Draft

Review of Data Used by NIOSH in Support of OCAS-RPT-001 for Assigning NP Ratios in Behalf of the Hanford Site Single Pass Reactors

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RELEVANT BACKGROUND INFORMATION

In June 2008, NIOSH issued OCAS-RPT-001 – *A Bounding Estimate of Neutron Dose Based on Measured Photon Dose around Single Pass Reactors at the Hanford Site*.

In October 2008, SC&A submitted its evaluation of OCAS-RPT-001 as part of the Hanford SEC Evaluation Review under Task Order 5. As stated in Section 5.0 of our report, SC&A concluded ". . . that the approach taken by NIOSH for amending neutron-to-photon (NP) ratios in behalf of Hanford's single pass reactors is technically sound."

However, this conclusion was based on limited information and was, therefore, deemed conditional. As part of our conclusion (on page 9 of the report), SC&A raised the two following issues/concerns:

(1) Selection of Survey Data. From among **238** boxes of available survey data, NIOSH requested **83** boxes, received **81** boxes, and found that **64** boxes contained survey data for the Hanford 100 Area production reactors. Of the **64** boxes, **57** boxes contained survey data that met the selection criteria for paired neutron and photon measurements.

The initial request for 83 boxes from a pool of 238 boxes represents a statistically sound sample set. At this time, however, OCAS-RPT-001 provides no information regarding the process by which the 83 boxes were identified/selected.

(2) Selection of Paired Measurements. NIOSH's selection of 5,773 paired measurements provides a reasonable distribution of data in behalf of (1) individual reactors, (2) years of operation, and (3) facility location. (**Note, as part of this review, however, SC&A has not been provided the raw data that defines the 5,773 paired measurements**.)

In response to the above-cited concerns, NIOSH, on December 19, 2008, provided Dr. Melius and members of the Hanford Work Group with the ". . . supporting data file . . . used in the preparation of the report OCAS-RPT-001."

The data file consists of an Excel® spreadsheet that represents data in behalf of 5,773 paired neutron and photon measurements that NIOSH had gleaned from survey records contained in the aforementioned 57 DOE file boxes. (Important to note here is that the supporting data file does **not contain original records**, but represents collated and transcribed data entered into an Excel® spreadsheet from original survey reports.)

Provided herein as Exhibit 1 are salient data (Columns H through V from the Excel® spreadsheet) for the first 271 paired NP survey measurements. Presented below are preliminary comments and questions regarding the data file that makes reference to Exhibit 1.

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PRELIMINARY COMMENTS AND THE NEED FOR ADDITIONAL INFORMATION

After a cursory inspection of the 5,773 paired NP data points, SC&A has the following comments and requests for information/data clarification.

Comments:

Columns P and Q are identified as "neutron" and "photon," respectively, but do not identify the unit(s) of measurement. However, based on Columns T, U, and V, which correspond to SN (or slow neutrons), IN (or intermediate neutrons), and FN (or fast neutrons), respectively, the metric for "neutron" is in the unit of "mrem."

Questions:

(1) Is the metric for Columns P and Q a dose **rate** for both neutrons and photons that is normalized in the units of mrem/hour?

(2) How were the original neutron survey measurements recorded? Were they recorded as neutron flux (i.e., η/cm^2 sec) or in neutron flux dose equivalent (i.e., mrem/hr)?

(3) If either AEC/DOE or NIOSH converted neutron flux to dose equivalent values, what were the assumed quality factors for neutrons?

Comments:

Column M in Exhibit 1 identifies the metric "PWR." SC&A assumes that "PWR" identifies the power level of the single pass production reactor at the time of the NP survey.

For many paired data entries throughout the 5,773 paired measurements, this entry is **blank**. For example, Exhibit 1 shows entries 2 through 84 as blanks

In addition, it is assumed that the reactor power level directly and proportionately affects the neutron flux, but affects the photon dose rate in a more complex way (in addition to Rx power levels, the duration of reactor operation and build-up of fission and activation products is another critical variable that affects photon levels). For example, entries #271 and #272 identifies two datasets at the identical location and time for the 105 F reactor. While paired measurements for entry #271 identify a NP ratio of 0.0717, entry #272 shows the identical photon dose rate, but a 13-fold higher neutron dose rate, which proportionately raises the NP ratio to 0.9383. This difference is likely the result of a transient change of Rx power level.

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Questions:

(1) What assumptions should be made for paired measurements that do **not** identify the Rx power level? Should these values be excluded?

(2) Were surveys conducted on a **fixed** routine schedule during reactor operations, or was the timing of surveys dictated by other variables that included or affected the reactor power level? For example, surveys that coincide with pulling targets at reduced power levels would bias NP ratios toward a lower value. In the absence of assigning time-weighted values to NP ratios, paired NP measurements may have to be restricted to those time periods when the reactor was operating at its normal production power level.

Comments:

As noted in OCAS-RPT-001, surveys involving **neutron** measurements at different reactors and over time involved several types of instruments, which included single and double moderated BF_3 detectors and the Cheng and Eng neutron detector.

Information regarding instrumentation used for **photon** dose rate measurements is **not** described in OCAS-RPT-001.

Reported dose rates for neutrons included dose rates as low 0.1 mrem/hour. Dose rates for photons were frequently reported at 1 mrem/hour.

Questions:

(1) For neutron and photon survey instruments, what were the lower limits for detection of dose rates? For example, entries #75 through #78 cite 10 mrem/hour as a minimum reportable gamma dose; however, dose rates as low as 1 mrem/hour are frequently cited elsewhere.

(2) What is the **uncertainty** of dose rate measurements for these instruments at the low end of the detection level? For example, the uncertainty of BF_3 neutron flux detectors is driven by counting statistics, energy distribution, etc.

Currently, OCAS-RPT-001 provides NP ratios along with geometric standard deviation value that do not include the uncertainty of the individual measurements.

Before SC&A conducts a more comprehensive and detailed analysis of the 5,773 paired survey measurements, we are requesting the Hanford Work Group to arrange a forum for the purpose of answering these and other questions.

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EXHIBIT 1: EXCERPTS FROM EXCEL® SPREADSHEET DATA USED TO DERIVE NP RATIOS FOR HANFORD SINGLE PASS REACTORS

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Reactor	General	Specifc	Date	Year	PWR	QA		Neutron	Photon	NP Ratio	Notes	SN (mrem)	IN (mrem)	FN (mrem)
2	105F	Front Face	Tube 3274	6/2/1945	1945		Y		8.60	11	0.7818		8		0.6
3	105D	X-1 Level	Max Readings	6/9/1945	1945		Y		4.70	4	1.1750				
4	105D	Top of Unit	Max Readings	6/9/1945	1945		Y		10.50	8	1.4000				
5	105D	X-1 Level	Max Readings	6/23/1945	1945		Y		27.80	15	1.8533				
6	105F	Process Monitor Room (-9 Level)	Hole #1	6/23/1945	1945		Y		2.40	1	4.8000		2		0.4
7	105F	Process Monitor Room (-9 Level)	Hole #2	6/23/1945	1945		Y		3.10	2	2.0667		2.5		0.6
8	105F	Process Monitor Room (-9 Level)	Hole #3	6/23/1945	1945		Y		3.40	3	1.3600		2.7		0.7
9	105F	Process Monitor Room (-9 Level)	Hole #4	6/23/1945	1945		Y		2.50	1	5.0000		2.2		0.3
10	105B	Front Face	Max Readings	6/30/1945	1945		Y		1.20	6	0.2105		0.1		1.1
11	105B	Front Face	Average	6/30/1945	1945		Y		0.90	3	0.3462		0.1		0.8
12	105B	Process Monitor Room (-9 Level)		6/30/1945	1945		Y		1.10	2	0.5500		0.1		1
13	105B	X-1 Level	Hole A	6/30/1945	1945		Y		1.50	3	0.5000		0.9		0.6
14	105B	X-1 Level	Hole B	6/30/1945	1945		Y		1.70	8	0.2125		0.1		1.6
15	105B	X-1 Level	Hole C	6/30/1945	1945		Y		0.90	6	0.1500		0.2		0.7
16	105B	X-1 Level	Hole D	6/30/1945	1945		Y		26.90	7	4.1385		1.9		25
17	105B	X-1 Level	Hole E	6/30/1945	1945		Y		0.50	3	0.1667		0.1		0.4
18	105B	X-1 Level	Hole F	6/30/1945	1945		Y		0.50	3	0.1667		0.1		0.4
19	105B	Top of Unit	Max Readings	6/30/1945	1945		Y		3.30	11	0.3000		0.3		3
20	105B	Top of Unit	Average	6/30/1945	1945		Y		4.60	14	0.3286		0.5		4.1
21	105D	X-1 Level	Hole A	6/30/1945	1945		Y		1.30	4	0.3250		0.2		1.1
22	105D	X-1 Level	Hole B	6/30/1945	1945		Y		0.30	3	0.1200		0.1		0.2
23	105D	X-1 Level	Hole C	6/30/1945	1945		Y		0.40	4	0.1000		0.4		0
24	105D	X-1 Level	Hole D	6/30/1945	1945		Y		10.60	13	0.8281		4.3		6.3
25	105D	X-1 Level	Between D and E	6/30/1945	1945		Y		31.30	36	0.8694		4		27.3
26	105D	X-1 Level	Hole E	6/30/1945	1945		Y		0.10	1	0.1000		0.1		0
27	105D	X-1 Level	Hole F	6/30/1945	1945		Y		4.90	4	1.2250		0.2		4.7
28	105D	Process Monitor Room (-9 Level)		6/30/1945	1945		Y		0.50	3	0.1667		0.5		0
29	105D	Top of Unit	Max Readings	6/30/1945	1945		Y		11.60	8	1.4500		1.1		10.5
30	105D	Top of Unit	Average	6/30/1945	1945		Y		6.80	5	1.5111		0.8		6
31	105F	Front Face	Tube 2787	6/30/1945	1945		Y		3.70	17	0.2242	Tube Loca	2.4		1.3
32	105D	X-1 Level	Hole D (Front)	7/27/1945	1945		Y		1.70	3	0.6800		0.1		1.6
33	105D	X-1 Level	Hole D (Top)	7/27/1945	1945		Y		3.20	1	3.2000		0.1		3.1
34	105D	X-1 Level	Hole D (Top Aga	7/27/1945	1945		Y		4.80	1	4.8000		0.1		4.7
35	105D	Top of Unit	Opposite VSR#3	11/28/1945	1945		Y		10.70	5	2.1400				
36	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		5.10	24	0.2125		0.6		4.5
37	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		7.20	9	0.8000		0.6		6.6
38	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		6.30	6	1.0500		0.6		5.7
39	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		5.90	5	1.3111		0.6		5.3
40	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		5.80	4	1.6571		0.6		5.2
41	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		5.50	4	1.5714		0.6		4.9
42	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		4.70	3	1.8800		0.6		4.1
43	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		4.10	3	1.6400		0.6		3.5
44	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		6.20	4	1.7714		0.6		5.6
45	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		6.80	5	1.5111		0.6		6.2
46	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		7.50	5	1.5000		0.6		6.9
47	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		7.30	6	1.3273		0.6		6.7
48	105F	Top of Unit	Top Railing VSR	12/13/1945	1945		Y		6.10	5	1.3556		0.6		5.5
49	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		4.90	11	0.4455		0.6		4.3
50	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		7.80	8	1.0400		0.6		7.2
51	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		7.90	6	1.4364		0.6		7.3
52	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		7.10	4	1.7750		0.6		6.5
53	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		6.00	4	1.5000		0.6		5.4
54	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		5.30	4	1.5143		0.6		4.7
55	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		4.50	3	1.8000		0.6		3.9
56	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		3.20	2	1.6000		0.6		2.6
57	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		4.80	3	1.6000		0.6		4.2
58	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		7.40	5	1.4800		0.6		6.8
59	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		6.30	6	1.0500		0.6		5.7
60	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		6.90	6	1.1500		0.6		6.3
61	105F	Top of Unit	Bottom Railing V	12/13/1945	1945		Y		5.00	4	1.2500		0.6		4.4
62	105F	Top of Unit	Floor VSR 10	12/13/1945	1945		Y		6.20	8	0.8267		0.6		5.6
63	105F	Top of Unit	Floor VSR 11	12/13/1945	1945		Y		7.90	7	1.2154		0.6		7.3
64	105F	Top of Unit	Floor VSR 12	12/13/1945	1945		Y		7.80	5	1.5600		0.6		7.2
65	105F	Top of Unit	Floor VSR 13	12/13/1945	1945		Y		7.10	4	1.7750		0.6		6.5
66	105F	Top of Unit	Floor VSR 14	12/13/1945	1945		Y		6.70	4	1.6750		0.6		6.1
67	105F	Top of Unit	Floor VSR 20	12/13/1945	1945		Y		5.70	4	1.6286		0.6		5.1
68	105F	Top of Unit	Floor VSR 27 (W	12/13/1945	1945		Y		5.00	3	2.0000		0.6		4.4
69	105F	Top of Unit	Floor VSR 27 (Se	12/13/1945	1945		Y		3.10	2	2.0667		0.6		2.5
70	105F	Top of Unit	Floor VSR 38	12/13/1945	1945		Y		5.80	3	2.3200		0.6		5.2
71	105F	Top of Unit	Floor VSR 37	12/13/1945	1945		Y		8.90	6	1.6182		0.6		8.3
72	105F	Top of Unit	Floor VSR 36	12/13/1945	1945		Y		8.00	7	1.2308		0.6		7.4
73	105F	Top of Unit	Floor VSR 35	12/13/1945	1945		Y		8.00	6	1.4545		0.6		7.4
74	105F	Top of Unit	Floor VSR 34	12/13/1945	1945		Y		6.10	4	1.5250		0.6		5.5
75	105D	Top of Unit	Rod Rail at VSR#	12/24/1946	1946		Y		16.00	10	1.6000	Gamma based on minimum repor			16
76	105D	Top of Unit	Rod Rail at VSR#	12/24/1946	1946		Y		12.00	10	1.2000	Gamma based on minimum repor			12
77	105D	Top of Unit	Rod Rail at VSR#	12/24/1946	1946		Y		6.00	10	0.6000	Gamma based on minimum repor			6
78	105D	Top of Unit	Rod Rail at VSR#	12/24/1946	1946		Y		10.00	10	1.0000	Gamma based on minimum repor			10
79	105D	Front Face	Tube 1663 (maxi	1/14/1947	1947		Y		1.00	2	0.5000		1		
80	105D	Front Face	Special Tubes	3/10/1947	1947		Y		1.00	5	0.2000	Likely same special tubes listed above (3574			
81	105F	Top of Unit	VSR #37	3/24/1947	1947		Y		11.40	60	0.1900				11.4
82	105D	Front Face	Tube 1582	3/30/1947	1947		Y		45.00	95	0.4737		15		30
83	105D	X-0 Level	Outer Rod Room	4/7/1947	1947		Y		280.00	700	0.4000		50		230
84	105D	X-1 Level	Hole B (Open Cc	7/14/1947	1947		Y		5200.00	8000	0.6500		2700		2500
85	105D	X-1 Level	Hole B	8/4/1947	1947	250	Y		3600.00	5000	0.7200				3600
86	105F	X-1 Level	Hole B	8/11/1947	1947	35	Y		40.00	16	2.5000		10		30
87	105F	Top of Unit	VSR #10	12/30/1947	1947	275	Y		10.00	25	0.4000				10
88	105F	30' Level	Inner Rod Room	1/21/1948	1948	275	Y		0.24	100	0.0024		0.119048		0.125
89	105F	X-1 Level	D Hole (Left Side	1/29/1948	1948	275	Y		2.91	15	0.1941		0.825		2.08625
90	105D	Front Face	Tube 2177	3/2/1948	1948	275	Y		570.00	170	3.3529		220		350
91	105D	Front Face	Tube 2286	3/2/1948	1948	275	Y		530.00	170	3.1176		130		400
92	105D	Front Face	Tube 2287	3/2/1948	1948	275	Y		390.00	170	2.2941		300		90
93	105D	Front Face	Tube 3672	3/2/1948	1948	275	Y		100.00	170	0.5882		50		50

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Exhibit 1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Reactor	General	Specifc	Date	Year	PWR	QA		Neutron	Photon	NP Ratio	Notes	SN (mrem)	IN (mrem)	FN (mrem)
94	105D	Front Face	Tube 3684	3/2/1948	1948	275	Y		80.00	170	0.4706		30		50
95	105F	X-1 Level	Hole #6 Max	3/2/1948	1948	275	Y		35.00	40	0.8750		28		7
96	105F	Front Face	Tube 0159	3/6/1948	1948	240	Y		1.41	1	1.4095		0.609524		0.8
97	105F	Front Face	Tube 0160	3/6/1948	1948	240	Y		1.61	1	1.6148		0.654762		0.96
98	105F	Front Face	Tube 0187	3/6/1948	1948	240	Y		1.81	1	1.8077		1.295238		0.5125
99	105F	Front Face	Tube 0188	3/6/1948	1948	240	Y		1.18	1	1.1771		0.457143		0.72
100	105F	Front Face	Tube 0354	3/6/1948	1948	240	Y		9.92	4	2.4810		7.92381		2
101	105F	Front Face	Tube 0393	3/6/1948	1948	240	Y		9.27	6	1.5448		6.628571		2.64
102	105F	Front Face	Tube 0453	3/6/1948	1948	240	Y		1.25	1	1.2533		0.533333		0.72
103	105F	Front Face	Tube 0494	3/6/1948	1948	240	Y		2.28	1	2.2769		1.636905		0.64
104	105F	Front Face	Tube 0951	3/6/1948	1948	240	Y		2.54	1	2.5371		2.057143		0.48
105	105F	Front Face	Tube 0996	3/6/1948	1948	240	Y		2.92	1	2.9181		2.438095		0.48
106	105F	Front Face	Tube 1051	3/6/1948	1948	240	Y		4.32	1	4.3200		3.2		1.12
107	105F	Front Face	Tube 1091	3/6/1948	1948	240	Y		1.10	1	1.0971		0.457143		0.64
108	105F	Front Face	Tube 0187	3/7/1948	1948	260	Y		0.44	1	0.4395		0.159524		0.28
109	105F	Front Face	Tube 0354	3/7/1948	1948	260	Y		0.31	1	0.3102		0.071429		0.23875
110	105F	Front Face	Tube 0393	3/7/1948	1948	260	Y		0.33	1	0.3349		0.052381		0.2825
111	105F	Front Face	Tube 0494	3/7/1948	1948	260	Y		0.48	1	0.4796		0.108333		0.37125
112	105F	X-1 Level	A Hole (Left @ u	3/8/1948	1948	275	Y		2.25	10	0.2253		0.455952		1.7975
113	105F	Front Face	Tube 0187	3/8/1948	1948	275	Y		0.72	2	0.3601	Gamma Re	0.595238		0.125
114	105F	Front Face	Tube 0160	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
115	105F	Front Face	Tube 0159	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
116	105F	Front Face	Tube 0354	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
117	105F	Front Face	Tube 0353	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
118	105F	Front Face	Tube 0394	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
119	105F	Front Face	Tube 0393	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
120	105F	Front Face	Tube 0453	3/8/1948	1948	275	Y		1.34	1	1.3402	Gamma Re	0.595238		0.745
121	105F	Front Face	Tube 0494	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
122	105F	Front Face	Tube 0951	3/8/1948	1948	275	Y		2.17	1	2.1667	Gamma Re	2.041667		0.125
123	105F	Front Face	Tube 0996	3/8/1948	1948	275	Y		2.75	1	2.7500	Gamma Re	2.125		0.625
124	105F	Front Face	Tube 1051	3/8/1948	1948	275	Y		3.95	1	3.9467	Gamma Re	2.166667		1.78
125	105F	Front Face	Tube 1096	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
126	105F	Front Face	Tube 1481	3/8/1948	1948	275	Y		0.85	20	0.0425	Gamma Re	0		0.85
127	105F	Front Face	Tube 2451	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
128	105F	Front Face	Tube 2496	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
129	105F	Front Face	Tube 3757	3/8/1948	1948	275	Y		1.22	5	0.2440	Gamma Re	0.595238		0.625
130	105F	Front Face	Tube 4674	3/8/1948	1948	275	Y		1.22	1	1.2202	Gamma Re	0.595238		0.625
131	105F	X-1 Level	D Hole (@ Shiek	3/9/1948	1948	275	Y		16.33	40	0.4083		5.208333		11.125
132	105F	X-1 Level	D Hole (@ Rail)	3/9/1948	1948	275	Y		6.04	10	0.6036		0.535714		5.5
133	105D	Top of Unit (51' Level)	Far Edge and Tc	3/9/1948	1948	275	Y		44.00	60	0.7333				44
134	105F	X-1 Level	D Hole	3/17/1948	1948	275	Y		23.00	20	1.1500	First Measurement with the Neut			23
135	105F	X-1 Level	D Hole	3/17/1948	1948	275	Y		25.00	40	0.6250				
136	105F	Top of Unit	VSR #10	4/2/1948	1948	275	Y		1.00	75	0.0133	Gamma From Survey F 4729			1
137	105F	Top of Unit	VSR #11	4/2/1948	1948	275	Y		3.13	45	0.0694	Gamma From Survey F 4729			3.125
138	105F	Top of Unit	VSR #12	4/2/1948	1948	275	Y		2.00	30	0.0667	Gamma From Survey F 4729			2
139	105F	Top of Unit	VSR #13	4/2/1948	1948	275	Y		1.25	45	0.0278	Gamma From Survey F 4729			1.25
140	105F	Top of Unit	VSR #20	4/2/1948	1948	275	Y		1.00	20	0.0500	Gamma From Survey F 4729			1
141	105F	Top of Unit	VSR #27	4/2/1948	1948	275	Y		1.00	20	0.0500	Gamma From Survey F 4729			1
142	105F	Top of Unit	VSR #34	4/2/1948	1948	275	Y		3.13	15	0.2083	Gamma From Survey F 4729			3.125
143	105F	Top of Unit	VSR #36	4/2/1948	1948	275	Y		1.00	40	0.0250	Gamma From Survey F 4729			1
144	105F	Top of Unit	VSR #37	4/2/1948	1948	275	Y		3.44	20	0.1719	Gamma From Survey F 4729			3.4375
145	105F	Top of Unit	VSR #38	4/2/1948	1948	275	Y		1.00	20	0.0500	Gamma From Survey F 4729			1
146	105F	Top of Unit	Seam 4	4/8/1948	1948	275	Y		0.38	11	0.0343		0.147619		0.23
147	105F	Top of Unit	Seam 5	4/8/1948	1948	275	Y		0.30	11	0.0275		0.097619		0.205
148	105F	X-1 Level	B Hole (After Shi	4/14/1948	1948	275	Y		1.50	15	0.1000		1.5		
149	105F	X-1 Level	B Hole (Max reac	4/14/1948	1948	275	Y		5.83	15	0.3889		5.833333		
150	105F	Top of Unit	VSR #10	4/16/1948	1948	275	Y		1.12	75	0.0149	Gamma Fr	0.119048		1
151	105F	Top of Unit	VSR #11	4/16/1948	1948	275	Y		3.27	45	0.0728	Gamma Fr	0.14881		3.125
152	105F	Top of Unit	VSR #12	4/16/1948	1948	275	Y		2.18	30	0.0726	Gamma Fr	0.178571		2
153	105F	Top of Unit	VSR #13	4/16/1948	1948	275	Y		1.49	45	0.0331	Gamma Fr	0.238095		1.25
154	105F	Top of Unit	VSR #20	4/16/1948	1948	275	Y		1.07	20	0.0537	Gamma Fr	0.07381		1
155	105F	Top of Unit	VSR #27	4/16/1948	1948	275	Y		1.12	20	0.0562	Gamma Fr	0.12381		1
156	105F	Top of Unit	VSR #34	4/16/1948	1948	275	Y		3.36	15	0.2242	Gamma Fr	0.238095		3.125
157	105F	Top of Unit	VSR #36	4/16/1948	1948	275	Y		1.36	40	0.0339	Gamma Fr	0.357143		1
158	105F	Top of Unit	VSR #37	4/16/1948	1948	275	Y		3.72	20	0.1862	Gamma Fr	0.285714		3.4375
159	105F	Top of Unit	VSR #38	4/16/1948	1948	275	Y		1.14	20	0.0571	Gamma Fr	0.142857		1
160	105F	Top of Unit	@ Tape	4/21/1948	1948	275	Y		0.25	90	0.0027		0.090476		0.15625
161	105F	Top of Unit	Opposite Max CF	4/21/1948	1948	275	Y		0.66	100	0.0066		0.180952		0.48125
162	105F	X-1 Level	Hole D	5/10/1948	1948	275	Y		0.49	15	0.0329		0.119048		0.375
163	105F	Front Face	Tube 0865	5/21/1948	1948	275	Y		0.33	1	0.3301		0.09881		0.23125
164	105F	Top of Unit	Seam #1	5/28/1948	1948	275	Y		0.10	40	0.0026		0.033333		0.06875
165	105F	Top of Unit	Seam #2	5/28/1948	1948	275	Y		0.31	60	0.0051		0.066667		0.24125
166	105F	Top of Unit	Seam #3	5/28/1948	1948	275	Y		0.46	100	0.0046		0.07619		0.38625
167	105F	Top of Unit	Seam #4	5/28/1948	1948	275	Y		0.80	140	0.0057		0.092857		0.70375
168	105F	Top of Unit	Seam #5	5/28/1948	1948	275	Y		0.55	110	0.0050		0.07619		0.47
169	105F	Top of Unit	Seam #6	5/28/1948	1948	275	Y		0.39	60	0.0064		0.072619		0.3125
170	105F	Top of Unit	Seam #7	5/28/1948	1948	275	Y		0.25	25	0.0099		0.055952		0.19125
171	105F	X-1 Level	B Hole (Beam)	7/10/1948	1948	275	Y		3365.48	11000	0.3060		65.47619		3300
172	105B	X-1 Level	Hole E	7/14/1948	1948	100	Y		4000.00	5000	0.8000				4000
173	105F	X-1 Level	Hole B	7/14/1948	1948	275	Y		3300.00	11000	0.3000				3300
174	105F	Top of Unit	VSR #14	7/24/1948	1948	275	Y		1.12	60	0.0186		0.117857		1
175	105F	Top of Unit	VSR #27	7/24/1948	1948	275	Y		1.18	9	0.1312		0.180952		1
176	105F	Top of Unit	VSR #38	7/24/1948	1948	275	Y		3.25	13	0.2496		0.245238		3
177	105B	X-1 Level	Hole A	7/29/1948	1948	275	Y		204.00	250	0.8160		4		200
178	105B	X-1 Level	Hole B	7/29/1948	1948	275	Y		53.00	40	1.3250		11		42
179	105B	X-1 Level	Hole C	7/29/1948	1948	275	Y		3.00	6	0.5000		1		2
180	105B	X-1 Level	Hole D	7/29/1948	1948	275	Y		32.00	80	0.4000		8		24
181	105B	X-1 Level	Hole E	7/29/1948	1948	275	Y		3.00	6	0.5000		1		2
182	105B	X-1 Level	Hole F	7/29/1948	1948	275	Y		3.00	6	0.5000		1		2
183	105B	Balcony	Maximum	7/29/1948	1948	275	Y		4.08	15	0.2722		0.833333		3.25
184	105B	X-1 Level	Test Hole A	7/29/1948	1948		Y		104.00	250	0.4160		4		100
185	105B	X-1 Level	Hole A	7/30/1948	1948	275	Y		104.00	250	0.4160		4		100

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Exhibit 1 (Continued)

	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Reactor	General	Specifc	Date	Year	PWR	QA		Neutron	Photon	NP Ratio	Notes	SN (mrem)	IN (mrem)	FN (mrem)
186	105B	X-1 Level	Hole B	7/30/1948	1948	275	Y		32.00	40	0.8000		11		21
187	105B	X-1 Level	Hole C	7/30/1948	1948	275	Y		2.00	6	0.3333		1		1
188	105B	X-1 Level	Hole D	7/30/1948	1948	275	Y		18.00	80	0.2250		8		10
189	105B	X-1 Level	Test Hole B	7/30/1948	1948		Y		32.00	40	0.8000		11		21
190	105B	X-1 Level	Test Hole C	7/31/1948	1948		Y		2.00	6	0.3333		1		1
191	105B	X-1 Level	Test Hole D	8/1/1948	1948		Y		20.00	80	0.2500		8		12
192	105B	X-1 Level	Test Hole E	8/2/1948	1948		Y		2.00	6	0.3333		1		1
193	105B	X-1 Level	Test Hole F	8/3/1948	1948		Y		2.00	6	0.3333		1		1
194	105B	X-1 Level	Test Hole A	8/28/1948	1948		Y		2.20	30	0.0733				2.2
195	105B	X-1 Level	Test Hole B	8/28/1948	1948		Y		19.10	15	1.2733		9.6		9.5
196	105B	X-1 Level	Test Hole C	8/28/1948	1948		Y		2.90	3	0.9667		1.9		1
197	105B	X-1 Level	Test Hole D	8/28/1948	1948		Y		2.70	10	0.2700		1.7		1
198	105B	X-1 Level	Test Hole E	8/28/1948	1948		Y		1.00	1	1.0000				1
199	105B	X-1 Level	Test Hole F	8/28/1948	1948		Y		1.00	1	1.0000				1
200	105B	X-1 Level	Hole B	10/15/1948	1948	275	Y		53.96	45	1.1991		28.33333		25.625
201	105B	X-1 Level	Hole B	11/15/1948	1948	275	Y		102.08	125	0.8167		40.83333		61.25
202	105D	X-1 Level	Hole A	11/15/1948	1948	275	Y		69.17	800	0.0865		1.666667		67.5
203	105D	Front Face	Tube 2186	2/1/1949	1949	275	Y		5.75	13	0.4423		5.75		
204	105D	Top of Unit	Seam #4	6/1/1949	1949	305	Y		525.08	1400	0.3751		25.08333		500
205	105F	Top of Unit	Far Edge	6/1/1949	1949	275	Y		125.08	3200	0.0391		97.08333		28
206	105B	Top of Unit	Neutron Beam at	6/27/1949	1949		Y		9.90	10	0.9900		1.3	2.3	6.3
207	105B	Top of Unit	Neutron Beam at	7/25/1949	1949	275	Y		28.00	16	1.7500		1.3	26.7	
208	105B	Top of Unit	Far Edge	7/27/1949	1949		Y		16.79	140	0.1199		1	1.291667	14.5
209	105B	Top of Unit	Neutron Beam at	8/29/1949	1949	275	Y		15.50	14	1.1071		1		14.5
210	105B	Top of Unit	Neutron Beam at	9/15/1949	1949	275	Y		19.40	35	0.5543		0.1	13.3	6
211	105B	Top of Unit	Neutron Beam at	10/14/1949	1949	275	Y		6.10	30	0.2033		0.1	2.5	3.5
212	105H	X-1 Level	Instrument Cubic	11/1/1949	1949	275	Y		105.00	80	1.3125		105		
213	105B	Top of Unit	Neutron Beam at	11/18/1949	1949	275	Y		11.80	30	0.3933		0.1	1.7	10
214	105B	Top of Unit	Neutron Beam at	12/19/1949	1949	275	Y		2.50	22	0.1136		0.2	2.3	
215	105B	Top of Unit	Opposite VSR #3	1/1/1950	1950		Y		68.40	60	1.1400		2.7	32.3	33.4
216	105B	X-1 Level	Neutron Beam at	1/1/1950	1950		Y		16.90	160	0.1056		0.2	1.7	15
217	105B	Process Monitor Room (-9' Level)	-9' Level Holes	1/1/1950	1950		Y		2.80	1	5.6000		0.5	1.3	1
218	105B	Top of Unit	Neutron Beam at	1/19/1950	1950	275	Y		2.30	20	0.1150		0.2	2.1	
219	105B	Top of Unit	Opposite VSR #3	2/1/1950	1950		Y		53.40	28	1.9071		2.4	29.1	21.9
220	105B	Top of Unit	Front of VSR enc	2/1/1950	1950		Y		32.50	13	2.5000				
221	105B	Top of Unit	Far Side VSR En	2/1/1950	1950		Y		28.80	13	2.2154				
222	105B	Top of Unit	Neutron Beam at	2/1/1950	1950		Y		3.00	80	0.0375		0.2	1.8	1
223	105B	Top of Unit	Opposite VSR #3	2/1/1950	1950		Y		53.40	28	1.9071				
224	105F	Top of Unit	VSR #19 (While	2/1/1950	1950		Y		407.96	200	2.0398		44	173.9583	190
225	105B	Top of Unit	Neutron Beam at	2/22/1950	1950	275	Y		2.00	120	0.0167		0.2	1.8	
226	105B	Top of Unit	Neutron Beam at	3/1/1950	1950		Y		6.20	29	0.2138		0.2	1.6	4.4
227	105B	Top of Unit	Opposite VSR #3	3/1/1950	1950		Y		54.70	24	2.2792		1.5	28.2	25
228	105B	Top of Unit	3' from VSRs	3/1/1950	1950		Y		45.30	13	3.4846				
229	105B	Top of Unit	5' from VSR #27	3/1/1950	1950		Y		17.60	5	3.5200				
230	105B	Top of Unit	Top of the Wye L	3/1/1950	1950		Y		6.00	3	2.0000				
231	105B	Top of Unit	Balcony Railing -	3/1/1950	1950		Y		14.20	9	1.5778		0.8	6.5	6.9
232	105B	Top of Unit	Balcony Railing -	3/1/1950	1950		Y		7.30	5	1.4600		0.6	4.2	2.5
233	105B	Top of Unit	Balcony Railing -	3/1/1950	1950		Y		7.20	4	2.0571		0.7	4	2.5
234	105B	Top of Unit	Balcony Railing -	3/1/1950	1950		Y		3.50	4	0.8750				3.5
235	105B	X-1 Level	Neutron Beam at	3/1/1950	1950		Y		47.50	4	11.8750		1.2	40	6.3
236	105B	Process Monitor Room (-9' Level)	#2 Hole	3/1/1950	1950		Y		0.70	1	0.7000		0.1	0.5	0.1
237	105B	Top of Unit	Neutron Beam at	3/27/1950	1950	275	Y		6.20	29	0.2138		0.2	1.6	4.4
238	105F	Top of Unit	Far Edge	3/31/1950	1950		Y		1516.67	4500	0.3370		141.6667	62.5	1312.5
239	105B	Top of Unit	Neutron Beam at	4/10/1950	1950	290	Y		2.50	14	0.1786		0.5	2	
240	105B	Top of Unit	Neutron Beam at	5/23/1950	1950	290	Y		50.10	200	0.2505		0.3	2.3	47.5
241	105F	X-1 Level	"A" Test Hole	6/1/1950	1950		Y		2118.00	4400	0.4814		159	59	1900
242	105B	Top of Unit	Neutron Beam at	6/26/1950	1950	305	Y		1.80	60	0.0300		0.2	0.6	1
243	105B	Top of Unit	Seam #4	7/1/1950	1950		Y		69.80	80	0.8725		0.1	0.7	69
244	105B	X-1 Level	Neutron Beam at	7/1/1950	1950		Y		69.80	80	0.8725		0.1	0.7	69
245	105B	Top of Unit	Opposite VSR #3	7/1/1950	1950		Y		87.00	70	1.2429		1.1	23.9	62
246	105F	X-1 Level	"A" Test Hole	7/1/1950	1950		Y		1454.00	2800	0.5193		80	24	1350
247	105B	Top of Unit	Neutron Beam at	7/26/1950	1950	305	Y		69.80	80	0.8725		0.1	0.7	69
248	105B	Top of Unit	VSR # 36	8/1/1950	1950	335	Y		58.18	40	1.4544		1.966667	26.20833	30
249	105B	Top of Unit	Seam #4	8/1/1950	1950		Y		8.27	19	0.4353		0.208333	1.1875	6.875
250	105H	X-1 Level	Hole D	8/1/1950	1950		Y		22.96	25	0.9183		4	18.95833	
251	105B	X-1 Level	Neutron Beam at	8/1/1950	1950		Y		8.30	19	0.4368		0.2	1.2	6.9
252	105B	Top of Unit	Opposite VSR #3	8/1/1950	1950		Y		58.20	40	1.4550		2	26.2	30
253	105B	Top of Unit	VSR #36 at the F	8/1/1950	1950		Y		32.00	40	0.8000		2		30
254	105B	Top of Unit	VSR #36 at the F	8/1/1950	1950		Y		71.90	37	1.9432		1.9		70
255	105B	Top of Unit	#4 T Seam	8/1/1950	1950		Y		9.20	19	0.4842		0.2		9
256	105B	Top of Unit	Neutron Beam at	8/22/1950	1950	335	Y		8.30	19	0.4368		0.2	1.2	6.9
257	105B	Top of Unit	VSR #36	9/1/1950	1950		Y		100.25	37	2.7095		1.916667	28.33333	70
258	105F	Top of Unit	Far Edge	9/1/1950	1950		Y		565.75	2000	0.2829		30.75	17.5	517.5
259	105B	Top of Unit	Opposite VSR #3	9/1/1950	1950		Y		100.30	37	2.7108		1.9	28.4	70
260	105B	X-1 Level	Neutron Beam at	9/1/1950	1950		Y		11.10	46	0.2413		0.2	1.5	9.4
261	105B	Top of Unit	#4 T Seam	9/1/1950	1950		Y		9.60	46	0.2087		0.2		9.4
262	105F	Top of Unit	Far Edge	9/1/1950	1950		Y		565.73	2000	0.2829		30.73333	17.5	517.5
263	105B	Top of Unit	Neutron Beam at	9/20/1950	1950	335	Y		11.10	46	0.2413		0.2	1.5	9.4
264	105D	X-1 Level	Hole B	11/1/1950	1950	320	Y		876.28	110	7.9662		1.283333		875
265	105F	Top of Unit	Seam #4	11/1/1950	1950		Y		470.42	2200	0.2138		86.66667	33.75	350
266	105B	Top of Unit	VSR #36	12/1/1950	1950	340	Y		59.88	25	2.3952		1.858333	29.27083	28.75
267	105B	Top of Unit	Far Edge	12/1/1950	1950	340	Y		22.68	37	0.6128		0.216667	9.958333	12.5
268	105B	Top of Unit	Opposite VSR #3	12/1/1950	1950		Y		60.00	25	2.4000		1.9	29.3	28.8
269	105B	Top of Unit	Neutron Beam at	12/1/1950	1950		Y		22.70	37	0.6135		0.2	10	12.5
270	105F	Top of Unit	VSR Enclosure	12/1/1950	1950		Y		68.00	20	3.4000		3	27	38
271	105F	Front Face	Tube 0263	2/1/1951	1951	380	Y		43.00	600	0.0717		43		
272	105F	Front Face	Tube 0263	2/1/1951	1951		Y		563.00	600	0.9383		43	520	

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