Hanford Company, Richland, Washington.

Ecology - Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. 1996. *Hanford Federal Facility Agreement and Consent Order.* Document No. 89-10, Rev. 4 (The Tri-Party Agreement), Ecology, Olympia, Washington.

RCRA - Resource Conservation and Recovery Act. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq.

WAC 173-160, Washington Administrative Code. *Minimum Standards for Construction and Maintenance of Wells.* Olympia, Washington.

WAC 173-303, Washington Administrative Code. *Dangerous Waste Regulations.* Olympia, Washington.

Appendix A

Well Construction and Completion Documentation

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 9/12/98
Finish Date: 9/26/98
Page 1 of 1

Specification No.: 0200X-SP-V0001 Rev. No.: 0	Well Name: 299-E33-44 ~~Temp. Well No.:~~ W.N B8554
ECNs: NA	Approximate Location: 100' East of 241-BY Tankfarm, 200 E
Project: 1998 RCRA Drilling	Other Companies: CH2M Hill
Drilling Company: Layne Christensen	Geologist(s): D.C. Weekes
Driller: M. Wraspir	

TEMPORARY CASING AND DRILL DEPTH

*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.
Carbon steel (FJ)	0' - 247.8'	0.8'/0.66'
	-	
	-	
	-	
	-	

*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design

DRILLING METHOD/HOLE DIAMETER

Auger:	Diameter From ____ to ____
Cable Tool: DB 0-247' HT 247'-255'	Diameter From 8" 0' to 255'
Air Rotary:	Diameter From ____ to ____
A.R. w/Sonic:	Diameter From ____ to ____
	Diameter From ____ to ____
	Diameter From ____ to ____
	Diameter From ____ to ____

Drilling Fluid: Water

Total Drilled Depth: 255' Hole Dia @ TD: 8"

Total Amt. Of Water Added During Drilling: 4591 during HT 2991 during DB

Well Straightness Test Results: NA

Static Water Level: 239.36 Date: 9/26/98

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Na I (Gross gamma)	0' - 254'	9/23/98		-	
Neutron	0' - 254'	9/23/98		-	
Spectral Gamma (K-UT)	0' - 254'	9/24/98		-	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annual Seal/Filter Pack	Volume	Mesh Size
4" Type 304 SS	~~1.94'~~ above - 238.0'	✓	NA	Portland cement	0 - 9.8	12.9 ft³	Type I-II-V
4" Type 304 SS	238.0' - 253.0'	✓	0.010-in	Med. sym. Bentonite chunks Colorado Silica Sand	9.8 - 199	78.0 ft³	Medium
4" Type 304 SS (FJ cap)	253' - 253.3'	✓	NA	Bentonite pellets	199 - 227.2	9.9 ft³	1/4"
	-			Colorado Silica Sand	227.2 - 253.9	10.1 ft³	20-40
	-				-		

OTHER ACTIVITIES

Aquifer Test:	Date:	Well Abandoned:	Yes:	No: X	Date:
Description:		Description:			

WELL SURVEY DATA

Date:	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Cap Elevation:

COMMENTS/REMARKS

Assumptions: 1-100# sack of 20-40 mesh sand = 1.12 ft³, 1-50# bucket of 1/4" pellets = 0.62 ft³, 1-50# sack of medium bentonite chunks = 0.69 ft³, and 1-94# sack of port. cement + water = 1.285 ft³.

Reported By: D.C. Weekes	Reported By: EE Rafuse
Title: Geologist Date: 9/26/98	Title: Field Engineer (BHI) Date: 09/30/98
Signature: (D.C. Weekes)	Signature: EE Rafuse

BHI-EE-181 (12/97)

WELL SUMMARY SHEET

Page 1 of 1

Date: 9/26/98

Well ID: B8554		Well Name: 299-E33-44	
Location: 100' East of 241-TY Tank Farm, 200E		Project: 1998 RCRA Drilling	
Prepared By: DC Weekes	Date: 9/26/98	Reviewed By: EDWARD RAFUSE	Date: 09/29/98
Signature: DC Weekes		Signature: Edward Rafuse	

CONSTRUCTION DATA

Description	Diagram
Portland Cement 0'-9.8'	
Med. chunk Bentonite 9.8'-199'	
1/4" Bentonite Pellets 199'-227.2'	
Colorado Silica Sand (20-40) from 227.2'-253.9'	
4" ID Type 304 stainless steel (flush joint threaded) 1.94' above ground to 238.0' below ground	
4" ID Type 304 SS 0.010-in slot continuous wire wound screen from 238.0'-253.0'	
SS end cap 253.0'-253.3'	
Centralizers (SS) above and below the screen and at ~ 40 ft intervals on the riser.	
Water level 239.36' (9/26/98)	
All depths are from ground surf.	
All temporary casing removed from the ground	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0'-9': Silty Sandy GRAVEL
		9'-23': Sandy GRAVEL
		23'-39': Slightly Silty Gravelly SAND
		39'-44': Gravelly SAND
50		44'-70': SAND
		70'-74.5': Silty SAND
		74.5'-124': SAND
100		
		124'-128': Silty Sandy GRAVEL
		128'-134': Slightly Silty SAND
150		134'-154': SAND
		154'-163.5': Slightly Silty SAND
		163.5'-165': Silty SAND
		165'-167.5': Sandy SILT
		167.5'-174.5': SAND
200		174.5'-207': Gravelly SAND
		207'-208': SILT; 208'-209.5': SAND
		209.5'-212.5': Silty Sandy GRAVEL
		212.5'-229': Silty Sandy GRAVEL
▽		229'-231': Gravelly Silty SAND
250		231'-247.4': Silty Sandy GRAVEL
		TD@255' 247.4'-255': BASALT

BHI-EE-189 (12/97)

BOREHOLE LOG

Boring or Well No. 299-E33-44/B8554

Sheet 1 of 7

Location 100' East of 241-BY Tank Farm, 200E Project 1998 RCRA Drilling

Prepared By DC Weekes / NC Weekes (Sign/Print Name) Date 9/14/98

Reviewed By Edward Parsons / Edward Parsons (Sign/Print Name) Date 09/29/98

Depth (ft)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
		DB		0'-9' : Silty Sandy GRAVEL (msG), 70% gravel, 15% sand, 15% silt, 10YR 4/3 dark brown (moist), 10YR 6/3 pale brown (dry), moist, dry to ~2 ft, v poorly sorted, SA-R; gravels are 40% basalt, 60% other, white $CaCO_3$ coatings common, max size ~12 in, strong rxn to HCl	Started 9/12/98 <det B, δ except up to 400 dpm in upper 4 ft 0-9' Possible fill material <det B, δ. 4.91 ft of 9" casing <det ÖVM (10.6eV), & LEL Added 9.65' of casing. Total = 14.56'
	2 Lithology 1 $CaCO_3$ (moist)			9'-23' : Sandy GRAVEL (sG), 65% gravel, 25% sand, 10% silt, same color, 10YR 6/2 light brownish gray (dry), moist, v poorly sorted, SA-R; gravels are 80-90% bas; 10% other, SA-R, sand is 80-90% bas, bimodal, A-SR, max size 8 in, strong rxn to HCl, minor mica	
10	2 Lith 1 $CaCO_3$ (moist)				Casing @ 6.5 ft. <d B δ Large rock @ 11 ft
	2 Lith 1 $CaCO_3$ (moist)				Casing @ 14.1 ft. <d B δ Added 9.65' of casing. Total = 24.21'
					End of shift 9/12/98
20	2 Lith 1 $CaCO_3$ (moist)				<d B δ
	2 Lith 1 $CaCO_3$ (moist)			23'-39' : Slightly Silty Gravelly SAND (mg)S, 15% g, 15% vcs, 15% cs, 10% ms, 15% fs, 15% vfs, 15% silt, 10YR 4/3 dark brown (moist), 10YR 6/2 light brownish gray (dry), moist, v poorly sorted, gravel is SR-R, 95% bas, 5% other; sand is 80-90% bas, 10% other, A-SR; max 15 mm, strong rxn to HCl	<d B δ Added 9.65' of casing. Total = 33.86' (new)
30	2 Lith 1 $CaCO_3$ (moist)			30' is ~10% silt, weak rxn to HCl, otherwise similar to 25' sample.	<d B δ Added 9.65' of casing. Total = 33.86'
	2 Lith 1 $CaCO_3$ (moist)			35' sample is ~2% gravel otherwise similar to 25' sample.	<d B δ, casing @ 32.6'.
	2 Lith 1 $CaCO_3$ (moist)				<d B δ, casing @ 32.6' (new) 34'

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BOREHOLE LOG

Boring or Well No. 299-E33-44/B8554

Sheet 2 of 7

Location 100' East of 241-BY Tank Farm, 200E

Project 1998 RCRA Drilling

Prepared By DC Weekes DC Weekes (Sign/Print Name) Date 9/14/98

Reviewed By Edward Bertsch / Edward Bertsch (Sign/Print Name) Date 09/29/98

Depth (ft)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
40		DB		39'-44' : Gravelly SAND (gS)	
				10% vf to ~~medium~~ pebble, 50% vcs, 20% cs,	Added 9.65' of casing. Total = 43.51'
				10% ms, 10% f-vfs, tr silt, 10YR6/2 light	
	2 Lith 1 CaCO3 / moist			brownish gray (dry), 10YR4/3 dark brown	
				(moist), moist; gravel is 60% bas, 40% otha, A-SA	Casing @ 43.6', < d BY
				Sand is 60% bas, 40% otha, max 9 mm, moderate	
				rxn to HCl, well sorted	
				44'-70' : SAND (S), 5-<10% gravel,	
	2 Lith 1 CaCO3 / moist			40% vcs, 30% cs, 15% m-vfs, tr to 5%	Added 9.69' of casing. Total = 53.2'
50				silt, colors moist + dry as above, moist,	< d BY
				mineralogy as above, max 20 mm, moderate	
				rxn to HCl, tr mica	
	2 Lith 1 CaCO3 / moist			weak rxn to HCl, ~10% gravel	< d BY, casing @ 53'
	2 Lith 1 CaCO3 / moist			Strong rxn to HCl, tr gravel	< d BY, casing @ 53'
60					Added 9.65' of casing. Total = 62.85'
	2 Lith 1 CaCO3 / moist			Strong rxn to HCl, tr gravel	< d BY, casing @ 63'
					Added 9.69' of casing. Total = 72.54'
70	2 Lith 1 CaCO3 / moist			70'-74.5' : Silty SAND (mS), 75% f-vf	< d BY
				sand, 25% silt, 2.5Y5/3 light olive brown	
				(moist), 2.5Y6/2 light brownish gray (dry),	
				moist, well sorted, max size ~0.25 mm, strong	
	2 Lith 1 CaCO3 / moist			rxn to HCl	< d BY
				74.5'-124' : Same material as above	
				~~silty~~ sand with thin silty sand	Added 9.64' of casing. Tot = 82.18'
				lenses, 10YR5/2 grayish brown (moist),	
				10YR6/2 light brownish gray (dry), moist,	
	2 Lith 1 CaCO3 / MOT			moderately sorted, strong rxn to HCl	< d BY

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BOREHOLE LOG

Boring or Well No. 299-E33-44/B8554

Sheet 3 of 7

Location 100' East of 241-BY Tank Farm; 200E Project 1998 RCRA Drilling

Prepared By DC Weekes (Sign/Print Name) Date 9/15/98 Reviewed By Edward Rylance / Frances Ratliff (Sign/Print Name) Date 9/22/98

Depth (ft)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
80		DB			
					End of shift 9/14/98
	2 1/2 in CaCO3 Liner			SAND (continued) tr gravel, 15% vc, 20% c, 40% m, 15% f, 5% vf, 5% silt, otherwise as above, 20% bas, 80% qtz and other, A-SA, max size 5mm, strong rxn to HCl, moderately sorted	<d BF, casing @ 82.3' Added 9.64' of casing. Tot = 91.82'
90	2 1/2 in CaCO3 Liner				<d BF, casing @ 88'
	2 1/2 in CaCO3 Liner				<d BF, casing @ 92.2' Added 9.47' of casing. Tot = 101.29'
100	2 1/2 in CaCO3 Liner				<d BF, casing @ 98.2'
	2 1/2 in CaCO3 Liner				<d BF, casing @ 101.6' Added 9.65' of casing. Tot = 110.94'
110	2 1/2 in CaCO3 Liner				<d BF, casing @ 108'
	2 1/2 in CaCO3 Liner			~~Add~~ 5% gravel, 40% vcs, 30% cs, 10% ms, 10% fs, 5% vfs, tr silt; 40% bas, 60% other, weak rxn to HCl, well sorted, same colors, moist	<d BF, casing @ 110.9' Added 9.66' of casing. Tot = 120.60'
	2 1/2 in CaCO3 Liner			tr gravel, 15% vcs, 15% cs, 15% ms, 25% fs,	<d BF, casing @ 118.5'

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BOREHOLE LOG

Boring or Well No. 299-E33-44 / B8554

Sheet 4 of 7

Location 100' East of 244-BY Tank Farm, 200E

Project 1998 RCRA Drilling

Prepared By DC Ukeles (Sign/Print Name) Date 9/16/98

Reviewed By Edward Rahe / Edward Rahe (Sign/Print Name) Date 09/29/98

Depth (ft)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
120		DB		20% vfs, 10% silt, moist, slightly brownish, strong rxn to HCl @121.5' Pebbles in sandy matrix (vcs)	Added 9.65' of casing. Tot = 130.25'
	2 liter CaCO3 1 MT 1 sieve			124'-128': Silty Sandy GRAVEL (msG), 40% gravel (mostly f-vfp), 15% vcg, 10% cg, 10% mg, 5% fc, 5% vfs, 15% silt, 2.5Y 5/3 light olive brown (moist), 2.5Y 6/2 light brownish gray (dry), moist,	<d BY, casing @ 122.5'
130	2 liter CaCO3 1 MT			gravel is 50% bas, 50% other, SA-SR; sand is A-SA, 30% bas, 70% other, tr mica, poorly sorted, max 90 mm, strong rxn to HCl, moderately consolidated, FeOx common, $CaCO_3$ adheres to gravel (common). Paleosol?	<d BY, casing @ 128' End of shift 9/15/98
	2 liter CaCO3 1 MT			128'-134': Slightly Silty SAND (m)S, 5% vf-fp, 15% vcs, 15% cs, 15% ms, 15% fs, 20% vfs, 15% silt, same colors as above, moist, A-SA, 30% bas, 70% other, tr mica, poorly sorted, max 8 mm, strong rxn to HCl	<d BY, casing @ 130.6'
140	2 liter CaCO3 1 MT			134'-154': SAND (S), 5% vfp, 5% vfc, 10% mc, 15% fc, 10% vfs, 5% silt, 10YR 2.5Y 4/2 dark grayish brown (moist), 2.5Y 6/2 light brownish gray (dry), moist, moderately sorted, A-SA, 40% bas, 60% other, max 5 mm, moderate rxn to HCl, tr mica	<d BY, casing @ 130.6' Added 9.66' of casing. Tot = 139.90' Added 9.66' of casing. Tot = 149.56' <d BY, casing @ 141'
150	2 liter CaCO3 1 MT			Basalt content increases to ~50%	<d BY, casing @ 147.1'
	2 liter CaCO3 1 MT			154'-163.5' (drill) 154'-164': Slightly Silty SAND (m)S, 5% vfp, 15% vc, 15% c, 15% m, 15% f, 15% vf, 20% silt, 2.5Y 5/2 grayish brown (moist), 2.5Y 6/2 light brownish gray (dry), moist, poorly sorted, A-SA, max 5 mm, strong rxn to HCl	<d BY, casing @ 149.8' Added 9.65' of casing. Tot = 159.21' End of shift 9/16/98
	2 liter CaCO3 1 MT				<d BY, casing @ 157'

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BOREHOLE LOG

Boring or Well No. 299-E33-44/B8554

Sheet 5 of 7

Location 100' East of 241-BY Tank Farm, 200E

Project 1998 RCRA Drilling

Prepared By DC Weekes / DC Weekes (Sign/Print Name) Date 9/18/98

Reviewed By Edward Rohay / Edward Rohay (Sign/Print Name) Date 09/29/98

Depth (ft)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
160		DB	DB	163.5'-165' : Silty SAND(mS)),	163.5'-165' Chunky & drills
				+r gravel, 10%vc, 15%c, 25%m, 25%f, 5%vf	harder
	2 Lithology CaCO3 1 MT			20% silt, 2.5Y 4/2 dark grayish brown(moist),	nonplastic silt; mod sorted
	2 Lithology CaCO3 1 MT			2.5Y5/2 grayish brown(dry), moist, 60%	<d BX, casing @ 162.8'
	2 Lithology CaCO3 1 MT			bas, 40% other, max 4mm, strong rxn to HCl	<d BX, casing @ 164.5'
	2 Lithology CaCO3 1 MT			165'-~167.5' : Sandy SILT (sM),	Added 9.66' of casing. Tot = 168.87'
				5%vc, 10%c, 15%m, 15% vf-f, 55% silt,	
				same colors, moist, moderately sorted,	Gradational change
	2 Lithology CaCO3 1 MT			60% bas, 40% other, max 2mm, strong	
170				rxn to HCl	<d BX, casing @ 164.5'
				167.5'-174.5' : SAND(S), 100% vf-	
				f, colors as above, max 0.25mm, micaceous	
				strong rxn to HCl, 10% silt, moist	
	2 Lithology CaCO3 1 MT			silt (~0.1' thick) above contact	<d BX
				Sharp contact @ 174.5'	<d BX, casing @ 169'
				174.5'-207' : Gravelly SAND (gS),	Added 9.66' of casing. Tot = 178.53'
				20% gravel, 10%vc, 20%c, 20%m, 20%f-vf,	
				10% silt, colors as above, moist; gravel	
				is 60% bas, 40% other, SA-R; sand is	
	2 Lithology CaCO3 1 MT			60% bas, 40% other, A-SA, max 40mm,	<d BX, casing @ 177.1'
180				strong rxn to HCl, FeOx common, poorly	
				sorted	
					End of shift 9/17/98
	2 Lithology CaCO3 1 MT			increasing gravel content (25-30%),	<d BX, casing @ 179'
				moderate rxn to HCl, as above	Added 9.65' of casing. Tot = 188.18'
	2 Lithology CaCO3 1 MT			gravel content (25-30%), 60% bas,	<d BX, casing @ 184'
190				30% other, A-R; sand is 70% bas, 30%	Added 9.65' of casing Tot = 197.83'
				other, A-SA; silt ~ 10-15%, trace mica,	Cobbles up to 180mm
				moderate to strong rxn to HCl, as above	found at 192'-193' in
					sandy matrix mostly
	2 Lithology CaCO3 1 MT			gravel is mostly vf-fp (25-30%) as above	basaltic cobbles. Driller
					believes the zone is actually
					190'-192' because casing
					drove hard through the zone.
					195' <d BX, casing @ 191.6'
	2 Lithology CaCO3 1 MT			gravel is mostly vf-fp (25-30%) as above	<d BX, casing @ 196'

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BOREHOLE LOG

Boring or Well No. 299-E33-44/B8554

Sheet 6 of 7

Location 100' East of 241-BY Tank Farm, 200E

Project 1998 RCRA Drilling

Prepared By DC Weekes (Sign/Print Name) Date 9/21/98

Reviewed By Edward Rokes/Frances Ruffner (Sign/Print Name) Date 10/6/98

Depth (ft)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
200		DB		174.5'-207': Gravelly SAND(gS)	
					Added 9.64' of casing. Tot= 207.47'
	2 Lith 1 CaCO3 1 MT			Gravels decrease to 10-15%, mostly vfp, moderate rxn to HCl, as above	<dBY, casing @ 201.4'
	2 Lith 1 CaCO3 1 MT			207'-208': SILT (M) 2.5Y5/3	
	SS	2.5' Run 2.0' Rcvd 208'-210.5' SS		light olive brown (moist), 2.5Y6/2 light	Drove SS 1645-1649 hrs
210				brownish gray (dry), moist, sand (vc-f)	<BY, casing @ 208', End of shift
		DB		mixed in with silt (from drilling), mod rxn to HCl	Collected 2 Lith, 1 CaCO3, 1 MT from drive barrel at 210'.
				208'-209.5': SAND (S) [logged through lexan liners], f-vf sand,	Added 9.65' of casing. Tot= 217.12'
	2 Lith 1 CaCO3 1 MT			brown (moist), moist, well sorted	<dBY, casing @ 213', Strong rxn
				209.5'-212.5(?): Silty Sandy GRAVEL (msG)	
				40% gravel (up to 180mm), 10% vc, 10% c, 10% m, 10% vf-f, 20% silt, 2.5Y6/2 light brownish	Change to silty sandy gravel (poss. Ringold "E")
	4 Lith 1 MT			gray (dry), moist, V poorly sorted, gravels	4T ~ 212.5' (uncertain).
220				are A-SR, 60% bas, 40% other; Sand is A-SA,	<dBY, casing @ 217.5'. mod. rxn
				70% bas, 30% other, MAX 180mm, strong rxn	Loose, dry material
	2 Lith 1 CaCO3 1 MT			212.5'-229': Silty Sandy GRAVEL (msG),	Added 9.66 of casing. Tot= 226.78'
				60% gravel (up to ~100mm), 10% vc, 10% c-f, 20% silt, 2.5Y5/2 grayish brown	
				(dry), dry to moist, V poorly sorted;	dry @ 225' casing @ 223.2'
				Gravel is 60% qtz, volcanics, metavolcanics,	<dBY, mod rxn to HCl
				40% bas, SA-R; Sand is 70% bas 30%	Loose, dry material
				other; looks more exotic than Hanford fm.	
230	4 Lith 1 CaCO3 1 MT			229'-231': Gravelly SAND, 10% gravel,	Water ring sample @ 230' <dBY
	1 plastic			5% vc, 15% c, 20% m, 10% f, 15% vf, 25%	<dBY casing @ 227.4' Added casing
	1 plastic			silt, same color as above, dry, poorly sorted,	Water ring sample @ 231' <dBY
	1 plastic			Strong rxn to HCl	Water ring sample @ 232' <dBY
	1 plastic			231'-241': Silty Sandy GRAVEL (msG)	Water ring sample @ 233', <dBY
	4 Lith 1 MT			same as 212.5'-229' interval, dry, slightly	End of shift 9/19/98
	1 plastic			cobbles to 140mm @ 235'	<dBY casing @ 231.6' Watering sample @ 234'
	1 plastic				"Reick" sample @ 235': Water ring sample @ 236'
	1 plastic				Water ring "sample @ 237' <dBY
	1 plastic				Water ring "sample @ 238' <dBY
	1 plastic				"Water ring" sample @ 239'
	2 Lith 1 CaCO3 1 plastic			dry, Strong rxn to HCl	"Water ring" sample @ 240' Water @ 240.2'

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. 299-E33-44/B8554

Sheet 7 of 7

Location 100' East of 244-BY Tank Farm; 200E

Project 1998 RCRA Drilling

Prepared By D.C. Weekes (Sign/Print Name) Date 9/23/98

Reviewed By Edward Rapp / Edward Rapp (Sign/Print Name) Date 10/6/98

Depth (ft)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
240	1 plastic	DB		moist to wet	<d BY; "water ring" sample @ 241'
	2 liter 1 Caco3			241'–247.4' : Silty Sandy GRAVEL	<d BY "water ring" sample @ 242'
	1 plastic			(msG), 60% gravel, 25% sand, 15% silt,	<d BY "water ring" sample @ 243'
	1 plastic			2.5Y 3/2 v. dark grayish brown (wet),	<d BY "water ring" sample @ 244'
	1/2 liter 1 plastic			2.5Y 6/2 light brownish gray (dry), wet;	<d BY "water ring" sample @ casing
	1 plastic			v poorly sorted; gravel is mostly ~1/2 in,	<d BY "water ring" sample @ 246'
				50% bas, 50% other, A-R; sand is 70%	End of shift 9/21/98
		HT		bas, 30% other, A-SA; max 70 mm, no	Minimum hole made by HT is 8":
				$CaCO_3$ coatings, Some "cemented" areas,	
250	2 liter 1 Caco3			probably Ringold gravels in a basaltic	casing @ 247.4'
				matrix which would be reworked Ringold,	End of shift 9/22/98
				basically same as above, mod to strong rxn to HCl	
				247.4'–255' : BASALT, finely	
				pulverized basalt w/ occasional	
	1 liter 1 Caco3			pebble or sand from material above,	N2 black (wet)
				N3 very dark gray (wet), N5 gray	Total casing = 251.06'.
				(dry), dense, no evidence of	TD @ 255' 9/23/98
				flow top, no rxn to HCl	
260					

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Appendix B

Physical and Chemical Properties Data

Appendix B

Physical and Chemical Properties Data

This Appendix includes the results of laboratory testing for pH, conductivity, particle size distribution, moisture content, total inorganic carbon, and major cations and anions from 1:1 water:sediment extractions.

Moisture content was measured as weight loss after drying an aliquot of the bulk sample at 105°C for 24 h or until weight was constant for two consecutive measurements.

Total inorganic carbon was measured from an air-dried aliquot of the <2 mm fraction. The sample was combusted in a total carbon analyzer at 975°C and the weight of evolved carbon dioxide was determined and converted to calcium carbonate equivalent. Reagent grade calcium carbonate was used as a standard. Instrument precision was ±3 weight percent based on replicate measurements of reagent grade calcium carbonate.

Exchangeable cations were determined by inductively coupled plasma analysis (ICP) after exchange with an ammonium acetate solution. Twenty grams of air dried sediment were mixed with 50 mL of 1 M ammonium acetate for 16 hours. Electrical conductivity, pH, and major cations and anions were determined from a 1:1 water:sediment extract. The concentrations of major cations were measured with ICP, anions were determined by ion chromatography (IC), and alkalinity was measured by titration. Electrical conductivity and pH were determined from unfiltered aliquots and cations and anions from aliquots of solution filtered through 0.45 µm membranes.

Particle size analysis was done using standard sieve techniques. Samples were oven dried at 105°C for 24 h (or until weight was constant for two consecutive measurements) prior to analysis.

Table B.1. Moisture Content, pH, and Electrical Conductivity of Samples from Well 299-W33-4

Depth (ft)	Moisture Content (wt%)	pH	Conductivity (µS/cm)	Temperature (°C)
24	5.1	8.55	163	22.3
25	4.9	8.55	180	22.4
30	4.7	8.45	137	22.2
70	7.7	8.02	323	22.3
75	3.0	8.55	194	22.2
80	9.4	8.09	478	22.2
95	4.7	8.53	242	22.2
100	4.3	8.44	303	22.3
105	4.8	8.35	272	22.4
140	3.5	8.2	292	22.2
150	3.5	8.23	395	22.2
165	5.3	8.27	409	22.3
166	14.9	7.96	913	22.5
170	5.9	8.07	366	22.2
174.5		7.92	616	22.4
175	5.5	8.18	374	22.2
205	3.5	8.3	255	22.3
208	13.5	8.04	508	22.3
210	2.9	8.21	375	22.3
230	2.6	8.42	228	22.3
231		8.42	182	22.3
232		8.57	140	22.4
239		8.52	181	22.3
240	2.6	8.48	208	22.3
241		8.57	147	22.3
242		8.62	120	22.3

Table B.2. Particle Size Distribution Data for Samples from Well 299-E33-44

Particle Size (mm)	Sieve	Weight of Dry Sample (g)	Weight Percent
Depth 70 to 74.5 ft			
2	10	0.93	0.5
0.88	20	2.36	1.3
0.425	40	2.86	1.6
0.25	60	1.96	1.1
0.106	140	21.58	12.1
0.075	200	20.5	11.5
<0.075	Pan	127.78	71.8
	Total	**177.97**	**100.0**
Depth 230 ft			
2	10	26.9	13.7
0.88	20	33.5	17.1
0.425	40	35.59	18.1
0.25	60	17	8.7
0.106	140	23.05	11.7
0.075	200	8	4.1
<0.075	Pan	52.35	26.7
	Total	**196.39**	**100.0**
Depth 234 ft			
2	10	408.6	51.7
0.88	20	69.57	8.8
0.425	40	65.37	8.3
0.25	60	37.04	4.7
0.106	140	51.31	6.5
0.075	200	15.81	2.0
<0.075	Pan	142.88	18.1
	Total	**790.58**	**100.0**

Particle Size (mm)	Sieve	Weight of Dry Sample (g)	Weight Percent
Depth 125 ft			
2	10	44.03	23.7
0.88	20	37.64	20.2
0.425	40	21.83	11.7
0.25	60	31.49	16.9
0.106	140	20.22	10.9
0.075	200	5.59	3.0
<0.075	Pan	25.29	13.6
	Total	**186.09**	**100.0**
Depth 231 ft			
2	10	37	18.9
0.88	20	41.63	21.3
0.425	40	40.35	20.6
0.25	60	17.11	8.8
0.106	140	17.75	9.1
0.075	200	5.99	3.1
<0.075	Pan	35.57	18.2
	Total	**195.4**	**100.0**
Depth 236 ft			
2	10	184.6	41.7
0.88	20	56.3	12.7
0.425	40	51.42	11.6
0.25	60	23.73	5.4
0.106	140	32.73	7.4
0.075	200	10.89	2.5
<0.075	Pan	82.95	18.7
	Total	**442.62**	**100.0**

Table B.2. (contd)

Particle Size (mm)	Sieve	Weight of Dry Sample (g)	Weight Percent
Depth 241 ft			
2	10	659.8	67.1
0.88	20	85.3	8.7
0.425	40	65.92	6.7
0.25	60	31.44	3.2
0.106	140	41.34	4.2
0.075	200	12.3	1.3
<0.075	Pan	86.75	8.8
	Total	**982.85**	**100.0**

Particle Size (mm)	Sieve	Weight of Dry Sample (g)	Weight Percent
Depth 243 ft			
2	10	367.7	74.3
0.88	20	40.17	8.1
0.425	40	27.31	5.5
0.25	60	13.88	2.8
0.106	140	16.15	3.3
0.075	200	5.4	1.1
<0.075	Pan	24	4.9
	Total	**494.61**	**100.0**

Particle Size (mm)	Sieve	Weight of Dry Sample (g)	Weight Percent
Depth 245 ft			
2	10	326.2	59.8
0.88	20	80.8	14.8
0.425	40	47.17	8.6
0.25	60	21.42	3.9
0.106	140	22.92	4.2
0.075	200	6.75	1.2
<0.075	Pan	40.23	7.4
	Total	**545.49**	**100.0**

Table B.3. Major Cation and Anion Concentrations from 1:1 Water:Sediment Extracts of Samples from Well 299-E33-44

Depth (ft)	Cations (mg/L)						Total Cations (meq/L)	Monovalent Cations (%)	Divalent Cations (%)
	Ba	Ca	K	Mg	Na	Sr			
24	0.00	7.58	0.00	2.03	23.61	0.05	1.57	65.27	34.73
25	0.05	9.27	1.44	2.22	21.31	0.05	1.61	59.83	40.17
30	0.06	8.75	3.12	2.67	10.65	0.04	1.20	45.21	54.79
70	0.05	23.12	0.00	6.75	15.96	0.13	2.41	28.85	71.15
75	0.03	9.74	0.00	3.00	21.25	0.04	1.66	55.73	44.27
80	0.06	27.81	2.80	9.25	41.09	0.15	4.01	46.34	53.66
95	0.02	12.39	0.00	3.63	26.28	0.06	2.06	55.44	44.56
100	0.00	14.90	0.98	4.17	30.60	0.08	2.44	55.48	44.52
105	0.06	15.31	1.47	4.76	22.34	0.08	2.17	46.56	53.44
140	0.02	23.43	3.56	6.75	10.94	0.12	2.29	24.70	75.30
150	0.00	31.67	6.59	9.15	15.52	0.18	3.18	26.53	73.47
165	0.02	27.06	12.58	8.05	36.62	0.17	3.93	48.70	51.30
166	0.06	76.87	14.66	23.89	58.59	0.43	8.73	33.47	66.53
170	0.07	33.27	9.16	8.59	26.61	0.17	3.76	36.98	63.02
174.5	0.08	47.08	15.94	16.85	39.64	0.28	5.87	36.29	63.71
175	0.05	31.79	13.95	10.34	27.39	0.18	3.99	38.80	61.20
205	0.04	17.75	14.14	5.16	24.93	0.11	2.76	52.40	47.60
208	0.01	42.65	13.18	11.58	33.36	0.23	4.87	36.68	63.32
210	0.08	24.65	18.84	6.69	35.17	0.15	3.80	52.98	47.02
230	0.00	15.46	10.33	3.94	22.94	0.09	2.36	53.49	46.51
231	0.08	17.79	10.12	4.21	21.32	0.11	2.42	48.94	51.06
232	0.00	10.43	7.52	2.45	18.56	0.07	1.72	58.00	42.00
239	0.07	12.75	2.94	3.11	12.12	0.09	1.50	40.22	59.78
240	0.04	14.79	2.46	4.12	15.17	0.10	1.80	40.10	59.90
241	0.02	9.71	0.00	2.46	10.72	0.06	1.15	40.40	59.60
242	0.00	9.51	0.00	2.50	6.97	0.06	0.99	30.78	69.22

Table B.3. (contd)

Depth (ft)	Anions (mg/L)					Total Anions (meq/L)	Electrical Balance (%)
	Alkalinity as $CaCO_3$	F	Cl	NO_3	SO_4		
24	54.98	0.39	1.31	10.53	9.17	1.52	3.59
25	61.65	0.48	2.14	7.20	13.45	1.72	-6.28
30	43.73	0.27	1.23	9.72	8.21	1.25	-4.10
70	48.76	0.40	8.80	14.16	69.00	2.91	-18.90
75	34.16	0.45	2.78	12.85	33.93	1.70	-2.41
80	47.49	0.50	13.89	66.76	104.48	4.62	-14.08
95	75.73	0.34	5.28	25.31	39.89	2.92	-34.47
100	133.40	0.38	6.60	41.31	57.69	4.74	-63.94
105	56.04	0.21	6.06	33.81	49.64	2.88	-28.26
140	63.64	0.35	10.28	37.94	54.09	3.32	-36.51
150	329.02	0.32	14.21	48.31	65.15	9.13	-96.69
165	36.36	0.55	26.92	64.96	81.33	4.26	-7.94
166	44.02	0.58	58.62	77.90	242.85	8.88	-1.61
170	38.81	0.43	6.90	15.78	118.69	3.72	1.17
174.5	46.55	0.21	52.02	57.37	120.86	5.85	0.41
175	64.10	0.34	18.86	17.15	95.15	4.09	-2.48
205	44.67	0.48	12.68	7.38	47.60	2.39	14.50
208	40.17	0.62	31.40	27.78	128.69	4.85	0.54
210	56.51	0.62	8.94	<0.06	110.53	3.72	2.11
230	47.18	0.70	2.22	4.85	52.15	2.13	10.23
231	32.79	0.34	1.35	2.19	26.16	1.29	60.93
232	34.23	0.38	1.47	2.23	27.82	1.36	23.50
239	44.17	0.65	2.43	<0.06	38.45	1.79	-17.64
240	46.47	0.69	2.66	<0.06	40.98		
241	36.69	0.56	1.46	0.53	24.73	1.33	-14.00
242	27.97	0.38	1.24	2.39	15.08	0.97	1.87

Table B.4. Cation Exchange Capacity and $CaCO_3$ Content of Sediment Samples from Well 299-E33-44

Depth (ft)	Total CEC (meq/100 g)	Divalent Cations (%)	$CaCO_3$ Content (wt%)
5	9.25	88.38	10.80
24	6.38	88.81	0.97
25	5.87	91.47	1.10
30	5.28	93.92	1.01
65	5.02	94.06	1.18
70	6.74	93.79	2.00
75	5.21	92.77	2.68
80	6.07	91.28	1.22
95	4.73	92.86	2.95
100	5.37	92.40	1.86
105	5.03	92.81	1.56
140	4.55	94.99	2.44
150	4.71	93.04	1.03
165	5.71	90.51	1.55
166	7.11	92.41	2.28
170	5.47	95.85	1.70
174.5			2.34
175	6.09	93.68	1.83
200	5.71	92.91	0.73
205	5.18	92.33	0.92
208	8.64	94.52	2.20
210	6.21	90.87	1.00
230	6.15	93.13	0.89
231			1.43
232			0.72
239			0.95
240	6.58	91.93	1.19
241			0.68
242			0.56

Appendix C

Geophysical Logs

Appendix C

Geophysical Logs

This appendix contains the high purity, germanium spectral gamma-ray log; the sodium iodide spectral gamma-ray log (with units pCi/g); the sodium iodide spectral gamma-ray log (with units counts/second); and the neutron moisture log. All logs were run by Waste Management Federal Services, Inc., Northwest and log data analyses completed by Three Rivers Scientific Company. Included with each log are a Log Header sheet, Acceptance QA Processing data, and a Log Analysis Summary Report. In addition, a description of the method used to convert the pCi/g values from the sodium iodide log to counts per second values is included in this appendix.

RLS Spectral Gamma-Ray Borehole Survey
Waste Management Federal Services NW

Log Header

Project: RCRA Drilling – 1998 Well: 299 - E33 - 44

Log Type: HPGe Spectral Gamma-Ray

Borehole Information

Well ID	B8554	Water Depth	239.5	Total Depth	254.1 ft
Elevation Reference	No Data	Elevation	n/a ft		
Depth Reference	Ground Surface	Casing Stickup	3.65 ft		
Casing Diameter	8 in	Depth Interval	0 to 257.7 ft	Thickness	0.50 in
Casing Diameter	___ in	Depth Interval	_____ ft	Thickness	_____ in

Logging Information

Log Type:	HPGe Spectral Gamma Ray	
Company	Waste Management Federal Services NW	
Date/Archive File Name	Sept 24, 1998	H2E33044
Logging Engineers	A.Pearson	
Instrument Series	RLSG3.1	
Logging Unit	RLS2	
Depth Interval	0 to 180 ft	Prefix B217
	177 to 253.5 ft	Prefix B218
	253 to 225 ft	Prefix B218 (repeat)
Instrument Calibration Date	Sep 11, 1998	
Calibration Report	WHC-SD-EN-TI-292, Rev. 0	

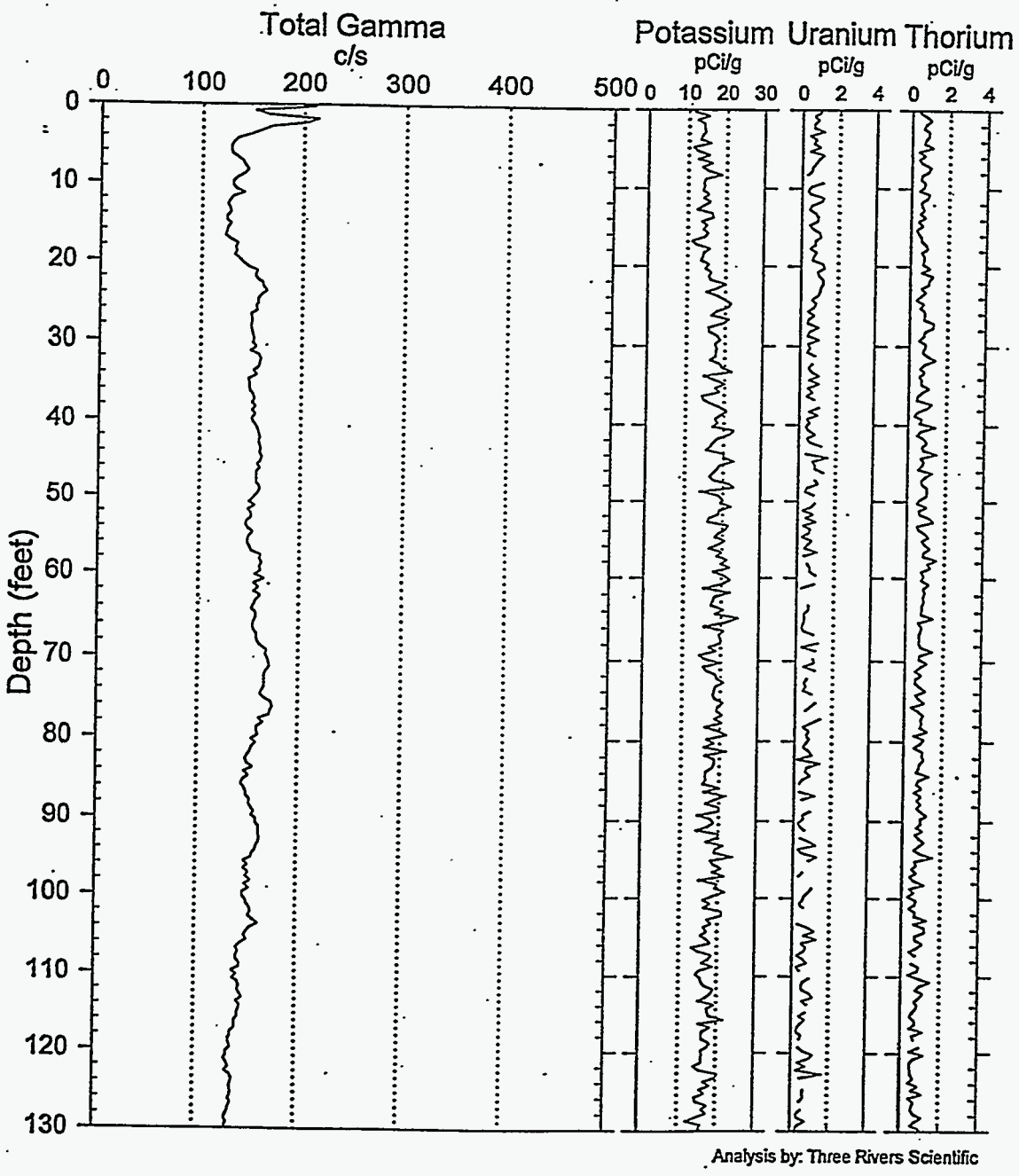
Analysis Information

Company	Three Rivers Scientific
Analyst	Randall Price
Date	Sept 30, 1998

Notes Cs-137 was identified near the surface (0.5 to 3.0 ft) with a maximum concentration of 3 pCi/g and at intermittent locations (less than 0.3 pCi/g) to the bottom of the well. No other man made radionuclides were detected.

RLS Spectral Gamma Ray Borehole Survey
Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24, 1998
Borehole: 299-E33-44 (B8554) Naturally Occurring Radionuclides

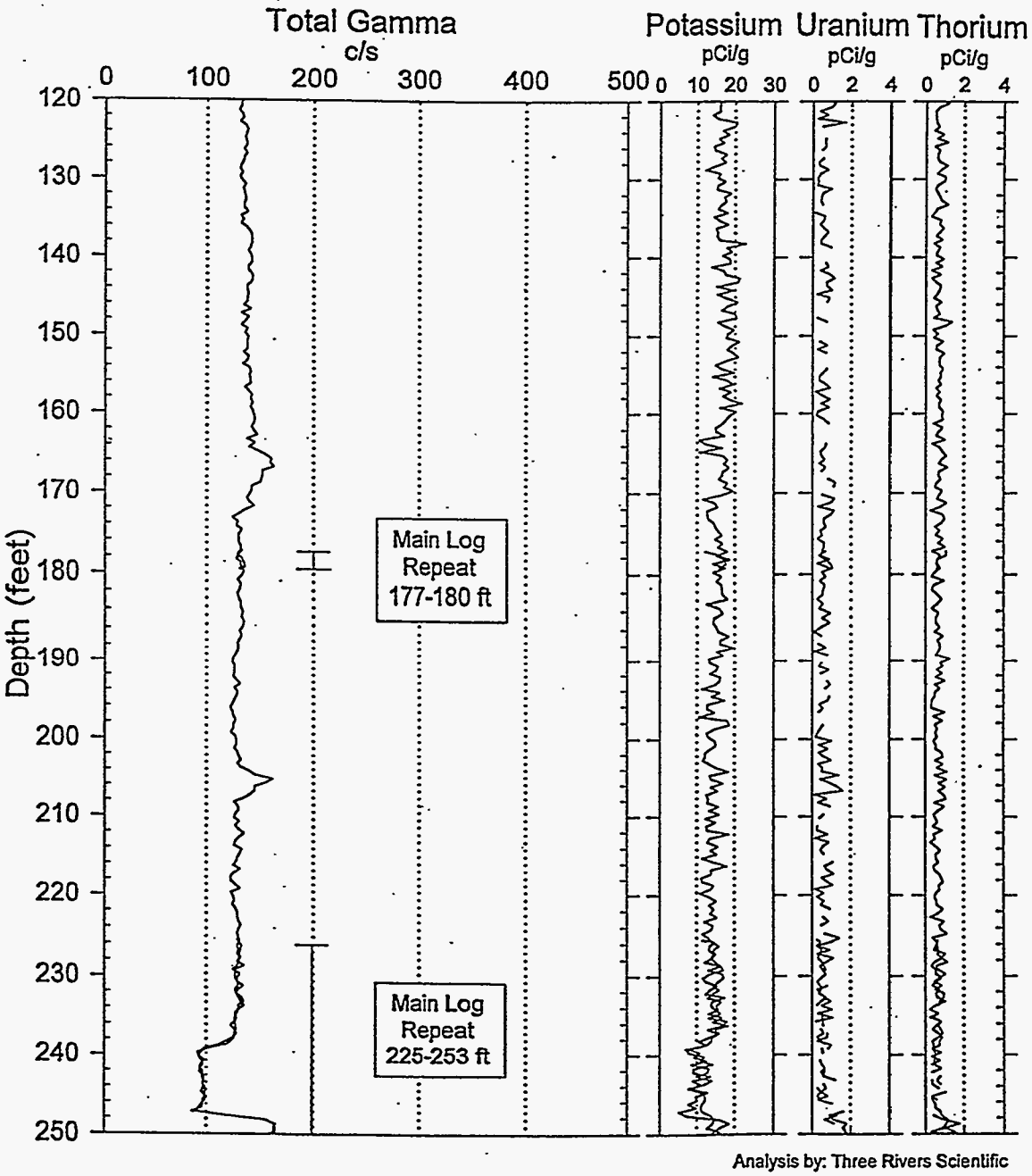


RLS Spectral Gamma Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24, 1998

Borehole: 299-E33-44 (B8554) Naturally Occurring Radionuclides



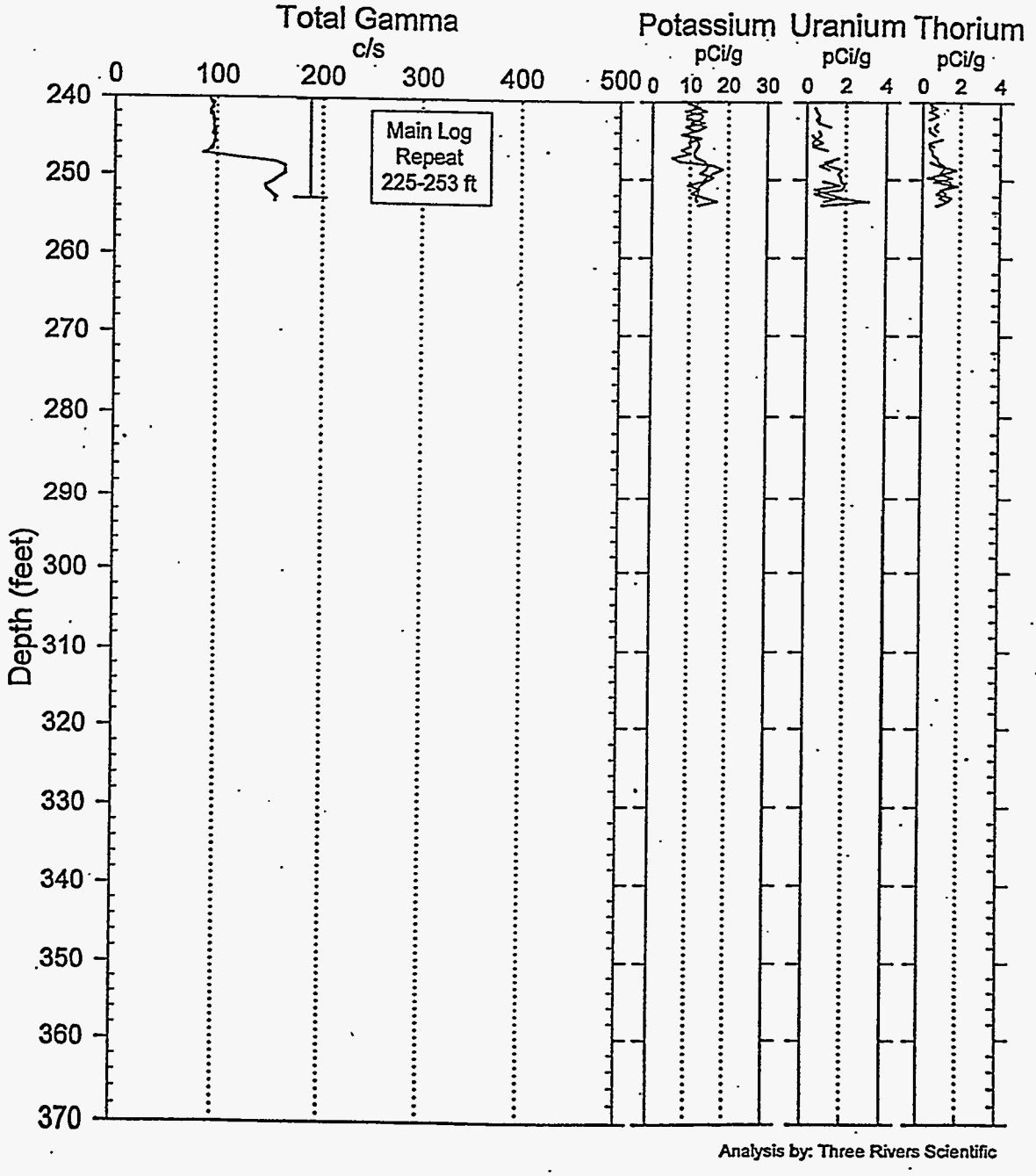
Analysis by: Three Rivers Scientific

RLS Spectral Gamma Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24, 1998

Borehole: 299-E33-44 (B8554) Naturally Occurring Radionuclides

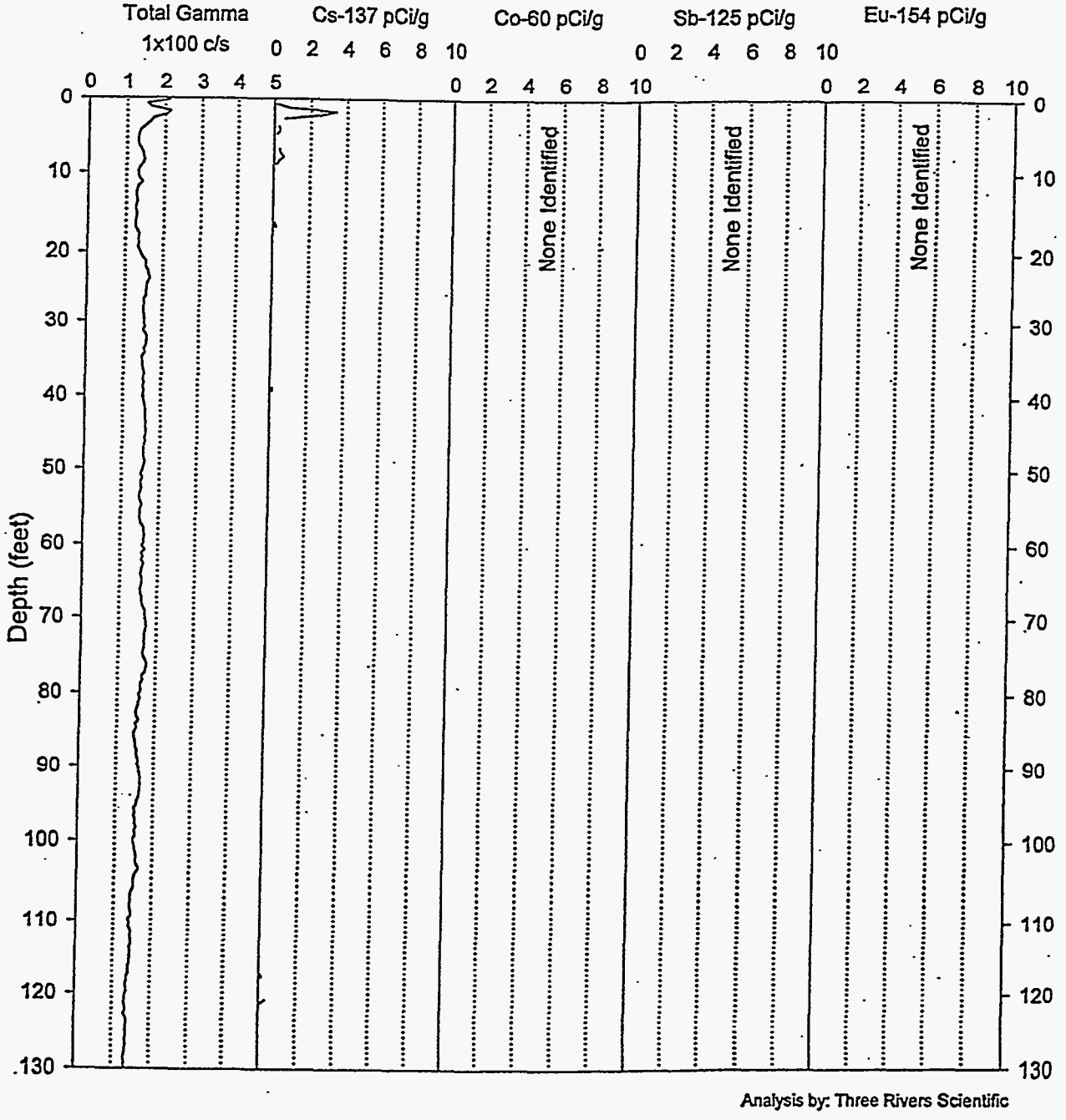


RLS Spectral Gamma-Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24 , 1998

Borehole: 299-E33-44 (B8554) Man-Made Radio-Isotopes of Concern



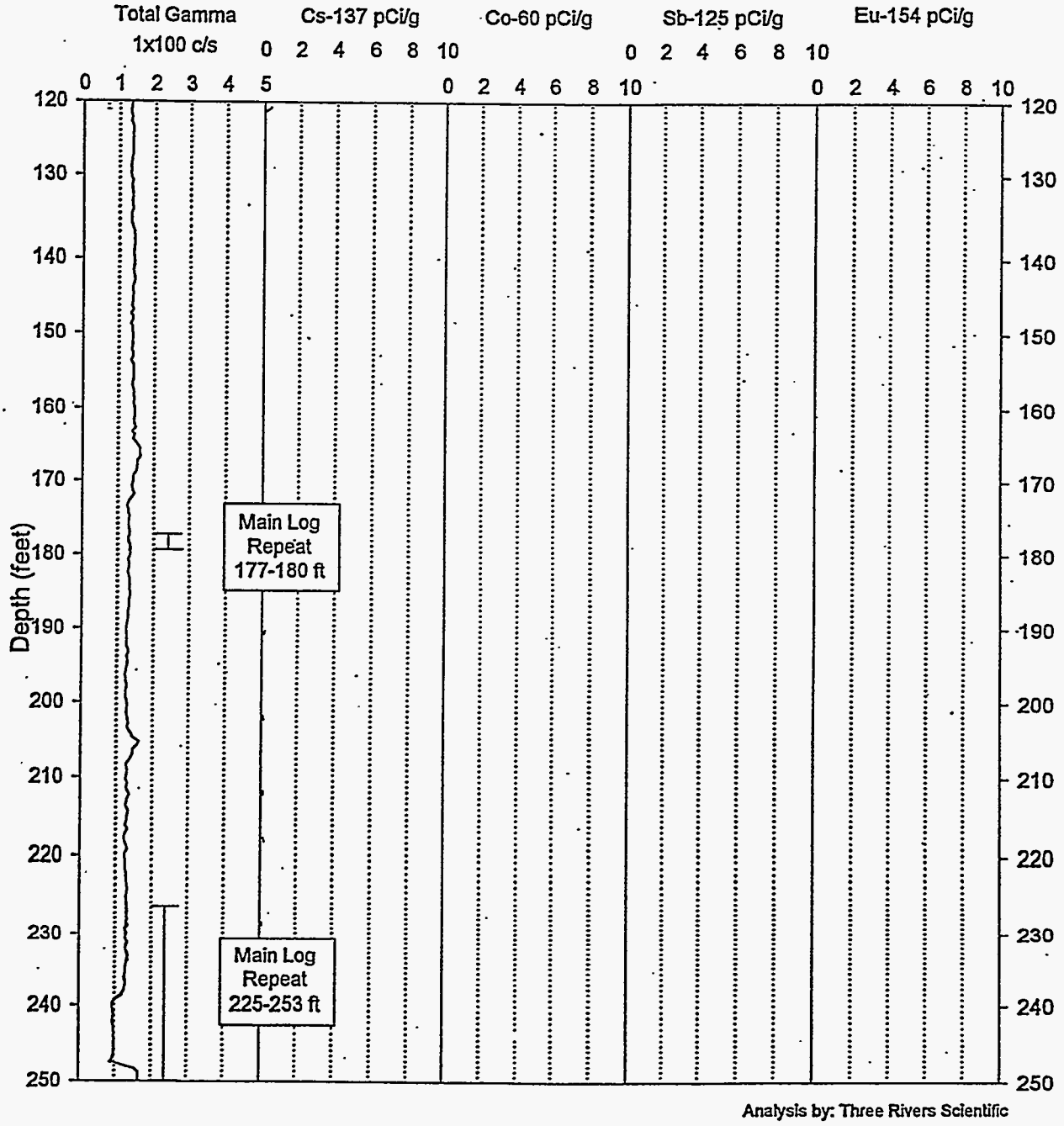
Analysis by: Three Rivers Scientific

RLS Spectral Gamma-Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24 , 1998

Borehole: 299-E33-44 (B8554) Man-Made Radio-Isotopes of Concern

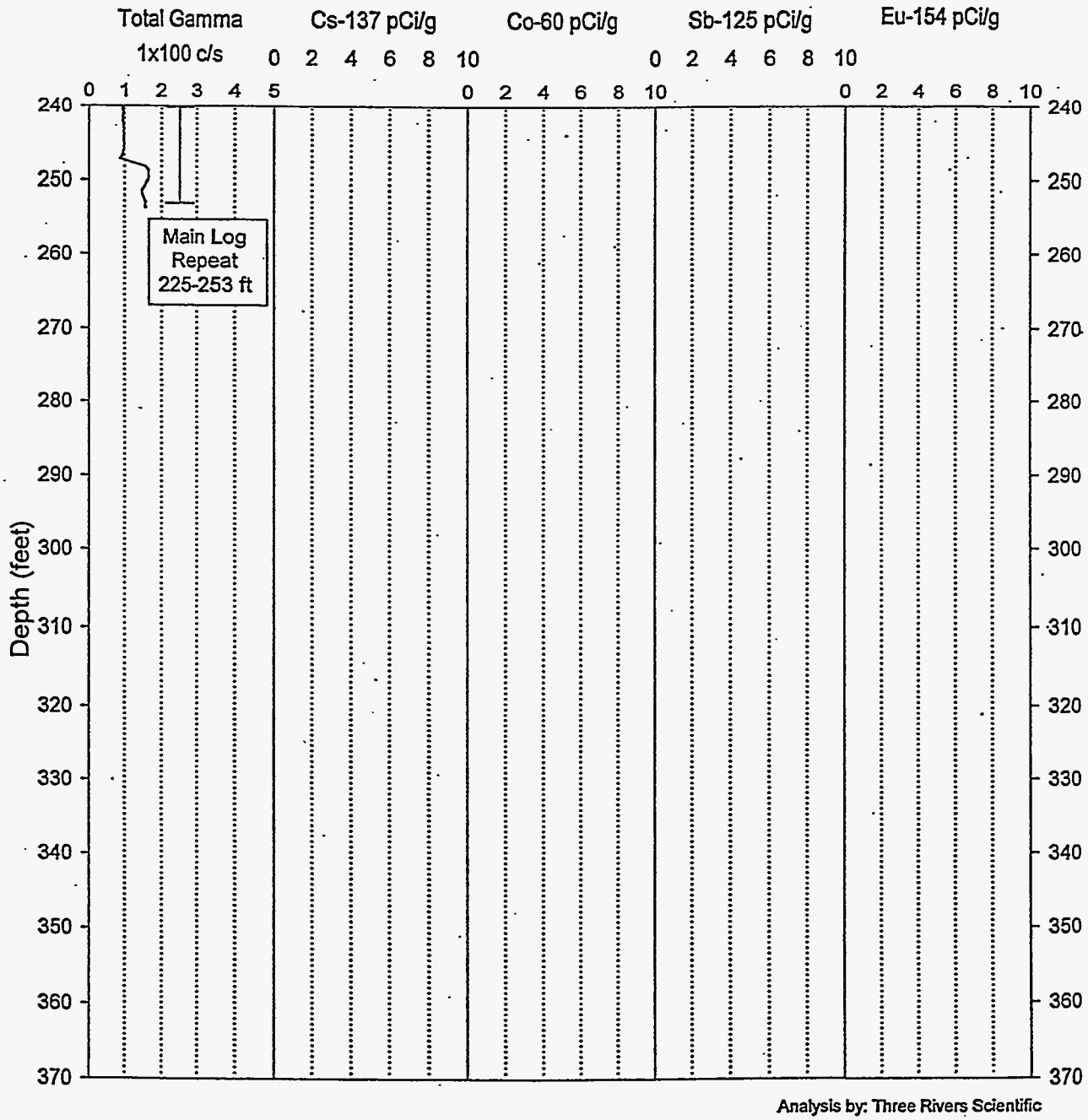


RLS Spectral Gamma-Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24 , 1998

Borehole: 299-E33-44 (B8554) Man-Made Radio-Isotopes of Concern

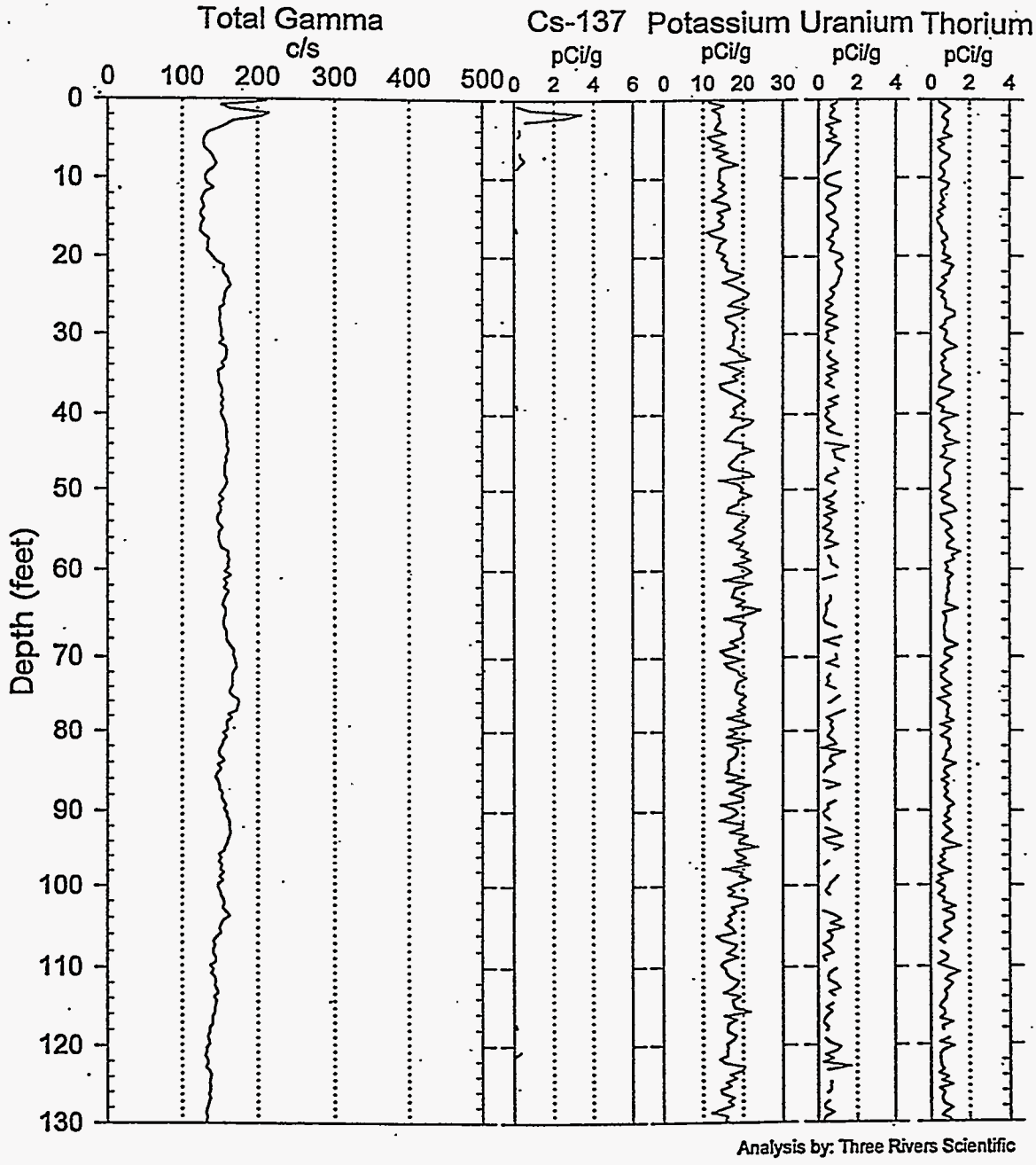


RLS Spectral Gamma Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24, 1998

Borehole: 299-E33-44 (B8554) Natural Radionuclides & Cs-137

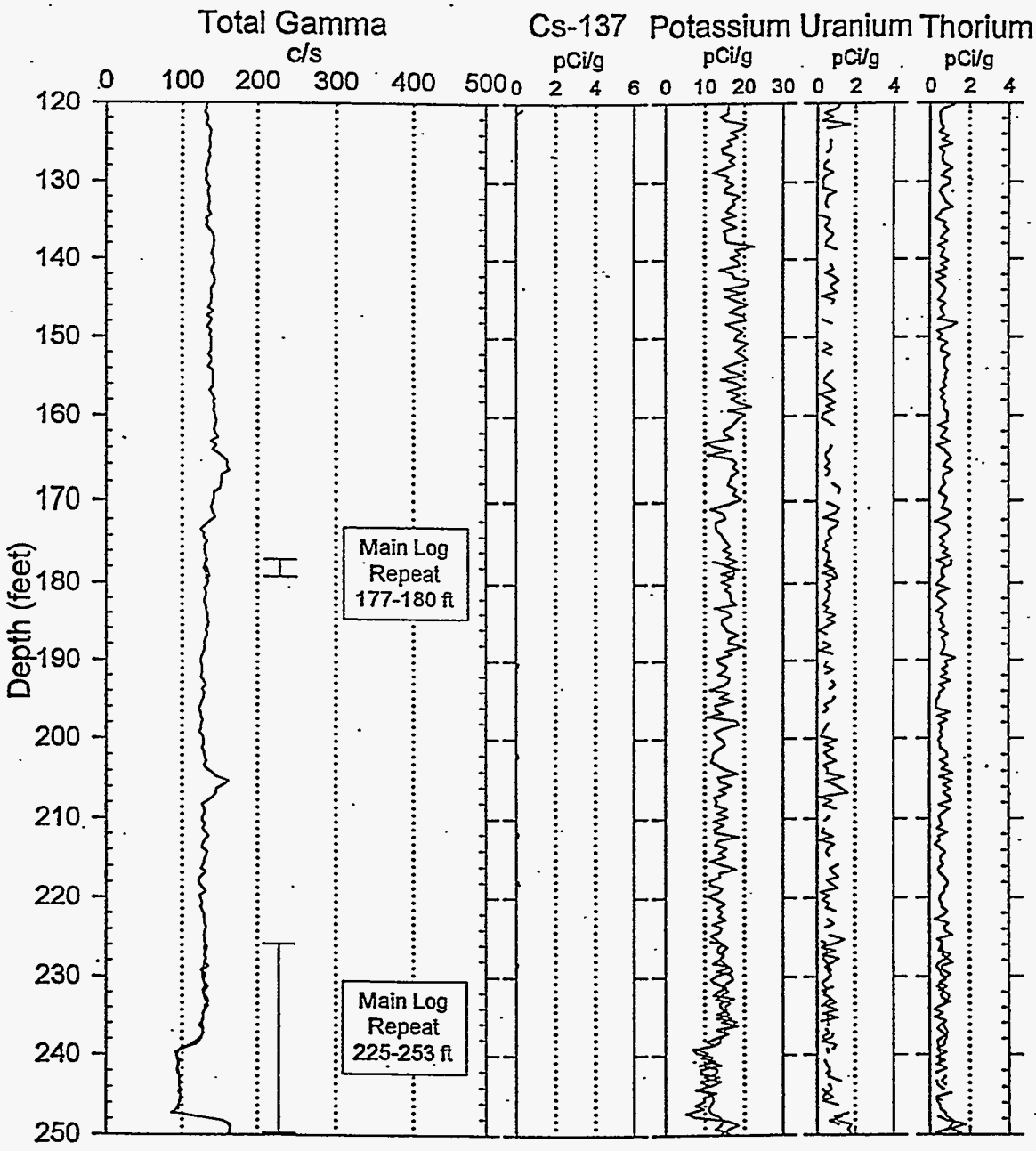


RLS Spectral Gamma Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24, 1998

Borehole: 299-E33-44 (B8554) Natural Radionuclides & Cs-137



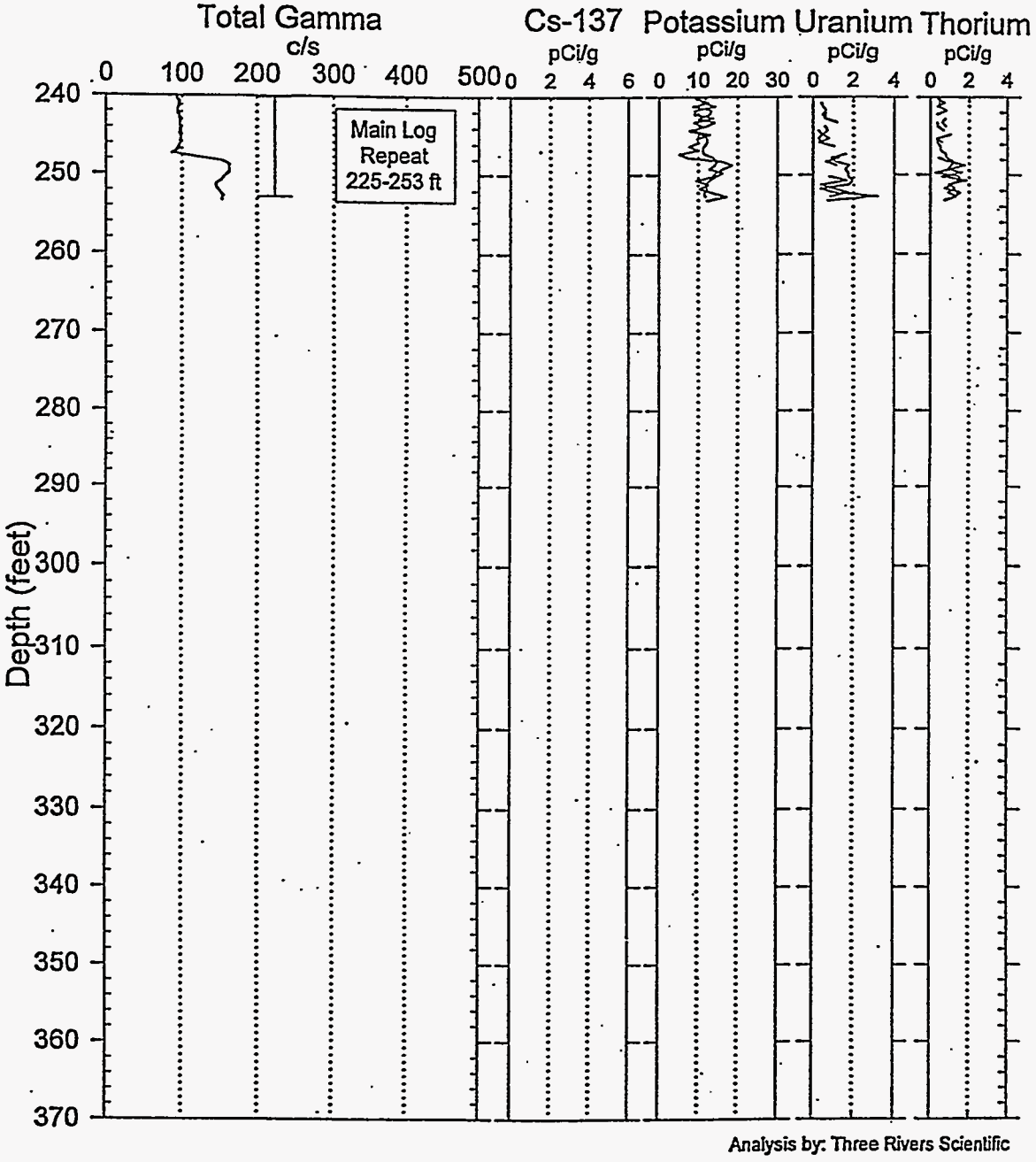
Analysis by: Three Rivers Scientific

RLS Spectral Gamma Ray Borehole Survey

Waste Management Federal Services NW

Project: RCRA Drilling - 1998 Log Date: Sept. 24, 1998

Borehole: 299-E33-44 (B8554) Natural Radionuclides & Cs-137



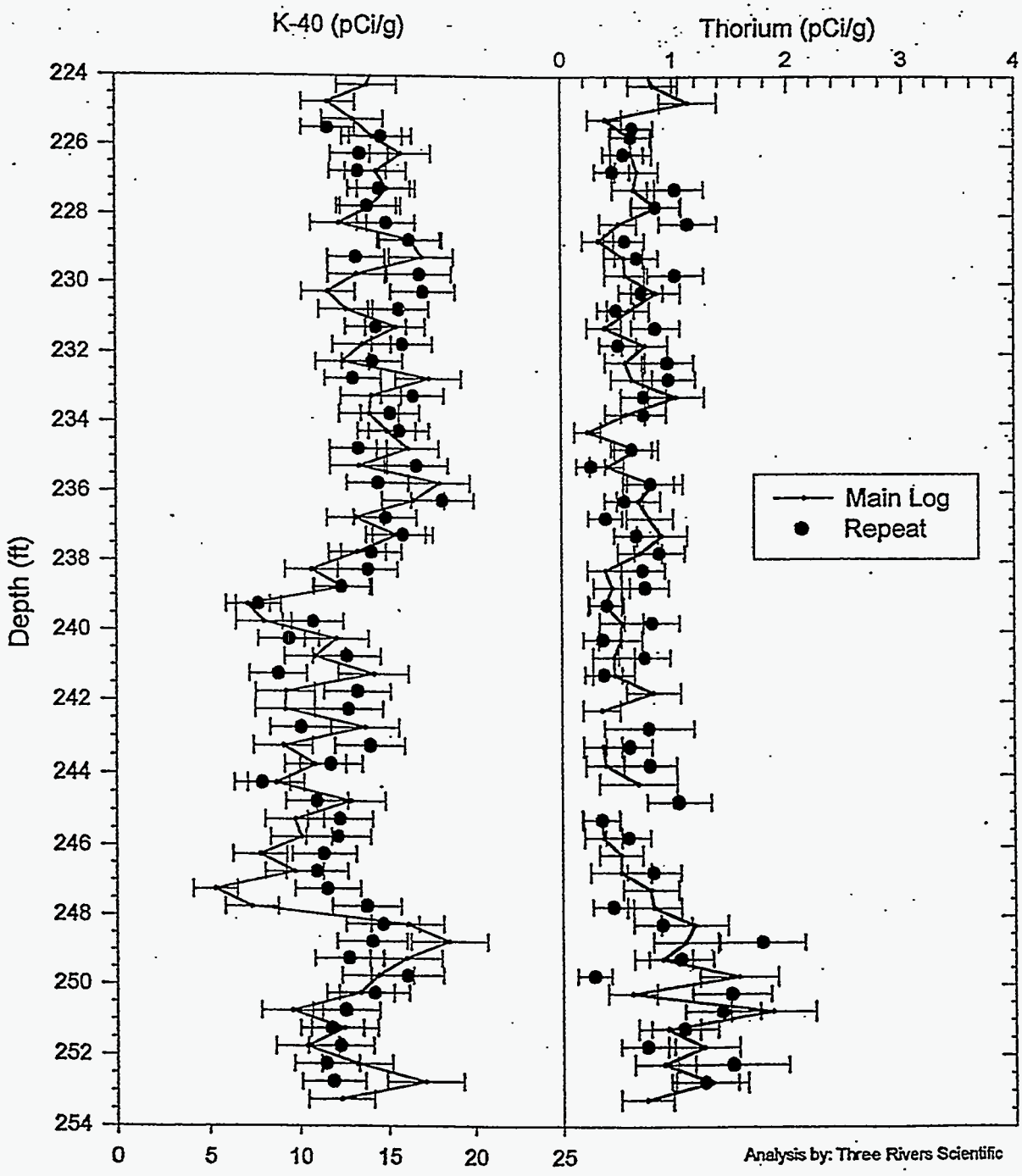
Analysis by: Three Rivers Scientific

RLS Spectral Gamma-Ray Borehole Survey

Acceptance QA Processing

Project: RCRA Drilling - 1998 Log Date: Sept 24, 1998

Borehole: 299-E33-44 (B8554) Compare Main Log & Repeat



RLS Spectral Gamma-Ray Borehole Survey

Waste Management Federal Services NW

Log Analysis Summary Report

Project:	RCRA Drilling - 1998	Well ID:	299-E33-44
Log Type:	HPGe Spectral Gamma-Ray	Log Dates:	Sept 24, 1998

General Notes:

Total gamma is a response to man made gamma-ray emitters and formation lithology from surface to 4 feet, and a function of formation lithology below 4 feet.

The system dead-time limit was not exceeded (less than 5%) for the borehole survey.

System Performance Verify: The pre- and post-log verification was performed using coleman #2 mantle, and passed the equipment performance check. The maximum FWHM for the 583 keV gamma ray photo peak for both survey dates was 2.20 keV. The maximum acceptable FWHM resolution is 3.10 keV for probe RLSG3.1 on the log dates.

Repeat Interval: The repeat interval, 225 to 253 ft, agrees with the main log within acceptable limits, refer to the Acceptance QA Processing plot.

Environmental Corrections: The KUT and man made radionuclide concentrations have been corrected for casing attenuation (entire well) and water inside the casing (below 239.5 ft) for a centralized detector configuration. No casing correction was applied to the total gamma due to Compton downscatter interference.

Radionuclides:

Cs-137 was identified near the surface (0.5 to 3.0 ft) with a maximum concentration of 3 pCi/g at 2 feet and at intermittent locations (less than 0.3 pCi/g at depths greater than 10 ft) to the bottom of the well. No other man made radionuclides detected.

Analysis by: Three Rivers Scientific

RLS Spectral Gamma Ray Borehole Survey
Waste Management Federal Services NW

Log Header

Project: RCRA Drilling Well: **299-E33-44**

Log Type: NaI Spectral Gamma Ray

Borehole Information

Well ID	B8554	Water Depth	239.5 ft	Total Depth	254.1 ft
Elevation Reference	UN	Elevation	UN ft		
Depth Reference	Ground Level	Casing Stickup	3.65 ft		
Casing Diameter	8 in ID	Depth Interval	0 to 254.1 ft	Thickness	0.5 in
Casing Diameter	in ID	Depth Interval	ft	Thickness	in

Logging Information

Log Type	NaI Spectral Gamma Ray
Company	Waste Management Federal Services NW
Date/Archive File Name	Sep 23, 1998 N2E33044
Logging Engineers	B Marks
Instrument Series	RLSN1-0
Logging Unit	RLS2
Depth Interval	0 to 254 ft Prefix N268 & N269
Instrument Calibration Date	Aug. 5, 1998
Calibration Report	WHC-SD-EN-TI-293, Rev. 0

Analysis Information

Company	Three Rivers Scientific
Analyst	Russ Randall
Date	September 30, 1998

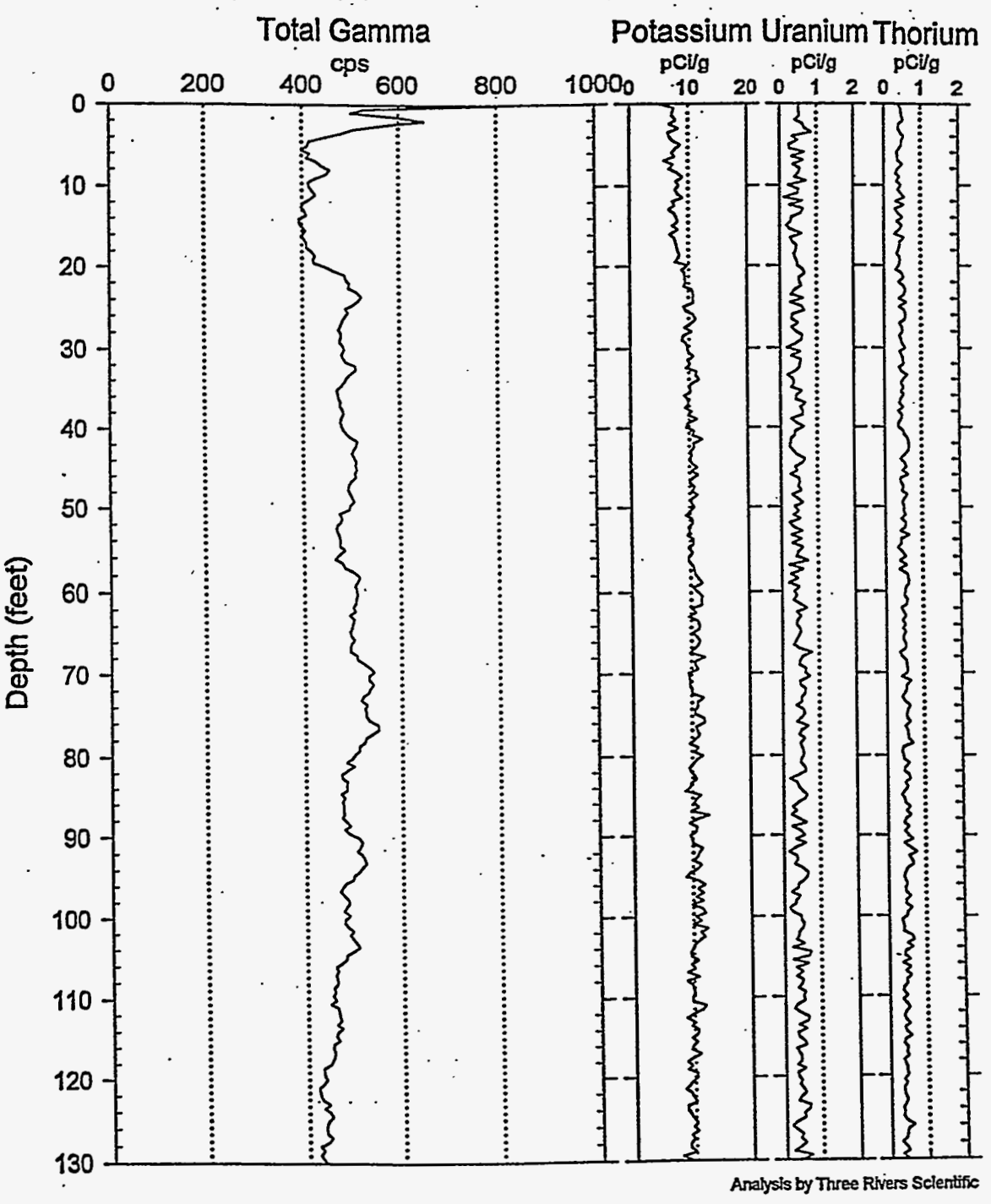
Notes: Casing thickness and water corrections applied to entire logged intervals.

RLS NaI KUT Processed Data

Waste Management Federal Services NW

Project: RCRA Drilling Log Date : Sep 23, 1998

Borehole: 299-E33-44

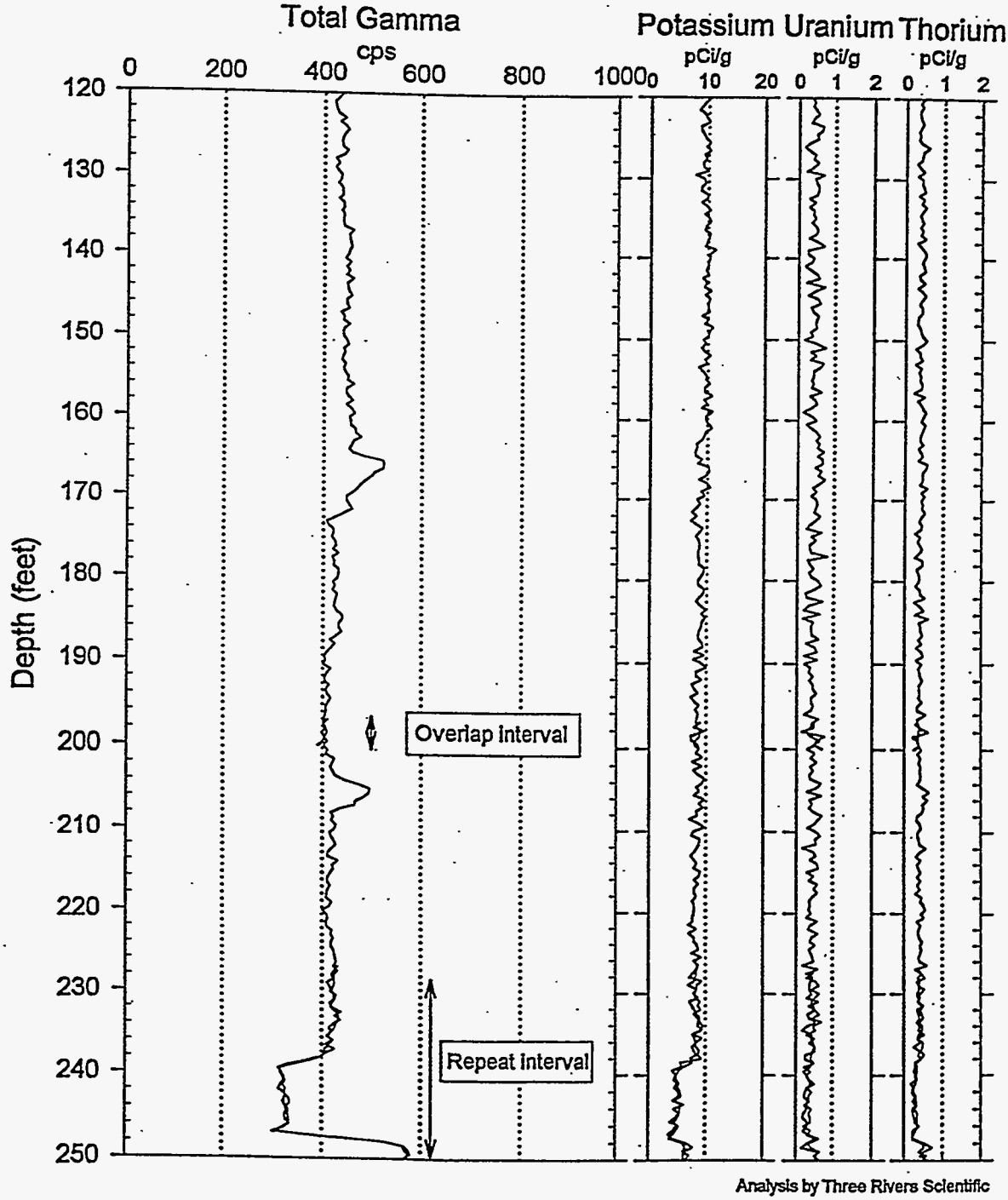


RLS NaI KUT Processed Data

Waste Management Federal Services NW

Project: RCRA Drilling Log Date : Sep 23, 1998

Borehole: 299-E33-44

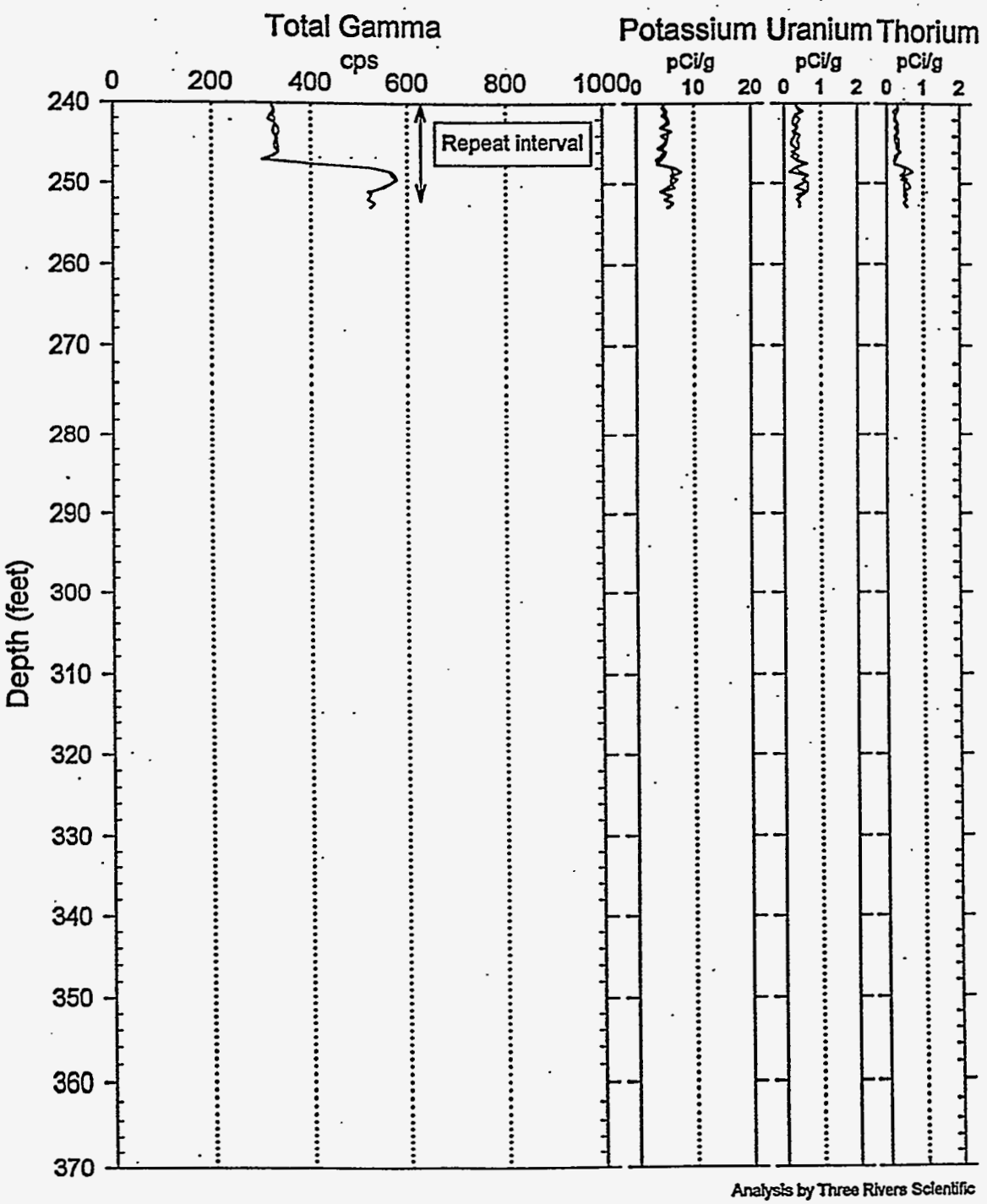


RLS NaI KUT Processed Data

Waste Management Federal Services NW

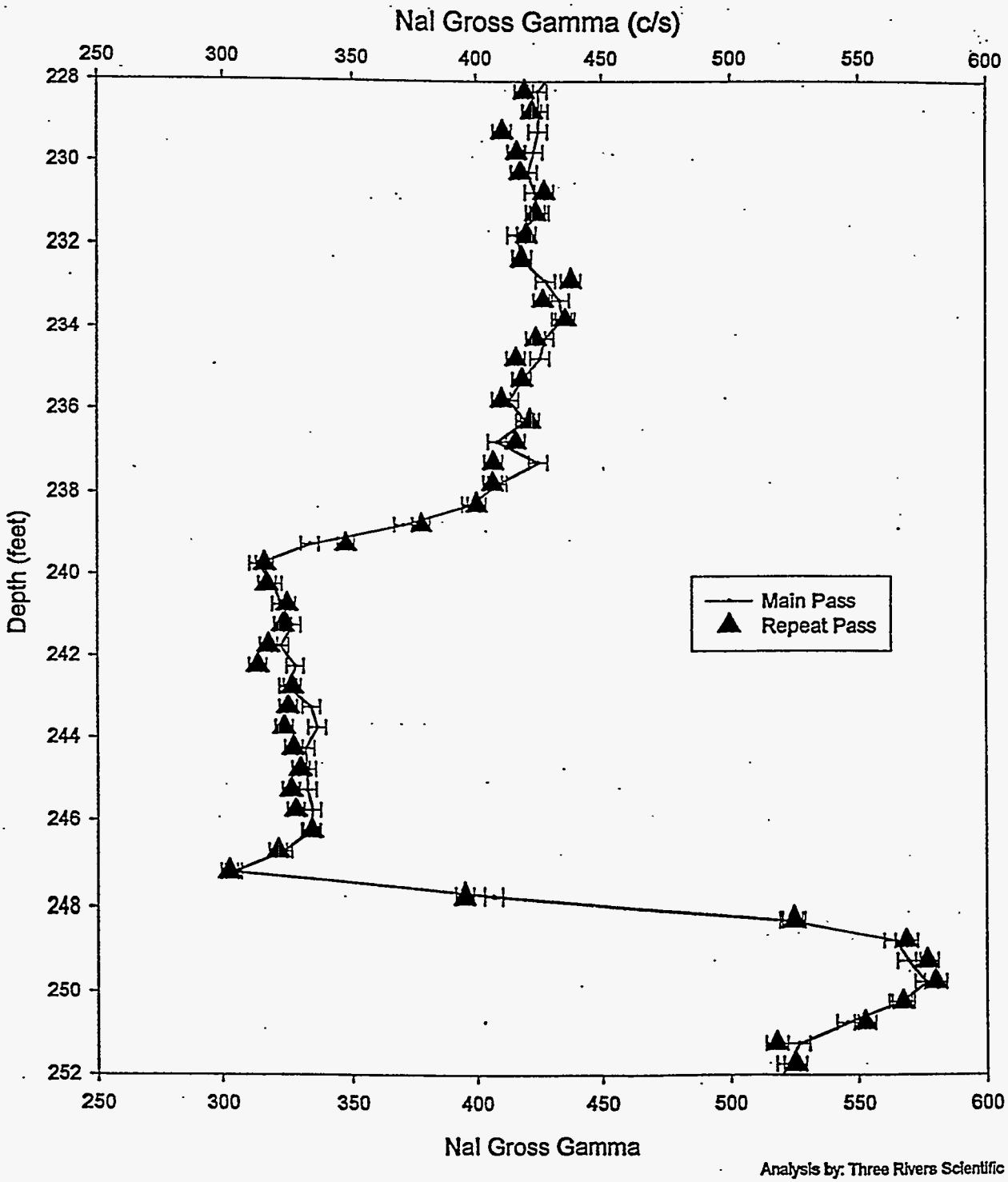
Project: RCRA Drilling Log Date : Sep 23, 1998

Borehole: 299-E33-44



RLS Spectral Gamma Ray Borehole Survey
Acceptance QA Processing

Project: RCRS Drilling **Log Date:** SEp 23, 1998
Borehole: 299-E33-44 **Compare Main Log and Repeat**



Analysis by: Three Rivers Scientific

RLS Spectral Gamma Ray Borehole Survey

Waste Management Federal Services NW

Log Analysis Summary Report

Project:	RCRA Drilling	Well ID:	299-E33-44
Log Type:	NaI Spectral Gamma Ray	Log Dates:	Sep 23, 1998

Basic Response:

Total gamma is, in general, a response of formation lithology, except for the near surface peak at 2 feet. Cs-137 is identified with the HPGe logging system in the peak at 2 feet. The NaI detector logging system is only calibrated for the natural radionuclides and not man-made radionuclides.

The potassium, uranium and thorium concentrations are normal for Hanford formations.

Repeat Interval:

The repeat interval, 228 to 252 feet, agrees with the main log within acceptable limits (refer to the Acceptance QA Processing plot).

Environmental Corrections:

The KUT concentrations have been corrected for casing attenuation over the entire well. No casing correction was applied to the total gamma due to Compton downscatter interference. Water correction was applied over the intervals where water is present in the borehole.

Analysis by: Three Rivers Scientific

RLS Spectral Gamma Ray Borehole Survey

Waste Management Federal Services NW

Log Header

Project: RCRA Drilling Well: **299-E33-44**

Log Type: NaI Spectral Gamma Ray

Borehole Information

Well ID	B8554	Water Depth	239.5 ft	Total Depth	254.1 ft
Elevation Reference	UN	Elevation	UN ft		
Depth Reference	Ground Level	Casing Stickup	3.65 ft		
Casing Diameter	8 in ID	Depth Interval	0 to 254.1 ft	Thickness	0.5 in
Casing Diameter	in ID	Depth Interval	ft	Thickness	in

Logging Information

Log Type	NaI Spectral Gamma Ray
Company	Waste Management Federal Services NW
Date/Archive File Name	Sep 23, 1998 N2E33044
Logging Engineers	B.Marks
Instrument Series	RLSN1.0
Logging Unit	RLS2
Depth Interval	0 to 254 ft Prefix N268 & N269
Instrument Calibration Date	Aug. 5, 1998
Calibration Report	WHC-SD-EN-TI-293, Rev. 0

Analysis Information

Company	Three Rivers Scientific
Analyst	Russ Randall
Date	December 12, 1998

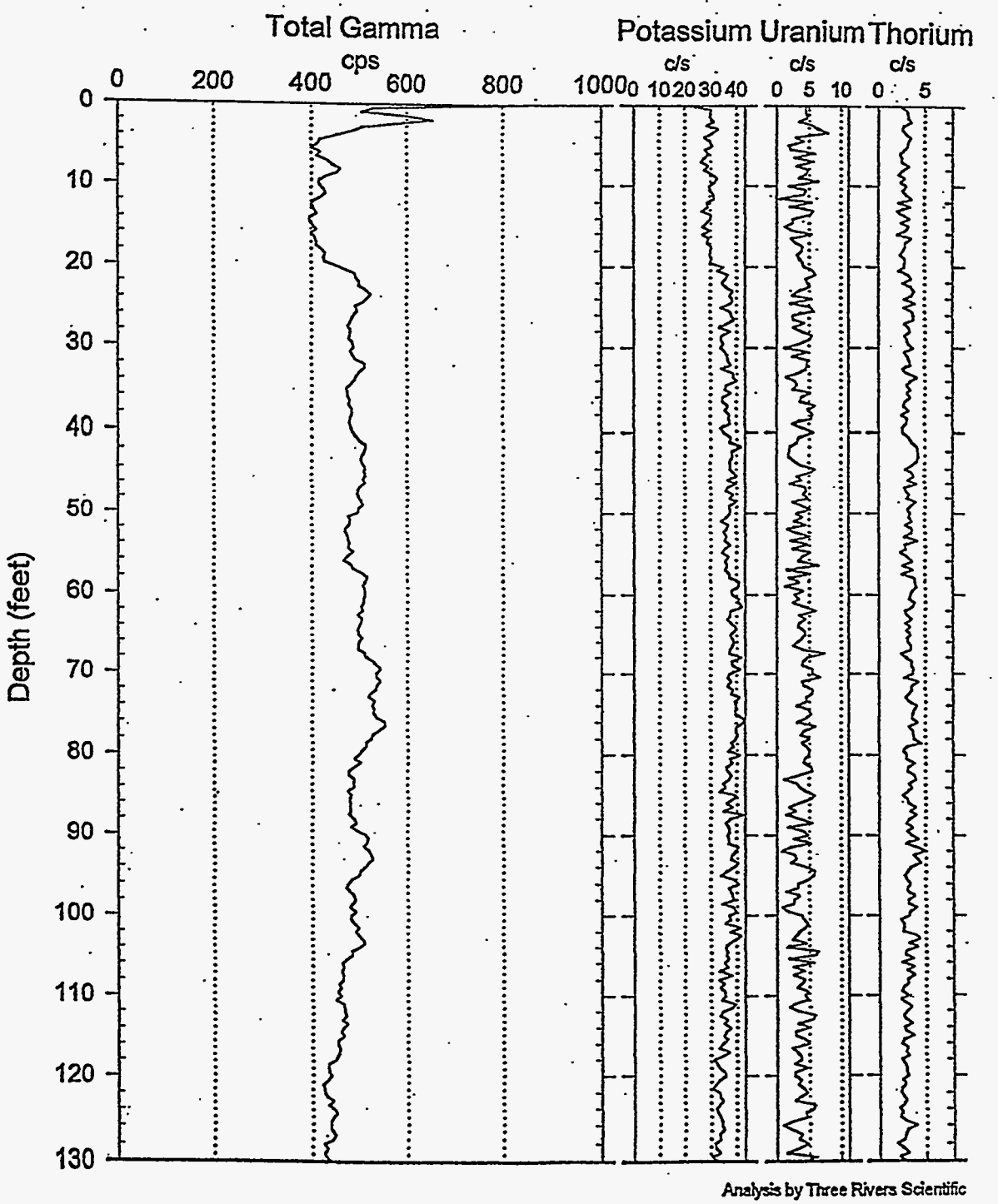
Notes Casing thickness and water corrections applied to entire logged intervals and the KUT units are in count per second as part of the requested special processing.

RLS NaI Special Processed Data

Waste Management Federal Services NW

Project: RCRA Drilling
Borehole: 299-E33-44

Log Date : Sep 23, 1998
KUT Processed for Counts/Second



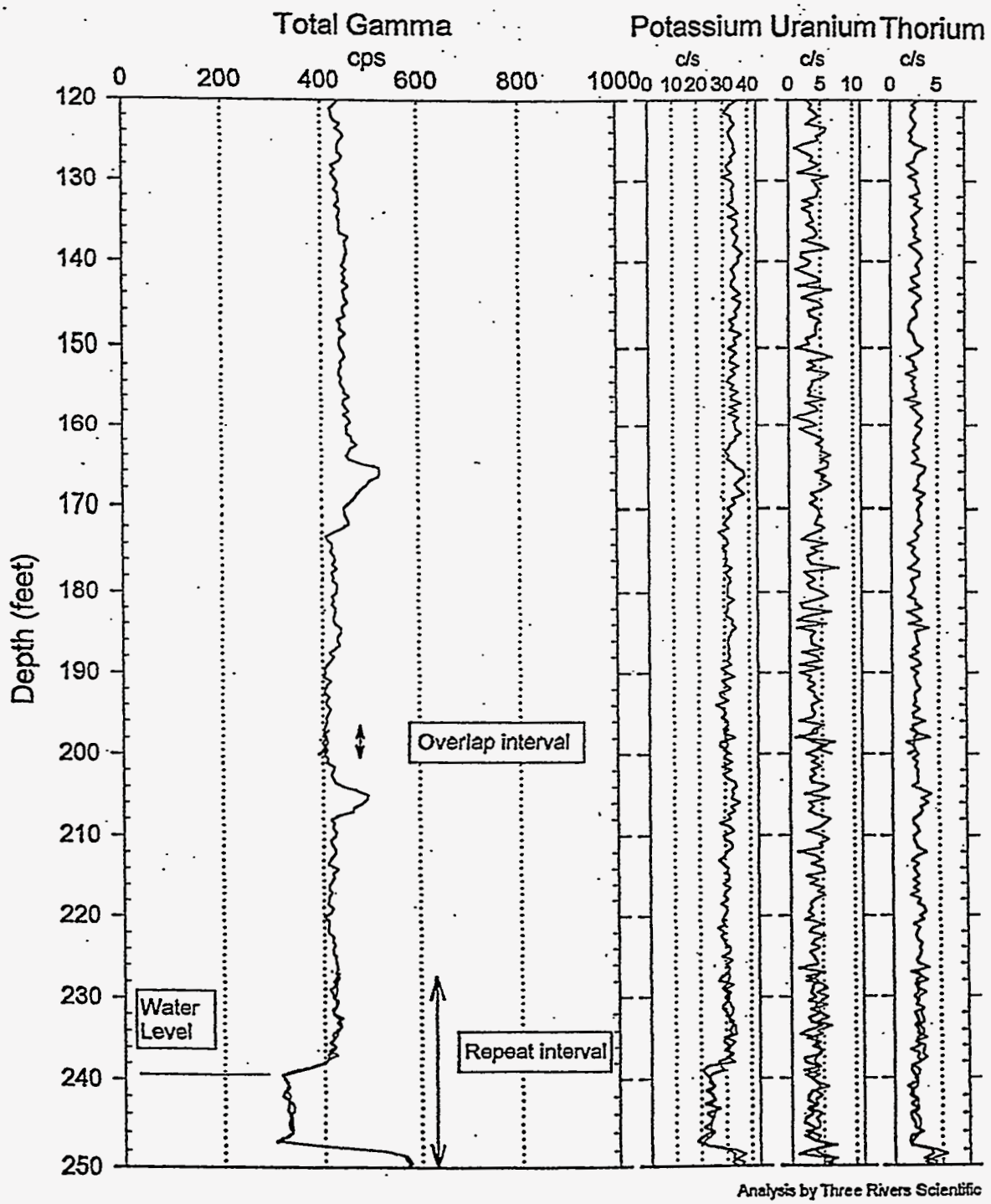
Analysis by Three Rivers Scientific

RLS Nal Special Processed Data

Waste Management Federal Services NW

Project: RCRA Drilling
Borehole: 299-E33-44

Log Date : Sep 23, 1998
KUT Processed for Counts/Second



Analysis by Three Rivers Scientific

RLS Nal Special Processed Data

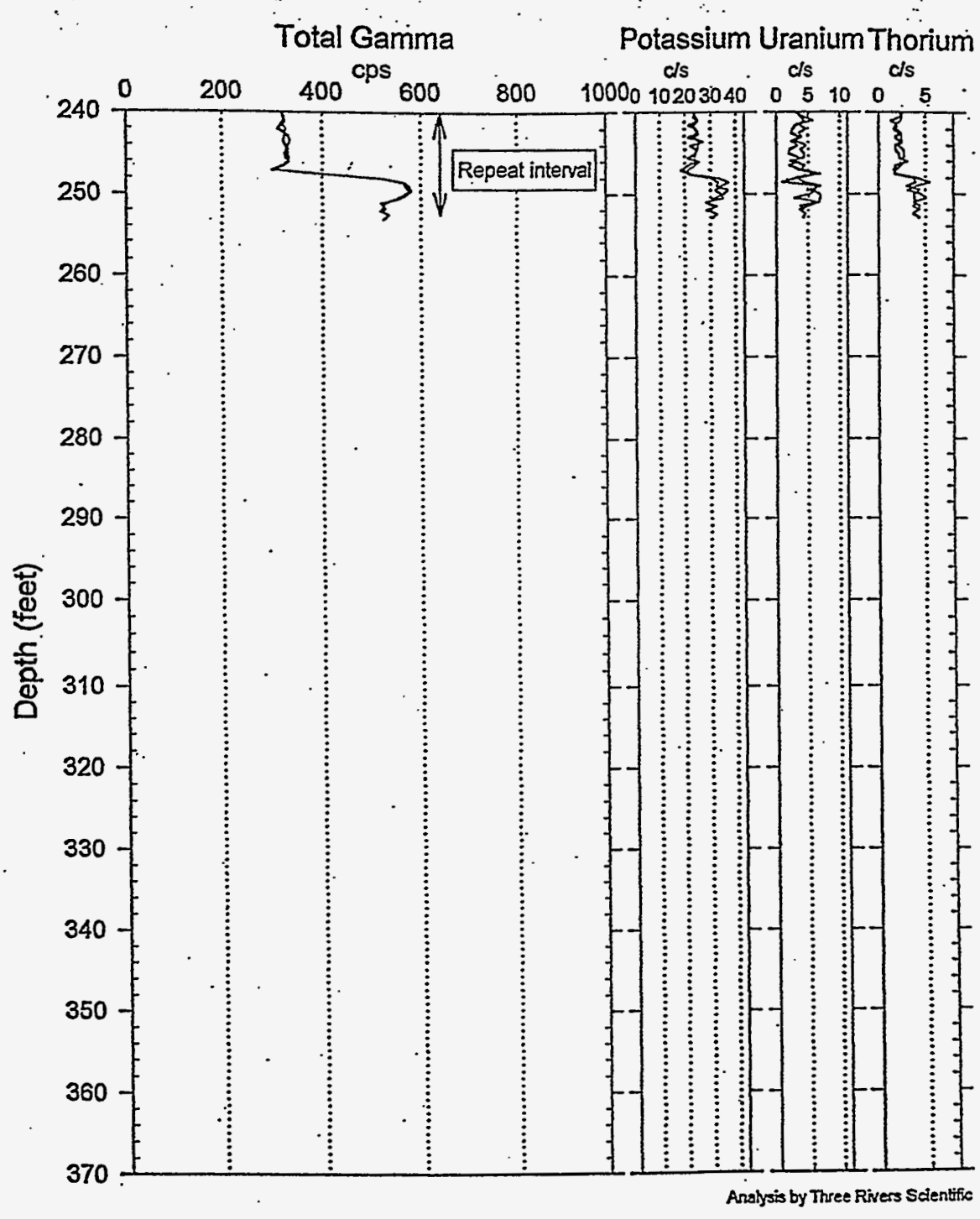
Waste Management Federal Services NW

Project: RCRA Drilling

Log Date : Sep 23, 1998

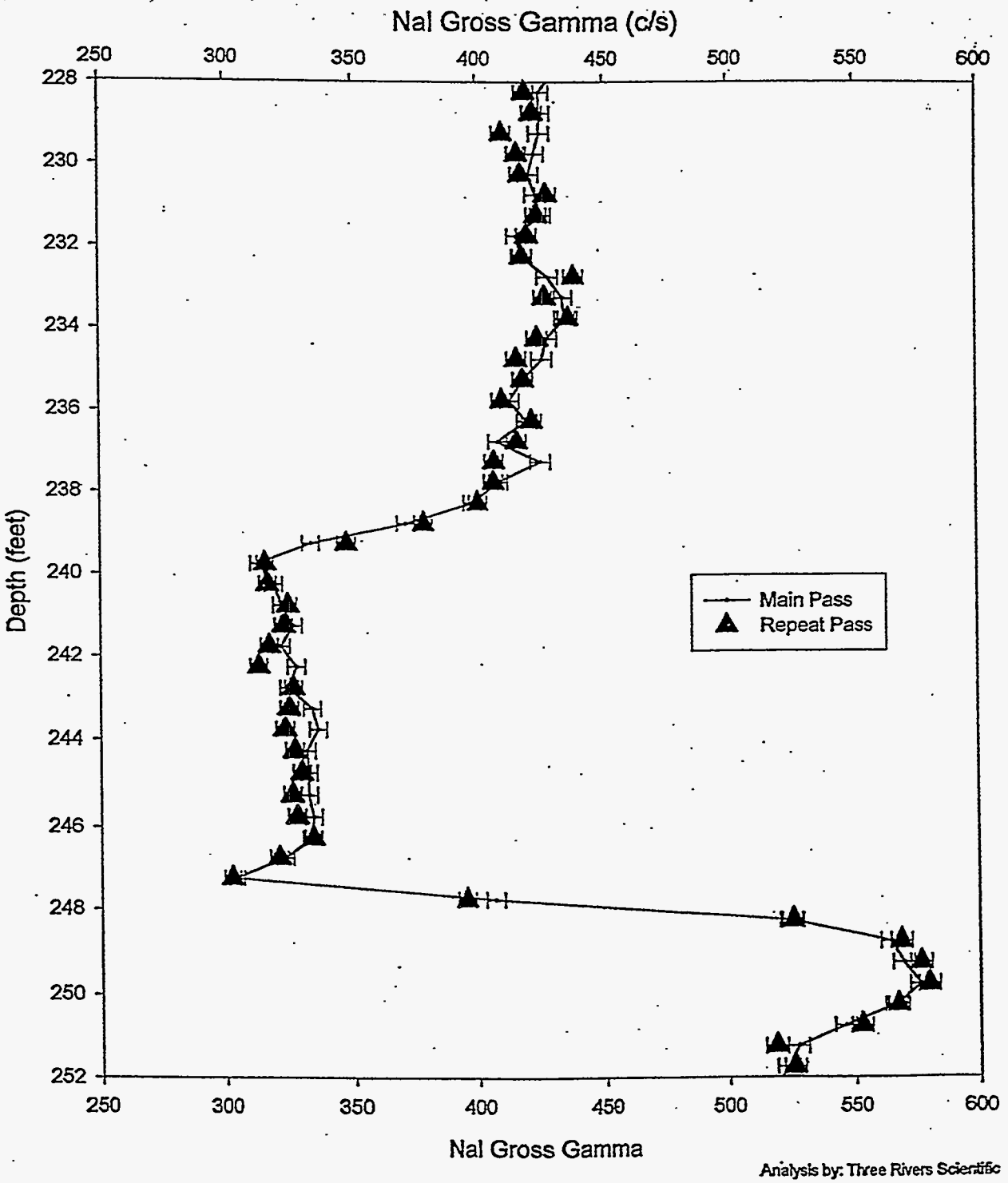
Borehole: 299-E33-44

KUT Processed for Counts/Second



RLS Spectral Gamma Ray Borehole Survey
Acceptance QA Processing

Project: RCRS Drilling **Log Date:** SEp 23, 1998
Borehole: 299-E33-44 **Compare Main Log and Repeat**



Analysis by: Three Rivers Scientific

RLS Spectral Gamma Ray Borehole Survey
Special Counts/Second Processing
Waste Management Federal Services NW

Log Analysis Summary Report

Project:	RCRA Drilling	Well ID:	299-E33-44
Log Type:	NaI Spectral Gamma Ray	Log Dates:	Sep 23, 1998

Basic Response:

Total gamma is, in general, a response of formation lithology, except for the near surface peak at 2 feet. Cs-137 is identified with the HPGe logging system in the peak at 2 feet. The NaI detector logging system is only calibrated for the natural radionuclides and not man-made radionuclides.

The potassium, uranium and thorium concentrations are not plotted, but the equilivent count per second are plotted. These count rates have been casing and water corrected.

Repeat Interval:

The repeat interval, 228 to 252 feet, agrees with the main log within acceptable limits (refer to the Acceptance QA Processing plot).

Environmental Corrections:

The KUT count rates have been corrected for casing attenuation over the entire well. No casing correction was applied to the total gamma due to Compton downscatter interference. Water correction was applied to the KUT count rates over the intervals where water is present in the borehole.

There is no relative difference between the units of count rates and concentrations. This fact is due to the scaling factor relationship between the casing corrected count rates and the concentrations. The scales for the KUT plots have been adjusted to produce an exact overlay of the two sets of plots. The scales are specifically:

K: 0 – 43.3 c/s
U: 0 – 11.3 c/s
Th: 0 – 7.94 c/s

Analysis by: Three Rivers Scientific

Methodology for Deriving KUT Net Count Rates for NaI Spectral Data
Russel Randall, PhD
December 14, 1998

Background

NaI spectral data collected by Waste Management Northwest (WM-NW) is presently processed to produce K, U, & Th concentrations. The calibration[1] produces a set of coefficients that are used to convert the count rate observed in selected energy windows to the K, U, & Th concentrations. This 3 by 3 matrix of coefficients does not produce the net effective K, U, & Th count rates.

A request was made to produce count rates for each of the radionuclides K, U, & Th from NaI logging data. In order to meet this request, a different calibration technique is required, and then application of resulting coefficients to the log data yields net count rates. This document provides the description of the methodology used to derive the coefficients that can be applied to log data in order to generate the net count rates for K, U, & Th as a function of depth.

Basic Spectral Response

The detected signal for NaI logging data is observed events as a function of the energy of the pulse event detected. Figure 1 contains a representative spectra from the K model and the U

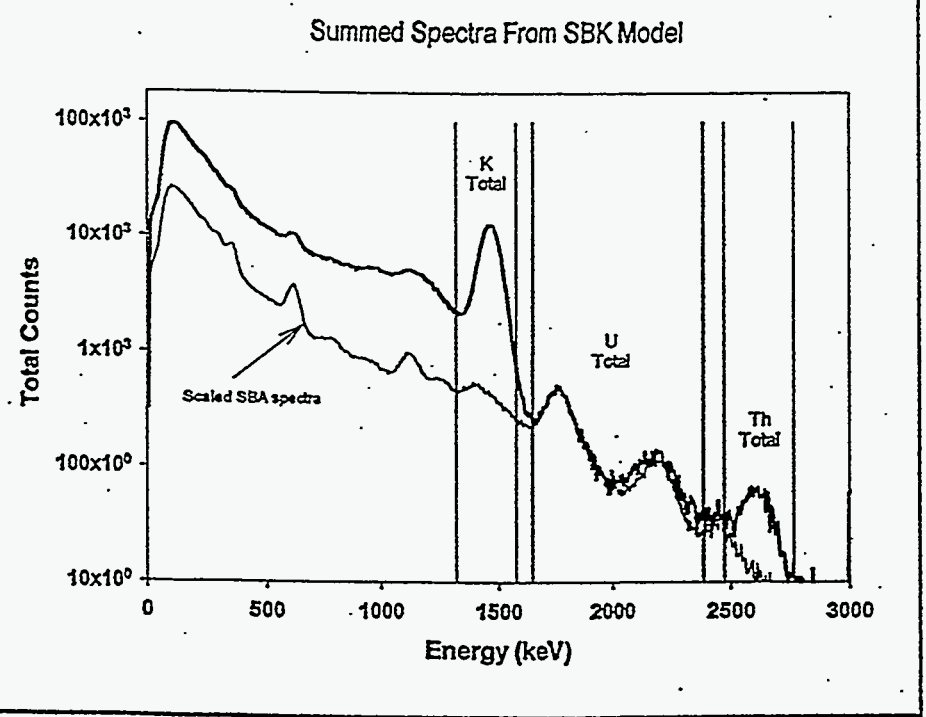


Figure 1. Summed spectra from the K calibration model with a scaled spectra from the SBA model, with notation of the energy windows used.

model at the Hanford site. The inherent energy resolution of the NaI crystal becomes an issue when there are either multiple radionuclides or any given radionuclide has multiple photo peaks from several gamma rays. Both natural uranium, U, and thorium, Th, have many photo peaks that are not clearly resolved. However, there are analysis techniques that can be applied to deconvolve the response of K, U, & Th gamma rays from a minimum of three observed count rates from three energy windows (refer to fig.1 for the windows used by WM-NW analysis procedures).

Consider the energy window labeled K-Total. This energy window covers all the observed gamma events between 1320 and 1575 keV. Any observed gamma event recorded in this window can be from one of the following:

1. K photo peak
2. K Compton (on the lower portion of the window)
3. U photo peaks
4. U Compton
5. Th photo peaks
6. Th Compton

All of these 6 sources of observed gamma rays can be lumped into three terms; all event caused by the presence of K, all events caused by the presence of U, and likewise, Th. All events cause by K is defined as the net K count rate component of the events recorded in the total window. All events observed in the window due to the presence of K is proportional to the K concentrations, thus,

$$K = \alpha_K \cdot C_K^{net} \qquad \text{Eq. 1}$$

where, K is the potasium concentration in pCi/g, α_K is a calibration coefficient, and C_K^{net} is the net count rate in the K-total window that is due to the presence of K. On the basis of the above discussion for the sources of the recorded events, the net count rate from K can be described by the following:

$$C_K^{net} = C_K - a_{KU} \cdot U - a_{KT} \cdot T \qquad \text{Eq. 2}$$

where, C_K is the total observed count rate in the K-total window, U is the uranium concentration in the formation, a_{KU} is a calibration coefficient to be determined, T is the Th concentration in the formation, a_{KT} is a calibration coefficient to be determined. Substitution of this expression into the previous results in:

$$K = \alpha_K \cdot C_K - \beta_{KU} \cdot U - \beta_{KT} \cdot T \qquad \text{Eq. 3}$$

$$\beta_{KU} \equiv \alpha_K \cdot a_{KU}$$

$$\beta_{KT} \equiv \alpha_K \cdot a_{KT}$$

Therefore, the above equation has three unknowns and can be solved using a minimum of three measurements. The data collected in the SBK, SBA, and SBT models were used to solve for these three coefficients.

Data Analysis

The three model measurements can be used to solve Eq.3 for the coefficients, given the radionuclide concentrations of the models, and the observed K-total count rate of the instrument

in each model. The derivation for U and Th is similar, except there are only 2 gamma event contributors and therefore, only 2 coefficients to solve for. Therefore, the case of U and Th is overdetermined, given three model measurements.

The calibration models at Hanford have known concentrations of K, U, & Th[2]. Table 1 lists the standards for the models used in this formulation.

Table 1. Standard values for the Hanford calibration models

Model	K-40 (pCi/g)	U (Ra-226) (pCi/g)	Thorium (pCi/g)
SBK	53.5	1.16	0.11
SBA	11[a]	63.0[b]	0.66[a]
SBT	10.63	10.02	58.11

[a] Adjused on the basis of similar values for the SBU model

[b] Adjusted on the basis of the difference quoted for the SBU model with the KUT values versus the gross values

The SBU model has more rigorously defined concentrations of all components over the SBA model, but the detector exceed the high count rate limit for the SBU model. The NaI crystal is designed to be very large and therefore sensitive in order to obtain the most lithologic information with the lowest cost of logging. Likewise, the SBM model exceeds the high count rate limitation for this instrument.

Calibration data were collected in the three models, SBT, SBK, and SBA. Each model was used to record ten spectra of 300 seconds each. Table 2 contains the average total count rate observed for each of the selected energy windows used in the KUT processing. Also included in table 2 are the energy ranges for each of the processing windows.

Table 2. Observed average count rates in the energy windows

Model	K-Total (c/s) 1320-1575 keV	U-Total (c/s) 1650-2390 keV	Th-Total (c/s) 2475-2765 keV
SBK	83.58	6.98	0.637
SBA	335.9	361.3	11.44
SBT	297.2	563.4	231.7

Appendix A contains the details of the calculations for the coefficients. The only coefficients of application are the coefficients of eq. 1 for each of the radionuclides, K, U, & Th. Table 3 contains the resulting values as determined from the calibration data and simultaneous solutions.

Table 3. Resulting conversion coefficients for the effective net count rates

Radionuclide	Calibration Factor (pCi/g)/(c/s)
K-40	0.692
Uranium (Ra-226)	0.176
Thorium	0.252

Verification

It is possible to arrive at an independent estimate for the K net count rate since this radionuclide has only one emitted gamma ray. This fact can be used to derive the net photo peak count rate by fitting a gaussian to observed spectra. This estimate will be somewhat less than the value derived

and listed in table 3, since only the photo peak net count rate can be measured using this technique, and the derived coefficients are a result of photo peak intensity and Compton background intensity due to the presence of K.

A gaussian plus linear background fit was performed for the K-model summed spectra for the dominant 1461 keV gamma ray, refer to fig 1. Appendix B contains the details of this peak fitting calculation. The resulting count rate for this photo peak intensity above background is 65.2 c/s. This count rate is 14% lower than that derived on the basis of the coefficient listed in table 3. As can be seen in fig 1, some of the count recorded in the K-total window are due to both K-40 and its Compton down scatter. Thus the 14% lower figure for just the photo peak is reasonable and substantiates the total "net" count rates that can be arrived at by using the coefficients in table 3.

Results

The methods have been described covering the derivation of the scaling factors that relate the net effective count rates for K, U, & Th from the elemental concentrations. This derivation has been verified using a peak fitting for the single photo peak of K-40 in the SBK calibration model.

The application of this derivation to the production of log plots in "net" effective KUT count rates is then straight forward. If the normal log analysis has been performed, then the elemental concentrations have been casing and/or water level corrected and the count rates are simply a result of scaling the concentrations by division of the coefficients listed in table 3. Note if the normal log analysis has not been performed, then apply this normal analysis and then proceed with the scaling to produce the net effective count rates. It must be pointed out that since the scaling factor is a constant, then there is no relative difference between the elemental concentrations and the net effective count rates.

References

1. R. Randall and D. Stromswold, "Procedures for Calibrating Scintillation Gamma-Ray- Well Logging Tools Using Hanford Formation Models, WHC-SD-EN-TI-293, Rev. 0, Westinghouse Hanford Company, Richland, WA 1995.
2. W.D. Steele and D.C. George, "Field Calibration Facilities for Environmental Measurement of Radium, Thorium and Potassium," US. Dept. of Energy report GJ/TMC-01 (2nd ed.) UC-70A, Bendix Field Eng., Grand Junction, CO, 1986.

Appendix A Computations for Coefficients

Finding coefficient for Th coversion from count rates to concentration...

$\alpha T := \frac{58}{232}$ $kt := .05$ $\alpha T =$

Given

$58.11 = \alpha T \cdot 231.7 - kt \cdot 10.02$ SBT model

$0.66 = \alpha T \cdot 11.44 - kt \cdot 63.0$ SBA model

$\begin{bmatrix} a \\ k \end{bmatrix} := \text{Find}(\alpha T, kt)$

$a =$ (pCi/g)/(c/s) $k =$

$\beta T := \frac{k}{a}$ $\beta T =$

Check of solutions

$a \cdot 231.7 - a \cdot \beta T \cdot 10.02 =$

$a \cdot 11.44 - k \cdot 63.0 =$

Alternately use other two models

$\alpha T := \frac{58}{232}$ $kt := .05$ $\alpha T =$

Given

$58.11 = \alpha T \cdot 231.7 - kt \cdot 10.02$ SBT model

$0.11 = \alpha T \cdot .637 - kt \cdot 1.16$ SBK model

$\begin{bmatrix} a \\ k \end{bmatrix} := \text{Find}(\alpha T, kt)$

$a =$ (pCi/g)/(c/s) $k =$

$\beta T := \frac{k}{a}$ $\beta T =$

Check of solutions

$a \cdot 231.7 - a \cdot \beta T \cdot 10.02 =$

$a \cdot .637 - k \cdot 1.16 =$

Only difference from 0.252 to 0.25

Process for U coefficient

$U = \alpha u * Gu - k1 * K - k2 * T$ for each model

$au := \frac{63}{361}$ $k1 := .01$ $k2 := 5$ $au =$ $au^{-1} =$

Given

$63.0 = au \cdot 361.3 - k2 \cdot .66$ SBA model

$10.02 = au \cdot 563.4 - k2 \cdot 58.11$ SBT model

$\begin{bmatrix} a \\ d \end{bmatrix} := \text{Find}(au, k2)$

$a =$ $d =$

Checking

$a \cdot 361.3 - d \cdot .66 =$

$a \cdot 563.4 - d \cdot 58.11 =$

$a \cdot 6.98 - d \cdot .11 =$

Alternate solution for other set of two models

Given

$63.0 = au \cdot 361.3 - k2 \cdot .66$ SBA model

$1.16 = au \cdot 6.98 - k2 \cdot .11$ SBK model

$\begin{bmatrix} a \\ d \end{bmatrix} := \text{Find}(au, k2)$

$a = 0.175$ $d = 0.587$

Checking

$a \cdot 361.3 - d \cdot .66 = 63$

$a \cdot 563.4 - d \cdot 58.11 = 64.722$ Difference is acceptable, (.177 to .175)

$a \cdot 6.98 - d \cdot .11 = 1.16$

Process for K coefficient

$K = ak * Gk - k1 * U - k2 * T$ for each model

$ak := \frac{53 \cdot .2}{83}$ $k1 := 1.5$ $k2 := 2$ $ak = 0.128$

Given

$11 = ak \cdot 335.9 - k1 \cdot 63.0 - k2 \cdot .66$ SBA model

$10.63 = ak \cdot 297.2 - k1 \cdot 10.02 - k2 \cdot 58.11$ SBT model

$53.5 = ak \cdot 83.58 - k1 \cdot 1.16 - k2 \cdot .11$ SBK model

$\begin{bmatrix} a \\ c \\ d \end{bmatrix} := \text{Find}(ak, k1, k2)$

$a = 0.692$ $c = 3.487$ $d = 2.756$

Appendix B Calculations for peak and background fitting

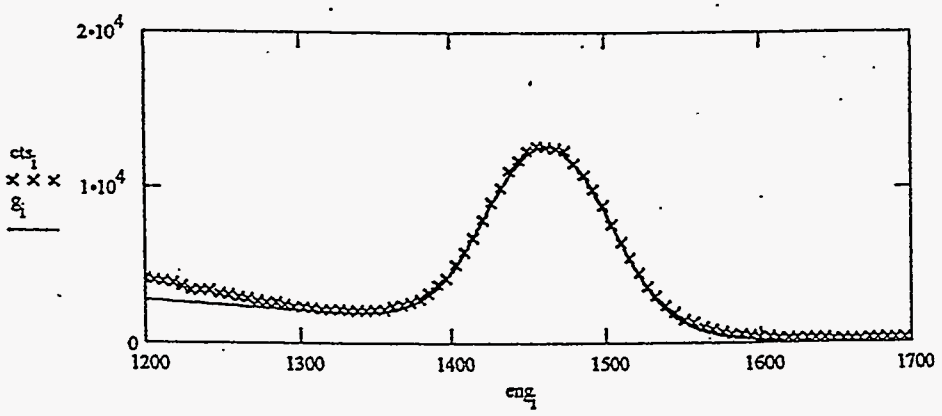
K spectral stripping...

$fil := "Kmodsum.dat"$

$A := READPRN(fil)$ $eng := A^{<0>}$ $cts := A^{<1>}$ $N := last(eng)$ $i := 0..N$

$a := \frac{1700}{-250}$ $b := 11000$

$$g_i := 11700 \cdot e^{\frac{(eng_i - 1463)^2 - 1}{3100}} + a \cdot eng_i + b$$



$$\int_{1320}^{1575} \left[11700 \cdot e^{\frac{-(E-1463)^2}{3100}} \right] dE = 1.152 \cdot 10^6$$

$$\frac{1.152 \cdot 10^6}{5.97 \cdot 295.8 \cdot 10} = 65.235$$ Versus the 62.4 c/s from GammaVision

When I fit the exponential only the total curve, I get 14% higher count rate due mostly t the Compton background on the low energy side. Thus the true stripped net is low by a least 15% from the K contribution in the energy window used.

RLS Moisture Borehole Survey
Waste Management Federal Services NW

Log Header

Project: RCRA Drilling Well: **299-E33-44**

Log Type: Moisture

Borehole Information

Well ID	B8554	Water Depth	239.5 ft	Total Depth	254.1 ft
Elevation Reference	UN	Elevation	UN ft		
Depth Reference	Ground	Casing Stickup	3.65 ft		
Casing Diameter	8.0 in ID	Depth Interval	0 to 254.1 ft	Thickness	0.500 in
Casing Diameter	___ in ID	Depth Interval	_____ ft	Thickness	_____ in

Logging Information

Log Type	Moisture	
Company	Waste Management Federal Services NW	
Date/Archive File Name	Apr. 18, 1998 M2E33044	
Logging Engineers	A.Pearson	
Instrument Series	RLSM3.1	
Logging Unit	RLS2	
Depth Interval	0 to 99.5 ft	Prefix MS64
	98 to 195 ft	Prefix MS65
	192 to 229 & 160 to 180 ft	Prefix MS54
Instrument Calibration Date	Dec. 18, 1997	
Calibration Report	WHC-SD-EN-TI-306, Rev. 0	

Analysis Information

Company	Three Rivers Scientific
Analyst	Russ Randall
Date	September 30, 1998

Notes: The casing thickness correction was applied. The 8" calibration was applied since no 9" hole diameter calibration exists.

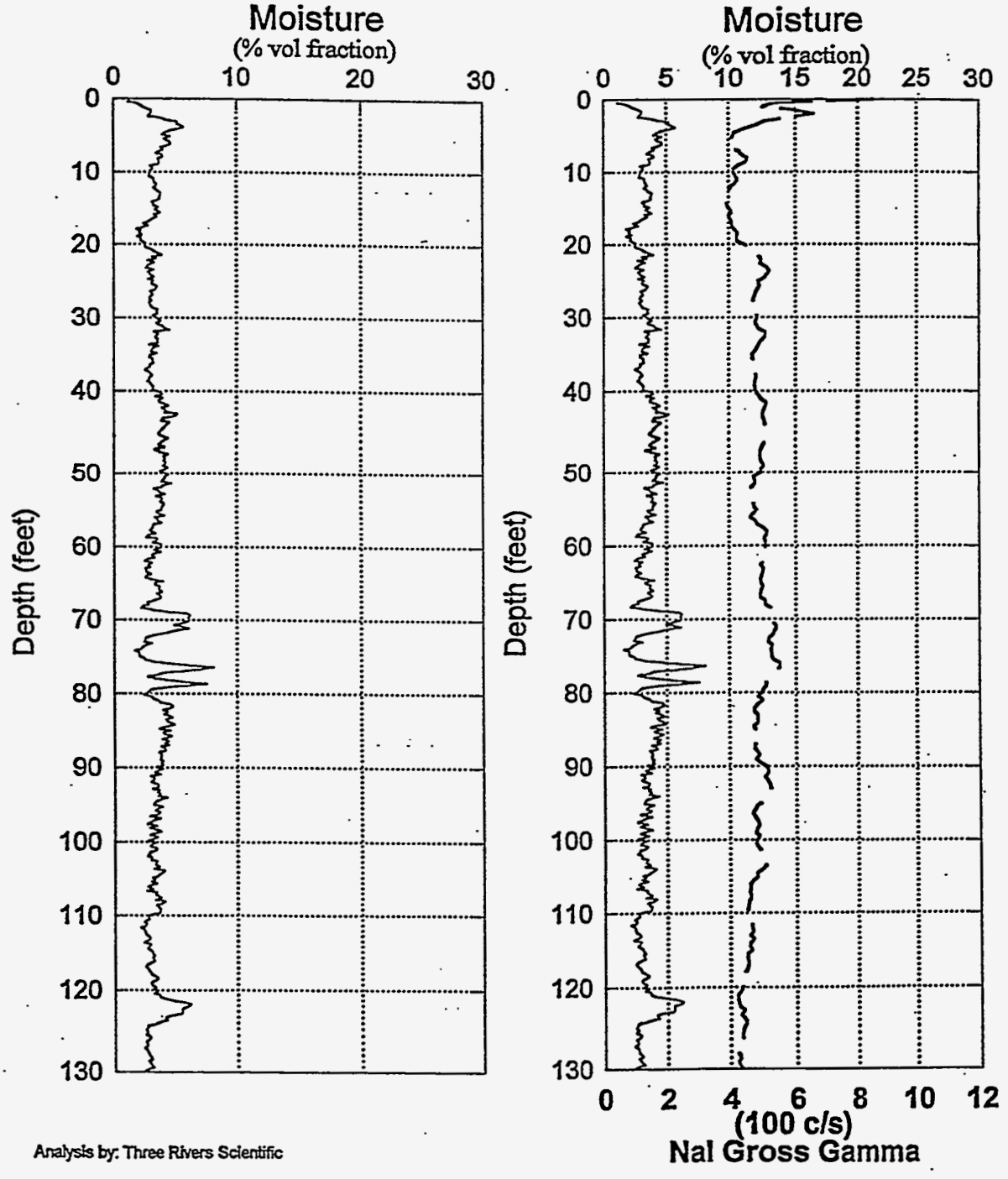
RLS Moisture Processed Log Data

Waste Management Federal Services NW

Project: RCRA Drilling

Borehole: 299-E33-44

Log Date Sep 23, 1998



Analysis by: Three Rivers Scientific

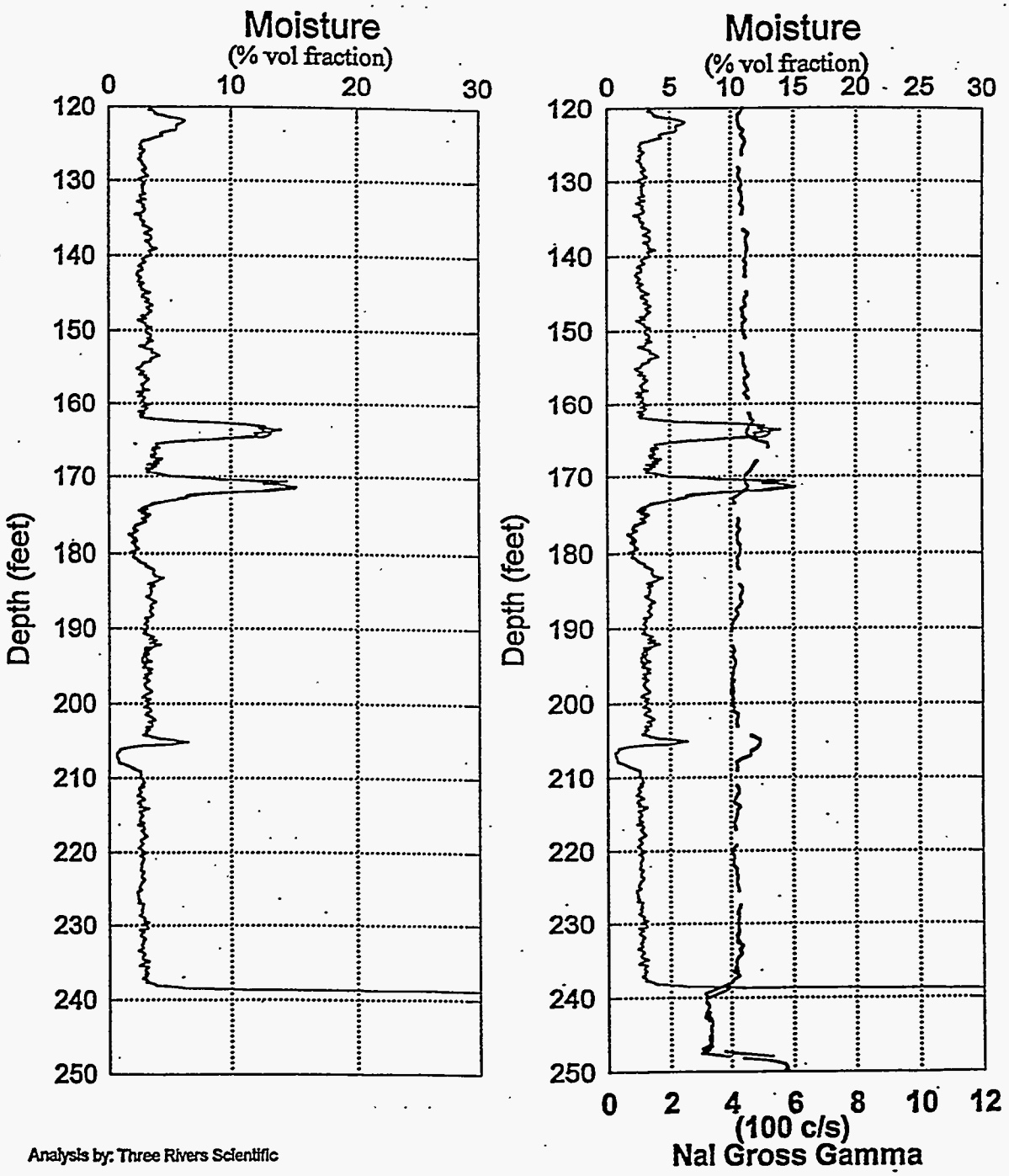
RLS Moisture Processed Log Data

Waste Management Federal Services NW

Project: RCRA Drilling

Borehole: 299-E33-44

Log Date Sep 23, 1998



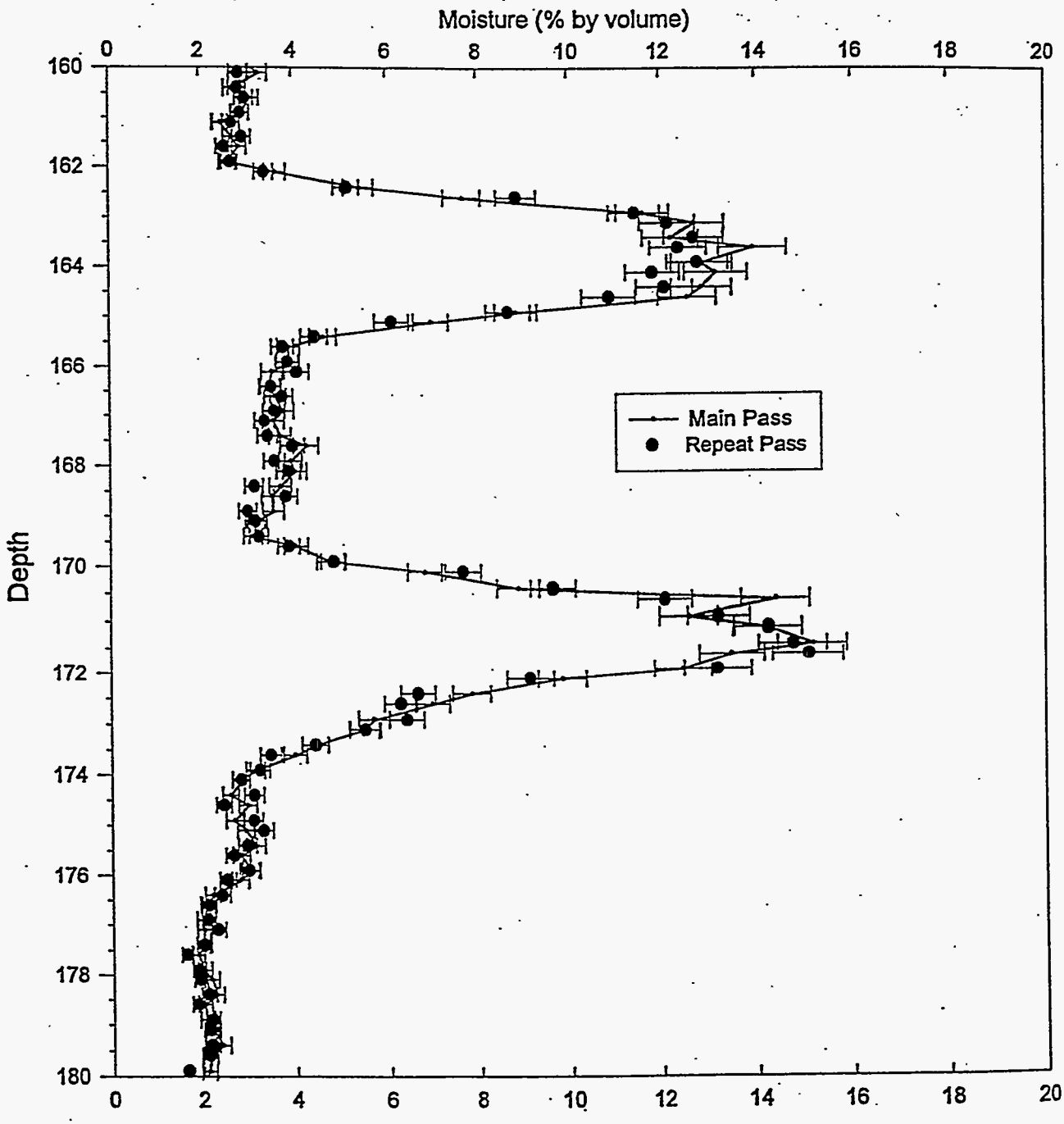
Analysis by: Three Rivers Scientific

RLS Moisture Borehole Survey

Acceptance QA Processing

Project: RCRA Drilling
Borehole: 299-E33-44

Log Date: Sep 23, 1998
Compare Main Log and Repeat



Analysis by: Three Rivers Scientific

RLS Moisture Borehole Survey

Waste Management Federal Services NW

Log Analysis Summary Report

Project:	RCRA Drilling	Well ID:	299-E33-44
Log Type:	Moisture	Log Dates:	Sep 23, 1998

General Notes:

At these low moisture values for the earth surround the borehole, other parameters such as void space and formation density affect the instrument readings more than moisture, since so little moisture is present. There are two elevated moisture zones at 164 and 172 feet. Also, the very low reading zone at 207 feet is most likely the presence of a void space behind the casing.

There does appear a small correlation between gross gamma ray (i.e. lithology) and the moisture.

System Performance Verification: The pre- and post-log verification was performed using instrument carrier. The pre-log reading is 4% lower than the post-log reading, well within tolerance.

Repeat Interval: The repeat interval, 160 to 180 feet, agrees with the main log within acceptable limits (refer to the Acceptance QA Processing plot).

Environmental Corrections: The casing thickness, correction has been applied. A density correction was not applied.

The borehole diameter is a nominal 9 inch value and there is no calibration for this diameter. However, at these low moisture values, an extrapolation would not yield any significant change.

Analysis by: Three Rivers Scientific

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