UPNY-ConEd Voltage Collapse Transfer Limits

A Report by the Operations Engineering Staff
New York Independent System Operator

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Executive Summary

In light of the network upgrades and on-going work related to the Segment A and Segment B transmission projects, the NYISO deemed it appropriate to conduct a study of area voltage performance, including the investigation of voltage collapse transfer limits, for the UPNY-ConEd operating interface. This report presents the methodology, analysis and results of this study.

The voltage collapse limits currently in use for the UPNY-ConEd interface were developed in 2021 and reviewed in 2022. This study re-evaluates these limits to maintain reliable operation of the bulk power system. New derates were developed to account for new transmission, such as the Princetown-New Scotland 345 kV 361 and 362 lines, Smart Wire Smart Valve at Hurley Ave on the Leeds – Hurley (301) 345 kV line, and the new Knickerbocker 345 kV station and related transmission changes.

This study shows overall increases in voltage collapse limits as a result of new transmission strengthening the existing network. Analysis also shows that no adjustments to pre-contingency low voltage limits are necessary.

These limits will remain in effect until the Segment A and B projects are completed sometime at the end of 2023.

Table of Contents

List of Figures

Introduction

The purpose of this study is to evaluate the UPNY-ConEd Voltage Collapse Transfer Limits for all-lines-in-service and significant equipment outage conditions expected for the system configuration for the Summer 2023 season. This analysis was conducted on the NYISO Summer 2022 Operating Study base case. Details of base case development are included in this report.

This report documents the results of the analysis and provides recommendations based on the simulation results for operating criteria contingencies. Tables of the recommended derates, the contingencies evaluated, examples of power-voltage (PV) plots and summaries of the transfer base case conditions are included.

The New York State Reliability Council (NYSRC) Reliability Rules for Planning and Operating the New York State Power System provide the documented methodology employed to develop System Operating Limits (SOLs) within the NYISO Reliability Coordinator Area. NYSRC Reliability Rules require compliance with all North American Electric Reliability Corporation (NERC) Standards and Northeast Power Coordinating Council (NPCC) Standards and Criteria. NYSRC Rule C.1, Establishing Operating Transfer Capabilities, addresses the contingencies to be evaluated and the performance requirements to be applied. Rule C.1 also references NYISO Bus Voltage Limits as found in Tables A.2 and A.3 of the "NYISO Emergency Operations Manual". The applicable process for establishing voltage collapse limits is established by the "Guideline for Voltage Analysis and Determination of Voltage-Based Transfer Limits" found in the NYISO "Transmission Expansion and Interconnection Manual" Attachment G.

Recommendations

It is recommended that the limits presented in Figure 1 below be employed to secure the bulk power system for the applicable system conditions identified in this study. Figure 1 shows the breakdown of the UPNY-ConEd Voltage Collapse Transfer Limit components. Tables showing the changes in limits can be found in the Discussion section. Figures 2 and 3 below show the changes between the new proposed limits and those approved in 2021.

The results of the study also showed that no changes are needed for pre-contingency low voltage limits, given the recommended establishment of the UPNY-ConEd interface voltage collapse limits.

Figure 1: UPNY-ConEd Voltage Collapse Limits for 2023

UPNY-ConEd Voltage Collapse Transfer Limits*			
Equipment Status	**Voltage (kV)**	**Limit (MW)**	
		w/ SB/Dun SR Bypassed and SB-EGC/Gow SR I/S	**w/ SB-EGC/Gow SR Bypassed and SB/Dun SR I/S**
All Equipment I/S		8050	7700
1 Bowline I/S	-	7715	7365
0 Bowline I/S	-	7355	7005
1 Roseton I/S	-	7830	7480
0 Roseton I/S	-	7460	7110
0 Danskammer I/S	-	7820	7470
2 Cricket Valley I/S	-	7860	7510
1 Cricket Valley I/S	-	7795	7445
0 Cricket Valley I/S	-	7630	7280
Millwood Caps (2 O/S)	345	7960	7610
E. Fishkill Caps (2 O/S)	345	8050	7700
Van Wagner Caps (2 O/S)	345	8050	7700
Hopatcong-Ramapo 5018 O/S	500	7795	7445
Knickerbocker-Pleasant Valley Y57 O/S	345	7885	7535
Knickerbocker Series Compensation @ 0%	345	8050	7700
Knickerbocker Series Compensation @ 17%	345	8050	7700
Knickerbocker Series Compensation @ 33%	345	8050	7700
Leeds-Hurley 301 O/S	345	8050	7700
Leeds-Hurley Smart Wire Bypassed	345	8050	7700
Ladentown-Buchanan S. Y88 O/S	345	7695	7700
Ramapo-Buchanan N. Y94 O/S	345	7755	7195
Roseton-E.Fishkill RFK-305 O/S	345	7215	6865
Millwood W.-Eastview W99 (or W85 or W82) O/S	345	7810	7460
Buchanan S.-Millwood W. W97 (or W98) O/S	345	8015	7665
Wood St.-Pleasantville Y86 O/S	345	7475	7125
Wood St.-Pleasantville Y87 O/S	345	7470	7120

*Some Limits were additionally reduced to accommodate implementation in the NYISO Energy Management System.

Figure 2: Comparison of 2021 and 2023 Limits (SB/Dun SR Bypassed and SB-EGC/Gow SR I/S)

Comparison of 2021 and 2023 UPNY-ConEd Voltage Collapse Limits (SB/Dun SR Bypassed and SB-EGC/Gow SR In-Service)			
Equipment Status	**2021 Limit (MW)**	**2023 Limit (MW)**	**Difference (MW)**
All Equipment I/S	7815	8050	+235
1 Bowline I/S	7425	7715	+290
0 Bowline I/S	7040	7355	+315
1 Roseton I/S	7520	7830	+310
0 Roseton I/S	7090	7460	+370
0 Danskammer I/S	7455	7820	+365
2 Cricket Valley I/S	7735	7860	+125
1 Cricket Valley I/S	7575	7795	+220
0 Cricket Valley I/S	7460	7630	+170
Millwood Caps (2 O/S)	7495	7960	+465
E. Fishkill Caps (2 O/S)	7625	8050	+425
Van Wagner Caps (2 O/S)	-	8050	N/A
Hopatcong-Ramapo 5018 O/S	7480	7795	+315
Knickerbocker-Pleasant Valley Y57 O/S	-	7885	New Limit
Knickerbocker Series Compensation @ 0%	-	8050	N/A
Knickerbocker Series Compensation @ 17%	-	8050	N/A
Knickerbocker Series Compensation @ 33%	-	8050	N/A
Leeds-Hurley 301 O/S	-	8050	N/A
Leeds-Hurley Smart Wire Bypassed	-	8050	N/A
Ladentown-Buchanan S. Y88 O/S	7560	7695	+135
Ramapo-Buchanan N. Y94 O/S	7580	7755	+175
Roseton-E.Fishkill RFK-305 O/S	6680	7215	+535
Millwood W.-Eastview W99 (or W85 or W82) O/S	7550	7810	+260
Buchanan S.-Millwood W. W97 (or W98) O/S	7680	8015	+335
Wood St.-Pleasantville Y86 O/S	7210	7475	+265
Wood St.-Pleasantville Y87 O/S	7260	7470	+210

Figure 3: Comparison of 2021 and 2023 Limits (SB-EGC/Gow SR Bypassed and SB/Dun SR I/S)

Comparison of 2021 and 2023 UPNY-ConEd Voltage Collapse Limits (SB/Dun SR In-Service and SB-EGC/Gow SR Bypassed)			
Equipment Status	**2021 Limit (MW)**	**2023 Limit (MW)**	**Difference (MW)**
All Equipment I/S	7505	7700	+195
1 Bowline I/S	7115	7365	+250
0 Bowline I/S	6730	7005	+275
1 Roseton I/S	7210	7480	+270
0 Roseton I/S	6780	7110	+330
0 Danskammer I/S	7145	7470	+325
2 Cricket Valley I/S	7425	7510	+85
1 Cricket Valley I/S	7265	7445	+180
0 Cricket Valley I/S	7150	7280	+130
Millwood Caps (2 O/S)	7185	7610	+425
E. Fishkill Caps (2 O/S)	7315	7700	+385
Van Wagner Caps (2 O/S)	-	7700	N/A
Hopatcong-Ramapo 5018 O/S	7170	7445	+275
Knickerbocker-Pleasant Valley Y57 O/S	-	7535	New Limit
Knickerbocker Series Compensation @ 0%	-	7700	N/A
Knickerbocker Series Compensation @ 17%	-	7700	N/A
Knickerbocker Series Compensation @ 33%	-	7700	N/A
Leeds-Hurley 301 O/S	-	7700	N/A
Leeds-Hurley Smart Wire Bypassed	-	7700	N/A
Ladentown-Buchanan S. Y88 O/S	6850	7250	+400
Ramapo-Buchanan N. Y94 O/S	6870	7195	+325
Roseton-E.Fishkill RFK-305 O/S	6370	6865	+495
Millwood W.-Eastview W99 (or W85 or W82) O/S	7240	7460	+220
Buchanan S.-Millwood W. W97 (or W98) O/S	7370	7665	+295
Wood St.-Pleasantville Y86 O/S	6900	7125	+225
Wood St.-Pleasantville Y87 O/S	6950	7120	+170

Discussion

System Representation and Base Study Assumptions

The study was conducted on the 2022 NYISO Summer Peak Operating Study Base Case with a NYISO forecasted summer coincident peak load of 31,765 MW, and a GHIJ load of 14,965 MW. This base case was selected as the most recently reviewed case available.

The initial base case is modeled as an all-lines-in-service representation with all generation in-service, with both the new Knickerbocker Series Compensation at full 50% compensation, and the new Leeds-Hurley Smart Wire Smart Valve at full 100% series compensation mode.

To create transfers to stress the UPNY-ConEd interface, significant generation in the NYC zone needed to be shutoff. As is typical dispatch, oil fueled units were shutoff before gas fueled units. The Ravenswood 3 generating station was modeled in-service as this is tested as the largest single source generating contingency.

Two versions of the base case were created, representing the Sprain Brook/Dunwoodie Series Reactors in- and out-of- service. The Sprain Brook/Dunwoodie Series Reactors refer to the M51 and M52 series reactors at Sprain Brook and the 71 and 72 series reactors at Dunwoodie. When these series reactors are bypassed, the Y49 series reactor at Sprain Brook and the 41 and 42 series reactors at Gowanus must be in-service. Conversely, the Y49, 41 and 42 reactors must be bypassed when the M51/M52/71/72 reactors are in-service. Figure 4 below shows the status of the series reactors in each scenario.

Figure 4: Status of ConEd Series Reactors

	Sprain Brook / Dunwoodie Base Case	
Equipment Name	**Series Reactors Bypassed**	**Series Reactors In-Service**
Sprain Brook M51 &M52	Bypassed	In-Service
Dunwoodie 71 & 72	Bypassed	In-Service
Sprain Brook Y49	In-Service	Bypassed
Gowanus 41 & 42	In-Service	Bypassed

The initial base case dispatch real power transfers were adjusted to stress conditions through:

- L34 PAR modeled out-of-service
- Ontario generation set to attain an import of ~1780 MW

- 7040 flow set to 1,300 MW import from Hydro-Québec
- 200 MW import on Cedars-Dennison
- Sandbar PAR set to achieve 100 MW flow on PV20
- Ontario-Michigan PARS set to maintain Lake Erie circulation near zero
- Interfaces at Dysinger-East interface and Moses-South, and Central East stressed to 750, 2,270, and 2200 MW respectively.

To ensure utilization of available reactive resources, the following actions were taken:

- All capacitors in-service were switched in.
- All generator terminal voltages were set to local control, between .95 and 1.05.
- Assorted Generator and LTC control parameters were adjusted to maintain all bulk power buses within historic operating voltage ranges.
- Oswego area 345 kV stations (Fitzpatrick, Scriba, Oswego 5 and 6) modeled to typical voltages which can exceed 1.06 p.u.
- Marcy-South Series Capacitors were modeled in-service

Updates to the base case included additional transmission as part of the Segment A and B projects. This included the addition of the following elements:

- Princetown-New Scotland 345kV 361 and 362 lines
- Knickerbocker 345 kV station, which divides the New Scotland-Alps (2) 345 kV line into the New Scotland-Knickerbocker (2) 345 kV and Knickerbocker-Alps (6) 345 kV lines
- Knickerbocker-Pleasant Valley 345 (Y57) kV line
- Series compensation at Knickerbocker station on the Y57 line is modeled at 50%
- VanWagner 345 kV station which intersects the Athens-PV and Leeds-PV 345 kV 91 and 92 lines
- Two switched-shunt capacitors at VanWagner station totaling 270 MVAr

Study Criteria

This analysis was conducted in accordance with the “NYSRC Reliability Rules, Standards for Planning and Operation the New York ISO Bulk Power System” and "NPCC Regional Reliability Reference Directory # 1 Design and Operation of the Bulk Power System".

The NYISO Transmission Expansion and Interconnection Manual, Attachment G: NYISO Transmission Planning Guideline #2-1 "Guideline for Voltage Analysis and Determination of Voltage-Based Transfer Limits" describes the methodology employed to determine voltage transfer limits.

A pre-contingency kV limit is determined when the post-contingency voltages falls below the post-contingency low voltage limit. In this analysis the pre-contingency low voltages were recorded at the highest transfer at which the post-contingency low solved voltage reached the defined post-contingency low limit. The NYISO post-contingency low voltages employed in the analysis are found in the NYSO Emergency Operations Manual, Attachment A, Table A-2 "NYISO Voltage Limits".

Study Methodology

The Voltage Contingency Analysis Procedure (VCAP) is used to evaluate the steady state voltage performance of the power system for a series of power flow transfer conditions. A transmission interface in the vicinity of the area of the system to be studied is tested by preparing a series of power flow base cases with increasing MW transfer levels across that interface. The pre-contingency cases are then subjected to the most severe voltage contingencies for the area involved. The post-contingency cases are then reviewed for voltage performance at each of the monitored buses to best determine reactive conditions and develop guidelines for the operation of the system.

The basic principle employed is to develop a set of power transfer vs. voltage (PV) curves through the VCAP application. These PV curves are developed by progressively increasing transfers across UPNY-ConEd interface and recording the post contingency voltage for severe contingencies. Two potential limits are obtained through examination of the PV curves. A post-contingency voltage transfer limit is defined when the post contingency voltage crosses the predefined post contingency low voltage limit. A voltage collapse transfer limit is defined by identifying the highest transfer where post contingency power flow stopped increasing, also called the “knee” of the post contingent flow curve, and then applying a 5% margin. The voltage collapse transfer limit is then compared to that transfer level obtained by applying the applicable post-contingency low voltage limit. To ensure that a voltage-based transfer limit is determined with a safe margin, the lower of the two power transfer levels from the foregoing comparison is to be selected as the interface transfer limit.

A key level of conservatism in the development of voltage transfer limits developed for operations is all analysis is conducted under peak load conditions. This is conservative for two reasons. First, it is the highest end user reactive load condition, and thereby consumes the greatest amount of innate and controllable reactive resources at the point of delivery to the end user. Secondly, the delivery of power to the end user under peak load results in the highest-level reactive transmission losses across the system. Under anything less than peak load conditions, additional reactive resources are available to the system.

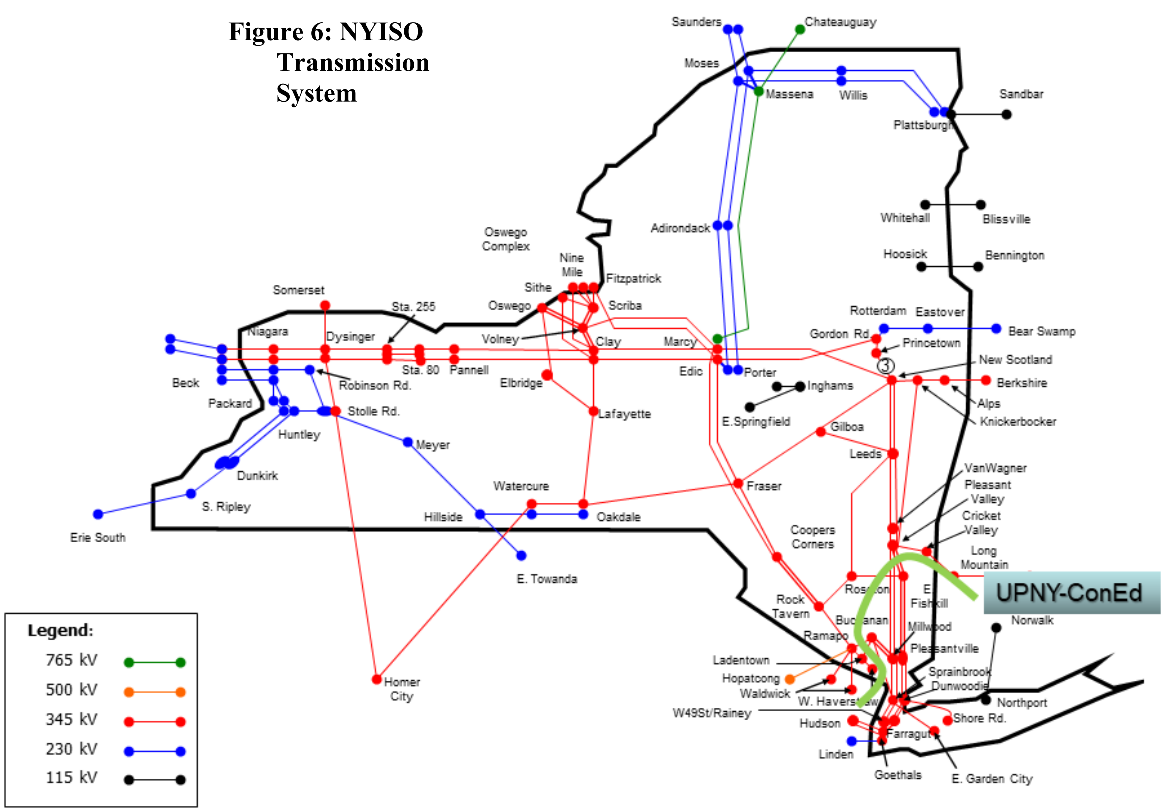
UPNY-ConEd Interface Definition

The UPNY-ConEd interface definition is given below in Figure 5 and illustrated in Figure 6.

Figure 5: UPNY-ConEd Interface Definition

UPNY-ConEd		
Hudson Valley (Zone G) - Millwood (Zone H)		
Name	Line ID	Voltage (kV)
*Ladentown-Buchanan South	Y88	345
*Pleasant Valley-Wood S	F30	345
*Pleasant Valley-Wood St	F31	345
*Pleasant Valley-East Fishkill	F36	345
*Pleasant Valley-East Fishkill	F37	345
*Ramapo-Buchanan North	Y94	345
Roseton-East Fishkill*	RFK305	345
*Fishkill Plains–Sylvan Lake	FP/990	115
East Fishkill 115/345*	BK1	115/345
East Fishkill 115/345*	BK2	115/345

Figure 6: NYISO Transmission System



Transfer Case Development

Transfer cases were developed by sourcing major generation on the 345 kV backbone in Western, Central, Capital and Hudson Valley zones of New York. Power was sinked to major generation on the 345 kV network in the NYC zone. For some configurations it was necessary to import power from New England to avoid causing voltage collapse on the Central East interface. This was sourced by scaling New England generation as a whole. Central East Voltage Collapse limits were respected to avoid influencing results on UPNY-ConEd. For base transfer conditions the bulk power system voltages were maintained in the .95-1.05 p.u. range.To ensure full utilization of available reactive resources, the following actions were taken:

- All switched shunt capacitors were switched in so long as it did not cause excessively high voltage
- All ConEd category 1 switched shunt reactors were kept in-service.
- ConEd category 2 switched shunt reactors were utilized as necessary to keep voltages within operating limits.
- Generator and LTC voltage control parameters were adjusted to maintain adequate voltages. In some cases, where generator step up transformer ratios warranted, plant voltage settings were set higher than 1.05 p.u.
- 0 MW flow on the A2253 PAR
- The B3402 & C3403 Lines are assumed out-of-service

Voltage Contingency Evaluation

Figure 7 below lists the contingencies that were evaluated for each configuration studied.

Figure 7: Contingencies Studied

ID	Description
log09	LOG09 L/O RAVENSWOOD 3
uc02	UC02 TWR Y86/Y87
uc04a	UC04 SBK BUCHANAN 345
uc18	UC18 TWR Y88/Y94 (BUCHANAN RIVER CROSSING)
uc20	UC20 TWR W89/W90
uc21	UC21 TWR 30/31
uc25	UC27 SBK ROCK TAV 345 (44 & 76)
uc27a	UC27 SBK ROCK TAV 345 (77 & CCRT-42)
uc28	UC28 TWR 76/77 new
uc31	UC31 TWR 34/42
uc32	UC32 TWR 34/44
uc33	UC33 TWR W97/W98

Configuration Modeling

Figure 8 below lists the equipment outages that were modeled and studied. For all configurations the Sprain Brook-Dunwoodie Series Reactors were modeled in-service and bypassed.

Figure 8: Configuration Modeling

Equipment Status	ID	Voltage
1 Bowline I/S	-	-
0 Bowline I/S	-	-
1 Roseton I/S	-	-
0 Roseton I/S	-	-
0 Danskammer I/S	-	-
2 Cricket Valley I/S	-	-
1 Cricket Valley I/S	-	-
0 Cricket Valley I/S	-	-
Millwood Caps (2 O/S)	-	345
E. Fishkill Caps (2 O/S)	-	345
Van Wagner Caps (2 O/S)	-	345
Hopatcong-Ramapo O/S	5018	500
Knickerbocker-Pleasant Valley O/S	Y57	345
Knickerbocker Series Compensation @ 0% (both SC bypassed)	RY5714 & RY5715	345
Knickerbocker Series Compensation @ 17% (single SC bypassed)	RY5714	345
Knickerbocker Series Compensation @ 33% (single SC bypassed)	RY5715	345
Leeds-Hurley O/S	301	345
Leeds-Hurley Smart Wire @ 0%	301501 & 301505	345
Ladentown-Buchanan S. O/S	Y88	345
Ramapo-Buchanan N. O/S	Y94	345
Roseton-E.Fishkill O/S	RFK-305	345
Millwood W.-Eastview O/S	W99/W85/W82	345
Buchanan S.-Millwood W. O/S	W97/W98	345
Wood St.-Pleasantville O/S	Y86	345
Wood St.-Pleasantville O/S	Y87	345

Monitored Buses

All buses in the Emergency Operations Manual A2 Bus List were monitored for pre-contingency and post-contingency low voltage limits.

Results

The Appendices contain all the tabular results. Due to the volume of material, the Appendices are a separate document. As an example, the results of the All-Lines-in-Service with Con Ed Series Reactors in-service base case analysis are presented here.

Figure 9 below shows the post-contingency flows for the most limiting contingencies for the All-Lines In-Service base case with Con Ed Series Reactors I/S. From this graph the knees of the curves are identified. In this case the most limiting contingency is the loss of Tower W89/W90 (uc20).

Figure 9: Sample Post-Contingency Flows Chart

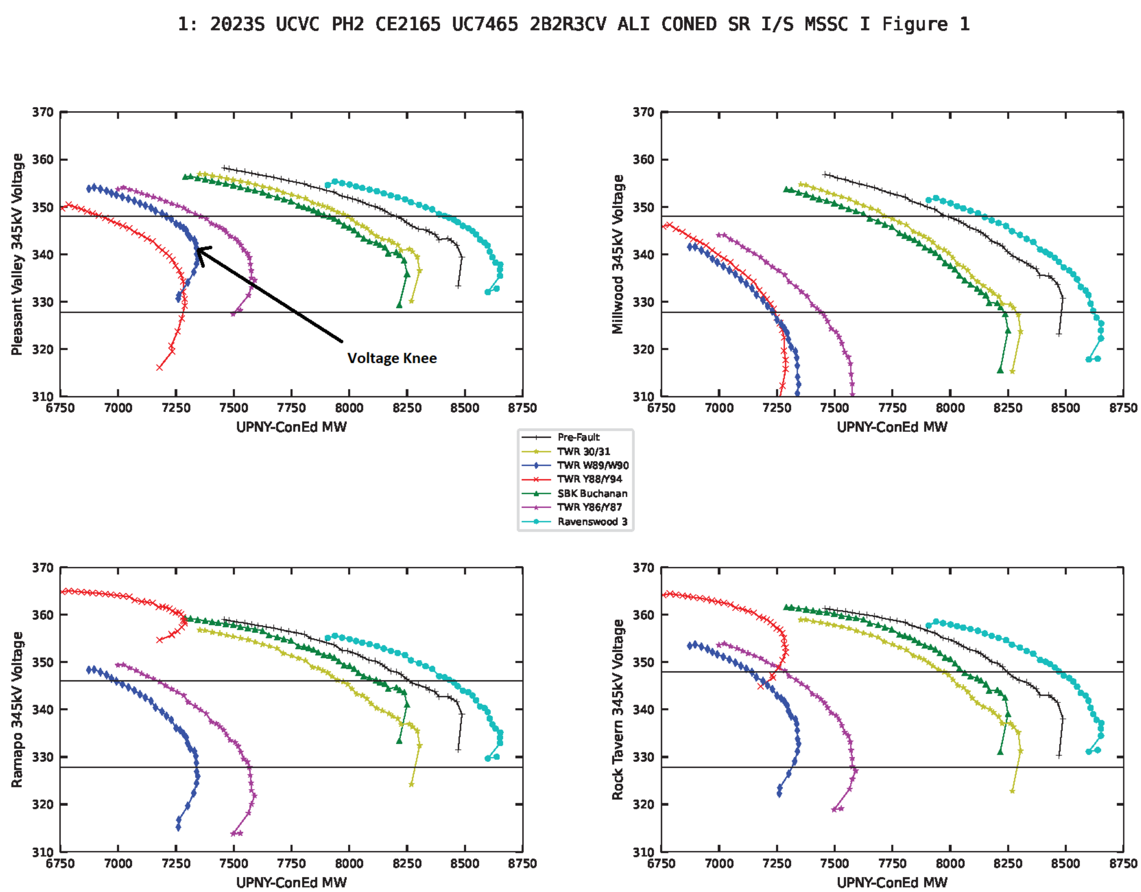


Figure 10 below shows the pre-contingency base flow with respect to the post contingency voltage for each of the most limiting contingencies. The graph is marked with at the MW level corresponding to the knee of the curve from the previous post-contingency plot. It is also marked at the MW level of the 5% margin of this knee. From the graph it is clear that the 5% margin on the knee of the most limiting contingency is more limiting than the post-contingency low voltage limit at Pleasant Valley 345kV station.

Figure 10: Sample Pre-Contingency Flows by Post Contingency Voltages

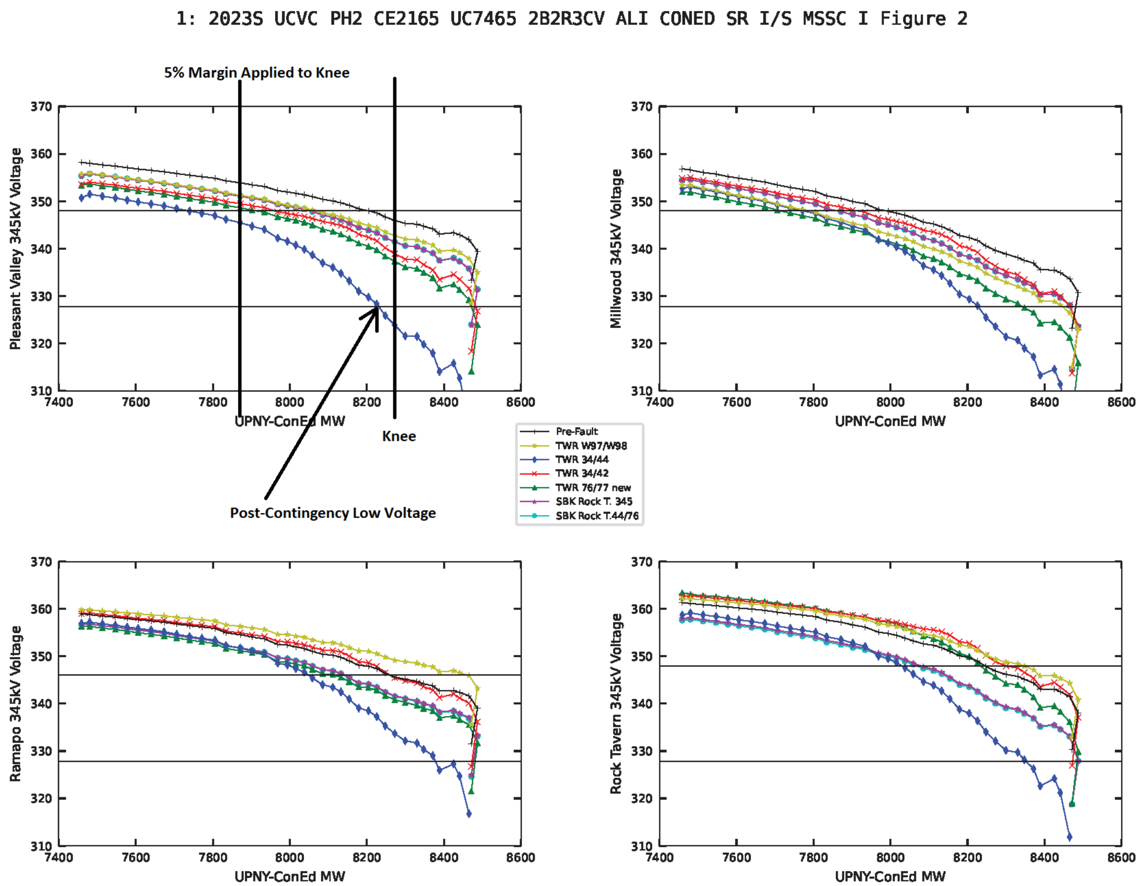


Figure 11 below shows the limits in tabular form, listing limiting elements in order of increasing pre-contingency UPNY-ConEd flow. The results of every single scenario shows that flows may be limited in real-time operations by pre-contingency low voltage limits.

Figure 11: Sample Tabular Voltage Collapse Limits

Limit	<---------FACILITY---------->	<---CONTINGENCY--->
7794	limit with 5% margin	TWR W89/W90
7814	limit with 5% margin	TWR Y88/Y94
7913	limit with 5% margin	Ravenswood 3
7913	limit with 5% margin	TWR Y86/Y87
7913	limit with 5% margin	TWR 34/44