

Date: December 16, 2003

From: Walter Harper, LAB 2C-N

To: John Higgins, CST17B-C

Subject: Browns Ferry Nuclear Plant Tower Usage and Load Reductions Under Proposed Increase in Reactor Power Levels and Unit 1 Restart

John,

I have run our simulation model for the period from January 1, 1969 through December 31, 2002, excluding the years 1989 and 1990. Two alternatives were evaluated, computing cooling tower usage and load reductions necessary to remain in compliance with all thermal standards and operating guidelines (turbine back-pressure).

Alternative 1

Units 2 and 3 are upgraded to 120% of design reactor power with no additional cooling tower capacity. The results of the Alternative 1 simulations are shown in Table 1 and Table 2.

Alternative 2

Units 1, 2, and 3 are upgraded to 120% of design reactor power, with one additional rectangular mechanical draft tower, built on the footprint of the original tower #4, bringing the total number of towers to six. The new tower would have design water and wet bulb temperatures similar to those of the current BFN cooling tower #3, but would have a 25% greater water flow rate. The results of the Alternative 2 simulations are shown in Table 3 and Table 4.

From this analysis, the net generation for Alternative 2 would be about 43% greater than the net generation for Alternative 1, 66% greater than the net generation for the current plant configuration (Table 5), and 16% greater than the net generation for the original plant configuration (Table 7).

Definitions of abbreviations/variable names for Safety/Operational limits:

bpmax - turbine backpressure limit (5.5 inches/hg)
tcmx - maximum allowable intake temperature
dtmmax - maximum allowable downstream river temperature rise
tdsmx - maximum allowable downstream river temperature

Please note the following assumptions/conditions:

1. Maximum cooling tower lift pump flow rates of 289 cfs/pump for the older towers (#'s 1,2,5, and 6) and 314 cfs/pump for the newer existing rectangular tower (#3) are based on estimates made by Marilyn Reeves (PEC 1A-BFN) in a phone conversation on 8/01/1999. This accounts for the necessary throttling of the pumps in the old towers to prevent overflow of structures within the towers. The new tower to be built under Alternative 2 is assumed to have a maximum cooling tower lift pump flow rate of 392.4 cfs/pump (25% greater than the existing tower #3).
2. The assumed tower capability of 80% for the old towers (1, 2, 5, and 6) is an average estimate based on historical operational data and single point measurements of tower effluent temperature received from Ray Swafford (PEC 2D-BFN) on 8/01/1999. Tower capabilities for tower #3 and the proposed tower #4 are set at 96%, based on the results of the thermal acceptance test of tower #3.
3. An "action level" of 89.0 °F was used for changes in cooling tower usage. When the computed 24 hour averaged downstream temperature reached 89.0 °F, additional lift pumps were turned on and/or additional unit(s) was placed on towers until the computed 24 hour averaged downstream temperature dropped below 89.0 °F. Towers were put in service in order of their cooling capacity, taking into account the reduced flow rates in the older towers, with the highest capacity towers being added first. If no additional tower operation was possible, no action was taken until one of the downstream thermal limits would be exceeded, at which point unit loads were reduced sufficiently to bring the downstream temperature within the thermal standards.
4. When load reductions were needed, unit loads were reduced on one unit at a time in 50 MWe increments until the thermal limits were met. If a unit was derated to below 440 MWe generation, it was shut down and derates began on the next unit. When a unit was shut down, its condenser cooling water (CCW) pumps remained in operation, but the unit's cooling water was sent directly to the diffusers instead of to the cooling towers. This allows the towers to cool the CCW flow from the remaining units more efficiently.
5. Note that a turbine backpressure limit of 5.5 inches Hg was used instead of the previously used value of 4.5 inches Hg. Early runs at the 120% power level indicated that significant load reduction would be needed to keep the turbine backpressure below 4.5 inch Hg.

Please call (865) 632-1882 if we can be of further assistance.

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Table 1. Load Reductions And Tower Usage For Units 2 And 3 At 120% Design Power Level With Existing Towers (Alternative 1)

Breakdown of Load Reductions and Tower Usage										
Number of Units: 2										
Number of Towers: 5										
Downstream Temperature Limit (24-hr avg): 90.0										
Cooling Tower Capabilities: 80 80 96 80 80										
Maximum Unit Reactor Power Levels (MWt): 0 3951 3951										
Maximum Unit Loads (MWe): 0 1280 1280										
Plant operation decisions based on 24 hr averaged downstream temperatures										
Maximum Unit Loads (MWe): 0 1280 1280										
Column 1: year										
Column 2: Net generation (MW-hr)										
Column 3: Cumulative hours of reduced load										
Column 4: Cumulative hours of cooling tower usage										
Column 5: Total load reductions & tower energy (Mw-Hr)										
Column 6: Total (non-tower) load reductions (Mw-Hr)										
Column 7: Number of cooling-tower-hours of required operation										
Column 8: Load reductions due to 24-hr tdsmax restriction										
Column 9: Load reductions due to dtmmax restriction										
Column 10: Load reductions due to 1-hr tdsmax restriction										
Column 11: Load reductions due to bpmax restriction										
Column 12: Load reductions due to tcmax restriction										
1985	22067774	0	163	4319	0	633	0	0	0	0
1986	21969254	37	835	66328	39654	3787	39654	0	0	0
1987	22036764	0	430	13785	0	1956	0	0	0	0
1988	22120170	0	579	18137	0	2583	0	0	0	0
1991	22036116	0	500	15574	0	2220	0	0	0	0
1992	22173664	0	28	686	0	102	0	0	0	0
1993	21887302	74	808	171046	144436	3760	144436	0	0	0
1994	22085834	0	27	817	0	117	0	0	0	0
1995	22015690	0	737	23414	0	3327	0	0	0	0
1996	22137316	0	171	4923	0	711	0	0	0	0
1997	22097194	0	288	8664	0	1242	0	0	0	0
1998	22013868	0	473	15209	0	2157	0	0	0	0
1999	21944674	38	598	95303	76686	2654	76686	0	0	0
2000	22087050	0	599	18218	0	2607	0	0	0	0
2001	22063492	0	221	6932	0	987	0	0	0	0
2002	21992824	0	924	29244	0	4158	0	0	0	0
Total:	3.53E+08	149	7381	492599	260776	33001	260776	0	0	0

**Table 2. Plant Shut Downs for Units 2 And 3 At 120% Design Power Level
With Existing Towers (Alternative 1)**

Breakdown of Plant Shut Downs					
Number of Units: 2					
Number of Towers: 5					
Downstream Temperature Limit (24-hr avg): 90.0					
Cooling Tower Capabilities: 80 80 96 80 80					
Maximum Unit Reactor Power Levels (MWt): 0 3951 3951					
Maximum Unit Loads (MWe): 0 1280 1280					
Plant operation decisions based on 24 hr averaged downstream temperatures					
Column 1: year					
Column 2: shut downs due to 24-hr tdsmax restriction					
Column 3: shut downs due to dtmmax restriction					
Column 4: shut downs due to 1-hr tdsmax restriction					
Column 5: shut downs due to bpmmax restriction					
Column 6: shut downs due to tcmax restriction					
1985	0	0	0	0	0
1986	3	0	0	0	0
1987	0	0	0	0	0
1988	0	0	0	0	0
1991	0	0	0	0	0
1992	0	0	0	0	0
1993	54	0	0	0	0
1994	0	0	0	0	0
1995	0	0	0	0	0
1996	0	0	0	0	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	26	0	0	0	0
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
Total:	83	0	0	0	0

Table 3. Load Reductions and Tower Usage for Units 1, 2, and 3 at 120% Design Power Level with One New Rectangular Mechanical Draft Towers (Alternative 2)

Breakdown of Load Reductions and Tower Usage										
Number of Units: 3										
Number of Towers: 6										
Downstream Temperature Limit (24-hr avg): 90.0										
Cooling Tower Capabilities: 80 80 96 96 80 80										
Maximum Unit Reactor Power Levels (MWt): 3951 3951 3951										
Maximum Unit Loads (MWe): 1280 1280 1280										
Plant operation decisions based on 24 hr averaged downstream temperatures										
Maximum Unit Loads (MWe): 1280 1280 1280										
Column 1: year										
Column 2: Net generation (MW-hr)										
Column 3: Cumulative hours of reduced load										
Column 4: Cumulative hours of cooling tower usage										
Column 5: Total load reductions & tower energy (Mw-Hr)										
Column 6: Total (non-tower) load reductions (Mw-Hr)										
Column 7: Number of cooling-tower-hours of required operation										
Column 8: Load reductions due to 24-hr tdsmax restriction										
Column 9: Load reductions due to dtmmax restriction										
Column 10: Load reductions due to 1-hr tdsmax restriction										
Column 11: Load reductions due to bpmmax restriction										
Column 12: Load reductions due to tcmax restriction										
1985	33096688	0	234	7768	0	1050	0	0	0	0
1986	32652206	146	993	393411	355533	5145	355533	0	0	0
1987	33043236	0	713	26223	0	3544	0	0	0	0
1988	33159156	9	792	40738	10899	4020	10899	0	0	0
1991	33044952	0	723	27914	0	3777	0	0	0	0
1992	33257576	0	58	2025	0	269	0	0	0	0
1993	32747752	129	1063	332053	289749	5716	289749	0	0	0
1994	33126744	0	67	1788	0	236	0	0	0	0
1995	32926900	37	924	124301	87383	4983	87383	0	0	0
1996	33201432	0	283	9571	0	1289	0	0	0	0
1997	33128752	9	375	25914	10827	2034	10827	0	0	0
1998	33007588	0	773	29895	0	4048	0	0	0	0
1999	32904652	46	736	148832	119591	3946	119591	0	0	0
2000	33107752	10	817	43012	11404	4264	11404	0	0	0
2001	33088148	0	322	12627	0	1712	0	0	0	0
2002	32934980	21	1155	89804	43962	6194	43962	0	0	0
Tota:	5.28E+08	407	10028	1315876	929348	52227	929348	0	0	0

Table 4. Plant Shut Downs for Units 1, 2, and 3 at 120% Design Power Level with Two New Rectangular Mechanical Draft Towers in New Footprints (Alternative 2A)

Breakdown of Plant Shut Downs					
Number of Units: 3					
Number of Towers: 6					
Downstream Temperature Limit (24-hr avg): 90.0					
Cooling Tower Capabilities: 80 80 96 96 80 80					
Maximum Unit Reactor Power Levels (MWt): 3951 3951 3951					
Maximum Unit Loads (MWe): 1280 1280 1280					
Plant operation decisions based on 24 hr averaged downstream temperatures					
Column 1: year					
Column 2: shut downs due to 24-hr tdsmax restriction					
Column 3: shut downs due to dtmmax restriction					
Column 4: shut downs due to 1-hr tdsmax restriction					
Column 5: shut downs due to bpmax restriction					
Column 6: shut downs due to tcmax restriction					
1985	0	0	0	0	0
1986	67	0	0	0	0
1987	0	0	0	0	0
1988	0	0	0	0	0
1991	0	0	0	0	0
1992	0	0	0	0	0
1993	48	0	0	0	0
1994	0	0	0	0	0
1995	18	0	0	0	0
1996	0	0	0	0	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	26	0	0	0	0
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	8	0	0	0	0
Total:	167	0	0	0	0

**Table 5. Load Reductions And Tower Usage For Two Units At 105% Design Power Level
With Existing Towers**

Breakdown of Load Reductions and Tower Usage										
Number of Units: 2										
Number of Towers: 5										
Downstream Temperature Limit (24-hr avg): 90.0										
Cooling Tower Capabilities: 80 80 96 80 80										
Maximum Unit Reactor Power Levels (MWt): 0 3457 3457										
Maximum Unit Loads (MWe): 0 1152 1152										
Plant operation decisions based on 24 hr averaged downstream temperatures										
Maximum Unit Loads (MWe): 0 1152 1152										
Column 1: year										
Column 2: Net generation (MW-hr)										
Column 3: Cumulative hours of reduced load										
Column 4: Cumulative hours of cooling tower usage										
Column 5: Total load reductions & tower energy (Mw-Hr)										
Column 6: Total (non-tower) load reductions (Mw-Hr)										
Column 7: Number of cooling-tower-hours of required operation										
Column 8: Load reductions due to 24-hr tdsmax restriction										
Column 9: Load reductions due to dtmmax restriction										
Column 10: Load reductions due to 1-hr tdsmax restriction										
Column 11: Load reductions due to bpmax restriction										
Column 12: Load reductions due to tcmax restriction										
1985	19963872	0	94	2398	0	354	0	0	0	0
1986	19890914	18	664	46073	24606	3042	24606	0	0	0
1987	19932444	0	339	10391	0	1485	0	0	0	0
1988	20005356	0	490	14631	0	2100	0	0	0	0
1991	19933376	0	389	11647	0	1671	0	0	0	0
1992	20046560	0	0	0	0	0	0	0	0	0
1993	19810152	61	727	135282	111876	3319	111876	0	0	0
1994	19973198	0	9	172	0	27	0	0	0	0
1995	19915576	0	641	20977	0	2967	0	0	0	0
1996	20015942	0	105	2608	0	387	0	0	0	0
1997	19978358	0	242	7484	0	1068	0	0	0	0
1998	19922140	0	352	11091	0	1578	0	0	0	0
1999	19869140	27	498	75094	59274	2248	59274	0	0	0
2000	19984442	0	489	14461	0	2079	0	0	0	0
2001	19959420	0	146	4596	0	654	0	0	0	0
2002	19902668	0	738	22530	0	3222	0	0	0	0
Total:	3.19E+08	106	5923	379435	195756	26201	195756	0	0	0

**Table 6. Plant Shut Downs For Two Units At 105% Design Power Level
With Existing Towers**

Breakdown of Plant Shut Downs					
Number of Units: 2					
Number of Towers: 5					
Downstream Temperature Limit (24-hr avg): 90.0					
Cooling Tower Capabilities: 80 80 96 80 80					
Maximum Unit Reactor Power Levels (MWt): 0 3457 3457					
Maximum Unit Loads (MWe): 0 1152 1152					
Plant operation decisions based on 24 hr averaged downstream temperatures					
Column 1: year					
Column 2: shut downs due to 24-hr tdsmax restriction					
Column 3: shut downs due to dtmmax restriction					
Column 4: shut downs due to 1-hr tdsmax restriction					
Column 5: shut downs due to bpmmax restriction					
Column 6: shut downs due to tcmax restriction					
1985	0	0	0	0	0
1986	9	0	0	0	0
1987	0	0	0	0	0
1988	0	0	0	0	0
1991	0	0	0	0	0
1992	0	0	0	0	0
1993	40	0	0	0	0
1994	0	0	0	0	0
1995	0	0	0	0	0
1996	0	0	0	0	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	27	0	0	0	0
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
Total:	76	0	0	0	0

**Table 7. Load Reductions And Tower Usage For Three Units At 100% Design Power Level
With Original Towers**

Breakdown of Load Reductions and Tower Usage										
Number of Units: 3										
Number of Towers: 6										
Downstream Temperature Limit (24-hr avg): 90.0										
Cooling Tower Capabilities: 80 80 80 80 80 80										
Maximum Unit Reactor Power Levels (MWt): 3293 3293 3293										
Maximum Unit Loads (MWe): 1098 1098 1098										
Plant operation decisions based on 24 hr averaged downstream temperatures										
Maximum Unit Loads (MWe): 1098 1098 1098										
Column 1: year										
Column 2: Net generation (MW-hr)										
Column 3: Cumulative hours of reduced load										
Column 4: Cumulative hours of cooling tower usage										
Column 5: Total load reductions & tower energy (Mw-Hr)										
Column 6: Total (non-tower) load reductions (Mw-Hr)										
Column 7: Number of cooling-tower-hours of required operation										
Column 8: Load reductions due to 24-hr tdsmax restriction										
Column 9: Load reductions due to dtmmax restriction										
Column 10: Load reductions due to 1-hr tdsmax restriction										
Column 11: Load reductions due to bpmax restriction										
Column 12: Load reductions due to tcmax restriction										
1985	28585390	0	148	4906	0	699	0	0	0	0
1986	28157826	189	820	390066	360057	4243	360057	0	0	0
1987	28525534	0	501	19124	0	2689	0	0	0	0
1988	28627942	0	633	25688	0	3598	0	0	0	0
1991	28519992	10	609	34348	9986	3416	9986	0	0	0
1992	28700332	0	18	344	0	54	0	0	0	0
1993	28193306	150	937	350834	313515	5230	313515	0	0	0
1994	28595610	0	38	1108	0	161	0	0	0	0
1995	28434696	38	846	110291	76601	4723	76601	0	0	0
1996	28648456	0	184	6485	0	920	0	0	0	0
1997	28563736	11	318	41704	29003	1783	29003	0	0	0
1998	28514820	0	572	21020	0	2973	0	0	0	0
1999	28408482	56	660	150105	124209	3636	124209	0	0	0
2000	28586760	20	657	44083	19494	3469	19494	0	0	0
2001	28571878	0	219	8547	0	1198	0	0	0	0
2002	28460740	22	993	65745	25976	5569	25976	0	0	0
Total:	4.56E+08	496	8153	1274398	958841	44361	958841	0	0	0

**Table 8. Plant Shut Downs For Three Units At 100% Design Power Level
With Original Towers**

Breakdown of Plant Shut Downs					
Number of Units: 3					
Number of Towers: 6					
Downstream Temperature Limit (24-hr avg): 90.0					
Cooling Tower Capabilities: 80 80 80 80 80 80					
Maximum Unit Reactor Power Levels (MWt): 3293 3293 3293					
Maximum Unit Loads (MWe): 1098 1098 1098					
Plant operation decisions based on 24 hr averaged downstream temperatures					
Column 1: year					
Column 2: shut downs due to 24-hr tdsmax restriction					
Column 3: shut downs due to dtmmax restriction					
Column 4: shut downs due to 1-hr tdsmax restriction					
Column 5: shut downs due to bpmmax restriction					
Column 6: shut downs due to tcmax restriction					
1985	0	0	0	0	0
1986	62	0	0	0	0
1987	0	0	0	0	0
1988	0	0	0	0	0
1991	0	0	0	0	0
1992	0	0	0	0	0
1993	62	0	0	0	0
1994	0	0	0	0	0
1995	18	0	0	0	0
1996	0	0	0	0	0
1997	8	0	0	0	0
1998	0	0	0	0	0
1999	26	0	0	0	0
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
Total:	176	0	0	0	0