DOE-GRAND JUNCTION LOGGING MODEL DATA SYNOPSIS

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INTRODUCTION

This report is a summary of existing information concerning the 20 logging models available at the U.S. Department of Energy (DoE) Grand Junction facility at the end of 1976. The relative location of these models is shown in Figure 1. Model N-3 is a calibration standard and Models N-3, U-1, U-2, and U-3 are used as standards for determining dead-time corrections for gross gamma-ray logging equipment. Three KUT (potassium, uranium, and thorium) models are used as standards for calibration of gamma-ray spectral logging equipment. The water factor model is used in conjunction with gross gamma-ray logging equipment to determine correction factors for borehole fluid (water), borehole size, and borehole casing. The remainder of the models are used either for research purposes or are infrequently used.

THE MODELS

Table 1 lists, in summary form, the available physical/chemical data relating to the on-site models. Figure 1 and Table 1 show the dates of construction of the various models. The physical/chemical construction data for the gross gamma-ray models are further detailed in Tables 1 through 5 and Tables 7 through 23. The KUT data are found in Tables 5 and 6 and Tables 24 through 26 (Knapp and Bush, 1975). Schematic drawings of the models are presented in Figures 2 through 21. Statements of need and work, construction details, and assays for the various models are presented in another report (Mathews, 1975). A review of all DoE calibration facilities is also available (Evans, 1978).

Methods used for calibrating industry logging units have been published (Eschliman, 1969; Duray, 1976). Following calibration, industry gamma-ray logging units are used to estimate the radiometric grades

(percent eU_3O_8) detected during exploration logging in the field.

MODEL GRADE ASSIGNMENT

The DoE-Grand Junction Geochemical Analysis Department Laboratory (operated by BFEC) has assigned grades (chemical and radiometric) to the models from samples obtained during construction of these models. The different grades (gross gamma-ray, chemical, and gamma-ray spectrometer) are individually averaged and listed in Tables 1 through 26. A detailed list of the samples and assays of these samples from each model has been published (Dodd and Drouillard, 1964).

A detailed review of the radiometric grades of the primary counting standards used in determining the radiometric grades (gross gamma-ray, percent eU_3O_8) of the various models was carried out (Higgins, et al., 1972); as a conclusion of this review, the radiometric grades of the primary counting standards were changed and all available samples from previously constructed models were reanalyzed. The reanalyses included samples from models N-3, U-1, U-2, and U-3. As a result of these analyses, the radiometric grades (percent eU_3O_8) assigned to the N-3, U-1, U-2, and U-3 models were revised. These updated values are tabulated in this report.

An alternate method of grade determination of the models was devised by Eschliman and Key (Eschliman and Key, 1972; Eschliman and Key, 1972a). This method involved a multiple model calibration technique utilizing a least-squares regression analysis to fit a curve of the form $y = ax^b$ to the count rate data that were corrected for the presence of free water in the model matrix. In this equation, the laboratory radiometric grade is represented by y; the area under the gamma-ray log response curve (A) divided by the zone thickness (T), is represented by x ($x = A/T$). The logarithm of a is the intercept, and b is the slope of the curve. This approach

corrects for variations among models of the average atomic number (Z), and for other effects which disturb the direct proportionality between y and x . When the coefficients a and b had been determined, a mean radiometric grade for each model (N-3, U-1, U-2, U-3) was assigned. The grade assignments, computed in this way, are tabulated in this report and listed in Tables 1 through 6 under the heading Gamma Log Analysis.

OTHER MODEL PARAMETERS

The physical parameters (dimensions, density, water content, ore type, porosity, etc.) of each model are listed in Table 1. The density of each model was determined by the Geochemical Analysis Department from samples obtained during construction of these models. This density is an approximation for each model, because it is determined on a dry-weight basis and does not take into account the free water in the matrix of the model.

The water content of each model was determined by the Geochemical Analysis Department from samples obtained during construction of these models. This water content is determined by a loss on drying (LOD) technique in which the sample is ground to 100 mesh and dried at 110°C for 24 hours. Also, another method for determining the water content of a model was used because the LOD technique does not account for the bound water in the matrix of the model. The on-site contractor logged the models (N-3, U-1, U-2, U-3) with a ^{252}Cf -based neutron-neutron probe (Eschliman and Key, 1972). This probe, when calibrated, provides a measure of the amount of in-situ hydrogen in a specific volume. The water content in the models was determined using this method for each model. These results are listed in Tables 1 through 6 under the heading % Water Content In-Situ Analysis.

Corrections for the influence of borehole size and borehole fluid type on the gross gamma-ray log response are obtained in a water factor model

(Knapp and Bush, 1975a). A drawing of this model is shown in Figure 11.

CONCLUSION

This synopsis provides the available data concerning the logging models at the DoE-Grand Junction facility, to date (1976). Because gamma-ray logs are used in uranium exploration to estimate the grade (percent eU_3O_8) and the thickness of uranium ore zones in exploration drill holes, logging models are required to calibrate the gamma-ray logging equipment in order to obtain accuracy, uniformity, standardization, and repeatability during logging. This quality control is essential for accurate ore reserve calculations and for estimates of ore potential. The logging models at the DoE-Grand Junction facility have been, and are available for use by private industry in calibrating their gamma-ray logging equipment.

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Figure 1. Test Model Location

TABLE 1. Physical/Chemical Properties of the C, R, P-D and P-W Models

	C Model 1968			R Model 1965			P-D Model 1960			P-W Model 1960		
	UB	OZ	LB	UB	OZ	LB	UB	OZ	LB	UB	OZ	LB
Gamma Only Analysis by Dry Weight % eU_3O_8		0.200			0.496			0.50			0.362 wet 0.489 dry	
Chemical Analysis by Dry Weight % U_3O_8		0.282			6.536			0.05			0.044	
Gamma Logging Analysis Δ % eU_3O_8												
Gamma Spec Analysis by Dry Weight												
Thickness in Feet	4.49	6.39	7.07	1.95	1.97	1.56	3.03	1.93	1.0	2.93	2.04	1.0
GT Product Gross Gamma Grade Times Thickness		1.789			0.977			0.965			0.738 wet 0.998 dry	
%Water Content (LOD at 110°C) Lab Analysis	5.06	6.58	3.59					0.686*			26.19*	
%Water Content In-Situ Analysis												
Density g/cc (dry) Lab Analysis	1.940	1.876	1.956		1.673			1.310			1.787	
Density g/cc In-Situ Analysis												
Borehole Size (inches) and Casing Type	4.5 in. uncased			4.5 in. uncased			4.5 in. uncased	4.4 in. cased (20 gal stainless)	4.5 in. uncased	4.5 in. uncased	4.4 in. cased (20 gal. stainless)	4.5 in. uncased
Magnetic Susceptibility (10^{-6} cgs)												
Ore Type & Amount and Grade % eU_3O_8	None	17000 lb of 0.287% S; 240 lb of 4.64% MV	None	None	286 lb 84.03% Climax Conc.	None	None	Climax Mill Tailings	None	None	Climax Mill Tailings	None
Sand Type & Amount		None		3 parts sand	2038 lb	3 parts sand		None			None	
Cement Amount		5690 lb		1 part cement	764 lb	1 part cement		None			None	
Water Amount												
Porosity												
Cracks or Fractures												
Diameter in Feet	7.0	7.0	7.0	4.0	4.0	4.0	5.0 sq	5.0	5.0 sq	5.0 sq	5.0	5.0 sq
Petrographic Analysis (Z eq.)												

LB - Lower barren zone
UB - Upper barren zone
OZ - Ore Zone
LOD - Loss on drying

Δ - Best grade estimate from free water normalization and regression analysis. See text for more detail.
GT - Grade times thickness

S - Schwartzwalder Ore
MV - Monument Valley Ore
* - Original water content
sq - square

TABLE 2. Physical/Chemical Properties of the N-1, N-2, N-3 and N-4 Models.

	N-1 Model 1958			N-2 Model 1958			N-3 Model 1958			N-4 Model 1958				
	UB	OZ	LB	UB	OZ	LB	UB	OZ	LB	UB	OZ _U (Z ₂)	MB	OZ _L (Z ₁)	LB
Gamma Only Analysis by Dry Weight % eU ₃ O ₈		0.2480			0.4296			0.240			0.9183		0.2459	
Chemical Analysis by Dry Weight % U ₃ O ₈		0.1936			0.3794			0.1855			0.8875		0.1920	
Gamma Logging Analysis Δ % eU ₃ O ₈								0.241 ±0.0008						
Gamma Spec Analysis by Dry Weight														
Thickness in Feet	4.0	1.17	4.0	4.0	1.04	4.0	4.0	4.15	4.0	4.0	1.0	4.0	2.31	4.0
GT Product Gross Gamma Grade Times Thickness		0.290			0.447			0.988			0.918		0.569	
%Water Content (LOD at 110°C) Lab Analysis								12.01						
%Water Content In-Situ Analysis								12.32						
Density g/cc (dry) Lab Analysis								1.83 dry 2.09 wet						
Density g/cc In-Situ Analysis														
Borehole Size (inches) and Casing Type	4.5 in. uncased			4.5 in. uncased			4.5 in. uncased			4.5 in. uncased				
Magnetic Susceptibility (10 ⁻⁶ cgs)														
Ore Type & Amount and Grade % eU ₃ O ₈	None	Little Man Mine	None	None	Little Man Mine	None	None	Little Man Mine	None	None	Little Man Mine	None	Little Man Mine	None
Sand Type & Amount														
Cement Amount														
Water Amount														
Porosity														
Cracks or Fractures														
Diameter in Feet	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Petrographic Analysis (Z eq.)														

LB - Lower barren zone
 UB - Upper barren zone
 OZ - Ore Zone
 LOD - Loss on drying
 GT - Grade times thickness

Δ - Best grade estimate from free water normalization and regression analysis. See text for more detail.
 S - Schwartzwalder Ore
 MV - Monument Valley Ore

* - Original water content
 sq - square
 OZ_U(Z₂) - Upper ore zone
 OZ_L(Z₁) - Lower ore zone
 MB - Middle barren zone

TABLE 3. Physical/Chemical Properties of the N-5 and the Gross Gamma-Ray Water Factor Models.

	N-5 Model								1958						Gross Gamma-Ray Water Factor 1973					
	UB	OZ _U (Z ₆)	OZ _{U2} (Z ₅)	MB(Z ₄)	OZ _{L1} (Z ₃)	OZ _{LM} (Z ₂)	OZ _{L2} (Z ₁)	LB	UB			OZ			LB					
Gamma Only Analysis by Dry Weight % eU ₃ O ₈		1.7145	0.2192		0.9464	0.1030	0.2500					0.320								
Chemical Analysis by Dry Weight % U ₃ O ₈		1.6308	0.1714		0.9095	0.0840	0.1960					0.321								
Gamma Logging Analysis Δ % eU ₃ O ₈																				
Gamma Spec Analysis by Dry Weight									K %	U ppm	Th ppm		K %	U ppm	Th ppm					
									1.79	3.1	8.5		1.73	2.8	6.8					
Thickness in Feet	4.0	0.47	0.57	0.54	1.10	0.74	0.50	4.0	4.0			4.0			4.0					
GT Product Gross Gamma Grade Times Thickness		0.806	0.125		1.041	0.0762	0.125					1.280								
% Water Content (LOD at 110°C) Lab Analysis									1.12			6.77			0.96					
%Water Content In-Situ Analysis																				
Density g/cc (dry) Lab Analysis									2.145			1.534			2.129					
Density g/cc In-Situ Analysis																				
Borehole Size (Inches) and Casing Type	4.5 in. uncased								4.5 in. uncased											
Magnetic Susceptibility (10 ⁻⁶ cgs)																				
Ore Type & Amount and Grade % eU ₃ O ₈	None	Little Man Mine	Little Man Mine	None	Little Man Mine	Little Man Mine	Little Man Mine	None	None			See below *			None					
Sand Type & Amount												10503 lb								
Cement Amount												6876 lb								
Water Amount																				
Porosity																				
Cracks or Fractures																				
Diameter in Feet	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5 x 12 rectangle			4.5 x 12 rectangle			4.5 x 12 rectangle					
Petrographic Analysis (Z eq.)																				

LB - Lower barren zone
 UB - Upper barren zone
 OZ - Ore Zone
 LOD - Loss on drying
 GT - Grade times thickness
 OZ_{LM} - lower middle ore zone

Δ - Best grade estimate from free water normalization and regression analysis. See text for more detail.
 OZ_{L1} - top lower ore zone
 OZ_{L2} - bottom lower ore zone
 OZ_{U1} - top upper ore zone
 OZ_{U2} - bottom upper ore zone

* Water Factor Model only:

Climax Ore	4632 lb.	0.301 %eU ₃ O ₈
Residue U-2	1885 lb.	1.107 %eU ₃ O ₈
Residue U-3	2260 lb.	0.418 %eU ₃ O ₈
Schwartzwalder	1553 lb.	3.008 %eU ₃ O ₈

TABLE 4. Physical/Chemical Properties of the U-1, U-2, U-3, S and T-1 Models

	U-1 Model 1969			U-2 Model 1969			U-3 Model 1969			S Model 1965	T-1 Model 1965		
	UB	OZ	LB	UB	OZ	LB	UB	OZ	LB		UB	OZ	LB
Gamma Only Analysis by Dry Weight % eU_3O_8		2 422			1 229			0 473				0 940%ThO ₂ 0 398% eU_3O_8	
Chemical Analysis by Dry Weight % U_3O_8		2 415			1 233			0 481				0 979%ThO ₂ 0 018% U_3O_8	
Gamma Logging Analysis Δ % eU_3O_8		2 482 +0 0071			1 201 +0 0038			0 459 +0 0015					
Gamma Spec Analysis by Dry Weight										K % 1 34	U ppm 1 9	Th ppm 6 2	
Thickness in Feet	3 0	4 18	2 99	3 12	4 06	3 08	3 16	4 03	3 08	3 0	1 93	3 11	1 97
GT Product Gross Gamma Grade Times Thickness		10 208			5 091			1 890					
% Water Content (LOD at 110°C) Lab Analysis		4 45			9 21			7 93				2 58	
%Water Content In-Situ Analysis		10 13			14 34								
Density g/cc (dry) Lab Analysis		2 074			1 699			1 667				2 212	
Density g/cc In-Situ Analysis													
Borehole Size (inches) and Casing Type	4 5 in uncased			4 5 in uncased			4 5 in uncased			4 5 in uncased	4 5 in uncased		
Magnetic Susceptibility (10 ⁻⁶ cgs)													
Ore Type & Amount and Grade % eU_3O_8	None	430.8 lb of 11.1% S	None	None	See * Below	None	None	See ** Below	None	None	None		None
Sand Type & Amount		4861.7 lb of 2.62% S								3 1 concrete grout mix			
Cement Amount		1755 lb			1755 lb								
Water Amount													
Porosity													
Cracks or Fractures													
Diameter in Feet	4 0	4 0	4 0	4 0	4 0	4 0	4 0	4 0	4 0	4 x 12 rectangle	4 0	4 0	4 0
Petrographic Analysis (Z eq)													

LB - Lower barren zone
 UB - Upper barren zone
 OZ - Ore Zone
 LOD - Loss on drying
 GT - Grade times thickness
 Δ - Best grade estimate from free water normalization and regression analysis
 See text for more detail
 S - Schwartzwalder Ore

*U-2 Model only

Residue U-1 716 lb 2 442 % eU_3O_8
 Schwartzwalder 1980 lb 2 62 % eU_3O_8
 Residue Texas high grade pit 1413 lb 2 205 % eU_3O_8
 Residue C model 1484 lb 0 280 % eU_3O_8

**U-3 Model only

Residue Texas low grade pit 1925 lb 0 257 % eU_3O_8
 Schwartzwalder Ore 1653 lb 2 62 % eU_3O_8
 Schwartzwalder Ore 689 lb 0 287 % eU_3O_8
 Residue C model 1821 lb 0 280 % eU_3O_8

TABLE 5. Physical/Chemical Properties of the T-2, T-3, and U Models

	T-2 Model 1965			T-3 Model 1965			U Model 1974								
	UB	OZ	LB	UB	OZ	LB	UB			OZ			LB		
Gamma Only Analysis by Dry Weight % eU ₃ O ₈		0.499%eThO ₂ 0.221%eU ₃ O ₈			0.105%eThO ₂ 0.047%eU ₃ O ₈					0.0655					
Chemical Analysis by Dry Weight % U ₃ O ₈		0.506%ThO ₂ 0.011%U ₃ O ₈			0.093%ThO ₂ 0.010%U ₃ O ₈		K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm
							2.03	3	5	1.27	0.0634	8.0	1.97	4.5	12
Gamma Logging Analysis Δ % eU ₃ O ₈															
Gamma Spec Analysis by Dry Weight							K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm
							1.9	3	8.3	0.95	522	18.7	1.99	3.5	8.9
Thickness in Feet	1.93	3.17	1.95	2.01	2.99	1.97	2.97			5.0			3.03		
GT Product Gross Gamma Grade Times Thickness										0.328					
%Water Content (LOD at 110°C) Lab Analysis		2.59			4.75		2.62			5.58			2.09		
%Water Content In-Situ Analysis															
Density g/cc (dry) Lab Analysis		2.099			2.014		2.22			2.56			2.25		
Density g/cc In-Situ Analysis															
Borehole Size (inches) and Casing Type	4.5 in. uncased			4.5 in. uncased			4.5 in. uncased								
Magnetic Susceptibility (10 ⁻⁶ cgs)							982			356			1084		
Ore Type & Amount and Grade % eU ₃ O ₈	None		None	None		None	None			1723 lb. of 0.33% Climax Ore			None		
Sand Type & Amount										4850 lb.					
Cement Amount										2193 lb.					
Water Amount															
Porosity															
Cracks or Fractures															
Diameter in Feet	4.0	4.0	4.0	4.0	4.0	4.0	4.0			4.0			4.0		
Petrographic Analysis (Z eq.)															

LB - Lower barren zone
UB - Upper barren zone
OZ - Ore Zone
LOD - Loss on drying

Δ - Best grade estimate from free water normalization and regression analysis. See text for more detail.
GT - Grade times thickness

TABLE 6. Physical/Chemical Properties of the T and K Models

	T Model 1974									K Model 1974								
	UB			OZ			LB			UB			OZ			LB		
Gamma Only Analysis by Dry Weight % eU ₃ O ₈																		
Chemical Analysis by Dry Weight % U ₃ O ₈	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm
	1.95	2.5	10.5	1.32	24	502	%	ppm	ppm	1.77	4	11	6.28	10	4	1.74	3	7.5
Gamma Logging Analysis Δ % eU ₃ O ₈																		
Gamma Spec Analysis by Dry Weight	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm	K %	U ppm	Th ppm
	1.84	3	8.4	1.36	26.1	508	%	ppm	ppm	1.90	2.9	8.1	6.30	2.9	2.5	1.77	2.9	7.5
Thickness in Feet	2.97			4.94			3.08			2.97			5.03			2.91		
GT Product Gross Gamma Grade Times Thickness																		
%Water Content (LOD at 110°C) Lab Analysis	2.40			5.77						1.98			2.88			1.78		
%Water Content In-Situ Analysis																		
Density g/cc (dry) Lab Analysis	2.20			1.88						2.23			1.86			2.24		
Density g/cc In-Situ Analysis																		
Borehole Size (inches) and Casing Type	4.5 in. uncased									4.5 in. uncased								
Magnetic Susceptibility (10 ⁻⁶ cgs)	1053			484						931			65			860		
Ore Type & Amount and Grade % eU ₃ O ₈	None			106.33 lb. of monazite sand			None			None			4379.7 lb feldspar (Canon City) 1855.3 lb feldspar (Grand Junction)			None		
Sand Type & Amount				6475 lb									None					
Cement Amount				2193 lb									2080 lb					
Water Amount																		
Porosity																		
Cracks or Fractures																		
Diameter in Feet	4.0			4.0			4.0			4.0			4.0			4.0		
Petrographic Analysis (Z eq.)																		

LB - Lower barren zone
 UB - Upper barren zone
 OZ - Ore zone
 LOD - Loss on drying

Δ - Best grade estimate from free water normalization and regression analysis. See text for more detail.
 GT - Grade times thickness

Figure 2. C Model

Table 7
Construction/Analysis Characteristics
of the C Model

ORE ZONES	ore type & amount	17000 lbs. 0.287% eU ₃ O ₈ Schwartzwalder 240 lbs. 4.640% eU ₃ O ₈ Monument Valley			
	cement amount	5690 lbs.			
	water amount	unknown			
	sand type & amount	none			
BARREN ZONE	sand type & amount	unknown			
	cement amount	unknown			
	water amount	unknown			
ASSAY ANALYSIS ORE ZONE	chemical	0.282% U ₃ O ₈			
	gamma only	0.280% eU ₃ O ₈			
	gamma spec	unknown			
	gamma logging	unknown			
ASSAY ANALYSIS BARREN ZONES	chemical	unknown			
	gamma only	unknown			
	gamma spec	unknown			
	gamma logging	unknown			
DENSITY	chemical analysis	upper barren 1.940 g/cc	ore zone 1.876 g/cc	lower barren 1.956 g/cc	
	in-situ	unknown			
WATER OR H ⁺	chemical analysis	average loss on drying at 110°C	upper bar. 5.06%	ore zone 6.58%	lower bar. 3.59%
	in-situ	unknown			
ZEQ (PETROGRAPHIC ANALYSIS)		unknown			
POROSITY		unknown			
CRACKS OR FRACTURES		unknown			
MAGNETIC SUSCEPTIBILITY		unknown

NOTE: Model cast in 4' corrugated pipe.

Figure 3. R Model

Table 8
Construction/Analysis Characteristics
of the R Model

ORE ZONES	ore type & amount	268 lbs. concentrate from Climax lot #111 (84.03% U_3O_8)
	cement amount	764 lbs.
	water amount	unknown
	sand type & amount	2038 lbs. (unknown)
BARREN ZONE	sand type & amount	3 parts sand (unknown)
	cement amount	1 part cement
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	6.536% U_3O_8
	gamma only	0.496% eU_3O_8
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	1.673 g/cc
	in-situ	unknown
WATER OR H^+	chemical analysis	unknown
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)		unknown
POROSITY		unknown
CRACKS OR FRACTURES		unknown
MAGNETIC SUSCEPTIBILITY		unknown

Ore zone is sealed gas tight in a circular galvanized steel tank. Bore hole is sealed with 20 ga. stainless steel pipe.

Figure 4. P-D Model

Table 9
Construction/Analysis Characteristics
of the P-D Model

ORE ZONES	ore type & amount	Climax maroon colored "slime" mill tailings unknown weight
	cement amount	none
	water amount	---
	sand type & amount	none
BARREN ZONE	sand type & amount	unknown
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.05% U_3O_8
	gamma only	0.50% eU_3O_8
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	1.310 g/cc
	in-situ	unknown
WATER OR H^+	chemical analysis	0.6860% Loss on drying at 110°C by weight
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)	unknown	
POROSITY	unknown	
CRACKS OR FRACTURES	unknown	
MAGNETIC SUSCEPTIBILITY	unknown

Figure 5. P-W Model

Table 10
Construction/Analysis Characteristics
of the P-W Models

ORE ZONES	ore type & amount	Climax maroon colored "slime" mill tailings unknown weight
	cement amount	none
	water amount	---
	sand type & amount	none
BARREN ZONE	sand type & amount	unknown
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.044% U_3O_8
	gamma only	0.362% eU_3O_8 w/ H_2O ---0.489% eU_3O_8 dry
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	1.787 g/cc
	in-situ	unknown
WATER OR H^+	chemical analysis	26.19% Loss on drying at 110°C by weight
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)	unknown	
POROSITY	unknown	
CRACKS OR FRACTURES	unknown	
MAGNETIC SUSCEPTIBILITY	unknown

Figure 6. N-1 Model

Table 11
Construction/Analysis Characteristics
of the N-1 Model

ORE ZONES	ore type* & amount	unknown weight (3:1) ratio of aggregate to cement
	cement amount	unknown
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown (3:1) ratio of aggregate to cement
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.1936 % U_3O_8
	gamma only	0.2480 % eU_3O_8
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	unknown
	in-situ	unknown
WATER OR H^+	chemical analysis	unknown
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)	unknown	
POROSITY	unknown	
CRACKS OR FRACTURES	unknown	
MAGNETIC SUSCEPTIBILITY	unknown	

*The ore came from the Little Man Mine,
SE $\frac{1}{4}$ S 14 T 27 N R 84 W, Carbon County, Wyoming;
a vein type ore (pitchblende) in Precambrian rock.

Figure 7. N-2 Model

Table 12
Construction/Analysis Characteristics
of the N-2 Model

ORE ZONES	ore type* & amount	unknown (3:1) ratio aggregate to cement
	cement amount	unknown
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown (3:1) ratio aggregate to cement
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.3794% U_3O_8
	gamma only	0.4296% eU_3O_8
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	unknown
	in-situ	unknown
WATER OR H^+	chemical analysis	unknown
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)	unknown	
POROSITY	unknown	
CRACKS OR FRACTURES	unknown	
MAGNETIC SUSCEPTIBILITY	unknown	

*The ore came from the Little Man Mine,
SE $\frac{1}{4}$ S 14 T 27 N R 84 W, Carbon County, Wyoming;
a vein type ore (pitchblende) in Precambrian rock.

Figure 8. N-3 Model

Table 13
Construction/Analysis Characteristics
of the N-3 Model

ORE ZONES	ore type & amount [*]	unknown weight (3:1) ratio of aggregate to cement
	cement amount	unknown
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown (3:1) ratio of aggregate to cement
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.1855% U_3O_8
	gamma only	0.240% eU_3O_8
	gamma spec	unknown
	gamma logging	$0.241 \pm 0.0008\%$ eU_3O_8
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	1.83 g/cc (dry); 2.09 g/cc (wet)
	in-situ	unknown
WATER OR H^+	chemical analysis	12.01% Loss on drying at 110°C by weight
	in-situ	12.32% by weight (neutron-neutron probe 601)
ZEQ (PETROGRAPHIC ANALYSIS)	unknown	
POROSITY	unknown	
CRACKS OR FRACTURES	unknown	
MAGNETIC SUSCEPTIBILITY	unknown	

*The ore came from the Little Man Mine,
SE $\frac{1}{4}$ S 14 T 27 N R 84 W, Carbon County, Wyoming;
a vein type ore (pitchblende) in Precambrian rock.

Figure 9. N - 4 Model

Table 14
Construction/Analysis Characteristics
of the N-4 Model

ORE ZONES	ore type*& amount	unknown weight (3:1) ratio of aggregate to cement	
	cement amount	unknown	
	water amount	unknown	
	sand type & amount	unknown	
BARREN ZONE	sand type & amount	unknown (3:1) ratio of aggregate to cement	
	cement amount	unknown	
	water amount	unknown	
ASSAY ANALYSIS ORE ZONE	chemical	lower zone (Z ₁) 0.1920% U ₃ O ₈	upper zone (Z ₂) 0.8875% U ₃ O ₈
	gamma only	0.2459% eU ₃ O ₈	0.9183% eU ₃ O ₈
	gamma spec	unknown	unknown
	gamma logging	unknown	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown	
	gamma only	unknown	
	gamma spec	unknown	
	gamma logging	unknown	
DENSITY	chemical analysis	unknown	
	in-situ	unknown	
WATER OR H ⁺	chemical analysis	unknown	
	in-situ	unknown	
ZEQ (PETROGRAPHIC ANALYSIS)		unknown	
POROSITY		unknown	
CRACKS OR FRACTURES		unknown	
MAGNETIC SUSCEPTIBILITY		unknown	

*The ore came from the Little Man Mine
SE $\frac{1}{4}$ S 14 T 27 N R 84 W, Carbon County, Wyoming;
a vein type ore (pitchblende) in Precambrian rock.

Figure 10. N-5 Model

Table 15
Construction/Analysis Characteristics
of the N-5 Model

ORE ZONES	ore type & amount *	unknown weight (3:1) ratio of aggregate to cement					
	cement amount	unknown					
	water amount	unknown					
	sand type & amount	unknown					
BARREN ZONE	sand type & amount	unknown (3:1) ratio of aggregate to cement					
	cement amount	unknown					
	water amount	unknown					
ASSAY ANALYSIS ORE ZONE	chemical %U ₃ O ₈	Z ₁ 0.1960	Z ₂ 0.0840	Z ₃ 0.9096	Z ₄ BARREN unknown	Z ₅ 0.1714	Z ₆ 1.6308
	gamma only %eU ₃ O ₈	0.2500	0.1030	0.9464	unknown	0.2192	1.7145
	gamma spec	unknown	unknown	unknown	unknown	unknown	unknown
	gamma logging	unknown	unknown	unknown	unknown	unknown	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown					
	gamma only	unknown					
	gamma spec	unknown					
	gamma logging	unknown					
DENSITY	chemical analysis	unknown					
	in-situ	unknown					
WATER OR H ⁺	chemical analysis	unknown					
	in-situ	unknown					
ZEQ (PETROGRAPHIC ANALYSIS)		unknown					
POROSITY		unknown					
CRACKS OR FRACTURES		unknown					
MAGNETIC SUSCEPTIBILITY		unknown					

* The ore came from the Little Man Mine,
SE ¼ S 14 T 27 N R 84 W, Carbon County, Wyoming;
a vein type ore (pitchblende) in Precambrian rock.

Figure II. Water Factor Model

Table 16
Construction/Analysis Characteristics
of the Gross Gamma-Ray Water Factor Model

ORE ZONES	ore type & amount	See below		
	cement amount	6876 lbs.		
	water amount	unknown		
	sand type & amount	unknown 10503 lbs.		
BARREN ZONE	sand type & amount	unknown		
	cement amount	unknown		
	water amount	unknown		
ASSAY ANALYSIS ORE ZONE	chemical	0.321% U_3O_8		
	gamma only	0.320% eU_3O_8		
	gamma spec	unknown		
	gamma logging	unknown		
ASSAY ANALYSIS BARREN ZONES	chemical	Upper Barren unknown	Lower Barren unknown	
	gamma only	unknown	unknown	
	gamma spec	eTh 8.5ppm; eU 3.1ppm; eK 1.79%	eTh 6.8ppm; eU 2.8ppm; eK 1.73%	
	gamma logging	unknown	unknown	
DENSITY	chemical analysis	Upper Barren 2.145 g/cc	Ore Zone 1.534 g/cc	Lower Barren 2.129 g/cc
	in-situ	unknown		
WATER OR H^+	chemical analysis	Upper Barren 1.12% Loss on drying	Ore Zone 6.77% Lqss on drying	Lower Barren 0.96% Loss on drying
	in-situ	unknown		
ZEQ (PETROGRAPHIC ANALYSIS)		unknown		
POROSITY		unknown		
CRACKS OR FRACTURES		unknown		
MAGNETIC SUSCEPTIBILITY		unknown		

Ore Used	Weight (lbs.)	% U_3O_8	% eU_3O_8
Climax Ore	4,632	0.134	0.301
Residue Model U-2	1,885	1.172	1.107
Residue Model U-3	2,260	0.426	0.418
Schwartzwalder Ore	1,553	2.924	3.008

NOTE: Model cast in 4' corrugated pipe.

Figure 12. U-1 Test Model

Table 17
Construction/Analysis Characteristics
of the U-1 Model

ORE ZONES	ore type & amount	430.8 lbs. of 11.19% eU_3O_8 Schwartzwalder Ore 4861.7 lbs. of 2.62% eU_3O_8 Schwartzwalder Ore
	cement amount	1755 lbs.
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	2.415 % U_3O_8
	gamma only	2.422 % eU_3O_8
	gamma spec	unknown
	gamma logging	$2.482 \pm 0.0071\%$ eU_3O_8
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	2.074 g/cc
	in-situ	unknown
WATER OR H^+	chemical analysis	4.4% Loss on drying at 110°C
	in-situ	10.13% (neutron-neutron probe)
ZEQ (PETROGRAPHIC ANALYSIS)		unknown
POROSITY		unknown
CRACKS OR FRACTURES		unknown
MAGNETIC SUSCEPTIBILITY		unknown

Figure I3. U-2 Test Model

Table 18
Construction/Analysis Characteristics
of the U-2 Model

ORE ZONES	ore type & amount	See below
	cement amount	1755 lbs.
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	1.233% U_3O_8
	gamma only	1.229% eU_3O_8
	gamma spec	unknown
	gamma logging	$1.201 \pm 0.0038\%$ eU_3O_8
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	1.699 g/cc
	in-situ	unknown
WATER OR H^+	chemical analysis	9.21% Loss on drying at 110°C
	in-situ	14.34% (neutron-neutron probe)
ZEQ (PETROGRAPHIC ANALYSIS)		unknown
POROSITY		unknown
CRACKS OR FRACTURES		unknown
MAGNETIC SUSCEPTIBILITY		unknown

716 lbs. of ground ore zone from the U-1 model
 1980 lbs. of 2.62% eU_3O_8 Schwartzwalder Ore
 1413 lbs. of ground ore zone from the high grade Texas model
 1480 lbs. of ground ore zone from the C model

NOTE. Model cast in 4' corrugated pipe

Figure 14. U-3 Test Model

Table 19
Construction/Analysis Characteristics
of the U-3 Model

ORE ZONES	ore type & amount	See below
	cement amount	1755 lbs.
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.481% U_3O_8
	gamma only	0.473% eU_3O_8
	gamma spec	unknown
	gamma logging	$0.459 \pm 0.0015\%$ eU_3O_8
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	1.667 g/cc
	in-situ	unknown
WATER OR H^+	chemical analysis	7.93% Loss on drying at 110°C
	in-situ	14.86% (neutron-neutron probe)
ZEQ (PETROGRAPHIC ANALYSIS)		unknown
POROSITY		unknown
CRACKS OR FRACTURES		unknown
MAGNETIC SUSCEPTIBILITY		unknown

1925 lbs. of ground ore zone from the low grade Texas model.
1653 lbs. of 2.62% eU_3O_8 Schwartzwalder Ore
689 lbs. of 0.287% eU_3O_8 Schwartzwalder Ore
1821 lbs. of ground ore zone from the C Model

Figure 15. S Model for Hole Size Calibration

Table 20
Construction/Analysis Characteristics
of the S Model

ORE ZONES	ore type & amount	None		
	cement amount	None		
	water amount	None		
	sand type & amount	None		
BARREN ZONE	sand type & amount	Unknown (3:1) concrete grout mix & course concrete aggregate		
	cement amount	unknown		
	water amount	unknown		
ASSAY ANALYSIS ORE ZONE	chemical	None		
	gamma only	None		
	gamma spec	None		
	gamma logging	None		
ASSAY ANALYSIS BARREN ZONES	chemical	unknown		
	gamma only	unknown		
	gamma spec	1.34% K	1.9 ppm eU	6.2 ppm eTh
	gamma logging	unknown		
DENSITY	chemical analysis	unknown		
	in-situ	unknown		
WATER OR H ⁺	chemical analysis	unknown		
	in-situ	unknown		
ZEQ (PETROGRAPHIC ANALYSIS)		unknown		
POROSITY		unknown		
CRACKS OR FRACTURES		unknown		
MAGNETIC SUSCEPTIBILITY		unknown

Note: Model cast in 4' corrugated pipe

Figure 16. T-1 Model

Table 21
Construction/Analysis Characteristics
of the T-1 Model

ORE ZONES	ore type & amount	unknown grout mix concrete and thorium ore
	cement amount	unknown
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown coarse concrete
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.979% ThO ₂ ; 0.018% U ₃ O ₈
	gamma only	0.940% eThO ₂ ; 0.398% eU ₃ O ₈
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	2.212 g/cc
	in-situ	unknown
WATER OR H ⁺	chemical analysis	2.58% Loss on drying at 110°C
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)		unknown
POROSITY		unknown
CRACKS OR FRACTURES		unknown
MAGNETIC SUSCEPTIBILITY		unknown

Note: Model cast in 4' corrugated pipe

Figure 17. T-2 Model

Table 22
Construction/Analysis Characteristics
of the T-2 Model

ORE ZONES	ore type & amount	unknown grout mix concrete and thorium ore
	cement amount	unknown
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown coarse concrete
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.506% ThO ₂ ; 0.011% U ₃ O ₈
	gamma only	0.499% eThO ₂ ; 0.221% eU ₃ O ₈
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	2.099 g/cc
	in-situ	unknown
WATER OR H ⁺	chemical analysis	2.59% Loss on drying at 110°C
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)		unknown
POROSITY		unknown
CRACKS OR FRACTURES		unknown
MAGNETIC SUSCEPTIBILITY		unknown

Note: Model cast in 4' corrugated pipe

Figure 18. T-3 Model

Table 23
Construction/Analysis Characteristics
of the T-3 Model

ORE ZONES	ore type & amount	unknown grout mix concrete and thorium ore
	cement amount	unknown
	water amount	unknown
	sand type & amount	unknown
BARREN ZONE	sand type & amount	unknown coarse concrete
	cement amount	unknown
	water amount	unknown
ASSAY ANALYSIS ORE ZONE	chemical	0.093% ThO ₂ ; 0.010% U ₃ O ₈
	gamma only	0.105% eThO ₂ ; 0.047% eU ₃ O ₈
	gamma spec	unknown
	gamma logging	unknown
ASSAY ANALYSIS BARREN ZONES	chemical	unknown
	gamma only	unknown
	gamma spec	unknown
	gamma logging	unknown
DENSITY	chemical analysis	2.014 g/cc
	in-situ	unknown
WATER OR H ⁺	chemical analysis	4.75% Loss on drying at 110°C
	in-situ	unknown
ZEQ (PETROGRAPHIC ANALYSIS)		unknown
POROSITY		unknown
CRACKS OR FRACTURES		unknown
MAGNETIC SUSCEPTIBILITY		unknown

NOTE: Model cast in 4' corrugated pipe

Figure 19. U Model

Table 24
Construction/Analysis Characteristics
of the U Model

ORE ZONES	ore type & amount	1,723 lbs. Climax Ore (0.33% U ₃ O ₈)		
	cement amount	2,193 lbs.		
	water amount	unknown		
	sand type & amount	4,850 lbs. plaster sand		
BARREN ZONE	sand type & amount	unknown (high pour redi-mix concrete)		
	cement amount	unknown		
	water amount	unknown		
ASSAY ANALYSIS ORE ZONE	chemical	1.27% K; 0.0634% U ₃ O ₈ ; 8.0 ppm Th		
	gamma only	0.0655% eU ₃ O ₈		
	gamma spec	0.95% K; 522 ppm U or 0.061% eU ₃ O ₈ ; 18.7 ppm Th		
	gamma logging	unknown		
ASSAY ANALYSIS BARREN ZONES	chemical	Lower Barren 1.97%K; 4.5ppm U; 12ppm Th	Upper Barren 2.03%K; 3ppm U; 5ppm Th	
	gamma only	unknown	unknown	
	gamma spec	1.99%K; 3.5ppm U; 8.9ppm Th	1.9%K; 3ppm U; 8.3ppm Th	
	gamma logging	unknown	unknown	
DENSITY	chemical analysis	Upper Barren 2.22 g/cc	Ore Zone 2.56 g/cc	Lower Barren 2.25 g/cc
	in-situ	unknown		
WATER OR H ⁺	% L.O.D. at 110°C chemical analysis	Upper Barren 2.62%	Ore Zone 5.58%	Lower Barren 2.09%
	in-situ	unknown		
ZEQ (PETROGRAPHIC ANALYSIS)		unknown		
POROSITY		unknown		
CRACKS OR FRACTURES		unknown		
MAGNETIC SUSCEPTIBILITY (10 ⁻⁶ cgs)		Upper Barren 982	Ore Zone 356	Lower Barren 1084

NOTE Model cast in 4' corrugated pipe

Figure 20. T Model

Table 25
Construction/Analysis Characteristics
of the T - Model

ORE ZONES	ore type & amount	106.33 lbs. monazite sands		
	cement amount	2193 lbs.		
	water amount	unknown		
	sand type & amount	6475 lbs. plaster sand		
BARREN ZONE	sand type & amount	unknown (high pour redi-mix concrete)		
	cement amount	unknown		
	water amount	unknown		
ASSAY ANALYSIS ORE ZONE	chemical	1.32% K	24 ppm U	502 ppm Th
	gamma only	unknown		
	gamma spec	1.36% K	26.1 ppm U	508 ppm Th
	gamma logging	unknown		
ASSAY ANALYSIS BARREN ZONES	chemical	Upper Barren 1.95% K 2.5 ppm U 10.5 ppm Th		Lower Barren unknown
	gamma only	unknown		unknown
	gamma spec	1.84% K 3.0 ppm U 8.4 ppm Th		unknown
	gamma logging	unknown		unknown
DENSITY	chemical analysis	Upper Barren 2.20 g/cc	Ore Zone 1.88 g/cc	Lower Barren unknown
	in-situ	unknown		
WATER OR H ⁺	% LOD at 110°C chemical analysis	Upper Barren 2.40%	Ore Zone 5.77%	Lower Barren unknown
	in-situ	unknown		
ZEQ (PETROGRAPHIC ANALYSIS)		unknown		
POROSITY		unknown		
CRACKS OR FRACTURES		unknown		
MAGNETIC SUSCEPTIBILITY (10 ⁻⁶ cgs)		Upper Barren 1035	Ore Zone 484	Lower Barren unknown

NOTE: Model cast in 4' corrugated pipe

Figure 21. K Model

Table 26
Construction/Analysis Characteristics
of the K Model

ORE ZONES	ore type & amount	4379.7 lbs. feldspar (Canon City) 1855.3 lbs. feldspar (Grand Jct.)		
	cement amount	2080 lbs.		
	water amount	unknown		
	sand type & amount	None		
BARREN ZONE	sand type & amount	unknown (high pour redi-mix concrete)		
	cement amount	unknown		
	water amount	unknown		
ASSAY ANALYSIS ORE ZONE	chemical	6.28% K; 10 ppm U; 4 ppm Th		
	gamma only	unknown		
	gamma spec	6.30% K; 2.9 ppm U; 2.5 ppm Th		
	gamma logging	unknown		
ASSAY ANALYSIS BARREN ZONES	chemical	Upper Barren 1.77% K; 4 ppm U; 11 ppm Th	Lower Barren 1.74% K; 3 ppm U; 7.5 ppm Th	
	gamma only	unknown	unknown	
	gamma spec	1.9% K; 2.9 ppm U; 8.1 ppm Th	1.77% K; 2.9 ppm U; 7.5 ppm Th	
	gamma logging	unknown	unknown	
DENSITY	chemical analysis	Upper Barren 2.23 g/cc	Ore Zone 1.86 g/cc	Lower Barren 2.24 g/cc
	in-situ	unknown		
WATER OR H ⁺	% L.O.D. at 110°C	Upper Barren	Ore Zone	Lower Barren
	chemical analysis	1.98%	2.88%	1.78%
	in-situ	unknown		
ZEQ (PETROGRAPHIC ANALYSIS)		unknown		
POROSITY		unknown		
CRACKS OR FRACTURES		unknown		
MAGNETIC SUSCEPTIBILITY (10 ⁻⁶ cgs)		Upper Barren 931	Ore Zone 65	Lower Barren 860