Appendix B

Southwest Twin Cities Load Serving Study Review

Addendum to Southwest Twin Cities Load Serving Study Review (Highway 212 Corridor conversion)

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05/09/2012

1. Background of Study Models

This document is an addendum, to Southwest Twin Cities Load Serving Study Review (Highway 212 Corridor conversion), created to correct the study model assumptions for Shakopee 69 kV substation, generation assumptions for New Prague and Montgomery and Dahlgren substation addition. The load at Shakopee substation was double counted as NSP owned and City owned. The distribution substation is owned by NSP, but the load is owned by the City of Shakopee, therefore the load in the model, shown as 'owned by NSP', had to be removed. Similarly local generators at New Prague and Montgomery were modeled as being online, that is corrected to model the generators as being offline. This assessment also includes the new Dahlgren substation being built by NSP to reduce the load at Chaska downtown substation.

The following corrections and modifications were made to the (Highway 212 Corridor conversion) base case study model:

1. 'X0' load, approximately 15 MW was removed at Shakopee
2. New Dahlgren substation was added to the Scott County – Carver County 115 kV line near City of Carver. The NSP load from City of Chaska (7.8 MW) was transferred over to this new Dahlgren 115 kV distribution substation.
3. The generator at New Prague was tuned off as it is not a base load generator (17 MW)
4. Similarly the generator at Montgomery was turned off (20 MW).
5. For study purposes the line between Scott County and Augusta was closed through, this might involve challenges associated with protective relaying.

2. Base Case Analysis (Project need)

The analysis, to identify the deficiencies of the study area, is based on three different base case scenarios.

Scenario 1: In this scenario, all the 69 kV lines between Carver County, Scott County and St. Bonifacius substations are assumed to be closed in the base case. This system configuration is not recommended for operation, as the entire load between Scott County, Carver County and St. Bonifacius substations (approximately 78 MW) would be exposed to faults on approximately 33 miles of 69 kV line, as there are no breakers or 'normally open switches' to reduce the fault exposure. Table 1 below provides the list of transmission deficiencies in this configuration:

Table 1

Contingency	Facility	Rating	%Overload
Loss of one of the Scott County TR	2nd Scott County TR	70	113%
Loss of Scott County – Chaska 69 kV line	Augusta – Victoria tap 69 kV line	47	103%
	Carver County tap – Augusta line	47	121%

Scenario 2: In this scenario, the 69 kV line between Chaska and Victoria tap is assumed to be operated normally open in the base case model. This configuration sectionalizes the system such that the load on Scott County transformers is reduced significantly, and also reduces the amount of load at risk for faults on the 69 kV line between Scott County, Carver County and St. Bonifacius. In this configuration the load at Chaska downtown substation would be served from Scott County substation, the remaining loads at West Creek, Victoria, Augusta, NSP Waconia and GRE Waconia are served from Carver County and St. Bonifacius substations. Table 2 below provides the list of deficiencies if the system is operated under this configuration.

Table 2

Contingency	Facility	Rating	%Overload
Loss of St. Bonifacius transformer	Carver County – Carver County tap 69 kV line	68	120%
Loss of Scott County – Chaska 69 kV line	Augusta – Victoria tap 69 kV line	47	103%
	Carver County tap – Augusta line	47	121%
Loss of Carver County tap - Carver County 69 kV line.	St. Bonifacius transformer	70	151%
	St. Bonifacius – Waconia 69 kV line	48	150%
	NSP Waconia – GRE Waconia 69 kV line	48	100%
	GRE Waconia – Carver County tap 69 kV line	45	101%
	Carver County tap – Augusta 69 kV line	47	97%
	Voltage at West Creek		87%
	Voltage at Victoria		87%
	Voltage at Augusta		88%

Scenario 3: In this scenario, the 69 kV line between Victoria tap and Augusta is assumed to be operated normally open in the base case. Similar to scenario 2, this configuration helps reduce exposure of load to faults on the line between Scott County, Carver County and St. Bonifacius substations. In this configuration, the load at Chaska downtown substation, Victoria and West Creek are served from Scott County substation. Augusta, NSP Waconia and GRE Waconia are served from Carve County and St. Bonifacius substations.

Table 3

Contingency	Facility	Rating	%Overload
Loss of one of the Scott County 115/69 kV TR	2nd Scott County TR	70	134%
Loss of Scott County – Chaska 69 kV line	Augusta – Victoria tap 69 kV line	47	103%
	Carver County tap – Augusta line	47	121%
Loss of Carver County – Carver County tap 69 kV line	St. Bonifacius transformer	70	101%

Based on the results from the above scenarios, it can be seen that Scenario 1 has least number of deficiencies, however, operating the system in this configuration will result in more than 78 MW of load at risk for faults on any 69 kV line between Carver County, Scott County and St. Bonifacius substations. In order to reduce the exposure of load to faults, a new 69 kV switching station may be required at Carver County tap. In addition, even in this configuration (from Table 1), the Scott County 115/69 kV transformers are loaded to 113% of their normal rating, and would require a replacement

soon after the West Creek load reaches 20 MW level. Therefore the existing transmission system serving Chaska, Victoria and Augusta is considered insufficient for the expected load growth along the study corridor. The Powerflow slider files associated with Tables 1, 2 and 3 are included in Appendix.

3. Alternative Analysis

The proposed Highway 212 Corridor project, involving Augusta, Victoria and West Creek substation conversion to 115 kV, was applied to the 2015 model, with corrections listed in Section 1. Analysis was performed on this model to ensure that the proposed project does not create any new violations. It is also assumed that the 115 kV mitigation plan involves retiring the Chaska downtown substation. The entire load from downtown substation was assumed to be moved to West Creek substation, after the conversion of 69 kV line to 115 kV.

The changes to the base model, listed in section 1, have minimal impact on the alternative analysis performed in "Southwest Twin Cities Load Serving Study Review (Highway 212 Corridor conversion)". As the reduced (corrected) load at Shakopee helps unload the Scott County transformers, and relocation of load to Dahlgren substation from Chaska would reduce the load in the study corridor, no negative impacts would be expected on the proposed project, due to the corrections listed in section 1. The analysis of the model indicates that there were no further violations on the 69 kV or 115 kV systems between Carver County, St. Bonifacius and Scott County substations.

Note: Currently the line between NSP Waconia and GRE Waconia is operated 'normally open'. After the completion of Southwest Twin Cities Phase 1 project, this line should be closed from Carver County to St. Bonifacius. This is required to avoid severe overloads on NSP's Gleason Lake – Mound 69 kV line for the loss of St. Bonifacius 115/69 kV transformer.

4. Incremental Load serving capability of preferred plan

PV analysis was performed with the Preferred plan and alternative plan to identify the incremental load serving capabilities, without NSP's load at Chaska (moved to Dahlgren substation) and with Chaska downtown load (moved to West Creek substation).

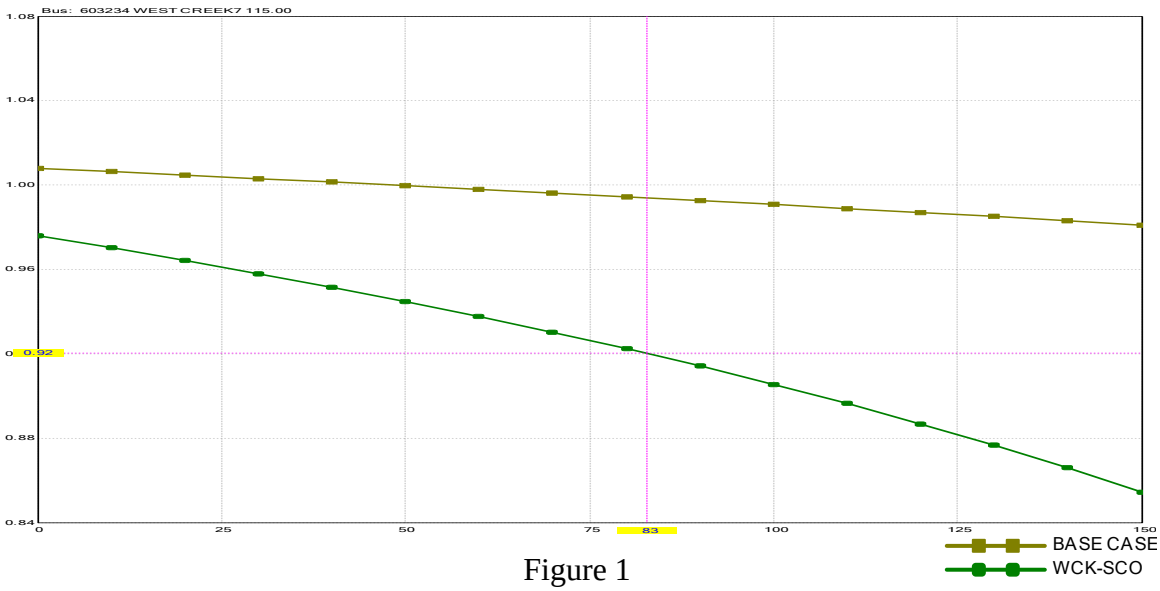


Figure 1

The initial load in the area is approximately 53.8 MW. The analysis indicates that, after conversion of the 69 kV line to 115 kV, the transmission system can accommodate a growth of approximately 83 MW. This is consistent with the analysis from "Southwest Twin Cities Load Serving Study Review (Highway 212 Corridor Conversion)", as the incremental load serving capability identified in the study was 78 MW. The increased load serving capability is due to the relocation of load from Chaska substation to West Creek and Dahlgren substations. Similarly the incremental load serving capability of the alternative plan is 72 MW.

	Preferred Plan (Option 1)	Alternative Plan (Option 2)
Load serving Capability	83 MW	72 MW

Incremental load serving capability for NERC Category C contingencies:

Analysis was performed on the preferred plan with NERC category C3 contingencies (n-2) to identify the incremental load serving capability of the proposed plan. The following contingencies were used for this analysis:

- Loss of Dickinson – St. Bonifacius 115 kV line + Carver County – Scott County 115 kV line.
- Loss of Dickinson – St. Bonifacius 115 kV line + Glencoe – McLeod 115 kV line.
- Loss of Scot County – West Creek 115 kV line + Scott County – Carver County 115 kV line
- Loss of Dickinson – St. Bonifacius 115 kV line + Scott County – West Creek 115 kV line
- Loss of Scott County – West Creek 115 kV line + Glencoe – McLeod 115 kV line.

Figure 2 provides the results of PV analysis, it can be inferred from the plots that approximately 50 MW of additional load can be served between Augusta, Victoria and West Creek substations before the voltages drop below 92%. The limiting contingency is the loss of Scott County – West Creek 115 kV line combined with the loss of Dickinson – St. Bonifacius 115 kV line.

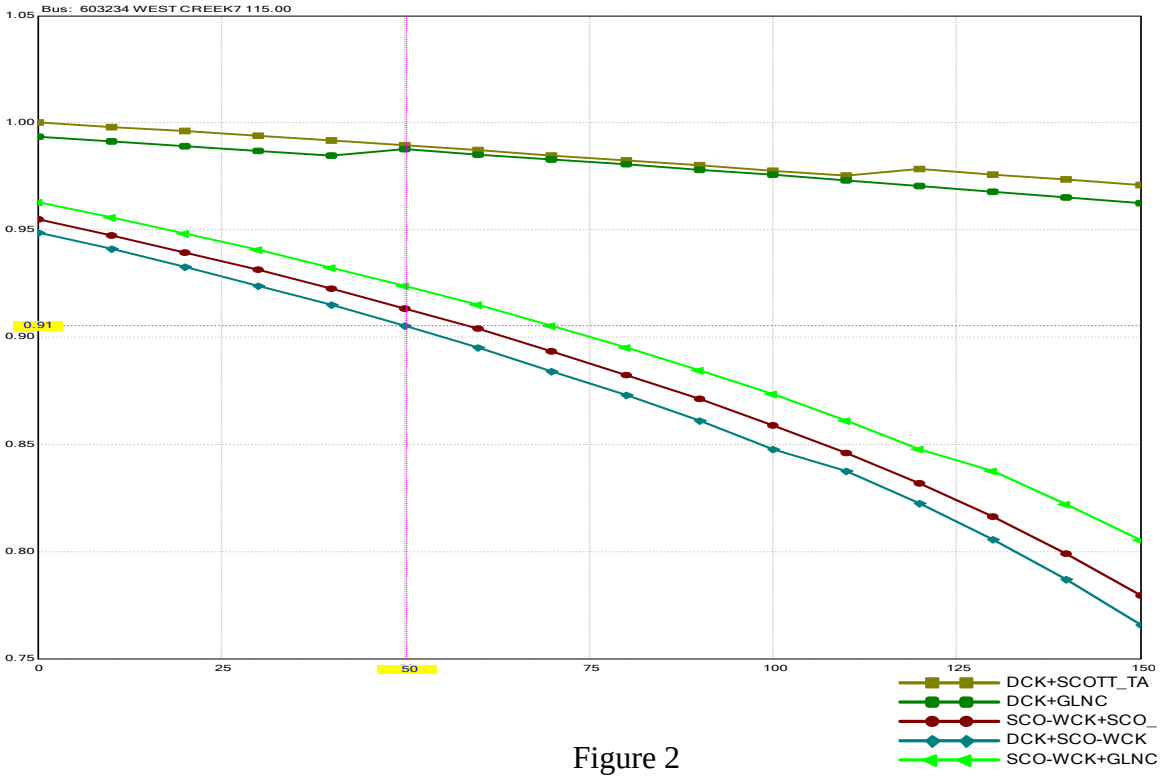


Figure 2

5. Loss Analysis

Loss analysis was performed on both the preferred and Alternative plans. The loss analysis indicates the losses are not impacted significantly by the conversion of the line 69 kV line to 115 kV.

	Base Case	Preferred Plan	Alternative Plan
Losses	346.9 MW	346.2 MW	346.4 MW

6. 2013 Summer Operating Challenges

The West Creek substation is expected to be energized by spring 2013 at 69 kV. Based on the load data, provided by the City of Chaska, the new data center would add approximately 12 MW of the proposed 20 MW, by June of 2013, at West Creek substation. Currently the CON and route permit for upgrading the line between Carver County and Aue Lake (1 mile west of Augusta) is approved. This upgrade is required to meet the needs of existing load, without the new data center. In addition, the conversion of Scott County – Excelsior – Deephaven – Westgate 69 kV line to 115 kV is not

expected to be completed before the end of 2014. This section of the report describes the analysis performed to identify the impact of adding 12 MW of load at West Creek substation in 2013 summer peak, after the completion of Southwest Twin Cities Phase 1 project and Dahlgren substation.

The base case model is based on the 2015 summer peak model described in Section 1. This base case model was modified to remove the Scott County – Excelsior – Deephaven – Westgate line conversion from 69 kV to 115 kV. In addition, the planned Dahlgren substation, near the city of Carver, was included, such that approximately 7 MW of NSP's load is moved from Chaska to Dahlgren substation.

In order to accurately model the 2013 summer peak conditions, the non-coincident peak loads for the substations between Scott County, Carver County and St. Bonifacius are updated using the forecasted 2013 summer peak values. The 2013 loads are shown in the Table 4 below.

Table 4

Substation	Loads (MW)
Chaska	13.5
West Creek	12
Victoria	10.2
Augusta	6
Waconia (NSP)	21.4
Waconia (GRE)	2.2

7. Analysis of 2013 summer peak model

In the proposed system configuration, the 69 kV transmission line between St. Bonifacius, Carver County and Scott County substations was assumed to be closed and operated as a three terminal line. Analysis of this model indicates that the loss of one of the Scott County transformers will result in overloading the other transformer to 120%. For operations planning purposes, the Scott County 115/69 kV transformers have an overload capability of 125% for 2 hours and 115% for 8 hours. The transformer can be overloaded for multiple peak and off peak cycles, as long as the peak load on the transformer is less that 115% of its normal rating. Therefore, after the outage of one of the Scott County transformers, the line between Chaska and Scott County can be opened with in 2 Hours, such that the load on Scott County transformer, that is in-service, will drop from 120% to 104% of its normal rating. This would provide the ability to operate the Scott County transformers within the applicable rating for multiple load cycles, while the long term outage of the other transformer is resolved. It should be noted that construction outages cannot be taken during peak load period, in order to avoid overload on Scott County transformers. Therefore the construction outages for West Waconia – Scott County 69 kV line conversion to 115 kV cannot be obtained till Fall of 2013.

With the projected 2013 peak loads, with 12 MW of load at West Creek, the following conditions have to be met in order to operate the system within the applicable ratings:

1. NSP's line between Carver County substation and Aue Lake (1 mile west of Augusta) has to be rebuilt before 2013 summer peak, as part of Southwest Twin Cities Phase 1 project.
2. The 69 kV line connecting Waconia substation to Carver County – Augusta 69 kV line (Carver County tap) has to be in-service before 2013 summer peak, with a hard tap, as part of Southwest Twin Cities Phase 1 project.
3. The relay settings at Scott County, Carver County and St. Bonifacius substations have to be set, such that the 69 kV line can be operated at a three terminal line.
4. During the outage of one of the Scott County transformers, the line between Scott County and Chaska has to be opened within 2 Hours to unload the transformer that is in-service.

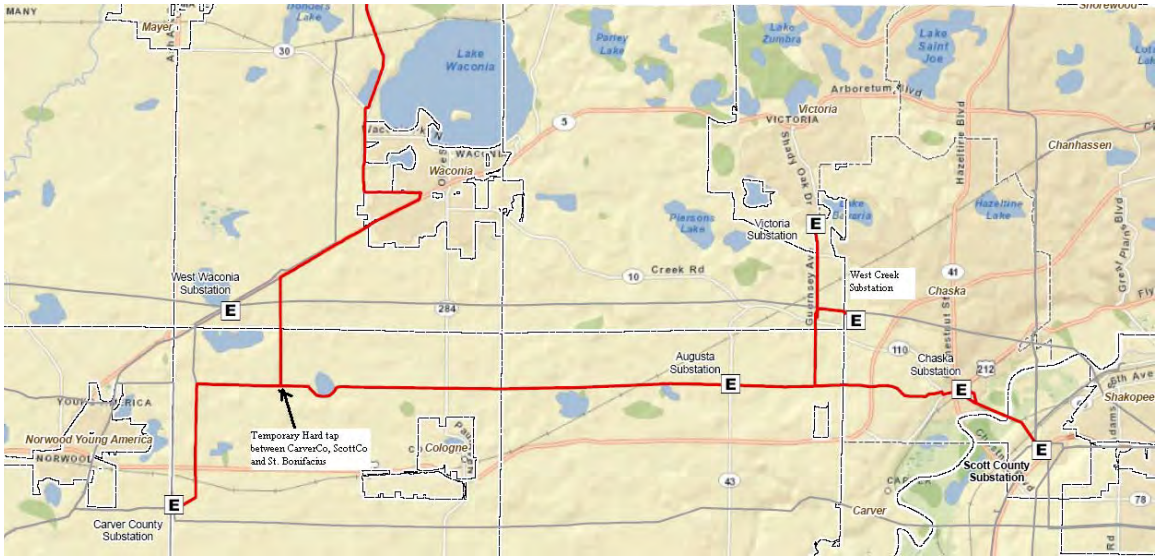
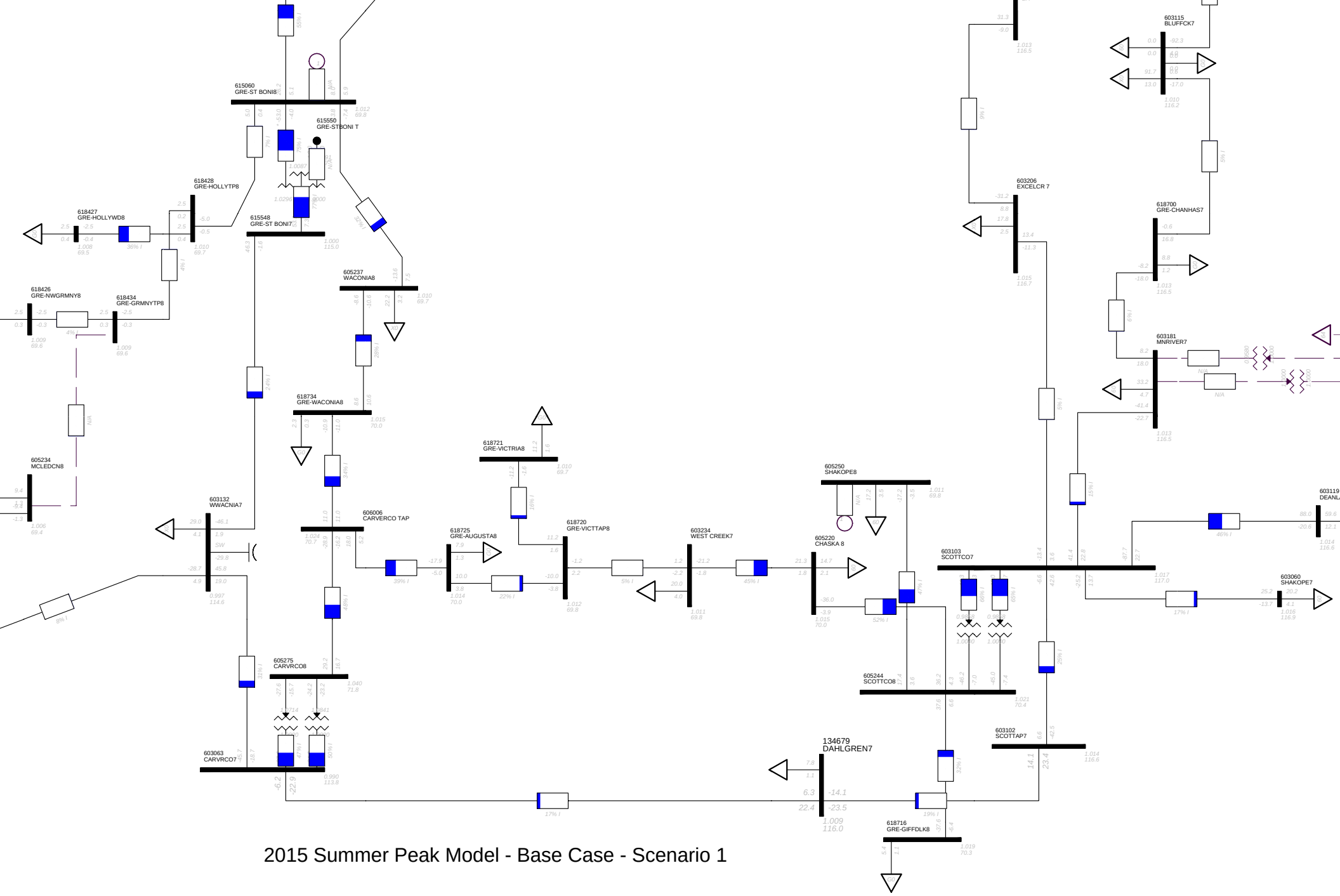


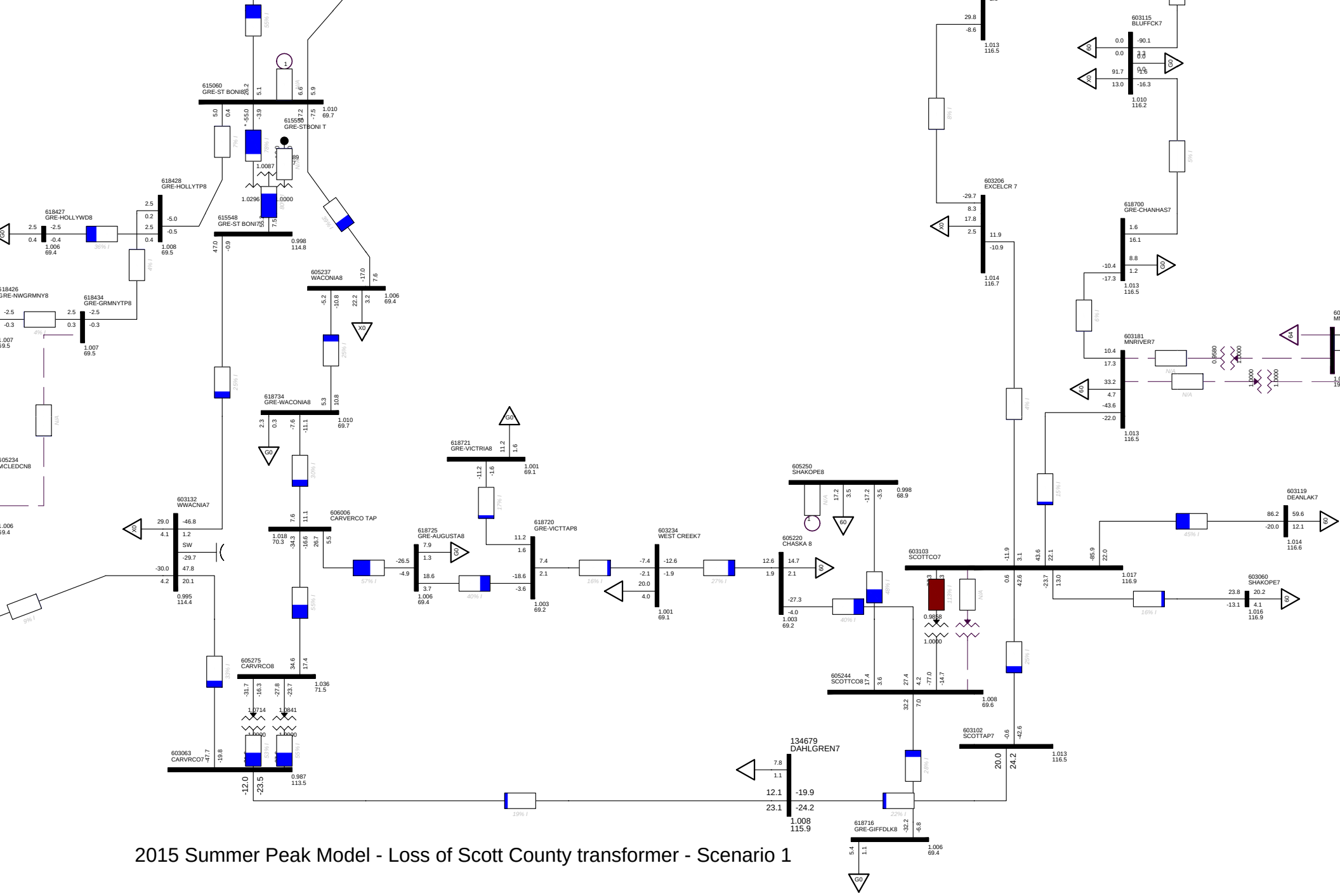
Figure 1

The powerflow maps associated with the 2013 load analysis is included in Appendix.

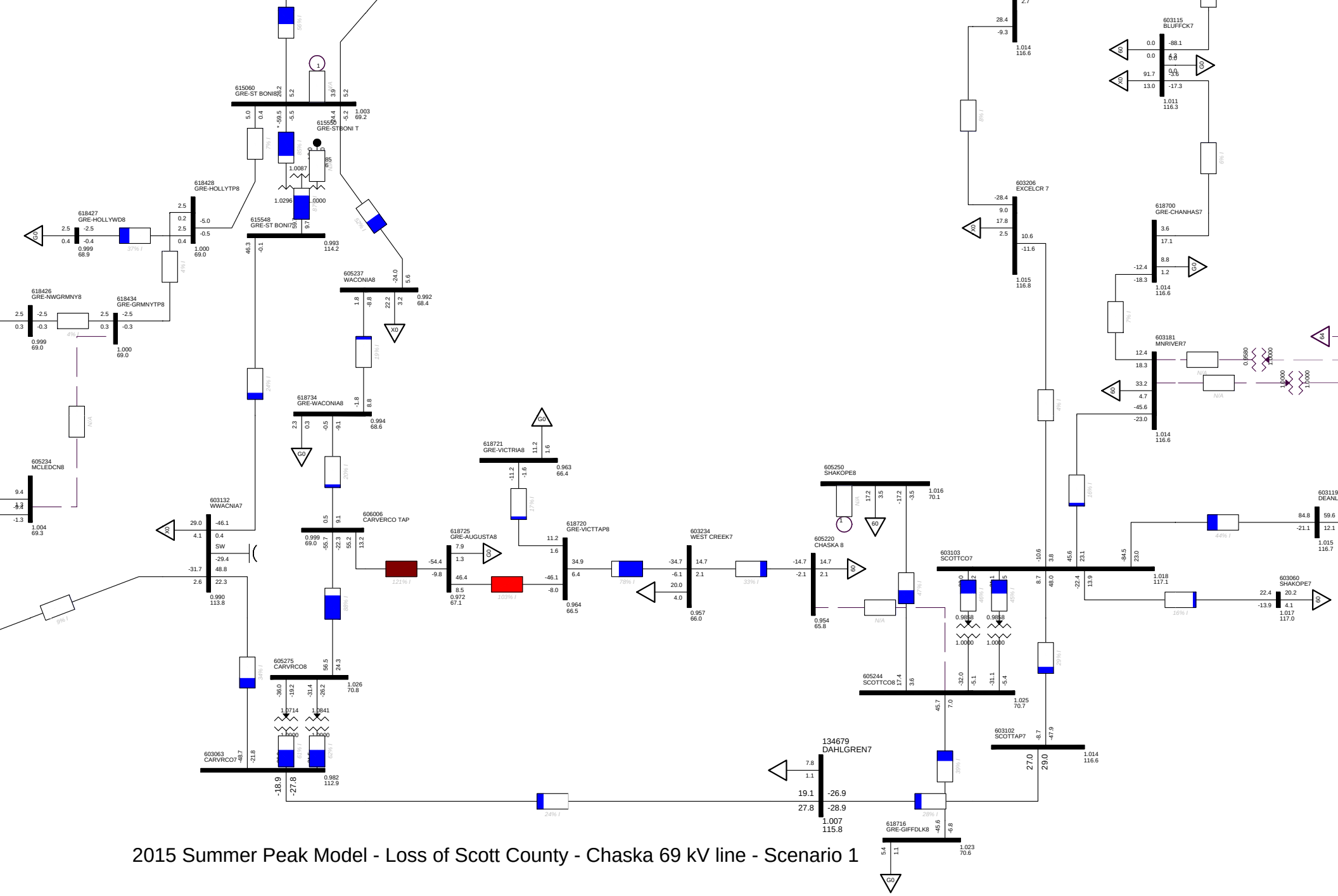
Appendix



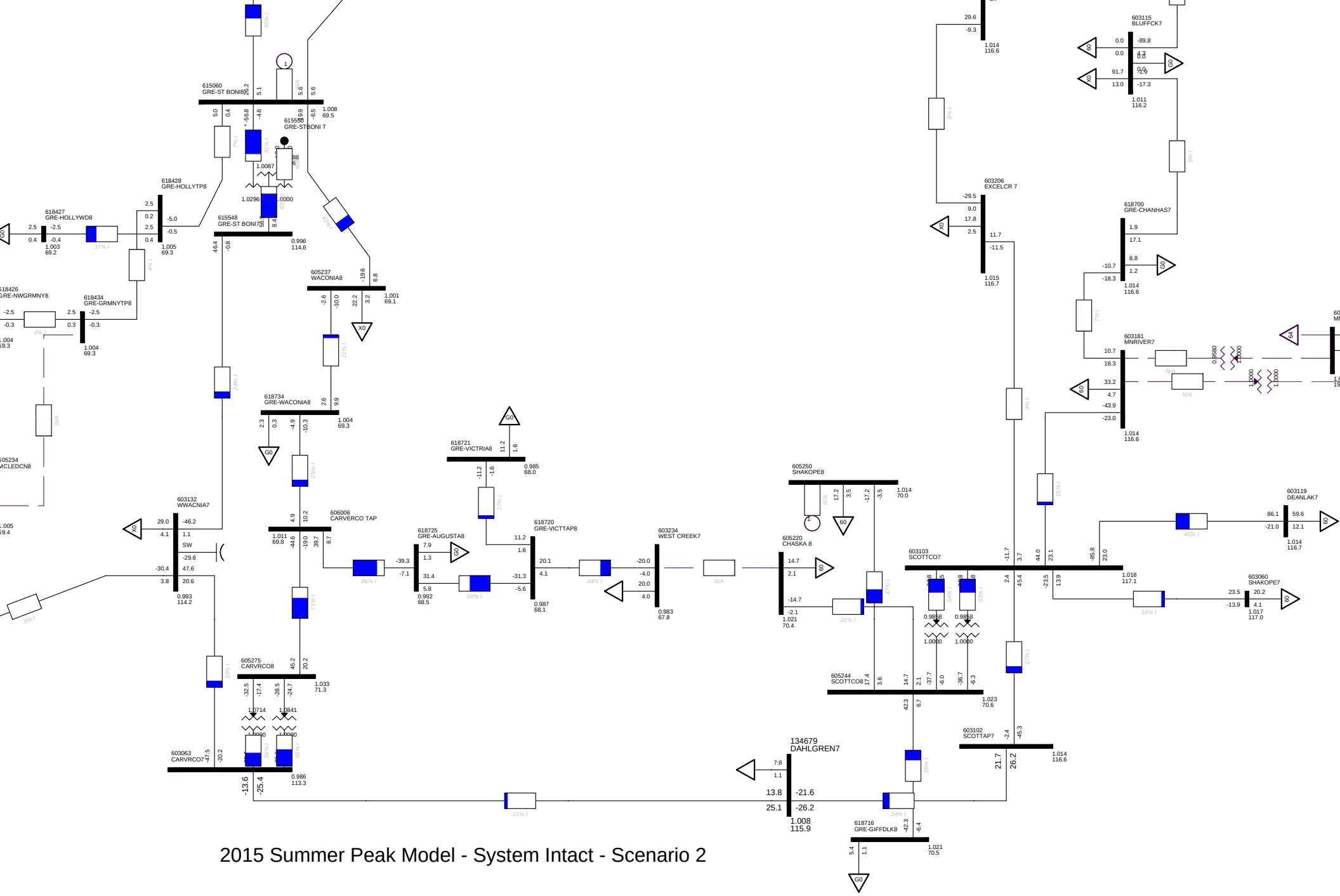
2015 Summer Peak Model - Base Case - Scenario 1



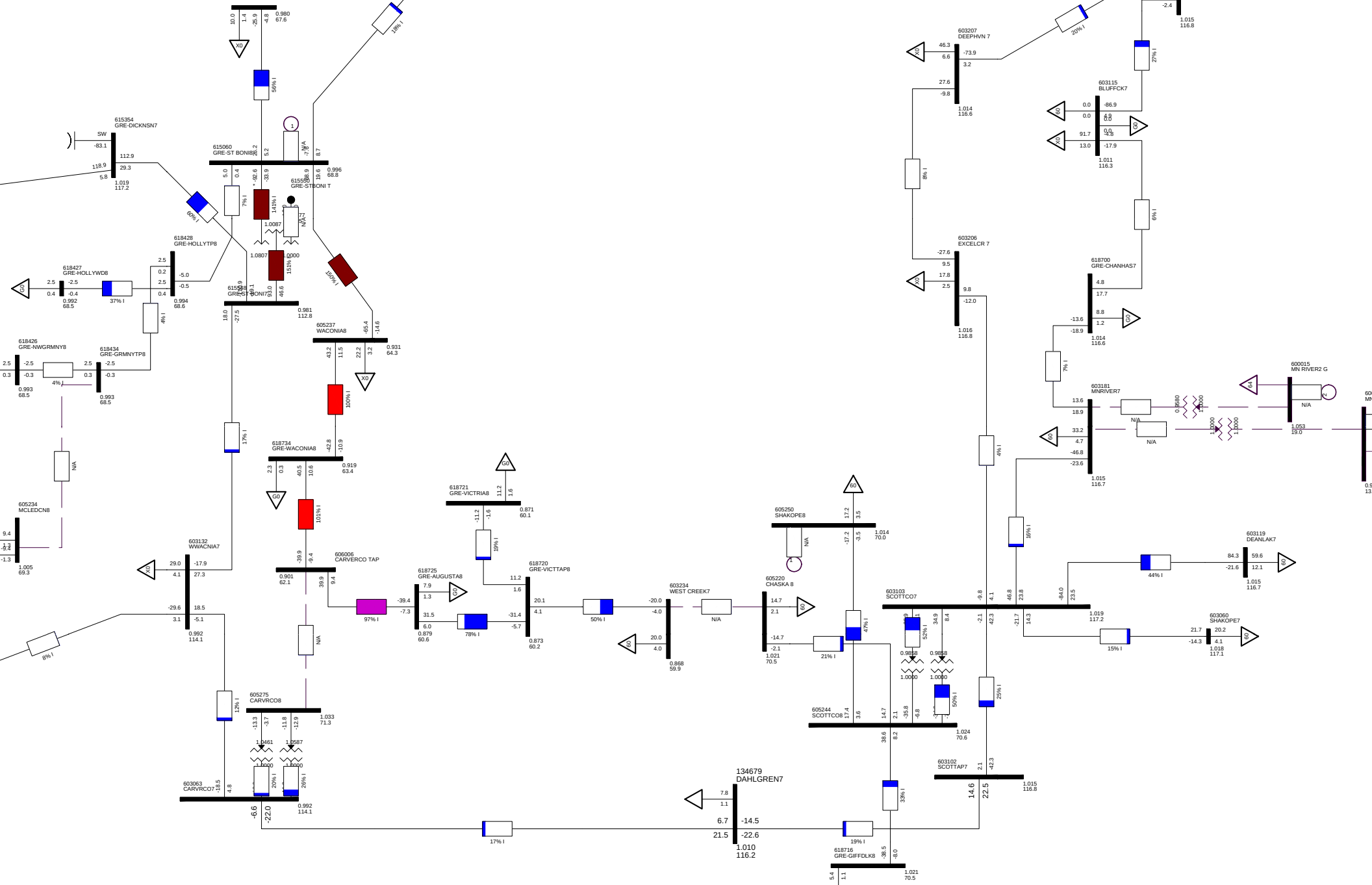
2015 Summer Peak Model - Loss of Scott County transformer - Scenario 1



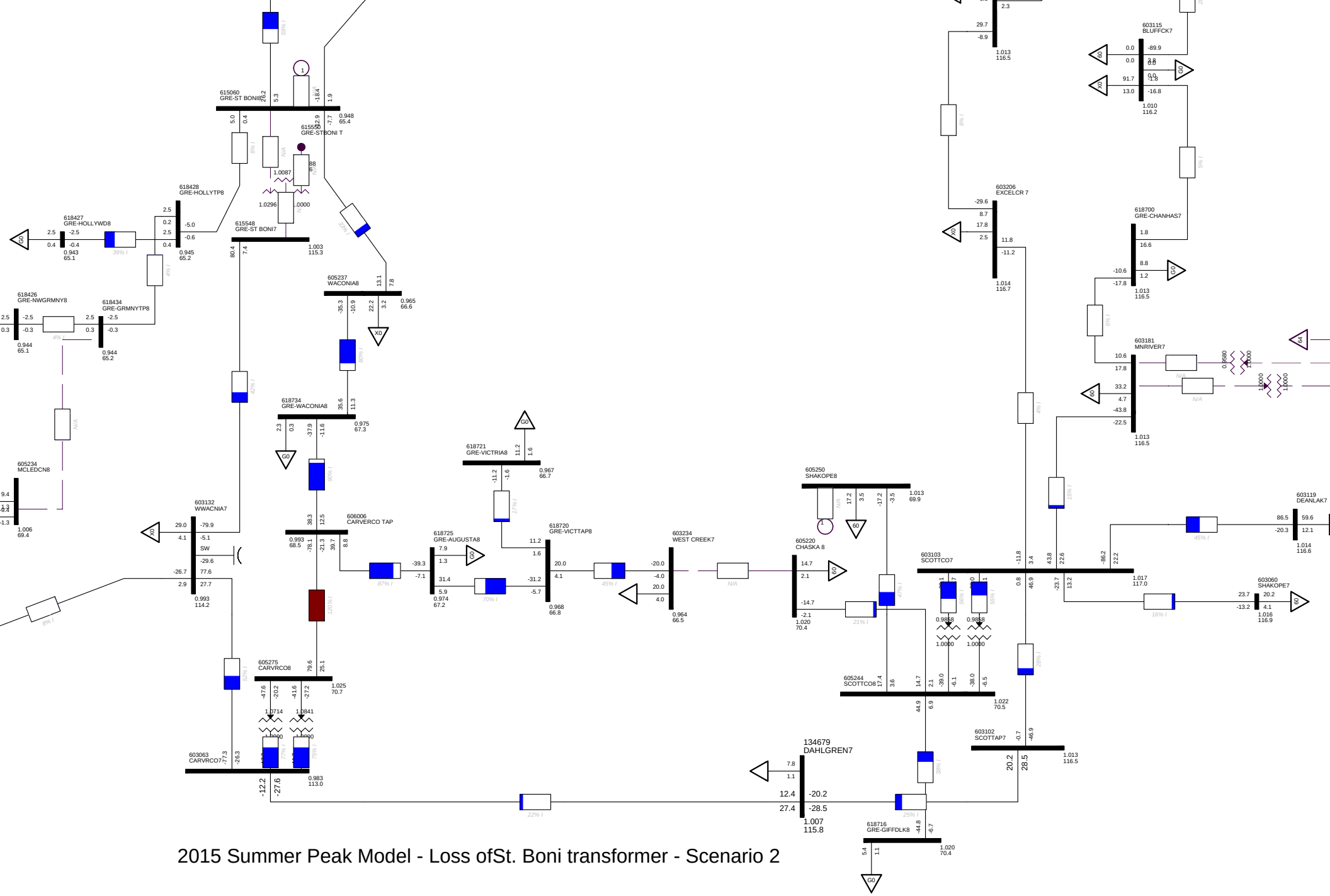
2015 Summer Peak Model - Loss of Scott County - Chaska 69 kV line - Scenario 1



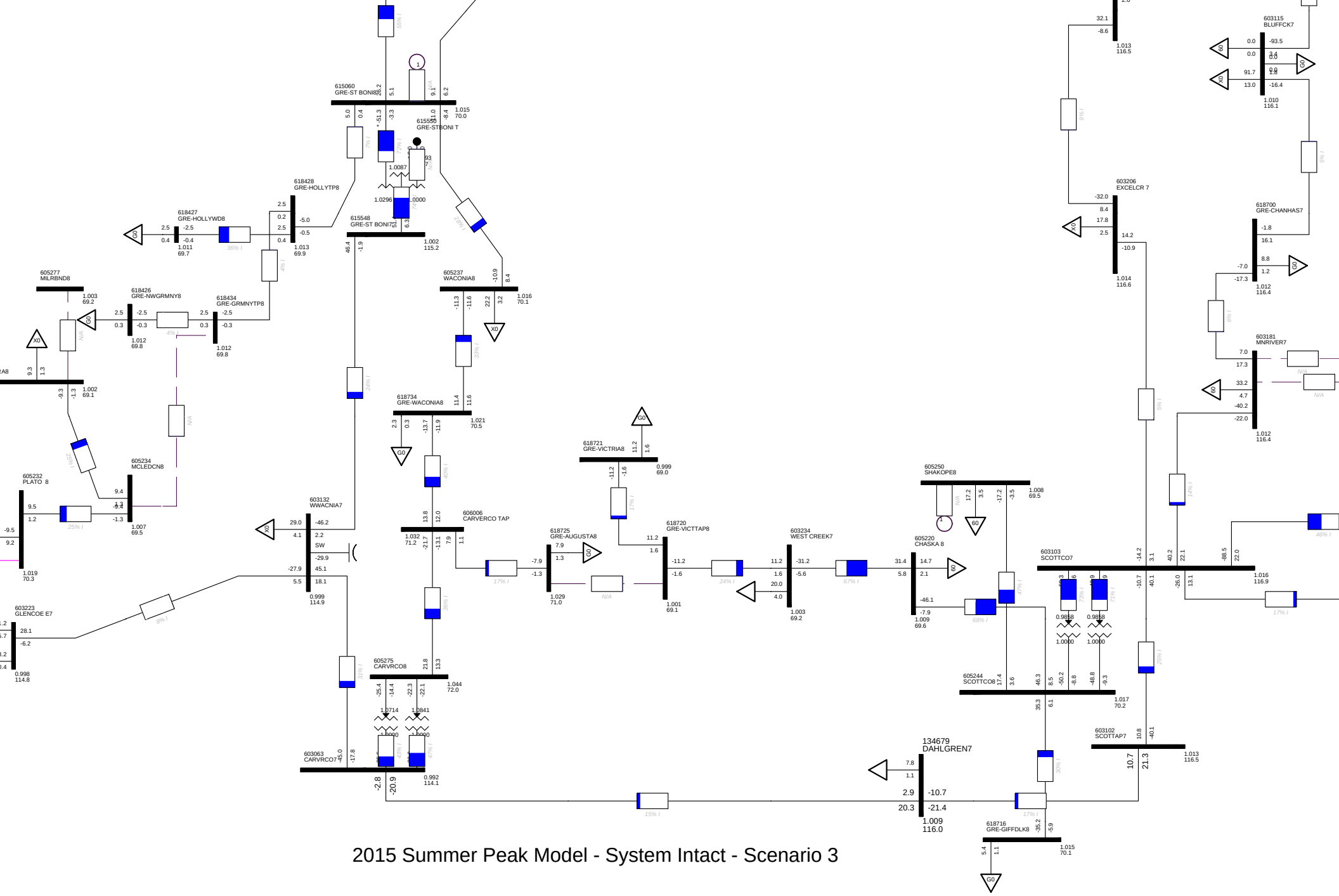
2015 Summer Peak Model - System Intact - Scenario 2



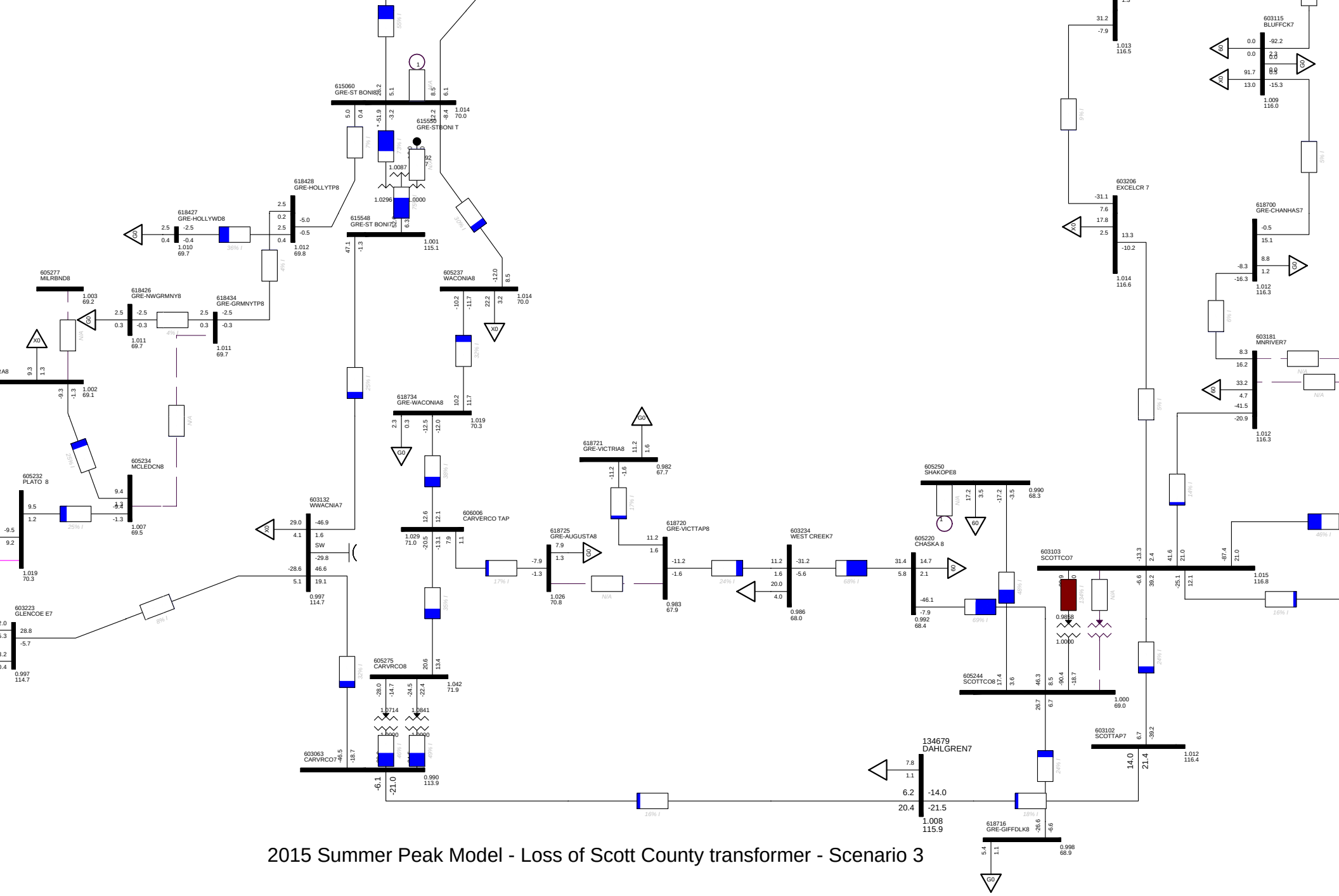
2015 Summer Peak Model - Loss of Loss of Carver County - Carver County tap line - Scenario 2



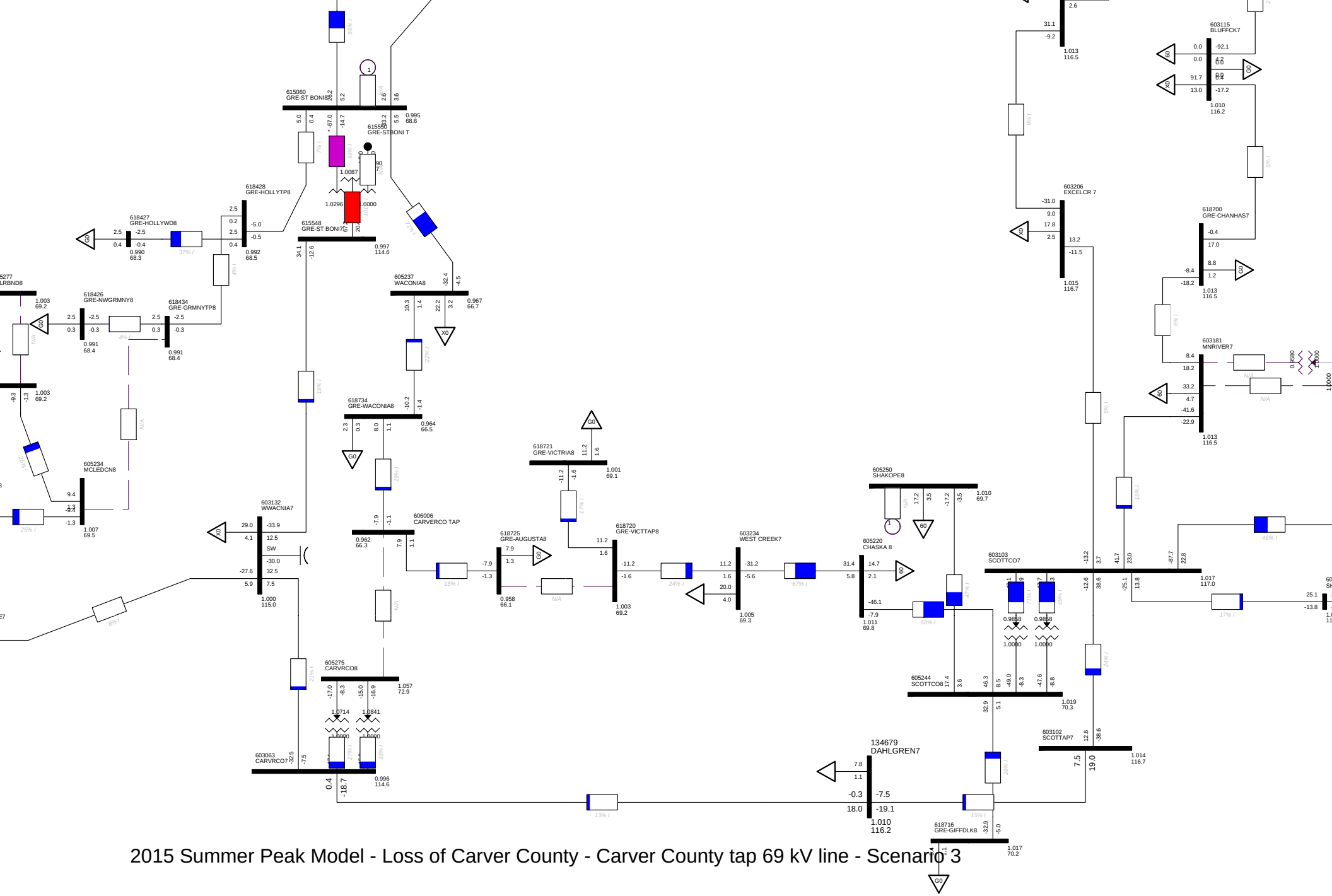
2015 Summer Peak Model - Loss ofSt. Boni transformer - Scenario 2



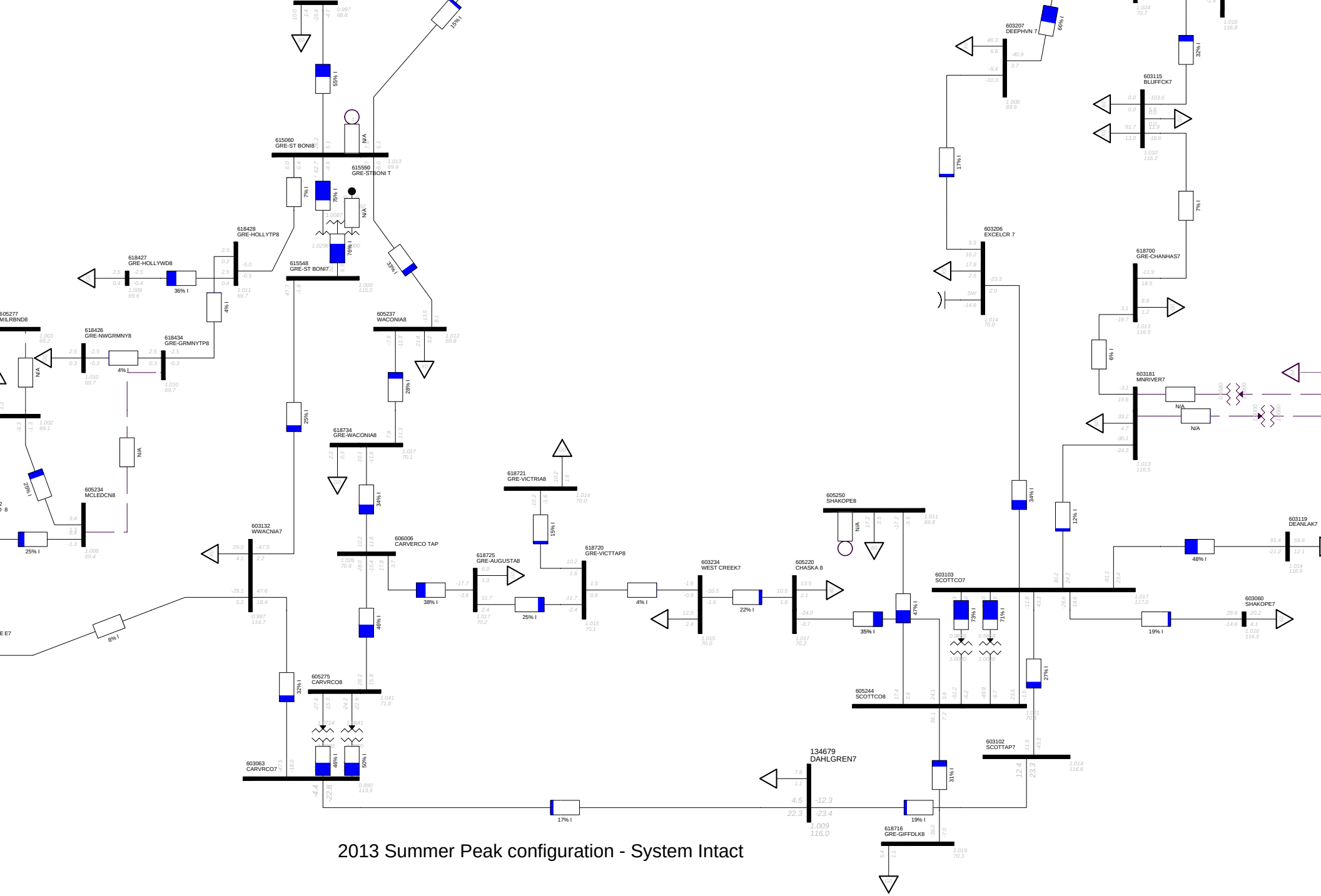
2015 Summer Peak Model - System Intact - Scenario 3



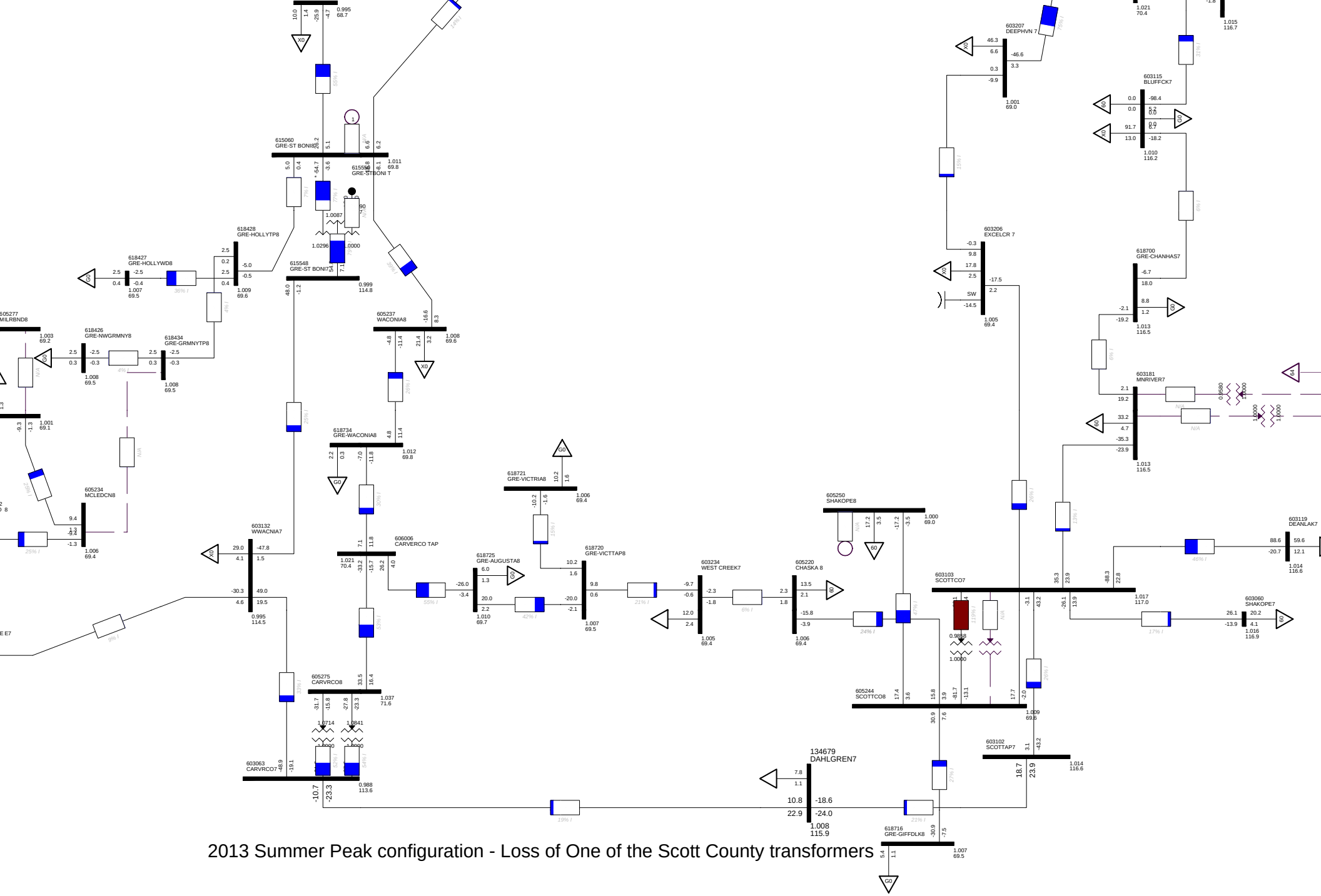
2015 Summer Peak Model - Loss of Scott County transformer - Scenario 3



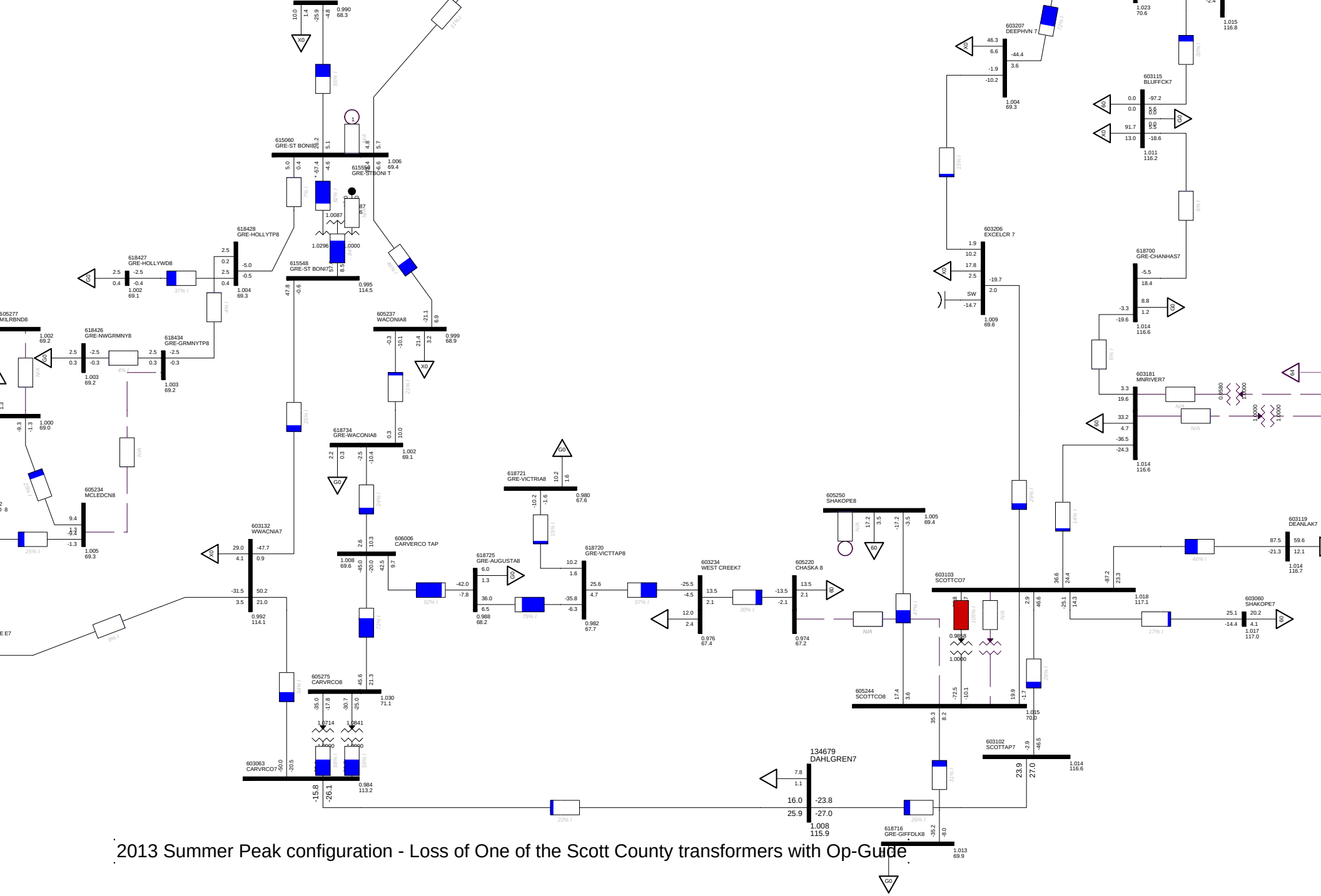
2015 Summer Peak Model - Loss of Carver County - Carver County tap 69 kV line - Scenario 3



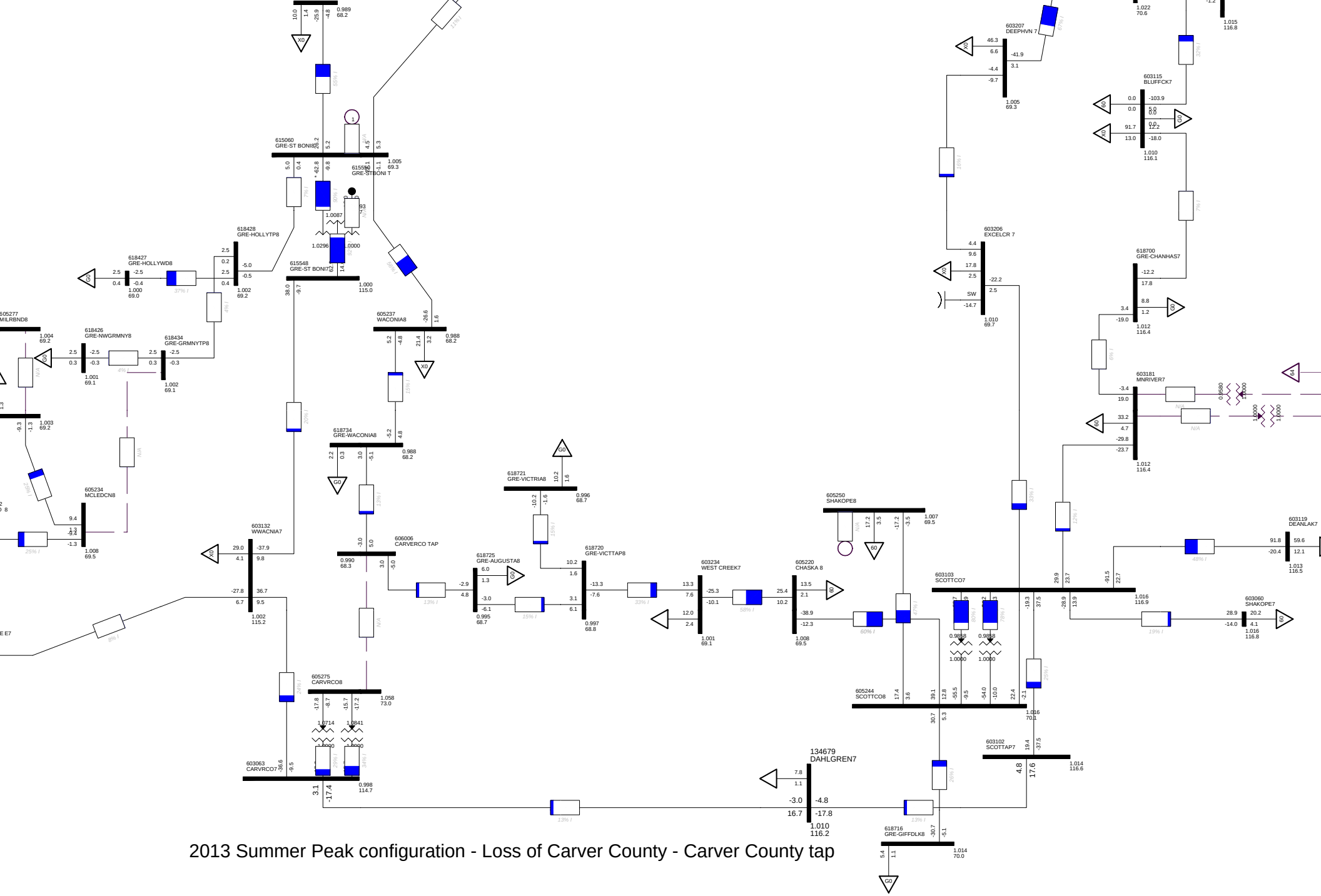
2013 Summer Peak configuration - System Intact



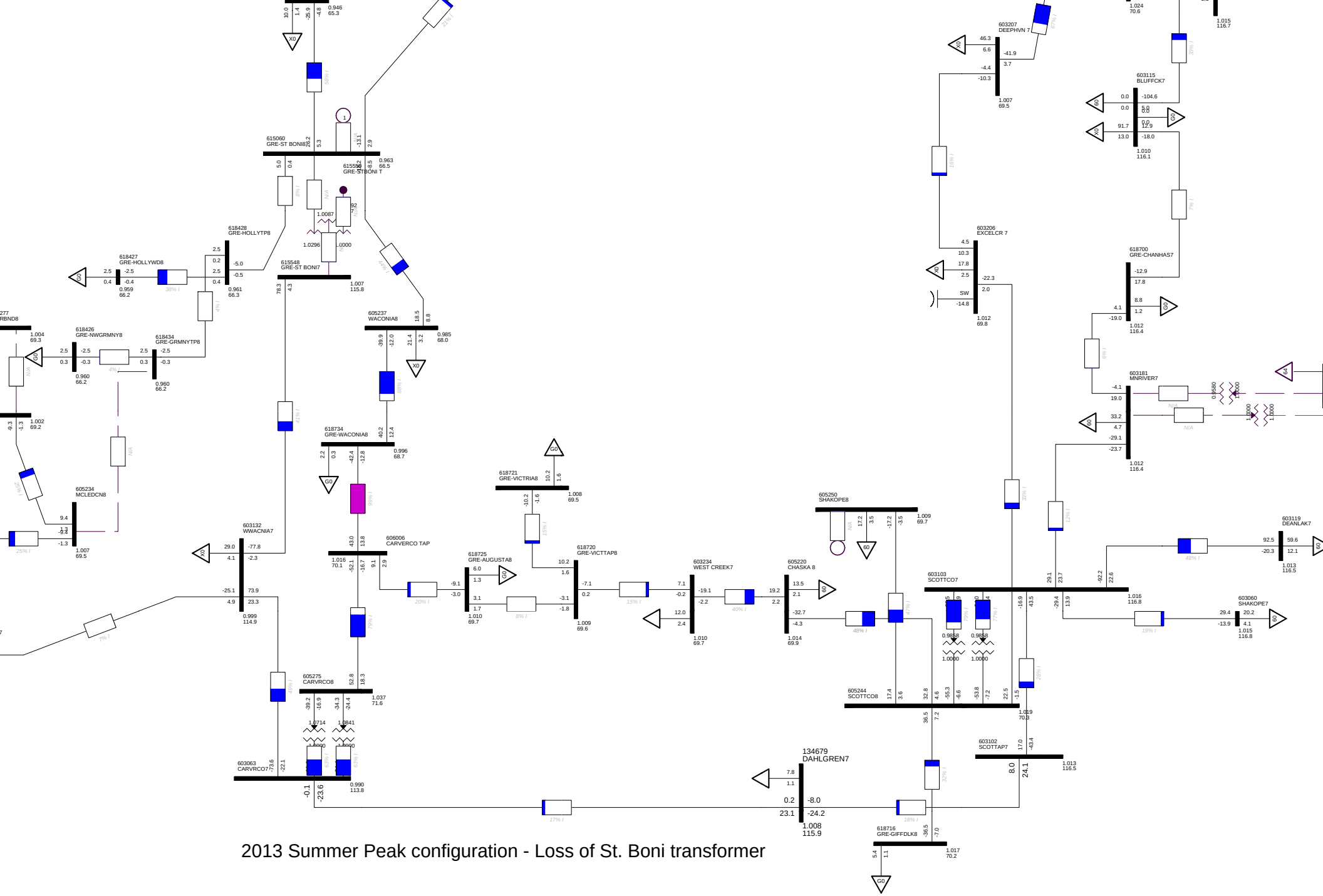
2013 Summer Peak configuration - Loss of One of the Scott County transformers



2013 Summer Peak configuration - Loss of One of the Scott County transformers with Op-Guide



2013 Summer Peak configuration - Loss of Carver County - Carver County tap



2013 Summer Peak configuration - Loss of St. Boni transformer

Southwest Twin Cities Load Serving Study Review

(Highway 212 Corridor 115 kV conversion)

Executive Summary

This study is performed as an extension of Southwest Twin cities 115kV conversion – Phase 1 (Glencoe – West Waconia – Augusta). The need for this study is driven by the addition of new datacenter load at the City of Chaska. This new load is expected to be around 20 MW by 2014. The Phase-1 of Southwest Twin Cities 115 kV conversion is expected to meet the nominal load growth till 2018. However the addition of new 20MW load by 2014 would require additional transmission to meet the load demand.

Certification

I hereby certify that this plan, specification,
or report was prepared by me or under my direct
supervision and that I am a duly License
Professional Engineer under the laws of the
State of Minnesota

Srinivas Vemuri
Date 08/08/2011 License# 48351

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1. Introduction

The "Southwest Twin Cities Load Serving Study Review (Glencoe, Waconia and Chaska)" proposed to convert the 69 kV lines between Glencoe and West Waconia to 115 kV. As part of the same study, a large section of the line between Augusta and Carver County was proposed to be upgraded to 115 kV construction, and 69 kV operation, with a 69 kV tap to Waconia substation. This 69 kV tap line is planned to be built to accommodate a 2nd 115 kV line between West Waconia substation and the existing Carver County – Augusta 69 kV line. The map shown in figure below describes the transmission system, after the completion of this project, along with the conversion of Scott County – Excelsior – Deephaven – Westgate 69 kV line to 115 kV.

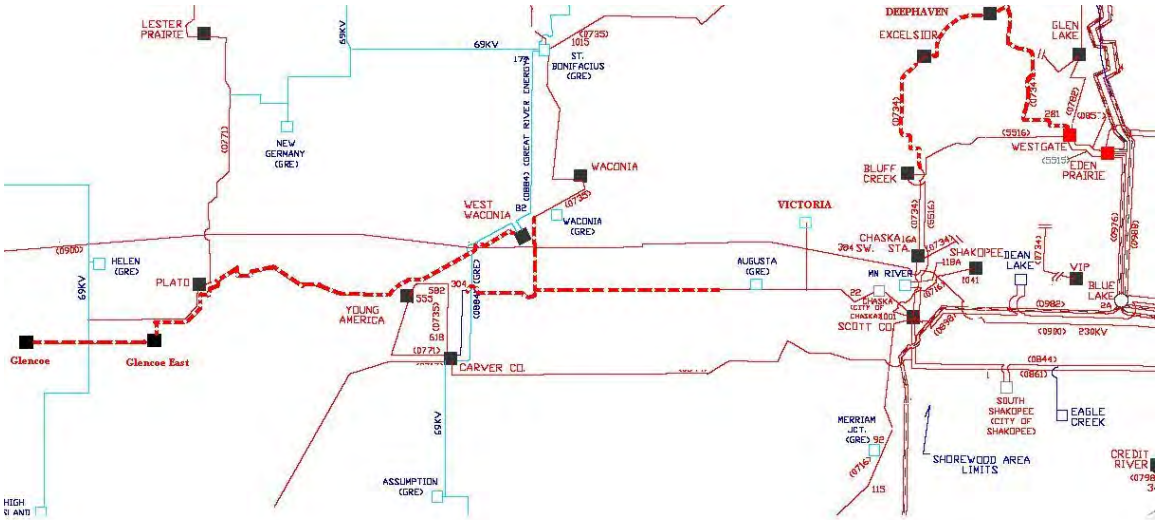


Figure 1.1

With the addition of new data center at West Creek Corporate Park, additional transmission would be required to support the new 20MW load in the area.

2. Models and Assumptions

The study is based on the models used for Southwest Twin Cities Phase 1 (2009 series 2015 summer peak model). The base model includes the Glencoe – West Waconia 115 kV conversion project, Carver County tap to Augusta 69kV line rebuild to 115kV (operated at 69kV), and the conversion of Scott County – Excelsior – Deephaven – Westgate 69 kV line to 115 kV. This is to ensure that any deficiencies identified in the current study are not associated with planned projects.

The base model assumes that the West Creek substation will be located between existing Chaska substation and Victoria tap. An initial load of 20 MW is assumed be served from West Creek substation in the base model.

The 69 kV line between Scott County and Chaska is represented by a normally open line in the base models. From the phase 1 study, this is required to avoid transformer overload at Scott County during contingencies. However, with the addition of West Creek load, severe thermal and voltage violations could occur with this configuration under system intact conditions, therefore the line was closed through Scott County in the base model used for this study.

3. Analysis

Criteria

Table 3.1 below provides NSP's criteria for system performance. For study analysis, to identify deficiencies in the study area, any facility loaded above 100% or close to 100% is documented. Similarly any low voltage condition with voltage less than 92% or close to 92% are documented. This is done to ensure that any future problems in the study area are also identified.

Table 3.1

	% Line loading	% Transformer loading	Minimum %Voltage	Maximum %Voltage
System intact	100	100	95	105
Contingency	110	115	92% (Twin Cities) 90% (outside Twin cities)	105

Deficiencies

With the addition of West Creek load, several transmission deficiencies were identified in the study area. The loss of Scott County – Chaska 69 kV line would result in overloading the Carver County – Augusta 69 kV line (sections that are not upgraded to higher capacity). This outage also results in 0.93 PU voltage at Chaska. The loss of one of the Scott County transformers would result in overloading the other transformer.

Table 3.2

Facility	**Contingency**	**%loading or PU voltage**
Chaska	Scott County – Chaska 69 kV line	0.936PU
Carver County – Carver County tap 69 kV line	Scott County – Chaska 69 kV line	99%
Carve County tap – Augusta 69 kV line[1]	Scott County – Chaska 69 kV line	150%
Augusta – Victoria tap	Scott County – Chaska 69 kV line	123%
Victoria tap – West Creek 69 kV line	Scott County – Chaska 69 kV line	98%
Scott County TR 1 (or 2)	Scott County TR 2 (or 1)	117%

[1] 1 mile section West of Augusta

Mitigation plans

The mitigation plans studied as part of this study involved only 115kV transmission options. This was required as the City of Chaska indicated that there is possibility of further load development of up to 20 MW in addition to the planned datacenter load.

Option 1:

This option involves building 115 kV line between West Waconia, Augusta, Victoria, West Creek, Chaska and Scott County substations. This could be achieved by

- rebuilding 1.9 mile Scott County – Chaska 69 kV line to 115 kV
- rebuilding Chaska substation to 115 kV
- Rebuilding 1.9 mile Chaska – Victoria tap line, and building one mile of 115 kV line towards West Creek and, 1 mile of new 115 kV line from West Creek to Victoria tap line. This would involve retiring 1 mile of existing 69 kV line
- Upgrading Victoria substation to 115 kV[2]
- Upgrading 1.5 mile Victoria tap to Augusta 69 kV line to 115kV
- Upgrading Augusta substation to 115 kV
- Upgrading 1 mile of 69 kV line West of Augusta to 115 kV[3]
- Stringing 2.5 miles 115 kV line double circuited with the Waconia – Waconia tap[4] 69 kV line

The map of the proposed plan is shown below Figure 3.1.

[2] This substation is built for 115 kV, however the transformer needs to be upgraded
[3] Rest of this line is planned to be upgraded as part of the first phase of Southwest Twin Cities 115kV plan
[4] This 69 kV line would be built as part of phase 1 of Southwest Twin Cities 115 kV conversion plan, the poles would be designed to include this 115 kV line.

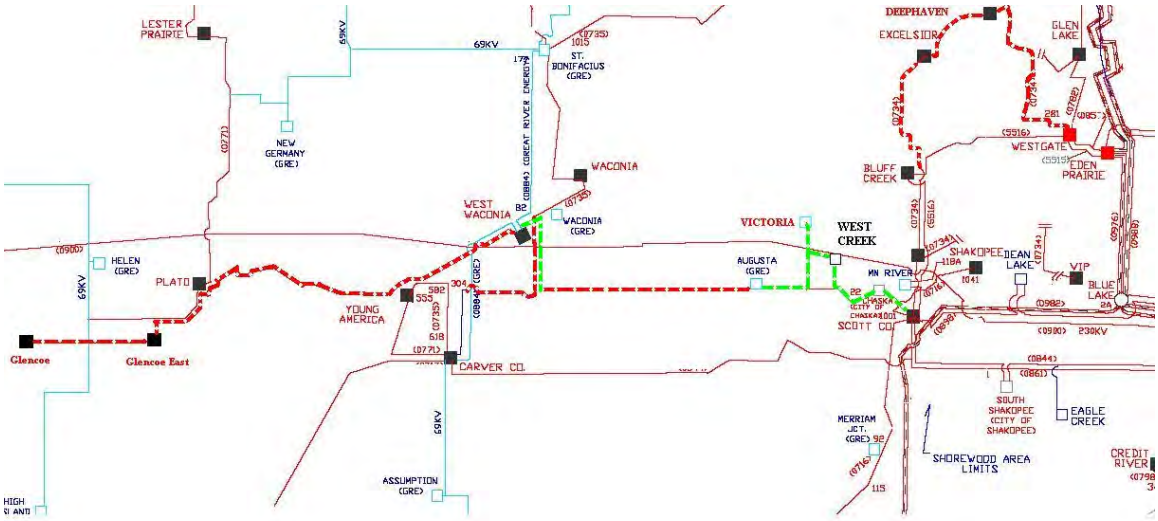


Figure 3.1

Option 2:
This option involves building 115 kV line from Carver County to Scott County through Augusta, Victoria, West Creek and Chaska substations. This could be achieved by

- Building 2.5 mile new 115 kV line from Carver County towards Augusta.
- Upgrading 1 mile of 69 kV line West of Augusta to 115 kV.
- Converting Augusta substation to 115 kV.
- Rebuilding Augusta to Victoria tap to 115 kV
- Upgrading Victoria substation to 115 kV
- Rebuilding 1.9 mile Chaska – Victoria tap line to 115 kV, and building one mile 115 kV line towards West Creek, and 1 mile of new 115 kV line from West Creek to Victoria tap line. This would involve retiring 1 mile of existing 69 kV line
- Rebuilding Chaska substation to 115 kV
- Building new 115 kV line from Chaska to Minnesota River substation.

The map to proposed alternative is shown below Figure 3.2

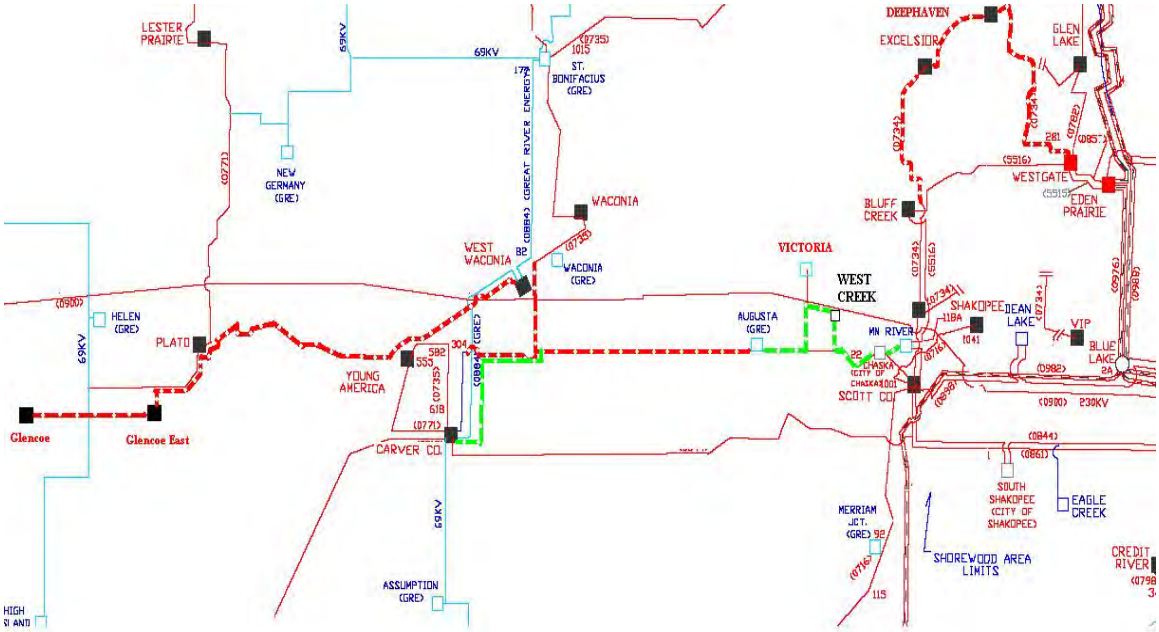


Figure 3.2

Full AC Contingency Analysis

AC contingency analysis was performed on the study area with the proposed 115 kV options to mitigate the deficiencies identified in Table 3.2. There were no new violations found with the proposed 115 kV transmission options for Category B or C contingencies. In case of option2, the loss of Bluff Creek – Westgate 115 kV line combined with the loss of Scott County – Minnesota River 115 kV line would cause severe low voltages in the region. This is discussed further at the end of this section.

Incremental load serving capability

The incremental load serving capability of each of the options is determined using the critical single and double contingencies in the area. FCITC analysis was not performed to determine the thermal overloads as all the new transmission lines would be built to 795 ACSS or equivalent conductor. This would provide up to 361 MVA of rating under normal conditions and 397 MVA during emergency conditions. Therefore PV analysis was sufficient to determine the incremental load serving limit based on the voltages during single and double contingencies.

Load serving capability during single outage

The critical single contingency for the proposed option 1 is the loss of Scott County – Chaska 115 kV line. The PV curve for this contingency with the load between Augusta and Scott County as sink and Sherburne county generation as source is shown below in Figure 3.3

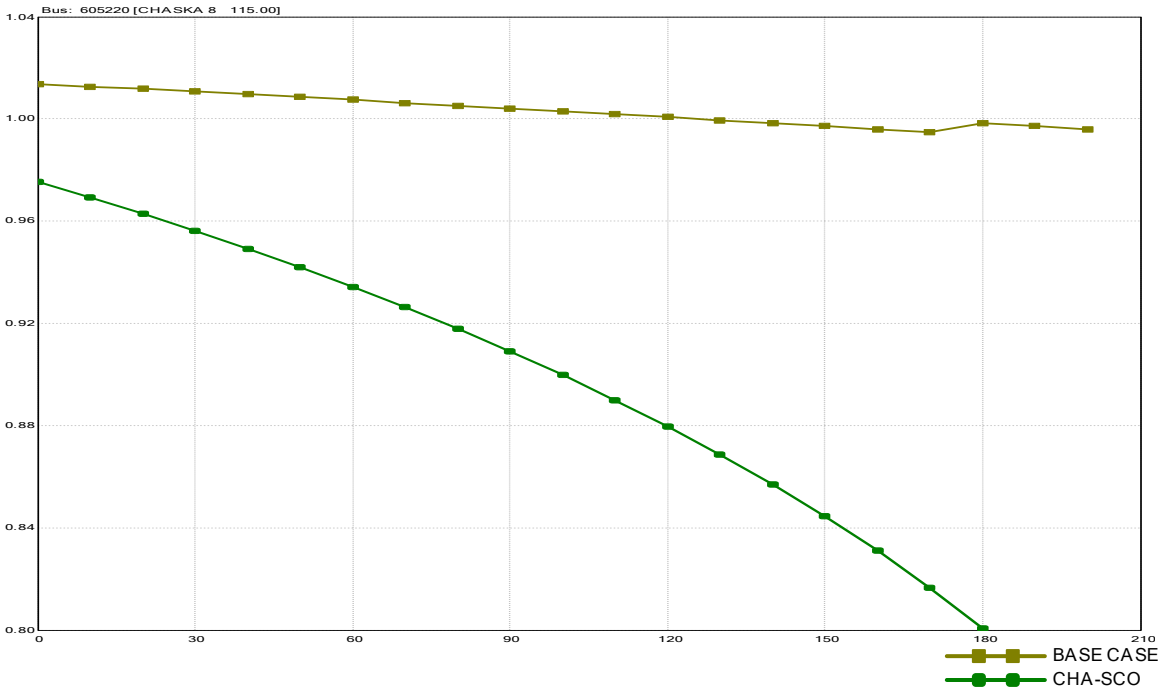


Figure 3.3

From Figure 3.3, if the load between Chaska and Augusta alone is increased, Option 1 would provide an incremental load serving capability of approximately 78 MW, for the loss of Chaska – Scott County 115 kV line, before the voltage drops to 92%.

For option 2, the critical contingency is the loss of Minnesota River to Chaska 115 kV line. The PV analysis for this outage is performed by using the loads between Augusta and Chaska as sink, and Sherburne county generators as source. Figure 3.4 below provides the voltages at Chaska for this outage. It can be seen that approximately 70 MW of additional load can be served before the voltage at City of Chaska drops to 92%.

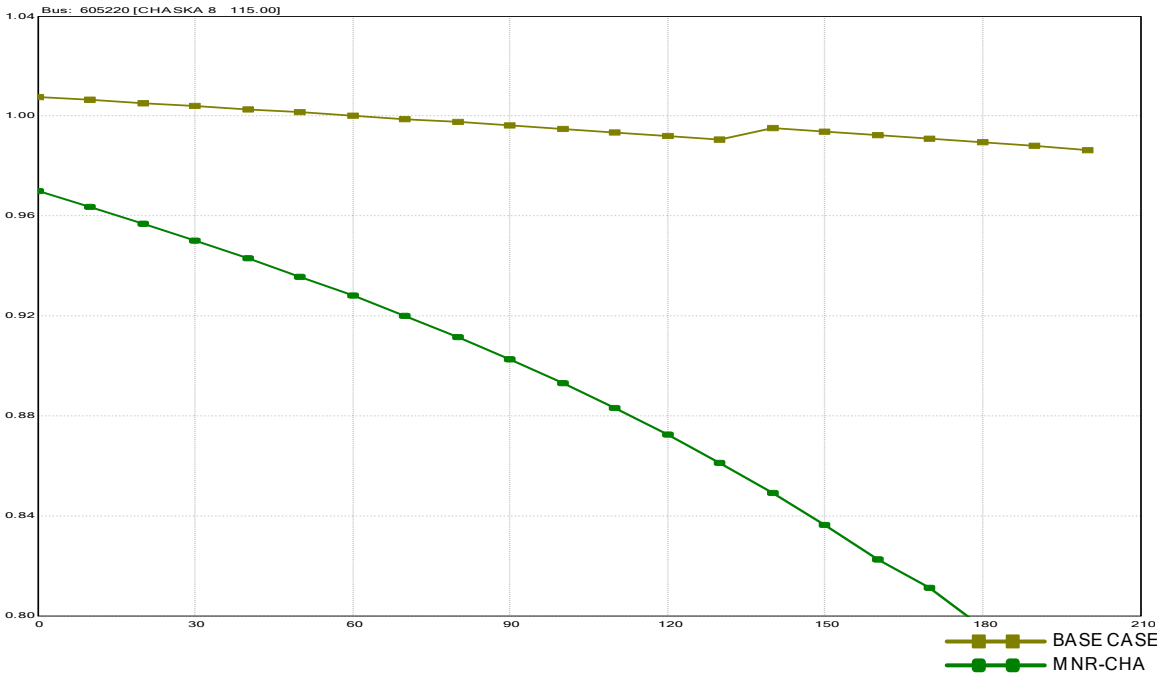


Figure 3.4

Load serving capabilities for single and double contingencies

The suggested improvements through option 1 or 2[5] would significantly improve the performance of 115 kV system between McLeod and Scott County substations for double (n-2) contingency conditions. PV analysis was performed to identify the incremental load growth that can be served under n-2 conditions, between McLeod and Scott County, for options 1 and 2. The analysis for this area was performed using the loads and generation listed in Table 3.3 below.

Table 3.3

Source (generators)	**Sink (load)**
Sherburne County generator	Chaska
	West Creek
	Victoria
	Augusta
	Waconia GRE and NSP
	West Waconia
	Plato
	Glencoe Muni

[5] After completion of SW Twin Cities Phase 1 and 2

The critical single and double contingencies for option 1 are:

- Loss of Scott County – Chaska 115 kV line
- Loss of Dickinson source to St. Boni
- Loss of Scott County – Carver County 115 kV line combined with the loss of Dickinson – St. Boni 115 kV line
- Loss of St. Boni – Dickinson combined with the loss of McLeod – Glencoe 115 kV line
- Loss of Scott County – Chaska 115 kV line combined with the loss of Scott County – Carver County 115 kV line
- Loss of Scott County – Chaska 115 kV line combined with the loss of Dickinson – St. Boni 115 kV line.
- Loss of Scott County – Chaska 115 kV line combined with the loss of McLeod – Glencoe 115 kV line

The PV plots for these critical single and double contingencies for option 1 are provided in Figure 3.5, 3.6 and 3.7 below, for Chaska, St. Boni and Glencoe respectively.

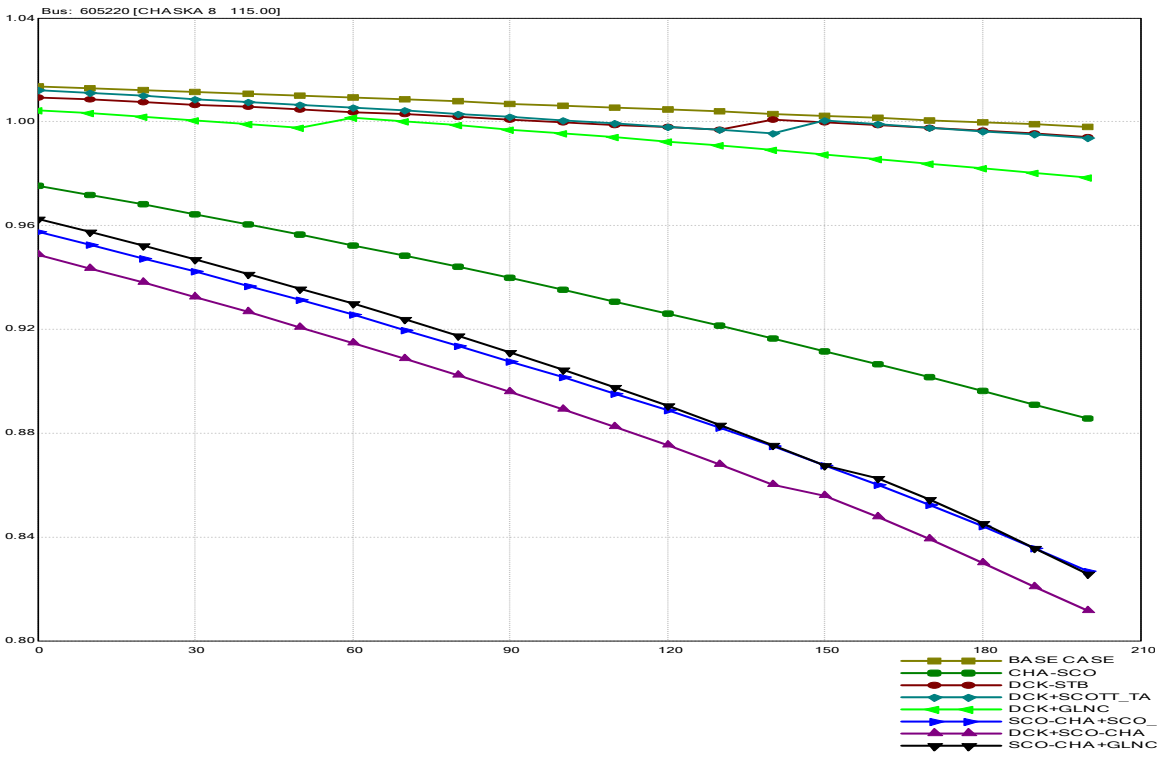


Figure 3.5

Figure 3.5 shows the voltage at Chaska for contingencies listed above. From the PV curves it can be seen that the loss of Scott County – Chaska,

combined with the loss of Dickinson – St. Boni 115 kV line, would be the most severe contingency for voltages at Chaska. It can be seen that the load in the area can be increased by nearly 50 MW, before the voltage at Chaska drops to 92%.

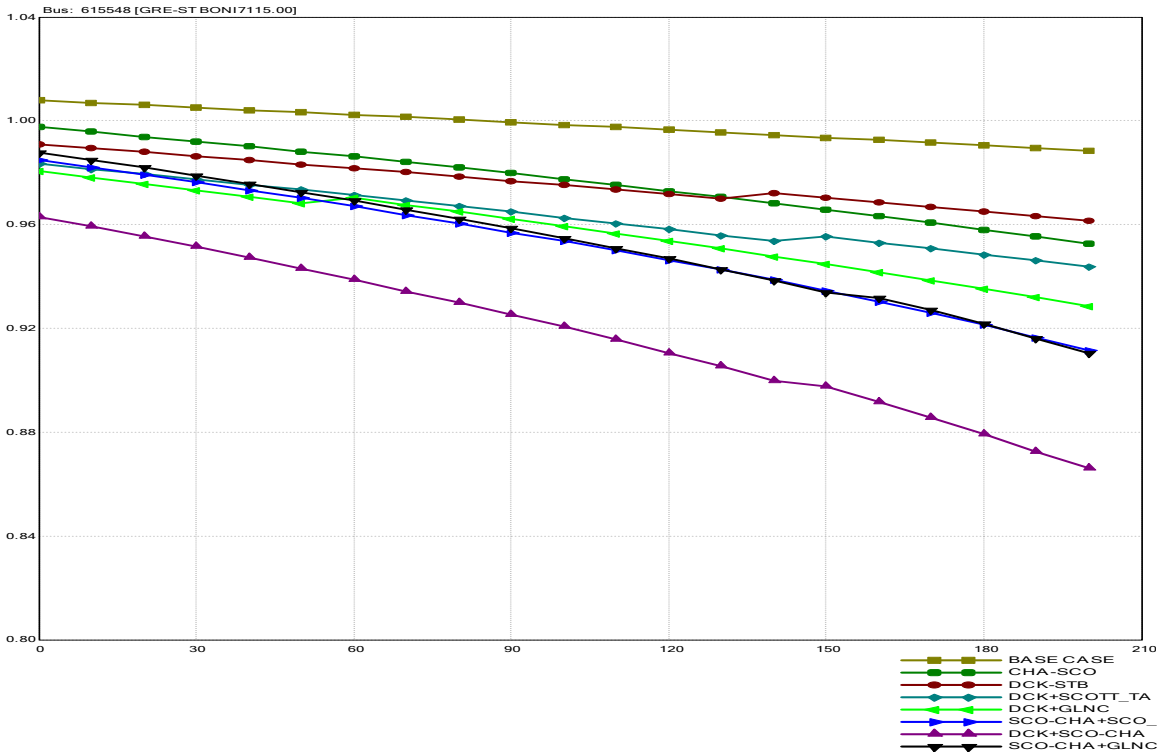


Figure 3.6

Figure 3.6 provides the voltage at St. Boni, from the PV plots it can be seen that the loss of Chaska – Scott County 115kV line, combined with the loss of Dickinson – St. Boni 115 kV line, is also the most severe contingency for voltage at St. Boni. It can also be noticed from the plot that the load in the region has to grow approximately 100 MW before the voltage at St. Boni drops to 92%.

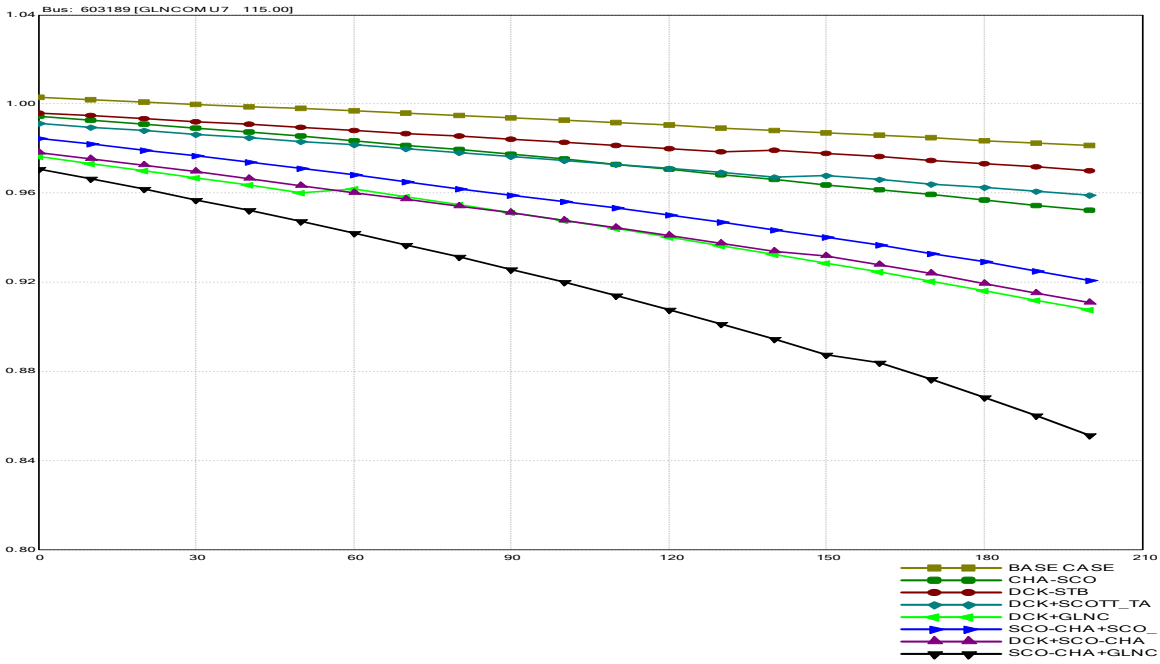


Figure 3.7

Figure 3.7 provides the voltage at Glencoe during the contingencies listed earlier. From Figure 3.7 it can be seen that the loss of Scott County – Chaska combined with the loss of Glencoe – McLeod would be the most severe contingency for voltages at Glencoe. It can be noticed that an approximately 100 MW of load can be served with the proposed plan before the voltage at City of Glencoe drops to 92%.

The other critical single and double contingencies, for the area between McLeod and Minnesota River, for option 2 involve

- Loss of Minnesota River – Chaska 115 kV line
- Loss of Dickinson – St. Boni 115 kV line
- Loss of Dickinson – St. Boni 115 kV line combined with the loss of Chaska – Minnesota River 115 kV lines
- Loss of Chaska – Minnesota River combined with the loss of Scott County – Carver County 115 kV line
- Loss of Dickinson – St. Boni 115 kV line combined with the loss of McLeod – Glencoe 115 kV line.
- Loss of Minnesota River – Chaska 115 kV line combined with the loss of McLeod – Glencoe 115 kV line.
- Loss of Dickinson – St. Boni combined with the loss of Scott County – Carver county 115 kV lines.

Similar to the analysis performed on option 1, the load at Glencoe, West Waconia, Augusta, Victoria, West Creek, Chaska and Waconia substations were used as sink and the generation at Sherburne County was used as source. The voltages were monitored at Chaska, St. Boni and City of Glencoe.

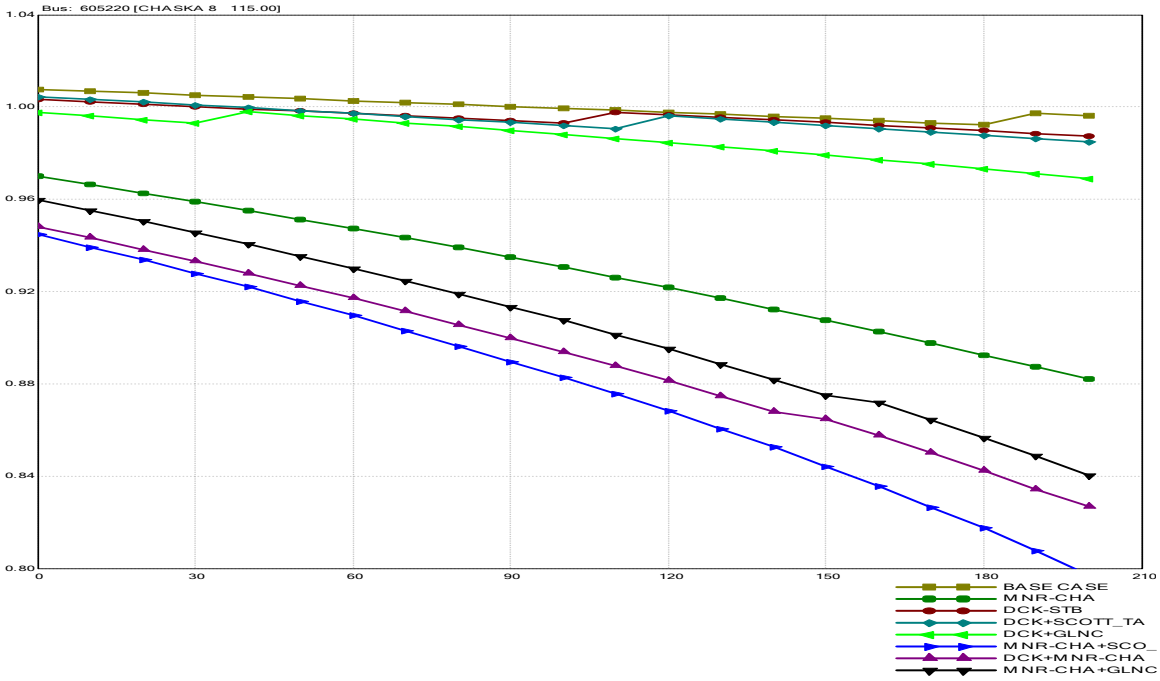


Figure 3.8

Figure 3.8 shows the PV plots, for Chaska voltage, for the critical contingencies listed above. It can be seen that the critical contingency for this area is loss of Minnesota River – Chaska combined with the loss of Scott County – Carver County 115 kV line, approximately 42 MW of load growth can be accommodated with this option before the voltage at Chaska drops to 92%.

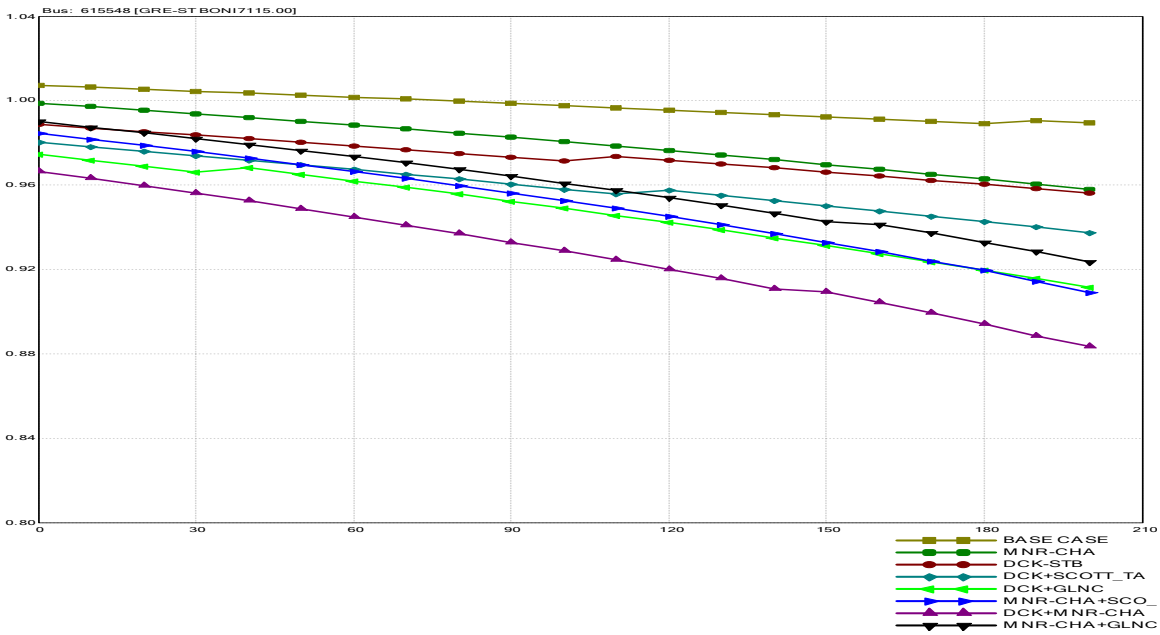


Figure 3.9

Figure 3.9 shows the PV plots, for voltages at St. Boni, for critical contingences in the area. It can be seen that the worst contingency for this area is the loss of Dickinson – St. Boni combined with the loss of Minnesota River – Chaska 115 kV lines. Approximately 120 MW of load growth can be accommodated with this option before the voltage at St. Boni drops below 92%.

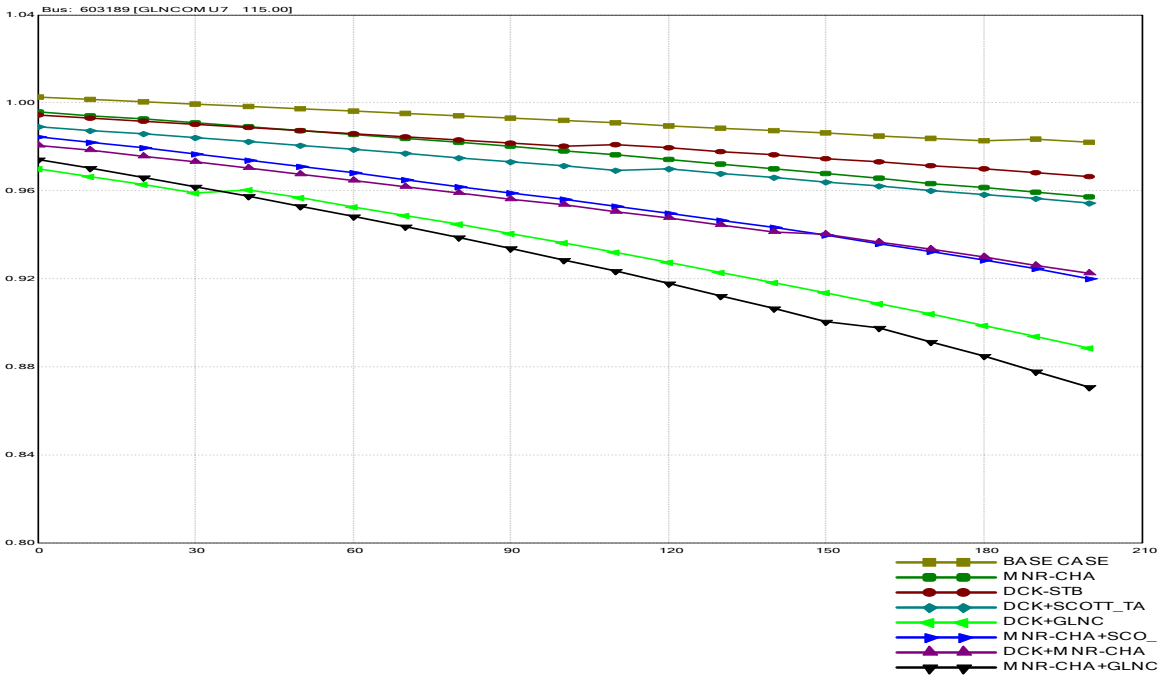


Figure 3.10

Figure 3.10 shows the PV plots, for Glencoe voltages, for critical contingencies. It can be seen that the worst contingency for this area is the loss of Dickinson – St. Boni combined with the loss of McLeod – Glencoe 115 kV lines. Approximately 117 MW of load growth can be accommodated with this option before the voltage at Glencoe drops to 92%.

Summary of PV analysis

Table 3.3 provides the summary of PV analysis with the load between Augusta and Chaska used as sink. The total initial load on these substations is 61.6 MW, including the 20 MW load at West Creek substation. Therefore both the transmission alternatives can accommodate more than 100% additional load growth between West Waconia and Chaska under single contingency condition.

Table 3.3

	Approx Incremental Growth	
Critical Contingency	**Option 1**	**Option 2**
Loss of Chaska – Scott County/Minnesota River	78 MW	70 MW

Table 3.4 provides the summary of PV analysis with the 115 kV loads at Glencoe, Plato, West Waconia, Waconia, GRE-Waconia, Augusta, Victoria, West Creek and Chaska used as sink. The total initial load on these substations is 145 MW, including 20MW of new load at West Creek substation.

Table 3.4

Option 1	**MW growth**
Loss of Scott County – Chaska + Loss of St. Boni – Dickinson, resulting in low voltages at Chaska	50 MW
Loss of Scott County – Chaska + Loss of St. Boni – Dickinson, resulting in low voltages at St. Boni	100 MW
Loss of Scott County – Chaska + Loss of Glencoe – McLeod, resulting in low voltages at City of Glencoe	100 MW
Option 2	
Loss of Minnesota River – Chaska + Loss of Scott County – Carver County resulting in low voltages at Chaska	42 MW
Loss of Dickinson – St. Boni + Loss of Minnesota River – Chaska resulting in low voltages at St. Boni	120 MW
Loss of McLeod – Glencoe + Loss of Minnesota River – Chaska resulting in low voltages at Glencoe	117 MW

It can be concluded from Tables 3.3 and 3.4 that option 1 performs well for n-1 and n-2 conditions for the Chaska area. However the n-2 performance would be better for St. Boni and Glencoe areas for option 2. It should be noted that the difference in load serving capabilities for n-2 conditions is for load growth beyond 100MW, and the low voltages at Chaska would have to be mitigated before the load reaches the 100 MW level at which St. Boni and City of Glencoe would experience low voltages.

Figures 3.11 through 3.14 below provide the PV curves for Chaska, St. Boni and Glencoe after the addition of an 80 MVAR capacitor bank at West Waconia.

Table 3.5

	Approx Incremental Growth	
Critical Contingency	**Option 1**	**Option 2**
Loss of Chaska – Scott County/Minnesota River	137 MW	120 MW

Table 3.6

Option 1	**MW growth**
Loss of Scott County – Chaska + Loss of St. Boni – Dickinson, resulting in low voltages at Chaska	160 MW
Loss of Scott County – Chaska + Loss of St. Boni – Dickinson, resulting in low voltages at St. Boni	210 MW
Loss of Scott County – Chaska + Loss of Glencoe – McLeod, resulting in low voltages at City of Glencoe	200 MW
Option 2	
Loss of Minnesota River – Chaska + Loss of Scott County – Carver County resulting in low voltages at Chaska	145 MW
Loss of Dickinson – St. Boni + Loss of Minnesota River – Chaska resulting in low voltages at St. Boni	210 MW
Loss of McLeod – Glencoe + Loss of Minnesota River – Chanhassen resulting in low voltages at Glencoe	190 MW

Tables 3.5 provides the incremental load serving capabilities of options 1 and 2, with 80 MVAR capacitor at West Waconia and Carver County substations respectively, with load between Augusta and Chaska used as sink and Sherburne County generator used as source.

Table 3.6 provides the incremental load serving capability of the two options, during n-2 conditions, with an 80 MVAR capacitor added at West Waconia and Carver County for options 1 and 2 respectively. The load at substations between Glencoe, West Waconia, and Chaska were used as source, and generation at Sherburne County generation was used as sink.

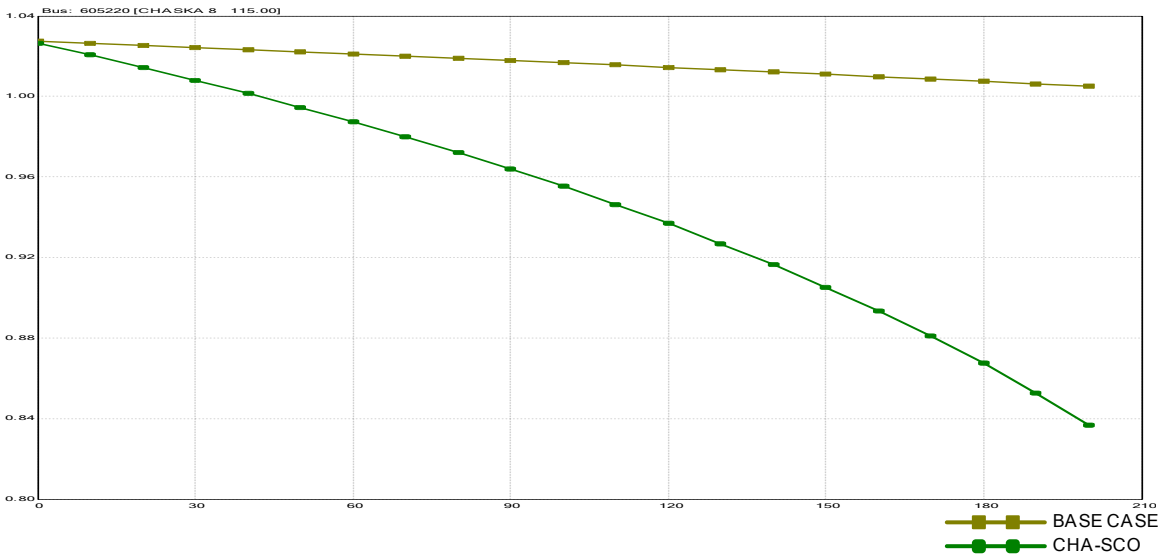


Figure 3.11
Option 1 with addition of 80MVAR capacitor bank at West Waconia.
Load between Augusta and Chaska used at sink.

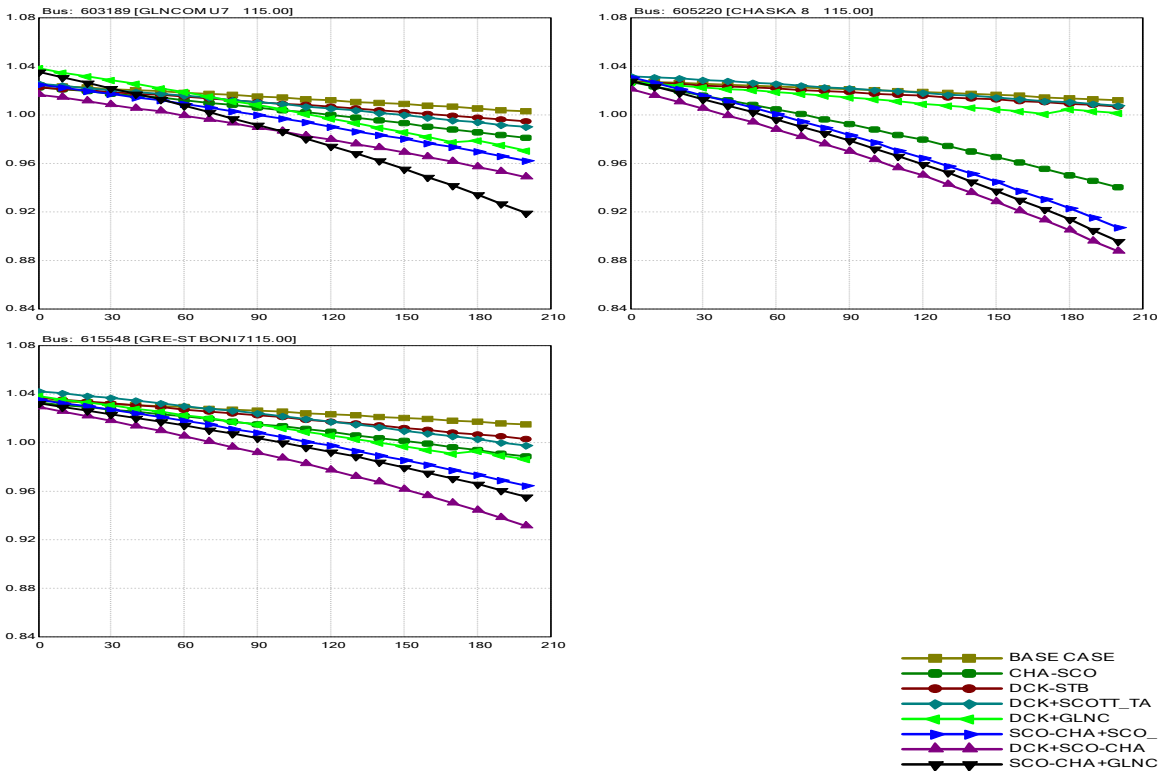


Figure 3.12
Option 1 with addition of 80 MVAR capacitor bank at West Waconia.
The load between Glencoe, St. Boni and Chaska was used at sink.

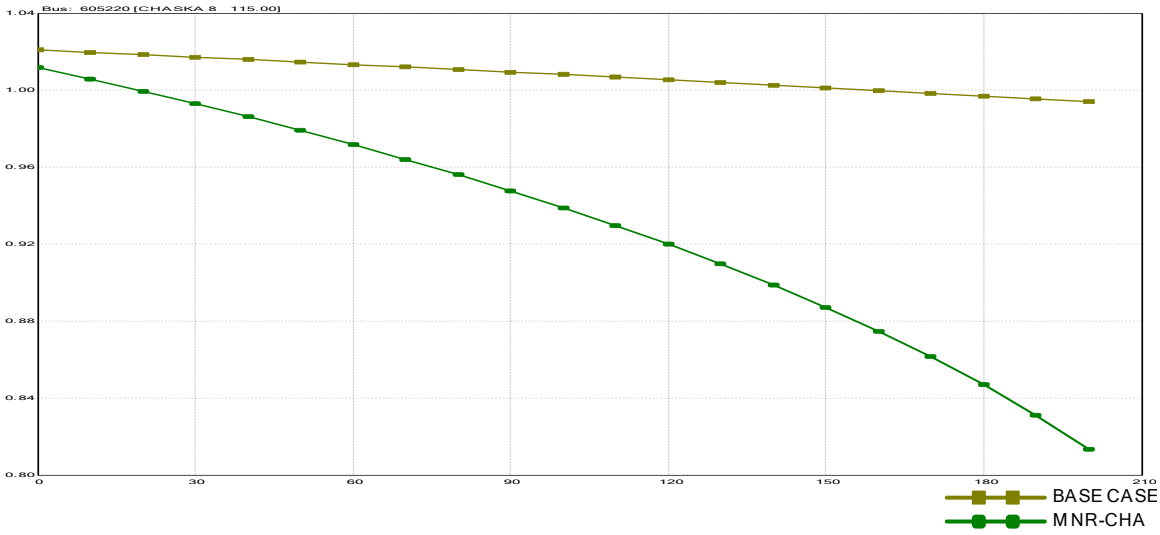


Figure 3.13
Option 2 with addition of 80 MVAR capacitor bank at Carver County.
The load between Augusta and Chaska was used as Sink

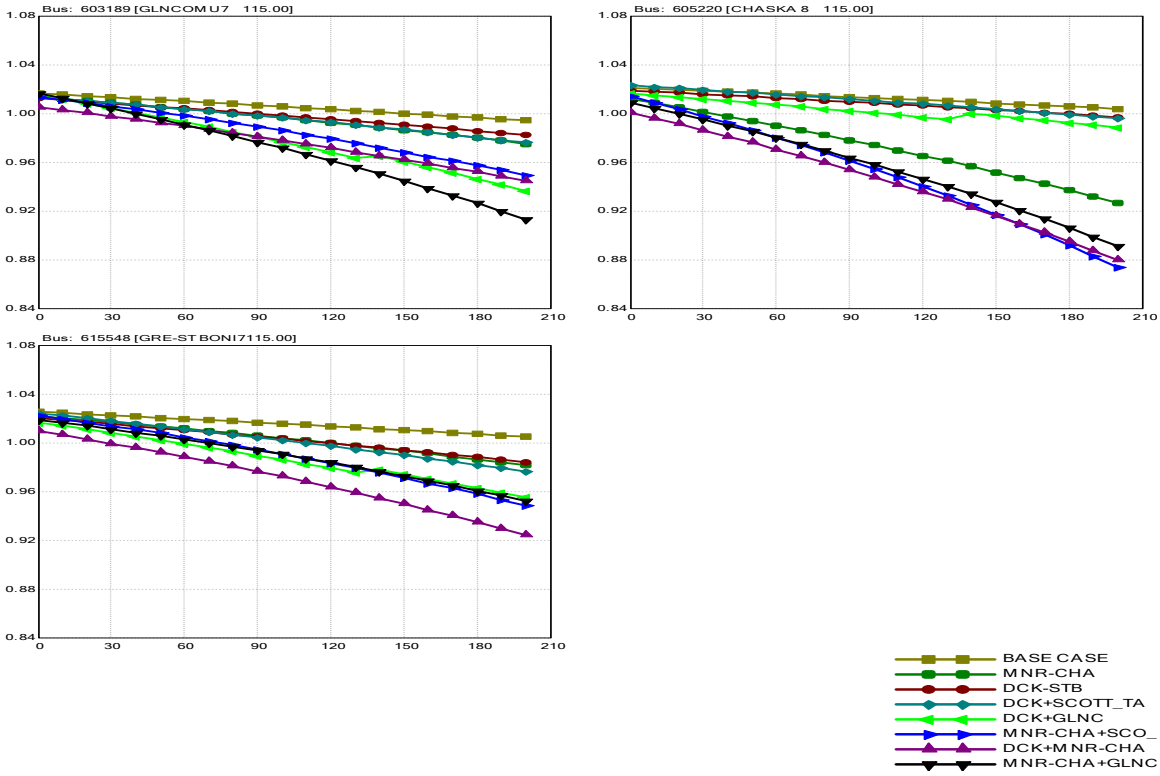


Figure 3.14
Option 2 the addition of 80 MVAR capacitor bank at Carver County.
The load between Glencoe and Chaska was used at sink.

Loss analysis

Table 3.7 below provides the losses in base case compared with options 1 and 2, for GRE and NSP areas. The two losses provided in base case are based on the Scott County – Chaska 69 kV line being open and close. It should be noted that the losses would be higher in the base case with this line open. Without the West Creek substation it would be desirable to operate the system with the line open as there would not be any voltage violations or Scott County transformer overload concerns. However with the addition of West Creek load, the voltages at Chaska would drop below the 95% requirement for system intact condition. Closing the line would result in overloading one of the Scott County transformers during the loss of other.

Table 3.7

System Topology	Losses in MW
Base case with Scott County – Chaska line open	349.6
Base case with Scott County – Chaska line closed	345.9
Option 1 – 115 kV line from W Waconia – Scott Co	344.7
Option 2- 115 kV line from Carver Co – MN River	344.8

Table 3.8 below provides the losses on individual sections of transmission lines between Carver County/West Waconia and Scott County for base case option 1 and option 2. The loss reduction identified for each section of transmission line is not considered an accurate measure of loss savings since the flows can be significantly altered on the adjacent lines due to change in impedance.

Table 3.8

Facility	Base Case[6]	Base Case[7]	Option 1	Option 2
West Waconia - Augusta			0.1	-
Carver County – Augusta	2.1	0.3	-	0.0
Augusta – West Creek	0.8	0.1	0.0	0.0
West Creek – Chaska	0.1	0.0	0.0	0.1
Chaska – Scott County	-	0.2	0.0	-
Chaska – Minnesota River	-	-	-	0.0
Total	**3.0**	**0.6**	**0.1**	**0.1**

From Table 3.7 and 3.8, it can be noticed that there is no significant difference in losses between the two proposed options, therefore no further analysis was performed to identify the financial benefits of loss reduction.

[6] With Scott County – Chaska normally open.
[7] With Scott County – Chaska normally closed

Cost Analysis

The planning level, indicative estimate for each of the options is listed below in Tables 3.8. Since the entire project would be built at the same time, net present value analysis is not required.

Table 3.8

Option 1	Cost
Convert West Waconia – Augusta 69 kV line to 115 kV[8]	$ 2,035,000
Convert Augusta substation to 115 kV	$ 1,500,000
Augusta – West Creek 115 kV line	$ 1,875,000
Convert Victoria substation to 115 kV	$ 1,500,000
West Creek – Chaska 115 kV line	$ 2,630,000
Convert Scott County – Chaska 69 kV line to 115 kV	$ 2,260,000
Convert Chaska substation to 115 kV	$ 2,000,000
New West Creek distribution substation	$ 2,600,000
115 kV line termination at Scott County substation	$ 2,070,000
115 kV line termination at West Waconia substation	$ 1,980,000
Total	**$ 20.45 Million**

Option 2	Cost
Convert Carver County – Augusta 115 kV line to 115 kV[9]	$ 4,500,000
Convert Augusta substation to 115 kV	$ 1,500,000
Convert Augusta – West Creek line to 115 kV	$ 1,875,000
Convert Victoria substation to 115 kV	$ 1,500,000
Convert the 69 kV line between (1 miles east of) West Creek and Minnesota River to 115 kV (this would include new right of way)	$ 5,500,000
Convert Chaska substation to 115 kV	$ 2,000,000
New West Creek distribution substation	$ 2,600,000
115 kV line termination at Carver county substation	$ 3,150,000
115 kV line termination at Minnesota River substation	$ 1,000,000
Total	**$ 23.62 Million**

From Table 3.8, option 1 would be less expensive compared to option 2. Since the Southwest Twin Cities phase 1 project would build the 2.5 mile circuit from West Waconia to Augusta tap, the cost of adding the 115kV circuit would be significantly less than building a new 115 kV line from Carver County to Augusta tap. In addition to the difference in cost of 115 kV line, a new 115 kV line termination at Carver County is expected to be expensive compared to a new line termination at West Waconia substation.

[8] Only the sections that are not built to 115 kV and the 1.5 mile 69 kV section West of the tap on Augusta – Carver County 69 kV line. It is assumed that the Phase 1 of SW TC conversion project would build the line from West Waconia to existing Carver County – Augusta line, and only the cross arms, insulators and conductor have to be installed to complete this section.

[9] This would involve building 115/69 kV double circuit tap from the Carver County tap to Carver County substation, in order to terminate the 69 kV line from Waconia into Carver County substation.

Additional Concerns

For option 2, full n-2 contingency analysis also indicated that the loss of Scott County – Minnesota River 115 kV line combined with the loss of Westgate – Bluff Creek would cause severe low voltages (close to 85%) at Bluff Creek, Minnesota River, Chanhassen, Chaska, West Creek, Victoria and Augusta substations. This is expected as the entire load between Bluff Creek and Minnesota River substation would be served from Carver County substation during this contingency. In addition this would also cause the GRE 115kV line, between Augusta and West Creek substations, to overload beyond 200%.

In order to mitigate this NERC category C3 contingency, after the first contingency (loss of Scott County source or Westgate source), the line between Chaska and Minnesota River has to be opened. This would result in dropping the entire load between Westgate and Scott County substations after the second contingency. Although this is an acceptable mitigation plan for NERC Category C3 contingency, this would put additional burden on the transmission system operators, and therefore not desirable.

4. Conclusion

The preferred plan is to build a 115 kV line from West Waconia to Scott County through Augusta, Victoria, West Creek and Chaska. This can be achieved by re-building sections of existing 69 kV line to 115 kV.

The southwest Twin Cities phase 1 project converts a major section of the line between Carver County and Augusta to 115 kV (operated at 69 kV). The new load demand can be met by converting Scott County - Chaska and Augusta – Victoria tap sections of 69 kV line to 115 kV. To serve West Creek substation, the Victoria tap line needs to be tapped one mile South of Victoria substation. Approximately 2 miles of new 115 kV line would be needed to provide two way service to West Creek substation. This would also result in retiring 1 mile of 69 kV line between Victoria tap and Chaska.

The project would also consist of stringing 2.5 miles of 115 kV line on 115/69 kV structures, proposed as part of Southwest Twin Cities 115 kV conversion-phase 1, between West Waconia and existing Carver County – Augusta 69 kV line. The one line diagram and map for the preferred plan are shown below.

As part of this project, Augusta and Chaska downtown substations have to be re-built to 115 kV and the transformer at Victoria substation would have to be upgraded to 115 kV.

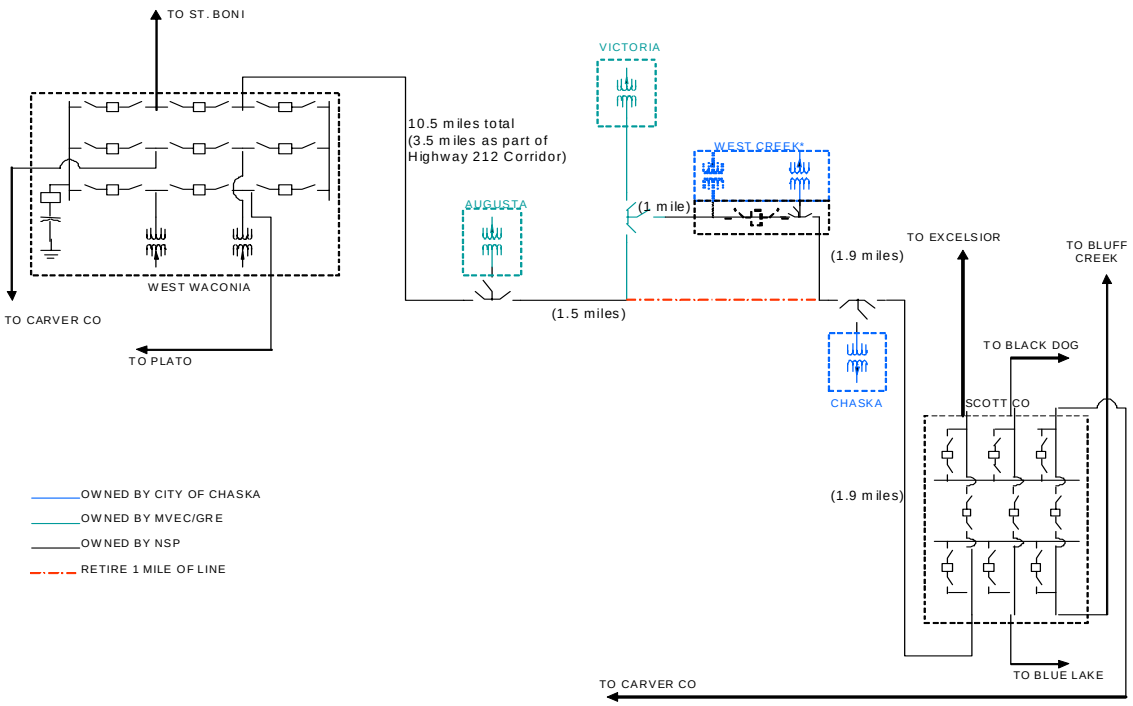
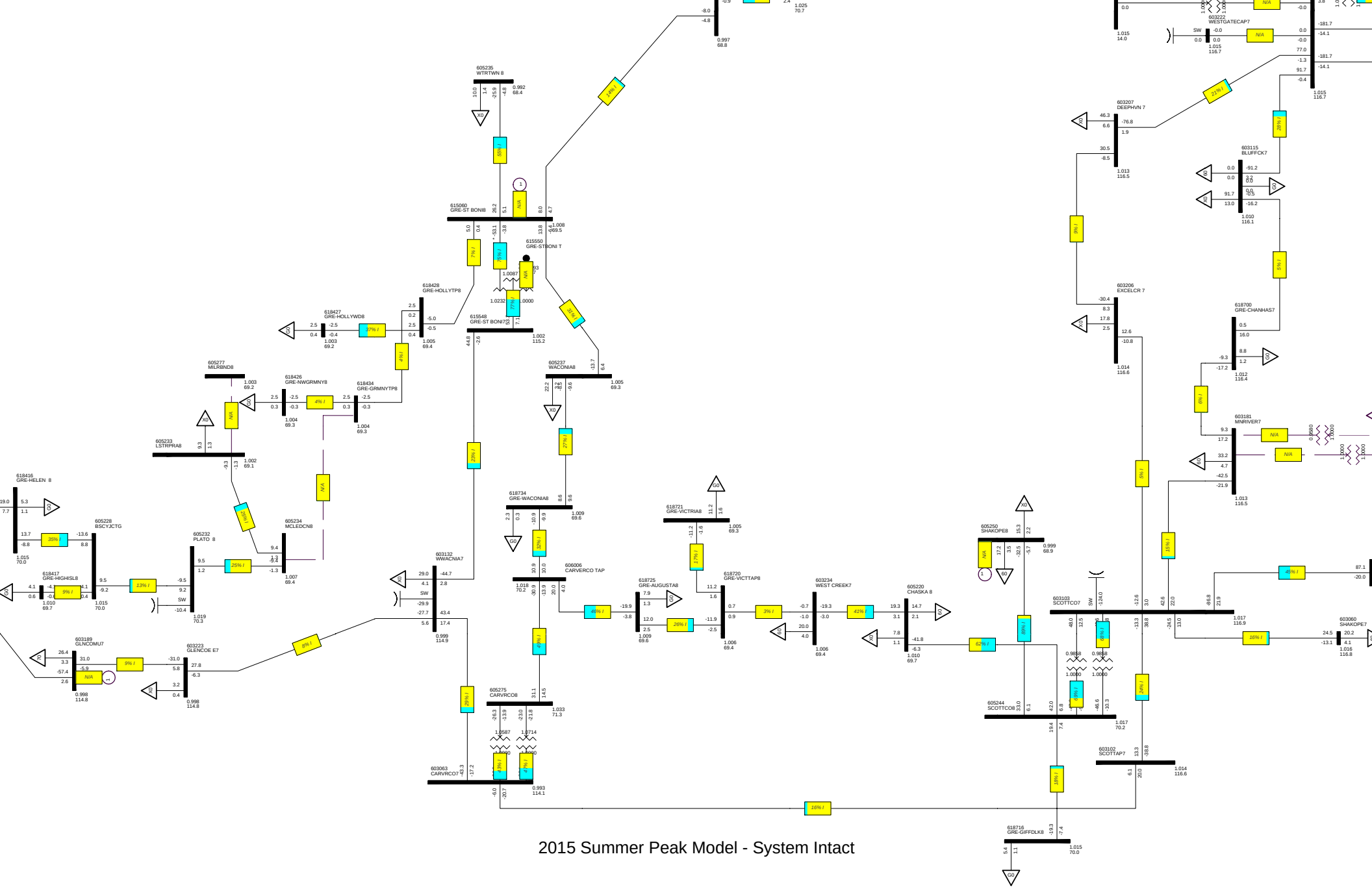

TO ST. BONI
VICTORIA
10.5 miles total
(3.5 miles as part of
Highway 212 Corridor)
WEST CREEK
AUGUSTA
(1 mile)
TO EXCELSIOR
TO BLUFF
CREEK
(1.9 miles)
WEST WACONIA
TO CARVER CO
(1.5 miles)
TO PLATO
TO BLACK DOG
CHASKA
SCOTT CO
OWNED BY CITY OF CHASKA
OWNED BY MVEC/GRE
OWNED BY NSP
RETIRE 1 MILE OF LINE
(1.9 miles)
TO BLUE LAKE
TO CARVER CO

Figure 4.1

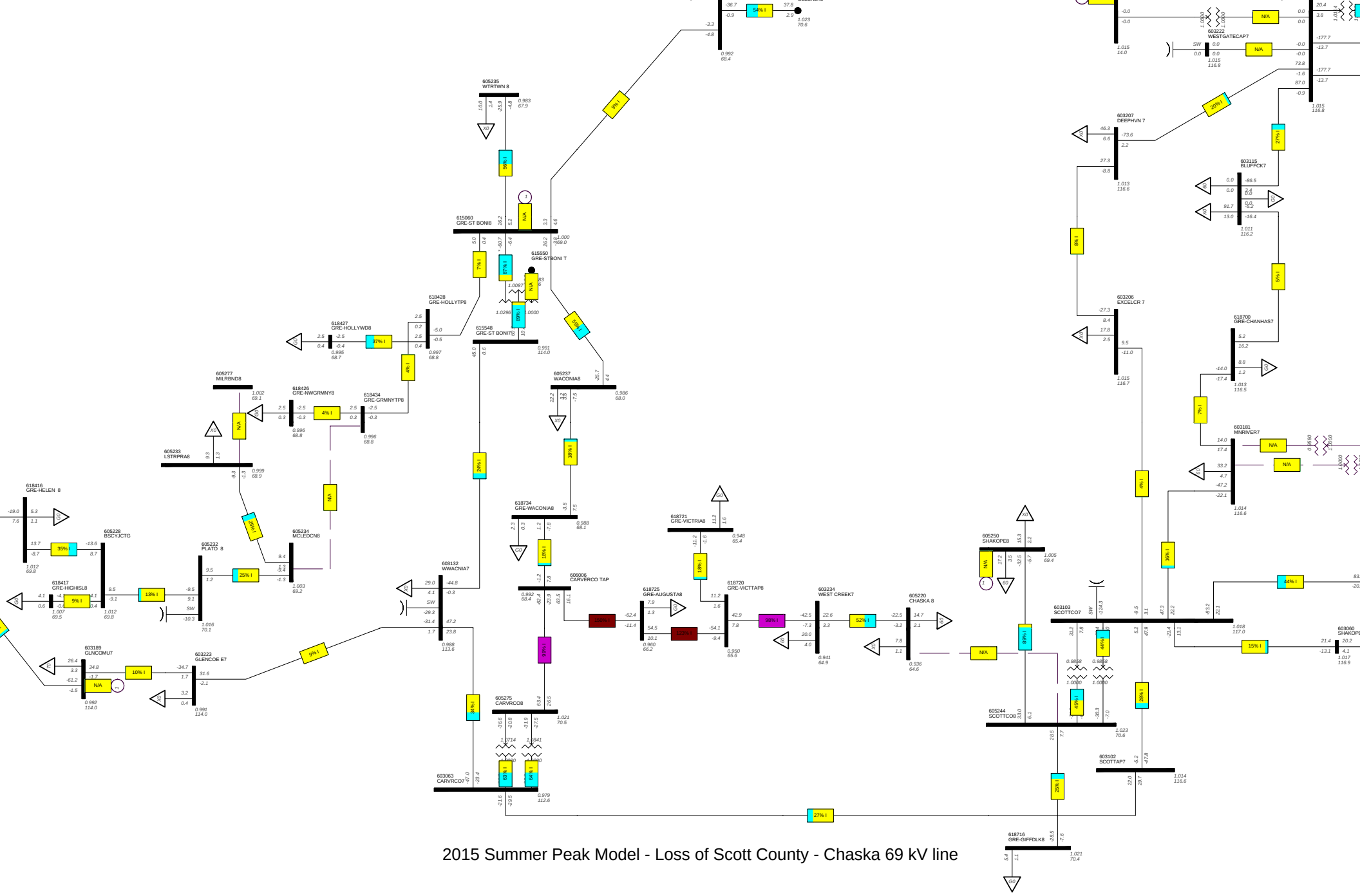
Appendix A

Power Flow Maps

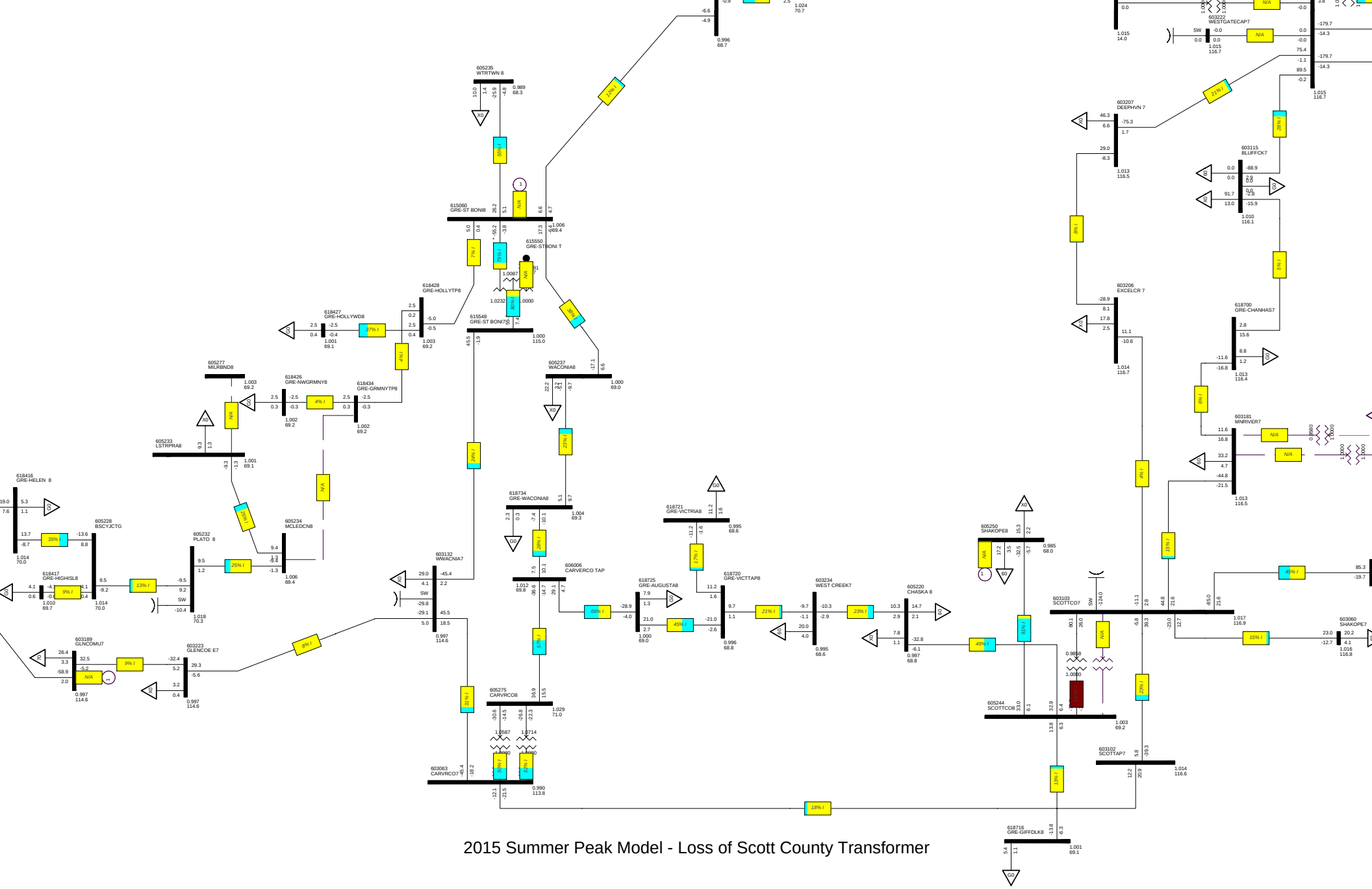
Base Case



2015 Summer Peak Model - System Intact

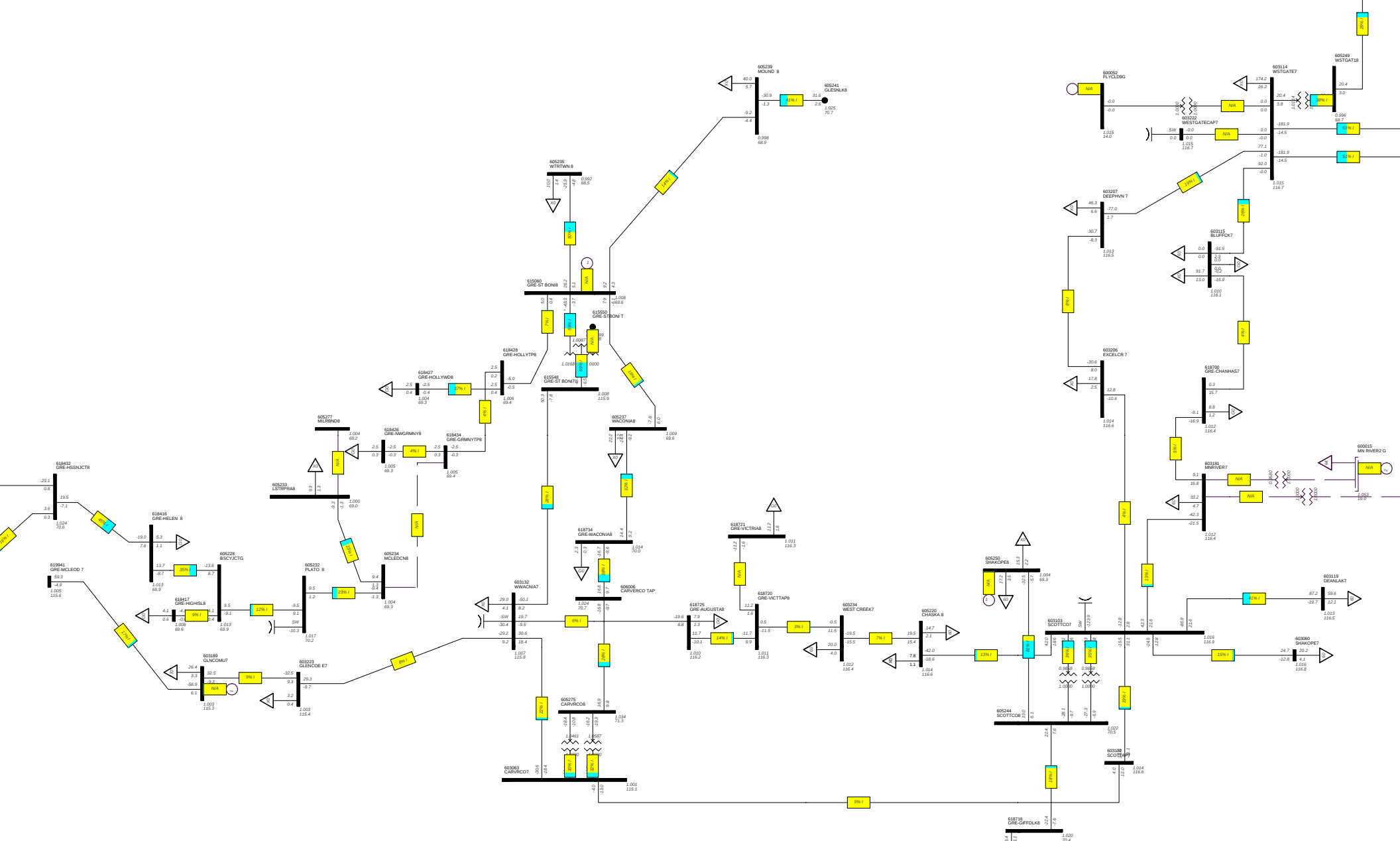


2015 Summer Peak Model - Loss of Scott County - Chaska 69 kV line

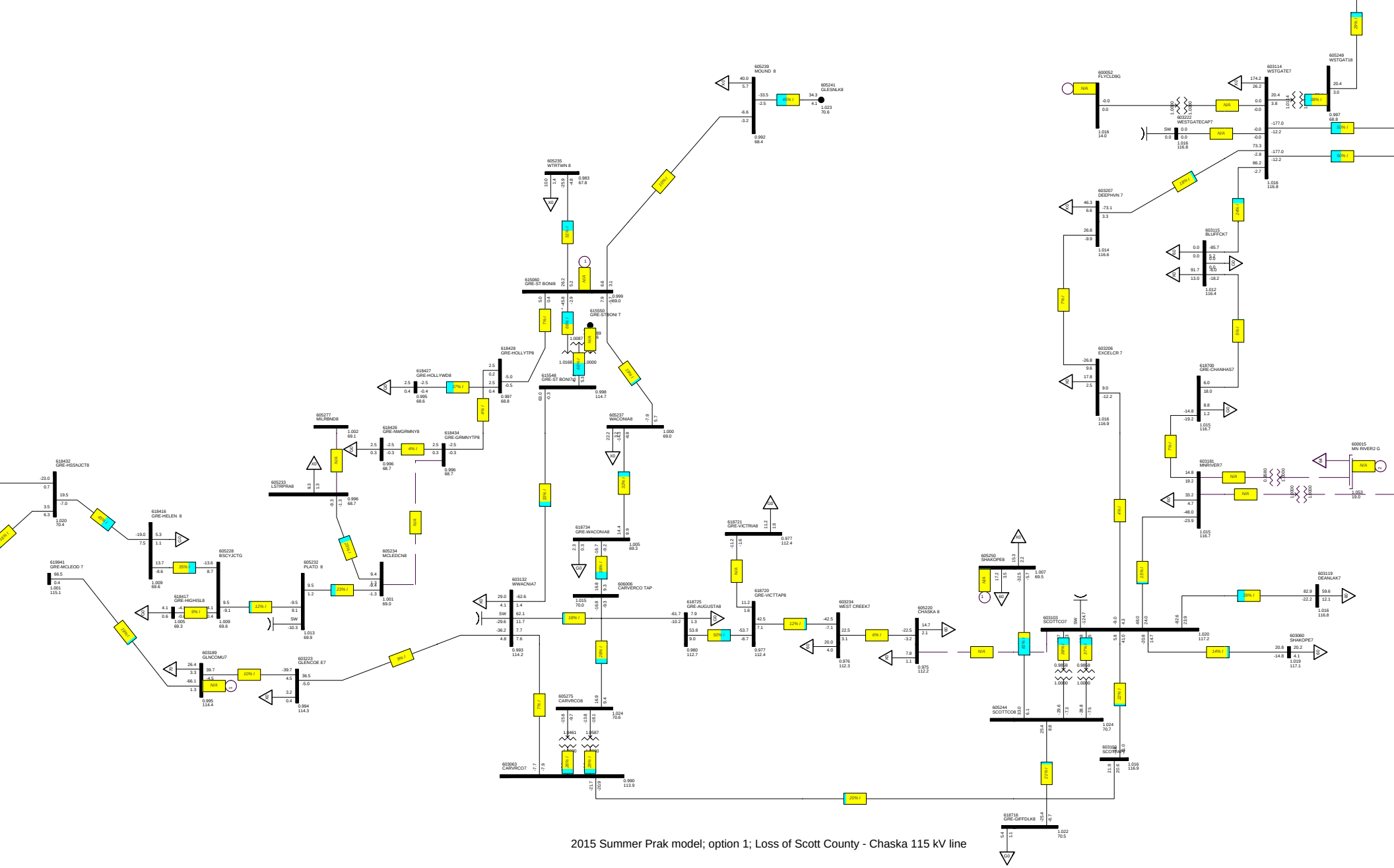


2015 Summer Peak Model - Loss of Scott County Transformer

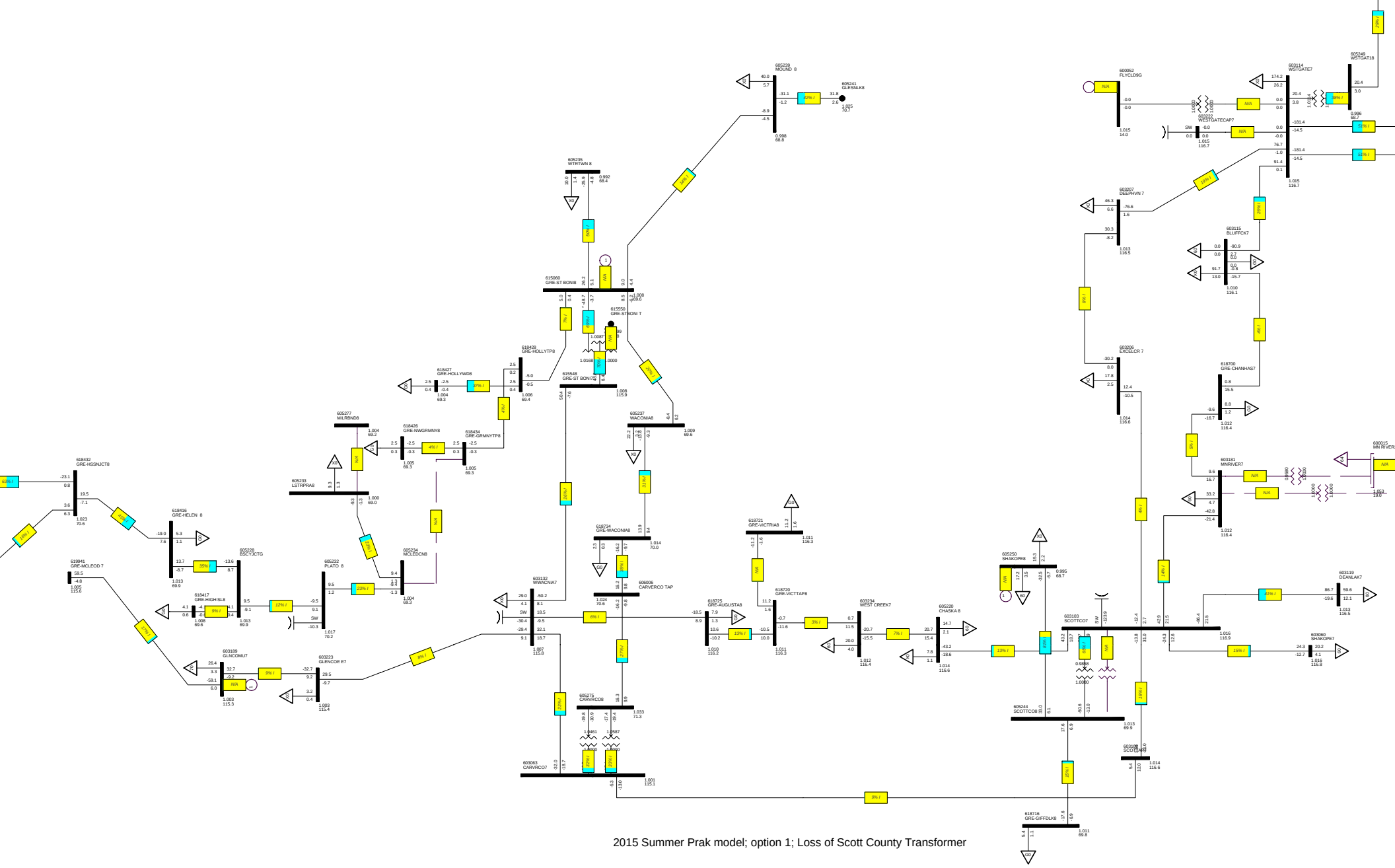
Option 1



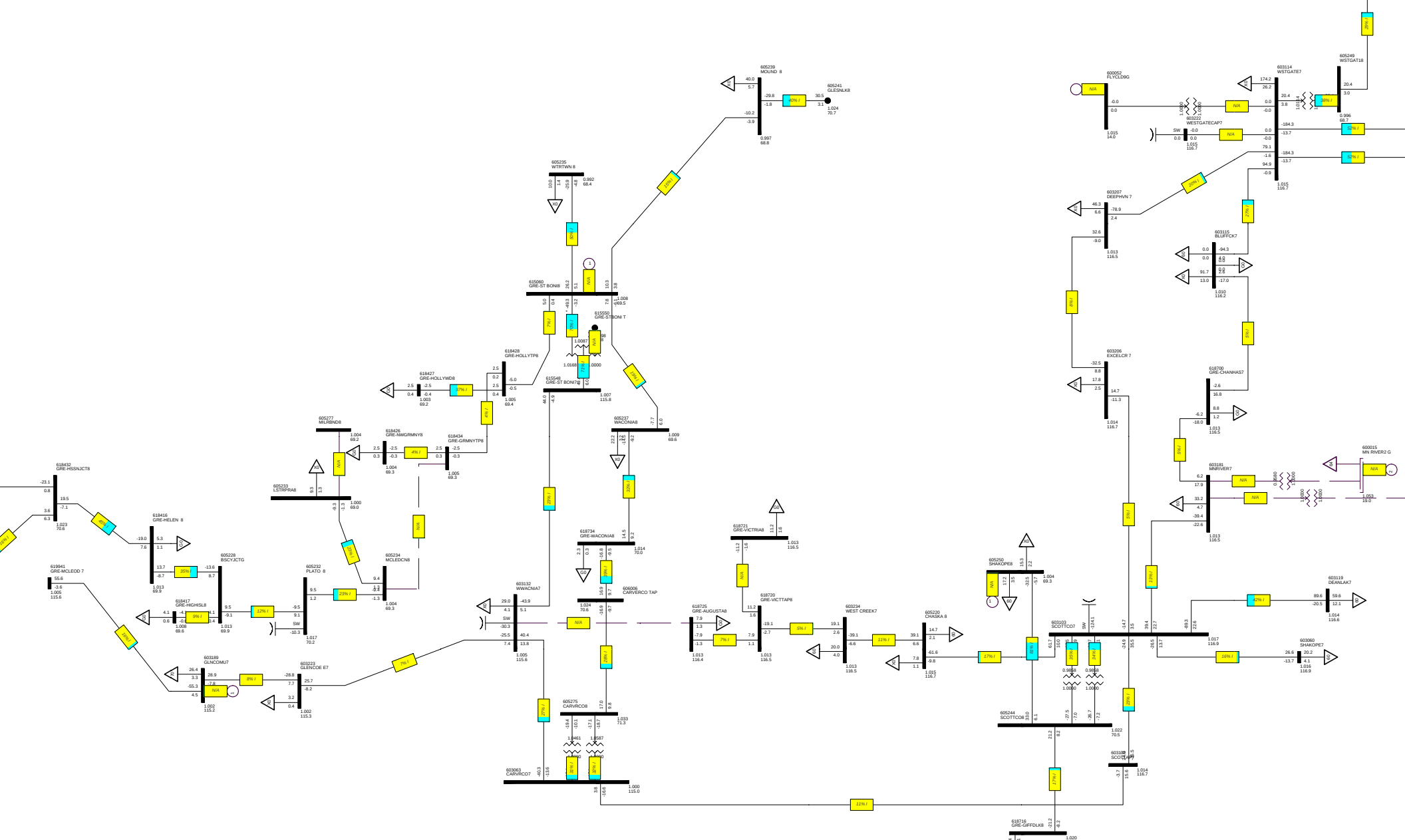
2015 Summer Prak model; option 1; System Intact



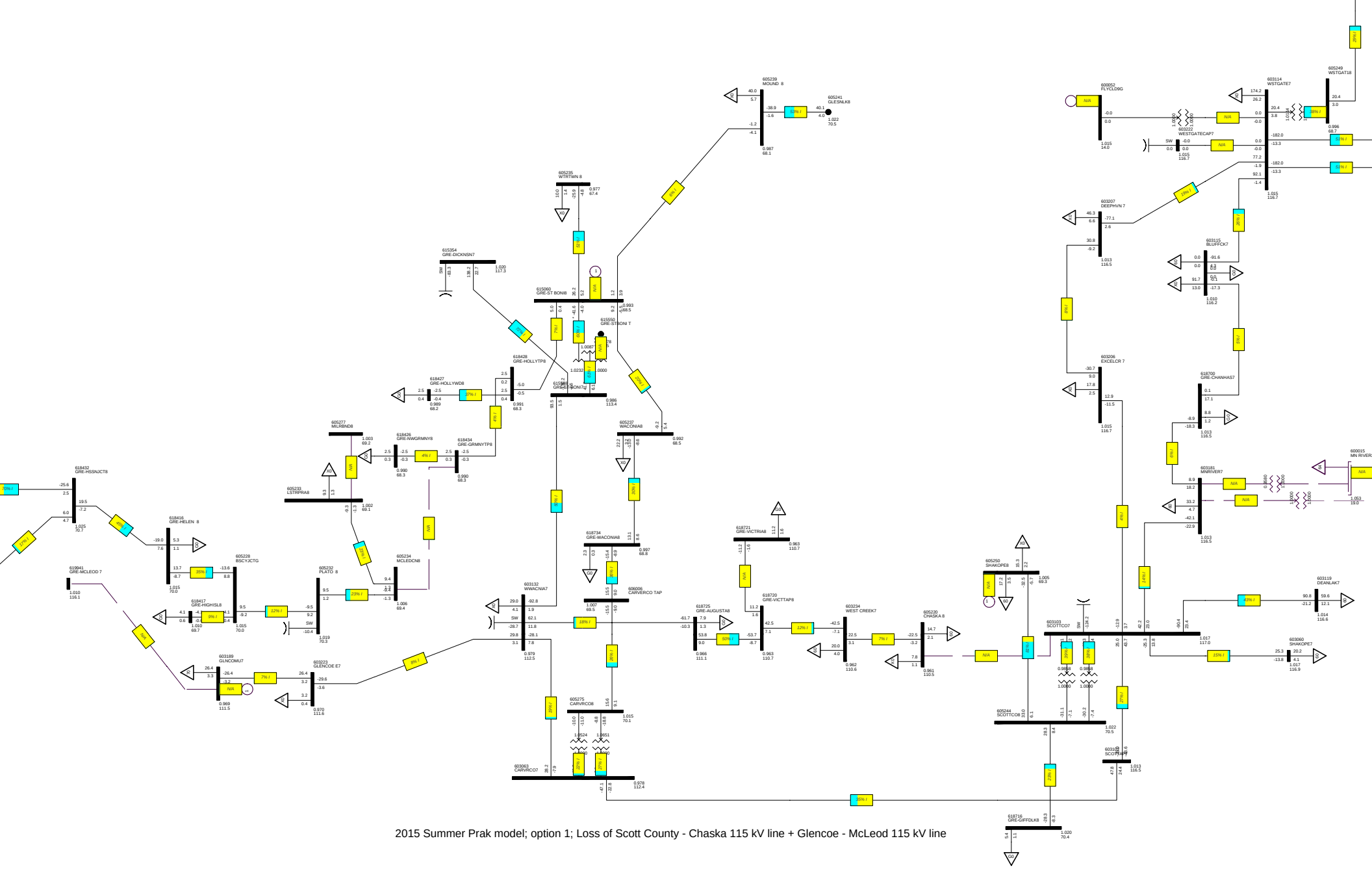
2015 Summer Prak model; option 1; Loss of Scott County - Chaska 115 kV line



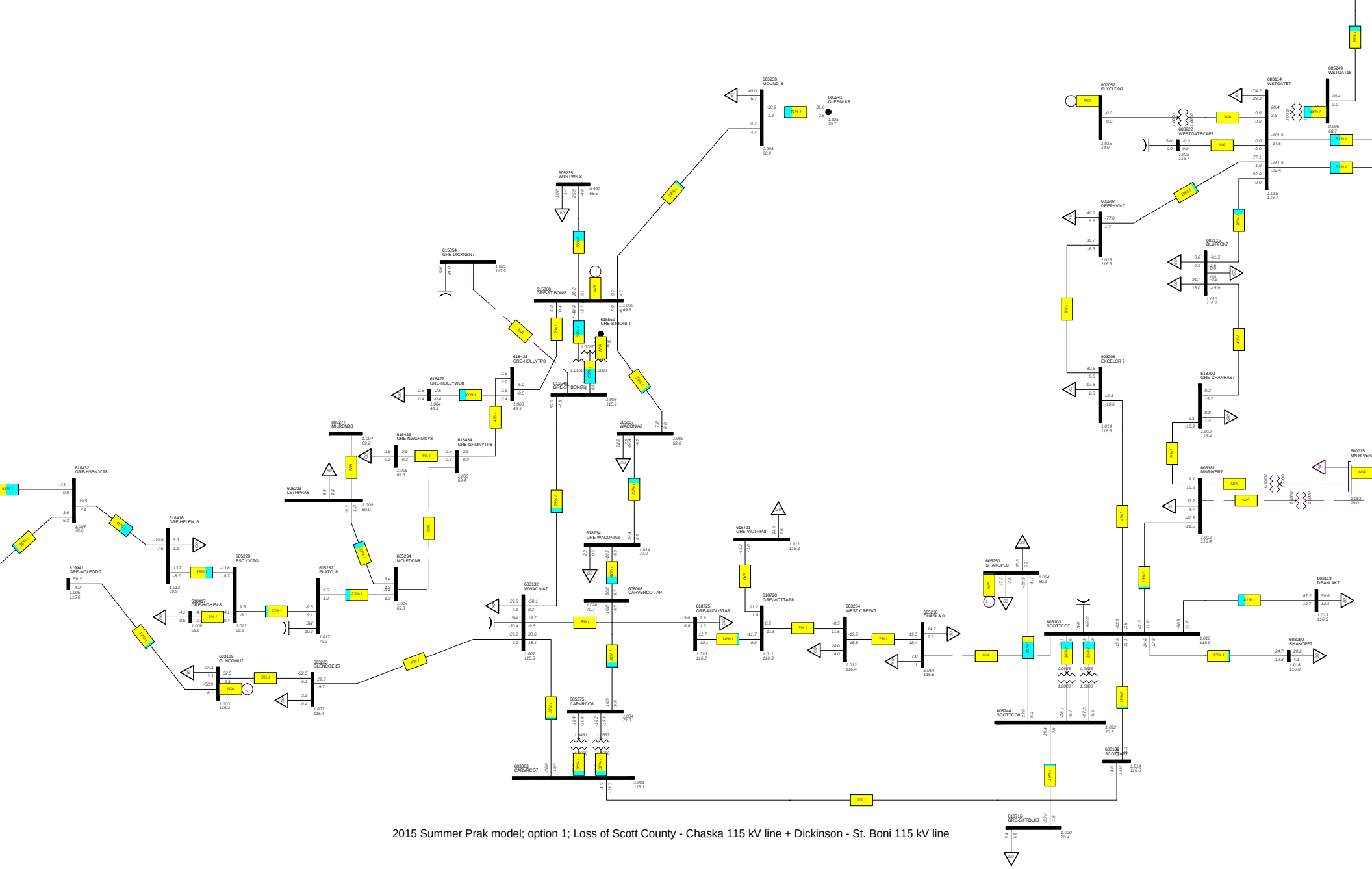
2015 Summer Prak model; option 1; Loss of Scott County Transformer



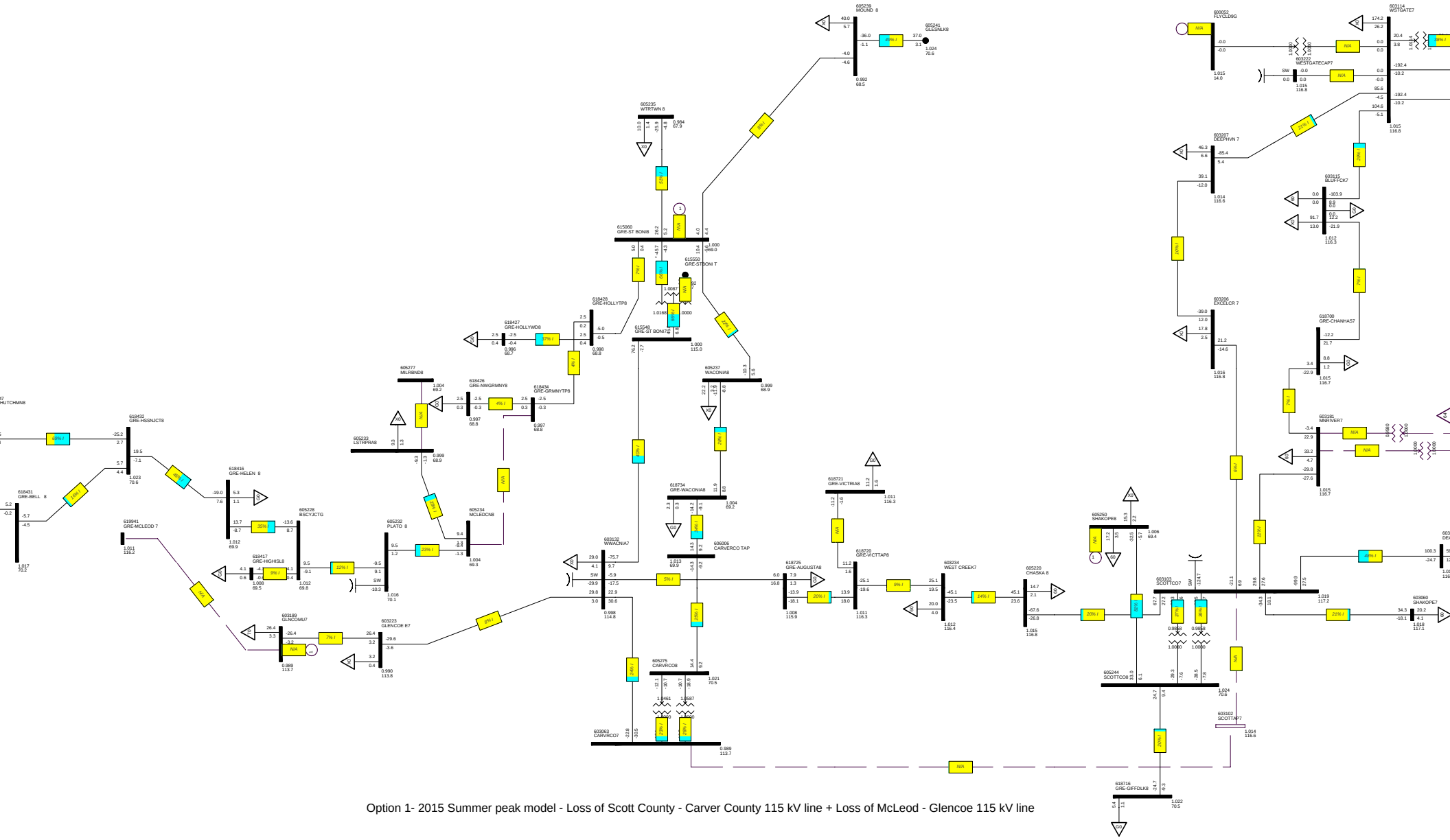
2015 Summer Prak model; option 1; Loss of West Waconia - Augusta 115 kV line



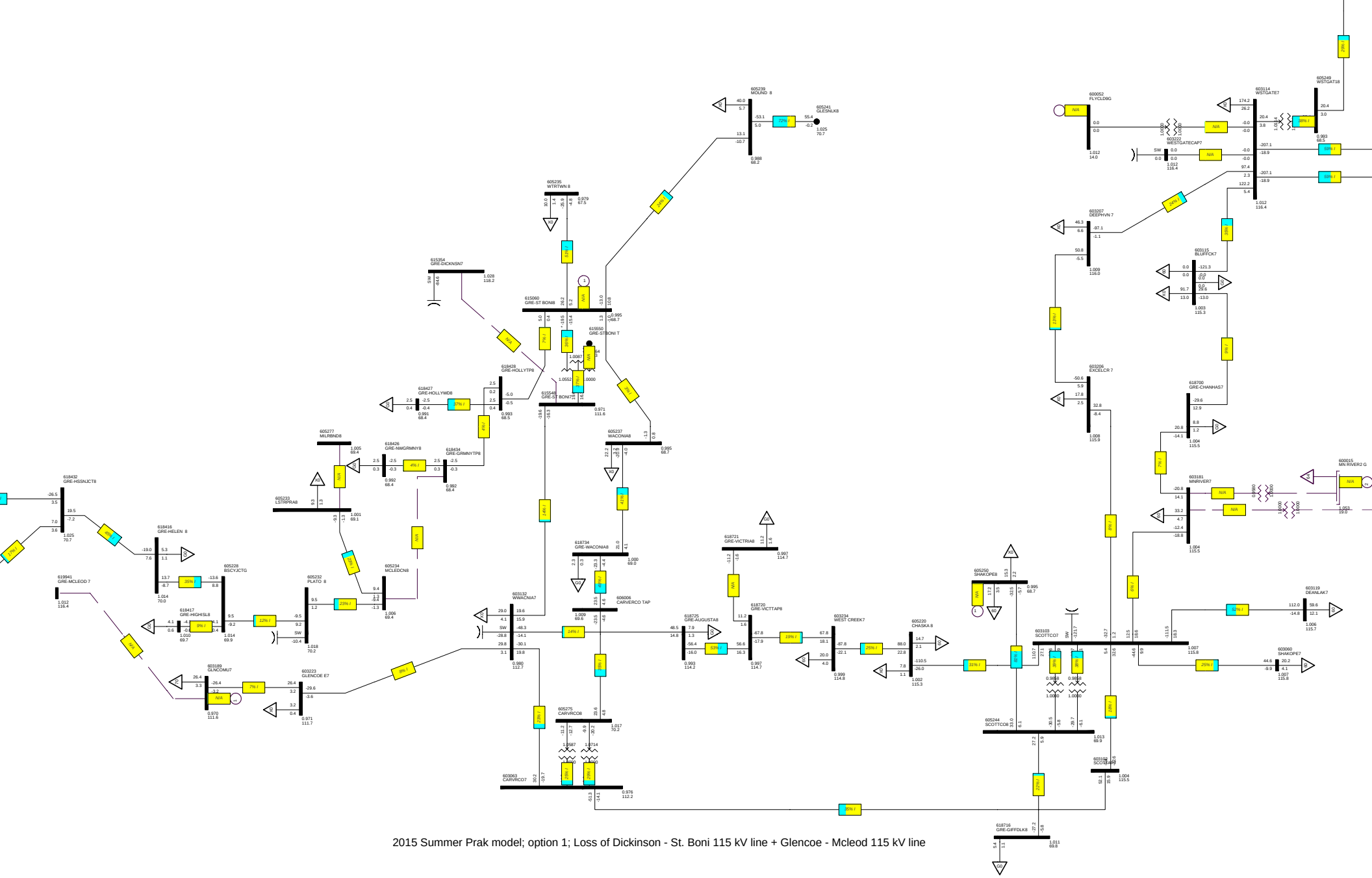
2015 Summer Prak model; option 1; Loss of Scott County - Chaska 115 kV line + Glencoe - McLeod 115 kV line



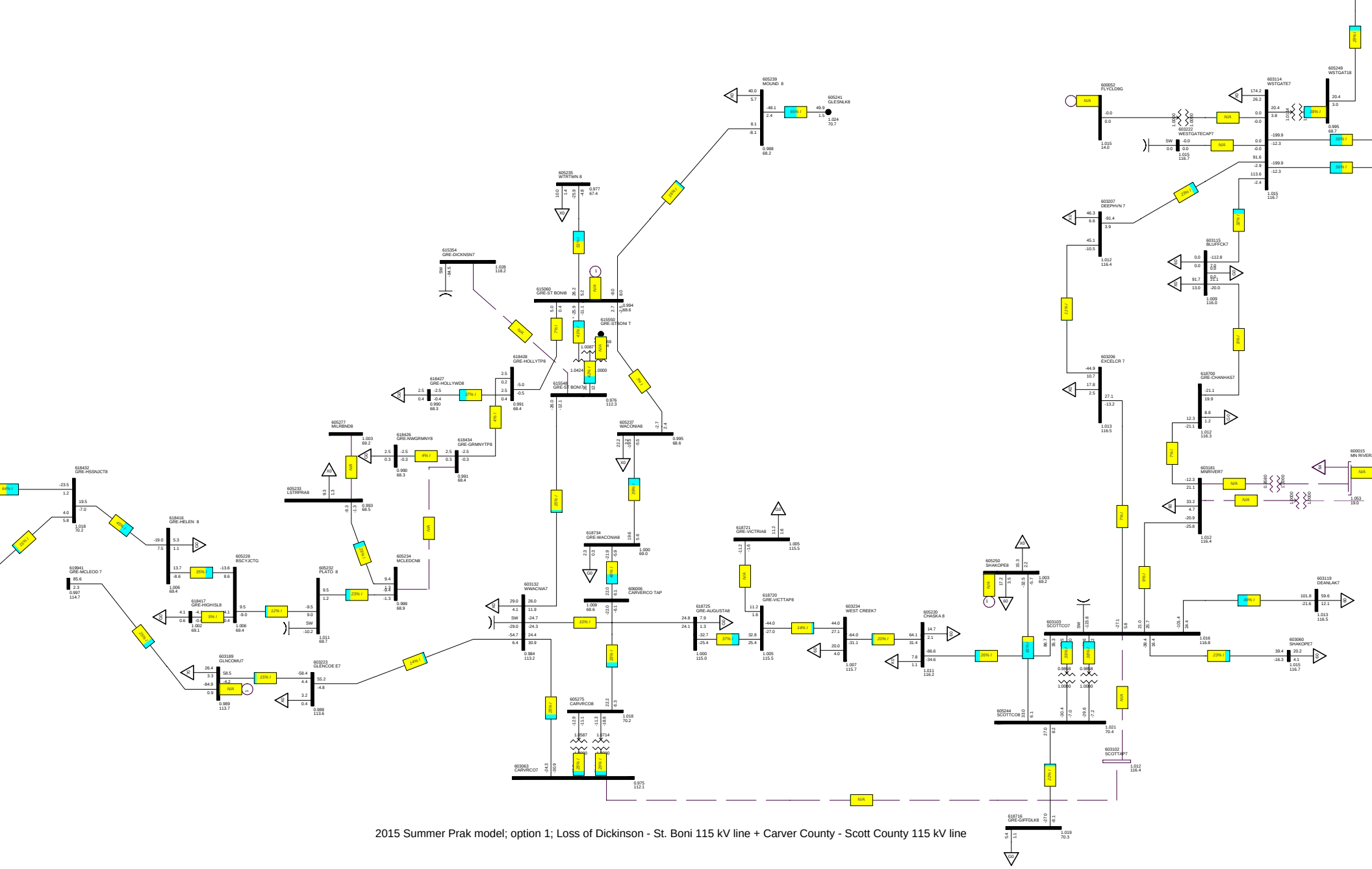
2015 Summer Prak model; option 1; Loss of Scott County - Chaska 115 kV line + Dickinson - St. Boni 115 kV line



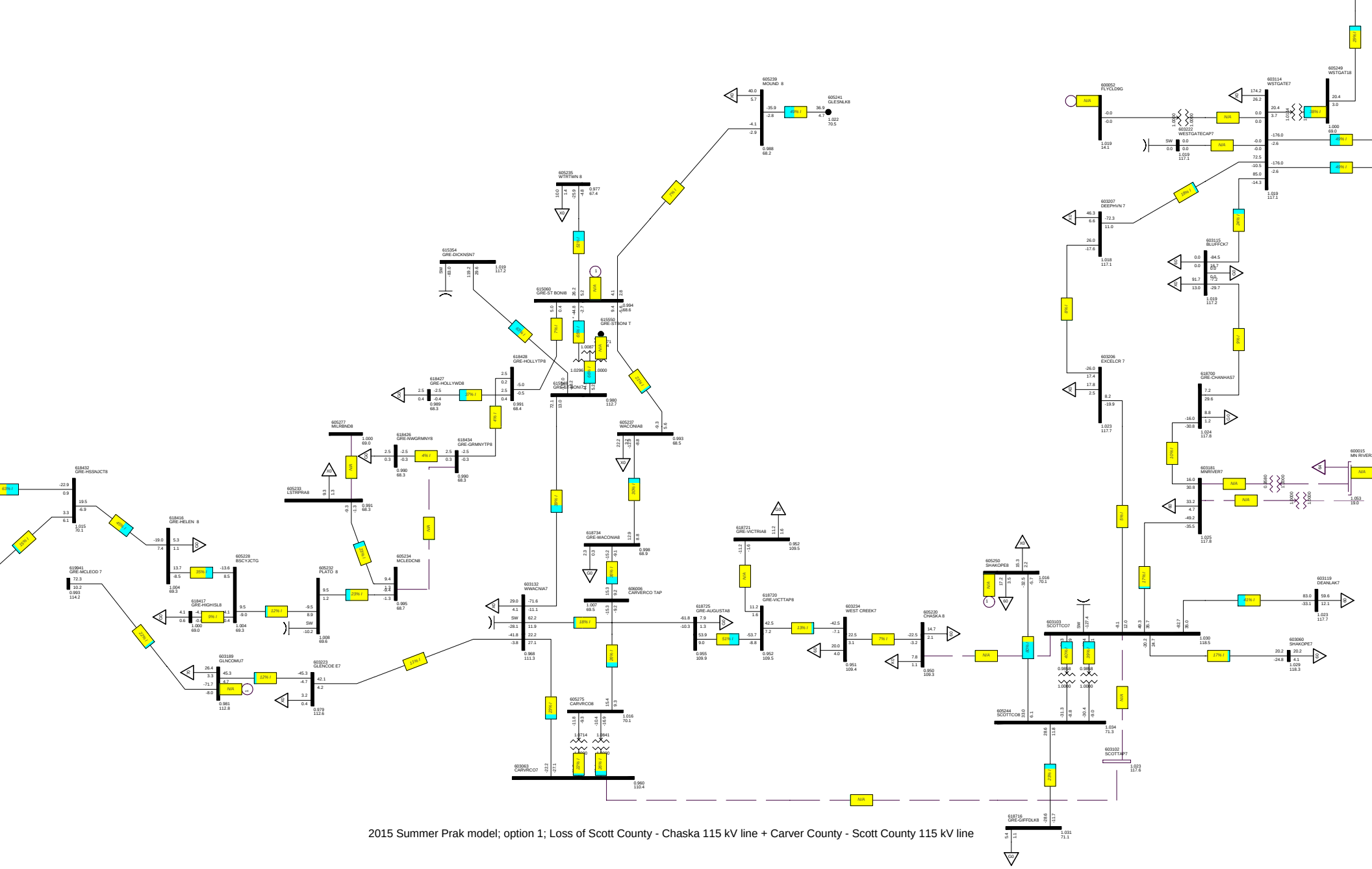
Option 1- 2015 Summer peak model - Loss of Scott County - Carver County 115 kV line + Loss of McLeod - Glencoe 115 kV line



2015 Summer Prak model; option 1; Loss of Dickinson - St. Boni 115 kV line + Glencoe - Mcleod 115 kV line

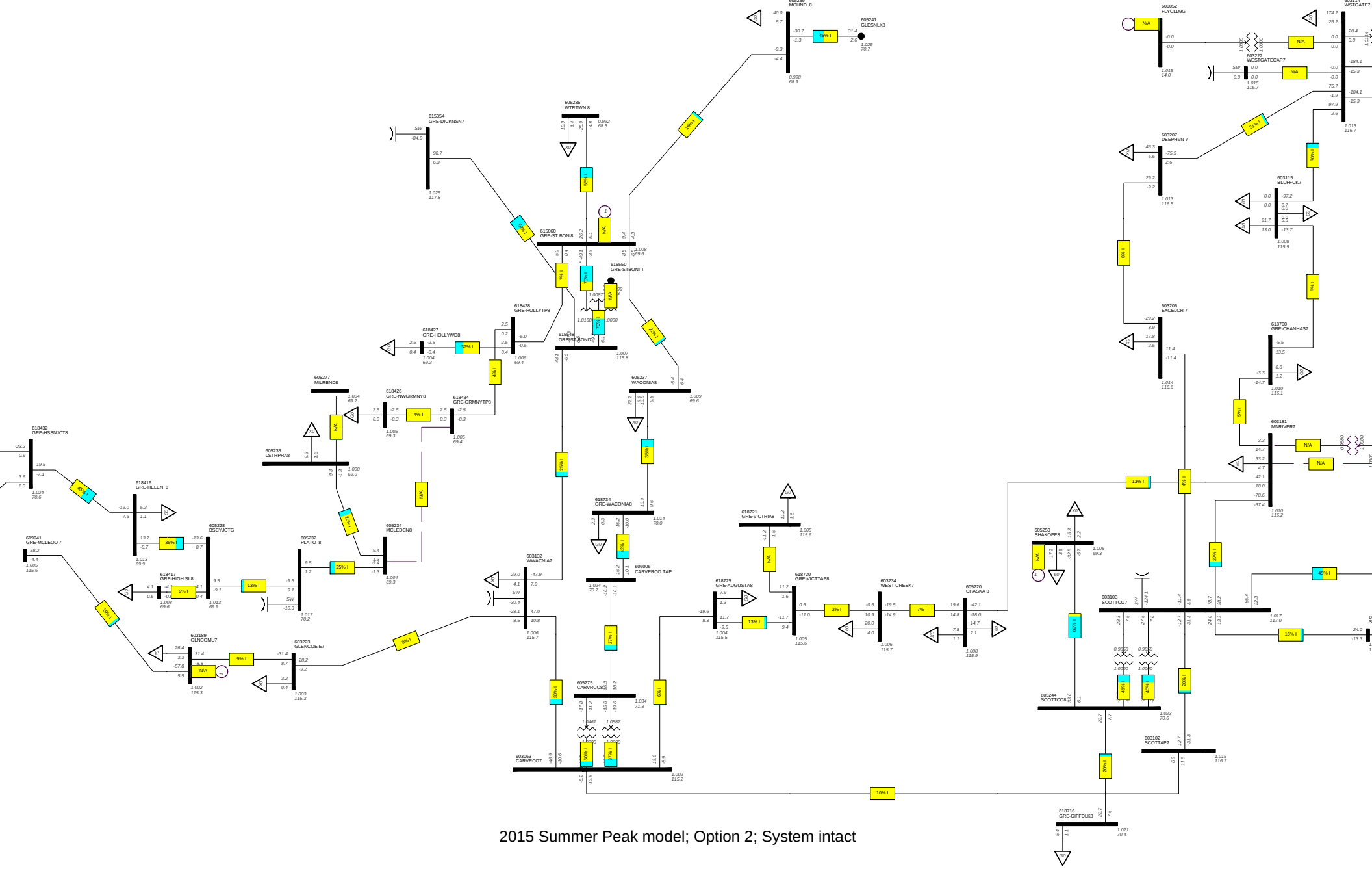


2015 Summer Prak model; option 1; Loss of Dickinson - St. Boni 115 kV line + Carver County - Scott County 115 kV line

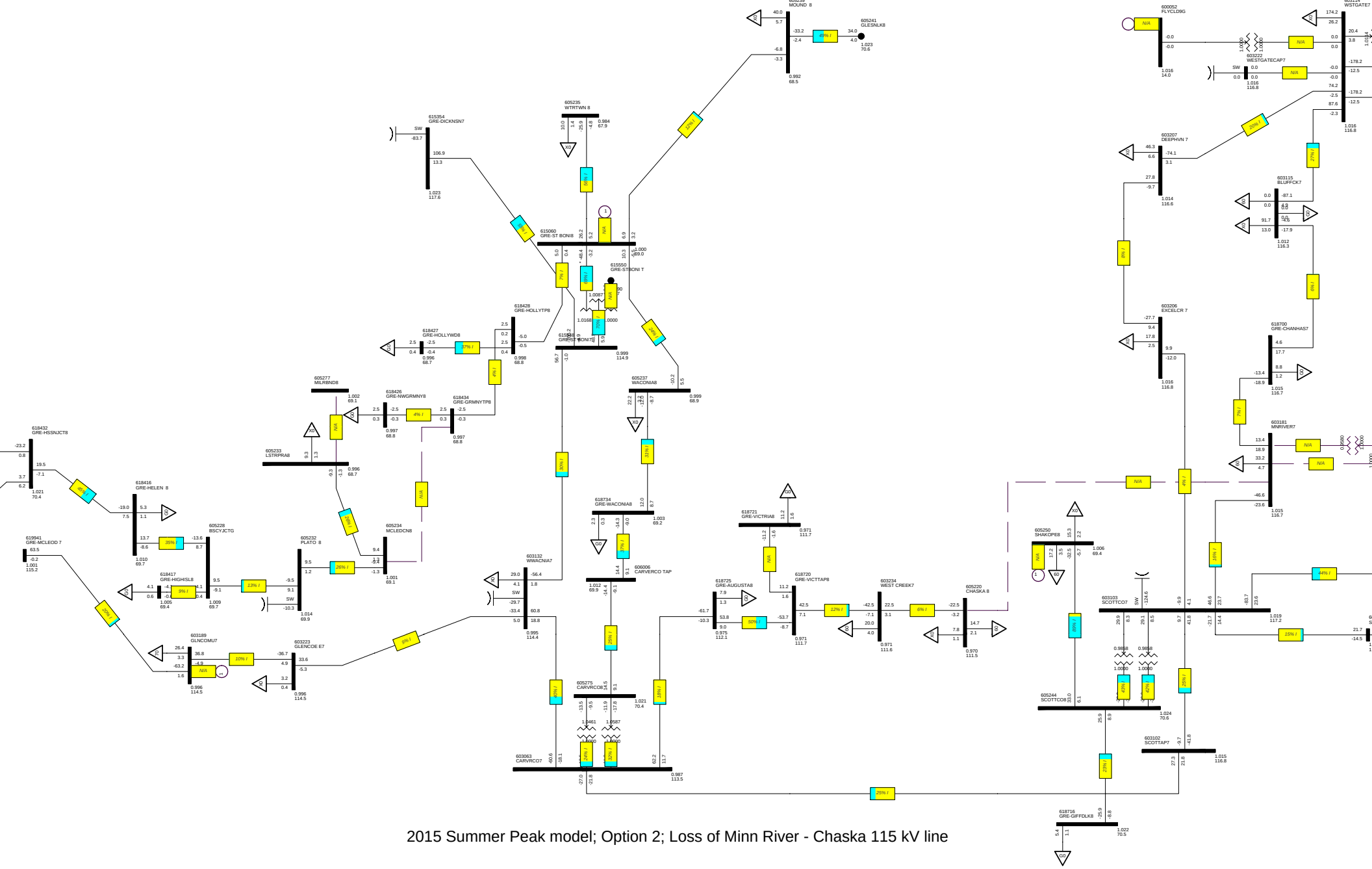


2015 Summer Prak model; option 1; Loss of Scott County - Chaska 115 kV line + Carver County - Scott County 115 kV line

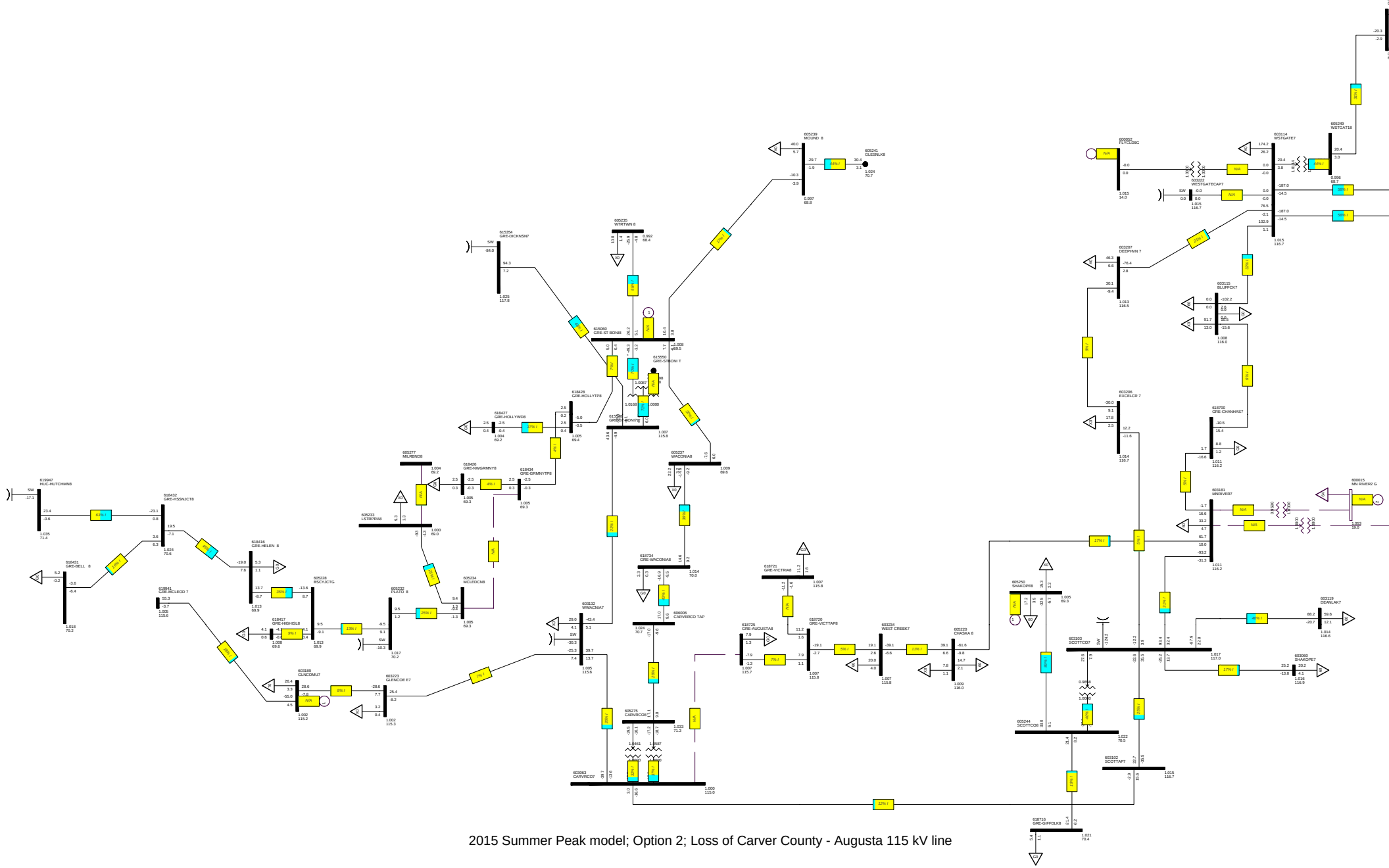
Option 2



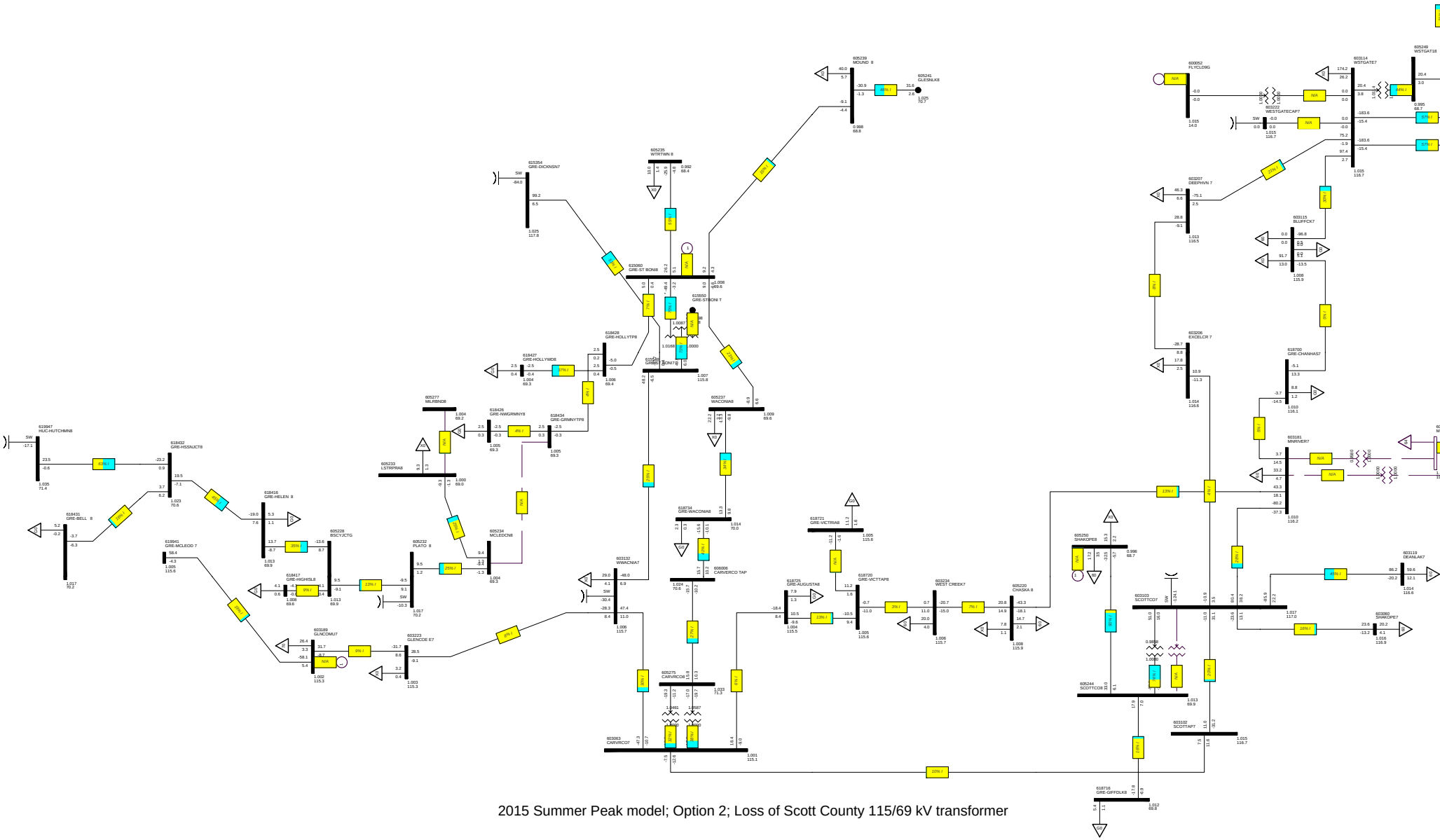
2015 Summer Peak model; Option 2; System intact



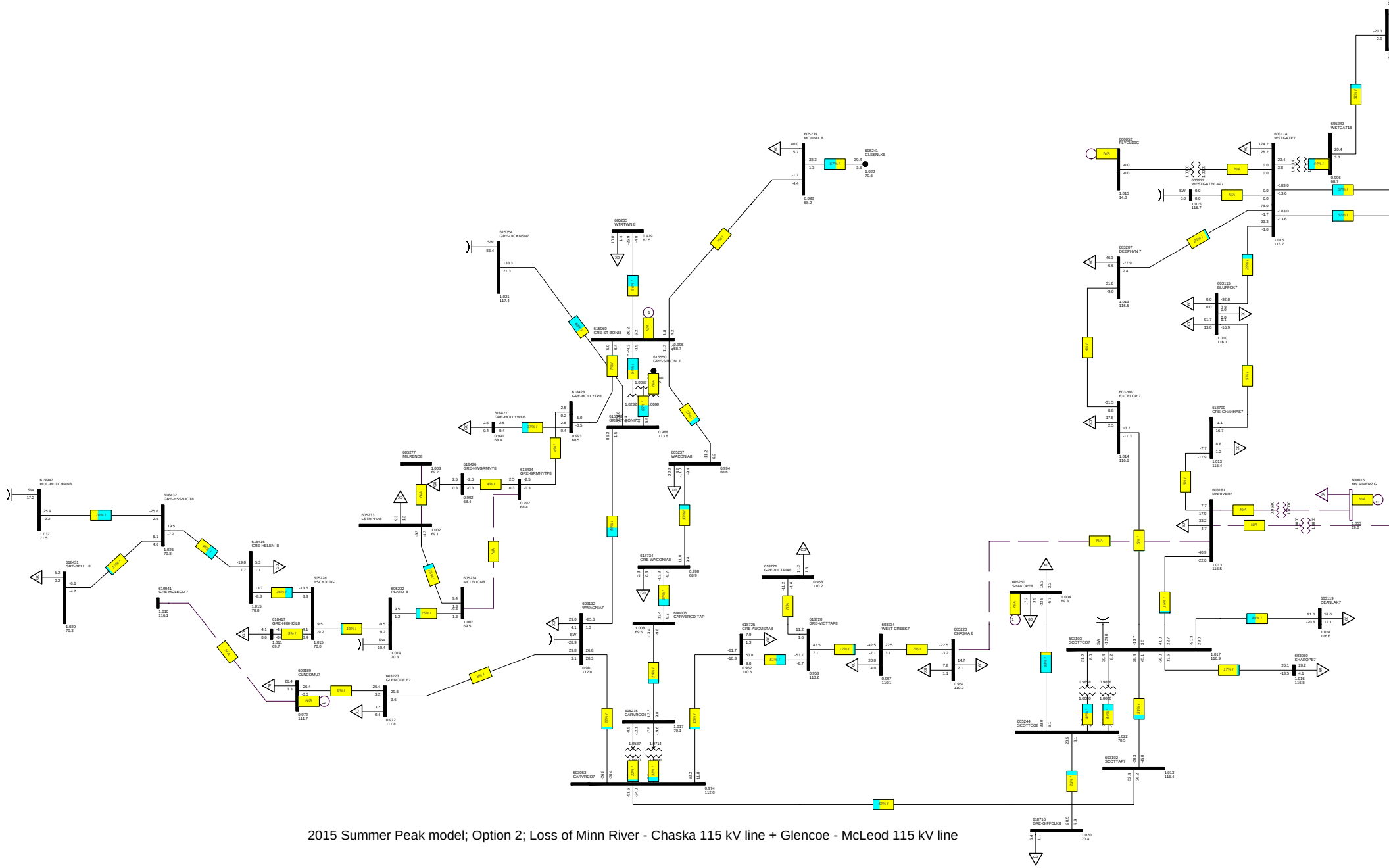
2015 Summer Peak model; Option 2; Loss of Minn River - Chaska 115 kV line



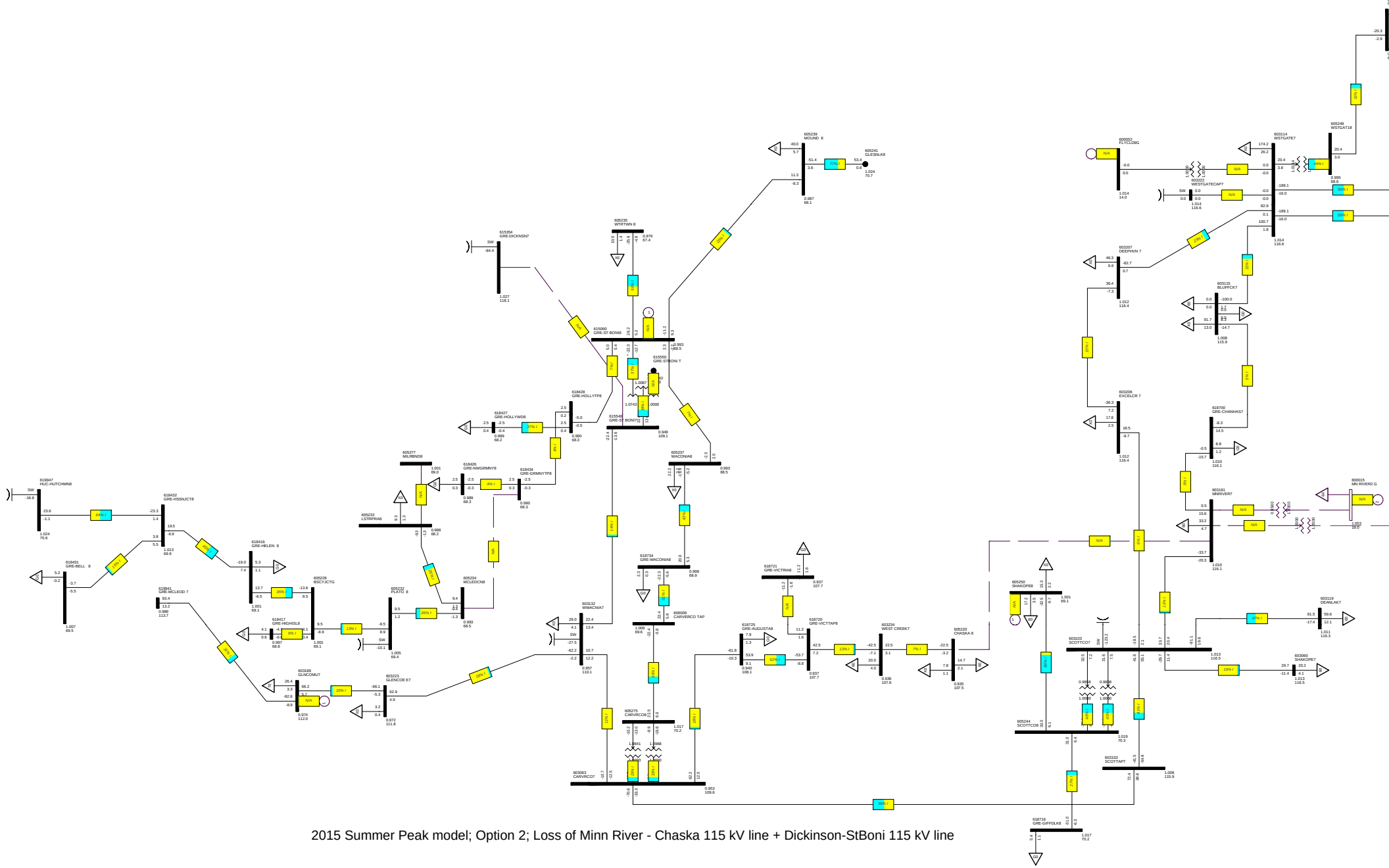
2015 Summer Peak model; Option 2; Loss of Carver County - Augusta 115 kV line



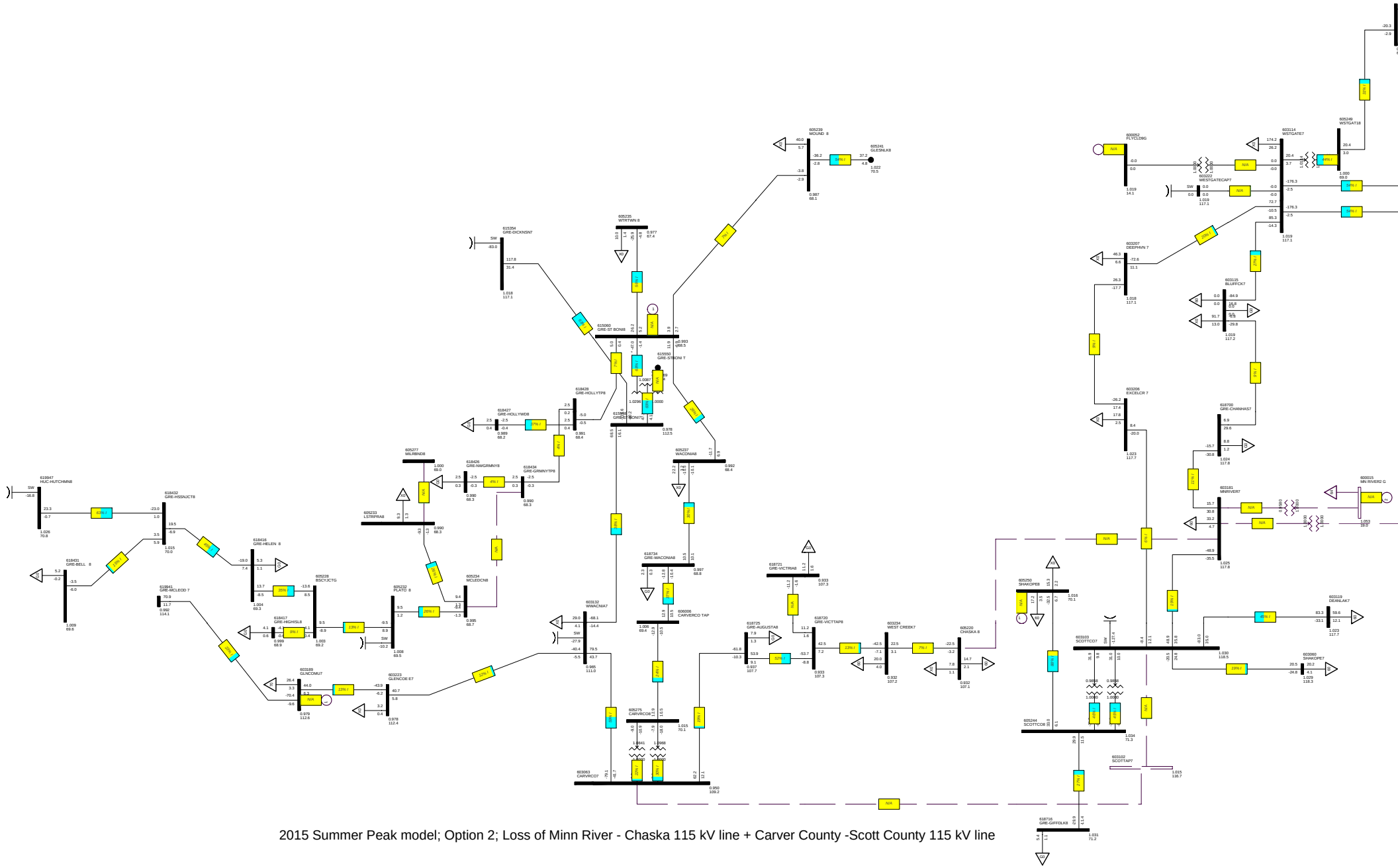
2015 Summer Peak model; Option 2; Loss of Scott County 115/69 kV transformer



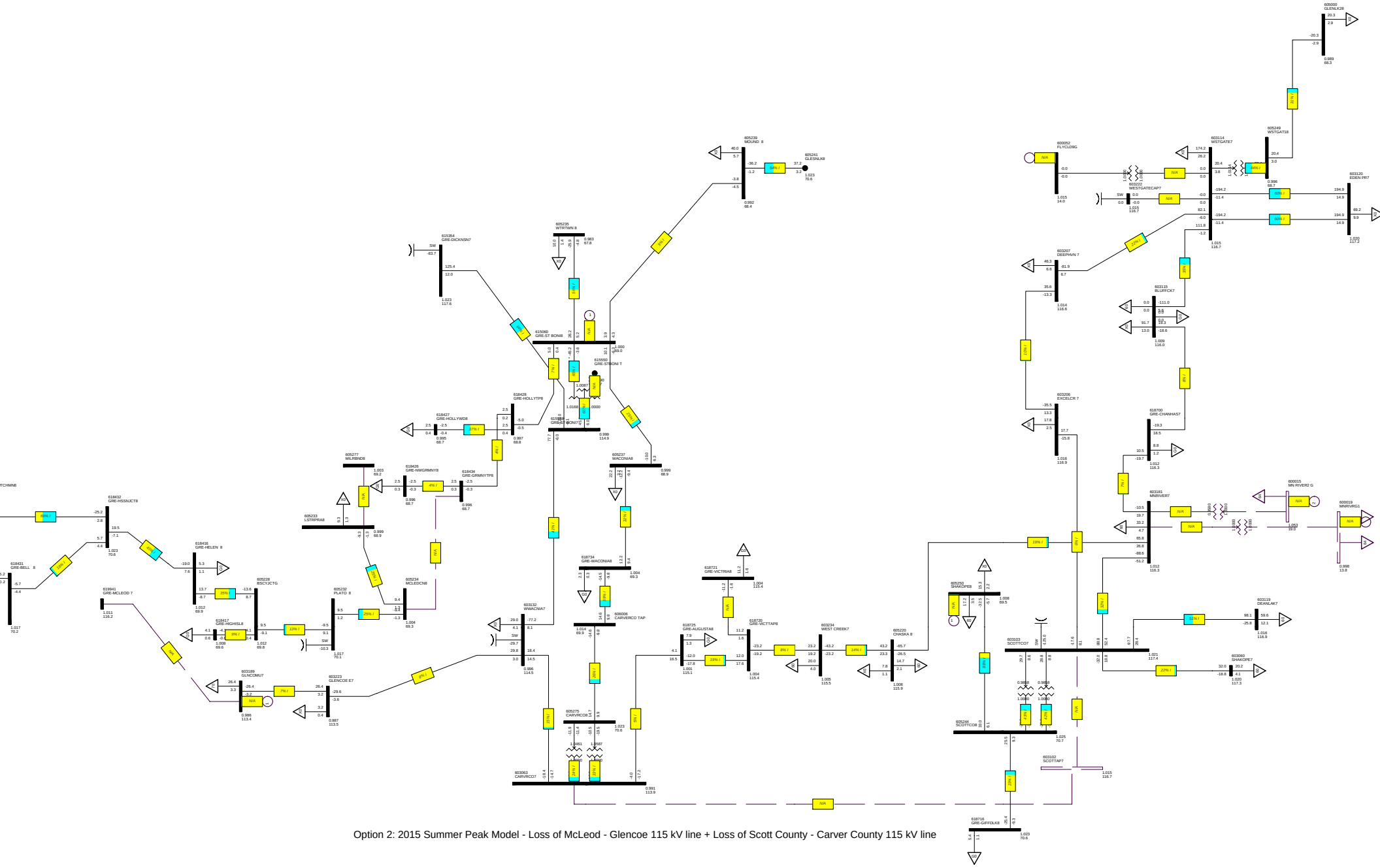
2015 Summer Peak model; Option 2; Loss of Minn River - Chaska 115 kV line + Glencoe - McLeod 115 kV line



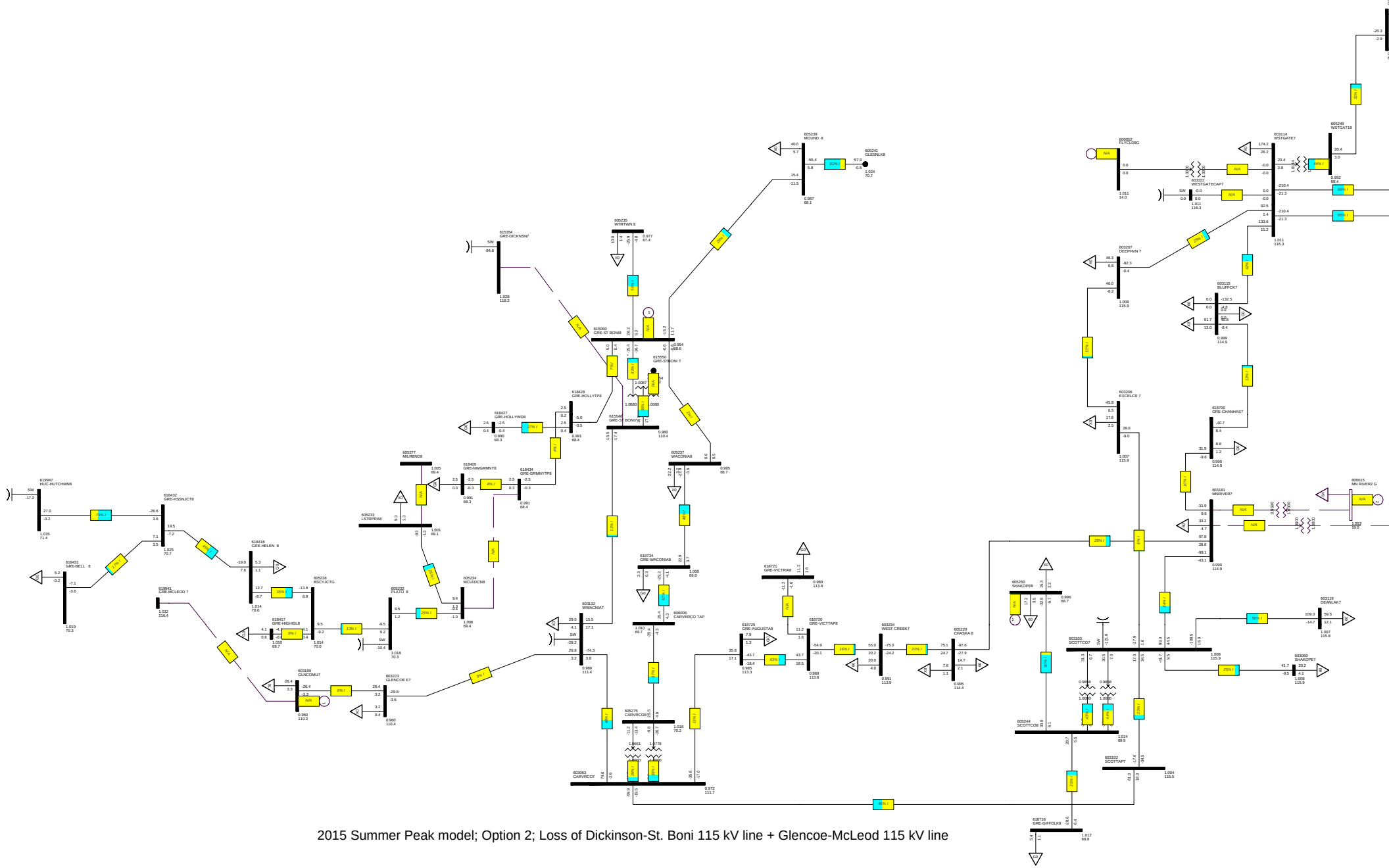
2015 Summer Peak model; Option 2; Loss of Minn River - Chaska 115 kV line + Dickinson-StBoni 115 kV line



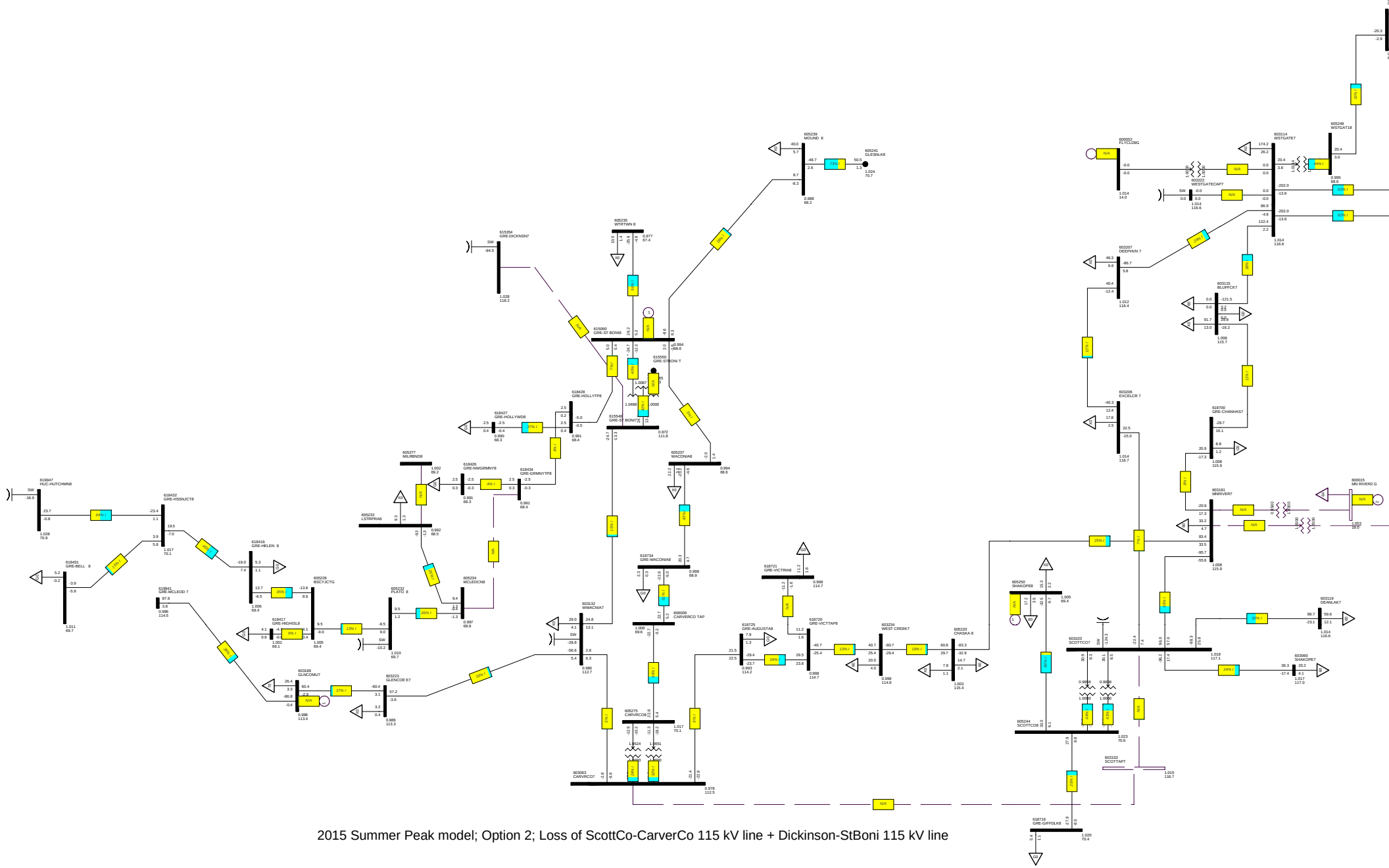
2015 Summer Peak model; Option 2; Loss of Minn River - Chaska 115 kV line + Carver County -Scott County 115 kV line



Option 2: 2015 Summer Peak Model - Loss of McLeod - Glencoe 115 kV line + Loss of Scott County - Carver County 115 kV line



2015 Summer Peak model; Option 2; Loss of Dickinson-St. Boni 115 kV line + Glencoe-McLeod 115 kV line



2015 Summer Peak model; Option 2; Loss of ScottCo-CarverCo 115 kV line + Dickinson-StBoni 115 kV line

Appendix B

AC CONTINGENCY ANALYSIS RESULTS
(Available on request)