Northeast
Utilities System

The Eastern Connecticut Reliability Project

Stability Analysis

revised April 12, 2004
revised April 29,2004

Timothy F. Laskowski
Northeast Utilities
Transmission Planning

Executive Summary

This report summarizes time simulations performed to evaluate stability on the Eastern region of Connecticut.

Several probable contingencies, such as the loss of the 69-kV 100-line or the loss of the 115-kV 1080-line or the loss of the 1000-1080 DCT, result in either severe overloads, extremely low, unacceptable voltages or voltage collapse. Steady state analysis of the region indicated the following upgrades to relieve the problems:

- Splitting the existing 345-kV Sherman to Lake Road 347 line, terminating the ends to the Tracy 14M Substation, which creates a new Tracy to Sherman 347E line and a new Tracy to Lake Road 347W line. A 345 kV breaker is to be added at the Tracy end of the 347E line.
- Add a new 345/115-kV autotransformer at the Tracy 14M Substation with a 600/600/600 MVA summer thermal rating and (0.00063 + 0.03703) per unit impedance on a 100 MVA base. Additional 115 KV breakers for the transformer are added at Tracy 14M.
- Add a new 345 kV breaker at the Card 11F substation.

Results of this study indicate that the proposed upgrades would not cause an adverse stability impact on the reliability or operating characteristics of the NEPOOL power system.

The study also results in the recommendation that the Lake Road SPS will shut down all three of the Lake Road units and disconnect them from the system within three to four seconds of a trip for the 347E or 347W Line, eliminating the need to trip for the 330 line.

The project is to be completed and placed in service in December 2006.

Introduction

The purpose of this report is to present the Eastern Connecticut, Reliability Project dynamic stability analysis to the Stability Task Force. The proposed in service date for the Project is December 2006.

The Eastern Connecticut System extends from the Rhode Island border in a westerly direction for 20 to 25 miles. It runs from Long Island Sound to Massachusetts.

The Eastern Connecticut area was evaluated using steady-state analyses to determine its capability to serve peak load and light load.

The required transmission upgrades from the steady-state analyses report are as follows:

1. Split the existing 345-kV Sherman to Lake Road 347 line, terminating the ends to the Tracy 14M Substation, which creates a new Tracy to Sherman 347E line

and a new Tracy to Lake Road 347W line. A 345 kV breaker is to be added at the Tracy end of the 347E line.

2. Add a new 345/115-kV autotransformer at the Tracy 14M Substation with a 600/600/600 MVA summer thermal rating and (0.00063 + 0.03703) per unit impedance on a 100 MVA base. Additional 115 KV breakers for the transformer are added at Tracy 14M.
3. Add a new 345 kV breaker at the Card 11F substation.

A transmission network one-line diagram of the Eastern Connecticut area with the Tracy auto is shown in Figure 1. A proposed Tracy 14M Substation one-line diagram appears in Figure 2. Figure 3 shows the location of the new Card breaker.

Methodology

System Representation

The cases were developed from ISO-New England's (ISO-NE) 2000 library. The following system upgrades were added to the library case:

1. Phase 1 of the Southwest Connecticut project,
2. Haddam autotransformer,
3. Glenbrook statcom,
4. Shunock substation.

In the peak case, the New England Power Pool (NEPOOL) load is representative of approximately 27,700 MW. This is representative of a 2006 extreme summer peak load level (90/10). In the light load case, the New England Power Pool (NEPOOL) load is representative of approximately 11,700 MW. This is the 2006 light load level in the 2003 CELT report. Both cases include the required upgrades listed in the "Introduction" part of this report. The Tracy autotransformer is modeled to hold a 1.0348 per unit voltage at the 115-kV Tracy 14M Substation bus.

Initial Conditions

The peak load case was developed with the New Brunswick (NB) to New England (NE) transfer maintained at 700 MW. Power flow on the Long Island Cable(1385) was maintained at 0 MW. The Cross Sound Cable was exporting approximately 350 MW to Long Island. The New England to New York (NY) transfer was set at approximately 750 MW. The Phase II HVdc dispatch was maintained at 2000 MW. The Connecticut import was set at approximately 500 MW. The peak load case summary appears in Table 1.

The light load case was developed with the NB-NE transfer maintained at 700 MW. Power flow on the Long Island Cable(1385) was maintained at 0 MW. The Cross Sound Cable was exporting approximately 350 MW to Long Island. The New England to New York (NY) transfer was set at approximately 1200 MW. The Phase II HVdc dispatch was maintained at 0 MW. The Connecticut import was set at approximately 800 MW. Lake Road was considered out of Connecticut when calculating the import. The light load case summary appears in Table 2.

For both the peak and the light load case, the Eastern Connecticut and Western Rhode Island generation was scheduled to maximize stresses in the area around the Tracy autotransformer. In the light load case, the SEMA/RI export was approximately 3000 MW and the East-West interface was at 1700 MW. Note that in measuring the East-West interface flow that the Lake Road units were assumed in the West. If these units are assumed in the East, the East-West interface would be approximately 2600 MW.

Dynamic Stability Analysis

The dynamic stability analysis was performed using Power Technologies Inc. PSS/E version 28 software package. Simulations were first executed with the proposed project in place. If a simulation result was unacceptable, then a before project simulation was executed. The results from the pre-and post-project simulations are compared to determine the Project's impact on the power system.

Selection of Stability Contingencies

The majority of contingency faults that were simulated were located in and around the new Tracy 345 kV bus. All normal design criteria contingency faults were cleared by the slower of the two protection groups. A set of limiting normal and extreme contingencies were simulated. If the extreme contingency violated the normal contingency criteria, the corresponding normal contingency was simulated.

The contingency list appears in Table 3.

Lake Road Generating Station SPS

The current type 3 Lake Road SPS will shut down all three of the Lake Road units and disconnect them from the system within three to four seconds of a trip of either the 330 or 347 Line. Discussions late last year with the plant manager of Lake Road, indicated that Lake Road could accept a delta power change of 0.5 per unit that resulted from reclosing of the 345 kV lines connected to the plant. Table 4 shows the resulting delta power for a variety of Connecticut imports and exports. The resulting change in power after reclosing was never greater than 0.5 for the 330 line. The SPS which results in tripping of the Lake Road units should be modified such that it only trips the units when either the 347W or 347E line trips, eliminating the need for the 330 line trip.

Note that for simulations involving the loss of the 330 line from Lake Road to Card that the Lake Road units were never tripped. However, except for simulation 1 which was for Bulk Power System testing, whenever the 347W line from Lake Road to Tracy was tripped, a simulation with and without tripping of the Lake Road units was made. This demonstrates the consequences of failure of the Lake Road SPS.

Stability Performance Criteria

The following criteria define stable transmission system performance for normal contingencies.

- All units transiently stable except for units tripped for fault clearing
- A 50% reduction in the magnitude of system oscillations must be observed over four periods of the oscillation.
- Loss of source not greater than 1200 MW
- Having no Keswick GCX Relay entry

The following criteria define stable transmission system performance for an extreme contingency.

- A 50% reduction in the magnitude of system oscillations must be observed over four periods of the oscillation.
- A loss of source greater than 1400 MW is not immediately acceptable
- A loss of source between 1400 MW and 2200 MW may be acceptable depending upon the likelihood of occurrence and other factors
- A loss of source above 2200 MW is not acceptable
- NB tie Zone 2 entry

Discussion of Stability Results

Bulk Power System Testing

Simulation 1 is to test whether the Tracy 115 kV bus must be a Bulk Power System (BPS) station. In this simulation, a three phase fault was placed on the Tracy 115 kV bus. It was assumed that there was no communication from the station and thus all the remote terminals had to clear the fault. It was assumed that this occurred five seconds after fault inception. Four seconds after fault clearing the Lake Road units tripped as a result of the Lake Road Generating Station SPS on the 347 line. Since no other units lost synchronism and had to be tripped and since neither the Keswick GCX Relay nor the 396 line protection operating characteristics were entered, it was determined that it is not necessary for the Tracy 115 kV bus to be a BPS station.

The Tracy 345 kV bus will be a BPS station.

Other Simulations

The plots of all peak load simulations with the project are contained in Appendix A. The simulation number on the top of each page corresponds to the contingency as described in Table 3. All peak load simulations were stable, did not result in any additional machines being tripped and did not enter the Keswick GCX Relay.

The plots of all the light load simulations with the project are contained in Appendix B. As for the peak load simulations, the simulation number on the top of each page corresponds to the contingency described in Table 3. The Keswick SPS GCX relay entry occurred in Light Load Simulation 19 and Light Load Simulation 20. These are extreme contingency simulations of a 3 phase fault at the Card 11F end of the 330 line where either the Card 1T or 3T breaker sticks. These two simulations were then repeated

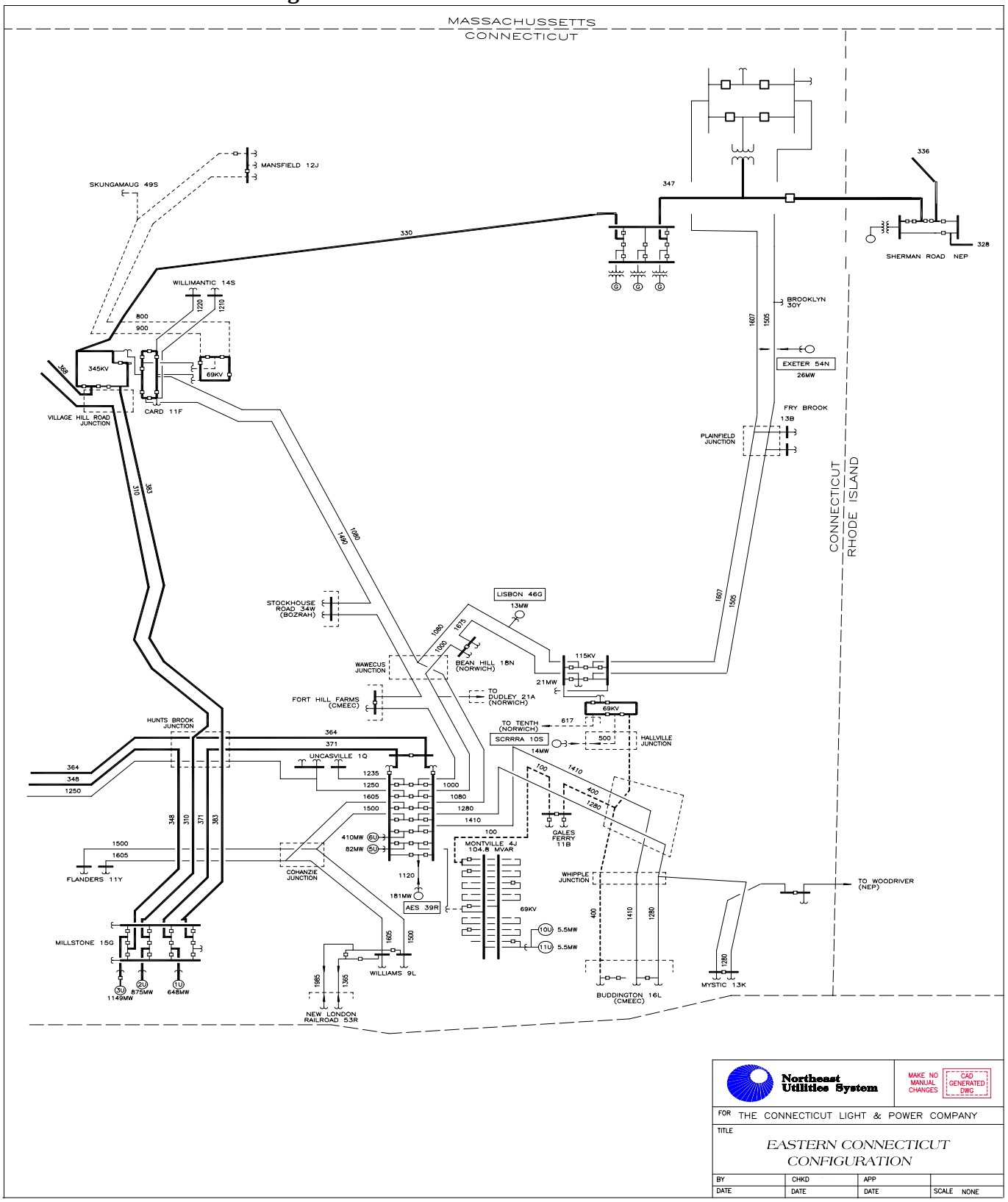
without the project. The resulting simulation plots are shown in Appendix C. Without the project Keswick SPS GCX entry also results. Since these two simulations were extreme contingencies, they were repeated with line to ground faults rather than three phase faults. The results of the simulations are labeled Light Load line-ground 19 and Light Load line-ground 20 are contained in Appendix D. No Keswick SPS GCX entry occurs.

Table 5 summarizes the simulations where the Lake Road SPS resulted in the Lake Road units being tripped.

Conclusion

The simulation results indicate that this project, specifically addition of the Tracy 345/115 kV autotransformer does not adversely impact the system from a stability view point.

Figure 1 – Eastern Connecticut



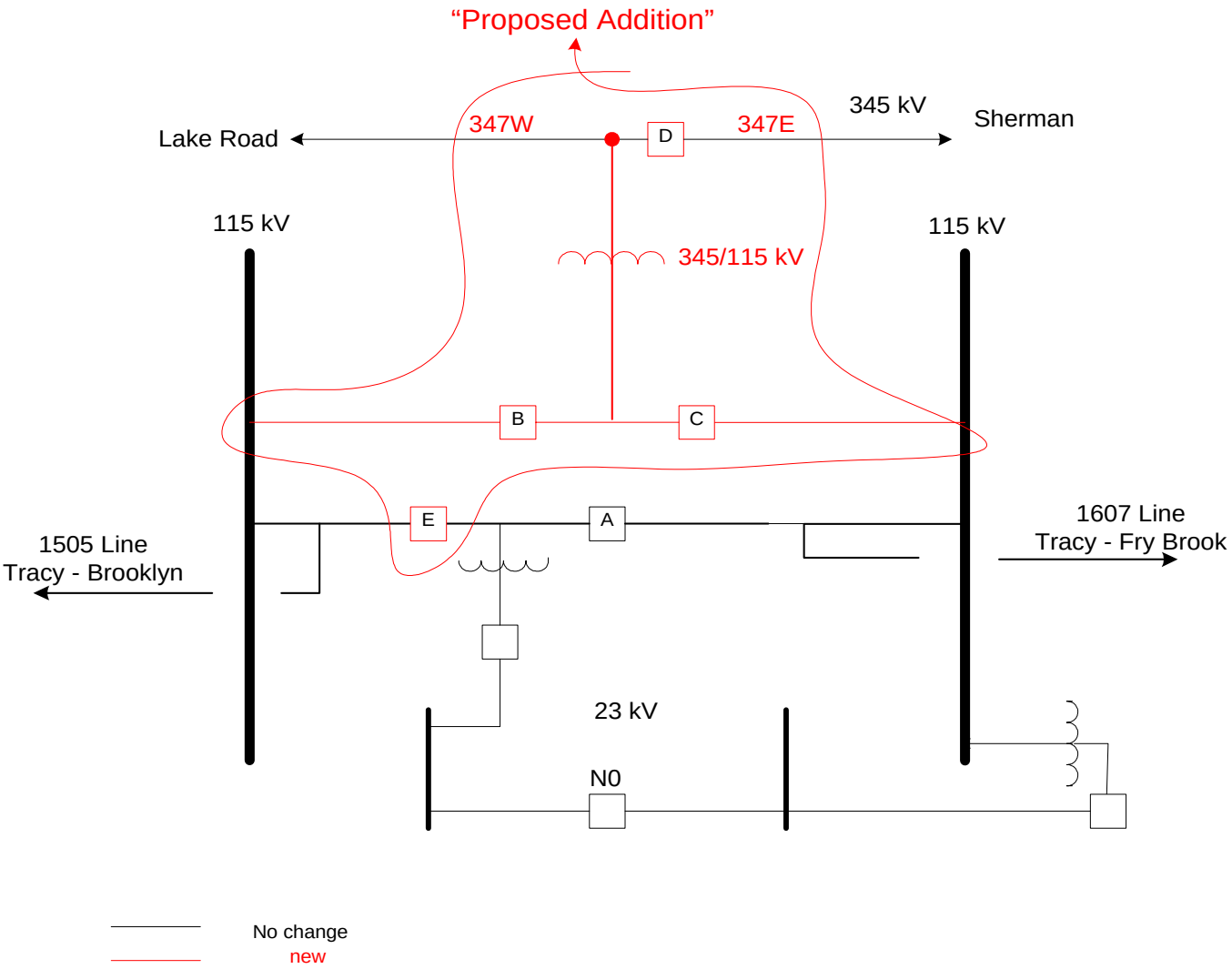


Figure 2. Tracy 14M expansion

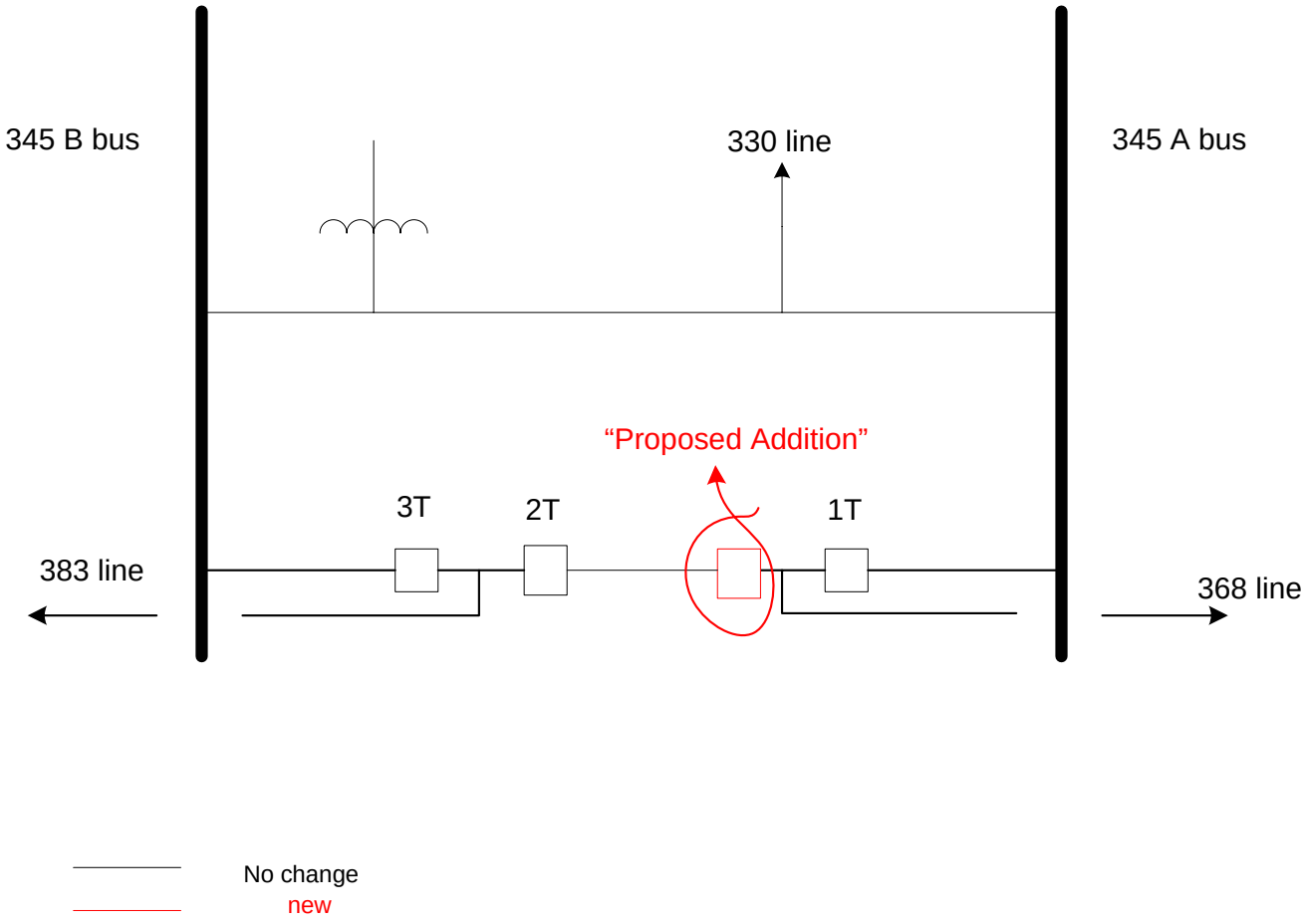


Figure 3. Card 11F Substation

Table 1 - Peak Load Summary

PEAK LOAD, NEW ENGLAND LIBRARY 2000
TRACY AUTO

GENERATION

#		V	MW	MX	#		V	MW	MX	#		V	MW	MX
70705	VTYAK G	0.980	667	150*	73072	ALT12 PF	1.032	65	20*	73073	ALT34 PF	1.031	80	20*
72986	BERKPWR	1.034	305	45	73069	MAPR1 PF	0.000	0	0	73070	MAPR2 PF	0.000	0	0
73071	MAPR3 PF	0.000	0	0	73085	MT.TOM	1.011	146	26	72512	BRSWP G1	0.989	280	57
72513	BRSWP G2	0.989	280	57	73083	NRTHFD12	0.000	0	0	73084	NRTHFD34	0.000	0	0
72933	STNYBK 1	1.043	87	15	72930	STNYBK1A	1.043	65	13	72931	STNYBK1B	1.043	65	13
72932	STNYBK1C	1.043	65	13	72934	STNYBK2A	1.043	65	13	72935	STNYBK2B	1.043	65	13
73080	WSPFLD 3	0.000	0	0	72244	MILLENST	0.000	0	0	72243	MILLENCT	0.000	0	0
73538	AESTH PF	0.990	180	16	73654	BE 10 ST	1.000	180	36	73652	BE 11	0.999	170	34
73653	BE 12	0.999	170	34	73647	BPTHBR#2	0.962	170	34	73648	BPTHBR#3	0.981	375	75
73570	DEVGAS11	1.041	40	14	73571	DEVGAS12	1.050	40	14	73572	DEVGAS13	1.050	40	14
73573	DEVGAS14	1.041	40	14	73553	DEVON#7	1.016	106	36	73554	DEVON#8	1.013	106	36
73565	LAKERD#1	1.010	305	68	73566	LAKERD#2	1.010	305	68	73567	LAKERD#3	1.010	305	68
73588	MERIDEN1	0.000	0	0	73589	MERIDEN2	0.000	0	0	73555	MIDDTN#2	0.991	117	13
73556	MIDDTN#3	0.978	236	13	73557	MIDDTN#4	1.019	400	165	73574	MILFD#1	1.017	305	11
73575	MILFD#2	1.017	305	11	73562	MILL#2	0.996	940	144	73563	MILL#3	0.992	1260	144
73558	MONTV#5	0.977	81	7	73559	MONTV#6	0.987	402	36	73651	NH HARBR	1.000	447	175*
73551	NORHAR#1	0.977	159	-9	73552	NORHAR#2	0.977	168	-9	73549	SMD1112J	1.051	72	4*
73550	SMD1314J	1.051	72	4*	73594	WALL LV1	1.025	102	14	73595	WALL LV2	1.025	102	14
73596	WALL LV3	1.025	51	11	73276	LISBN PF	1.015	14	0	73281	EXETR PF	1.030	26	22
70060	MIS GT1	0.000	0	0	70061	MIS GT2	0.000	0	0	70062	MIS ST	0.000	0	0
70377	AEC G1	0.000	0	0	70378	AEC G2	0.000	0	0	70379	AEC G3	0.000	0	0
70389	BUCKS G4	0.000	0	0	70426	CHAMP G2	0.919	15	6*	70424	CHAMP G3	0.997	65	32*
70374	MASON G3	0.000	0	0	70375	MASON G4	0.000	0	0	70376	MASON G5	0.000	0	0
70425	BC COGEN	0.000	0	0	70381	RPA CG1	0.000	0	0	70382	RPA SG2	0.000	0	0
70422	WARRN G1	0.997	51	15*	70423	WARRN G2	0.000	0	0	70386	WBK G1	0.000	0	0
70387	WBK G2	1.040	172	34	70388	WBK G3	0.000	0	0	70365	WF WY #1	0.000	0	0
70366	WF WY #2	1.014	57	8	70367	WF WY #3	1.014	100	16	70368	WF WY #4	0.000	0	0
71857	COMRF G1	1.010	41	-1	71858	COMRF G2	1.010	41	-1	71859	COMRF G3	1.010	41	-1
71860	COMRF G4	1.010	41	-1	71861	MOORE G1	1.002	48	-2	71862	MOORE G2	1.005	48	-2
71863	MOORE G3	1.020	48	11	71864	MOORE G4	1.038	48	11	72868	NWNGT G1	1.019	422	180*
70010	NEW_G1	0.000	0	0	70011	NEW_G2	0.000	0	0	70012	NEW_G3	0.000	0	0
71950	GRANRDG1	0.000	0	0	71951	GRANRDG2	0.000	0	0	72701	AESSTG	0.000	0	0
72866	MERMK G1	1.027	113	15	72867	MERMK G2	1.027	320	43	72869	SBRK G1	1.004	1314	309*
72870	SCHILLER	0.000	0	0	72872	SCHILLER	0.000	0	0	72871	SCHILLER	0.000	0	0
71123	KENDALL	0.000	0	0	72670	TIVER G2	0.000	0	0	71394	EMI_GEN	0.993	185	28
71067	MYS8 GTS	1.026	554	71	71068	MYS8 ST	1.039	311	71	71069	MYS9 GTS	1.095	554	468*
71070	MYS9 ST	1.081	311	200*	71060	MYST G4	0.000	0	0	71061	MYST 5G	0.000	0	0
71062	MYST G6	0.000	0	0	71063	MYST G7	1.018	565	71	71073	N.BOST 1	0.000	0	0
71074	N.BOST 2	0.000	0	0	71946	SALEM G1	0.000	0	0	71947	SALEM G2	0.000	0	0
71948	SALEM G3	1.028	143	41	71949	SALEM G4	1.032	400	124	72066	LOWELL	0.000	0	0
71095	ANPBLCK1	1.076	290	112	71096	ANPBLCK2	1.076	290	112	72377	BELL #1	1.086	290	150*
72378	BELL #2	1.086	290	150*	72372	BP #1 GN	0.000	0	0	72375	BP #2 GN	1.017	241	117*
72370	BP #3 GN	1.029	605	140	72371	BP #4 GN	1.036	425	105	71531	OSP1 PF	1.017	77	10
71532	OSP2 PF	1.017	77	10	71533	OSP3 PF	1.017	108	13	71534	OSP4 PF	1.017	77	10
71535	OSP5 PF	1.017	77	10	71536	OSP6 PF	1.017	108	13	71084	NEA GTPF	1.041	111	40*
71085	NEA GTPF	1.041	110	40*	71086	NEA STPF	1.058	80	55*	72666	FRSQ SC1	0.991	46	-5
72667	FRSQ SC2	0.991	46	-3	72668	FRSQ SC3	0.995	46	-5	72661	MANCH09A	1.001	119	15
72662	MANCH10A	1.000	119	15	72663	MANCH11A	1.001	119	15	72671	HOPE G1	1.074	180	67
72672	HOPE G2	1.070	180	67	72673	HOPE G3	1.075	185	67	72373	MPLP 1PF	0.000	0	0
72374	MPLP 2PF	0.000	0	0	71251	CANAL G1	1.029	566	239*	71252	CANAL G2	1.005	577	120*
71094	PLGRM G1	1.046	734	260*	70909	EDG GT1	1.022	276	28	70910	EDG GT2	1.022	276	28
70911	EDG ST1	1.020	311	28	71522	SOM G6	1.014	105	85	72669	TIVER G1	0.000	0	0

	MW	MX		MW	MX		MW	MX
MILLSTONE	2200	289	BRPT-ENERGY	520	104	MIDDLETOWN	753	190
MONTVILLE	483	44	NORWALK	327	-18	BPTHBR	550	111
NHHARBOUR	447	175	DEVON	212	73	MERIDEN	0	0
WALLINGFORD	255	40	TOWANTIC	0	0	BERKSHIRE	305	45
LAKEROAD	915	205	STONYBROOK	412	80	MILLENNIUM	0	0
BRAYTONPT	1271	361	HOPE	545	201	FRSQ	495	32
SOMERSET	105	85	OSP	523	65	NEA	301	135
CANAL	1143	359	PILGRIM	734	260	MASSPWRR	0	0
ANP-BELLINGHAM	580	300	ANP-BLACKSTONE	580	224	EMI-TIVERTON	0	0
EMI-DIGHTON	185	28	SITHE-EDGAR	863	85	MYSTIC	565	71
NEWBOSTON	0	0	SALEMHBR	543	165	SITHE-MYSTIC	1730	811
SEABROOK	1314	309	NEWINGTON	422	180	ConEd_Newington	0	0
SCHILLER	0	0	MERRIMACK	433	58	WYMAN	157	24
VTYANKEE	667	150	BEARSWAMP	560	115	NORTHFIELD	0	0
ALTRESCO	146	41	MIS	0	0	AEC	0	0

RPA	0	0	WESTBROOK	172	34	BUCKSPORT	0	0

INTERFACE FLOWS

NB-NE	700	-44	ORRING-SOUTH	311	-101	SUROWIEC-SOUTH	-429	24
MEYANKEE-SOUTH	18	-44	MAINE-NH	-671	6	NNE-SCOBIE+394	579	35
SEABROOK-SOUTH	993	93	NORTH-SOUTH	211	12	CMFD/MOORE-SO	257	-34
SNDYPOND-SOUTH	1411	236	CONN IMPORT	494	-149	CONN-MASS	-149	82
CONN-RI	-705	51	SW CONN IMPORT	1147	384	NORWLK-STAMFORD	968	-24
BOSTON IMPORT	2550	308	NEMA/BOS IMPORT	3040	206	SEMA/RI EXPORT	2743	241
SEMA EXPORT	686	-78	CONVEX-REMVEC	-1221	108	EAST-WEST	866	-36
NY-NE 2200(170	-749	-36	PLAT PAR	144	-3	CT-LI-1385	1	-65

HVDC TRANSFERS FROM H-Q

CHAT-1 = 0		HIGHGATE = 225
MADAWASK = -151	PHII-P1 = 1000	PHII-P2 = 1000
EEL = 74		

BUS VOLTAGES

	V	LMT			V	LMT			V	LMT	
70001 CHESTER 345	342.			72692 NWGTN345 345	354.			72694 SEBRK345 345	355.		
71789 TEWKS 345	357.			70759 MYSTIC 345	360.			71797 MILLBURY 345	353.		
72925 LUDLOW 345	350.			72926 NRTHFLD 345	354.			73106 SOUTHGTN 345	353.		
73108 CARD 345	355.			73109 MONTVILE 345	357.			73110 MILLSTNE 345	357.		
73116 MIDDLTWN 345	358.			71801 BRAYTN P 345	358.			71811 KENT CO. 345	353.		
71326 BRIDGWTR 345	353.			71336 SHERMAN 345	356.			71338 OS POWER 345	356.		
71337 WFARNUM 345	354.			70772 W MEDWAY 345	352.			70780 WWALP345 345	350.		
70783 PILGRIM 345	356.			70773 NEA 336 345	355.			71193 CANAL 345	353.		
71133 CARVER 345	351.			70655 CHAMPLAN 345	0.	*E		70795 FRMNGHAM 230	225.		
70793 MDFRM230 230	233.			70794 MDWLT230 230	236.			70818 MYSTC MA 115	119.		
71891 SALEM HR 115	119.			72096 MILLBURY 115	107.	L	63.0 *	71377 SOMERSET 115	116.		
72277 MIDWEYMT 115	116.			72259 MINK 183 115	118.			72574 WARRN 84 115	115.		
72569 FRSQ 115	119.		63.0 *	72566 PHILP183 115	119.			72553 ADMIRAL3 115	119.		
71405 PAWTUCKT 115	113.			71379 SWANSEA 115	115.			72269 WITNPD43 115	108.	L	
72278 FIELD 1 115	117.			72266 READ ST 115	114.			72267 S WREN29 115	106.	L	
72254 DEPOT129 115	107.	L		72255 DEPOT130 115	107.	L		72582 WOONSCKT 115	115.		
71403 WFARNUM 115	116.			72579 WOLF 171 115	117.			72584 HARTAVE 115	119.		
72544 JOHNSTN1 115	119.		0.0	72545 JOHNSTN2 115	118.		0.0	72560 DRUMROCK 115	118.		12.6
72565 KENT CO 115	118.		75.6 *	72570 SOCK187 115	117.			72571 SOCK188 115	117.		
72557 DAVIST85 115	116.			72559 DAVIS 90 115	117.			72572 W.KINGST 115	115.		18.9 *
72538 KENYON 115	115.			72581 WOOD RIV 115	115.			70512 ESX B-2 115	114.		
70487 COOL 345 345	358.			70520 W RUTLND 115	117.						

AREA/ZONE TOTALS

NEPOOL_GEN	25362	NEPOOL_LOAD	27065	NEPOOL_LOSS	705
NEPOOL_INT	-2423	NEPOOL_LOAD+LOSS	27770		

Table 2 - Light Load Dispatch Summary

LIGHT LOAD, NEW ENGLAND LIBRARY 2000
DISPATCH #2, TRACY AUTO

GENERATION

#		V	MW	MX	#		V	MW	MX	#		V	MW	MX
70705	VTYAK G	0.954	667	50	73072	ALT12 PF	1.020	65	10	73073	ALT34 PF	1.019	80	10
72986	BERKPWR	0.000	0	0	73069	MAPR1 PF	1.015	106	24	73070	MAPR2 PF	1.016	106	24
73071	MAPR3 PF	1.012	95	24	73085	MT.TOM	0.974	146	-24	72512	BRSWP G1	0.971	-280	67
72513	BRSWP G2	0.971	-280	67	73083	NRTHFD12	0.986	-500	109*	73084	NRTHFD34	0.985	-500	109*
72933	STNYBK 1	1.043	87	15	72930	STNYBK1A	1.043	65	14	72931	STNYBK1B	1.043	65	14
72932	STNYBK1C	1.043	65	14	72934	STNYBK2A	1.043	65	14	72935	STNYBK2B	1.043	65	14
73080	WSPFLD 3	0.959	107	-37	72244	MILLENST	0.000	0	0	72243	MILLENCT	0.000	0	0
73538	AESTH PF	0.000	0	0	73654	BE 10 ST	0.000	0	0	73652	BE 11	0.000	0	0
73653	BE 12	0.000	0	0	73647	BPTHBR#2	0.000	0	0	73648	BPTHBR#3	0.000	0	0
73570	DEVGAS11	0.000	0	0	73571	DEVGAS12	0.000	0	0	73572	DEVGAS13	0.000	0	0
73573	DEVGAS14	0.000	0	0	73553	DEVON#7	0.000	0	0	73554	DEVON#8	0.000	0	0
73565	LAKERD#1	1.030	305	114	73566	LAKERD#2	1.030	305	114	73567	LAKERD#3	1.030	305	114
73588	MERIDEN1	0.000	0	0	73589	MERIDEN2	0.000	0	0	73555	MIDDTN#2	0.000	0	0
73556	MIDDTN#3	0.000	0	0	73557	MIDDTN#4	0.000	0	0	73574	MILFD#1	0.000	0	0
73575	MILFD#2	0.000	0	0	73562	MILL#2	1.016	940	330	73563	MILL#3	1.009	1260	330
73558	MONTV#5	1.010	81	27*	73559	MONTV#6	0.000	0	0	73651	NH HARBR	0.000	0	0
73551	NORHAR#1	0.000	0	0	73552	NORHAR#2	0.000	0	0	73549	SMD1112J	0.000	0	0
73550	SMD1314J	0.000	0	0	73594	WALL LV1	0.000	0	0	73595	WALL LV2	0.000	0	0
73596	WALL LV3	0.000	0	0	73276	LISBN PF	1.025	14	0	73281	EXETR PF	1.034	26	4
70060	MIS GT1	0.000	0	0	70061	MIS GT2	0.000	0	0	70062	MIS ST	0.000	0	0
70377	AEC G1	1.040	52	11	70378	AEC G2	1.040	52	11	70379	AEC G3	1.040	52	11
70389	BUCKS G4	0.000	0	0	70426	CHAMP G2	0.000	0	0	70424	CHAMP G3	1.034	65	32*
70374	MASON G3	0.000	0	0	70375	MASON G4	0.000	0	0	70376	MASON G5	0.000	0	0
70425	BC COGEN	0.000	0	0	70381	RPA CG1	0.000	0	0	70382	RPA SG2	0.000	0	0
70422	WARRN G1	0.000	0	0	70423	WARRN G2	0.000	0	0	70386	WBK G1	0.000	0	0
70387	WBK G2	0.000	0	0	70388	WBK G3	0.000	0	0	70365	WF WY #1	0.000	0	0
70366	WF WY #2	0.990	57	-1	70367	WF WY #3	0.000	0	0	70368	WF WY #4	0.000	0	0
71857	COMRF G1	0.000	0	0	71858	COMRF G2	0.000	0	0	71859	COMRF G3	0.000	0	0
71860	COMRF G4	0.000	0	0	71861	MOORE G1	0.000	0	0	71862	MOORE G2	0.000	0	0
71863	MOORE G3	0.000	0	0	71864	MOORE G4	0.000	0	0	72868	NWNGT G1	0.000	0	0
70010	NEW_G1	0.000	0	0	70011	NEW_G2	0.000	0	0	70012	NEW_G3	0.000	0	0
71950	GRANRDG1	0.000	0	0	71951	GRANRDG2	0.000	0	0	72701	AESSTG	0.000	0	0
72866	MERMK G1	0.000	0	0	72867	MERMK G2	0.000	0	0	72869	SBRK G1	0.994	1314	110
72870	SCHILLER	0.000	0	0	72872	SCHILLER	0.000	0	0	72871	SCHILLER	0.000	0	0
71123	KENDALL	1.029	63	0	72670	TIVER G2	0.000	0	0	71394	EMI_GEN	0.965	185	6
71067	MYS8 GTS	0.000	0	0	71068	MYS8 ST	0.000	0	0	71069	MYS9 GTS	0.000	0	0
71070	MYS9 ST	0.000	0	0	71060	MYST G4	0.000	0	0	71061	MYST 5G	0.000	0	0
71062	MYST G6	0.000	0	0	71063	MYST G7	0.000	0	0	71073	N.BOST 1	0.000	0	0
71074	N.BOST 2	0.000	0	0	71946	SALEM G1	0.000	0	0	71947	SALEM G2	0.000	0	0
71948	SALEM G3	0.000	0	0	71949	SALEM G4	0.981	400	-53	72066	LOWELL	1.011	94	-6
71095	ANPBLCK1	1.003	290	-14	71096	ANPBLCK2	1.003	290	-14	72377	BELL #1	1.048	290	79
72378	BELL #2	1.048	290	79	72372	BP #1 GN	0.982	238	24	72375	BP #2 GN	0.982	232	24
72370	BP #3 GN	0.991	605	-19	72371	BP #4 GN	0.987	425	-14	71531	OSP1 PF	0.997	77	0
71532	OSP2 PF	0.997	77	0	71533	OSP3 PF	0.996	108	0	71534	OSP4 PF	0.997	77	0
71535	OSP5 PF	0.997	77	0	71536	OSP6 PF	0.996	108	0	71084	NEA GTPF	1.008	111	17
71085	NEA GTPF	1.008	110	17	71086	NEA STPF	1.011	80	17	72666	FRSQ SC1	0.000	0	0
72667	FRSQ SC2	0.000	0	0	72668	FRSQ SC3	0.000	0	0	72661	MANCH09A	0.000	0	0
72662	MANCH10A	0.000	0	0	72663	MANCH11A	0.000	0	0	72671	HOPE G1	1.055	180	37
72672	HOPE G2	1.053	180	37	72673	HOPE G3	1.055	185	37	72373	MPLP 1PF	1.037	108	28
72374	MPLP 2PF	1.031	44	21	71251	CANAL G1	0.000	0	0	71252	CANAL G2	0.000	0	0
71094	PLGRM G1	1.029	734	156	70909	EDG GT1	0.000	0	0	70910	EDG GT2	0.000	0	0
70911	EDG ST1	0.000	0	0	71522	SOM G6	0.000	0	0	72669	TIVER G1	0.000	0	0

	MW	MX		MW	MX		MW	MX
MILLSTONE	2200	660	BRPT-ENERGY	0	0	MIDDLETOWN	0	0
MONTVILLE	81	27	NORWALK	0	0	BPTHBR	0	0
NHHARBOUR	0	0	DEVON	0	0	MERIDEN	0	0
WALLINGFORD	0	0	TOWANTIC	0	0	BERKSHIRE	0	0
LAKEROAD	915	341	STONYBROOK	412	84	MILLENNIUM	0	0
BRAYTONPT	1500	15	HOPE	545	111	FRSQ	0	0
SOMERSET	0	0	OSP	523	0	NEA	301	50
CANAL	0	0	PILGRIM	734	156	MASSPWRR	307	73
ANP-BELLINGHAM	580	159	ANP-BLACKSTONE	580	-29	EMI-TIVERTON	0	0
EMI-DIGHTON	185	6	SITHE-EDGAR	0	0	MYSTIC	0	0
NEWBOSTON	0	0	SALEMHBR	400	-53	SITHE-MYSTIC	0	0
SEABROOK	1314	110	NEWINGTON	0	0	ConEd_Newington	0	0
SCHILLER	0	0	MERRIMACK	0	0	WYMAN	57	-1

VTYANKEE	667	50	BEARSWAMP	-560	133	NORTHFIELD	-1000	219
ALTRESCO	146	21	MIS	0	0	AEC	157	32
RPA	0	0	WESTBROOK	0	0	BUCKSPORT	0	0

INTERFACE FLOWS

NB-NE	702	-42	ORRING-SOUTH	464	-120	SUROWIEC-SOUTH	163	-76
MEYANKEE-SOUTH	237	-30	MAINE-NH	31	-40	NNE-SCOBIE+394	1069	-62
SEABROOK-SOUTH	973	-21	NORTH-SOUTH	1317	71	CMFD/MOORE-SO	-6	-10
SNDYPOND-SOUTH	-28	178	CONN IMPORT	789	51	CONN-MASS	-330	47
CONN-RI	-1087	91	SW CONN IMPORT	1156	27	NORWLK-STAMFORD	347	-140
BOSTON IMPORT	1503	113	NEMA/BOS IMPORT	1527	113	SEMA/RI EXPORT	2975	-187
SEMA EXPORT	-166	30	CONVEX-REMVEC	-2350	149	EAST-WEST	1723	-187
NY-NE 2200(170	-1185	248	PLAT PAR	108	-9	CT-LI-1385	0	-64

HVDC TRANSFERS FROM H-Q

CHAT-1 = 0		HIGHGATE = 150
MADAWASK = 0	PHII-P1 = 0	PHII-P2 = 0

BUS VOLTAGES

	V	LMT		V	LMT		V	LMT	
70001 CHESTER 345	342.		72692 NWGTN345 345	357.			72694 SEBRK345 345	357.	
71789 TEWKS 345	358.		70759 MYSTIC 345	359.			71797 MILLBURY 345	353.	
72925 LUDLOW 345	350.		72926 NRTHFLD 345	351.			73106 SOUTHGTN 345	347.	
73108 CARD 345	354.		73109 MONTVILE 345	353.			73110 MILLSTNE 345	357.	
73116 MIDDLTWN 345	345.		71801 BRAYTN P 345	352.			71811 KENT CO. 345	354.	
71326 BRIDGWTR 345	353.		71336 SHERMAN 345	354.			71338 OS POWER 345	354.	
71337 WFARNUM 345	354.		70772 W MEDWAY 345	351.			70780 WWALP345 345	351.	
70783 PILGRIM 345	355.		70773 NEA 336 345	352.			71193 CANAL 345	354.	
71133 CARVER 345	353.		70655 CHAMPLAN 345	0.	*E		70795 FRMNGHAM 230	234.	
70793 MDFRM230 230	237.		70794 MDWLT230 230	237.			70818 MYSTC MA 115	117.	
71891 SALEM HR 115	117.		72096 MILLBURY 115	116.	63.0 *		71377 SOMERSET 115	115.	
72277 MIDWEYMT 115	119.		72259 MINK 183 115	118.			72574 WARRN 84 115	116.	
72569 FRSQ 115	119.	0.0	72566 PHILP183 115	119.			72553 ADMIRAL3 115	119.	
71405 PAWTUCKT 115	114.		71379 SWANSEA 115	115.			72269 WITNPD43 115	116.	
72278 FIELD 1 115	119.		72266 READ ST 115	116.			72267 S WREN29 115	115.	
72254 DEPOT129 115	117.		72255 DEPOT130 115	117.			72582 WOONSCKT 115	117.	
71403 WFARNUM 115	117.		72579 WOLF 171 115	118.			72584 HARTAVE 115	119.	
72544 JOHNSTN1 115	119.	0.0	72545 JOHNSTN2 115	119.	0.0		72560 DRUMROCK 115	119.	0.0
72565 KENT CO 115	119.	63.0	72570 SOCK187 115	118.			72571 SOCK188 115	118.	
72557 DAVIST85 115	118.		72559 DAVIS 90 115	118.			72572 W.KINGST 115	117.	6.3
72538 KENYON 115	117.		72581 WOOD RIV 115	116.			70512 ESX B-2 115	116.	
70487 COOL 345 345	360.		70520 W RUTLND 115	117.					

AREA/ZONE TOTALS

NEPOOL_GEN	11974	NEPOOL_LOAD	11410	NEPOOL_LOSS	402
NEPOOL_INT	143	NEPOOL_LOAD+LOSS	11813		

Table 3 List of Contingencies

	Contingency Type	Fault Type	Location	Elements Switched	Switching Times(cycles/sec)
1	BPS test	3 phase	Tracy 115	347E,347W, 330 1505, 1607 and Tracy auto Lake Road units	300.0/5.0 240.0/4.0
2	Normal	3 phase	Lake Road end of 347W line	347W line Lake Road - Tracy Tracy 345/115 auto Reclose 347W line Lake Road - Tracy	4.0/0.066666 5.0/0.083333 304.0/5.06666
3	Normal	3 phase	Lake Road end of 347W line	347 W line Lake Road - Tracy Tracy 345/115 auto plus trip of Lake Road units Reclose 347W line Lake Road - Tracy	4.0/0.066666 5.0/0.083333 240.0/4.0 304.0/5.06666
4	Normal	3 phase	Sherman end of 347E line	347E line Tracy - Sherman Reclose 347E line	4.0/0.066666 304.0/5.0666
5	Normal	3 phase	Sherman end of 347E line	347E line Tracy - Sherman plus trip of Lake Road units Reclose 347E line	4.0/0.066666 240.0/4.0 304.0/5.0666
6	Normal	3 phase	Tracy end of 347E line	347E line Tracy - Sherman Reclose 347E line	4.0/0.066666 304.0/5.0666
7	Normal	3 phase	Tracy end of 347E line	347E line Tracy - Sherman plus trip of Lake Road units Reclose 347E line	4.0/0.066666 240.0/4.0 304.0/5.0666
8	Normal	3 phase	Lake Road end of 330 line	330 line Reclose 330 line	4.0/0.066666 304.0/5.0666
9	Normal	3 phase	Tracy end of 1505 line	1505 breaker at Tracy 1505 breaker at Tunnel	5.0/0.08333 34.5/0.575
10	Normal	3 phase	Tracy end of 1607 line	1607 breaker at Tracy 1607 breaker at Tunnel	5.0/0.083333 34.5/0.575
11	Extreme	3 phase	Tracy end of 347W line Tracy D sticks	347W line at Lake Road Tracy 345/115 auto 347E line	4.0/0.06666 5.0/0.083333 9.5/0.158333
12	Extreme	3 phase	Tracy end of 347W line	347W line at Lake Road	4.0/0.06666

			Tracy D sticks	Tracy 345/115 auto	5.0/0.083333
				347E line	9.5/0.158333
				plus trip of Lake Road units	240.0/4.0
13	Extreme	3 phase	Tracy end of 347W line	347W & D breaker	4.0/0.066666
			Tracy B sticks	C breaker opens	5.0/0.083333
				E breaker opens, splitting Tracy bus	12.0/0.2
				1505 breaker at Tunnel	14.25/0.24166
14	Extreme	3 phase	Tracy end of 347W line	347W & D breaker	4.0/0.066666
			Tracy B sticks	C breaker opens	5.0/0.083333
				E breaker opens, splitting Tracy bus	12.0/0.2
				1505 breaker at Tunnel	14.25/0.24166
				plus trip of Lake Road units	240.0/4.0
15	Extreme	3 phase	Tracy end of 347W line	347W & D breaker	4.0/0.066666
			Tracy C sticks	B breaker opens	5.0/0.083333
				A breaker opens, splitting Tracy bus	12.0/0.2
				1607 breaker at Tunnel	14.25/0.24166
16	Extreme	3 phase	Tracy end of 347W line	347W & D breaker	4.0/0.066666
			Tracy C sticks	B breaker opens	5.0/0.083333
				A breaker opens, splitting Tracy bus	12.0/0.2
				1607 breaker at Tunnel	14.25/0.24166
				plus trip of Lake Road units	240.0/4.0
17	Extreme	3 phase	Tracy end of 347E line	347E line	4.0/0.066666
			Tracy D sticks	347W line	10.5/0.175
				Tracy 345/115 auto	12.0/0.2
18	Extreme	3 phase	Tracy end of 347E line	347E line	4.0/0.066666
			Tracy D sticks	347W line	10.5/0.175
				Tracy 345/115 auto	12.0/0.2
				plus trip of Lake Road units	240.0/4.0
19	Extreme	3 phase	Card end of 330 line	Lake Road end of 330 line,3T breaker opens	4.0/0.066666
			Card 1T sticks	345/115 auto opens	5.0/0.083333
				new breaker opens hanging 383 line	9.0/0.15
				368 line opens clearing fault	11.25/0.1875

20	Extreme	3 phase	Card end of 330 line Card 3T sticks	Lake Road end of 330 line, 1T breaker opens 345/115 auto opens 2T opens hanging 368 line 383 line opens clearing fault	4.0/0.066666 5.0/0.083333 9.0/0.15 11.25/0.1875
21	Extreme	3 phase	Millstone end of 383 line Card 3T sticks	Millstone end of 383,2T breaker opens 1T opens hanging 368 line 330 line Card 345/115 auto,clearing fault	4.0/0.066666 9.0/0.15 11.25/0.1875 12.25/0.2041666
22	Extreme	3 phase	Manchester end of 368 line Card 1T sticks	Manchester end of 368,new breaker opens 3T opens hanging 383 line 330 line Card 345/115 auto,clearing fault	34.5/0.568 34.5/0.569 34.5/0.570 34.5/0.571
23	Normal	2 phase	Tracy end of 1505 line	Tracy end of 1505 line Tracy end of 1607 line Tunnel end of 1505 line Tunnel end of 1607 line	34.5/0.572 34.5/0.573 34.5/0.574 34.5/0.575

Table 4 Delta P analysis

Power Flow	CT EXPORT	# of LR units in service	Flow Lake Road to Card	Flow Tracy to Lake Road	Delta P for 330 Reclosure	Delta P for 347W Reclosure	Delta P for 347E Reclosure
Peak Load	-2200	3	848	10	0.324	0.146	
Peak Load	-2200	3	847	10	0.321	0.138	
Peak Load	-2200	3	960	123	0.347	0.224	
Peak Load	-2900	3	1056	218	0.399	0.381	
Peak Load	814	3	-223	-1060	0.095	0.762	
Peak Load	642	3	-172	-1009	0.073	0.755	
Peak Load	476	3	-123	-960	0.051	0.747	
Peak Load	307	3	-73	-910	0.03	0.739	
Peak Load	137	3	-22	-860	0.009	0.731	
Peak Load	-155	3	92	-746	0.039	0.709	
Peak Load	-426	3	150	-687	0.063	0.697	0.648
Light Load	-2029	2	969	411	0.415	0.513	
Light Load	-2200	2	1012	454	0.432	0.525	
Light Load	-2181	3	1100	262	0.414	0.384	
Light Load	2200	2	-309	-867	0.165	0.633	
Light Load	2214	3	-230	-1058	0.106	0.654	
Light Load	2048	2	-264	-822	0.14	0.624	
Light Load	1889	2	-220	-778	0.115	0.615	
Light Load	1728	2	-174	-732	0.091	0.606	
Light Load	1584	2	-134	-692	0.068	0.599	0.57

Table 5 Source Loss Contingencies – Lake Road units

Simulation	Appendix
Peak Load Simulation 1	A
Peak Load Simulation 3	A
Peak Load Simulation 5	A
Peak Load Simulation 7	A
Peak Load Simulation 12	A
Peak Load Simulation 14	A
Peak Load Simulation 16	A
Peak Load Simulation 18	A
Light Load Simulation 1	B
Light Load Simulation 3	B
Light Load Simulation 5	B
Light Load Simulation 7	B
Light Load Simulation 12	B
Light Load Simulation 14	B
Light Load Simulation 16	B
Light Load Simulation 18	B

Appendix A Peak Load Simulations

Appendix B Light Load Simulations

Appendix C Light Load Simulations without Project

Appendix D Light Load Simulations for Non-extreme Comparison