Introduction

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  - Avista System Planning
    - BSEE, Idaho, 1992
    - Graduate Diploma, Naval War College, 1999
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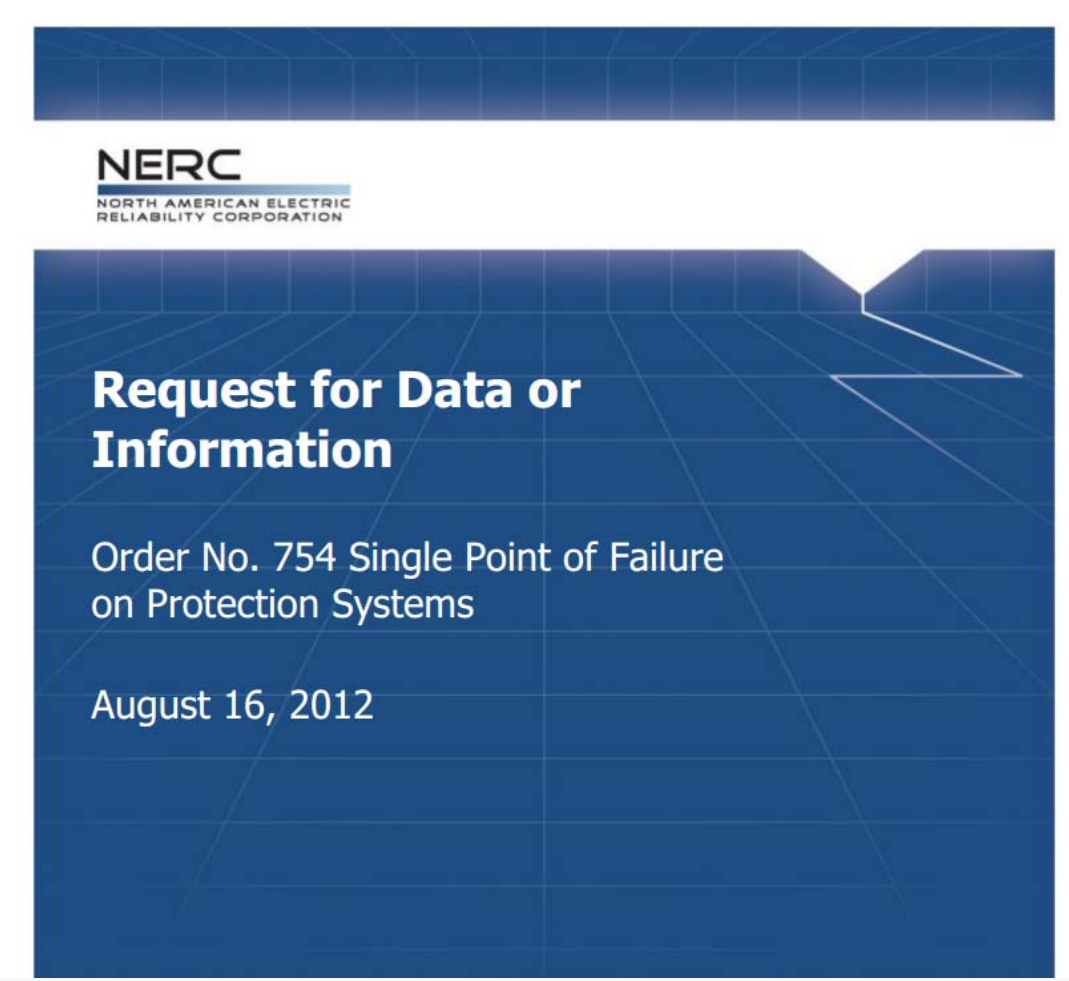
FERC Order 754



– http://www.nerc.com/docs/standards/dt/Order_754-Request_for_Data_or_Information_08162012.pdf

Planner's Deliverable

Method

1. Each Transmission Planner will develop a "List of Buses to be Tested," including each bus[9] in its transmission planning area that meets the criteria in Table A, "Criteria for Buses to be Tested."

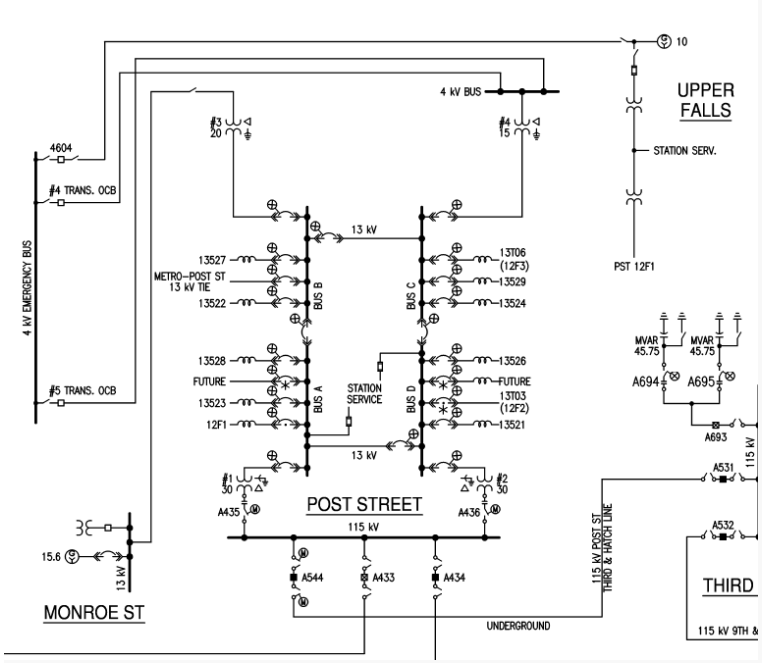
Table A: Buses to be Tested
Buses operated at 200 kV or higher with 4 or more circuits
Buses operated at 100 kV to 200 kV with 6 or more circuits
Buses operated at 100 kV or greater with 4 or more circuits and at which a bus fault and tripping of all connected Elements at the remote terminals will result in 300 MW or more of consequential load loss[1] as a result of remote clearing
Buses with aggregate generation of 1,000 MW or higher
Buses supplying off-site power to a nuclear generating station

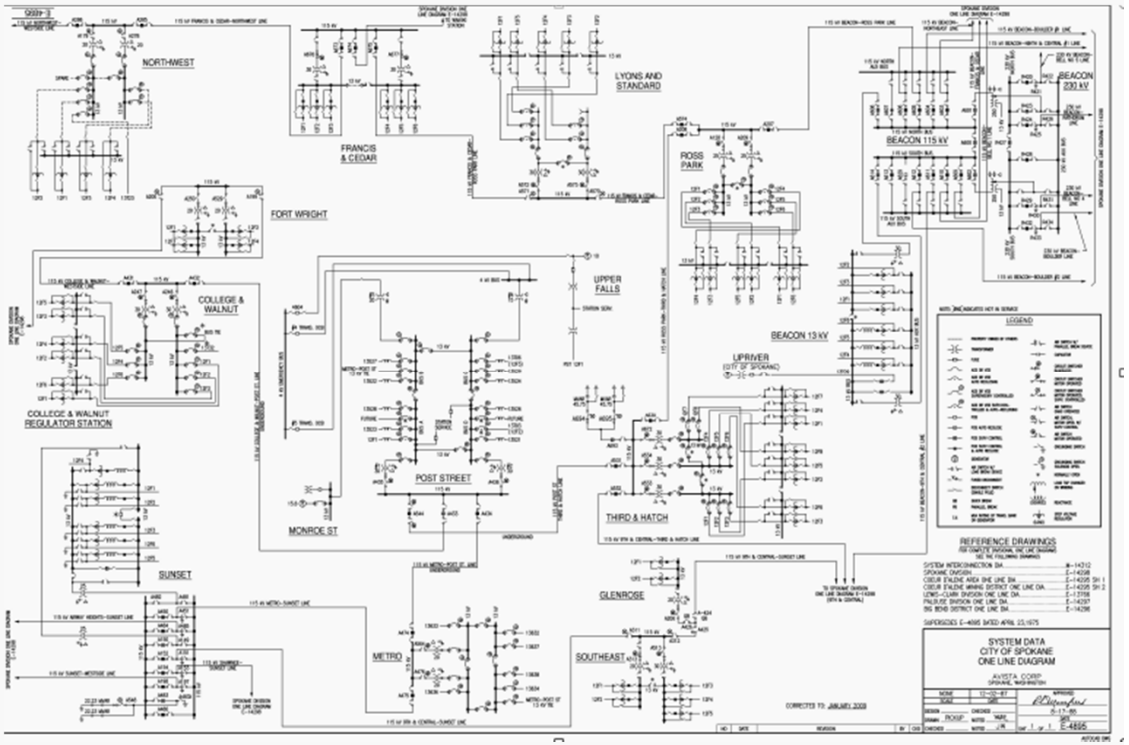
Performance Measures

Table C: Performance Measures
1. Loss of synchronism of generating units totaling greater than 2,000 MW or more in the Eastern Interconnection or Western Interconnection, or 1,000 MW or more in the ERCOT or Québec Interconnections
2. Loss of synchronism between two portions of the system
3. Negatively damped oscillations

How Can We Do This (Quickly)?

- One Line Diagrams?
  - Accurate, but…
    - Do you REALLY want to squint and count lines?





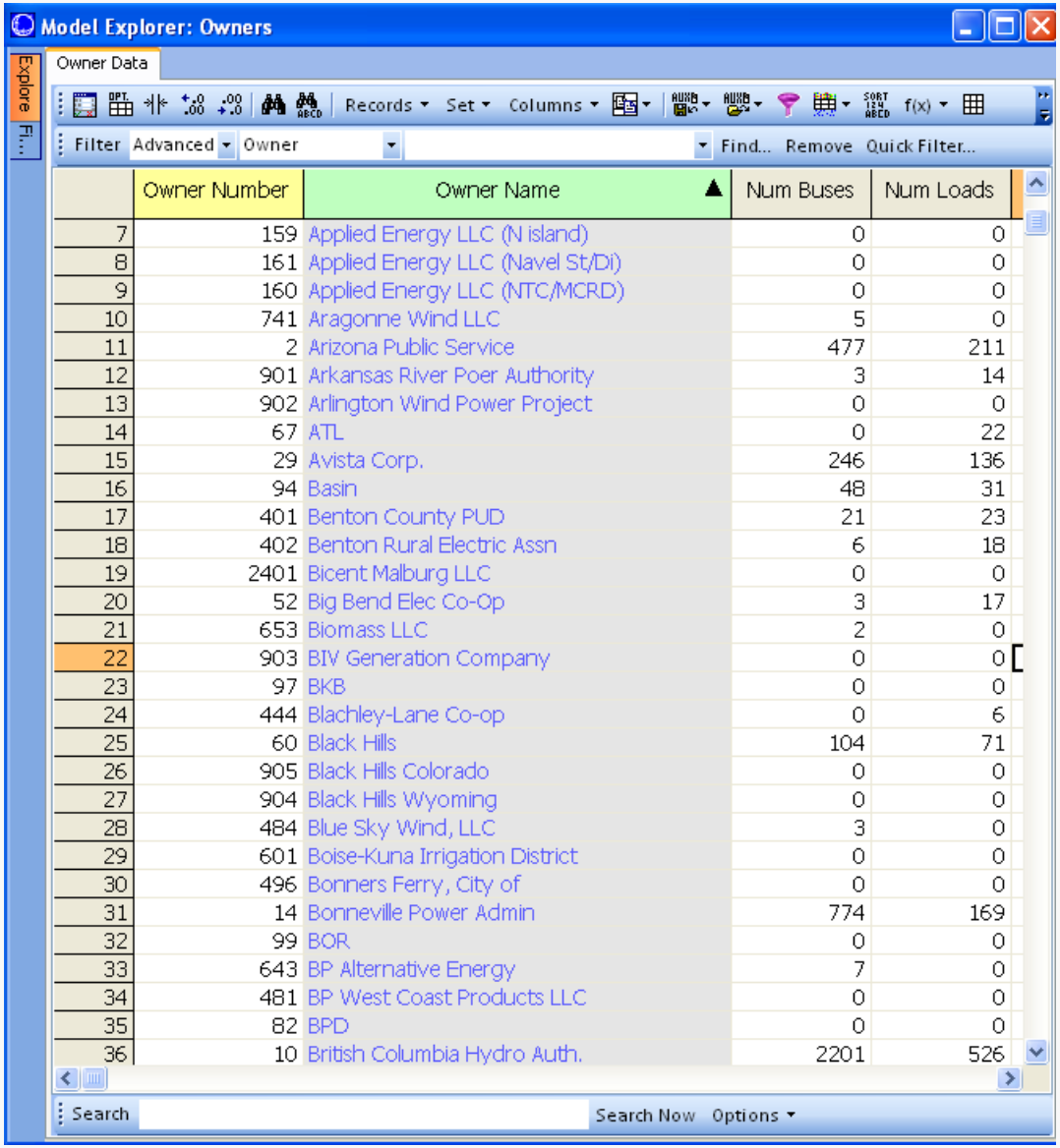
Or…Use PWS

- Filters (ownership AND)
  - Buses at 200 kV or higher with 4 or more ckts
  - Buses 100 to 200 kV or higher with 4 or more ckts
  - Buses 100 kV and up, with aggregate bus fault load loss of 300 MW
  - Buses with aggregate generation of 1000 MW or higher

Step by Step…

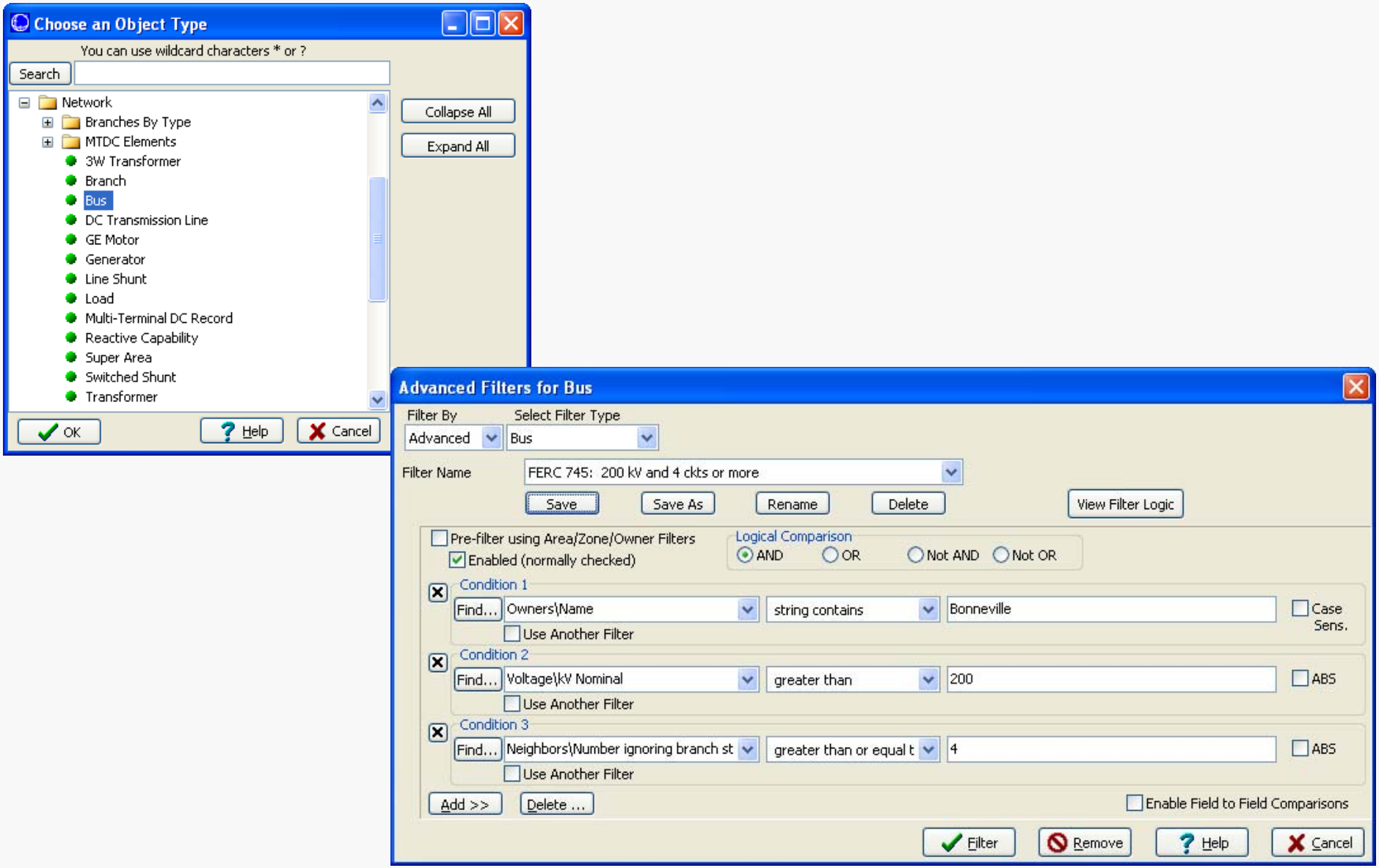
1. Figure out ownership
2. Build filter for 200 kV and 4 ckts
3. Save filter

Identify Ownership



	Owner Number	Owner Name	Num Buses	Num Loads
7	159	Applied Energy LLC (N island)	0	0
8	161	Applied Energy LLC (Navel St/Di)	0	0
9	160	Applied Energy LLC (NTC/MCRD)	0	0
10	741	Aragonne Wind LLC	5	0
11	2	Arizona Public Service	477	211
12	901	Arkansas River Poer Authority	3	14
13	902	Arlington Wind Power Project	0	0
14	67	ATL	0	22
15	29	Avista Corp.	246	136
16	94	Basin	48	31
17	401	Benton County PUD	21	23
18	402	Benton Rural Electric Assn	6	18
19	2401	Bicent Malburg LLC	0	0
20	52	Big Bend Elec Co-Op	3	17
21	653	Biomass LLC	2	0
22	903	BIV Generation Company	0	0
23	97	BKB	0	0
24	444	Blachley-Lane Co-op	0	6
25	60	Black Hills	104	71
26	905	Black Hills Colorado	0	0
27	904	Black Hills Wyoming	0	0
28	484	Blue Sky Wind, LLC	3	0
29	601	Boise-Kuna Irrigation District	0	0
30	496	Bonners Ferry, City of	0	0
31	14	Bonneville Power Admin	774	169
32	99	BOR	0	0
33	643	BP Alternative Energy	7	0
34	481	BP West Coast Products LLC	0	0
35	82	BPD	0	0
36	10	British Columbia Hydro Auth.	2201	526

200 kV & 4 or more ckts

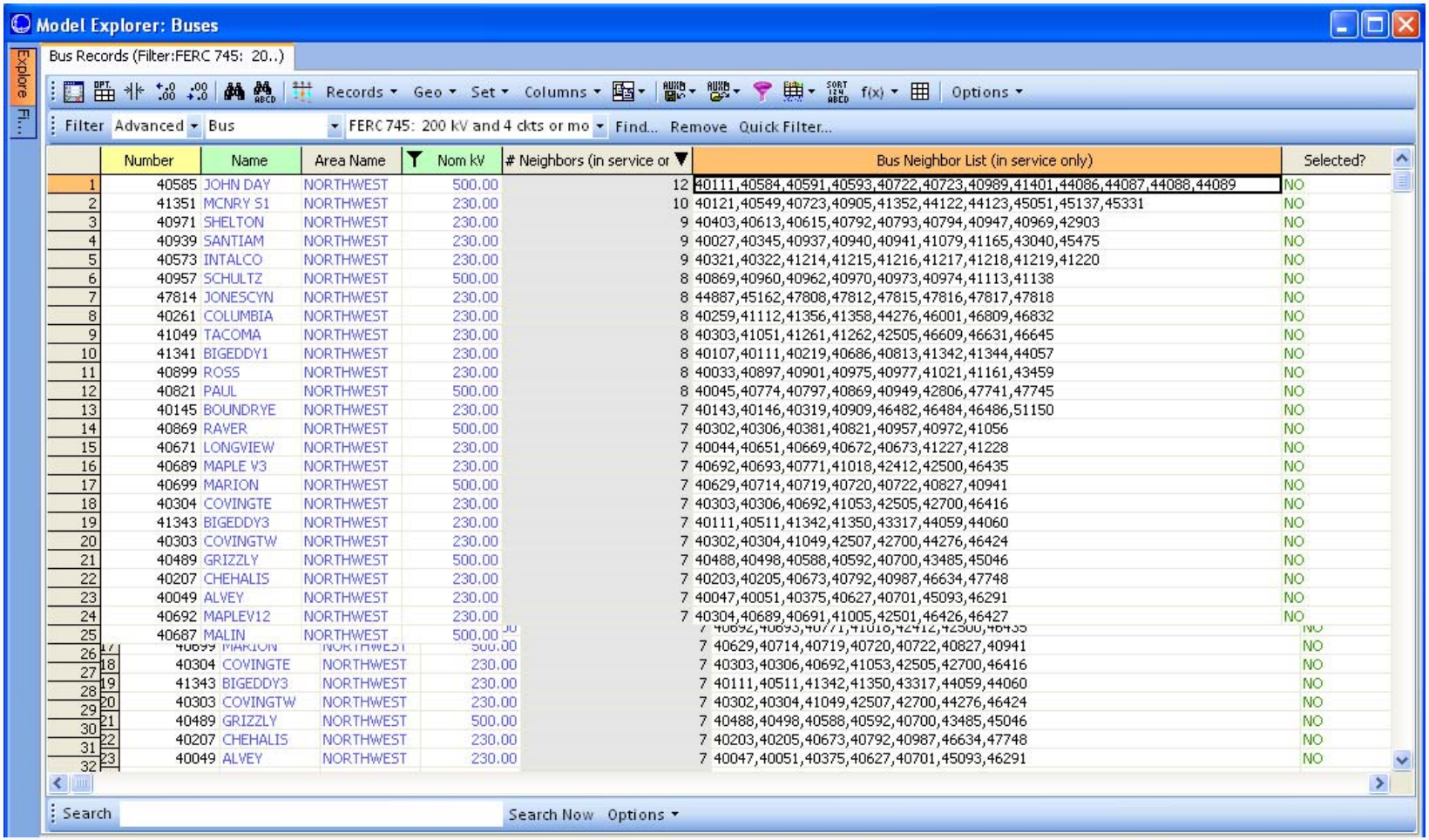


Auxiliary File (BPA/200kV/4ckt)

```
DATA (FILTER, [ObjectType,FilterName,FilterLogic,FilterPre,Enabled])
{
"Bus" "FERC 745:  200 kV and 4 ckts or more" "AND" "NO " "NO "
  <SUBDATA Condition>
    OwnerName contains "Bonneville"
    BusNomVolt >= 200.00000
    BusNeighbors:1 >= 4
  </SUBDATA>
}
```

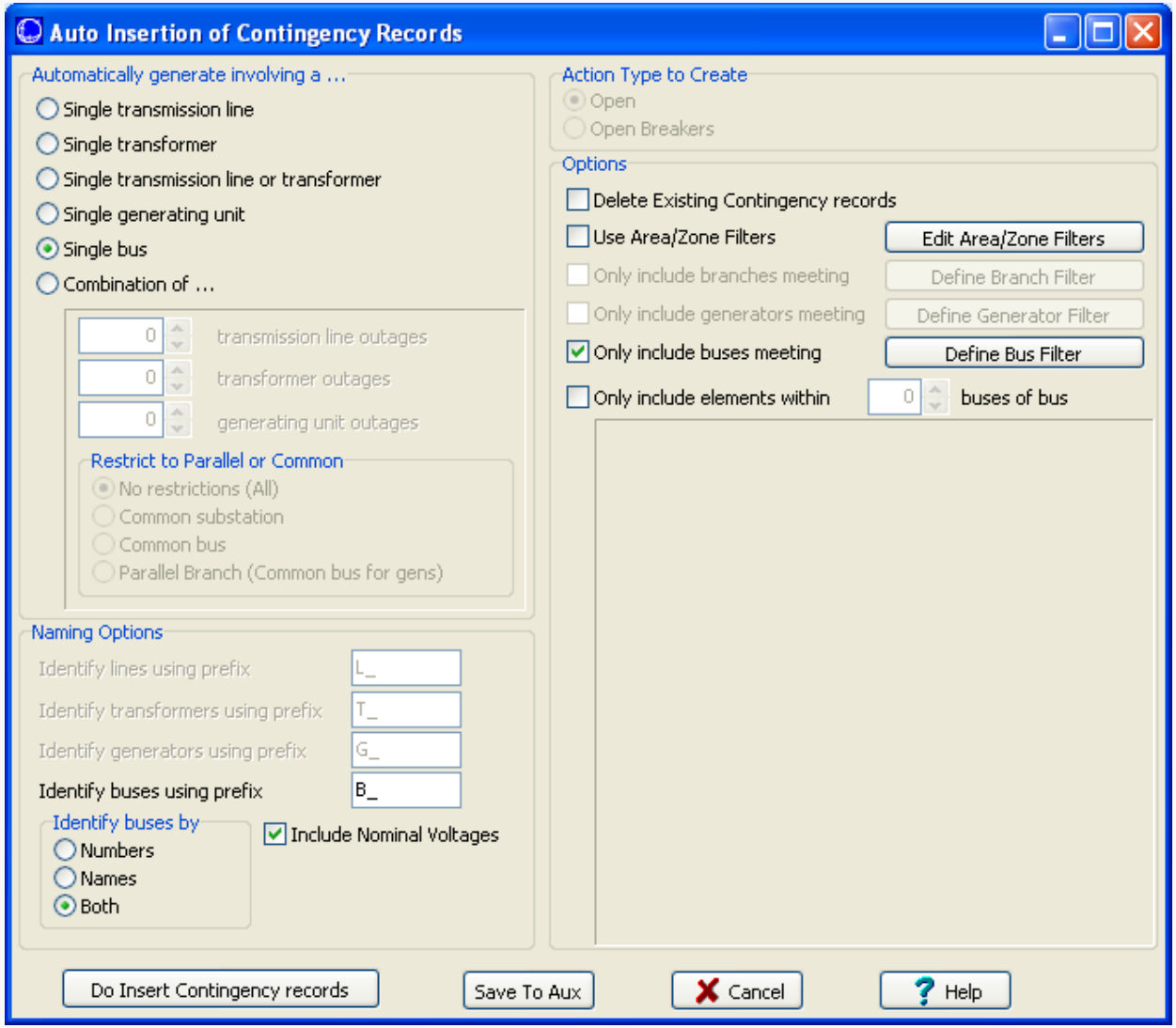
Filter BPA/200 kV/4 ckts Results

12HS4A Ops Case yields 99 buses

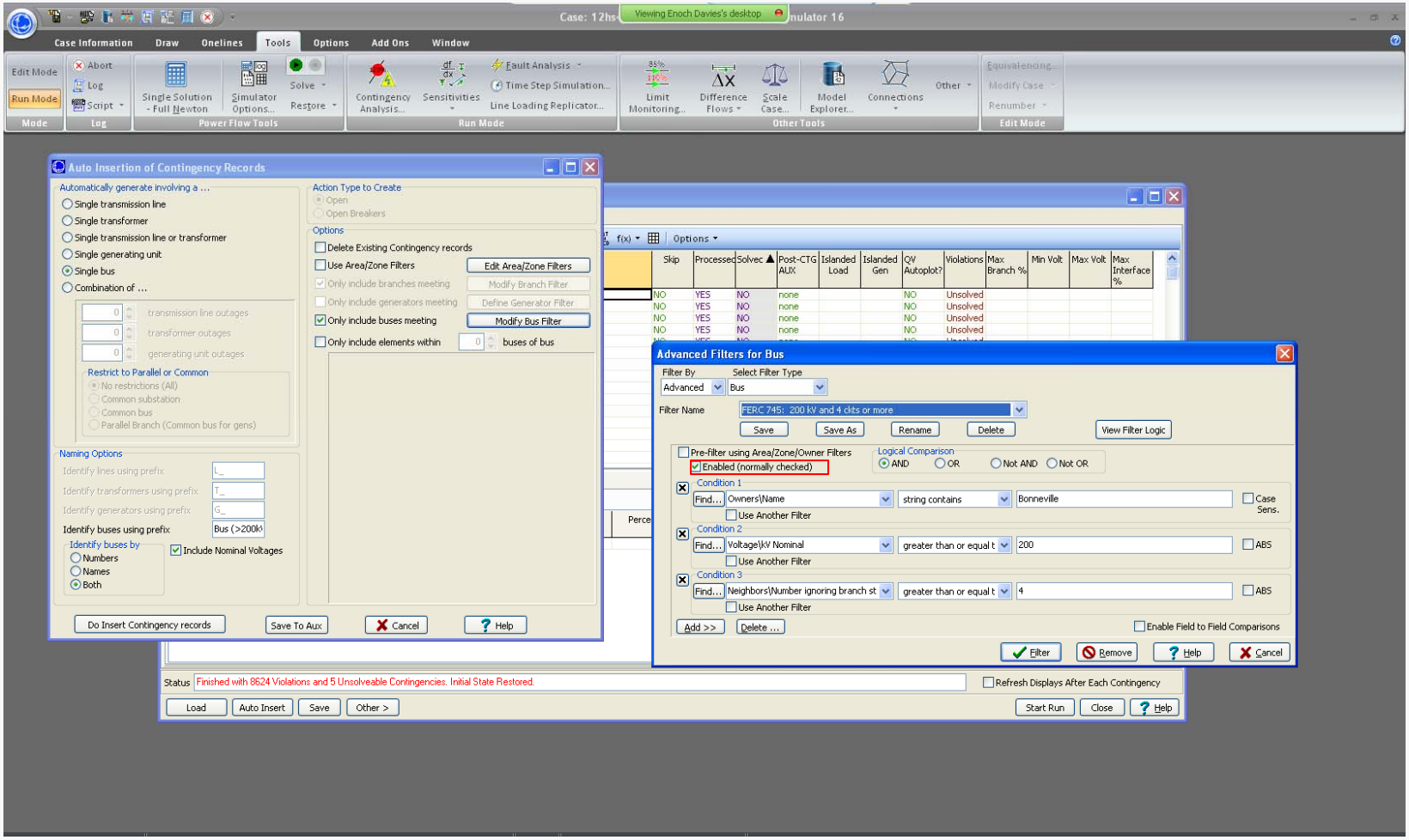


	Number	Name	Area Name	Nom kV	# Neighbors (in service or	Bus Neighbor List (in service only)	Selected?
1	40585	JOHN DAY	NORTHWEST	500.00	12	40111,40584,40591,40593,40722,40723,40989,41401,44086,44087,44088,44089	NO
2	41351	MCNRY S1	NORTHWEST	230.00	10	40121,40549,40723,40905,41352,44122,44123,45051,45137,45331	NO
3	40971	SHELTON	NORTHWEST	230.00	9	40403,40613,40615,40792,40793,40794,40947,40969,42903	NO
4	40939	SANTIAM	NORTHWEST	230.00	9	40027,40345,40937,40940,40941,41079,41165,43040,45475	NO
5	40573	INTALCO	NORTHWEST	230.00	9	40321,40322,41214,41215,41216,41217,41218,41219,41220	NO
6	40957	SCHULTZ	NORTHWEST	500.00	8	40869,40960,40962,40970,40973,40974,41113,41138	NO
7	47814	JONESCYN	NORTHWEST	230.00	8	44887,45162,47808,47812,47815,47816,47817,47818	NO
8	40261	COLUMBIA	NORTHWEST	230.00	8	40259,41112,41356,41358,44276,46001,46809,46832	NO
9	41049	TACOMA	NORTHWEST	230.00	8	40303,41051,41261,41262,42505,46609,46631,46645	NO
10	41341	BIGEDDY1	NORTHWEST	230.00	8	40107,40111,40219,40686,40813,41342,41344,44057	NO
11	40899	ROSS	NORTHWEST	230.00	8	40033,40897,40901,40975,40977,41021,41161,43459	NO
12	40821	PAUL	NORTHWEST	500.00	8	40045,40774,40797,40869,40949,42806,47741,47745	NO
13	40145	BOUNDRYE	NORTHWEST	230.00	7	40143,40146,40319,40909,46482,46484,46486,51150	NO
14	40869	RAVER	NORTHWEST	500.00	7	40302,40306,40381,40821,40957,40972,41056	NO
15	40671	LONGVIEW	NORTHWEST	230.00	7	40044,40651,40669,40672,40673,41227,41228	NO
16	40689	MAPLE V3	NORTHWEST	230.00	7	40692,40693,40771,41018,42412,42500,46435	NO
17	40699	MARION	NORTHWEST	500.00	7	40629,40714,40719,40720,40722,40827,40941	NO
18	40304	COVINGTE	NORTHWEST	230.00	7	40303,40306,40692,41053,42505,42700,46416	NO
19	41343	BIGEDDY3	NORTHWEST	230.00	7	40111,40511,41342,41350,43317,44059,44060	NO
20	40303	COVINGTW	NORTHWEST	230.00	7	40302,40304,41049,42507,42700,44276,46424	NO
21	40489	GRIZZLY	NORTHWEST	500.00	7	40488,40498,40588,40592,40700,43485,45046	NO
22	40207	CHEHALIS	NORTHWEST	230.00	7	40203,40205,40673,40792,40987,46634,47748	NO
23	40049	ALVEY	NORTHWEST	230.00	7	40047,40051,40375,40627,40701,45093,46291	NO
24	40692	MAPLEV12	NORTHWEST	230.00	7	40304,40689,40691,41005,42501,46426,46427	NO
25	40687	MALIN	NORTHWEST	500.00	7	40692,40693,40771,41018,42412,42500,46435	NO
26	40699	MARION	NORTHWEST	500.00	7	40629,40714,40719,40720,40722,40827,40941	NO
27	40304	COVINGTE	NORTHWEST	230.00	7	40303,40306,40692,41053,42505,42700,46416	NO
28	41343	BIGEDDY3	NORTHWEST	230.00	7	40111,40511,41342,41350,43317,44059,44060	NO
29	40303	COVINGTW	NORTHWEST	230.00	7	40302,40304,41049,42507,42700,44276,46424	NO
30	40489	GRIZZLY	NORTHWEST	500.00	7	40488,40498,40588,40592,40700,43485,45046	NO
31	40207	CHEHALIS	NORTHWEST	230.00	7	40203,40205,40673,40792,40987,46634,47748	NO
32	40049	ALVEY	NORTHWEST	230.00	7	40047,40051,40375,40627,40701,45093,46291	NO

As a matter of form, run ctg

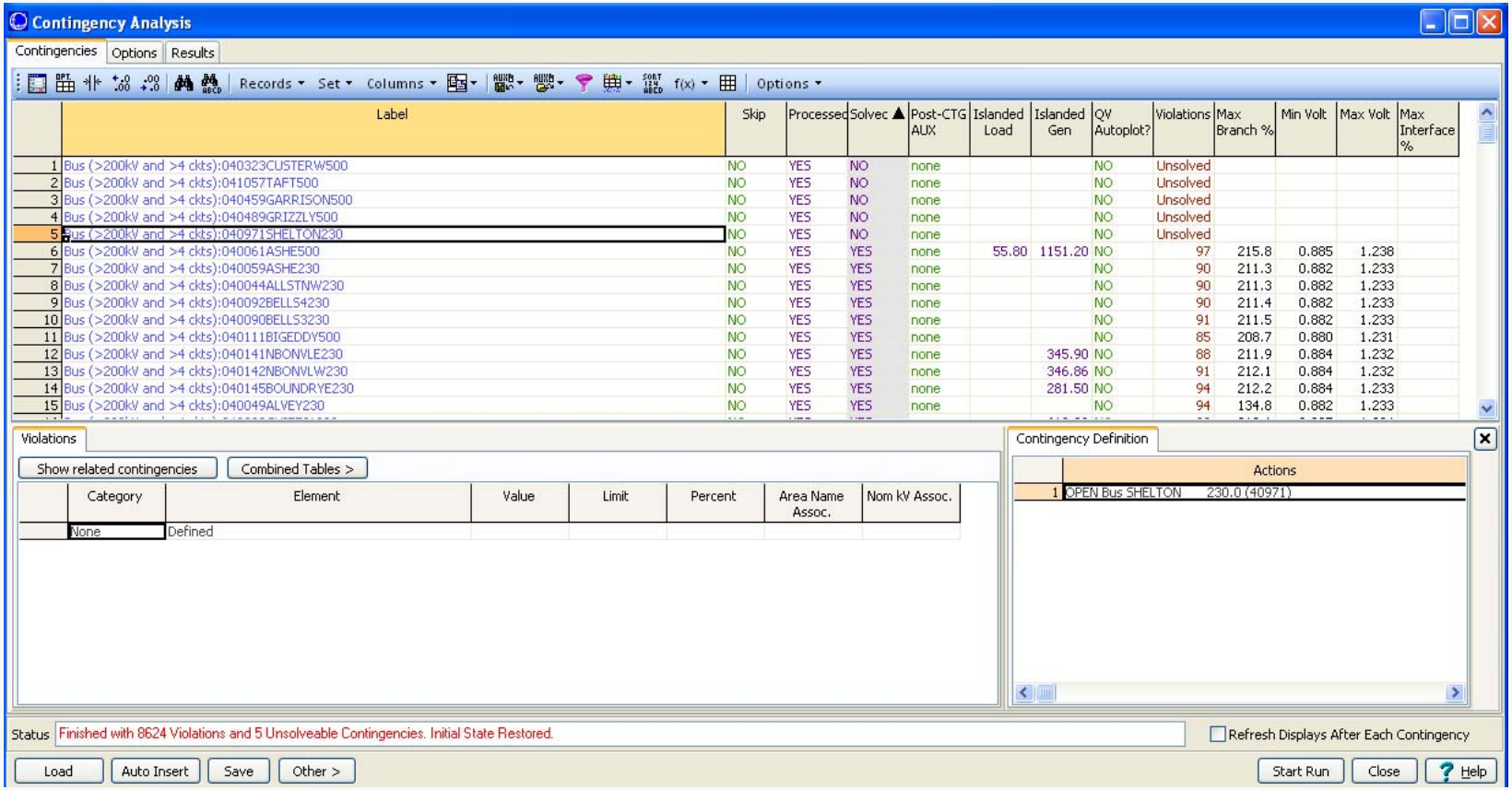


Insert Contingencies



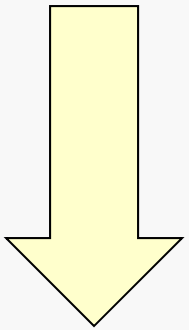
Power Flow Contingency Results

Not required by FERC 754,but the results are easily obtained and have some value.



Identified Need: Ctg Converter

```
DATA (CONTINGENCY, [CTGLabel,CTGSkip,CTGProc,CTGSolved,CtgFileName,LoadMW,GenMW,QVAutoplot,CTGViol,
  CTGViolMaxLine,CTGViolMinVolt,CTGViolMaxVolt,CTGViolMaxInterface])
{
"Bus (>200kV and >4 ckts):040323CUSTERW500" "NO " "YES" "NO " "none" "" "" "NO " Unsolved "" "" "" ""
  <SUBDATA CTGElement>
    "BUS 40323  OPEN" "" CHECK
  </SUBDATA>
```



Need a automated way to convert power flow contingencies to stability events.
OR
Need an automatic insert tool for transient stability events.

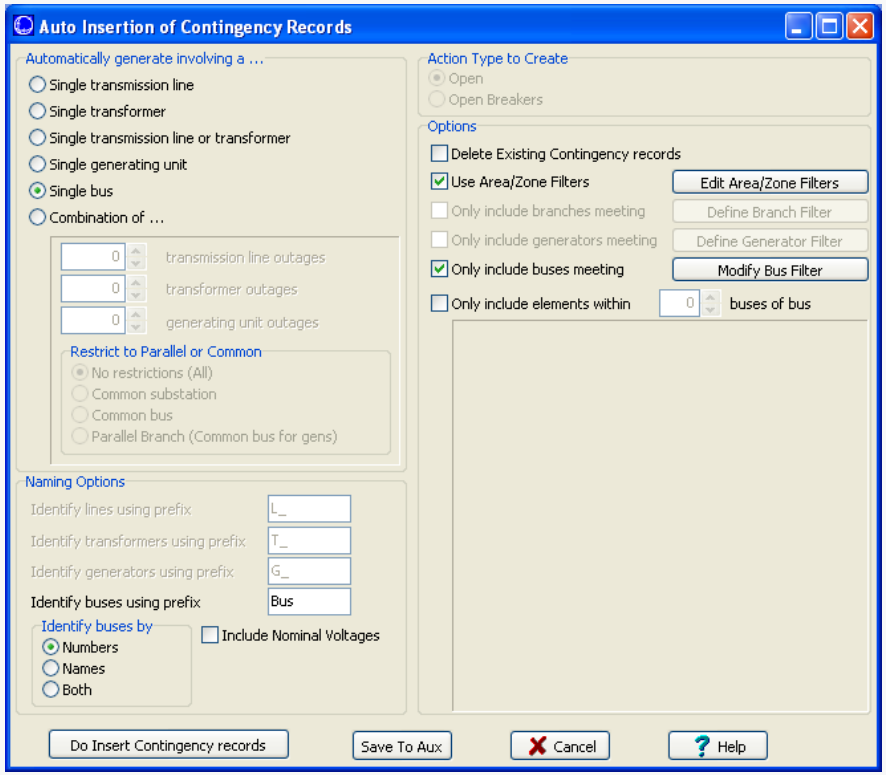
```
DATA (TSCONTINGENCY, [TSCTGName,StartTime,EndTime,UseCyclesForTimeStep,TimeStep,CTGSkip,CTGSolved,
  CTGViol,TSTotalLoadMWTripped,TSTotalGenMWTripped,PLVisible,PLColor,
  PLThickness,SODashed,SymbolType])
{
"Custer 500 kV bus"  0.000 10.000 "YES"  0.500 "NO " "NO " 0  0.000  0.000 "YES" -1 Default "Default" "Default"
}

DATA (TSCONTINGENCYELEMENT, [TSCTGName,TSTimeInSeconds,WhoAmI,TSEventString,Enabled,FilterName])
{
"Custer 500 kV bus"  1.000 "Bus '40323'" "FAULT 3PB SOLID" "CHECK" ""
"Custer 500 kV bus"  1.100 "Bus '40323'" "CLEARFAULT" "CHECK" ""
}
```

PWS to Excel to PWS

Transient Stability Events			
Contingency Name	***Time (Seconds)***	***Object***	***Description***

The End



The Beginning

PWS to Excel to PWS..

Contingency Records
Bus040021
Bus040043
Bus040044
Bus040045
Bus040049
Bus040059
Bus040061
Bus040086

From ctg tool

Transient Stability Events Contingency Name
Bus Fault 040021
Bus Fault 040043
Bus Fault 040044
Bus Fault 040045
Bus Fault 040049
Bus Fault 040059
Bus Fault 040061
Bus Fault 040086

=CONCATENATE("Bus Fault ",MID(A3,4,9))

Time (Seconds)
1
1
1
1
1
1
1
1

Manual cell fill

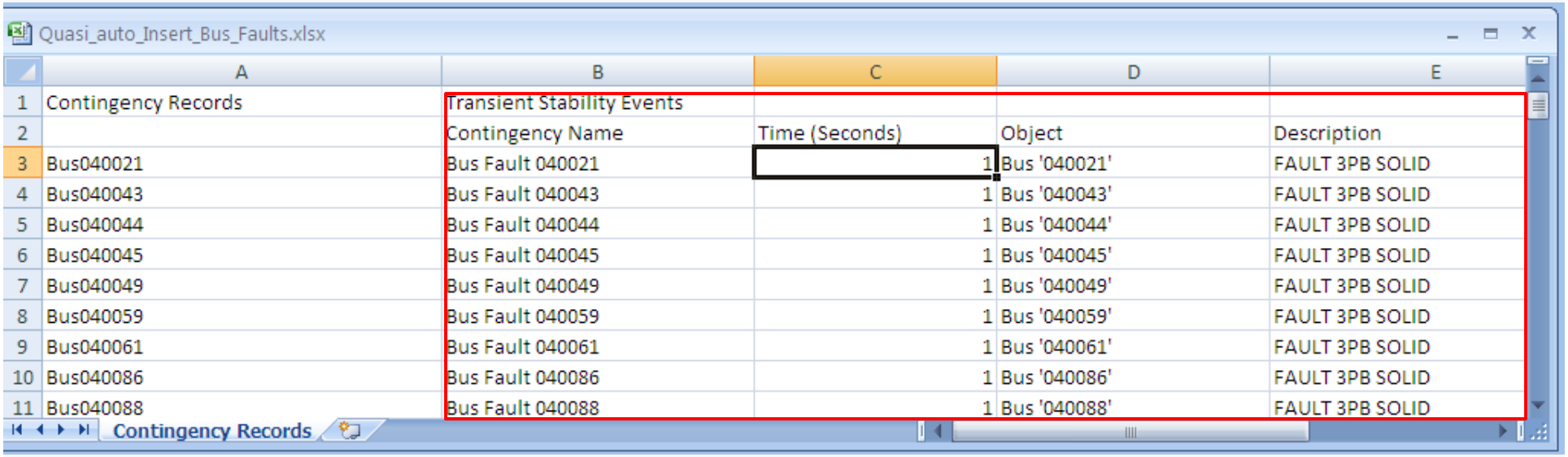
Object
Bus '040021'
Bus '040043'
Bus '040044'
Bus '040045'
Bus '040049'
Bus '040059'
Bus '040061'
Bus '040086'

=CONCATENATE(LEFT(A3,3)," '",MID(A3,4,9),"'")

Description
FAULT 3PB SOLID
FAULT 3PB SOLID
FAULT 3PB SOLID
FAULT 3PB SOLID
FAULT 3PB SOLID
FAULT 3PB SOLID
FAULT 3PB SOLID
FAULT 3PB SOLID

Manual cell fill

PWS to Excel to PWS.



Quasi_auto_Insert_Bus_Faults.xlsx

	A	B	C	D	E
1	Contingency Records	Transient Stability Events			
2		Contingency Name	Time (Seconds)	Object	Description
3	Bus040021	Bus Fault 040021	1	Bus '040021'	FAULT 3PB SOLID
4	Bus040043	Bus Fault 040043	1	Bus '040043'	FAULT 3PB SOLID
5	Bus040044	Bus Fault 040044	1	Bus '040044'	FAULT 3PB SOLID
6	Bus040045	Bus Fault 040045	1	Bus '040045'	FAULT 3PB SOLID
7	Bus040049	Bus Fault 040049	1	Bus '040049'	FAULT 3PB SOLID
8	Bus040059	Bus Fault 040059	1	Bus '040059'	FAULT 3PB SOLID
9	Bus040061	Bus Fault 040061	1	Bus '040061'	FAULT 3PB SOLID
10	Bus040086	Bus Fault 040086	1	Bus '040086'	FAULT 3PB SOLID
11	Bus040088	Bus Fault 040088	1	Bus '040088'	FAULT 3PB SOLID

Contingency Records

PWS to Excel to PWS…

- The table below gets us halfway…we still need clearing times

Quasi_auto_Insert_Bus_Faults.xlsx

	A	B	C	D	E
1	Contingency Records	Transient Stability Events			
2		Contingency Name	Time (Seconds)	Object	Description
3	Bus040021	Bus Fault 040021	1	Bus '040021'	FAULT 3PB SOLID
4	Bus040043	Bus Fault 040043	1	Bus '040043'	FAULT 3PB SOLID
5	Bus040044	Bus Fault 040044	1	Bus '040044'	FAULT 3PB SOLID
6	Bus040045	Bus Fault 040045	1	Bus '040045'	FAULT 3PB SOLID
7	Bus040049	Bus Fault 040049	1	Bus '040049'	FAULT 3PB SOLID
8	Bus040059	Bus Fault 040059	1	Bus '040059'	FAULT 3PB SOLID
9	Bus040061	Bus Fault 040061	1	Bus '040061'	FAULT 3PB SOLID
10	Bus040086	Bus Fault 040086	1	Bus '040086'	FAULT 3PB SOLID
11	Bus040088	Bus Fault 040088	1	Bus '040088'	FAULT 3PB SOLID

Contingency Records

- We need two spreadsheets
  - Fault on (time, nature of fault)
  - Clear fault (time, clear fault, open breaker)

PWS to Excel to PWS….

Quasi_auto_Insert_Bus_Faults.xlsx

	A	B	C	D	E
1	Contingency Records	Transient Stability Events			
2		Contingency Name	Time (Seconds)	Object	Description
3	Bus040021	Bus Fault 040021	1	Bus '040021'	FAULT 3PB SOLID
4	Bus040043	Bus Fault 040043	1	Bus '040043'	FAULT 3PB SOLID
5	Bus040044	Bus Fault 040044	1	Bus '040044'	FAULT 3PB SOLID
6	Bus040045	Bus Fault 040045	1	Bus '040045'	FAULT 3PB SOLID
7	Bus040049	Bus Fault 040049	1	Bus '040049'	FAULT 3PB SOLID
8	Bus040059	Bus Fault 040059	1	Bus '040059'	FAULT 3PB SOLID
9	Bus040061	Bus Fault 040061	1	Bus '040061'	FAULT 3PB SOLID
10	Bus040086	Bus Fault 040086	1	Bus '040086'	FAULT 3PB SOLID
11	Bus040088	Bus Fault 040088	1	Bus '040088'	FAULT 3PB SOLID

Contingency Records

- Cut and paste, add clear time and new description

PWS to Excel to PWS…..

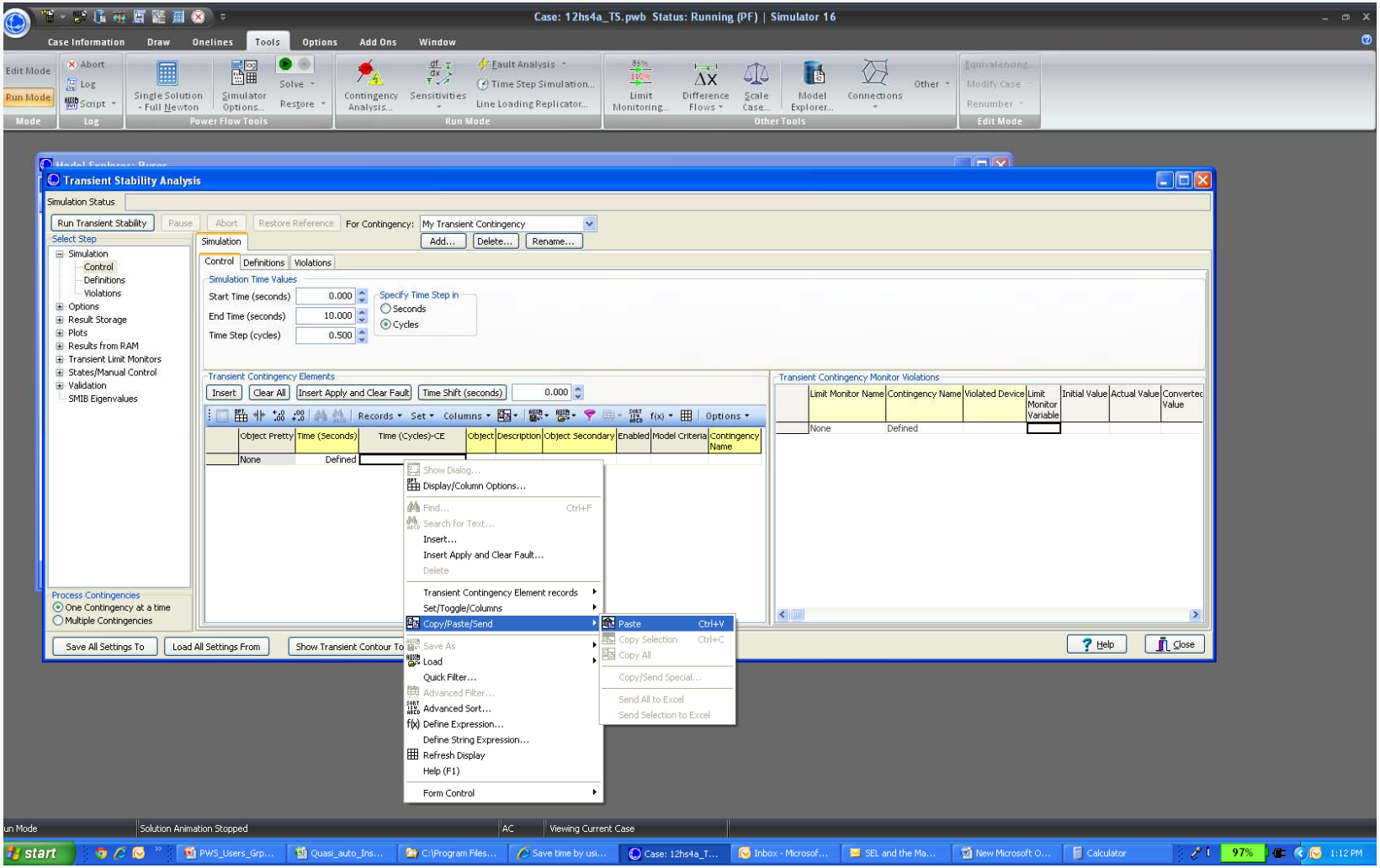
- Cut and paste to make this spreadsheet

Quasi_auto_Insert_Bus_Faults.xlsx

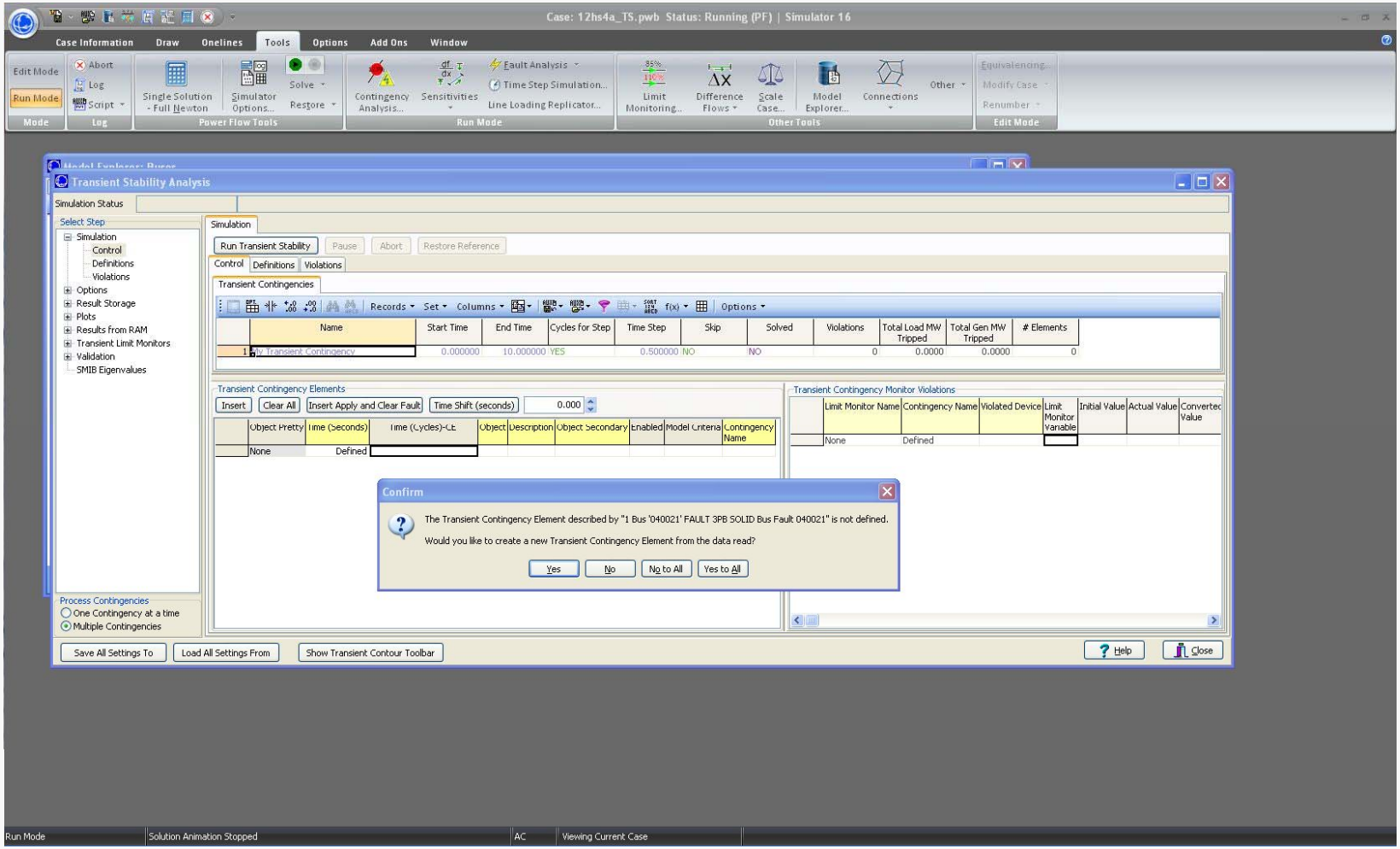
	F	G	H	I	J	K
1	Transient Stability Events					
2	Contingency Name	Time (Seconds)	Object	Description		
3	Bus Fault 040021	1.1	Bus '040021'	OPEN		
4	Bus Fault 040043	1.1	Bus '040043'	OPEN		
5	Bus Fault 040044	1.1	Bus '040044'	OPEN		
6	Bus Fault 040045	1.1	Bus '040045'	OPEN		
7	Bus Fault 040049	1.1	Bus '040049'	OPEN		
8	Bus Fault 040059	1.1	Bus '040059'	OPEN		
9	Bus Fault 040061	1.1	Bus '040061'	OPEN		
10	Bus Fault 040086	1.1	Bus '040086'	OPEN		
11	Bus Fault 040088	1.1	Bus '040088'	OPEN		

Contingency Records

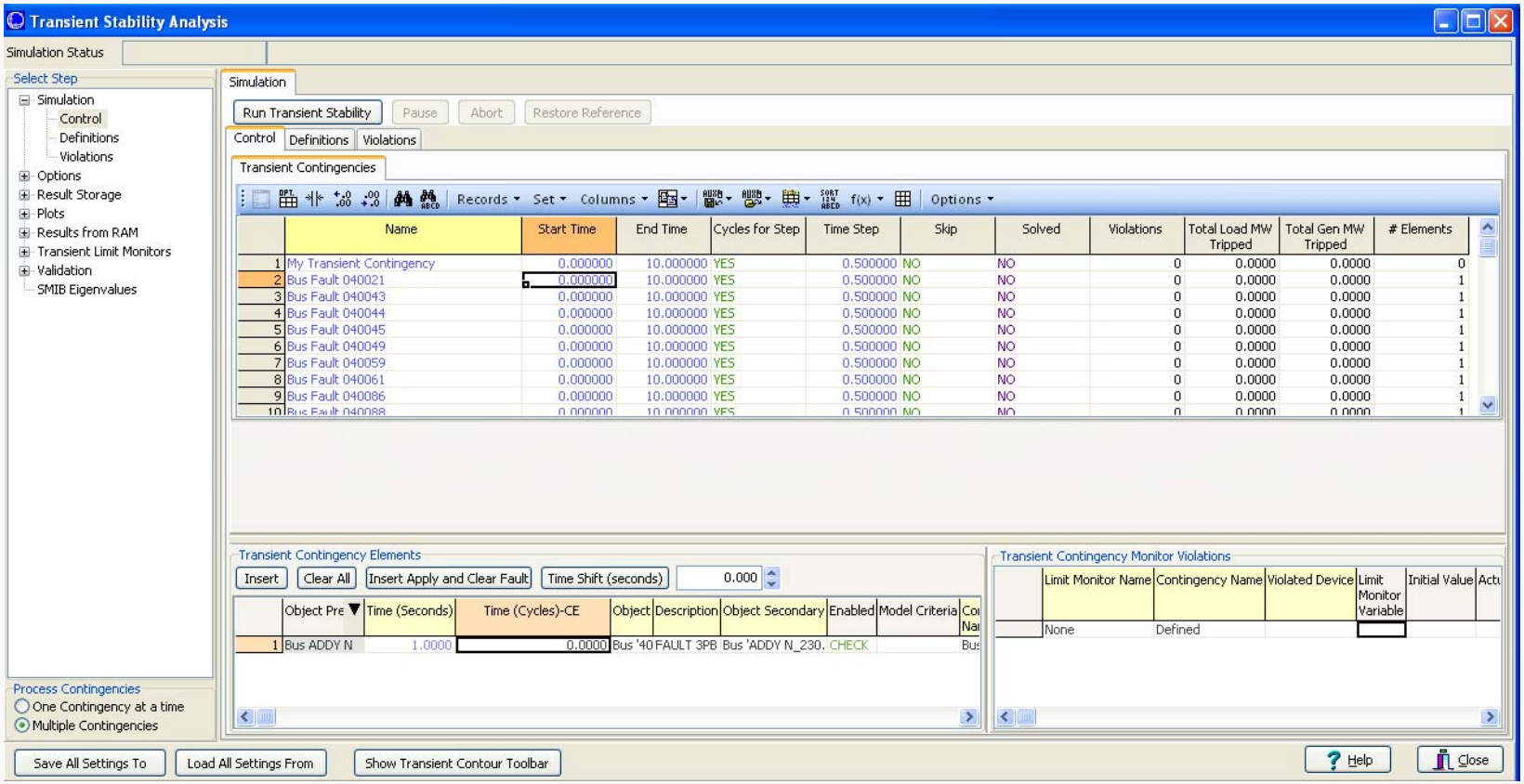
Pasting into PWS.



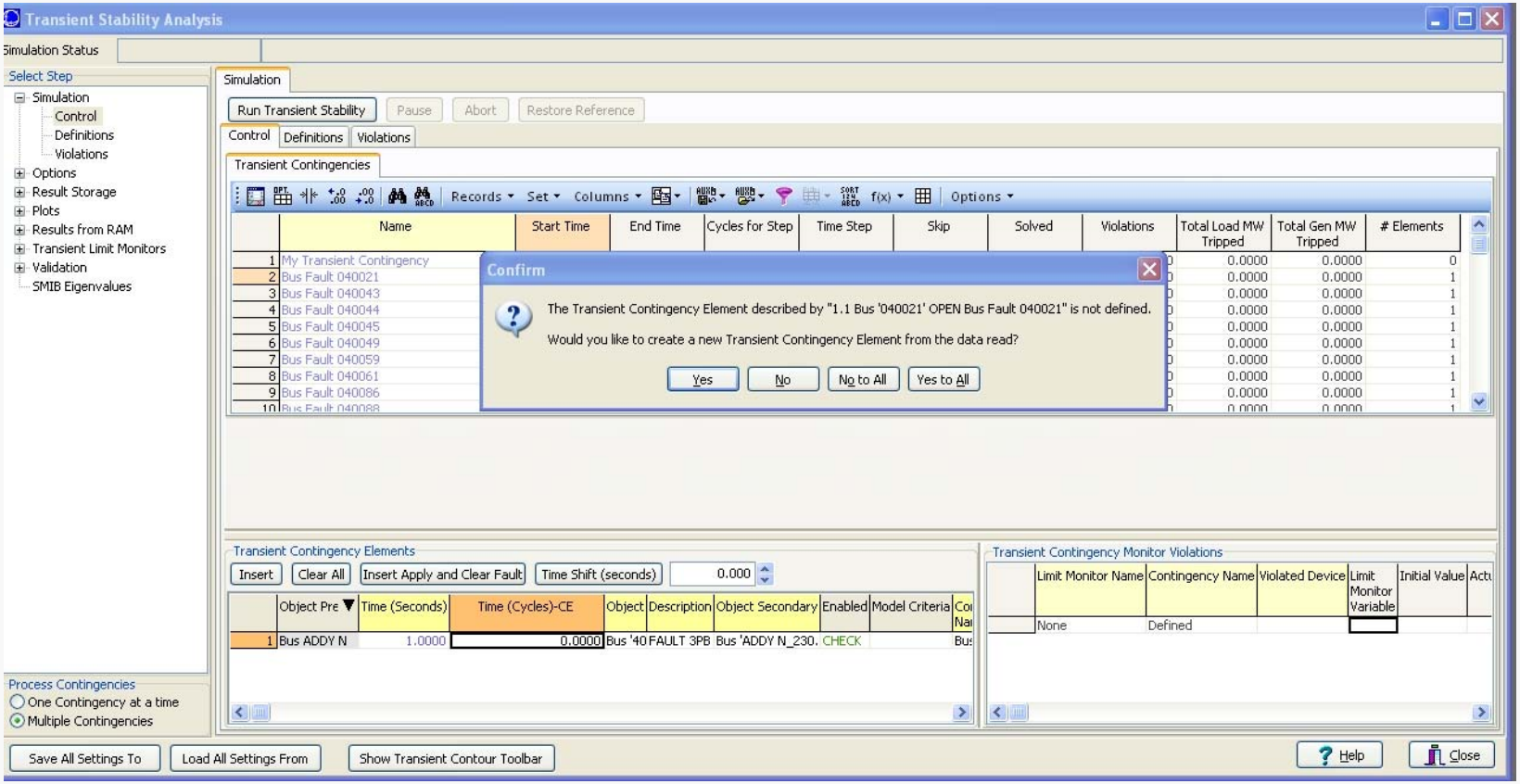
Pasting into PWS..



Refresh by Switching to Multiple

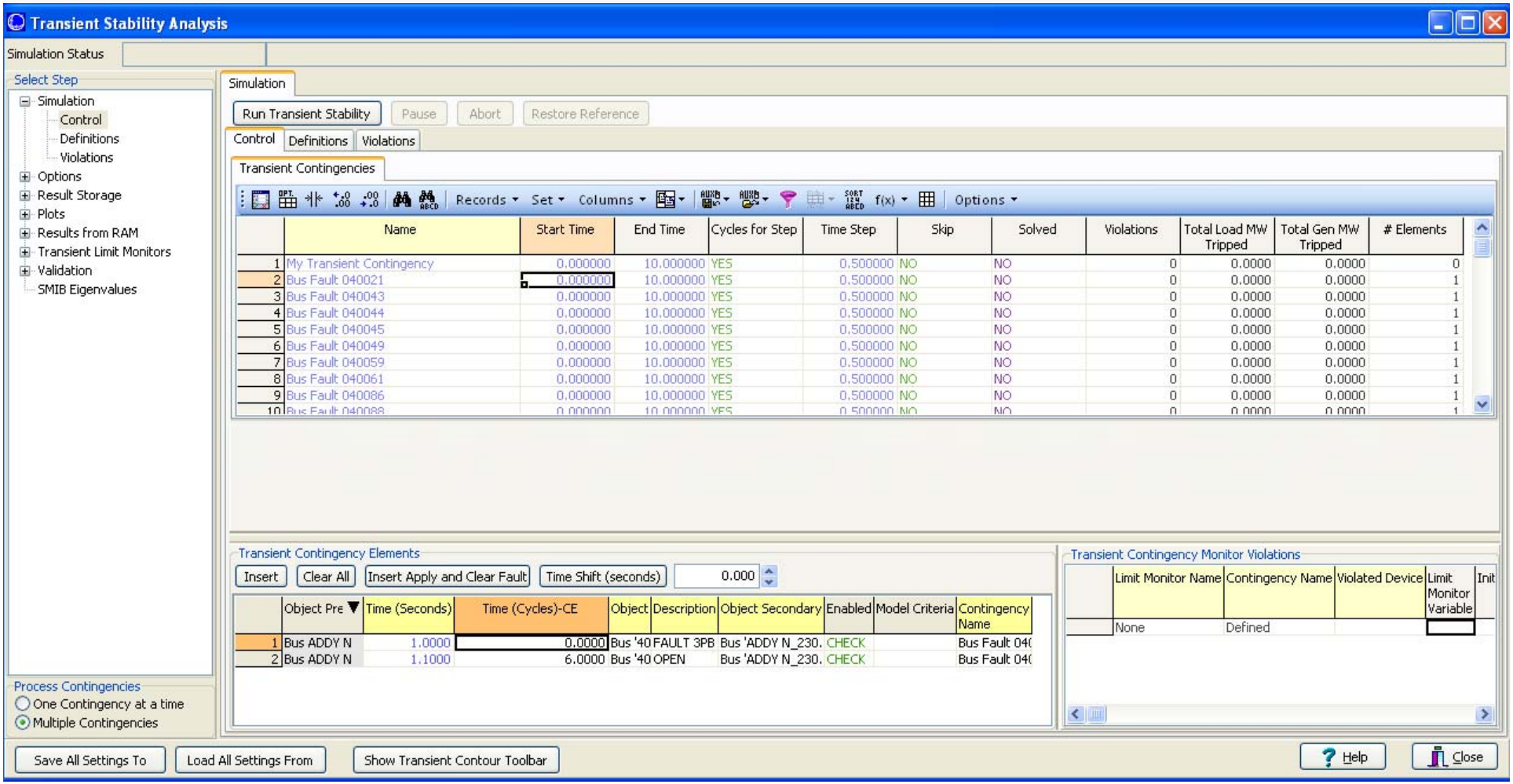


Paste in Clearing



Final Result (Bus Fault/Clear)

- With practice, 2 minutes to get here.



Filter (200 kV/4 ckts)

DATA (FILTER, [ObjectType,FilterName,FilterLogic,FilterPre,Enabled])
{
"Bus" "FERC 745: 200 kV and 4 ckts or more" "AND" "NO " "NO "
  <SUBDATA Condition>
    OwnerName contains "**INSERT OWNER NAME HERE**"
    BusNomVolt >= 200.00000
    BusNeighbors:1 >= 4
  </SUBDATA>
}

Filter (100-200kV/6 ckts)

DATA (FILTER, [ObjectType,FilterName,FilterLogic,FilterPre,Enabled])

{

"Bus" "FERC 745: 100 kV to 200 and 6 ckts or more" "AND" "NO "
"NO "

<SUBDATA Condition>

OwnerName contains " **INSERT OWNER NAME HERE** "

BusNomVolt between 100.00000 200.00000

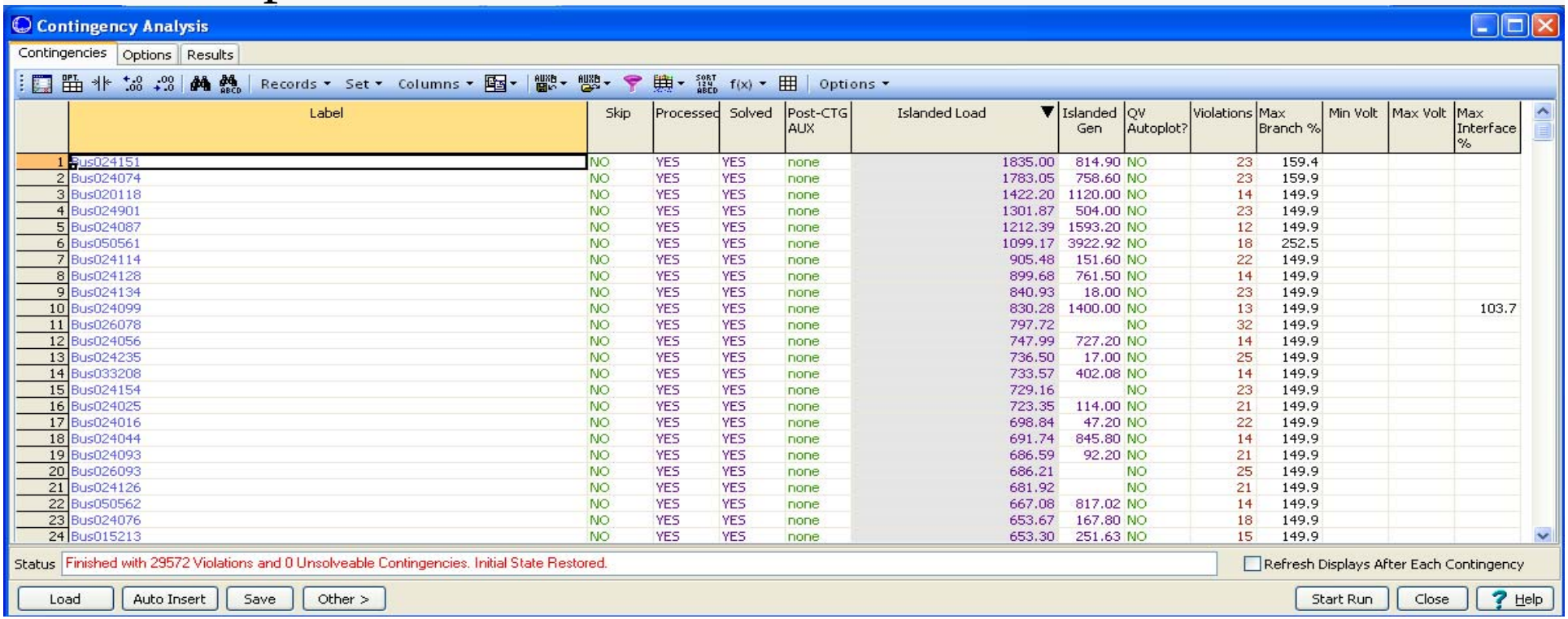
BusNeighbors:1 >= 6

</SUBDATA>

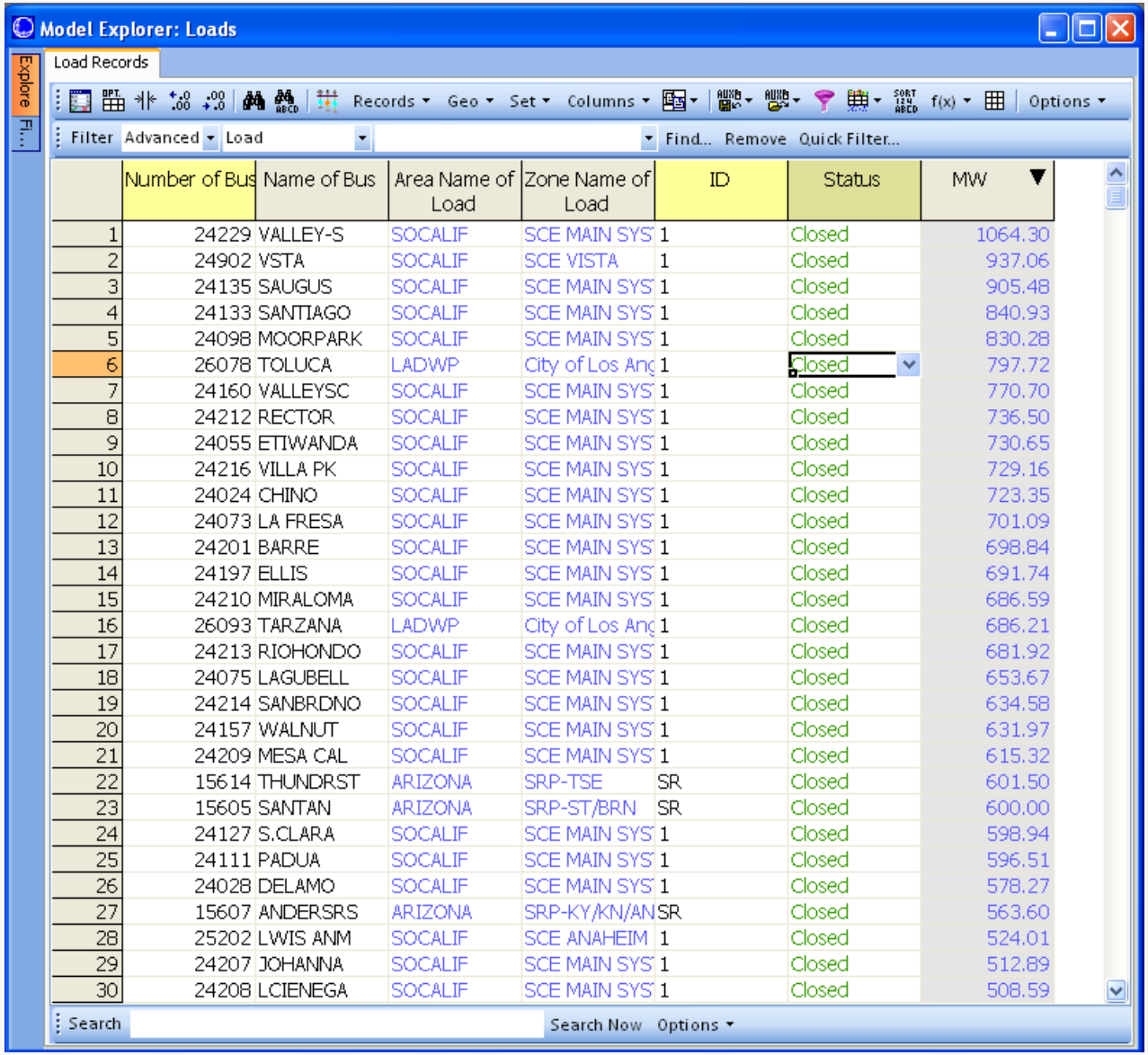
}

Filter (100 kV/4 ckts-300 MW)

- Apply 100 kV and up and 4 and up ckt filter
- Run DC ctg analysis WECC wide
  - Think REAL HARD about load modeling practices



Consider Disaggregating Loads



	Number of Bus	Name of Bus	Area Name of Load	Zone Name of Load	ID	Status	MW
1	24229	VALLEY-S	SOCALIF	SCE MAIN SYS	1	Closed	1064.30
2	24902	VSTA	SOCALIF	SCE VISTA	1	Closed	937.06
3	24135	SAUGUS	SOCALIF	SCE MAIN SYS	1	Closed	905.48
4	24133	SANTIAGO	SOCALIF	SCE MAIN SYS	1	Closed	840.93
5	24098	MOORPARK	SOCALIF	SCE MAIN SYS	1	Closed	830.28
6	26078	TOLUCA	LADWP	City of Los Ang	1	Closed	797.72
7	24160	VALLEYSC	SOCALIF	SCE MAIN SYS	1	Closed	770.70
8	24212	RECTOR	SOCALIF	SCE MAIN SYS	1	Closed	736.50
9	24055	ETIWANDA	SOCALIF	SCE MAIN SYS	1	Closed	730.65
10	24216	VILLA PK	SOCALIF	SCE MAIN SYS	1	Closed	729.16
11	24024	CHINO	SOCALIF	SCE MAIN SYS	1	Closed	723.35
12	24073	LA FRESA	SOCALIF	SCE MAIN SYS	1	Closed	701.09
13	24201	BARRE	SOCALIF	SCE MAIN SYS	1	Closed	698.84
14	24197	ELLIS	SOCALIF	SCE MAIN SYS	1	Closed	691.74
15	24210	MIRALOMA	SOCALIF	SCE MAIN SYS	1	Closed	686.59
16	26093	TARZANA	LADWP	City of Los Ang	1	Closed	686.21
17	24213	RIOHONDO	SOCALIF	SCE MAIN SYS	1	Closed	681.92
18	24075	LAGUBELL	SOCALIF	SCE MAIN SYS	1	Closed	653.67
19	24214	SANBRDNO	SOCALIF	SCE MAIN SYS	1	Closed	634.58
20	24157	WALNUT	SOCALIF	SCE MAIN SYS	1	Closed	631.97
21	24209	MESA CAL	SOCALIF	SCE MAIN SYS	1	Closed	615.32
22	15614	THUNDRST	ARIZONA	SRP-TSE	SR	Closed	601.50
23	15605	SANTAN	ARIZONA	SRP-ST/BRN	SR	Closed	600.00
24	24127	S.CLARA	SOCALIF	SCE MAIN SYS	1	Closed	598.94
25	24111	PADUA	SOCALIF	SCE MAIN SYS	1	Closed	596.51
26	24028	DELAMO	SOCALIF	SCE MAIN SYS	1	Closed	578.27
27	15607	ANDERSRS	ARIZONA	SRP-KY/KN/AN	SR	Closed	563.60
28	25202	LWIS ANM	SOCALIF	SCE ANAHEIM	1	Closed	524.01
29	24207	JOHANNA	SOCALIF	SCE MAIN SYS	1	Closed	512.89
30	24208	LCIENEGA	SOCALIF	SCE MAIN SYS	1	Closed	508.59

Filter (Buses-gen>1000)

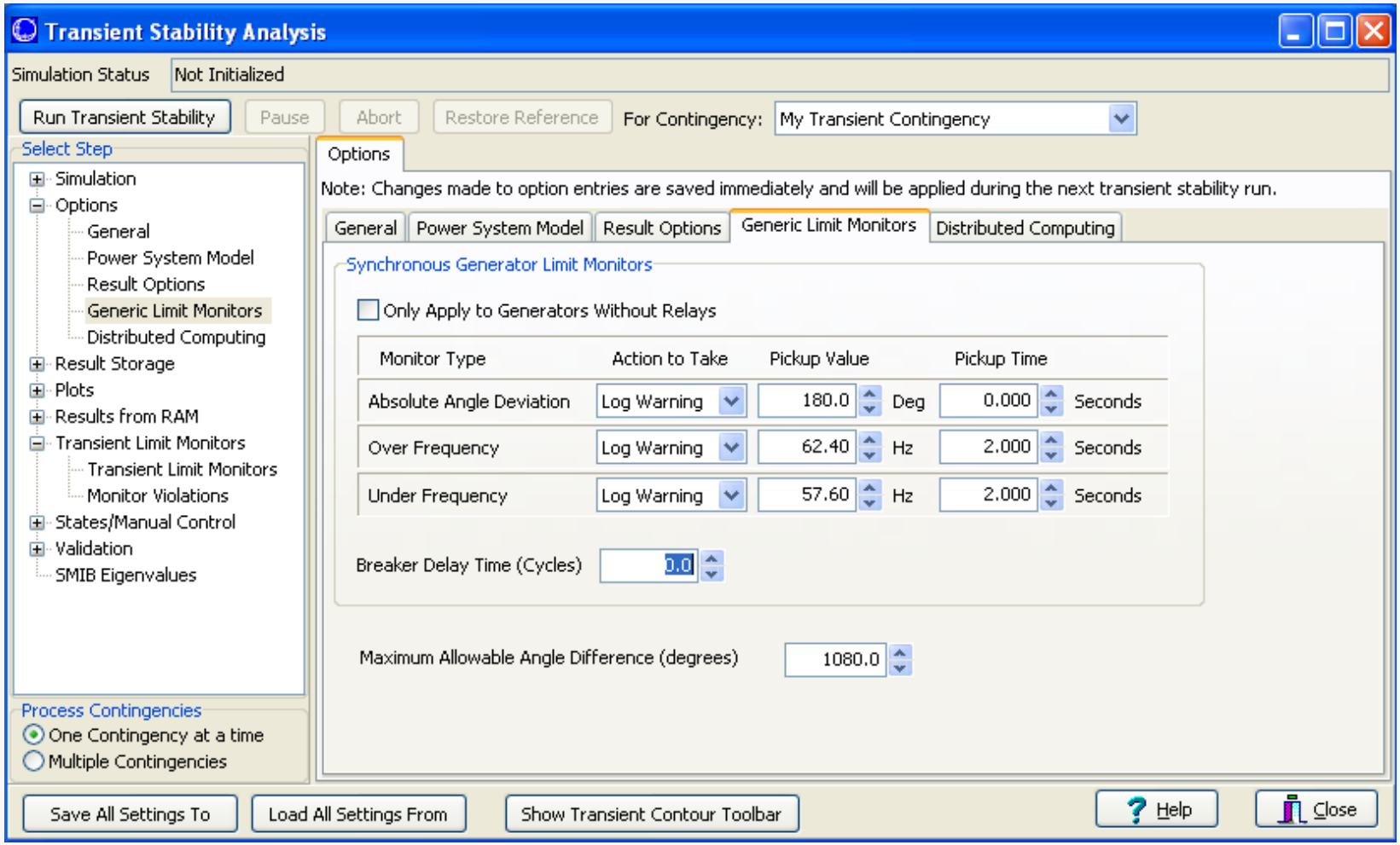
```
DATA (FILTER, [ObjectType,FilterName,FilterLogic,FilterPre,Enabled])
{
"Bus" "FERC 754:  Gen > 1000 MW at bus" "AND" "NO " "YES"
   <SUBDATA Condition>
     GenMWMax >= 1000.00000
   </SUBDATA>
}
```

Performance Measures

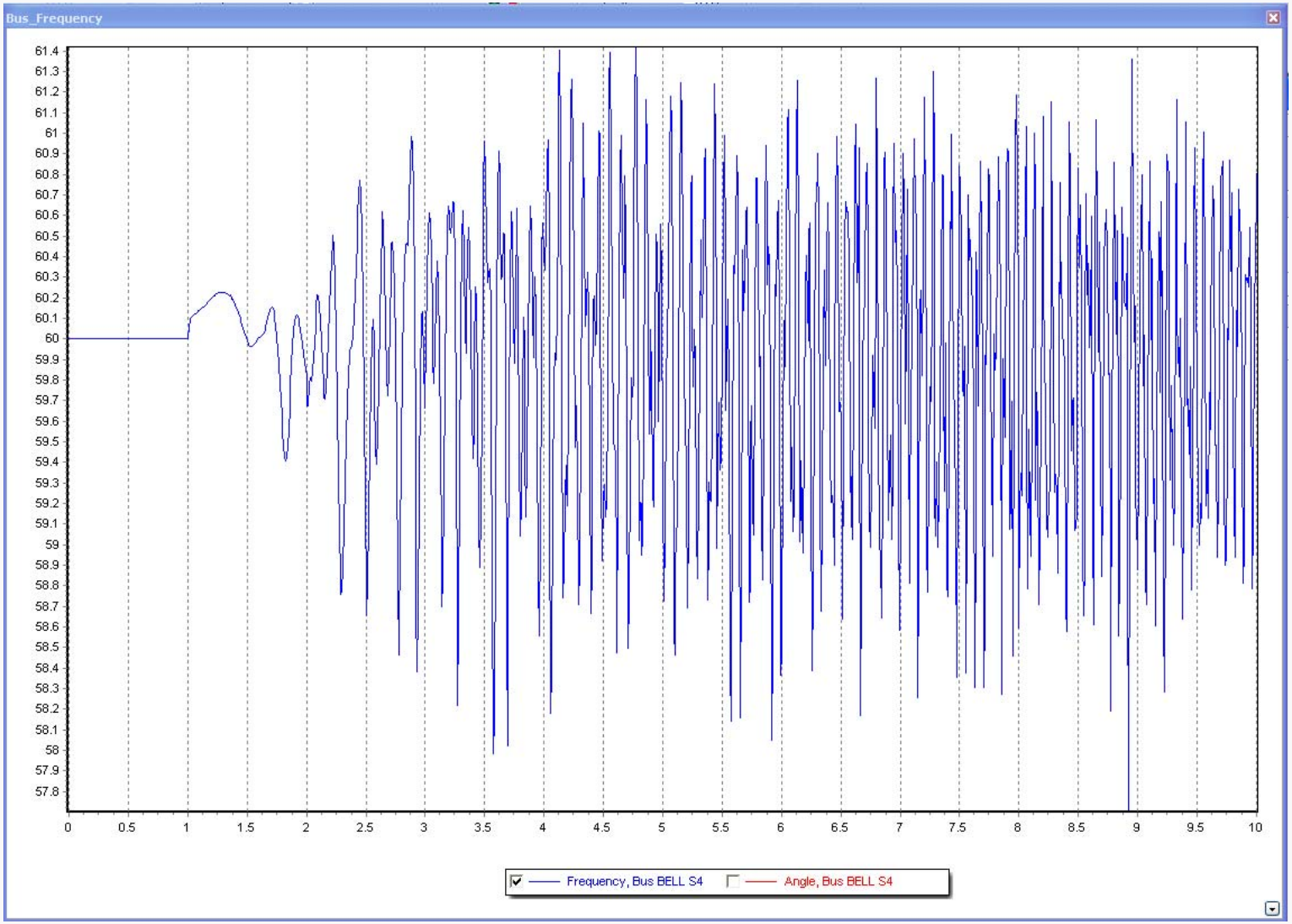
Table C: Performance Measures
1. Loss of synchronism of generating units totaling greater than 2,000 MW or more in the Eastern Interconnection or Western Interconnection, or 1,000 MW or more in the ERCOT or Québec Interconnections
2. Loss of synchronism between two portions of the system
3. Negatively damped oscillations

Performance Measures.

- Absolute Angle Deviation for Loss of Sync



Performance Issues



These Would Be Bad

Solution Finished in 0.216 Seconds
Simulation: Successful Power Flow Solution
Transient Stability Started at 10-09-2012 9:05:20 AM
Time: 1.000 Event: Apply Solid Fault (3PB) Bus BELL S3
Time: 1.150 Event: Relay Target Pickup Line SOUTH W TO ORCHRD CKT 1
Time: 1.167 Event: Relay Target Pickup Line PEARL TO HIGHLDTA CKT 1
Time: 1.300 Event: GENROU Large Angle Deviation: Warning Event Gen NINEMI34 #3
Time: 1.342 Event: Relay Target Pickup Line CHRISTOP TO MERIDITH CKT 1
Time: 1.350 Event: Gen Overexcitation Relay OEL1 action: Open Gen DETROIT #1
Time: 1.375 Event: Induction Machine Motor1 Under Voltage Trip: Opened for UnderVoltage Gen INVRGGN1 #1
Time: 1.383 Event: GENROU Large Angle Deviation: Warning Event Gen LITFAL12 #1
Time: 1.383 Event: GENROU Large Angle Deviation: Warning Event Gen LITFAL34 #3
Time: 1.392 Event: GENROU Large Angle Deviation: Warning Event Gen LONGLKG1 #1
Time: 1.400 Event: GENROU Large Angle Deviation: Warning Event Gen LONGLKG3 #3
Time: 1.425 Event: GENROU Large Angle Deviation: Warning Event Gen IEP-A #1
Time: 1.425 Event: GENROU Large Angle Deviation: Warning Event Gen IEP-B #1
Time: 1.475 Event: GENROU Large Angle Deviation: Warning Event Gen KETTLEAV #1
Time: 1.492 Event: GenTPJ Large Angle Deviation: Warning Event Gen ALBENI F #1
Time: 1.492 Event: GenTPJ Large Angle Deviation: Warning Event Gen ALBENI F #2
Time: 1.492 Event: GENROU Large Angle Deviation: Warning Event Gen CABGOR34 #3
Time: 1.492 Event: GENROU Large Angle Deviation: Warning Event Gen NOXON34 #3
Time: 1.492 Event: Induction Machine Motor1 Under Voltage Trip: Opened for UnderVoltage Gen GLCRWGN2 #1
Time: 1.500 Event: GenTPF Large Angle Deviation: Warning Event Gen SACHEEN #1

Questions/Thoughts?

- This IS a workshop topic
  - We can walk the dog through this tomorrow
- Best practices for things like FERC 754
  - Should you model large aggregate loads?
    - Consider modeling additional buses, network if appropriate
  - Other tools: Connections
- Cut/paste works in Transient Stability
  - Really easy for bus fault insertion
  - A bit more complicated for line faults