Exhibit 141a
Amended Rough Calculations: Dose Emanating from Bottom of Tipped-Over Cask

In this supplementary exhibit to Exhibit 141, I corrected several assumptions in prefiled Exhibit 141 and recalculated the exposures at the fence post. The changed assumptions are the following.

a) In exhibit 141, HI-TRAC was assumed to have a 1" lead thickness. The correct value is 1.5". This increases the original estimate of internal dose rate.
b) In exhibit 141, the HI-STORM was assumed to have a 3" base plate, whereas the correct value is 2". This increases the original estimate of external dose rate at 1 meter.
c) The closest distance from the overturned casks to the fence post was assumed to be 555m in exhibit 141, whereas the correct value is 600m. This decreases the dose.
d) The inverse relation between distance and dose rate was taken in exhibit 141 to be $I = S*\theta/h$, where h is the distance from the line of overturned casks to the fence post, S is the linear dose rate and θ is the angle to each side of the row of casks, approximately 45°. In fact, the relation is $I = S*\theta/4\pi h$. This decreases the dose by a factor of 4π.

All gamma dose calculations are identical except for the above changes and correction of minor errors in the previous calculation. The results for gamma dose rates are shown in Tables 11-14 for both the pre-filed testimony and the recalculated dose rates. The final gamma dose results are given for hourly, 2000 hr/y and 8760 hr/y doses, the latter being for a full-time resident.

Following the gamma dose rates I calculated the neutron dose rate from the bottom of the cask that was inadvertently neglected in exhibit 141. The bottom of the HI-TRAC cask and the annulus of the HI-STORM cask have relatively thin layers of lead and steel, neither of which is effective as a neutron absorber. Hydrogen in the form of water or cement is far more effective as a neutron absorber. For neutrons I go through the same calculations as done previously for gamma doses. I limit the area to a ring annulus that effectively reduces the bottom dose rate by 13.45%. I consider the neutron source as a line source and evaluate it at the distance 600m to the fence post. Note we do not take into account the humidity that contains water. We also do not take into account the production of gamma rays due to the interaction between neutrons and steel or lead. The result for neutron dose rate is given in Table 15. The combined neutron plus gamma dose rate is given in Table 16.

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Docket No. _____ Official Exh. No. 141A

In the matter of PFS

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Intervenor ✓ REJECTED _____

Other _____ WITHDRAWN _____

DATE 6-25-02 Witness _____

Clerk pmp

Gamma Dose Rate Calculation

Table 1 below, materials parameters, is reproduced from Exhibit 141. Tables 11 through 16 below consecutively follow the numbering of tables from Exhibit 141.

Table 1: Tenth Value Layers of Radionuclides

Radionuclide	Gamma Energy (MeV)	Tenth-Value Layer Concrete (cm)	Steel (cm)	Lead (cm)	Shielding Coefficient Concrete (1/cm)	Steel (1/cm)	Lead (1/cm)
Cs-137	0.66	15.7	5.3	2.1	0.1467	0.4345	1.0965
Co-60	1.17, 1.33	20.6	6.9	4	0.1118	0.3337	0.5756

Table 11: Tipped-Over Cask Gamma Dose Rate

Radionuclide	HI-TRAC Dose Rate Outside (mrem/hr)	Pre-filed Dose Rate Inside (mrem/hr)	Recalculated Dose Rate Inside (mrem/hr)	Prefiled Bottom Dose Rate unshielded by concrete 13.45% (mrem/hr)	1.35% (mrem/hr)	Recalculated Bottom Dose Rate unshielded by concrete 13.45% (mrem/hr)	1.35% (mrem/hr)
Cs-137	238.28	80266.80	323070.89	394.02	39.40	4781.12	478.11
Co-60	3058.38	135772.02	282039.73	1436.10	143.61	6963.07	696.31

Table 12: Line Source Term and Dose Rate at Boundary

Radionuclide	Prefiled Single Cask Dose Rate @ 1 meter 13.45% (mrem/h)	1.35% (mrem/h)	Recalculated Single Cask Dose Rate @ 1 meter 13.45% (mrem/h)	1.35% (mrem/h)	Prefiled Linear Source Term 13.45% (mrem/m-hr)	1.35% (mrem/m-hr)	Recalculated Linear Source Term 13.45% (mrem/m-hr)	1.35% (mrem/m-hr)
Cs-137	394.02	39.40	4781.12	478.11	68.08	6.81	826.13	82.61
Co-60	1436.10	143.61	6963.07	696.31	248.14	24.81	1203.14	120.31

Table 13: Dose Rate at Controlled Area Boundary; No Attenuation in Air

	Prefiled Dose Rate @ 555 meters (13.45%)			Recalculated Dose Rate @ 600 meters (13.45%)		
Radionuclide	mrem/hr	2000 hr/yr mrem/yr	8760 hr/yr mrem/yr	mrem/hr	2000 hr/yr mrem/yr	8760 hr/yr mrem/yr
Cs-137	0.0970	194.02	849.80	0.0807	161.48	707.29
Co-60	0.3536	707.14	3097.27	0.1176	235.18	1030.07

Table 14: Dose Rate at Controlled Area Boundary with Attenuation in Air

	Prefiled Dose Rate @ 555 meters (13.45%)			Recalculated Dose Rate @ 600 meters (13.45%)		
Radionuclide	mrem/hr	2000 hr/yr mrem/yr	8760 hr/yr mrem/yr	mrem/hr	2000 hr/yr mrem/yr	8760 hr/yr mrem/yr
Cs-137	0.0045	9.06	39.68	0.0024	4.88	21.37
Co-60	0.0455	91.08	398.93	0.0110	21.99	96.30
		Total =	438.60		Total =	117.67

Neutron Dose Rate Calculation

Table 15: Tipped-Over Cask Neutron Dose Rate

	HI-TRAC Dose Rate Outside (mrem/hr)	Single Cask Dose Rate @ 1 meter 13.45% (mrem/h)	Linear Source Term (mrem/m-hr)	Neutron Dose Rate @ 600 meters (13.45%)		
				mrem/hr	2000 hr/yr mrem/yr	8760 hr/yr mrem/yr
Neutron	554.51	74.58	12.89	0.0013	2.52	11.03

As seen, the neutron dose contributes an additional 10% to the dose rate at the fence post. The combined gamma and neutron dose is shown in Table 16 below. As seen, the total yearly dose for a person continually residing at the fence post is 128.71 mrem/year, and the 50-year dose is then 6.4 rems, above the EPA's Protective Action Guide of 5 rems.

Table 16: Combined Neutron and Gamma Dose Rate

	Dose Rate @ 600 meters (13.45%)		
	mrem/hr	2000 hr/yr mrem/yr	8760 hr/yr mrem/yr
Neutron	0.0013	2.52	11.03
Gamma	0.0134	26.87	117.67
Total	0.0147	29.39	128.71