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Mr. Glenn Kelly
Nuclear Regulatory Commission
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DETAILS FOR THE SPENT FUEL POOL OPERATOR DOSE CALCULATIONS

Dear Glenn:

This letter is to summarize the details for the spent fuel pool operator dose calculations, and present the results of these calculations.

As we discussed, a series of calculations was performed to determine order-of-magnitude operator doses in the event that fuel is uncovered in the spent fuel pool during an accident scenario. Both representative PWR and BWR spent fuel building configurations will be examined. Diagrams showing elevation and floor-level sections of the PWR and BWR shielding transport models are shown in Figures 1 and 2, respectively. The following describe how the various dimensions and materials for the model were determined:

1. The pool dimensions for both the PWR and BWR models were averaged from values for several different reactors. Data for the averaging were taken from Reference 2, Table 4.2.1.

2. Building ceiling heights for the PWR models were obtained from Chapter 1 of the FSARs for the H.B. Robinson and Seabrook plants. The BWR building height was obtained from Chapter 1 of the FSAR for the LaSalle plant.

3. Fuel heights were extracted from values given in Reference 3, Volume 3, Tables 2A-11 and 2A-12. These heights are not actual dimensions, but are bracketed by the various types of PWR and BWR fuel elements used in reactors in the past. The values selected are near the upper end of the height ranges for the respective reactor fuel assemblies.

4. Building dimensions, wall thicknesses, and compositions were gleaned from Reference 5 for BWR (Dresden), and from Chapter 1 of the Seabrook and H.B. Robinson FSARs for the PWR. Based upon data in the H.B. Robinson FSAR, the walls of the older model PWR spent fuel building were determined to be of corrugated steel. For simplicity in modelling, this was assumed to be 16-gauge (1/16" thick) stainless steel. Both the modern PWR and BWR buildings were assumed to be of reinforced concrete.

5. Pool water depth, and, thus, axial fuel location, was determined from average pool depths and fuel heights by subtraction.

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6. To bound the possible spent fuel pool contents, three different photon spectra will be used for each reactor type. The three spectra will be from fuel with average (~50%) exposure decayed 1 year after removal from the reactor, fuel with full exposure decayed 1 year, and fuel with full exposure decayed 10 years. Photon spectra for these fuel exposure/decay combinations were obtained from Reference 3, Volume 1, Tables 2.4-27 to 2.4-30.

7. The fuel, which is assumed to be a homogeneous mixture of fuel assembly and water (if wet) or air (if dry), will occupy the entire volume shown in the attached elevation diagrams. It will be assumed that the pool will be filled with fuel elements to within 3 feet of the pool walls. The photon source will be uniformly distributed over this volume.

8. Operator doses will be computed as whole-body doses, with the operator standing in four different locations: at the pool lip; 10 feet back from the lip (5 feet for the older PWR model); and 3 meters and 20 meters outside the building wall.

9. The dry fuel configuration will have no water in the spent fuel pool; the wet configurations will allow 1, 3, 5, and 7 feet of water to cover the fuel elements.

Based on these assumptions, the following set of calculations was performed. Fifteen different configurations of spent fuel pool sources have been considered, asdescribed below.

1. Case bwr1a - BWR model, partially-burned (27.5 GWD/MTIHM) fuel decayed 1 year, dry
2. Case bwr1b - BWR model, fully-burned (40 GWD/MTIHM) fuel decayed 1 year, dry
3. Case bwr1c - BWR model, fully-burned fuel decayed 10 years, dry
4. Case bwr1d - BWR model, fully-burned fuel decayed 1 year, water level 1' above top of fuel
5. Case bwr1e - BWR model, fully-burned fuel decayed 1 year, water level 3' above top of fuel
6. Case bwr1f - BWR model, full-burned fuel decayed 1 year, water level 5' above top of fuel
7. Case bwr1g - BWR model, full-burned fuel decayed 1 year, water level 7' above top of fuel
8. Case pwr1a - older PWR model, partially-burned (33 GWD/MTIHM) fuel decayed 1 year, dry
9. Case pwr1b - older PWR model, fully-burned (60 GWD/MTIHM) fuel decayed 1 year, dry
10. Case pwr1c - older PWR model, fully-burned fuel decayed 10 years, dry
11. Case pwr1d - older PWR model, fully-burned fuel decayed 1 year, water level 1' above top of fuel
12. Case pwr1e - older PWR model, fully-burned fuel decayed 1 year, water level 3' above top of fuel
13. Case pwr1f - older PWR model, fully-burned fuel decayed 1 year, water level 5' above top of fuel
14. Case pwr1g - older PWR model, fully-burned fuel decayed 1 year, water level 7' above top of fuel
15. Case pwr2a - modern PWR model, fully-burned fuel decayed 1 year, dry

Operator dose rates were computed at four different locations for each case - at the pool lip, 10' from the pool (5' for the older PWR), 3m outside the building, and 20m outside the building. The

results are summarized in Table 1, with the pool water depth dose variations at the pool lip and 10' (5' for older PWR) from the pool edge for fully-burned fuel decayed 1 year displayed graphically in Figures 3 and 4.

For accident scenarios with relatively full spent fuel pools, i.e., approximately 30 core reloads, or 1000 MTIHM fuel, in the pool, the operator doses inside the building are rapidly lethal for all cases with dry fuel. Covering the fuel with even 1' of water allows the operator a few minutes of access if he does not approach the pool, and covering the fuel with 3' of water allows a few minutes access at the edge of the pool. Larger water depths allow significantly longer access times, with 7' of water allowing several hours of access for all configurations.

The BWR and modern PWR buildings, with their thick concrete walls, provide sufficient shielding to allow operators to approach the building closely. However, older PWRs, which have spent fuel buildings constructed with corrugated steel walls, provide little protection, and operators can only spend limited time within 20m of the building before exceeding personnel exposure limits.

If you have any comments or questions regarding these calculation, or require more details, please feel free to contact Charles A. Wemple at (208) 526-7667, cew@inel.gov.

Sincerely,

James A. Lake

Dr. James A. Lake
Director, Advanced Nuclear Energy

CAW:ps

Attachments

cc: D. M. Henry, MS 3850
S. Khericha, MS 3850
T. J. Leahy, MS 3850
C. A. Wemple file (2), MS 3885

Table 1. Results of operator dose calculations at several locations within and outside the spent fuel building.

	Doses (rem/hr/MTIHM) at Operator Locations			
Case name	Pool lip	10' from pool[1]	3m outside bldg.	20m outside bldg.
bwr1a	1.34E+01	4.20E-01	5.00E-06[2]	5.00E-06[2]
bwr1b	1.78E+01	5.70E-01	1.00E-06[2]	2.00E-06[2]
bwr1c	2.80E+00	9.70E-02	1.00E-07[2]	1.00E-07[2]
bwr1d	2.70E+00	1.10E-01	2.00E-07[2]	3.00E-07[2]
bwr1e	5.20E-02	1.40E-03	N/A[3]	N/A[3]
bwr1f	9.50E-04	N/A[3]	N/A[3]	N/A[3]
bwr1g	2.00E-05	N/A[3]	N/A[3]	N/A[3]
pwr1a	1.52E+01	6.50E-01	1.80E-01	4.00E-02
pwr1b	2.63E+01	1.12E+00	5.40E-01	6.00E-02
pwr1c	3.80E+00	1.60E-01	8.00E-02	1.00E-02
pwr1d	4.00E+00	1.50E-01	4.00E-02	1.00E-02
pwr1e	8.00E-02	6.00E-03	1.00E-03	2.00E-04
pwr1f	4.50E-03	1.10E-04	N/A[3]	N/A[3]
pwr1g	3.10E-04	N/A[3]	N/A[3]	N/A[3]
pwr2a	2.67E+01	8.50E-01	N/A[3]	N/A[3]

References

1. Seismic Failure and Cask Drop Analyses of the Spent Fuel Pool at Two Representative Nuclear Power Plants, NUREG/CR-5176, USNRC, January 1989.

2. Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools," NUREG-1353, USNRC, April 1989.

3. Characteristics of Spent Fuel, High-Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation, DOE/RW-0184, OCRWM, December 1987.

4. Nuclear Power Plant System Sourcebook for H.B. Robinson Unit 2, SAIC 89/1026, SAIC, February 1989, p. 78.

5. Dresden Unit 2 Drawing B-251.

[1]5' back for cases pwr1a - pwr1e (older PWR models).
[2]High variance tally - values may be in error by as much as an order of magnitude.
[3]Doses calculated were essentially zero (below background).

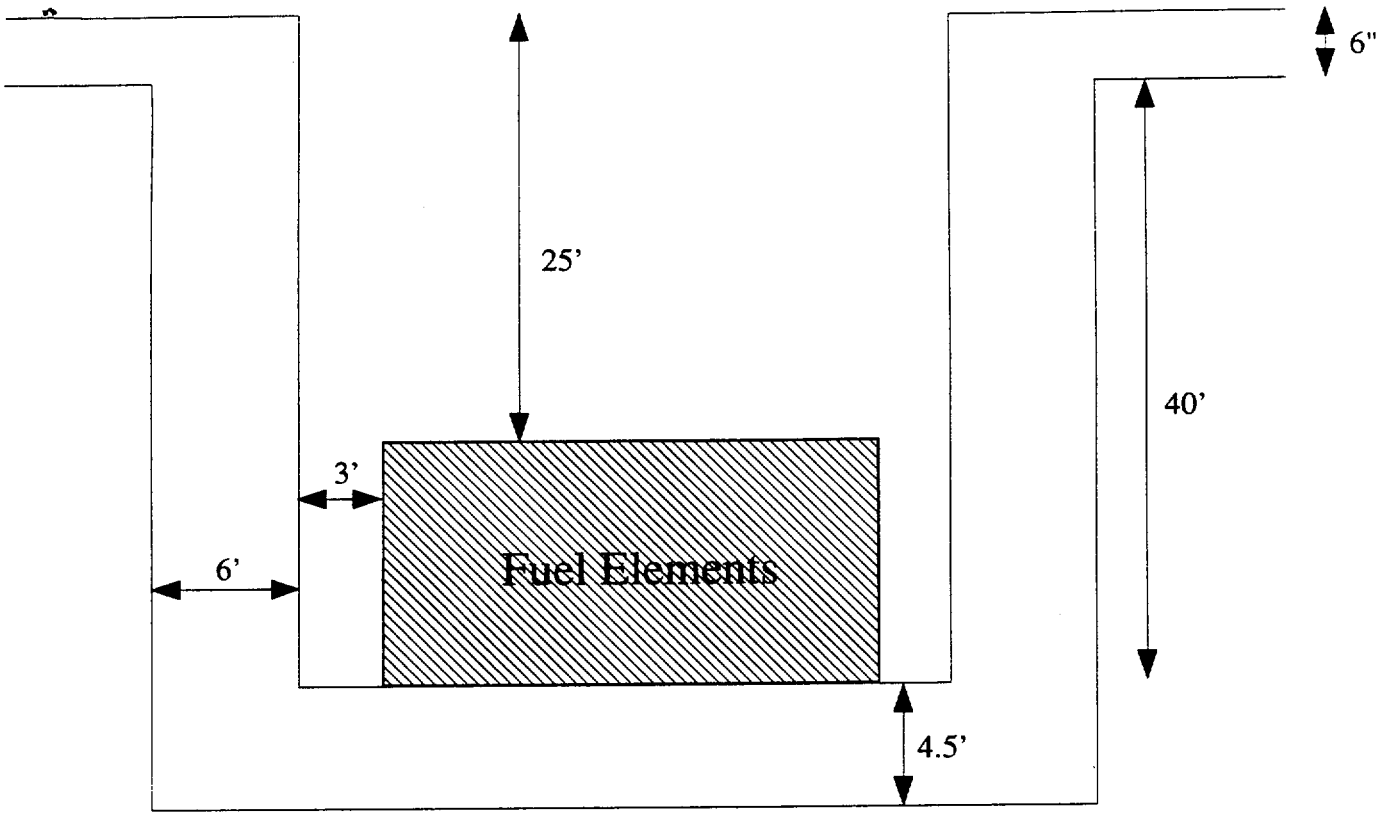

Figure 1a. PWR spent fuel pool model, elevation diagram.

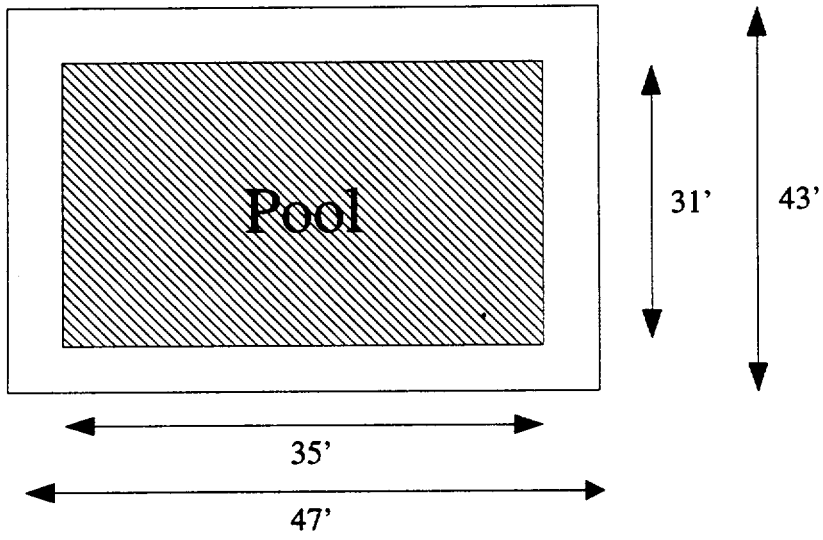

Figure 1b. Older PWR spent fuel building model.

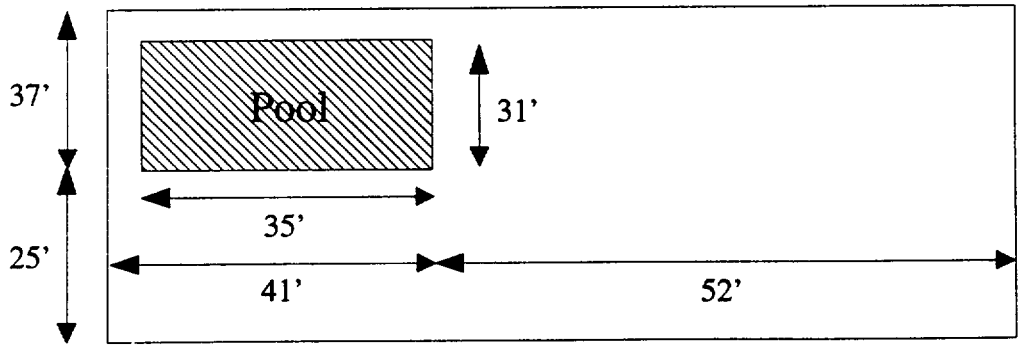

Figure 1c. Newer PWR spent fuel building model.

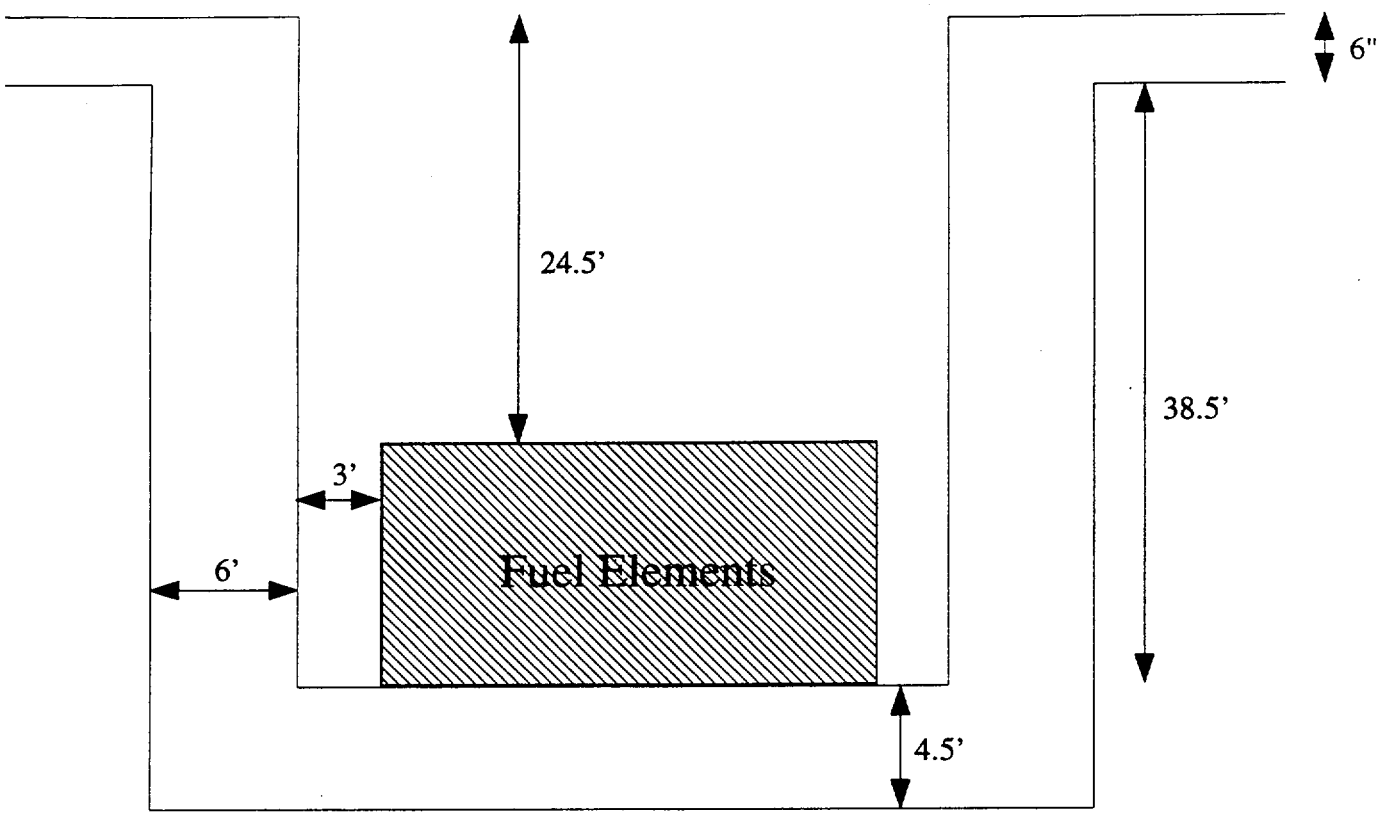

Figure 2a. BWR spent fuel pool model, elevation diagram.

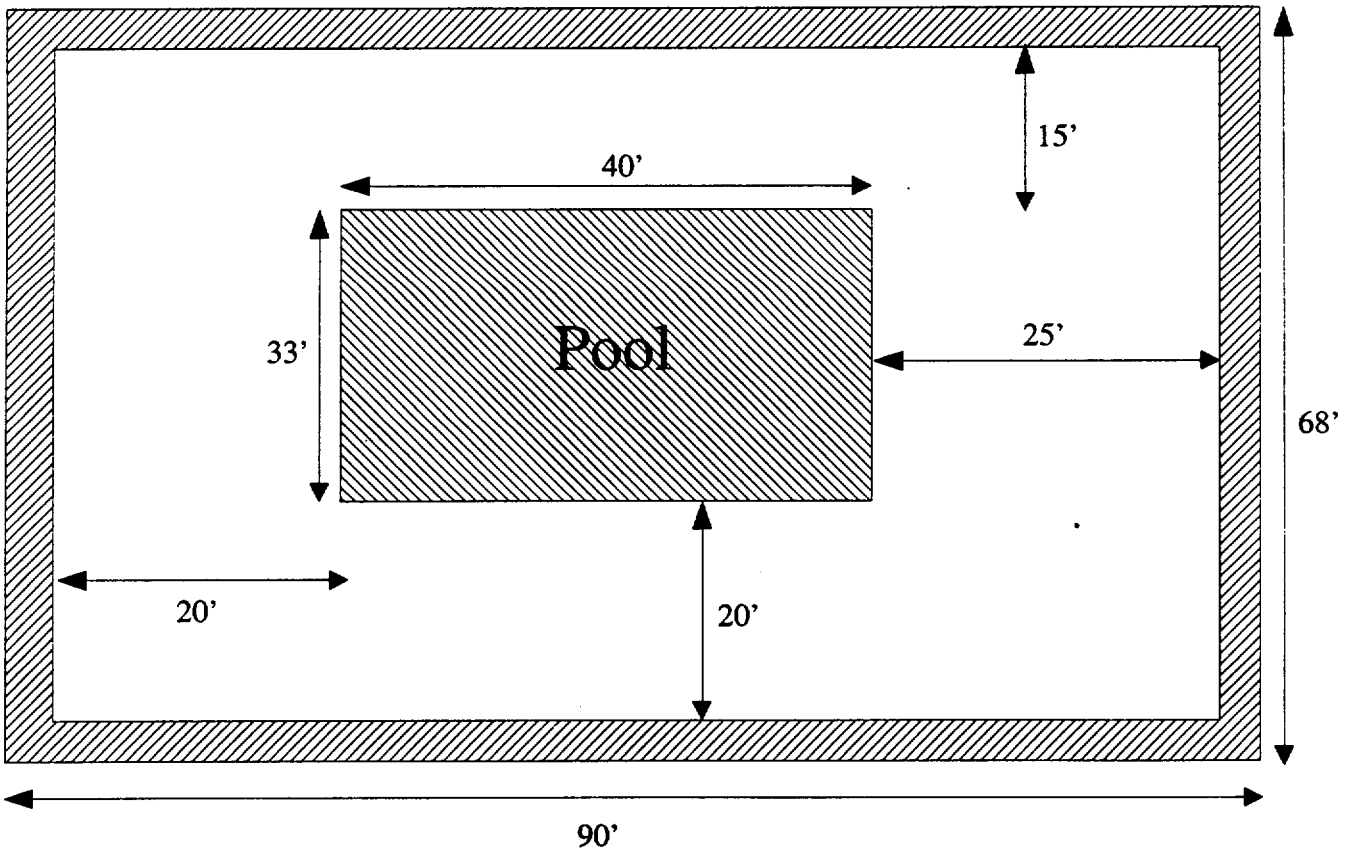

Figure 2b. BWR spent fuel building model, floor–level diagram.

Figure 3: Dose rate at Spent Fuel Pool Lip

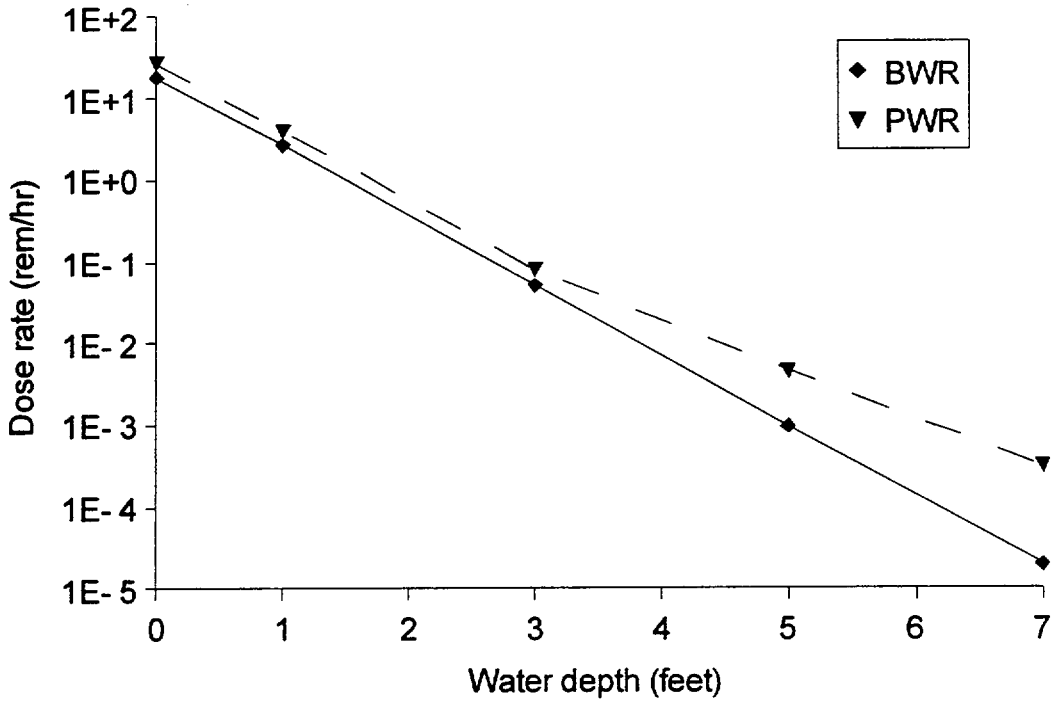

Figure 4: Dose Rate 5' from Pool Lip for PWR