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March 21, 2017

Docket Control
Arizona Corporation Commission
1200 West Washington
Phoenix, AZ 85007

RE: Notice of Errata for Arizona Electric Power Cooperative, Inc. Ten Year Transmission Plan
Docket No. E-00000D-17-0001

On January 27, 2017 Arizona Electric Power Cooperative ("AEPCO" or "Company") filed its 2017-2026 Ten-Year Transmission Plan and Technical Study Report in Docket No. E00000D-15-0001. On February 17, 2017 AEPCO filed a Notice of Errata in Docket No. E00000D-17-0001 to correct the inadvertent error of filing its 2017-2026 Ten-Year Plan in the Ninth Biennial Electric Transmission Assessment ("BTA") docket instead of the Tenth BTA docket, as well as to correct the misstatement that the proposed Thornydale to Twin Peaks line had been approved by Case No. 152.

Through this filing, AEPCO makes another correction to its 2017-2026 Ten-Year Plan filing, removing the CAP 115kV Line Tap to AEPCO Sandario Substation Project. That project is no longer needed to meet the region's energy needs. The revised 2017-2026 Ten Year Plan and Technical Study are attached to this notice.

An original copy plus thirteen copies included.

Sincerely,

Boris Tumarin
Manager of Transmission Planning

c/Corporate Records

http://azgt/sites/azgt/powerpln/Shared Documents/Transmission Planning/ACC/Ten Year Plans/2017/NoticeOfErrata_2017-2026.docx

Arizona G&T Cooperatives

Touchstone Energy® Cooperatives

TEN-YEAR TRANSMISSION PLAN

2017 – 2026
Docket No. E00000D-17-0001

MARCH 20, 2017

ARIZONA ELECTRIC POWER COOPERATIVE, INC.

TEN-YEAR TRANSMISSION PLAN

2017 – 2026

Prepared for the

ARIZONA CORPORATION COMMISSION

Docket No. E-00000D-17-0001

TABLE OF CONTENTS

ARIZONA ELECTRIC POWER COOPERATIVE, INC.

TEN-YEAR TRANSMISSION PLAN

GENERAL INFORMATION

This Ten-Year Plan is submitted to the Arizona Corporation Commission (Commission) to satisfy the requirements of § 40-360.02 of the Arizona Revised Statutes (A.R.S.), relating to power plant and transmission line siting requirements. It outlines the plans of Arizona Electric Power Cooperative, Inc. (AEPCO) to install electric facilities required to reliably meet the system load growth of its Distribution Cooperative Members (Members) and other network customers or reliability requirements applicable to AEPCO's transmission system.

This report contains transmission projects that AEPCO anticipates may be constructed over the next ten-year period. As noted in A.R.S. § 40-360.02.F, the plans contained in this report are tentative information only and are subject to change at any time at the discretion of AEPCO. AEPCO anticipates that any changes to this plan will likely to be due to changes in load forecasts, environmental constraints, economic considerations, other utilities' plans, regulatory and legal developments, as well as future regional and federal mandates. All transmission projects are subject to a peer-review by AEPCO's Operating Committee (OC) prior to submittal to the AEPCO Board of Directors for approval. Meetings of the OC are held quarterly, or as needed, and changes to these projects are reviewed as necessary to meet the Member needs. The OC reviews the Construction Work Plan (CWP) that is then submitted to the AEPCO Board of Directors for approval. Once the CWP is approved, the projects are considered by AEPCO as "planned" projects. Conceptual projects, or those that have not been vetted by the OC for placement into a CWP, may be included in ten-year plan filings but will be listed as conceptual projects with tentative or "to-be-determined" (TBD) in-service dates. TBD as used in this document means that in addition to the project not being yet vetted by the OC, it can also mean that the project is still in negotiations with other entities.

This specific report is divided into two sections, as outlined in the Table of Contents on page 2. Section I describes planned transmission lines and projects AEPCO may construct over the ten-year plan period, whose nominal voltage is equal to or greater than one hundred fifteen thousand volts (115 kV).

Section II contains AEPCO's internal planning criteria and facility ratings, pursuant to Commission Decision #63876, dated July 25, 2001.

A technical study report to satisfy the requirements of paragraph C.7 of A.R.S. §40-360.02 has been prepared as a stand-alone document and will be filed jointly with this document.

REGIONAL PLANNING

AEPCO has been an active participant in regional and sub-regional transmission planning efforts within the Western Interconnection for many years. This participation has been through the Southwest Area Transmission (SWAT), membership in the Western Electricity Coordinating Council (WECC) and WestConnect. AEPCO is involved in the following subcommittees of SWAT, either through active participation or copy interest:

- Arizona Subcommittee (SWAT-AZ)
- Short-circuit Work Group (SCWG)

AEPCO is an active participant within the following committees of WECC:

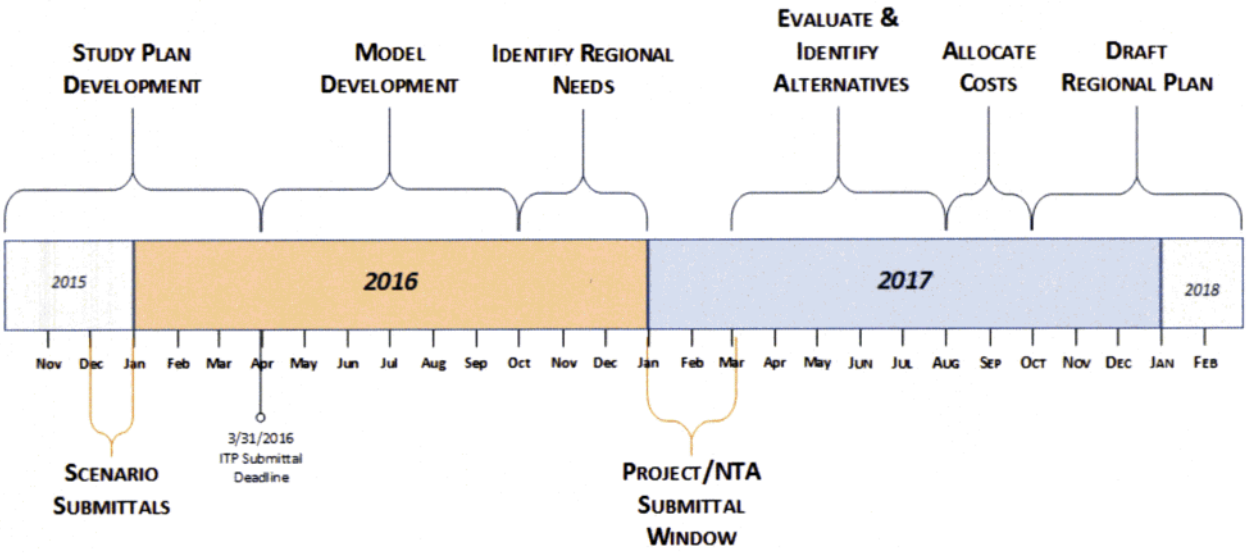
- Operating Committee (OC)
- Planning Coordination Committee (PCC)
- Technical Studies Subcommittee (TSS)
- System Review Work Group (SRWG)

In addition, AEPCO continues to monitor the efforts of the WECC Transmission Expansion Planning Policy Committee (TEPPC) which has been tasked with the development of 10- and 20- year transmission plans for the Western Interconnection.

On December 6, 2016, the WECC Board of Directors approved the recommendations of the Joint PCC-TEPPC Review Task Force (JPTRTF) which will combine the PCC, TEPPC, and all their subcommittees into a new Reliability Assessment Committee (RAC). AEPCO will continue to be involved in regional planning with representation on RAC, and any other subcommittees and Task Forces created in conjunction with RAC.

AEPCO continues its involvement in the regional transmission planning activities of WestConnect as a Coordinating Transmission Owner in the Transmission Owner with Load Serving Obligations Sector. WestConnect coordinates its efforts with other regional planning entities and inter-regionally within the Western Interconnection, to comply with the provisions of the Federal Energy Regulatory Commission (FERC) Order No. 1000 "Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities" that was issued July 21, 2011.

WestConnect completed its initial abbreviated planning cycle on December 31, 2015, and began its first full two-year planning cycle beginning January 1, 2016. As part of its first full planning cycle, AEPCO and other members of WestConnect spent 2016 working with Sub-regional Planning Groups, such as Southwest Area Transmission (SWAT) on data collection and modeling processes to identify any regional needs. 2017 will be used to evaluate and identify project alternatives, allocate costs, and draft the Regional Plan. The planning cycle is scheduled to be completed with its Regional Plan in early 2018. A timeline of the full planning cycle is illustrated in the following chart.



The Planning Management Committee (PMC) under the Planning Participation Agreement (PPA) that was filed on November 17, 2014 is responsible for development of a Regional Transmission Study Plan, development of an annual budget for the Regional and Inter-regional planning processes, activities, and functions, development of planning models, identification of Regional transmission needs, submittal of projects to meet Regional transmission needs and identification of beneficiaries and cost allocation. The structure of the PMC includes three standing subcommittees: (1) the Planning Subcommittee, (2) the Cost Allocation Subcommittee and (3) the Legal Subcommittee. Within the Planning Subcommittee are two working groups, the Expansion Planning Working Group that will perform benefits analyses and such other functions as defined and directed by the PMC, and the Power Flow Working Group that will perform power flow, voltage, stability, short circuit and transient analyses and such other functions as defined and directed by the PMC.

NINTH BIENNIAL TRANSMISSION ASSESSMENT (BTA) REQUIREMENTS

At the Arizona Corporation Commission (ACC) Open Meeting held on October 27 and 28 2016, the Commission reviewed the 9th BTA Report with Decision #75817 that adopted Staff's recommendations and the Commission ordered studies. The 9th BTA was docketed on

November 21, 2016. The specific recommendations and orders applying to AEPCO are listed below, along with AEPCO's response:

Recommendation b:

The use of collaborative transmission planning processes such as those that currently exist in Arizona, which help to facilitate competitive wholesale markets and broad stakeholder participation in grid expansion plans.

AEPCO Response:
AEPCO is committed to the collaborative transmission planning processes that currently exist in Arizona by its participation in WECC Committees, WestConnect, as well as Regional and Sub-Regional transmission planning groups.

Recommendation f:

That any requirement established in a prior BTA will continue in force unless the Commission suspends such requirement in a succeeding BTA. Nevertheless, Staff recommends that the Commission emphasize the importance of these continuing requirements for Arizona utilities:

i. Advise each interconnection applicant at the time the applicant files for interconnection of the need to contact the Commission for appropriate ACC requirements related to the Power Plant and Transmission Line Siting Committee.

   AEPCO Response: AEPCO has complied with this requirement since the policy was instituted by providing language to this effect in a document posted on its OASIS site and also by providing this Commission policy in writing to potential applicants filing for interconnection to the AEPCO system.

ii. Report relevant findings in future BTAs regarding compliance with transmission planning standards from North American Electric Reliability Corporation (NERC)/WECC reliability audits that have been finalized and Bled with FERC.

AEPCO Response: AEPCO is committed to complying with all transmission planning standards. AEPCO's latest NERC/WECC reliability audit for the period February 10, 2012 through October 24, 2014 was completed in February 2015. As a result of this audit, AEPCO was found to be in 100% compliance with all NERC and WECC standards.

iii. Address the effects of DG and EE on future transmission needs in their Ten-Year Plan filings.

AEPCO Response: Given that AEPCO is a transmission only cooperative with no retail load to serve, this recommendation is not applicable to AEPCO.

iv. Ensure that the Commission-ordered Ten Year Snapshot study monitors transmission elements down to and including the 115 kV level for thermal loading and voltage violations.

AEPCO Response: AEPCO provided information in regards to its system to SWAT-AZ for inclusion in the Ten Year snapshot study, by sharing its Ten-Year Plan, coordination of cases with other utilities in Arizona, and AEPCO's participation in the SWAT-AZ subcommittee.

v. Include planned transmission reconductor projects, transformer capacity upgrade projects, and reactive power compensation facility additions at 115 kV and above in future Ten-Year Plan filings.

AEPCO Response: AEPCO has no transmission reconductor projects to report in this ten-year plan. AEPCO is in the process of acquiring two distressed 345/230 kV 200 MVA transformers to be installed in parallel to existing transformers at Greenlee and Bicknell in 2019. There are reactive power compensation facility additions at 115 kV and above that are planned for this Ten-Year plan filing, as per the following schedule:

Year	Substation	MVAR Quantity
2016	Butterfield	14.4

2017	Bicknell	19.2
2018	Valencia	14.4
2018	Dos Condados	50.0 (Moved from Morenci)

Additional studies conducted in 2017, reflecting the recently approved 2016 Load Forecast or other circumstances that may tend to refine these values and/or suggest the need to adjust locations for reactive support to the AEPCO system. Any modifications will be reported in the next Ten-Year Plan filing.

Recommendation g:

The policy that the Load Serving Entitles (LSE) in Cochise and Santa Cruz Counties continue to monitor the reliability in Cochise and Santa Cruz Counties, respectively, and propose any modifications that they deem to be appropriate in future Ten-Year Plans. Staff also recommends that the Commission continue to collect applicable outage data from the respective utilities in order to monitor any changes to Cochise County and Santa Cruz County system reliability in future BTA proceedings.

AEPCO Response:

AEPCO continues to work with Arizona Public Service Company (APS) and Sulphur Springs Valley Electric Cooperative, Inc. (SSVEC) to develop the joint Tombstone Junction Project in Cochise County to effect reliability improvements among the utilities. AEPCO continues to target 2021 as an in-service date for this project. Applicable outage data continues to be collected to monitor any changes to system reliability.

Recommendation h:

The acceptance of the results of the following Commission-ordered studies provided as part of the Ninth BTA filings:

a. The SIL and MLSC are adequate to meet ten year local load forecasts.
b. The RMR studies were not required because none of the triggering factors occurred for the Ninth BTA that would require RMR study work in any of the RMR areas.

c. The Extreme Contingency Analysis for Arizona's major transmission corridors and substations and the associated risks and consequences of such overlapping contingencies.
d. Ten Year Snapshot study results documenting the performance of Arizona's statewide transmission system in 2025 for a comprehensive set of single (N-1) contingencies, each tested with the absence of different major planned transmission projects.
e. The EE/DG study results containing the Fifth-Year Contingency Analysis with and without disaggregated DG and EE loads.

AEPCO Response:

AEPCO accepts the results of all the Commission-ordered studies provided as part of the Ninth BTA filings

CHANGES FROM 2016 TEN-YEAR PLAN FILING

On November 9, 2016, AEPCO's Board of Directors approved the 2017-2020 Construction Work Plan (CWP). The CWP identified a number of projects that will be included in this year's Ten-Year Plan as planned projects. Projects that have projected in-service dates outside of the current CWP window but still have a high likelihood of being constructed are also included as planned projects. Additional projects that have a higher degree of uncertainty and no firm in-service dates are included as "Additional Projects Under Consideration."

PLANNED PROJECTS

APS Bagdad Interconnection Project. The project expands AEPCO's Bagdad Interconnect substation by installing a used 115/69 kV transformer and connecting it to APS' Bagdad substation via a new 115 kV line. This connection will provide mutual backup for APS loads in the town of Bagdad, and Mohave Electric Cooperative's Inc. (MEC) loads west of Bagdad. AEPCO and APS are currently discussing project configuration and cost allocations for this project. The driving factor for this project is reliability for both APS and MEC.

Dos Condados Capacitor Bank Installation. Relocate one of the two 50 MVAr capacitor banks at AEPCO's Morenci substation to AEPCO's Dos Condados substation. The driving factor for this project is reliability.

FMI Morenci – TEP Joint Project. The project will purchase a new 345/230 kV 400 MVA transformer for Morenci Water and Electric's (MW&E) Copper Verde substation and relocate the two existing transformers at Copper Verde to the AEPCO Greenlee substation and the AEPCO Bicknell substation and place them in satisfactory operation. Previous studies have identified TEP outages that have the potential to overload of AEPCO's Greenlee transformer during peak load periods. This project will alleviate these overloads. The driving factor for this project is reliability.

Valencia to CAP Black Mountain 115 kV line. This line segment was approved by the ACC Line Siting Committee on February 10, 2010 and by the Commission on April 14, 2010 (Case #152, Decision #71649) as part of the North Loop to Rattlesnake 115 kV Line Project. The project proposes a new 2.6 mile 115 kV line that will extend from the existing AEPCO Valencia Substation to tie to the turning structure of the 115 kV CAP line that heads directly north two miles to the existing Central Arizona Project (CAP) Black Mountain substation. The driving factor for this project is reliability on both AEPCO and CAP systems.

Marana-Thornydale-Saguaro Interconnect. The project involves the construction of a new 115 kV line from the existing Marana substation to the Thornydale substation and to acquire a single circuit of TEP's quad-circuit line from TEP's Tortilita substation, disconnecting from Tortolita, and connecting it to Saguaro, reenergizing the quad-circuit line to 115 kV and interconnect with AEPCO's Thornydale substation. The driving factor for this project is reliability.

Tombstone Junction Project. This Cochise County project involves looping the AEPCO Butterfield to San Rafael 230 kV line into a new Scheiffelin substation with a 230/69 kV transformation to the existing SSVEC Tombstone Junction substation and APS Boot Hill substation. AEPCO and APS are currently discussing project configuration and cost allocations for this project. The driving factor for this project is reliability.

ADDITIONAL PROJECTS UNDER CONSIDERATION

AEPCO continues to study the feasibility of additional projects for inclusion into future Ten-Year Plans that have been deferred from previous Ten-Year Plans for various reasons.

A brief description of each of these projects follows, for information purposes only. A driving factor is provided for each of these projects per BTA recommendations. These projects are under consideration, but have not advanced far enough to have a projected in-service date.

AEPCO will continue to hold discussions with potential project participants throughout 2017, and if refined project scopes have been established with agreements from project participants, and with approvals from governing boards, these projects may be reflected in next year's Ten-Year Plan.

Apache/Hayden to San Manuel 115 kV Line. This project has been presented in previous AEPCO Ten-Year Plans, but has been deferred beyond the Ten-Year Plan horizon. It was approved by the ACC Line Siting Committee on May 12, 2009 and by the Commission on July 9, 2009 (Case #142, Decision #71218). The project proposes the extension of a new 4.5 mile 115 kV line from the existing AEPCO Apache to Hayden 115 kV line to the existing APS San Manuel substation. The value to AEPCO of this project depends on working out contact paths with APS connecting AEPCO to Trico Electric Cooperative, Inc. (Trico) loads from the east and north. This line project will require the agreement of APS and additional studies. The driving factor for this project is reliability.

Thornydale to Twin Peaks 115 kV Line. The project proposes a new 8 mile 115 kV line between AEPCO's Thornydale substation and the CAP Twin Peaks substation. With the addition of Valencia to CAP Black Mountain 115 kV line, and the Marana-Thornydale-Saguaro Interconnect projects described in the previous section, this project would no longer be necessary. However, the same route may still be used as part of the Marana-Thornydale-Saguaro Interconnect. The driving factor for this project has been load growth and reliability.

Saguaro to Tucson 115 kV Line Loop-in To Marana. With the addition of Valencia to CAP Black Mountain 115 kV line, and the Marana-Thornydale-Saguaro Interconnect projects described in the previous section, this project is being studied as a sensitivity to determine additional reliability benefits that can be achieved. The driving factor for this project is reliability.

PROJECT MAPS

The following maps are included to show the location of existing and future transmission projects and as presented in the earlier Planned Projects section. The planned additions of AEPCO's Members are not included on these maps or reflected in this filing.

The maps included in this report are:

Figure 1 - AEPCO Northern Area

Figure 2 - AEPCO Southern Area

Figure 3 - AEPCO Western Area

Figure 4 – AEPCO California and Northwest Arizona Areas

Figure 1:

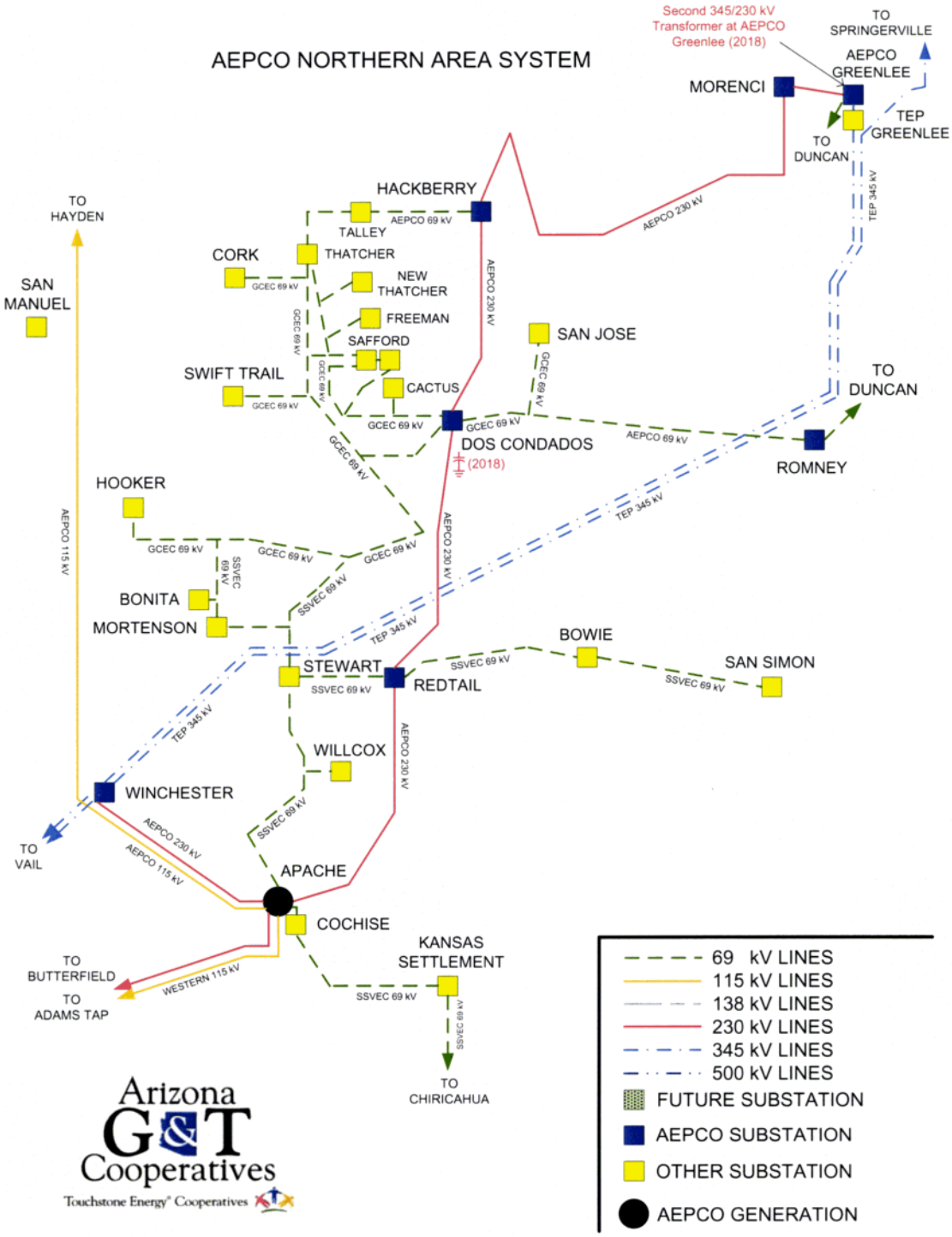

AEPCO NORTHERN AREA SYSTEM
Second 345/230 kV Transformer at AEPCO Greenlee (2018)
TO SPRINGERVILLE
AEPCO GREENLEE
MORENCI
TEP GREENLEE
TO DUNCAN
TEP 345 kV
AEPCO 230 kV
HACKBERRY
TALLEY
AEPCO 69 kV
TO HAYDEN
CORK
THATCHER
GCEC 69 kV
NEW THATCHER
FREEMAN
SAFFORD
SAN MANUEL
SWIFT TRAIL
CACTUS
SAN JOSE
DOS CONDADOS
(2018)
ROMNEY
TO DUNCAN
AEPCO 69 kV
HOOKER
AEPCO 115 kV
SSVEC 69 kV
BONITA
MORTENSON
STEWART
REDTAIL
BOWIE
SAN SIMON
SSVEC 69 kV
WILLCOX
WINCHESTER
TO VAIL
AEPCO 230 kV
AEPCO 115 kV
APACHE
COCHISE
KANSAS SETTLEMENT
TO BUTTERFIELD
TO ADAMS TAP
WESTERN 115 kV
TO CHIRICAHUA
Arizona G&T Cooperatives
Touchstone Energy® Cooperatives
69 kV LINES
115 kV LINES
138 kV LINES
230 kV LINES
345 kV LINES
500 kV LINES
FUTURE SUBSTATION
AEPCO SUBSTATION
OTHER SUBSTATION
AEPCO GENERATION

Figure 2:

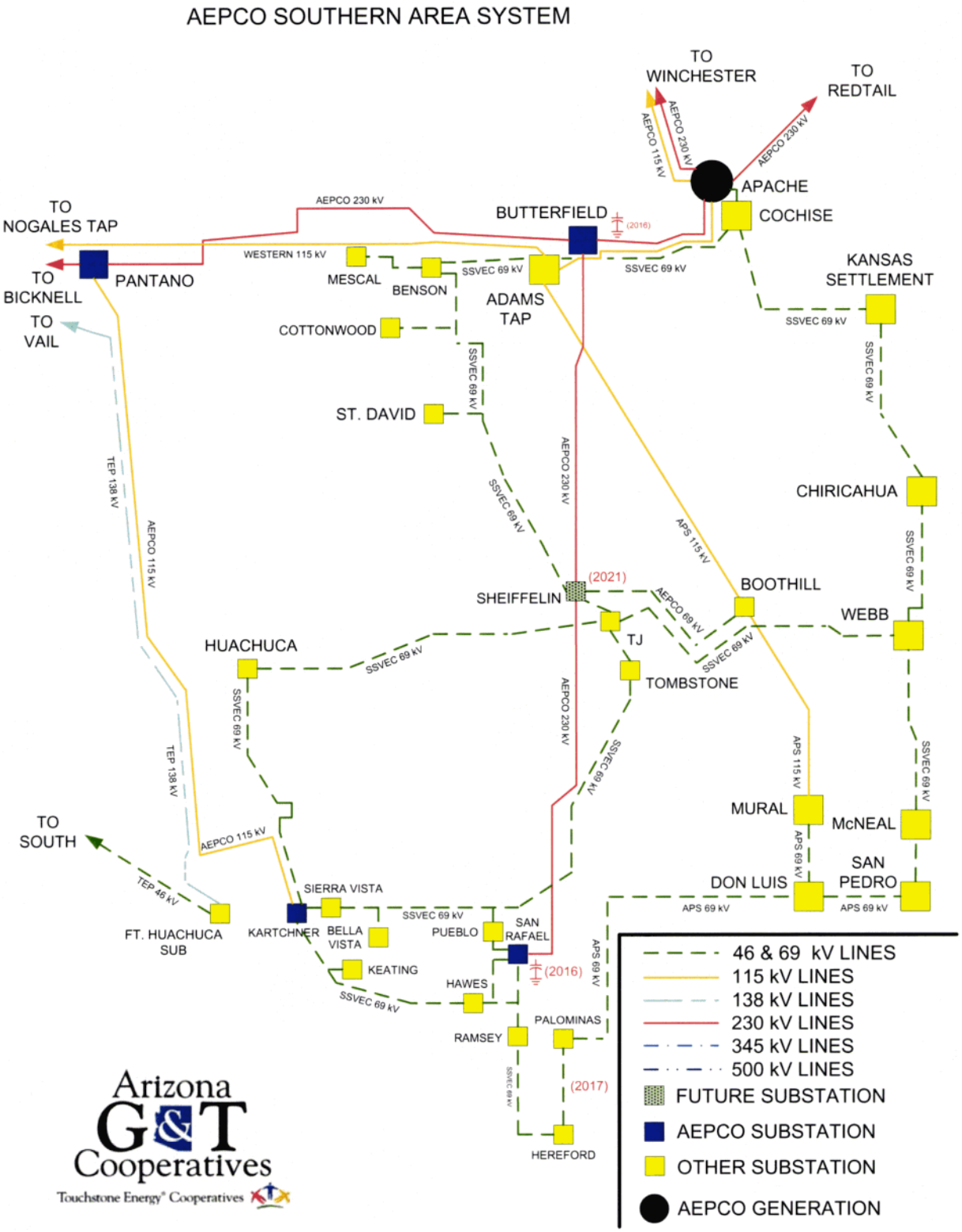

AEPCO SOUTHERN AREA SYSTEM
TO WINCHESTER
TO REDTAIL
AEPCO 115 kV
AEPCO 230 kV
AEPCO 230 kV
APACHE
COCHISE
TO NOGALES TAP
AEPCO 230 kV
BUTTERFIELD
(2016)
WESTERN 115 kV
MESCAL
BENSON
SSVEC 69 kV
SSVEC 69 kV
ADAMS TAP
KANSAS SETTLEMENT
SSVEC 69 kV
TO BICKNELL
PANTANO
TO VAIL
COTTONWOOD
SSVEC 69 kV
SSVEC 69 kV
ST. DAVID
TEP 138 kV
AEPCO 230 kV
CHIRICAHUA
SSVEC 69 kV
SSVEC 69 kV
APS 115 kV
AEPCO 115 kV
(2021)
SHEIFFELIN
BOOTHILL
AEPCO 69 kV
WEBB
TJ
HUACHUCA
SSVEC 69 kV
SSVEC 69 kV
TOMBSTONE
AEPCO 230 kV
SSVEC 69 kV
TEP 138 kV
APS 115 kV
SSVEC 69 kV
MURAL
McNEAL
TO SOUTH
AEPCO 115 kV
TEP 46 kV
APS 69 kV
SAN PEDRO
DON LUIS
APS 69 kV
APS 69 kV
SIERRA VISTA
SSVEC 69 kV
FT. HUACHUCA SUB
KARTCHNER
BELLA VISTA
PUEBLO
SAN RAFAEL
(2016)
KEATING
HAWES
SSVEC 69 kV
APS 69 kV
PALOMINAS
RAMSEY
(2017)
SSVEC 69 kV
HEREFORD
Arizona G&T Cooperatives
Touchstone Energy® Cooperatives
46 & 69 kV LINES
115 kV LINES
138 kV LINES
230 kV LINES
345 kV LINES
500 kV LINES
FUTURE SUBSTATION
AEPCO SUBSTATION
OTHER SUBSTATION
AEPCO GENERATION

Figure 3:

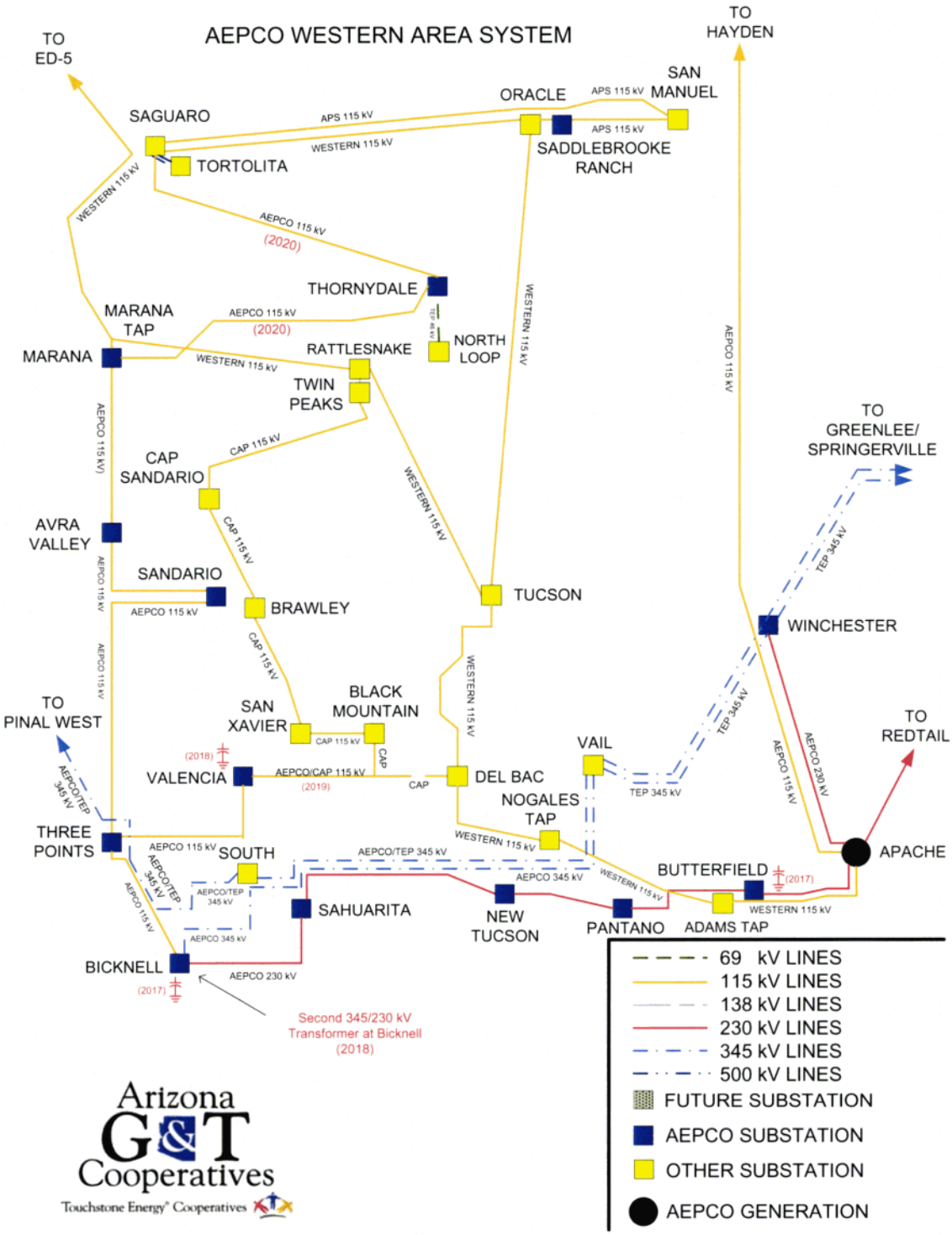
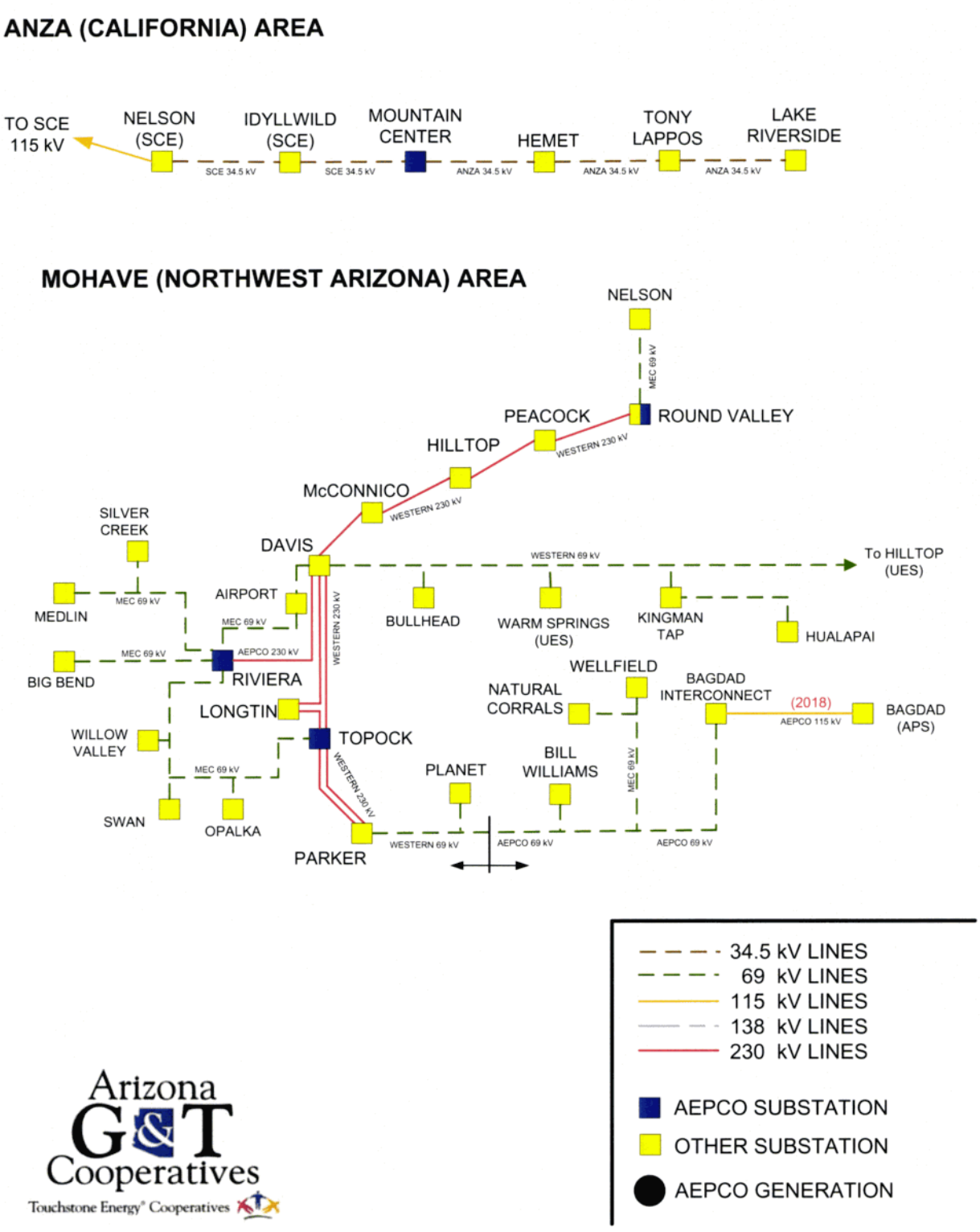

AEPCO WESTERN AREA SYSTEM
TO ED-5
TO HAYDEN
SAGUARO
TORTOLITA
ORACLE
SAN MANUEL
SADDLEBROOKE RANCH
APS 115 kV
WESTERN 115 kV
AEPCO 115 kV (2020)
THORNYDALE
MARANA TAP
MARANA
RATTLESNAKE
NORTH LOOP
TWIN PEAKS
CAP SANDARIO
CAP 115 kV
AVRA VALLEY
SANDARIO
AEPCO 115 kV
BRAWLEY
TUCSON
TO GREENLEE/ SPRINGERVILLE
TEP 345 kV
WINCHESTER
TO PINAL WEST
SAN XAVIER
BLACK MOUNTAIN
VALENCIA
(2018)
AEPCO/CAP 115 kV (2019)
CAP
DEL BAC
VAIL
NOGALES TAP
TO REDTAIL
AEPCO 230 kV
APACHE
THREE POINTS
SOUTH
AEPCO/TEP 345 kV
AEPCO 345 kV
SAHUARITA
NEW TUCSON
PANTANO
BUTTERFIELD
(2017)
ADAMS TAP
BICKNELL
Second 345/230 kV Transformer at Bicknell (2018)
69 kV LINES
115 kV LINES
138 kV LINES
230 kV LINES
345 kV LINES
500 kV LINES
FUTURE SUBSTATION
AEPCO SUBSTATION
OTHER SUBSTATION
AEPCO GENERATION
Arizona G&T Cooperatives
Touchstone Energy® Cooperatives

Figure 4:

AEPCO CALIFORNIA & NORTHWEST ARIZONA AREA SYSTEMS



SECTION I - PLANNED TRANSMISSION PROJECTS

Reactive Power Compensation

Description:

There are reactive power compensation facility additions at 115 kV and above that are planned for this ten-year plan filing, as per the following schedule:

Year	Substation	MVAR Quantity
2017	Bicknell	19.2
2018	Valencia	14.4
2018	Dos Condados	50.0 (Moved from Morenci)

Project Type: Capacitor Installations

Project Location: Pima and Graham Counties

Justification: Reliability

AEPCO Estimated Cost: $1,450,000

In Service Date: 2017 - 2018

APS Bagdad Interconnection Project

Description:

The project expands AEPCO's Bagdad Interconnect substation by installing a used 115/69 kV transformer and connecting it to APS' Bagdad substation via a new 115 kV line. This connection will provide mutual backup for APS loads in the town of Bagdad, and MEC's loads west of Bagdad. AEPCO and APS are currently discussing project configuration and cost allocations for this project. The driving factor for this project is reliability for both APS and MEC.

Project Type: Transformer Relocation and Transmission Line

Project Location: Yavapai County

Justification: Reliability

AEPCO Estimated Cost: $2,350,000

In Service Date: 2018

FMI Morenci – TEP Joint Project

Description:

The project will purchase a new 345/230 kV 400 MVA transformer for MW & E Copper Verde substation and relocate the two existing transformers at Copper Verde to the AEPCO Greenlee substation and the AEPCO Bicknell substation and place them in satisfactory operation. The driving factor for this project is reliability.

Project Type: Transformer Replacement and Relocation

Project Location: Graham and Pima Counties

Justification: Load Serving and Reliability

AEPCO Estimated Cost: $1,957,400

In Service Date: 2018

Valencia to CAP Black Mountain 115 kV line

Description:

The project proposes a new 2.6 mile 115 kV line that will extend from the existing AEPCO Valencia substation to tie to the turning structure of the 115 kV CAP line that heads directly north two miles to the existing CAP Black Mountain substation. The driving factor for this project is reliability on both AEPCO and CAP systems.

Project Type: Transmission Line

Project Location: Pima County

Justification: Reliability

AEPCO Estimated Cost: $2,537,500

In Service Date: 2019

Marana-Thornydale-Saguaro Interconnect

Description:

The project involves the construction of a new 115 kV line from the existing Marana substation to the Thornydale substation and to acquire a single circuit of TEP's quad-circuit line from TEP's Tortilita substation, disconnecting from Tortolita, and connecting it to Saguaro, reenergizing the quad circuit line to 115 kV and interconnect with (AEPCO Thornydale substation. The driving factor for this project is reliability.

Project Type: Transmission Line

Project Location: Pima and Pinal Counties

Justification: Reliability and Load Serving

AEPCO Estimated Cost: $16,200,000

In Service Date: 2020

Tombstone Junction Project.

Description:

This Cochise County project involves looping the AEPCO Butterfield to San Rafael 230 kV line into a new Scheiffelin substation with a 230/69 kV transformation to the existing SSVEC Tombstone Junction substation and APS Boot Hill substation. AEPCO and APS are currently discussing project configuration and cost allocations for this project. The driving factor for this project is reliability.

Project Type: Multiple Transmission Elements

Project Location: Cochise County

Justification: Reliability

AEPCO Estimated Cost: $13,800,000

In Service Date: 2021

SECTION II - INTERNAL PLANNING CRITERIA AND FACILITY RATINGS

AEPCO's current internal planning criteria and facility ratings have been documented in its Facility Ratings Methodology and Establish and Communicate Facility Ratings (FAC-008-3) last revised in July 2016, to meet requirements of the NERC Planning Standards. Portions of the document are reprinted below, which identify the assumptions and methodologies used by AEPCO to determine electrical facility ratings and also describe the electrical load limits for AEPCO on the various power system transmission lines, power transformers, and other facility equipment under normal and emergency operating conditions.

1.0 Introduction

In accordance with NERC and Western Electricity Coordinating Council (WECC) standards, this document sets forth the methodology to cover facilities solely owned by AEPCO. This document's purpose is to ensure that Facility Ratings used in the reliable planning and operation of the Bulk Electric System (BES) are determined based on technically sound principles. As industry standards change over the years, AEPCO will modify its rating methodology to comport with accepted industry practice. In particular, this document covers the methodologies used to establish the electrical ratings of transmission facilities owned by AEPCO, which are currently in commercial service. This document is intended to comply with the requirements of NERC Reliability Standard FAC-008-3.

2.0 Statement of Limitations

This document is limited to addressing operating conditions under normal and emergency situations and is not intended to address electrical faults, abnormal operations, failures of covered equipment or establish settings for protective devices. Additionally, the document does not make any assumptions as to the design criteria of legacy equipment and facilities.

2.1 The facilities addressed in this document include transmission conductors, transformers, relay protective devices, terminal equipment and compensation devices.

2.2 This methodology addresses Normal and Emergency ratings for the facilities that comprise AEPCO's BES.

2.3 This Facility Ratings Methodology considers the ratings provided by equipment manufacturers, The Institute of Electrical and Electronics Engineers, Inc., (IEEE) and American National Standards Institute (ANSI) standards, ambient conditions for solar input, temperature and wind speed, design criteria, operating limitations, and other assumptions, as applicable.

2.4 The ratings for all of AEPCO BES facilities, including but not limited to lines, transformers, and shunt compensation devices shall respect the most limiting applicable Equipment Rating of the individual equipment that comprises that facility.

2.5 In cases where a facility is jointly owned, the operator of the facility determines the rating and shares the rating with the other joint owners. AEPCO is a joint owner in two transmission lines: The Vail to Westwing 345 kV line, which it co-owns with Tucson Electric Power (TEP) (project operator), and the Hassayampa to Pinal West 500 kV line, which it co-owns with Electrical District 2 (ED2), Electrical District 3 (ED3), Electrical District 4 (ED4), Salt River Project (SRP) (project operator) and TEP. AEPCO is also a co-owner with TEP (project operator) in the Pinal West 500/345 kV transformer. Information on co-owned facilities is included in Appendices A and B.

2.6 In cases where a facility is owned in segments (such as a transmission line owned by one party with the breaker being owned by a different party), each owner will determine the rating for their segment and coordinate with the others to determine the most limiting segment. The rating for the most limiting segment will be used for the entire facility.

3.0 Facility Rating Methodologies for Generation and Transmission Facilities

The following sections describe the rating methodology for AEPCO facilities.

3.1 Generation Facilities

AEPCO has five generating facilities interconnected at voltages higher than 100 kV. These are Apache Station ST1, ST2, ST3, GT3, and GT4. These facilities comprise AEPCO's BES.

The following sections describe the rating method for the various facilities that comprise AEPCO's BES. The Facility Rating shall not exceed the most limiting applicable Equipment Rating of the individual equipment that comprises that Facility. AEPCO's Facility Ratings are expressed in megawatts. Equipment Ratings are expressed in megawatts based on the equipment's associated generator nameplate kilovolt-amperes and power factor. For equipment located on the secondary side of current transformer circuits, the Equipment Rating will be based on the primary side current, associated generator nameplate kV, and generator nameplate power factor.

The Normal Rating of any one generator is based on the generator manufacturer's nameplate rating and is equal to the maximum generator nameplate rating as reported on Form EIA-860 "Annual Electric Generator Report" and EIA 767. From

EIA 767, "…report the maximum generator nameplate rating in megawatts. If the nameplate rating is expressed in kilovolt-amperes, convert to kilowatts by multiplying the power factor by the kilovolt-amperes, then convert kilowatts to megawatts by dividing by 1,000. If more than one rating appears on the nameplate, select the highest rating. Do not indicate the nameplate rating of the turbine."

The Emergency Rating of each of AEPCO's generating facilities is equal to the Facility's Normal Rating.

Generator Facility Rating Summary

Facility	Owner's Normal Rating (MW)	Owner's Emergency Rating (MW)	Most Limiting Element
ST1	81.6	81.6	Generator @ p.f.=0.85
ST2	204.0	204.0	Generator @ p.f.=0.85
ST3	204.0	204.0	Generator @ p.f.=0.85
GT3	78.8	78.8	Generator @ p.f.=0.9
GT4	60.5	60.5	Generator @ p.f.=0.85

Generator ratings are determined in accordance with Energy Information Administration (EIA) methods based on nameplate MVA and power factor.

These ratings are for the purposes of FAC-008 and are only indicative of the generator and equipment manufacturer's stated electrical capability. They do not reflect the megawatt producing capability of the plant.

3.2 Overhead Conductors

In 2014, AEPCO updated its overhead conductor rating methodology based upon the parameters outlined in Table 2 below. The calculations for normal operating conditions use the design criteria of 75°C, and the emergency operating conditions use a conductor design temperature rating of 100°C. AEPCO incorporates the calculations used in the IEEE Standard 738 "IEEE Standard for Calculating the Current-Temperature of Bare Overhead Conductors," in its analysis of determining the current-temperature relationship of its conductors, given the parameters noted in Table 2.[1]

The ratings can be found in Table 1 below. The conductor ratings apply to the entire line, including the last span of the line entering a substation. The limiting factors of each transmission line are discussed in the next Section and a spreadsheet of AEPCO's transmission line ratings can be found in Appendix A "AEPCO Transmission Line Ratings." Appendix F "GE PSLF Power Flow Model" also shows the transmission line ratings based on their limiting factors as noted in Appendix A.

The updated conductor ratings have also been done to calculate year-round 15-minute, 30-minute and 4-hour emergency ratings, using an Excel based program to produce a loading guide for each conductor, based on the IEEE Standard 738. The same parameters noted in Table 2 below were used to calculate these emergency ratings.

[1] Information on AEPCO Conductor Ratings also found in the following reference documents:
System Operating Limits Methodology for the Operations Horizon, Version 6.1
Establish and Communicate System Operating Limits, Version 3.0

The 15-minute and 30-minute emergency ratings will be utilized by System Operations in their Dispatch Center where contingency overloads can be mitigated within 15 to 30 minutes.

The values for the four-hour emergency ratings for all conductors below are based on 130% of the normal ratings. It should be noted that the 15- and 30-minute emergency ratings for the smaller conductors, #2 CU to 636 ACSR, are the same as the 4-hour emergency ratings. For conductor sizes 795 AAC and up, all four values of ratings are shown: normal, 15-minute, 30-minute and 4-hour. The 15- minute ratings are 140% or normal and the 30 minute ratings are 135% of normal.

TABLE 1: Conductor Thermal Ratings			
At 75 Deg. Celsius Operating Temperature			
Based on 4 ft. per second Wind Velocity			
and 40 deg. Celsius Air Temperature			
15-Minute, 30-Minute and 4-Hour Ratings are same for smaller conductors to 636 ACSR			
15-Minute, 30-Minute and 4-Hour Ratings listed below for conductors 795 AAC & Up			
ACSR/AAC Conductor		Copper Conductor	
SIZE	AMPS	SIZE	AMPS
	(Normal/Emergency)		(Normal/Emergency)
1/0 – 105.7 ACSR	239/311	#2 – 3 Strand	235/306
2/0 – 133.0 ACSR	274/356	#2 – 7 Strand	228/296
3/0 – 167.7 ACSR	314/408	4/0 – 211.6 MCM	476/619
4/0 – 211.6 ACSR	361/469	350 MCM	653/849
266.8 ACSR	451/586		
336.4 ACSR	522/679		
397.5 ACSR	580/754		
477 AAC	631/820		
477.0 ACSR	652/848		
556.0 ACSR	718/933		
636.0 ACSR	781/1015		
795.0 AAC	870/1218/1175/1131		
795.0 ACSR	899/1259/1214/1169		
954.0 AAC	974/1364/1315/1266		
954.0 ACSR	989/1385/1335/1286		
2 – 954 ACSR	1978/2769/2670/2571		
1033.5 ACSR	1040/1456/1404/1352		
1192.5 ACSR	1135/1589/1532/1476		
1272.0 AAC	1164/1630/1571/1513		
1272.0 ACSR	1182/1655/1596/1537		
1351.5 ACSR	1228/1719/1658/1596		
1590.0 ACSR	1359/1903/1835/1767		
2167.0 ACSR	1624/2274/2192/2111		

The parameters upon which the conductor ratings are based are found in Table 2 below:

TABLE 2: Conductor Rating Parameters		
Parameters Common to All Locations/Conductors		
Parameter	**Continuous Rating**	**Emergency Rating**
Wind Direction	70° to Line	70° to Line
Emissivity	0.7	0.7
Absorptivity	0.8	0.8
Date	July 1	July 1
Time	4 PM	4 PM
Latitude and Longitude	32.5° North	32.5° North
Elevation	2500 Ft	2500 Ft
Solar Input	Clear	Clear
Allowable Cond. Temp (ACSR)	75°C	100°C or sag limit
Wind Speed	4 ft/s	4 ft/s
Ambient Temperature	40°C	40°C

The following items are pertinent with regard to the current conductor rating method:

a. The thermal ratings from Table 1, used by AEPCO to rate its transmission lines, are considered to be conservative. The emergency ratings are set at 130% of the normal rating based on ratings developed for each transmission line according to IEEE Standard 738. If through internal studies it is determined that a line will become stability limited, (at a value lower than the thermal limit) its rating will be based on its particular stability limit.

b. The weather parameters for development of the existing conductor thermal ratings are based on the values for wind direction, absorptivity, and wind speed as noted in Table 2 above. The conductor ratings are based on a 75°C operating temperature with a 4 ft. per second wind speed and a 40°C air temperature. Emergency ratings, as shown in Appendix A, are based on a 100°C operating temperature with a 4 ft. per second wind speed and a 40°C air temperature. AEPCO can exceed its normal ratings for up to 30 minutes. Where a transmission line, or line section, is constructed or upgraded with more than one size conductor, the overall line rating is determined by the rating of the most limiting sized conductor. If other equipment (switches, series capacitors, etc) in series with the transmission conductor is more limiting, the lowest limitation defines the transmission line rating.

c. Rigid Bus and Strain Bus design are determined by the Rural Utilities Service (RUS) Design Guide for Rural Substations Bulletin 1724E-300 (Bulletin) and NESC as a minimum. The design involves many factors, which are spelled out in the Bulletin. For new 115 kV substations, AEPCO uses a standard schedule 40 aluminum pipe conductor size of 3"and for new 230 kV substations, AEPCO uses an aluminum pipe conductor size of 4".

There is currently no case on the AEPCO system where the rigid bus or strain bus is a limiting factor for any of AEPCO's transmission line ratings. The ratings of the aluminum rigid bus or pipe conductor are based on IEEE Standard 605-1998 "IEEE Guide for Design of Substation Rigid-Bus Structures, using an emissivity of 0.5, with Sun, at a 40°C temperature rise above 40°C ambient for normal operating conditions, and a 60°C temperature rise above 40°C ambient for emergency operating conditions.

3.2.1 Transmission Line Ratings

Appendix A contains a summary table for the transmission line ratings followed by tables that show the individual rating of components that make up each transmission line. Currently, there are not operating limitations in effect as of the date of this revision. Any such limitations will be posted on the AEPCO OASIS. Specific items that are marked "N/A" mean that the facility in question is a legacy facility for which no specific data exists or the facility belongs to another entity that has not provided the requested information. The summary table allows for the finding of the most limiting factor of a transmission line, as well as the next most limiting factor.

AEPCO ensures that its transmission line ratings are aligned with current design tolerances based on the National Electric Safety Code (NESC) and likewise ensures that actual field conditions do not create conditions that will cause the facilities to be non-compliant with the NESC clearance requirements.

Based on historical, conservative design practices, AEPCO has incorporated additional design margin to compensate for minor variations between design conditions and actual field conditions. In addition, AEPCO verifies its "as-built" conditions by scheduled field visits. Each line segment part of the BES is monitored on an annual basis. AEPCO's current maintenance practices include an annual inspection on concrete and steel structures and a semi-annual inspection on wood structures. Inspections are performed by a journeyman hot stick lineman inspector who has been trained and provided the information to identify problems of a structural nature as well as phase to ground clearance issues. The inspector will note changes in field conditions such as new structures, tree growth, etc. In addition, the inspector has been trained in the use of measuring devices to determine pole integrity and phase to ground clearances. The inspection is a visual inspection designed to monitor the integrity, reliability, and compliance with NESC standards checking minimum conductor sag distances at key points throughout the system. Findings are documented, reported, and addressed as issues arise. In addition to on-ground line inspections, AEPCO also performs regular aerial bucket or climbing inspections in high risk areas outlined in AEPCO's Transmission Vegetation Management Plan (TVMP).

3.3 Transformers

AEPCO owns the following types of power transformers:

a. Load serving transformers with LTC
   - Conventional
   - Auto

b. Tie Autotransformers

The Normal and Emergency Ratings for terminal equipment are determined as follows:

Equipment	Normal Rating	Emergency Rating ½ Hour Maximum Overload
AEPCO Transformers	100% Manufacturer's highest Nameplate Rating @ 55°C or 65°C rise	125% of Manufacturer's Nameplate Rating @ 55°C or 65°C rise

During All Lines In Service (ALIS) operation the loading of the transformer should not exceed the normal rating. During system contingencies the loading of the transformer should not exceed its Emergency Rating, which is set at 125% of the normal rating based on ratings developed for each transformer according to IEEE Std. C57.91-1995 "Guide for Loading Mineral-Oil-Immersed Transformers." AEPCO can exceed its normal ratings for up to 30 minutes. In addition, AEPCO follows the recommendations of PRC-023 which limits the ability of automatic protection equipment to de-energize transformers. This allows time to permit operator intervention and helps avoid potential system cascading. Under special circumstances, AEPCO may wish to evaluate other sources in regard to manufacturer's specifications, such as the latest applicable versions of IEEE Standard C57.15.12.00-2010 "IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers," and IEEE Std. C57.119-2001 "IEEE Recommended Practice for Performing Temperature Rise Tests on Oil-Immersed Power Transformers at Loads Beyond Nameplate Ratings." Appendix B contains a summary table of AEPCO transformer data including the ratings as discussed in this Section.

Some transformers on the AEPCO system are owned by other entities or co-owned by AEPCO and other entities. Appendix B lists these specific transformers and notes the operating agent responsible for the transformer ratings.

3.4 Relay Protective Devices

None of AEPCO BES facilities have ratings that are limited by protection or monitoring devices. AEPCO's relays will not trip (trip on Zone 3) due to normal or emergency load current (See PRC-023-1 Transmission Relay Loadability). New facilities and protection schemes are reviewed by AEPCO to ensure that loadability requirements are met.

3.5 Terminal Equipment (switches, breakers, etc)

Power Circuit Breakers will be rated according to the manufacturer's nameplate ampacity at the nominal applied voltage. Normal and Emergency Ratings will be identical. This is in accordance with IEEE C37.010-1999 (R2005) "IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis," and IEEE C37.06 "IEEE Standard for Switchgear – AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities."

Power Circuit Switchers will be rated according to the manufacturer's nameplate ampacity at the nominal applied voltage. Normal and Emergency Ratings will be identical.

Air Disconnect Switches will be rated according to the manufacturer's nameplate ampacity at the nominal applied voltage. Normal and Emergency Ratings will be identical. This is in accordance with IEEE C37.30 "IEEE Standard Requirements for High-Voltage Switches" and IEEE C37.37a-1996 "IEEE Standard Loading Guide for AC High-Voltage Air Switches Under Emergency Conditions."

Current Transformers as installed on the AEPCO system are primarily Bushing Current Transformers that are supplied with power transformers and circuit breakers. These will be rated according to the corresponding unit's nameplate in accordance with IEEE C57.13-2008 "IEEE Standard Requirements for Instrument Transformers." A thermal rating factor will be applied to the normal and emergency ratings as provided by the manufacturer or developed based on industry practice. Normal and Emergency Ratings will be identical. Under certain circumstances, AEPCO may wish to evaluate other sources in regard to manufacturer's specifications, such as increasing a thermal rating factor for a legacy bushing current transformer.

For example, AEPCO uses a Westinghouse "Memorandum on Thermal Current Characteristics of Current Transformers used with Power Circuit Breakers and Power Transformers," dated June 26, 1969, to develop ratings for legacy bushing current transformers at the Pantano and Marana Substations.

There are very few free-standing current transformers on the AEPCO system, but there are also rated according to the corresponding unit's nameplate in according with IEEE C57.13-2008.

The Normal and Emergency Ratings for terminal equipment are determined as follows:

Equipment	Normal Rating	Emergency Rating
Power Circuit breakers	100% of Manufacturer's Nameplate Rating	100% of Manufacturer's Nameplate Rating
Power Circuit switchers	100% of Manufacturer's Nameplate Rating	100% of Manufacturer's Nameplate Rating
Air Disconnect switches	100% of Manufacturer's Nameplate Rating	100% of Manufacturer's Nameplate Rating
Current transformers	100% of Manufacturer's Nameplate Rating	100% of Manufacturer's Nameplate Rating

Additional applicable IEEE standards will be consulted as deemed necessary regarding the rating of its terminal equipment. Appendix C "AEPCO Power Circuit Breaker & Circuit Switcher Ratings," and Appendix D "Substation Switch Ratings," contains the summary table for AEPCO terminal equipment ratings.

3.6 Compensation Devices

a. Shunt Compensations
Shunt capacitors will be rated according to the manufacturer's nameplate ampacity and in accordance with IEEE 18-2012 "IEEE Standard for Shunt Power Capacitors." Appendix E "Shunt Capacitor Ratings" contains a summary table for AEPCO shunt capacitor ratings. The normal and emergency ratings for shunt compensation devices will be identical as follows:

Equipment	Normal Rating	Emergency Rating
Shunt Capacitors	100% of Manufacturer's Nameplate Rating	100% of Manufacturer's Nameplate Rating

b. Series Compensation
AEPCO has no series compensation devices on its system.

4.0 Internal Planning Criteria for Facility Ratings

The factors used to determine equipment ratings were outlined above. They represent criteria that is accepted within the utility industry, NERC, WECC, and the Federal Energy Regulatory Commission (FERC).

The following is AEPCO's internal transmission reliability planning criteria as published in its FERC FORM #715 filing:

1) Nominal Operating Limit
- Transmission lines should not be loaded greater than 100% of the thermal rating of the conductors.
- Transformers, circuit breakers, current transformers, and other equipment should not be loaded above their continuous nameplate rating.

- Transmission system voltages should not fall below 0.95 per unit (p.u.) of nominal rating nor rise above 1.05 p.u. of nominal rating.
- For long range planning system studies, an appropriate power factor for the planning period will be used.
- For operating system studies, an appropriate power factor for the operating planning period will be used.

2) Emergency Operating Limit
   - Transmission lines should not be loaded greater than the specified emergency rating of the conductors. (See Appendix A)
   - Transformers should not be loaded greater than the specified emergency rating of the transformers. (See Appendix B)
   - Circuit breakers, current transformers, and other equipment should not be loaded above their continuous nameplate rating, except as permitted under applicable standards. (See Appendices C, D, and E)
   - Transmission system voltages should not fall below 0.90 p.u. of nominal rating nor rise above 1.10 p.u. of nominal rating.
   - For long range planning system studies, an appropriate power factor for the planning period will be used.
   - For operating system studies, an appropriate power factor for the operating planning period will be used.

5.0 Establishment and Communication of Facility Ratings

AEPCO establishes the facility ratings for its BES in accordance with the facility rating methodologies described above. AEPCO submits its most up-to-date ratings as part of the WECC base case preparation process on a periodic basis as required by WECC. Appendix E "GE PSLF Powerflow Model" contains a table for typical AEPCO power flow modeling data.

AEPCO shall communicate its Facility Ratings Methodology for its solely and jointly owned Facilities that are existing Facilities, new Facilities, modifications to existing Facilities and re-ratings of existing Facilities to Peak RC, its Reliability Coordinator, its Planning Coordinator, and to other Transmission Owners, Operators, or Planners within 21 calendar days of a receipt of a request. If any of the aforementioned entities provides documented comments on its technical review of the AEPCO Facility Ratings Methodology, AEPCO shall provide a response to the commenting entity within 45 calendar days of a receipt of those comments, indicating whether a change will be made to the Facility Ratings Methodology and, if no change will be made, the reason why.

Within 30 calendar days (or a later date if specified by a requestor) for any requested Facility with a Thermal Rating that limits the use of Facilities under a requestor's authority by causing any of the following: 1) An Interconnection Reliability Operating Limit, 2) A limitation of Total Transfer Capability, 3) An impediment to generator deliverability, or 4) An impediment to service to a major load center, AEPCO shall identify the existing next

most limiting equipment of the Facility and the Thermal Rating for that most limiting equipment.

When AEPCO has determined that updated ratings are applicable, it will communicate those ratings as part of the WECC base case preparation process, by email or by telephone, as appropriate. AEPCO shall keep all superseded portions of its Facility Ratings Methodology for 12 months beyond the date of the change in that methodology and shall keep all documented comments on the Facility Ratings Methodology and associated responses for three calendar years, in accordance with NERC Standard FAC-008-3.

The following table of AEPCO Transmission Line Ratings is found in Appendix A of AEPCO's Facility Ratings Methodology:

AEPCO Transmission Line Rating Limits							
Station A From	Station B To	Voltage KV	Normal Limit Amps	Emergency Limit Amps	Normal Limit MVA	Emergency Limit MVA	Limiting Equipment
HASSAYAMPA	PINAL WEST	500	3000	3000	2598	2598	Breaker Out for Maintenance
PINAL WEST	HASSAYAMPA	500	3000	3000	2598	2598	
GREEN-SW	GREENLEE	345	1978	2571	1182	1537	Conductor
GREENLEE	GREEN-SW	345	1978	2571	1182	1537	Conductor
BICKNELL	VAIL	345	1600	1600	956	956	Station Motor-Operated Switch
VAIL	BICKNELL	345	1600	1600	956	956	
PINAL WEST	VAIL	345	1548	1858	925	1110	Station Terminal Equipment
VAIL	PINAL WEST	345	1548	1858	925	1110	
PINAL WEST	WESTWING	345	1548	1858	925	1110	Station Terminal Equipment
WESTWING	PINAL WEST	345	1548	1858	925	1110	
DOSCONDO	HACKBERRY	230	1164	1513	464	603	Conductor
HACKBERRY	DOSCONDO	230	1164	1513	464	603	Conductor
HACKBERRY	MORENCI	230	1164	1513	464	603	Conductor
MORENCI	HACKBERRY	230	1164	1513	464	603	Conductor
GREEN-SW	MORENCI	230	1182	1537	471	612	Conductor
MORENCI	GREEN-SW	230	1182	1537	471	612	Conductor
MORENCI	PD-MORNC	230	989	1286	394	512	Conductor
PD-MORNC	MORENCI	230	989	1286	394	512	Conductor
APACHE	BUTERFLD	230	899	1169	358	466	Conductor
BUTERFLD	APACHE	230	899	1169	358	466	Conductor
APACHE	RED TAIL	230	1182	1537	471	612	Conductor
RED TAIL	APACHE	230	1182	1537	471	612	Conductor
APACHE	WINCHESTER	230	1182	1537	471	612	Conductor
WINCHESTER	APACHE	230	1182	1537	471	612	Conductor
BUTERFLD	PANTANO	230	899	1169	358	466	Conductor
PANTANO	BUTERFLD	230	899	1169	358	466	Conductor
BUTERFLD	SAN RAF	230	989	1286	394	512	Conductor
PANTANO	NEWTUCSN	230	899	1169	358	466	Conductor
NEWTUCSN	PANTANO	230	899	1169	358	466	Conductor
NEWTUCSN	SAHUARITA	230	899	1169	358	466	Conductor
SAHUARITA	NEWTUCSN	230	899	1169	358	466	Conductor
SAHUARITA	BICKNELL	230	899	1169	358	466	Conductor
BICKNELL	SAHUARITA	230	899	1169	358	466	Conductor
RED TAIL	DOSCONDO	230	1182	1537	471	612	Conductor
DOSCONDO	RED TAIL	230	1182	1537	471	612	Conductor
DAVIS	RIVIERA	230	1182	1200	471	478	Conductor/ Disconnect Switch
APACHE	HAYDENAZ	115	631	740	126	147	Conductor
HAYDENAZ	APACHE	115	631	740	126	147	Conductor
MARANA	MARANATP	115	718	800	143	159	Disconnect Switch
MARANATP	MARANA	115	718	800	143	159	Disconnect Switch
MARANA	AVRA	115	870	1131	173	225	Conductor
AVRA	MARANA	115	870	1131	173	225	Conductor
AVRA	SANDARIO	115	870	1131	173	225	Conductor
SANDARIO	AVRA	115	870	1131	173	225	Conductor
SANDARIO	THREEPNT	115	361	469	72	93	Conductor
THREEPNT	SANDARIO	115	361	469	72	93	Conductor
BICKNELL	THREEPNT	115	652	848	130	169	Conductor
THREEPNT	BICKNELL	115	652	848	130	169	Conductor
THREEPNT	VALENCIA	115	652	848	130	169	Conductor
PANTANO	KARTCHNR	115	652	848	130	169	Conductor

Notes:

1) SRP is the operating agent for the Hassayampa to Pinal West 500 kV line and has determined its line ratings. SWTC owns 7.305% of this line.
2) TEP is the operating agent for Pinal West to Vail and Pinal West to Westwing 345 kV lines and have determined their line ratings. SWTC owns 24% of these lines.
3) Dos Condados to Hackberry and Hackberry to Morenci 230 kV Lines limited by 1272 AAC conductor.
4) Davis to Riviera 230 kV Line limited by 1272 ASCR conductor Normal Conditions and limited by 1200A disconnect switch Emergency Conditions.
5) Apache to Hayden 115 kV Line limited by 477 AAC conductor at Apache (SWTC Rating) and Hayden (SRP Rating).
6) Marana to Avra and Avra to Sandario 115 kV Lines limited by 795 AAC conductor at Avra.

Arizona G&T Cooperatives

Touchstone Energy® Cooperatives

TECHNICAL STUDY REPORT

2017 – 2026
Docket No. E00000D-17-0001

MARCH 20, 2017

ARIZONA ELECTRIC POWER COOPERATIVE, INC.

TEN-YEAR TRANSMISSION PLAN

2017 – 2026

Prepared for the

ARIZONA CORPORATION COMMISSION

Docket No. E-00000D-17-0001

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TECHNICAL STUDY REPORT

INTRODUCTION

This technical report is submitted to the Arizona Corporation Commission (Commission) pursuant to the Arizona Revised Statutes (A.R.S.) §40-360.02.C.7, and Decision No. 63876, dated July 25, 2001, regarding the Biennial Transmission Assessment prepared by Commission Utilities Division Staff.

Each year, Arizona Electric Power Cooperative, Inc. (AEPCO) performs an annual assessment of its interconnected transmission system in accordance with the North American Reliability Corporation (NERC) Transmission Planning Standards (TPL). Power flow analyses used for this report were performed in accordance with the NERC criteria for Planning Standard TPL-001- , and are contained in the AEPCO 2016 Transmission Planning Assessment Report that details study results for the years 2017 through 2026. As required by the Standards, the AEPCO transmission system was analyzed within the near-term planning horizon (2017-2021) and the long-term planning horizon (2022-2026). Heavy summer and heavy winter conditions were analyzed for all years of the 2017-2026 planning horizon, but only the years 2018, 2021 and 2026 will be discussed in this report. The diagrams and plots in this report will only represent Heavy Summer conditions for 2018, 2021 and 2026. Diagrams and plots for heavy winter conditions as well as other years are available upon request.

As has been done in previous years, the transmission planning assessment performed by AEPCO did not consider the Sunzia Southwest Transmission Project or the Southline Transmission Project. These projects are still undergoing study through the Western Electricity Coordinating Council (WECC) Three-Phase Rating Process. Consideration was made as to whether or not to include these projects in the bases cases for study, as they may potentially have an impact upon the AEPCO system, but for the present it was decided not include to them until a degree of certainty is achieved regarding completion of the projects.

The Ninth Biennial Transmission Assessment (BTA) was reviewed on October 27and 28, 2016 by the Commission as Decision #75817. Recommendations f-v. of the BTA states the following:

"Include planned transmission reconductor projects, transformer capacity upgrade projects and reactive power compensation facility additions at 115 kV and above in future Ten-Year Plan Filings."

The Ten-Year plan document that this report accompanies defines the projects included in this study. These projects are reflected in the results of this study based on their projected in-service dates.

2017 – Bicknell 19.2 MVAr Capacitor Bank Installation
2017 – Bagdad APS 69kV Interconnection
2018 – Valencia 14.4 MVAr Capacitor Bank Installation
2018 – Dos Condados 50.0 MVAr Capacitor Bank Installation (moved from Morenci)
2018 – Additional 200 MVA Transformer at Greenlee (Moved from Copper Verde)
2018 – Additional 200 MVA Transformer at Bicknell (Moved from Copper Verde)
2019 – Valencia to Black Mountain 115 kV Interconnection

2020 – Marana to Thornydale to Saguaro 115 kV Interconnection
2021 – Tombstone Junction Project

Additional studies conducted during 2017, due to the 2016 load forecast or other unforeseen circumstances may tend to refine the projected in-service dates, and/or suggest the need to adjust locations for reactive support to the AEPCO system. These will be reported in the next ten- year plan filing.

The analyses performed for this study have been done with the 2015 AEPCO load forecast and the results show that under a variety of outage conditions, the system will perform well with no violations of the NERC criteria.

AEPCO's current and planned transmission system maps are included in Appendix A.

The contingency list used for the TPL Assessment is included in Appendix B.

As part of AEPCO's TPL Assessment, all P1, P2, and selective P3, P4, P5, P6, and P7 outages of the AEPCO's High Voltage (HV) and Extra-High Voltage (EHV) outages were chosen to be included in the contingency list. Contingency simulations for radial transmission lines have been excluded from this listing. Selective power flow one-line diagrams, showing the entire AEPCO system under various heavy summer outage conditions, for the years 2018, 2021 and 2026, are included in Appendix C.

Post-transient studies for reactive margin for the interconnected AEPCO transmission system for heavy summer for the years 2018, 2021 and 2026 are presented in this report. Q-V plots can be found in Appendix D.

Dynamic stability evaluations for heavy summer conditions for the years 2018 and 2021 only are presented in this report. These can be found in Appendix E.

POWER FLOW ANALYSES

Power flow studies were performed using General Electric's Positive Sequence Load Flow (PSLF) program. The power flow base cases were created for the 2017-2026 study period, using the latest Arizona seed cases that have been developed from Western Electricity Coordinating Council (WECC) approved base cases. The cases used for this report are listed below:

- 2018HS Case (Created from SouthWest Area Transmission Arizona Subcommitee Study Group (SWAT-AZ) 2018 Summer Seasonal Study case that was originally developed from the WECC 2018hs2s approved base case) – Load Flow and Stability.
- 2021HW Case (Created from 2021 Winter Seasonal Study case that was original developed from the WECC 2021hw1 approved base case) – Load Flow and Stability.
- 2021HS Case (Created from the coordinated SWAT-AZ 2021HS seed case that was originally developed from the WECC 2021hs2 approved base case) – Load Flow and Stability.

- 2026HS Case (Created from coordinated SWAT-AZ 2026HS seed case that was originally developed from the WECC 2025hs1 approved base case) – Load Flow and Stability.

The Heavy Summer (HS) base cases represent the non-coincident peak summer load of the Member Cooperatives and the Heavy Winter (HW) base case represents the non-coincident peak winter load of the Member Cooperatives.

These base cases were based on the 2015 load forecast of AEPCO, using the medium economic forecast. Base case, single, and double contingency conditions were evaluated using PSLF to determine system impacts and timing of transmission facilities needed to mitigate those system impacts.

SPECIFIC ASSUMPTIONS FOR STUDY

Multiple power flow cases were used to assess the future transmission system adequacy. In each of the planning scenarios, the load flow and stability models that were used, originated from WECC approved base cases as discussed earlier.

Each of the different cases were assembled to match the forecasted heavy summer and heavy winter scenarios and include the lower voltage distribution networks (below 100 kV within the AEPCO system). Generation dispatch levels were varied as a means to assess the sensitivity of each case. It should be noted that the Anza Electric Cooperative, Inc. (Anza) load is not located in the southeast Arizona area and is represented as a transfer.

The cases prepared for these studies contain a power factor for AEPCO Distribution Cooperative Member systems that is approximately 0.98 per unit.

Specific study scenarios for the years 2018, 2021 and 2026 were conducted with the addition of the planned projects listed earlier with their anticipated in-service dates of the Ten-Year Plan Report that accompanies this technical study report. These projects are included in AEPCO's 2017-2020 construction work plan, or have a high likelihood of being advanced for approval and construction in a subsequent construction workplan. These scenarios were conducted for heavy summer conditions for 2018, 2021, and 2026, with the addition of studies for 2021 heavy winter. As stated earlier, only the heavy summer conditions have been provided in this Report.

2018 Scenario has the following project represented:

- A recently constructed connection with WAPA substation ED5 which bypasses Saguaro substation.
- A new 14.4 MVAr Capacitor Bank installed at Valencia 115 kV substation.
- A 69kV interconnection with APS for mutual backup of APS loads and Mohave Electric Cooperative, Inc. (MEC) loads near Bagdad Arizona.
- A new 19.2 MVAr Capacitor Bank installed at Bicknell 115 kV substation.

2021 and 2026 Scenarios have the following projects represented in each base year:

- All projects from the 2017 scenario plus:
  - A Capacitor Bank transferred from Morenci substation To Dos Condados substation.
  - A new 115 kV line between AEPCO's Valencia substation and Central Arizona Project's (CAP) Black Mountain substation.
  - A new 115 kV line between AEPCO's Marana substation to AEPCO's Thornydale substation to Arizona Public Service's (APS) existing Saguaro substation.
  - A new Tombstone Junction substation with a 230/69 kV transformation to the existing Sulphur Springs Valley Electric Cooperative, Inc. (SSVEC) Tombstone Junction 69 kV substation.
  - Existing APS Boothill substation with a 115/69 kV transformation to feed a 69 kV line to the existing SSVEC Tombstone Junction 69 kV substation.

NEARTERM ASSESSMENT (2017-2021)

2018 Heavy Summer Conditions

The AEPCO 2018 HS base case developed from the WECC approved 2016 HS base case, and coordinated through Southwest Area Transmission (SWAT)-AZ for the 2016 summer seasonal studies, was used as the base model for this projected timeframe. The load levels within the case were adjusted to represent the non-coincidental loads of the Member systems totaling 732.6 MW served by the AEPCO transmission system (not including system losses). Apache Station generation dispatch is at 404.7 MW.

The results are presented below, with an additional tabulation of the results in Appendix E TPL Criteria Violations (for all years). Additional system additions, if needed, are noted in the Mitigation Plans below.

CATEGORY P0 CRITERIA VIOLATIONS AND MITIGATION PLANS

With all lines and facilities in service, the AEPCO system for 2018 heavy summer conditions, meets the requirements and measures of the TPL Standards and does not require any further plans to meet Category P0 criteria.

CATEGORY P1 CRITERIA VIOLATIONS AND MITIGATION PLANS

Voltage Violations:

- Under one P1 outage, there are two buses with a voltage less than 0.90 per unit.

Voltage Deviations:

- Under four P1 outages, there are nine buses with voltage deviations greater than 5%.

Thermal Overloads:

- None.

There were no non-solved cases found on the system under the Category P1 criterion.

Mitigation Plans

The two buses presenting undervoltages below 0.9 p.u. are the Valencia 115 kV and Three Point 115 kV bus. This occurs during the outage of Bicknell to Three Point 115 kV line. This will be mitigated this year by the installation of the 14.4 MVAr capacitor bank at Valencia.

After the installation of the capacitor bank, there are still four buses exhibiting voltage deviation greater than 5%. This will be mitigated the following year when the Valencia – CAP interconnection is finished.

CATEGORY P2 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P2 criteria violations are as follows:

Voltage Violations:
- Under one P2 outage, there is one bus with a voltage less than 0.90 per unit.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

There are no non-solved cases found on the system under the Category P2 criterion.

Mitigation Plans

The one outage causing undervoltages below 0.9 p.u. is the breaker failure of Apache 230 kV breaker #207. The bus presenting undervoltage is Apache 115 kV, this bus will be added to the voltage exception list for being a no-load bus.

CATEGORY P3 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P3 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

Mitigation Plans

No mitigation plans are needed for Category P3 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P4 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P4 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P4 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P5 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P5 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P5 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P6 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P6 criteria violations are as follows:

Voltage Violations:

- Under twelve P6 outages, there are five buses with voltages less than 0.90 per unit.

Voltage Deviations:

- Under twelve P6 outages, there are five buses with voltage deviations greater than 10%.

Thermal Overloads

- Under three P6 outages, there are two transmission elements that exceeded their emergency rating.

There were six non-solved cases found on the system under the Category P6 criterion.

Mitigation Plans

The five buses exhibiting voltages less than 0.90 per unit are the Valencia 115 kV, Avra 115 kV, Sandario 115 kV, Three Point 115 kV, and Marana 115 kV.

Low voltages at Valencia 115 kV, Avra 115 kV, Sandario 115 kV, Three Point 115 kV, Marana 115 kV buses occur in the presence of several double contingences. This will be mitigated by adding a new capacitor bank at Valencia substation.

After the installation of the 14.4 MVAr capacitor bank at Valencia no undervoltages nor voltage deviation are seen for this year.

The overload of AEPCO Greenlee 345/230 kV transformer occurs for loss of Tucson Electric Power Company (TEP) Winchester to Willow 345 kV line along with either the Freeport McMoran Inc. (FMI) Greenlee to Copper Verde 345 kV line or the loss of the TEP Spring to Vail 345 kV line. Mitigation would be the responsibility of TEP and FMI.

The overload of one of AEPCO's Bicknell 230/115 kV transformer occurs for the loss of the second AEPCO's Bicknell 230/115 kV transformer and the loss of the Marana group outage. Mitigation will be accomplished by shedding load.

The first non-solved case occurs with the loss of the Apache to Butterfield 230 kV line along with the Marana group outage. This will be mitigated by shedding load.

In order to mitigate the remaining five non-solved cases, which involve the loss of the Bicknell 345/230 kV transformer, along with the loss of either the Marana Group, the Pantano to New Tucson 230 kV line, the New Tucson to Sahuarita 230 kV line, Sahuarita to Bicknell 230 kV line or the Apache to Butterfield 230 kV line, it will be necessary to shed load or to add a second transformer at Bicknell to bring post contingency voltages and thermal loading within the Category P6 criterion.

CATEGORY P7 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P7 criteria violations are as follows:

Voltage Violations:

- Under one P7 outages, there are two buses with voltages less than 0.90 per unit.

Voltage Deviations:

- Under one P7 outages, there are two buses with voltage deviations greater than 10%.

Thermal Overloads:

- None.

Mitigation Plans

The two buses exhibiting voltage under 0.9 p.u and voltage deviation greater than 10% are the Valencia 115 kV and the Three Point 115 kV. This is mitigated after the new capacitor bank of 14.4 MVAr is installed at Valencia 115 kV bus.

REACTIVE MARGIN

The Q-V analysis for reactive margin performed for this study year can be found in Appendix F.

TRANSIENT STABILITY

The transient stability analyses performed for this study year can be found in Appendix G. Various P1, P2, P4 and P6 outage conditions were analyzed.

Some stability runs for 2016 HS conditions were performed for various contingencies that did not solve, such as the P6 loss of the Apache to Butterfield 230 kV line, along with loss of the Bicknell 345/230 kV transformer. The plots for these outages reveal a need to shed load as a means of mitigation and to consider the need for a second Bicknell 345/230 kV transformer or one of larger MVA capacity.

It should also be noted that outages that did not meet the Standards for stability will not result in system-wide cascading.

2021 Heavy Summer Conditions

The 2021 HS AEPCO base case developed from the WECC approved 2021 HS base case, and coordinated through SWAT-AZ, was used as the base model for this projected timeframe. The load levels within the case were adjusted to represent the non-coincidental loads of the Member systems totaling 782 MW served by AEPCO transmission (not including system losses). Apache Station generation dispatch is at 368.42 MW.

There are no system additions represented in this base year. These results are discussed below.

CATEGORY P0 CRITERIA VIOLATIONS AND MITIGATION PLANS

With all lines and facilities in service, the AEPCO system for 2021 HS conditions meets the requirements and measures of the TPL Standards and does not require any further plans to meet Category P0 criteria.

CATEGORY P1 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P1 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

There were three non-solved cases found on the system under the Category P1 criterion.

Mitigation Plans

The three non-solved cases are caused by the outages of the Bicknell to Three Point 115 kV line, the Marana to Marana Tap 115 kV line and the Marana group. These cases will be mitigated with the inclusion of the Valencia – CAP interconnection and the Marana interconnection to Thornydale and Saguaro.

CATEGORY P2 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P2 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

There are three non-solved cases found on the system under the Category P2 criterion.

Mitigation Plans

The three non-solved cases occurs with the failure of the Bicknell breaker #203, #205 and the main bus fault at Bicknell substation. These cases will be mitigated with the inclusion of the Valencia – CAP interconnection and the Marana interconnection to Thornydale and Saguaro and the second 345/230 kV transformer at Bicknell.

CATEGORY P3 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P3 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P3 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P4 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P4 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P4 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P5 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P5 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

Mitigation Plans

No mitigation plans are needed for Category P5 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P6 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P6 criteria violations are as follows:

Voltage Violations:
- Under one P6 outages, there are four buses with voltages less than 0.90 per unit.

Voltage Deviations:
- Under one P6 outages, there are three buses with voltage deviation greater than 10%.

Thermal Overloads:
- Under three P6 outages, there are two transmission elements that exceeded their emergency ratings.

There were thirty-four non-solved cases found on the system under the Category P6 criterion.

Mitigation Plans

The four buses with voltages under 0.9 per unit are the Avra 115 kV, the Three Point 115 kV, Valencia 115 kV and Sandario 115 kV. All these buses but Three Point 115 kV also presented a voltage deviation greater than 10%.

The overload of the AEPCO Greenlee 345/230 kV transformer and the Bicknell 345/230 kV transformer are mitigated with the installation of a second transformer on each of the locations. This is accomplished by the FMI project.

After the Valencia – CAP interconnection, the Marana-Thornydale- Saguaro interconnection and the second 345/230 kV transformer at Bicknell are in place, all voltages deviation greater than 10%, voltages less than 0.9 per unit and 33 of the 34 non-solved cases are mitigated. The non-solved cases remaining that occurs with the outage of the Springville to Vail 345 kV line and the Pinal West to South 345 kV line must be mitigated by TEP.

CATEGORY P7 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P7 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

Mitigation Plans

No mitigation plans are needed for Category P7 voltage violations and thermal overloads on the AEPCO system.

REACTIVE MARGIN

The Q-V analysis for reactive margin performed for this study year can be found in Appendix F.

TRANSIENT STABILITY

The transient stability analyses performed for this Assessment can be found in Appendix G. Various P1, P2, P4 and P6 outage conditions were analyzed. It should also be noted that outages that did not meet the Standards for stability will not result in system-wide cascading.

2021 Heavy Winter Conditions

The 2021 HW AEPCO base case developed from the WECC approved 2021 HW base case, and coordinated through SWAT-AZ, was used as the base model for this projected timeframe. The load levels within the case were adjusted to represent the non-coincidental loads of the Member systems (excluding Anza) totaling 418.8 MW served by AEPCO transmission (not including system losses). Apache Station generation dispatch is at 182.7 MW.

There were no system additions represented in this base year.

CATEGORY P0 CRITERIA VIOLATIONS AND MITIGATION PLANS

With all lines and facilities in service, the AEPCO system for 2025 summer conditions meets the requirements and measures of the TPL Standards and does not require any further plans to meet Category P0 criteria.

CATEGORY P1 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P1 criteria violations are as follows:

Voltage Violations:
- None

Voltage Deviations:
- None.

Thermal Overloads:
- None.

There were no non-solved cases found on the system under the Category P1 criterion.

Mitigation Plans

No mitigation plans are needed for Category P1 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P2 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P2 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:

- None.

There were no non-solved cases found on the system under the Category P2 criterion.

Mitigation Plans:

No mitigation plans are needed for Category P2 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P3 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P3 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P3 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P4 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P4 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P4 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P5 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P5 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

Mitigation Plans

No mitigation plans are needed for Category P5 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P6 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P6 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- Under one P6 outage, there is one transmission elements that exceeded their emergency ratings.

There was one non-solved case found on the system under the Category P6 criterion.

Mitigation Plans

The transmission element overloading is the Three Point to Sandario 115 kV line, this occurs in presence of the outage of the 345/230 kV Bicknell transformer along with the Pantano to Sahuarita 230 kV line. This will be mitigated by the FMI project, adding a second 345/230 kV transformer at Bicknell.

The one non-solved case occurs during the outage of the 345/230 kV Bicknell transformer along with the Apache to Butterfield 230 kV line. This will be mitigated by the FMI Project, adding a second 345/230 kV transformer at Bicknell.

CATEGORY P7 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P7 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

Mitigation Plans

No mitigation plans are needed for Category P7 voltage violations and thermal overloads on the AEPCO system.

REACTIVE MARGIN

The Q-V analysis for reactive margin performed for this study year can be found in Appendix F.

TRANSIENT STABILITY

The transient stability analyses performed for this study year can be found in Appendix G. Various P1, P2, P4, and P6 outage conditions were analyzed.

It should also be noted that outages that did not meet the Standards for stability will not result in system-wide cascading.

LONG TERM ASSESSMENT (2021-2025)

2026 Heavy Summer Conditions

The 2026 HS base case developed from the WECC approved 2026 HS base case, and coordinated through SWAT-AZ was used as the base model for this projected timeframe. The load levels within the case were adjusted to represent approximately 100% of the peak non-coincidental summer peak loads of the Member systems (excluding Anza) totaling 885.7 MW served by AEPCO transmission (not including system losses). Apache Station generation dispatch is at 550 MW.

There were no system additions represented in this base year.

CATEGORY P0 CRITERIA VIOLATIONS AND MITIGATION PLANS

With all lines and facilities in service, the AEPCO system for 2026 HS conditions, meets the requirements and measures of the TPL Standards and does not require any further plans to meet Category P0 criteria.

CATEGORY P1 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P1 criteria violations are as follows:

Voltage Violations:
- None.

Voltage Deviations:
- None.

Thermal Overloads:
- None.

There were two non-solved cases found on the system under the Category P1 criterion.

Mitigation Plans

The two non-solved cases occur during the Bicknell to Three Point 115 kV line outage and the Marana group outage. These cases will be mitigated with the Valencia – CAP and the Marana-Thornydale-Saguaro interconnection and the FMI projects in place.

CATEGORY P2 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P2 violations are as follows:

Voltage Violations:
- Under two P2 outages, there are three buses with voltages less than 0.9 per unit.

Voltage Deviations:

- None

Thermal Overloads:

- None

There was one non-solved case found on the system under the Category P2 criterion.

Mitigation Plans

The buses presenting voltages less than 0.9 per unit are Marana 115 kV, Marana tap 115 kV and Avra 115 kV. This occurs for the opening of the Marana tap to Rattlesnake 115 kV and the Rattlesnake to Tucson 115 kV line section.

The non-solved case occurs for the opening of the Marana to Marana tap 115 kV line section.

The non-solved and the voltage violations cases will be mitigated with the Valencia – CAP and the Marana-Thornydale-Saguaro interconnection and the FMI projects in place.

CATEGORY P3 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P3 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P3 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P4 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P4 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P4 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P5 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P5 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P5 voltage violations and thermal overloads on the AEPCO system.

CATEGORY P6 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P6 criteria violations are as follows:

Voltage Violations:

- Under four P6 outages, there are five buses with voltages below 0.90 per unit.

Voltage Deviations:

- None.

Thermal Overloads:

- Under three P6 outages, there are two transmission element that exceeded its emergency rating.

There are thirty-five non-solved cases found on the system under the Category P6 criterion.

Mitigation Plans

One of the two overloaded transmission elements is the AEPCO Greenlee 345/230 kV transformer, for loss of the TEP Greenlee to Winchester 345 kV line along with the TEP Springville to Vail 345 kV line. This must be mitigated by TEP.

The five buses with voltages less than 0.9 per unit are Valencia 115 kV, Marana 115 kV, Marana tap 115 kV, Avra 115 kV and Three Point 115 kV. The outages casing these voltage violation are TEP's lines.

These will be mitigated with the Valencia – CAP and the Marana-Thornydale-Saguaro interconnection and the FMI projects in place.

CATEGORY P7 CRITERIA VIOLATIONS AND MITIGATION PLANS

The Category P7 criteria violations are as follows:

Voltage Violations:

- None.

Voltage Deviations:

- None.

Thermal Overloads:

- None.

Mitigation Plans

No mitigation plans are needed for Category P7 voltage violations and thermal overloads on the AEPCO system.

REACTIVE MARGIN ANALYSIS

Q-V Analyses for reactive margin was performed for the interconnected AEPCO transmission system for HS and HW conditions for the years 2018, 2021, and 2026. Q-V curve graphs for selected buses can be found in Appendix D.

STABILITY ANALYSIS

Transient stability analyses was performed for the interconnected AEPCO transmission system for HS and HW conditions for the years 2018, 2021, and 2026, using the cases listed in the Power Flow Analyses section above.

A representative sample of P1 and P6 outage conditions were selected for inclusion in this report.

The outages considered in this report are as follows:

P1 Outage conditions:

- Apache to Butterfield 230 kV line.
- Apache to Redtail 230 kV line.
- Bicknell to Vail 345 kV line.
- Saguaro East to Marana 115 kV line.

P6 Outage Conditions:

- Apache to Butterfield 230 kV and Saguaro East to Marana Tap 115 kV.
- Apache to Butterfield 230 kV and Bicknell to Vail 345 kV.

Under HS conditions, the P6 outage of Apache to Butterfield 230 kV and Bicknell to Vail 345 kV lines did not solve. For this double-contingency, operating procedures are in place to curtail load.

These selected stability plots can be found in Appendix E.

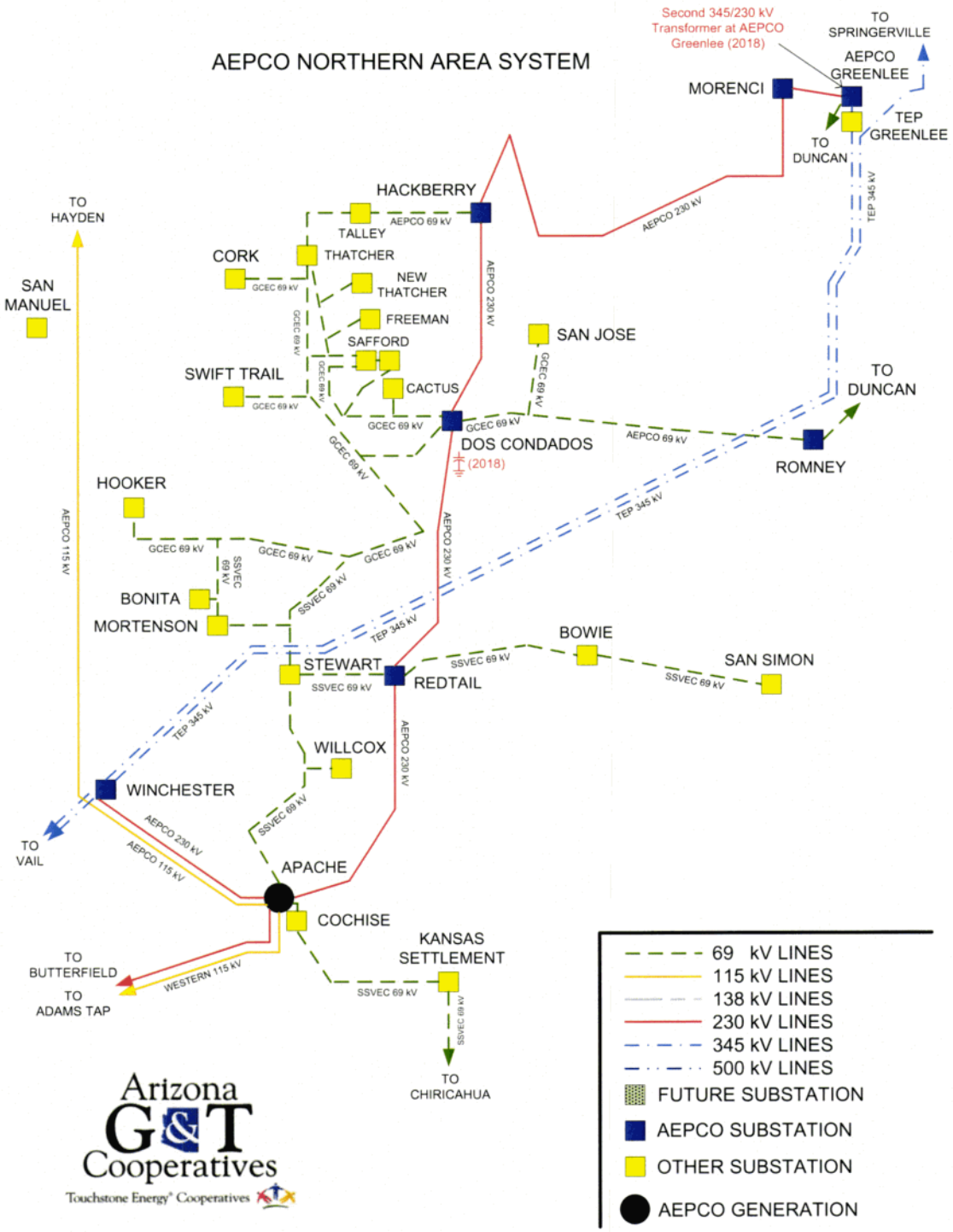
ARIZONA ELECTRIC POWER COOPERATIVE, INC.

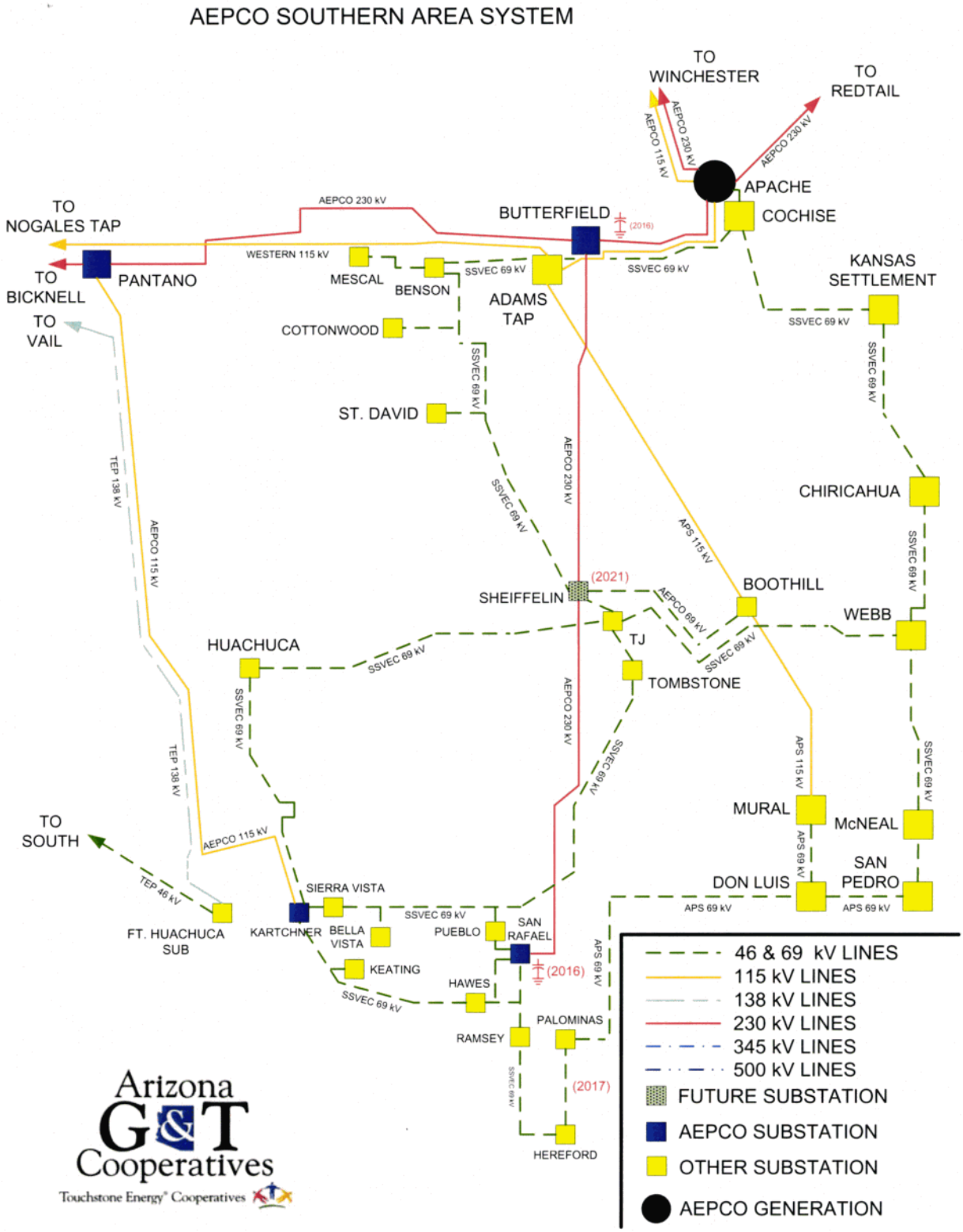
TEN-YEAR PLAN

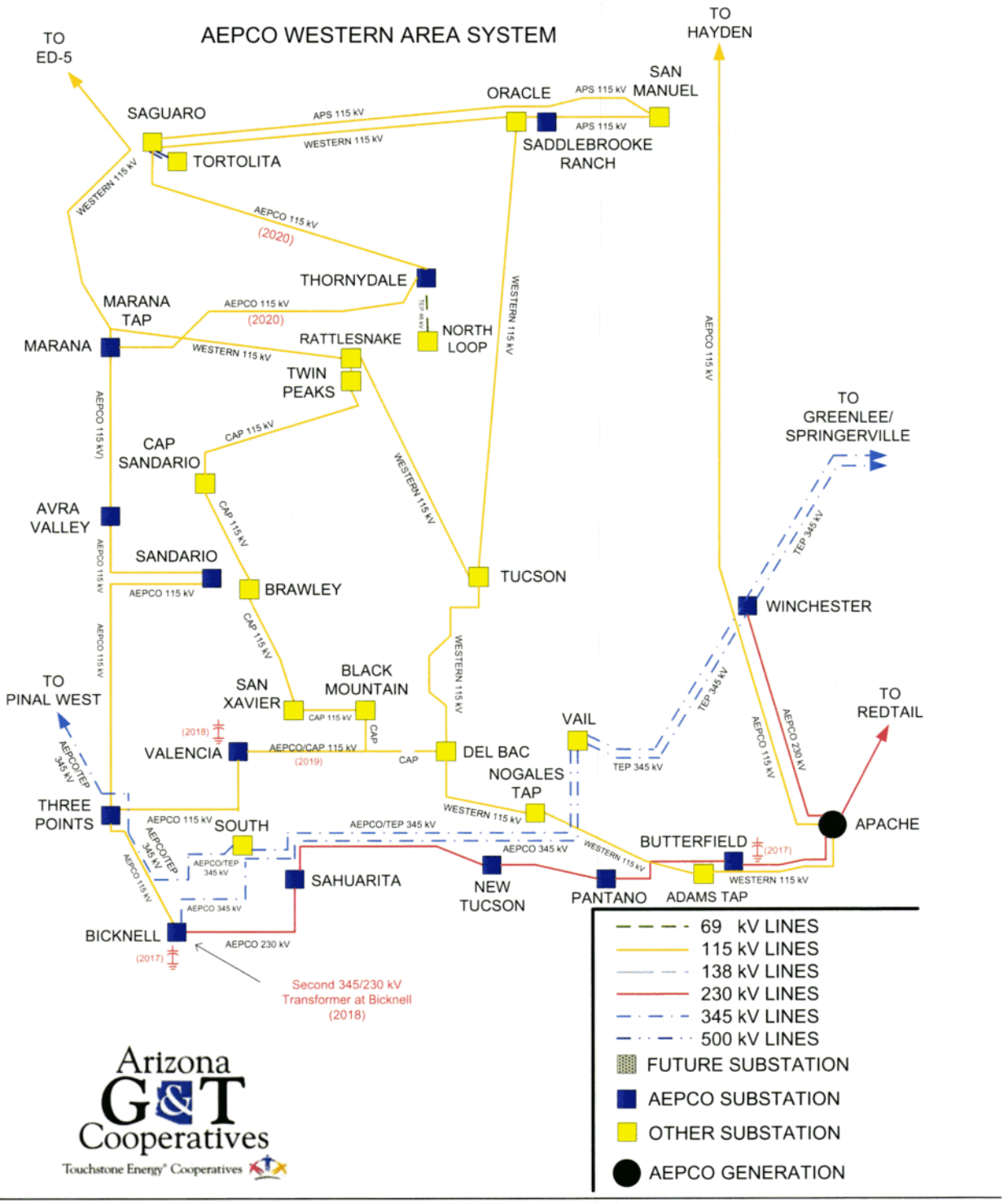
2017 – 2026

TECHNICAL STUDY REPORT APPENDICES

APPENDIX A: Current and Planned Transmission System Maps



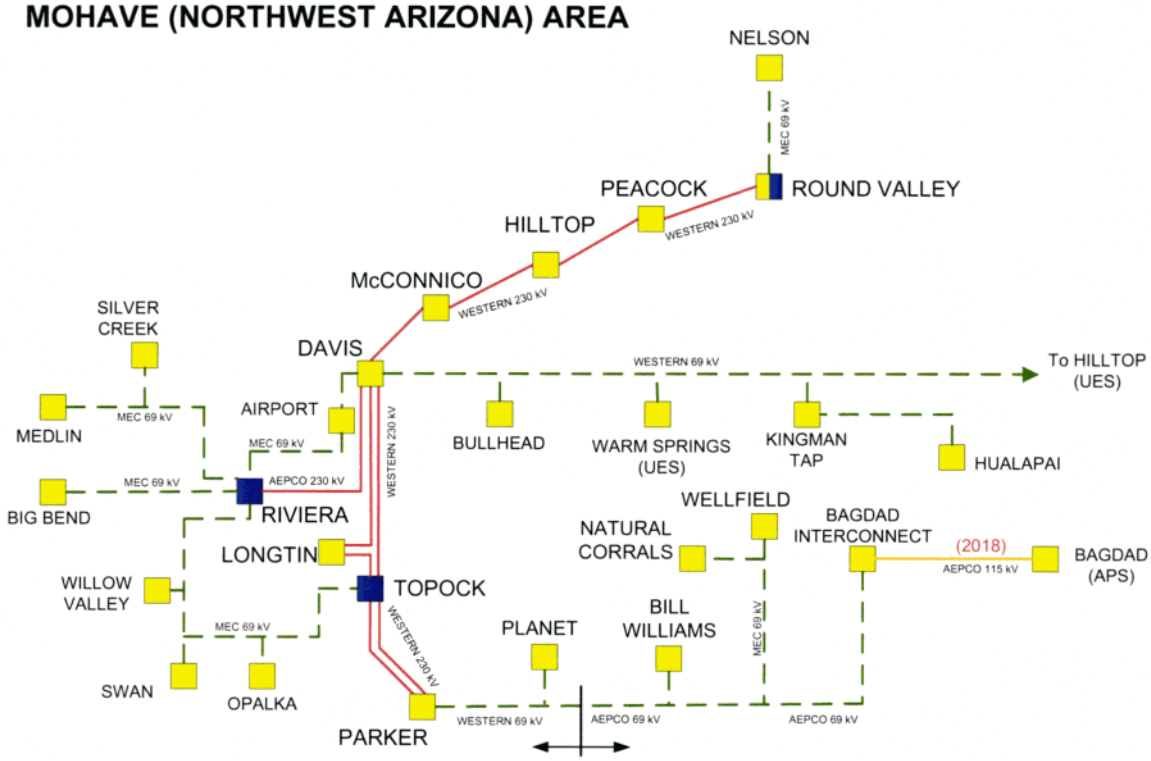

AEPCO SOUTHERN AREA SYSTEM
TO WINCHESTER
TO REDTAIL
AEPCO 115 kV
AEPCO 230 kV
AEPCO 230 kV
APACHE
COCHISE
TO NOGALES TAP
AEPCO 230 kV
BUTTERFIELD
(2016)
WESTERN 115 kV
MESCAL
BENSON
SSVEC 69 kV
SSVEC 69 kV
ADAMS TAP
KANSAS SETTLEMENT
SSVEC 69 kV
TO BICKNELL
PANTANO
TO VAIL
COTTONWOOD
SSVEC 69 kV
SSVEC 69 kV
ST. DAVID
TEP 138 kV
AEPCO 230 kV
CHIRICAHUA
SSVEC 69 kV
AEPCO 115 kV
APS 115 kV
(2021)
SHEIFFELIN
BOOTHILL
AEPCO 69 kV
WEBB
SSVEC 69 kV
SSVEC 69 kV
HUACHUCA
TJ
TOMBSTONE
SSVEC 69 kV
AEPCO 230 kV
SSVEC 69 kV
TEP 138 kV
APS 115 kV
SSVEC 69 kV
MURAL
McNEAL
TO SOUTH
AEPCO 115 kV
APS 69 kV
SAN PEDRO
TEP 46 kV
SIERRA VISTA
DON LUIS
APS 69 kV
APS 69 kV
SSVEC 69 kV
FT. HUACHUCA SUB
KARTCHNER
BELLA VISTA
PUEBLO
SAN RAFAEL
(2016)
APS 69 kV
KEATING
HAWES
SSVEC 69 kV
PALOMINAS
RAMSEY
(2017)
SSVEC 69 kV
HEREFORD
Arizona G&T Cooperatives
Touchstone Energy® Cooperatives
46 & 69 kV LINES
115 kV LINES
138 kV LINES
230 kV LINES
345 kV LINES
500 kV LINES
FUTURE SUBSTATION
AEPCO SUBSTATION
OTHER SUBSTATION
AEPCO GENERATION

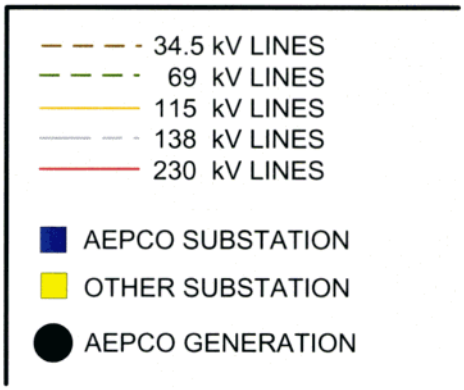

AEPCO WESTERN AREA SYSTEM
TO ED-5
TO HAYDEN
SAGUARO
TORTOLITA
ORACLE
SAN MANUEL
SADDLEBROOKE RANCH
APS 115 kV
WESTERN 115 kV
AEPCO 115 kV (2020)
THORNYDALE
MARANA TAP
MARANA
RATTLESNAKE
NORTH LOOP
TWIN PEAKS
CAP SANDARIO
AVRA VALLEY
SANDARIO
BRAWLEY
TUCSON
TO GREENLEE/ SPRINGERVILLE
TEP 345 kV
WINCHESTER
TO REDTAIL
AEPCO 230 kV
APACHE
TO PINAL WEST
SAN XAVIER
BLACK MOUNTAIN
CAP 115 kV
CAP
VALENCIA
(2018)
AEPCO/CAP 115 kV
(2019)
DEL BAC
VAIL
NOGALES TAP
AEPCO/TEP 345 kV
THREE POINTS
SOUTH
AEPCO 115 kV
AEPCO/TEP 345 kV
AEPCO 345 kV
SAHUARITA
NEW TUCSON
PANTANO
BUTTERFIELD
(2017)
ADAMS TAP
WESTERN 115 kV
BICKNELL
(2017)
AEPCO 230 kV
Second 345/230 kV Transformer at Bicknell (2018)
69 kV LINES
115 kV LINES
138 kV LINES
230 kV LINES
345 kV LINES
500 kV LINES
FUTURE SUBSTATION
AEPCO SUBSTATION
OTHER SUBSTATION
AEPCO GENERATION
Arizona G&T Cooperatives
Touchstone Energy® Cooperatives

AEPCO CALIFORNIA & NORTHWEST ARIZONA AREA SYSTEMS

ANZA (CALIFORNIA) AREA

MOHAVE (NORTHWEST ARIZONA) AREA





Arizona G&T Cooperatives
Touchstone Energy® Cooperatives

APPENDIX B: 2016-2025 Contingency List

The following contingency list was used for all cases of this Assessment.

Contingency 1 represents loss of the Adams Tap to Apache, Adams Tap to Nogales and the Adams to Adams Tap 115 kV lines, which are considered as a P1. It is referred to as the Adams Group.

Contingency 2 represents the loss of various line segments related to the CAP system, south of Rattlesnake and is referred to as the CAP Group.

Contingencies 3 – 20 represent various breaker failure and main bus fault scenarios (P2).

Contingencies 21 – 28 represent common ROW or adjacent transmission circuit outages as defined by NERC for Category P6 conditions.

Contingencies 29 – 105 represent P1 outage scenarios.

Contingencies 106 – 297 represent P6 outage scenarios.

Contingencies 298 – 303 represent various P1 and P6 outage scenarios which were chosen for the purposes of running voltage and transient stability plots.

Contingencies 304 – 314 represent various P4 outage scenarios which were run with voltage and transient stability plots.

Contingency 315 represents the only P7 on the AEPCO system.

1) **Adams_Group,P1-2:** ADAMSTAP115, APACHE115 | ADAMSTAP115, NOGALES,115 | ADAMS115, ADAMSTAP,115
2) **CAP_Group,P1-2:** RATTLSNK,115, TWINPEAK,115 | TWINPEAK,115, SANDARIO,115 | SANDARIO,115, BRAWLEY,115 | BRAWLEY,115, SANXAVER,115 | SANXAVER,115, SNYDHILL,115 | BLACKMTN,115, SNYDHILL,115
3) **Breaker_APA201,P2-3:** APACHE,230,17030,APACHST3,20 | APACHE,230, APACHE,115
4) **Breaker_APA202,P2-3:** APACHE,230, APACHST3,20 | APACHE,230, REDTAIL,230
5) **Breaker_APA204,P2-3:** APACHE,230, APACHST2,20,
6) **Breaker_APA205,P2-3:** APACHE,230 APACHST2,20 | APACHE,230, WINCHSTR,230,1 ,0
7) **Breaker_APA207,P2-3:** APACHE,230, APACHE,115 | APACHE,230, APACHE,115
8) **Breaker_APA210,P2-3:** APACHE,230, APACHCT4,13.8
9) **Breaker_APA211,P2-3:** APACHE,230, APACHCT4,13.8| APACHE,230, APACHE,115
10) **MainBusFault_APA115,P2-2:** APACHE,230, APACHE,115 | APACHE,230, APACHE,115 | APACHE,115, APACHST1,13.8 | APACHE,115,17026,APACHCT3,13.8 | APACH-SW,69, APACHE,115 | ADAMSTAP,115,APACHE,115 | ADAMSTAP,115, NOGALES,115 | ADAMS,115, ADAMSTAP,115 | APACHE,115, HAYDENAZ,115
11) **Breaker_BICK202,P2-3:** BICKNELL,230, BICKNELL,115 | BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
12) **Breaker_BICK203,P2-3:** BICKNELL,230, BICKNELL,115 | BICKNELL,230, BICKNELL,115

13) **Breaker_BICK204,P2-3:** BICKNELL,230, BICKNELL,115 | SAHUARIT,230, BICKNELL,230
14) **Breaker_BICK205,P2-3**SAHUARIT,230, BICKNELL,230 | BICKNELL,345,VAIL,345| BICKNELL,345, BICKNELL,230
15) **MainBusFault_BICK115,P2-2:** BICKNELL,69, BICKNELL,115 | BICKNELL,24.9, BICKNELL,115 | BICKNELL,230, BICKNELL,115 | BICKNELL,230, BICKNELL,115 | BICKNELL,115, THREEPNT,115 | BICKNELL,115, FP
16) **Breaker_BUTE230,P2-3:** APACHE,230, BUTERFLD,230 | BUTERFLD,230, PANTANO,230 | BUTERFLD,230, SAN RAF,230 | BUTERFLD,230, TOMB JCT,230,1,0
17) **Breaker_PANT230,P2-3:** BUTERFLD,230, PANTANO,230 | PANTANO,230, NEWTUCSN,230 | PANTANO,230, PANTANO,115
18) **Breaker_RED230,P2-3:** APACHE,230, RED TAIL,230 | RED TAIL,230, DOSCONDO,230
19) **Breaker_WINC230,P2-3:** WINCHSTR,345, WINCHSTR,230 | WINCHSTR,345, VAIL,345 | WINCHSTR,345, WILLOW,345
20) **Breaker_WINC230_2,P2-3:** WINCHSTR,345, WINCHSTR,230 | WINCHSTR,345, VAIL,345 | WINCHSTR,345, VAIL,345 | WINCHSTR,345, GREENLEE,345
21) **CommonROW_1,P6-1-1:** GREENLEE,345, COPPERVR,345 | MORENCI,230, GREEN-SW,230
22) **CommonROW_2,P6-1-1:** BUTERFLD,230, PANTANO,230 | ADAMSTAP,115, APACHE,115| ADAMSTAP,115, NOGALES,115 | ADAMS,115, ADAMSTAP,115
23) **CommonROW_3,P6-1-1:**APACHE,230, BUTERFLD,230 | ADAMSTAP,115, APACHE,115 | ADAMSTAP,115, NOGALES,115 | ADAMS,115, ADAMSTAP,115
24) **CommonROW_4,P6-1-1:**APACHE,230, BUTERFLD,230 | APACHE,115, HAYDENAZ,115
25) **CommonROW_5,P6-1-1:** VAIL,345, ,SOUTH,345| NEWTUCSN,230, SAHUARIT,230
26) **CommonROW_6,P6-1-1:** PINALWES,345, SOUTH,345 | BICKNELL,115, THREEPNT,115
27) **CommonROW_7,P6-1-1:** PINALWES,345, SOUTH,345 | THREEPNT,115, SNDARIO,115
28) **CommonROW_8,P6-1-1:** APACHE,230, BUTERFLD,230 | APACHE,230, WINCHSTR,230
29) **APAC115HAYD115,P1-2:** APACHE,115, HAYDENAZ,115
30) **APAC230APAC115,P1-3:** APACHE,230, APACHE,115
31) **APAC230APAC115,P1-3:** APACHE,230, APACHE,115
32) **APAC230WINC230,P1-2:** APACHE,230,WINCHSTR,230
33) **WINC345WINC230,P1-3:** WINCHSTR,345, WINCHSTR,230
34) **WINC345VAIL345,P1-2:** WINCHSTR,345, VAIL,345 | WINCHSTR,345, VAIL,345
35) **GREE345COPP345,P1-2:**GREENLEE,345, COPPERVR,345
36) **GREE345GREE345,P1-2:** GREEN-SW,345, GREENLEE,345
37) **SPRI345GREE345,P1-2:** SPRINGR,345, GREENLEE,345 | SPRINGR,345,GREENLEE,345
38) **BUTE230PANT230,P1-2:** BUTERFLD,230, PANTANO,230
39) **RED 230DOSC230,P1-2:** RED TAIL,230, DOSCONDO,230
40) **DOSC230HACK230,P1-2:** DOSCONDO,230, HACKBERY,230
41) **HACK230MORE230,P1-2:** HACKBERY,230, MORENCI,230
42) **MORE230GREE230,P1-2:** MORENCI,230, GREEN-SW,230
43) **GREE345GREE230,P1-3:** GREEN-SW,345, GREEN-SW,230
44) **PANT230NEWT230,P1-2:** PANTANO,230, NEWTUCSN,230
45) **PANT230PANT115,P1-3:** PANTANO,230, PANTANO,115
46) **NEWT230SAHU230,P1-2:** NEWTUCSN,230, SAHUARIT,230
47) **SAHU230BICK230,P1-2:** SAHUARIT,230, BICKNELL,230
48) **PANT115KART115,P1-2:** PANTANO,115, KARTCHNR,115
49) **VAIL345SOUT345,P1-2:** VAIL,345, SOUTH,345
50) **BICK345BICK230,P1-3:** BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
51) **PINA345SOUT345,P1-2:** PINALWES,345, SOUTH,345
52) **PINA500PINA345,P1-3:** PINAL_W,500, PINALWES,345
53) **WEST345PINA345,P1-2:** WESTWING,345, PINALWES,345
54) **WEST500WEST345,P1-3:**WESTWING,500, WESTWING,345
55) **BICK230BICK115,P1-3:** BICKNELL,230 ,BICKNELL,115
56) **BICK230BICK115,P1-3:** BICKNELL,230, BICKNELL,115
57) **BICK115THRE115,P1-2:** BICKNELL,115, THREEPNT,115
58) **THRE115SNDA115,P1-2:** THREEPNT,115, SNDARIO,115
59) **THRE115VALE115,P1-2:** THREEPNT,115, VALEN-SW,115

60) **AVRA115SNDA115,P1-2:** AVRA,115, SNDARIO,115
61) **MARA115AVRA115,P1-2:** MARANA,115, AVRA,115,
62) **SPRI345VAIL345,P1-2:** SPRINGR,345, VAIL2,345**:** SPRINGR,345, VAIL2,345
63) **SAG.115SAG.115,P1-2:** SAG.EAST,115, SAG.WEST,115
64) **SAG.115ORAC115,P1-2:** SAG.EAST,115, ORACLE,115
65) **SAGU500SAG.115,P1-3:** SAGUARO,500, SAG.EAST,115
66) **SAGU500SAG.115,P1-3:** SAGUARO,500, SAG.WEST,115
67) **SAGU230SAG.115,P1-3:** SAGUARO,230, SAG.EAST,115
68) **SAGU230SAG.115,P1-3:** SAGUARO,230, SAG.WEST,115
69) **ORAC115ORAC115,P1-2:** ORACLE,115, ,ORACLEAZ,115
70) **ORAC115S.BR115,P1-2:** ORACLE,115, S.BRKRCH,115
71) **TUCS115ORAC115,P1-2:** TUCSON,115, ORACLE,115
72) **SAG.115SNMA115,P1-2:** SAG.WEST,115, SNMANUEL,115
73) **S.BR115SNMA115,P1-2:** S.BRKRCH,115, SNMANUEL,115
74) **SAG.115THRN115,P1-2:** SAG.EAST,115, THRNYDLE,115
75) **THRN115TWIN115,P1-2:** THRNYDLE,115, TWINPEAK,115
76) **SNDA115BRAW115,P1-2:** SNDARIO,115, BRAWLEY,115
77) **VALE115BLAC115,P1-2:** VALEN-SW,115, BLACKMTN,115
78) **SAGU500TORT500,P1-2:** SAGUARO,500, TORTOLIT,500
79) **SAGU500TORT500,P1-2:** SAGUARO,500,16000,TORTOLIT,500
80) **VAIL345VAIL138,P1-3:** VAIL,345, VAIL,138
81) **VAIL345VAIL138,P1-3:** VAIL2,345, VAIL,138
82) **BUTE230SAN 230,P1-2:** BUTERFLD,230, SAN RAF,230
83) **BUTE230TOMB230,P1-2:** BUTERFLD,230, TOMB JCT,230
84) **TOMB230SAN 230,P1-2:** TOMB JCT,230, SAN RAF,230
85) **TOMB69TOMB230,P1-3:** TOMB JCT,69, TOMB JCT,230
86) **COPP345COPP230,P1-3:** COPPERVR,345, COPPERVR,230
87) **COPP345COPP230,P1-3:** COPPERVR,345, COPPERVR,230
88) **COPP230FRIS230,P1-2:** COPPERVR,230, FRISCO,230
89) **PD-M230FRIS230,P1-2:** PD-MORNC,230, FRISCO,230
90) **PINA500DUKE500,P1-2:** PINAL_C,500, DUKE,500
91) **PINA500DUKE500,P1-2:** PINAL_W,500, DUKE,500
92) **GREE345WILL345,P1-2:** GREENLEE,345, WILLOW,345,
93) **GREE345WINC345_2,P1-2:** GREENLEE,345, WIINCHESTER,345
94) **WINC345WILL345,P1-2:** WINCHSTR,345, WILLOW,345
95) **WINC345WILL345_2,P1-2:** WINCHSTR,345, GREENLEE,345
96) **ADAMTP115APAC115,P2-1:** ADAMSTAP,115, APACHE,115
97) **ADAMTP115NOGA115, P2-1:** ADAMSTAP,115, NOGALES,115
98) **ADAM115ADAMTP115, P2-1:** ADAMS,115, ADAMSTAP,115
99) **MARATP115MARA115, P2-1:** MARANATP,115, MARANA,115
100) **ED5115MARATP115, P2-1:** ED5,115, MARANATP,115
101) **MARA1TP15RSNK115, P2-1:** MARANATP,115, RATTLSNK,115
102) **RSNK115TUCS115, P2-1:** RATTLSNK,115, TUCSON,115
103) **ADAM115BOOTHILL115,P1-2:** ADAMS,115, BOOTHILL,115
104) **BOOTHILL115MURAL115,P1-2:** BOOTHILL,115, MURAL,115
105) **BOOTHILL115BOOTHILL69,P1-3:** BOOTHILL,69, BOOTHILL,115
106) **APAC230BUTE230 | APAC230RED 230,P6-1-1:**
APACHE,230, BUTERFLD,230 | APACHE,230RED TAIL,230
107) **APAC230BUTE230 | WINC345WINC230,P6-1-2:**
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108) **APAC230BUTE230 | WINC345WILL345,P6-1-1:**
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109) **APAC230BUTE230 | WINC345GREE345,P6-1-1:**
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110) **APAC230BUTE230 | WINC345VAIL345,P6-1-1:**
APACHE,230 BUTERFLD,230 | WINCHSTR,345, VAIL,345

111) APAC230BUTE230 | GREE345COPP345,P6-1-1:
APACHE,230, BUTERFLD,230 | GREENLEE,345, COPPERVR,345
112) APAC230BUTE230 | SPRI345GREE345,P6-1-1:
APACHE,230, BUTERFLD,230 | SPRINGR,345, GREENLEE,345
113) APAC230BUTE230 | HACK230MORE230,P6-1-1:
APACHE,230, BUTERFLD,230 | HACKBERY,230, MORENCI,230
114) APAC230BUTE230 | GREE345GREE230,P6-1-2:
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115) APAC230BUTE230 | SAHU230BICK230,P6-1-1:
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118) APAC230BUTE230 | BICK115THRE115,P6-1-1:
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120) APAC230BUTE230 | AVRA115SNDA115,P6-1-1:
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121) APAC230BUTE230 | MARA115AVRA115,P6-1-1:
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122) APAC230BUTE230 | SPRI345VAIL345,P6-1-1:
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124) APAC230RED 230 | WINC345WINC230,P6-1-2:
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125) APAC230RED 230 | WINC345WILL345,P6-1-1:
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126) APAC230RED 230 | WINC345GREE345,P6-1-1:
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127) APAC230RED 230 | WINC345VAIL345,P6-1-1:
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128) APAC230RED 230 | GREE345COPP345,P6-1-1:
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129) APAC230RED 230 | SPRI345GREE345,P6-1-1:
APACHE,230, RED TAIL,230 | SPRINGR,345, GREENLEE,345
130) APAC230RED 230 | HACK230MORE230,P6-1-1:
APACHE,230, RED TAIL,230 | HACKBERY,230, MORENCI,230,1,0
131) APAC230RED 230 | GREE345GREE230,P6-1-2:
APACHE,230, RED TAIL,230 | GREEN-SW,345, GREEN-SW,230
132) APAC230RED 230 | SAHU230BICK230,P6-1-1:
APACHE,230, RED TAIL,230 | SAHUARIT,230, BICKNELL,230
133) APAC230RED 230 | VAIL345SOUT345,P6-1-1:
APACHE,230, RED TAIL,230 | VAIL,345, SOUTH,345
134) APAC230RED 230 | BICK345BICK230,P6-1-2:
APACHE,230, RED TAIL,230 | BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
135) APAC230RED 230 | BICK230BICK115,P6-1-1:
APACHE,230, RED TAIL,230 | BICKNELL,230, BICKNELL,115
136) APAC230RED 230 | BICK115THRE115,P6-1-1:
APACHE,230, RED TAIL,230 | BICKNELL,115, THREEPNT,115
137) APAC230RED 230 | THRE115SNDA115,P6-1-1:
APACHE,230, RED TAIL,230 | THREEPNT,115, SNDARIO,115
138) APAC230RED 230 | AVRA115SNDA115,P6-1-1:
APACHE,230, RED TAIL,230 | AVRA,115, SNDARIO,115

139) APAC230RED 230 | MARA115AVRA115,P6-1-1:
APACHE,230, RED TAIL,230 | MARANA,115, AVRA,115
140) APAC230RED 230 | SPRI345VAIL345,P6-1-1:
APACHE,230, RED TAIL,230 | SPRINGR,345, VAIL2,345
141) APAC230RED 230 | SAG.115MARA115,P6-1-1:
APACHE,230, RED TAIL,230 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
142) APAC230WINC230 | WINC345WINC230,P6-1-2:
APACHE,230, WINCHSTR,230 | WINCHSTR,345, WINCHSTR,230
143) APAC230WINC230 | WINC345WILL345,P6-1-1:
APACHE,230, WINCHSTR,230 |WINCHSTR,345, WILLOW,345
144) APAC230WINC230 | WINC345GREE345,P6-1-1:
APACHE,230, WINCHSTR,230 |WINCHSTR,345, GREENLEE,345
145) APAC230WINC230 | WINC345VAIL345,P6-1-1:
APACHE,230, WINCHSTR,230 | WINCHSTR,345, VAIL,345
146) APAC230WINC230 | GREE345COPP345,P6-1-1:
APACHE,230, WINCHSTR,230 | GREENLEE,345, COPPERVR,345
147) APAC230WINC230 | SPRI345GREE345,P6-1-1:
APACHE,230, WINCHSTR,230| SPRINGR,345, GREENLEE,345
148) APAC230WINC230 | HACK230MORE230,P6-1-1:
APACHE,230, WINCHSTR,230 | HACKBERY,230, MORENCI,230
149) APAC230WINC230 | GREE345GREE230,P6-1-2:
APACHE,230, WINCHSTR,230 | GREEN-SW,345, GREEN-SW,230
150) APAC230WINC230 | SAHU230BICK230,P6-1-1:
APACHE,230, WINCHSTR,230 | SAHUARIT,230, BICKNELL,230
151) APAC230WINC230 | VAIL345SOUT345,P6-1-1:
APACHE,230, WINCHSTR,230 | VAIL,345, SOUTH,345
152) APAC230WINC230 | BICK345BICK230,P6-1-2:
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153) APAC230WINC230 | BICK230BICK115,P6-1-2:
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154) APAC230WINC230 | BICK115THRE115,P6-1-1:
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155) APAC230WINC230 | THRE115SNDA115,P6-1-1:
APACHE,230, WINCHSTR,230 | THREEPNT,115, SNDARIO,115
156) APAC230WINC230 | AVRA115SNDA115,P6-1-1:
APACHE,230, WINCHSTR,230 | AVRA,115, SNDARIO,115
157) APAC230WINC230 | MARA115AVRA115,P6-1-1:
APACHE,230, WINCHSTR,230 | MARANA,115, AVRA,115
158) APAC230WINC230 | SPRI345VAIL345,P6-1-1:
APACHE,230, WINCHSTR,230 | SPRINGR,345, VAIL2,345
159) APAC230WINC230 | SAG.115MARA115,P6-1-1:
APACHE,230, WINCHSTR,230 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
160) WINC345WINC230 | WINC345WILL345,P6-2-1:
WINCHSTR,345, WINCHSTR,230 | WINCHSTR,345, WILLOW,345
161) WINC345WINC230 | WINC345GREE345,P6-2-1:
WINCHSTR,345, WINCHSTR,230 | WINCHSTR,345, GREENLEE,345
162) WINC345WINC230 | WINC345VAIL345,P6-2-1:
WINCHSTR,345, WINCHSTR,230 | WINCHSTR,345, VAIL,345
163) WINC345WINC230 | GREE345COPP345,P6-2-1:
WINCHSTR,345, WINCHSTR,230 | GREENLEE,345, COPPERVR,345
164) WINC345WINC230 | SPRI345GREE345,P6-2-1:
WINCHSTR,345, WINCHSTR,230 | SPRINGR,345, GREENLEE,345
165) WINC345WINC230 | VAIL345SOUT345,P6-2-1:
WINCHSTR,345, WINCHSTR,230 |VAIL,345,SOUTH,345

166) WINC345WINC230 | SPRI345VAIL345,P6-2-1:
WINCHSTR,345, WINCHSTR,230 | SPRINGR,345, VAIL2,345
167) WINC345WINC230 | SAG.115MARA115,P6-2-1:
WINCHSTR,345, WINCHSTR,230 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
168) WINC345WILL345 | WINC345VAIL345,P6-1-1:
WINCHSTR,345, WILLOW,345 | WINCHSTR,345, VAIL,345
169) WINC345GREE345 | WINC345VAIL345,P6-1-1:
WINCHSTR,345, GREENLEE,345 | WINCHSTR,345, VAIL,345
170) WINC345WILL345 | GREE345COPP345,P6-1-1:
WINCHSTR,345, WILLOW,345 | GREENLEE,345, COPPERVR,345
171) WINC345GREE345 | GREE345COPP345,P6-1-1:
WINCHSTR,345, GREENLEE,345 | GREENLEE,345, COPPERVR,345
172) WINC345WILL345 | SPRI345GREE345,P6-1-1:
WINCHSTR,345, WILLOW,345 | SPRINGR,345, GREENLEE,345
173) WINC345GREE345 | SPRI345GREE345,P6-1-1:
WINCHSTR,345, GREENLEE,345 | SPRINGR,345, GREENLEE,345
174) WINC345WILL345 | HACK230MORE230,P6-1-1:
WINCHSTR,345, WILLOW,345 | HACKBERY,230, MORENCI,230
175) WINC345GREE345 | HACK230MORE230,P6-1-1:
WINCHSTR,345, GREENLEE,345 | HACKBERY,230, MORENCI,230
176) WINC345WILL345 | GREE345GREE230,P6-1-2:
WINCHSTR,345, WILLOW,345 | GREEN-SW,345, GREEN-SW,230
177) WINC345GREE345 | GREE345GREE230,P6-1-2:
WINCHSTR,345, ,GREENLEE,345 | GREEN-SW,345, GREEN-SW,230
178) WINC345WILL345 | SAHU230BICK230,P6-1-1:
WINCHSTR,345, WILLOW,345 | SAHUARIT,230, BICKNELL,230,1,0
179) WINC345GREE345 | SAHU230BICK230,P6-1-1:
WINCHSTR,345, GREENLEE,345 | SAHUARIT,230, BICKNELL,230,1,0
180) WINC345WILL345 | VAIL345SOUT345,P6-1-1:
WINCHSTR,345, WILLOW,345 | VAIL,345, SOUTH,345
181) WINC345GREE345 | VAIL345SOUT345,P6-1-1:
WINCHSTR,345, GREENLEE,345 | VAIL,345, SOUTH,345
182) WINC345WILL345 | BICK345BICK230,P6-1-2:
WINCHSTR,345, WILLOW,345 | BICKNELL,345, ,BICKNELL,230 | BICKNELL,345,VAIL,345
183) WINC345GREE345 | BICK345BICK230,P6-1-2:
WINCHSTR,345, GREENLEE,345 | BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
184) WINC345WILL345 | BICK230BICK115,P6-1-2:
WINCHSTR,345, WILLOW,345 | BICKNELL,230, BICKNELL,115
185) WINC345GREE345 | BICK230BICK115,P6-1-2:
WINCHSTR,345, GREENLEE,345 | BICKNELL,230, BICKNELL,115
186) WINC345WILL345 | BICK115THRE115,P6-1-1:
WINCHSTR,345, WILLOW,345 | BICKNELL,115, THREEPNT,115
187) WINC345GREE345 | BICK115THRE115,P6-1-1:
WINCHSTR,345, GREENLEE,345 | BICKNELL,115, THREEPNT,115
188) WINC345WILL345 | THRE115SNDA115,P6-1-1:
WINCHSTR,345, WILLOW,345 | THREEPNT,115, SNDARIO,115
189) WINC345GREE345 | THRE115SNDA115,P6-1-1:
WINCHSTR,345, GREENLEE,345 | THREEPNT,115, SNDARIO,115
190) WINC345WILL345 | AVRA115SNDA115,P6-1-1:
WINCHSTR,345, WILLOW,345 |AVRA,115, SNDARIO,115
191) WINC345GREE345 | AVRA115SNDA115,P6-1-1:
WINCHSTR,345, GREENLEE,345 | AVRA,115, SNDARIO,115
192) WINC345WILL345 | MARA115AVRA115,P6-1-1:
WINCHSTR,345, WILLOW,345 | MARANA,115, AVRA,115

193) WINC345GREE345 | MARA115AVRA115,P6-1-1:
WINCHSTR,345, GREENLEE,345 | MARANA,115, AVRA,115
194) WINC345WILL345 | SPRI345VAIL345,P6-1-1:
WINCHSTR,345, WILLOW,345 | SPRINGR,345, VAIL2,345
195) WINC345GREE45 | SPRI345VAIL345,P6-1-1:
WINCHSTR,345, GREENLEE,345 | SPRINGR,345, VAIL2,345
196) WINC345WILL345 | SAG.115MARA115,P6-1-1:
WINCHSTR,345, WILLOW,345 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
197) WINC345GREE345 | SAG.115MARA115,P6-1-1:
WINCHSTR,345, GREENLEE,345 | MARANATP,115,MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
198) WINC345VAIL345 | GREE345COPP345,P6-1-1:
WINCHSTR,345, VAIL,345 | GREENLEE,345, COPPERVR,345
199) WINC345VAIL345 | SPRI345GREE345,P6-1-1:
WINCHSTR,345, VAIL,345 | SPRINGR,345, GREENLEE,345
200) WINC345VAIL345 | HACK230MORE230,P6-1-1:
WINCHSTR,345, VAIL,345 | HACKBERY,230, MORENCI,230,1,0
201) WINC345VAIL345 | GREE345GREE230,P6-1-2:
WINCHSTR,345, VAIL,345 |GREEN-SW,345, GREEN-SW,230
202) WINC345VAIL345 | SAHU230BICK230,P6-1-1:
WINCHSTR,345, VAIL,345 | SAHUARIT,230, BICKNELL,230
203) WINC345VAIL345 | VAIL345SOUT345,P6-1-1:
WINCHSTR,345, VAIL,345 | VAIL,345, SOUTH,345
204) WINC345VAIL345 | BICK345BICK230,P6-1-2:
WINCHSTR,345, VAIL,345 | BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
205) WINC345VAIL345 | BICK230BICK115,P6-1-2:
WINCHSTR,345, VAIL,345 | BICKNELL,230, BICKNELL,115
206) WINC345VAIL345 | BICK115THRE115,P6-1-1:
WINCHSTR,345, VAIL,345 | BICKNELL,115, THREEPNT,115
207) WINC345VAIL345 | THRE115SNDA115,P6-1-1:
WINCHSTR,345, VAIL,345 | THREEPNT,115, SNDARIO,115
208) WINC345VAIL345 | AVRA115SNDA115,P6-1-1:
WINCHSTR,345, VAIL,345 | AVRA,115, SNDARIO,115
209) WINC345VAIL345 | MARA115AVRA115,P6-1-1:
WINCHSTR,345, VAIL,345 | MARANA,115, AVRA,115
210) WINC345VAIL345 | SPRI345VAIL345,P6-1-1:
WINCHSTR,345, VAIL,345 | SPRINGR,345, VAIL2,345
211) WINC345VAIL345 | SAG.115MARA115,P6-1-1:
WINCHSTR,345, VAIL,345 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
212) GREE345COPP345 | SPRI345GREE345,P6-1-1:
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213) GREE345COPP345 | HACK230MORE230,P6-1-1:
GREENLEE,345, COPPERVR,345 | HACKBERY,230, MORENCI,230
214) GREE345COPP345 | GREE345GREE230,P6-1-2:
GREENLEE,345, COPPERVR,345 | GREEN-SW,345, GREEN-SW,230
215) GREE345COPP345 | SAHU230BICK230,P6-1-1:
GREENLEE,345, COPPERVR,345 | SAHUARIT,230, BICKNELL,230
216) GREE345COPP345 | VAIL345SOUT345,P6-1-1:
GREENLEE,345, COPPERVR,345 | VAIL,345, SOUTH,345
217) GREE345COPP345 | BICK345BICK230,P6-1-2:
GREENLEE,345, COPPERVR,345 | BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
218) GREE345COPP345 | BICK230BICK115,P6-1-2
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219) GREE345COPP345 | BICK115THRE115,P6-1-1
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220) GREE345COPP345 | THRE115SNDA115,P6-1-1
GREENLEE,345, COPPERVR,345| THREEPNT,115, SNDARIO,115
221) GREE345COPP345 | AVRA115SNDA115,P6-1-1
GREENLEE,345, COPPERVR,345 | AVRA,115, SNDARIO,115
222) GREE345COPP345 | MARA115AVRA115,P6-1-1
GREENLEE,345, COPPERVR,345 | MARANA,115, AVRA,115
223) GREE345COPP345 | SPRI345VAIL345,P6-1-1
GREENLEE,345, COPPERVR,345 | SPRINGR,345, VAIL2,345
224) GREE345COPP345 | SAG.115MARA115,P6-1-1
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225) SPRI345GREE345 | HACK230MORE230,P6-1-1
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226) SPRI345GREE345 | GREE345GREE230,P6-1-2
SPRINGR,345, GREENLEE,345 | GREEN-SW,345, GREEN-SW,230
227) SPRI345GREE345 | SAHU230BICK230,P6-1-1
SPRINGR,345, GREENLEE,345 | SAHUARIT,230, BICKNELL,230
228) SPRI345GREE345 | VAIL345SOUT345,P6-1-1
SPRINGR,345, GREENLEE,345 | VAIL,345, SOUTH,345
229) SPRI345GREE345 | BICK345BICK230,P6-1-2
SPRINGR,345, GREENLEE,345 | BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
230) SPRI345GREE345 | BICK230BICK115,P6-1-2
SPRINGR,345, GREENLEE,345 | BICKNELL,230, BICKNELL,115
231) SPRI345GREE345 | BICK115THRE115,P6-1-1
SPRINGR,345, GREENLEE,345 | BICKNELL,115, THREEPNT,115
232) SPRI345GREE345 | THRE115SNDA115,P6-1-1
SPRINGR,345, GREENLEE,345 | THREEPNT,115, SNDARIO,115
233) SPRI345GREE345 | AVRA115SNDA115,P6-1-1
SPRINGR,345, GREENLEE,345 | AVRA,115, SNDARIO,115
234) SPRI345GREE345 | MARA115AVRA115,P6-1-1
SPRINGR,345, GREENLEE,345 | MARANA,115, AVRA,115
235) SPRI345GREE345 | SPRI345VAIL345,P6-1-1
SPRINGR,345, GREENLEE,345 | SPRINGR,345, VAIL2,345
236) SPRI345GREE345 | SAG.115MARA115,P6-1-1
SPRINGR,345, GREENLEE,345 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
237) HACK230MORE230 | VAIL345SOUT345,P6-1-1
HACKBERY,230, MORENCI,230 | VAIL,345, SOUTH,345
238) HACK230MORE230 | SPRI345VAIL345,P6-1-1
HACKBERY,230, MORENCI,230 | SPRINGR,345,16106,VAIL2,345
239) HACK230MORE230 | SAG.115MARA115,P6-1-1
HACKBERY,230, MORENCI,230 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
240) GREE345GREE230 | VAIL345SOUT345,P6-2-1
GREEN-SW,345, GREEN-SW,230 | VAIL,345, SOUTH,345
241) GREE345GREE230 | SPRI345VAIL345,P6-2-1
GREEN-SW,345, GREEN-SW,230 | SPRINGR,345, VAIL2,345
242) GREE345GREE230 | SAG.115MARA115,P6-2-1
GREEN-SW,345, GREEN-SW,230 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
243) SAHU230BICK230 | VAIL345SOUT345,P6-1-1
SAHUARIT,230, BICKNELL,230 | VAIL,345, SOUTH,345
244) SAHU230BICK230 | SPRI345VAIL345,P6-1-1
SAHUARIT,230, BICKNELL,230 | SPRINGR,345, VAIL2,345

245) SAHU230BICK230 | SAG.115MARA115,P6-1-1
SAHUARIT,230, BICKNELL,230 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
246) VAIL345SOUT345 | BICK345BICK230,P6-1-2
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247) VAIL345SOUT345 | BICK230BICK115,P6-1-2
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248) VAIL345SOUT345 | BICK115THRE115,P6-1-1
VAIL,345, SOUTH,345 | BICKNELL,115, THREEPNT,115
249) VAIL345SOUT345 | THRE115SNDA115,P6-1-1
VAIL,345, SOUTH,345 | THREEPNT,115, SNDARIO,115
250) VAIL345SOUT345 | AVRA115SNDA115,P6-1-1
VAIL,345, SOUTH,345 | AVRA,115, SNDARIO,115
251) VAIL345SOUT345 | MARA115AVRA115,P6-1-1
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252) VAIL345SOUT345 | SPRI345VAIL345,P6-1-1
VAIL,345, SOUTH,345 | SPRINGR,345, VAIL2,345
253) VAIL345SOUT345 | SAG.115MARA115,P6-1-1
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254) BICK345BICK230 | SPRI345VAIL345,P6-2-1
BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345 | SPRINGR,345, VAIL2,345
255) BICK345BICK230 | SAG.115MARA115,P6-2-1
BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345 | MARANATP,115, MARANA,115 SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
256) BICK230BICK115 | SPRI345VAIL345,P6-2-1
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257) BICK230BICK115 | SAG.115MARA115,P6-2-1
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258) BICK115THRE115 | SPRI345VAIL345,P6-1-1
BICKNELL,115, THREEPNT,115 | SPRINGR,345, VAIL2,345
259) BICK115THRE115 | SAG.115MARA115,P6-1-1
BICKNELL,115, THREEPNT,115 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
260) THRE115SNDA115 | SPRI345VAIL345,P6-1-1
THREEPNT,115, SNDARIO,115 | SPRINGR,345, VAIL2,345
261) THRE115SNDA115 | SAG.115MARA115,P6-1-1
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262) AVRA115SNDA115 | SPRI345VAIL345,P6-1-1
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263) AVRA115SNDA115 | SAG.115MARA115,P6-1-1
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264) MARA115AVRA115 | SPRI345VAIL345,P6-1-1
MARANA,115, AVRA,115 | SPRINGR,345, VAIL2,345
265) MARA115AVRA115 | SAG.115MARA115,P6-1-1
MARANA,115, AVRA,115 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
266) SPRI345VAIL345 | SAG.115MARA115,P6-1-1
SPRINGR,345, VAIL2,345 | MARANATP,115, MARANA,115 | SAG.EAST,115, MARANATP,115 | MARANATP,115, RATTLSNK,115 | RATTLSNK,115, TUCSON,115
267) HACK230MORE230 | DOSC230HACK230,P6-1-1
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268) RED 230DOSC230 | DOSC230HACK230,P6-1-1
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269) BICK345BICK230 | PANT230NEWT230,P6-2-1
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270) BICK115THRE115 | ADAM115APAC115,P6-1-1
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271) BICK345BICK230 | NEWT230SAHU230,P6-2-1
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272) BICK345BICK230 | SAHU230BICK230,P6-2-1
BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345 | SAHUARIT,230, BICKNELL,230
273) ADAM115APAC115 | APAC230BUTE230,P6-1-1
ADAMSTAP,115, APACHE,115 | ADAMSTAP,115, ,NOGALES,115 | ADAMS,115, ADAMSTAP,115 | APACHE,230, BUTERFLD,230
274) PINA345SOUT345 | ADAM115APAC115,P6-1-1
PINALWES,345, SOUTH,345 | ADAMSTAP,115, APACHE,115 | ADAMSTAP,115, NOGALES,115 | ADAMS,115, ADAMSTAP,115
275) SPRI345VAIL345 | ADAM115APAC115,P6-1-1
SPRINGR,345, VAIL2,345 | ADAMSTAP,115, APACHE,115 | ADAMSTAP,115, NOGALES,115 | ADAMS,115, ADAMSTAP,115
276) SPRI345VAIL345 | PINA345SOUT345,P6-1-1
SPRINGR,345, VAIL2,345 | PINALWES,345, SOUTH,345
277) BICK230BICK115 | MARA115AVRA115,P6-2-1
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278) APAC230APAC115 | APAC230BUTE230,P6-2-1
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279) APAC230APAC115 | APAC230RED 230,P6-2-1
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280) APAC230APAC115 | APAC230WINC230,P6-2-1
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281) APAC230APAC115 | WINC345WINC230,P6-2-2
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282) APAC230APAC115 | WINC345WILL345,P6-2-1
APACHE,230, APACHE,115 | WINCHSTR,345, WILLOW,345
283) APAC230APAC115 | WINC345GREE345,P6-2-1
APACHE,230, APACHE,115 | WINCHSTR,345, GREENLEE,345
284) APAC230APAC115 | WINC345VAIL345,P6-2-1
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285) APAC230APAC115 | GREE345COPP345,P6-2-1
APACHE,230, APACHE,115 | GREENLEE,345, COPPERVR,345
286) APAC230APAC115 | SPRI345GREE345,P6-2-1
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287) APAC230APAC115 | HACK230MORE230,P6-2-1
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288) APAC230APAC115 | GREE345GREE230,P6-2-2
APACHE,230, APACHE,115 | GREEN-SW,345, GREEN-SW,230
289) APAC230APAC115 | SAHU230BICK230,P6-2-1
APACHE,230, APACHE,115 | SAHUARIT,230, BICKNELL,230
290) APAC230APAC115 | VAIL345SOUT345,P6-2-1
APACHE,230, APACHE,115 | VAIL,345, SOUTH,345
291) APAC230APAC115 | BICK345BICK230,P6-2-2
APACHE,230, APACHE,115 | BICKNELL,345, BICKNELL,230 | BICKNELL,345, VAIL,345
292) APAC230APAC115 | BICK230BICK115,P6-2-2
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293) APAC230APAC115 | BICK115THRE115,P6-2-1
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294) APAC230APAC115 | THRE115SNDA115,P6-2-1
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295) APAC230APAC115 | AVRA115SNDA115,P6-2-1
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296) APAC230APAC115 | MARA115AVRA115,P6-2-1
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297) APAC230APAC115 | SPRI345VAIL345,P6-2-1
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298) APAC230BUTE230,P1-2: APACHE,230, BUTERFLD,230
299) APAC230RED 230,P1-2: APACHE,230, RED TAIL,230
300) BICK345VAIL345,P1-2: BICKNELL,345, VAIL,345
301) Group_MARA115,,P1-2:
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302) APAC230BUTE230 | ED5115MARA115,P6-1-1:
APACHE,230, BUTERFLD,230 | MARANATP,115, MARANA,115 | ED5,115, MARANATP,115 | MARANATP,115, ,RATTLSNK,115 | RATTLSNK,115, TUCSON,115
303) APAC230BUTE230 | BICK345BICK230,P6-1-2:
APACHE,230, ,BUTERFLD,230| BICKNELL,345, BICKNELL,230| BICKNELL,345, VAIL,345
304) Breaker_APA202_P4,P4-2:
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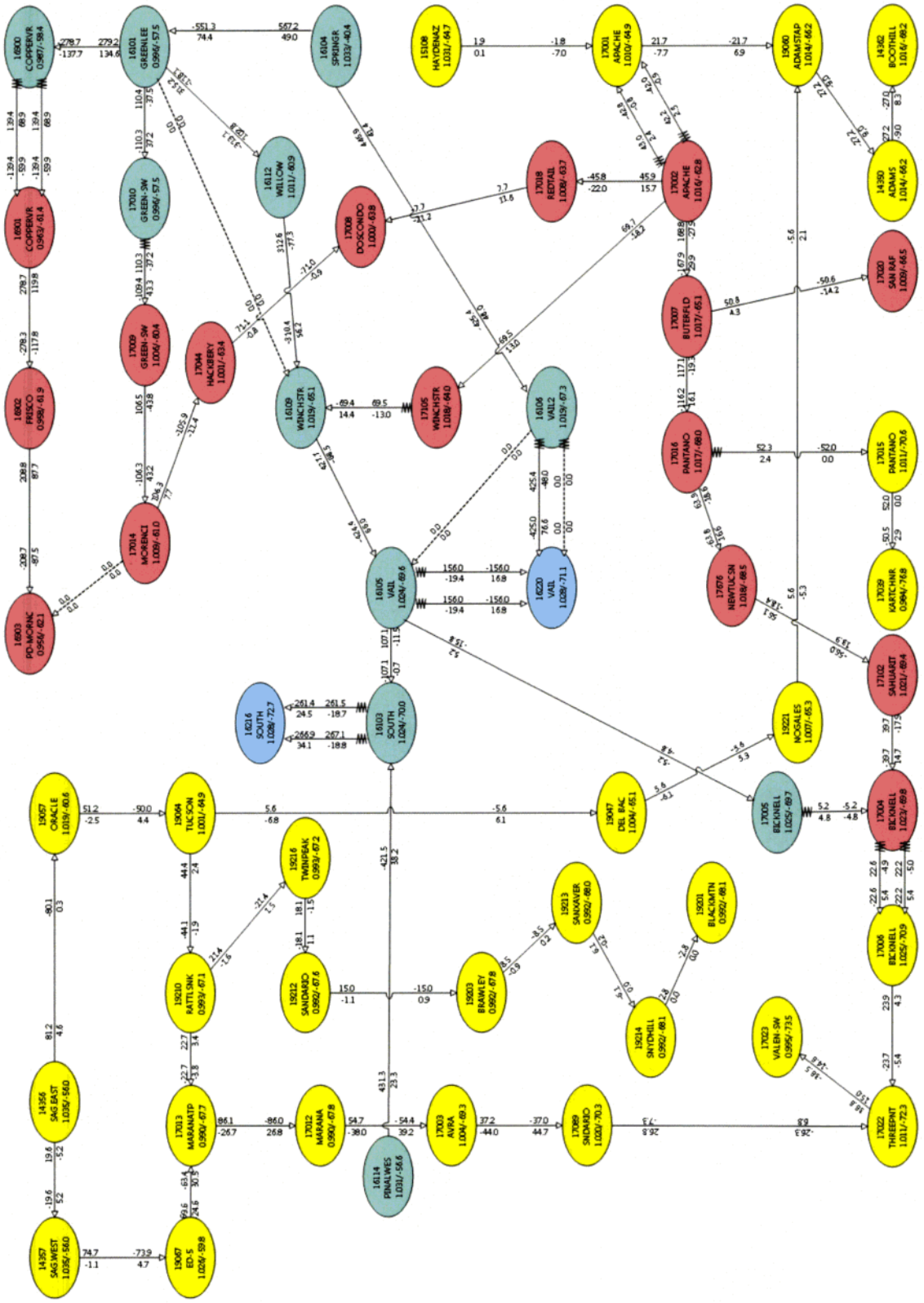
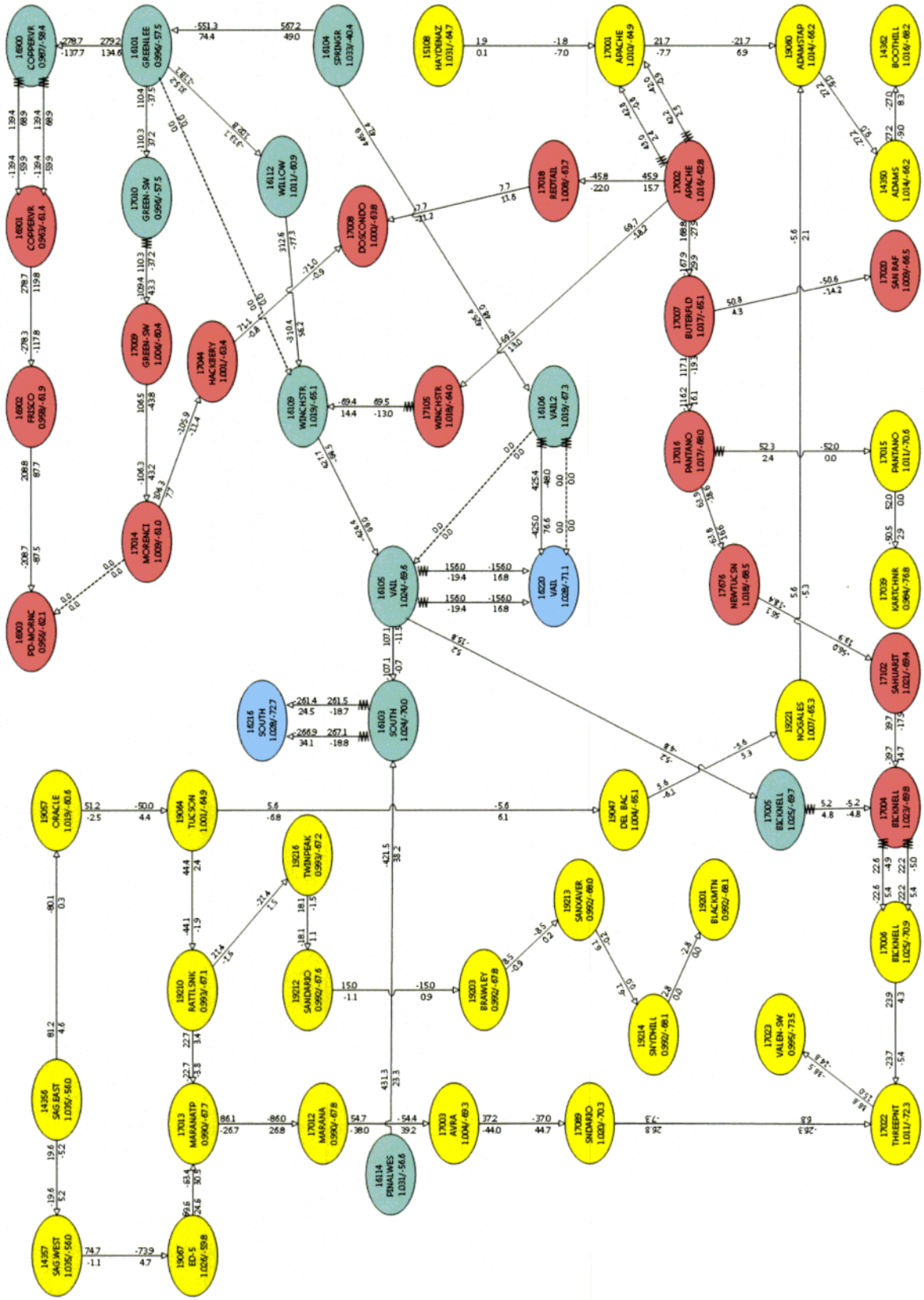
305) Breaker_BICK204_P4,P4-2:
BICKNELL,230, BICKNELL,115 | SAHUARIT,230, BICKNELL,230
306) Breaker_BICK205_P4,P4-2:
BICKNELL,345, BICKNELL,230 | SAHUARIT,230, BICKNELL,230 | BICKNELL,345, VAIL,345
307) Breaker_BUTE230_P4_SAN,P4-2:
APACHE,230, BUTERFLD,230 | BUTERFLD,230, PANTANO,230 | BUTERFLD,230, SAN RAF,230
308) Breaker_BUTE230_P4_PANT,P4-2:
APACHE,230, BUTERFLD,230 | BUTERFLD,230, PANTANO,230 | BUTERFLD,230, SAN RAF,230
309) Breaker_BUTE230_P4_APAC,P4-2:
APACHE,230, BUTERFLD,230 | BUTERFLD,230, PANTANO,230 | BUTERFLD,230, SAN RAF,230
310) Breaker_PANT230_P4_NEWT,P4-2:
BUTERFLD,230, PANTANO,230 | PANTANO,230, NEWTUCSN,230 | PANTANO,230, PANTANO,115
311) Breaker_PANT230_P4_BUTE,P4-2:
BUTERFLD,230, PANTANO,230 | PANTANO,230, NEWTUCSN,230 |PANTANO,230, PANTANO,115
312) Breaker_RED230_P4_DOS,P4-2:
APACHE,230, RED TAIL,230 | RED TAIL,230, DOSCONDO,230
313) Breaker_RED230_P4_APAC,P4-2:
APACHE,230, RED TAIL,230 | RED TAIL,230, DOSCONDO,230
314) Breaker_WINC230_P4,P4-2:
WINCHSTR,345, WINCHSTR,230 | APACHE,230, WINCHSTR,230
315) APAC230WINC230 | APAC115-HAYD115,P7-1:
APACHE,230, WINCHSTR,230 | APACHE,115, HAYDENAZ,115

APPENDIX C: Power Flow One Line Diagrams

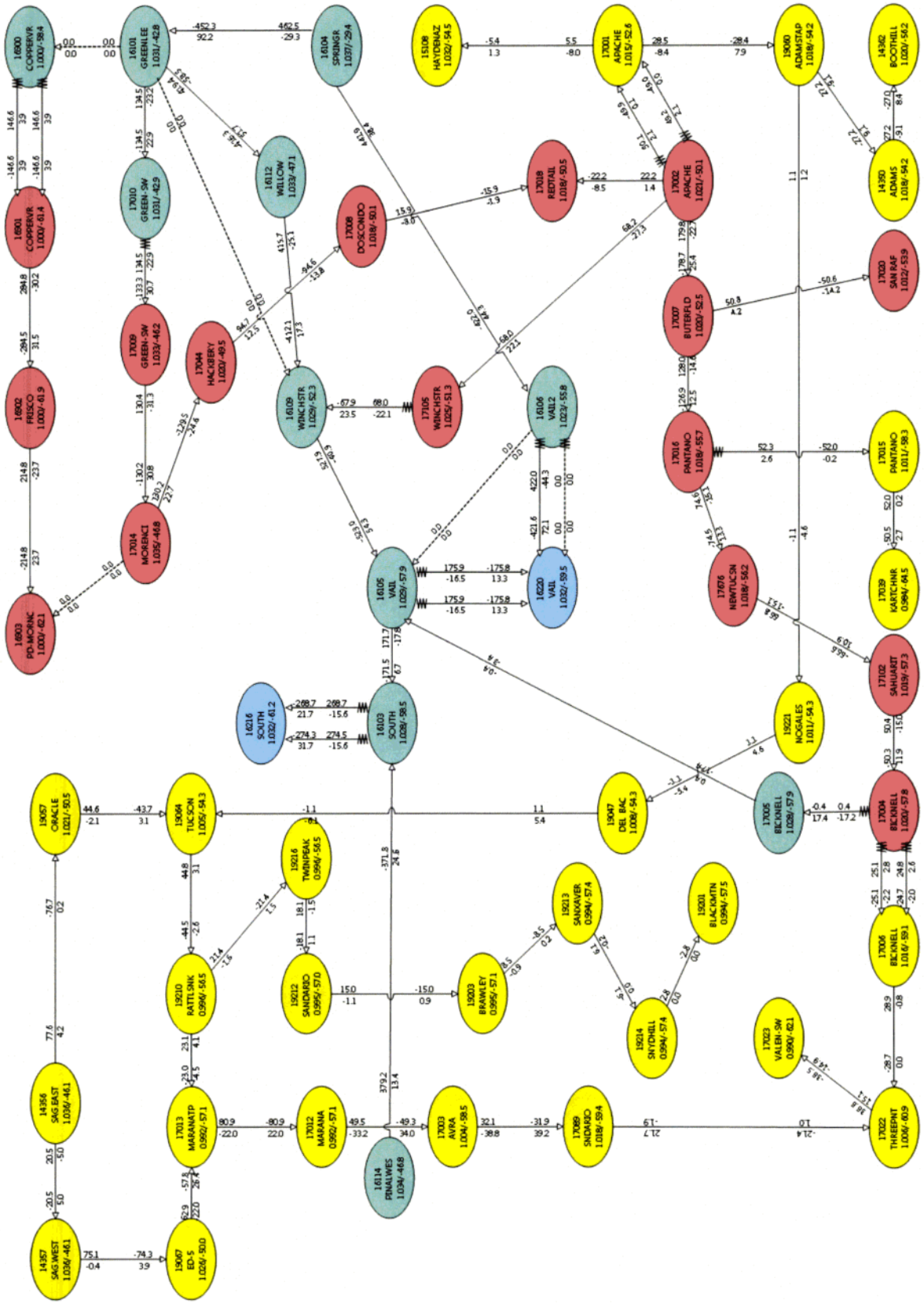
2018HS AEPCO System – All Lines in Service



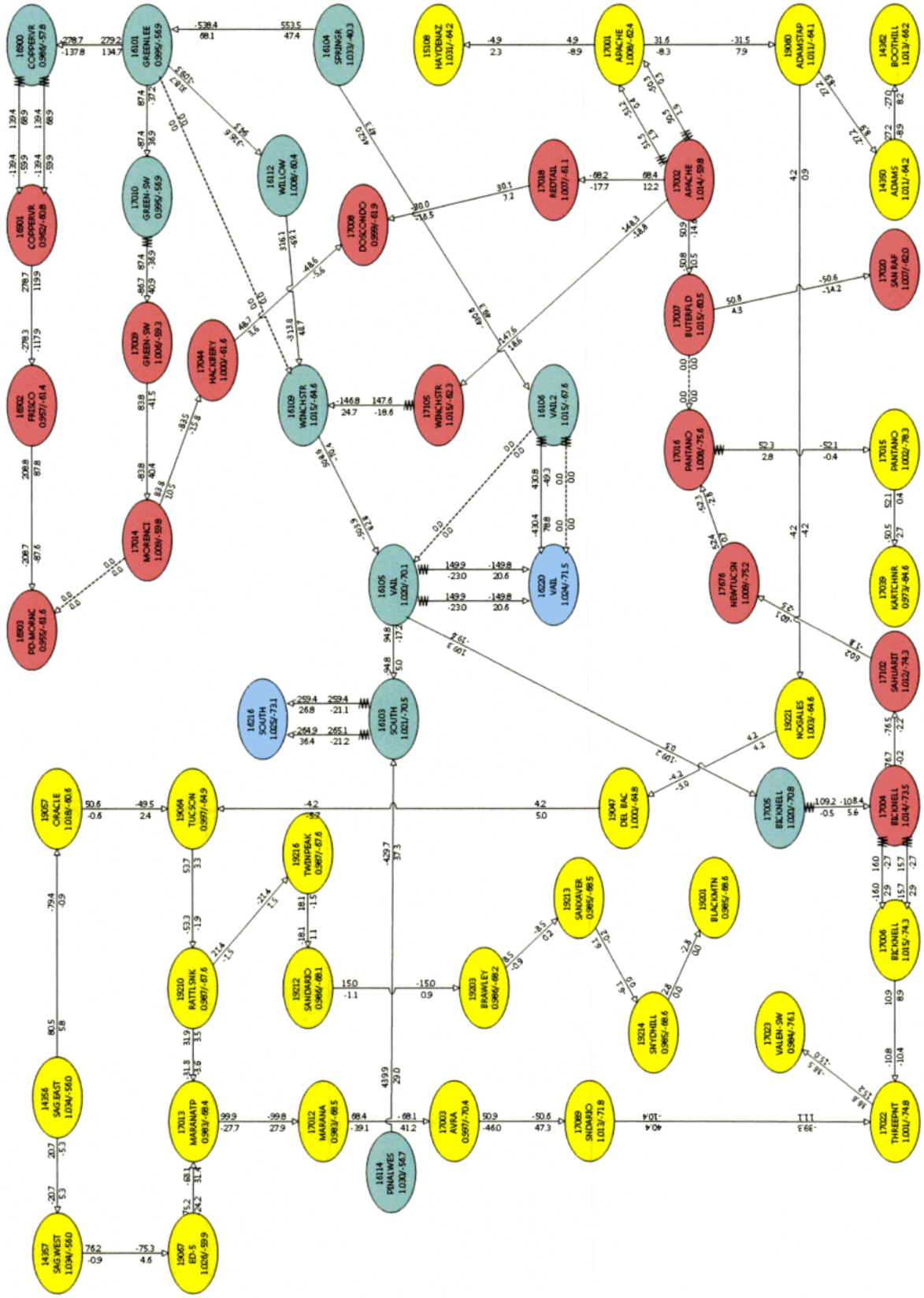
2018HS AEPCO System with Green-SW to Greenlee 345 kV Line out of service



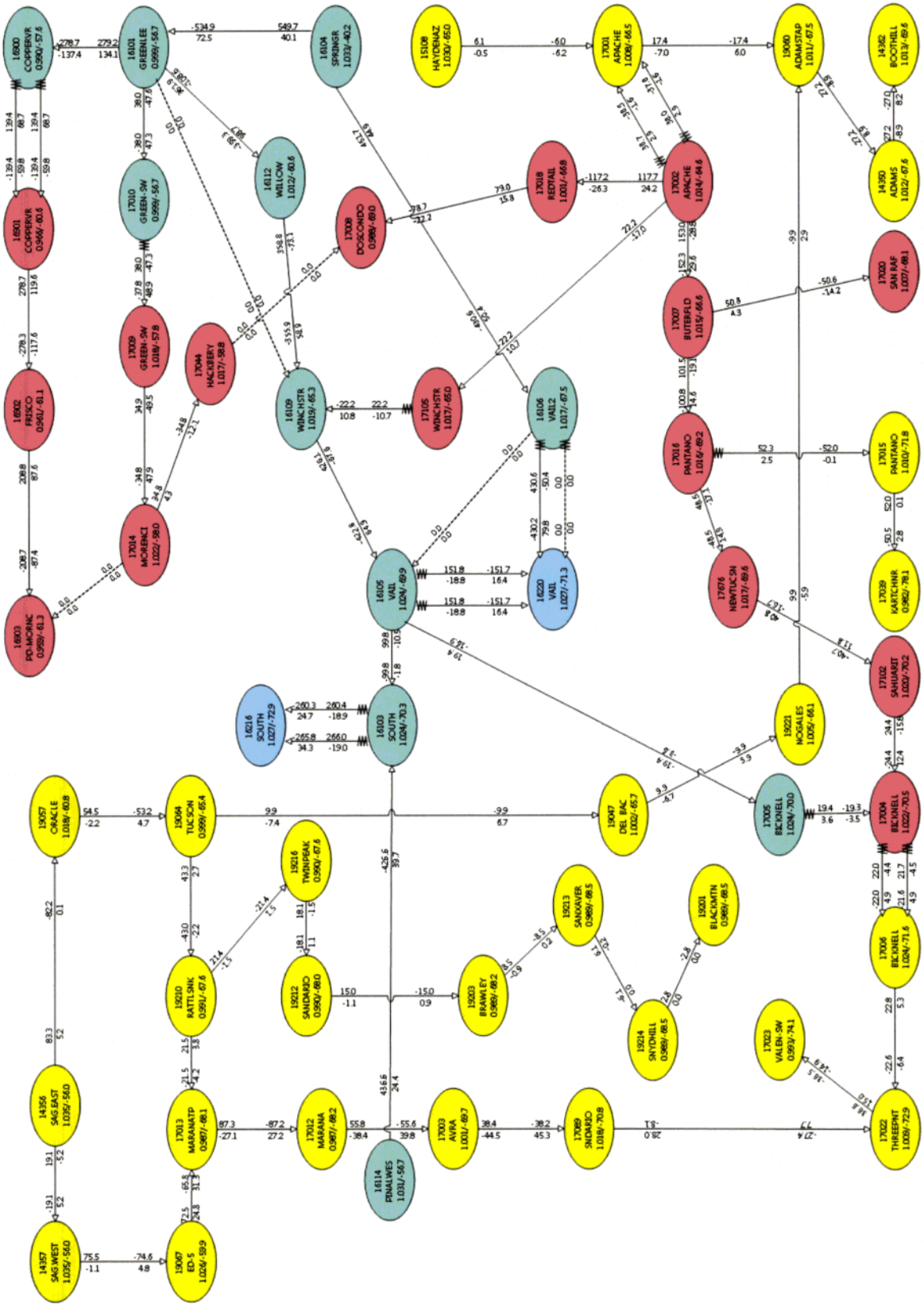
2018HS AEPCO System with Greenlee to Copper Verde 345 kV Line out of service



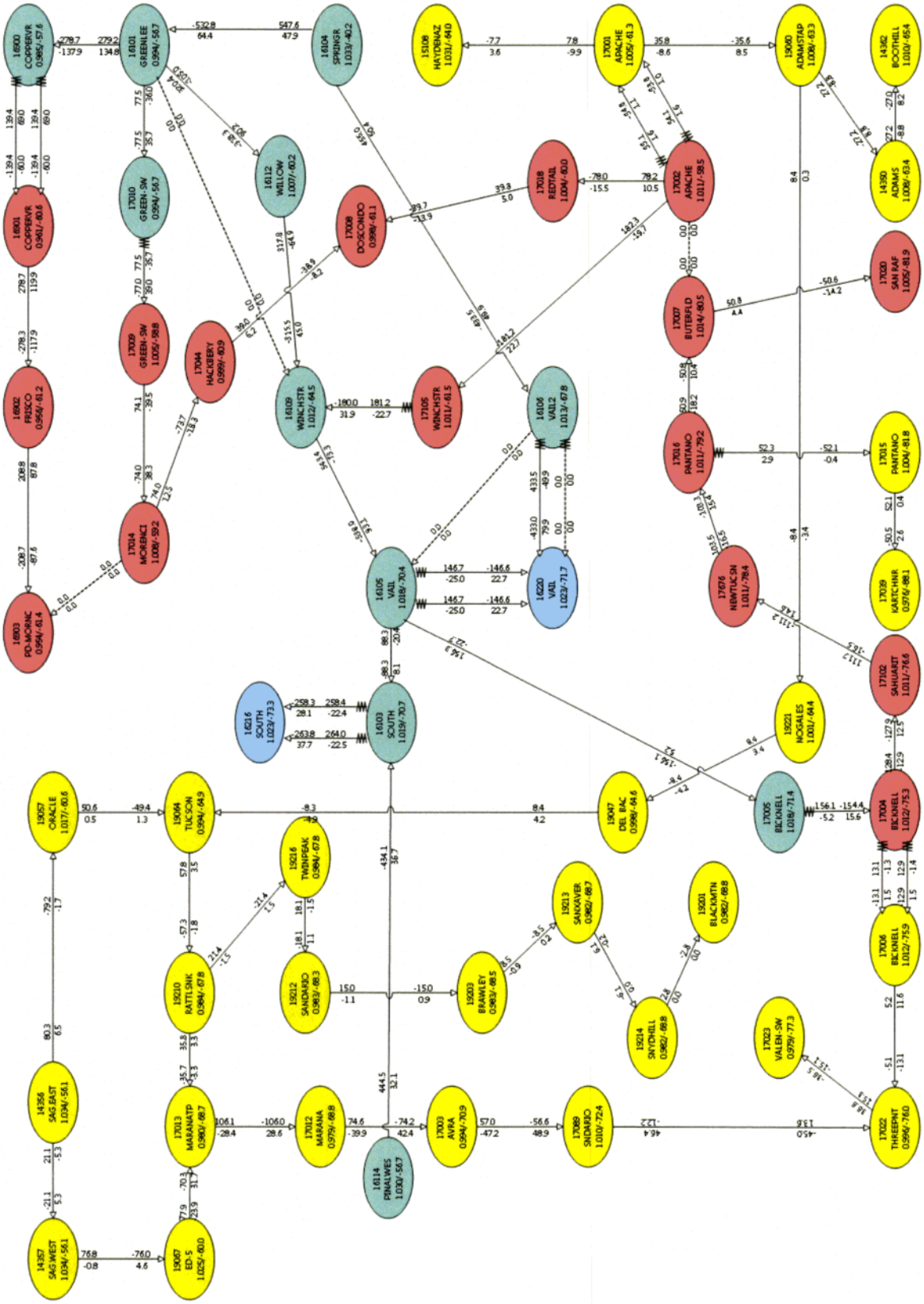
2018HS AEPCO System with Butterfield to Pantano 230 kV Line out of service



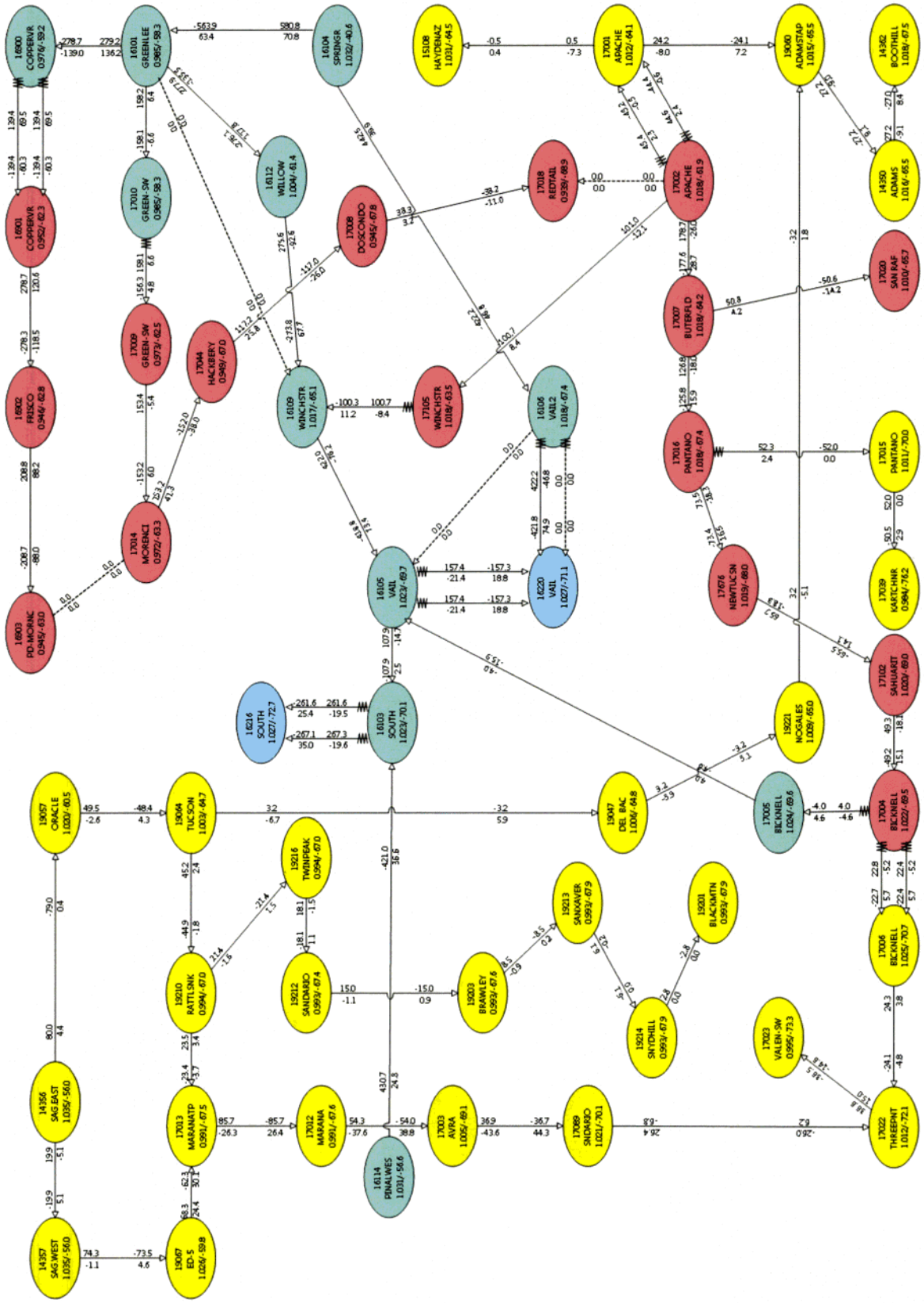
2018HS AEPCO System with Dos Condados to Hackberry 230 kV Line out of service



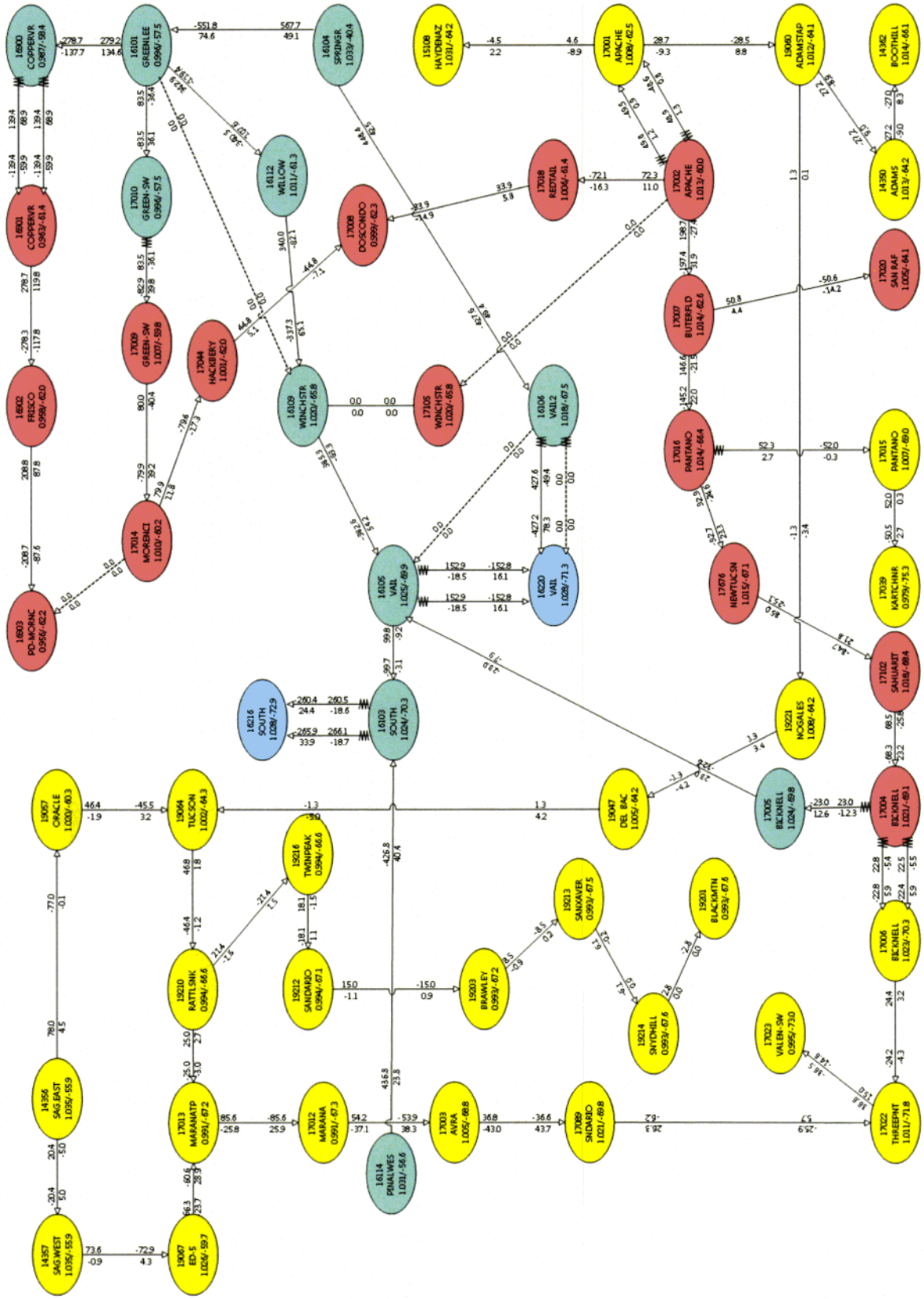
2018HS AEPCO System with Apache to Butterfield 230 kV Line out of service



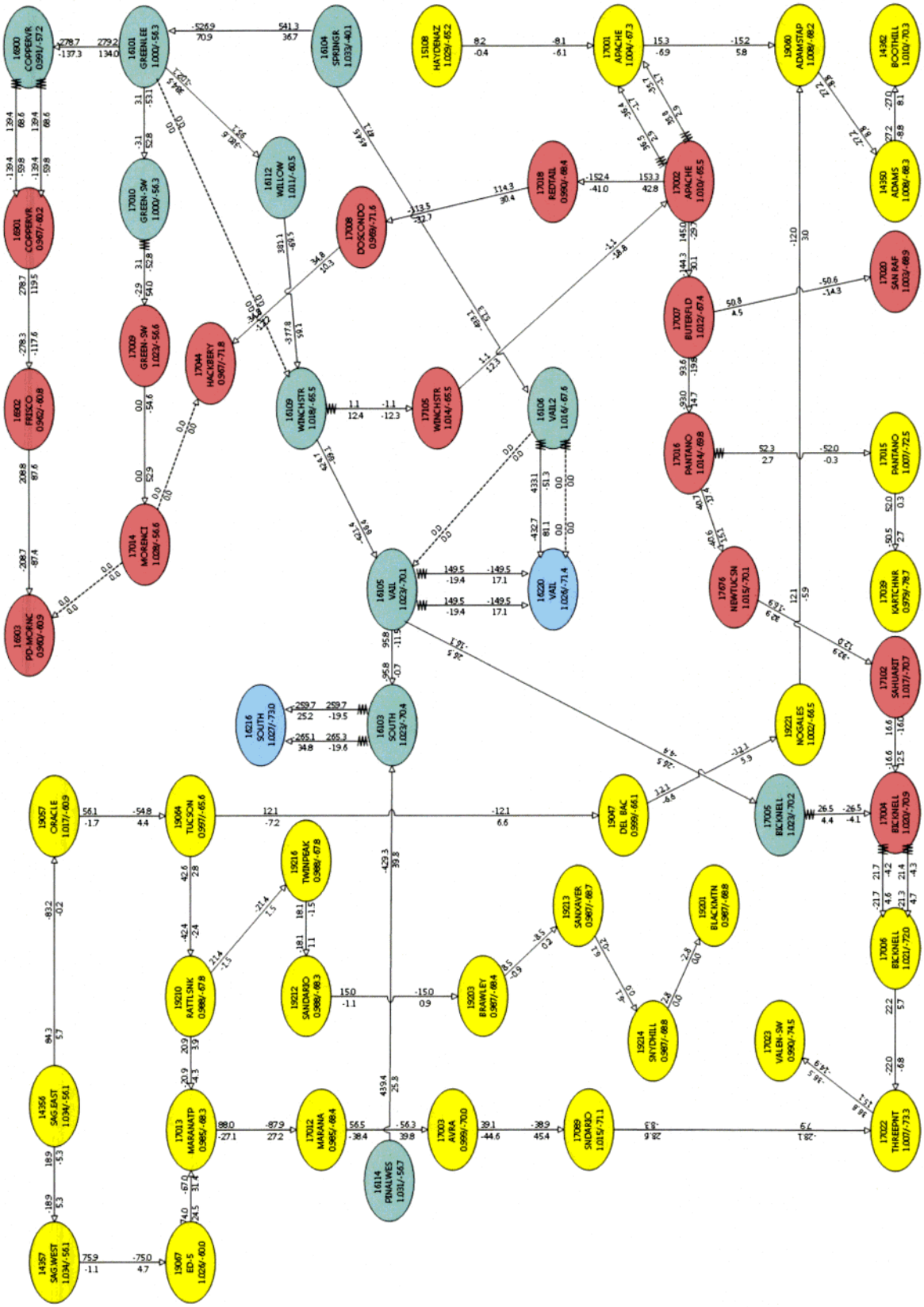
2018HS AEPCO System with Apache to Redtail 230 kV Line out of service



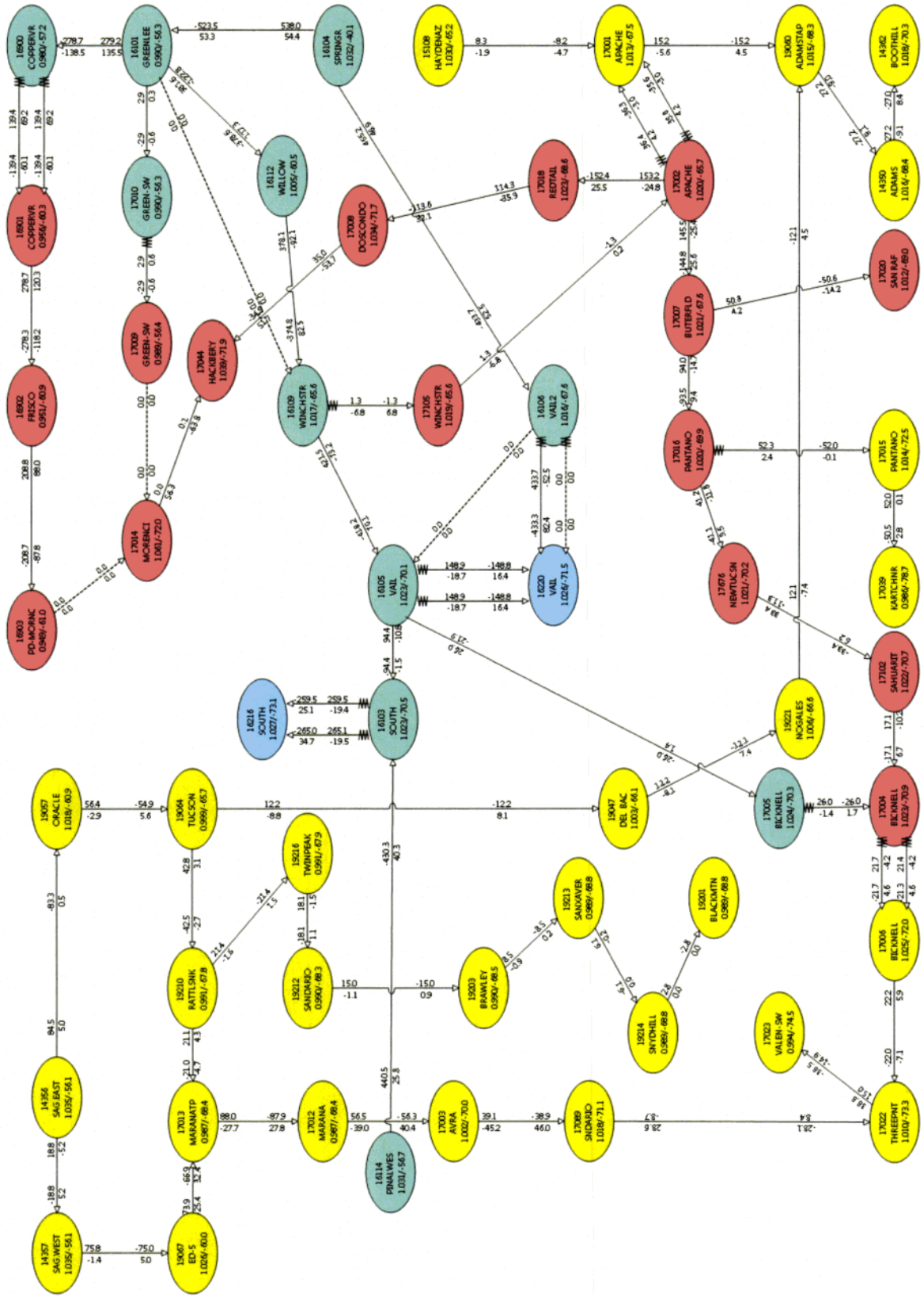
2018HS AEPCO System with Apache to Winchester 230 kV Line out of service



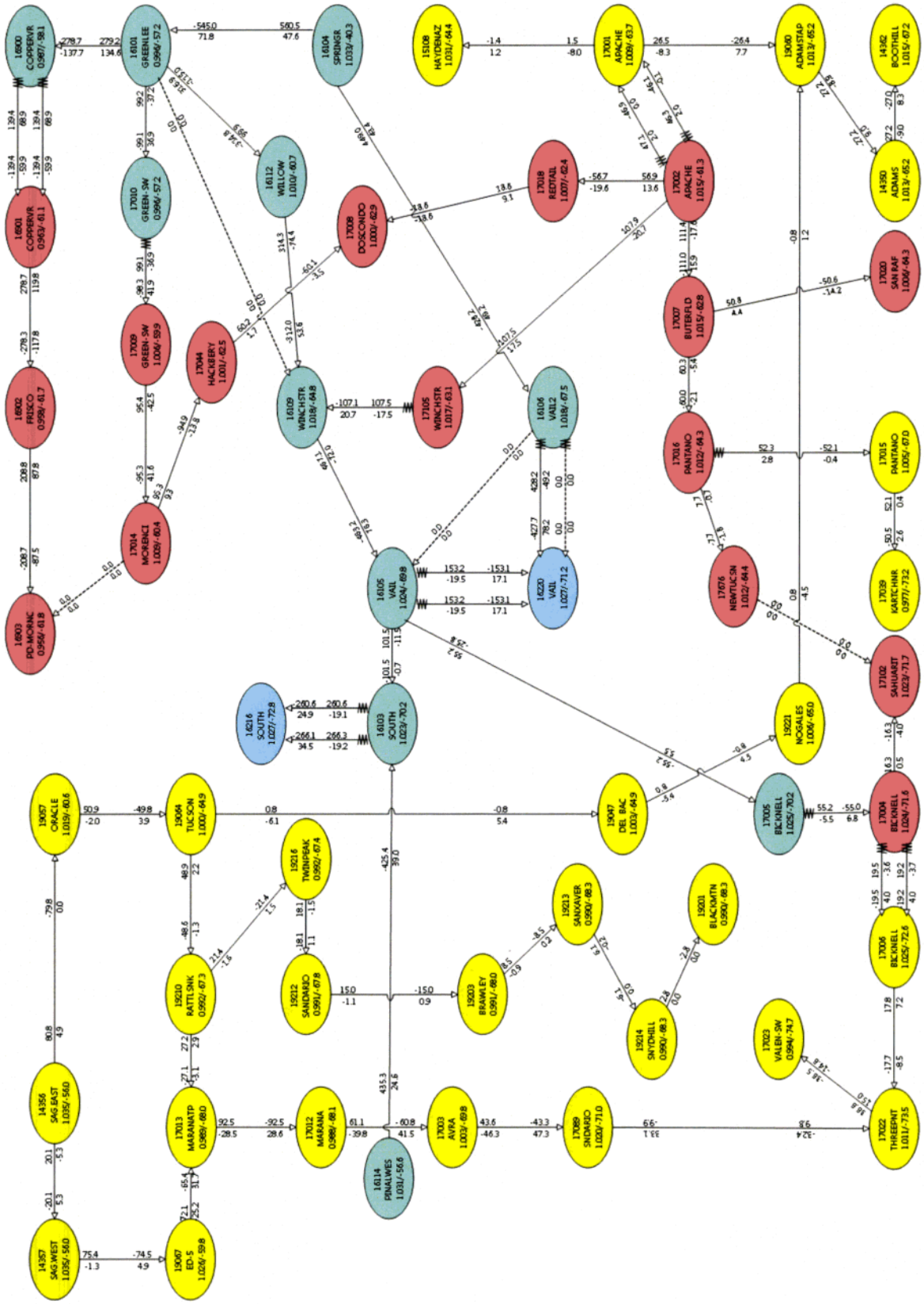
2018HS AEPCO System with Hackberry to Morenci 230 kV Line out of service



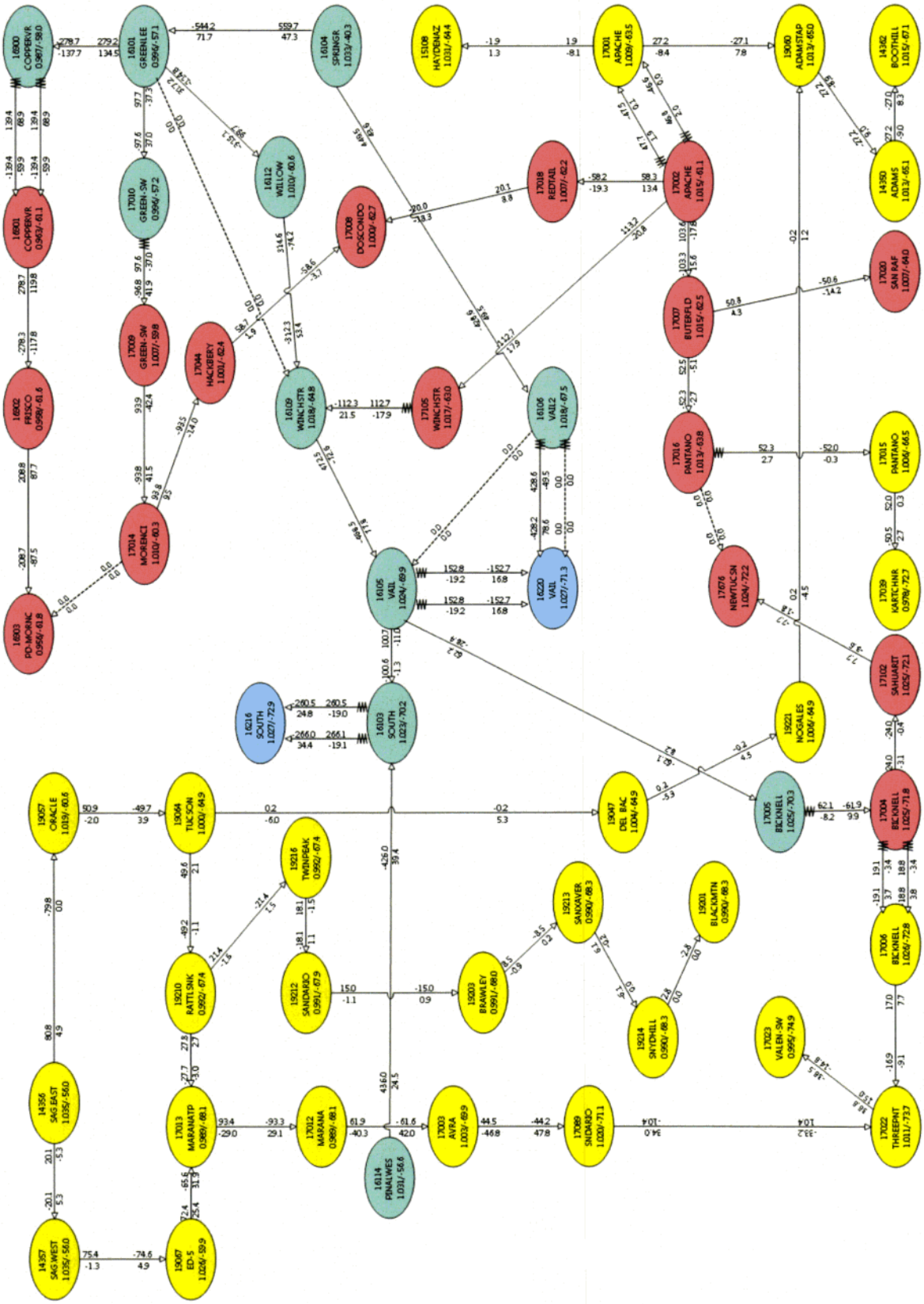
2018HS AEPCO System with Morenci to Greenlee-SW 230 kV Line out of service



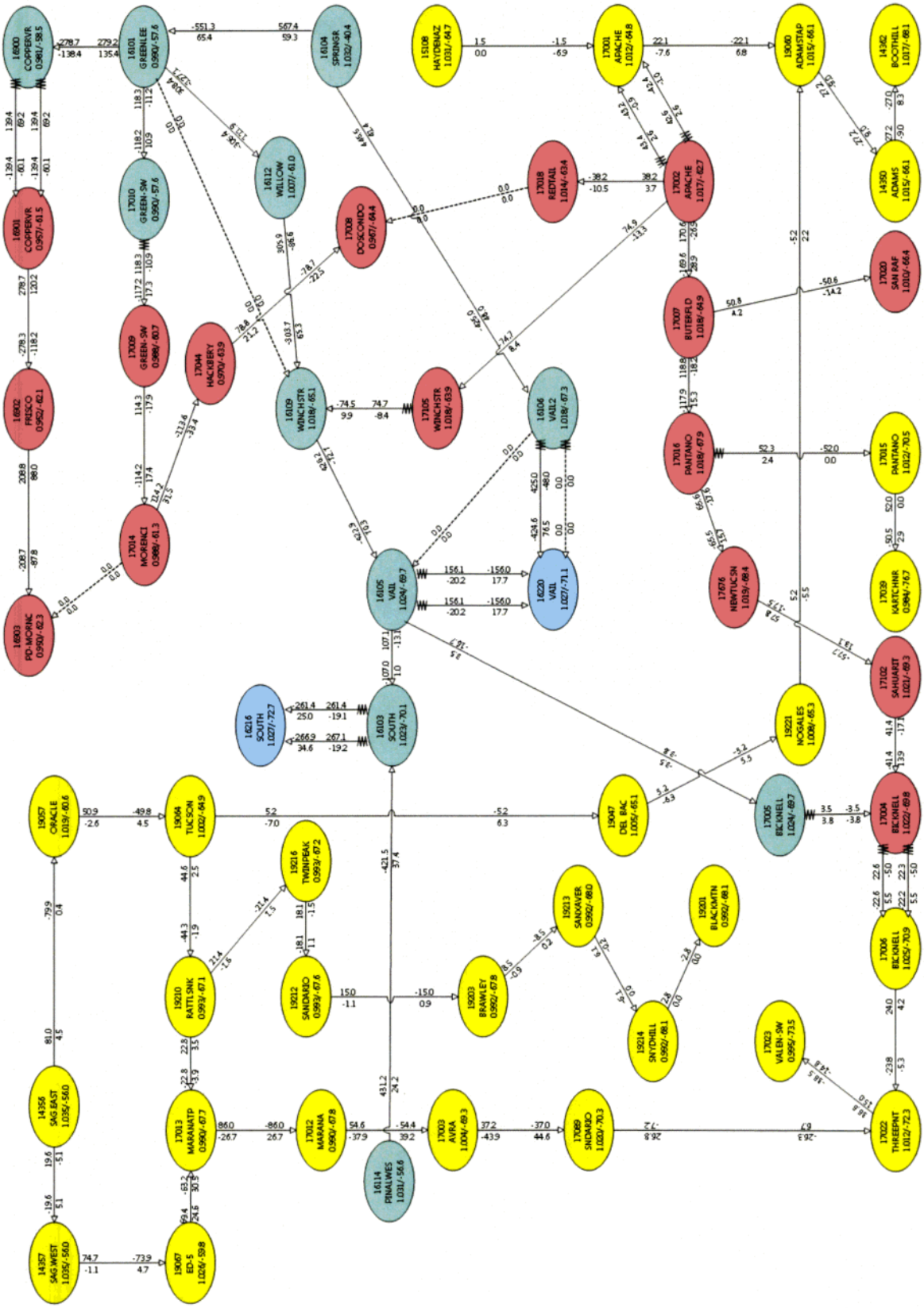
2018HS AEPCO System with New Tucson to Sahuarita 230 kV Line out of service



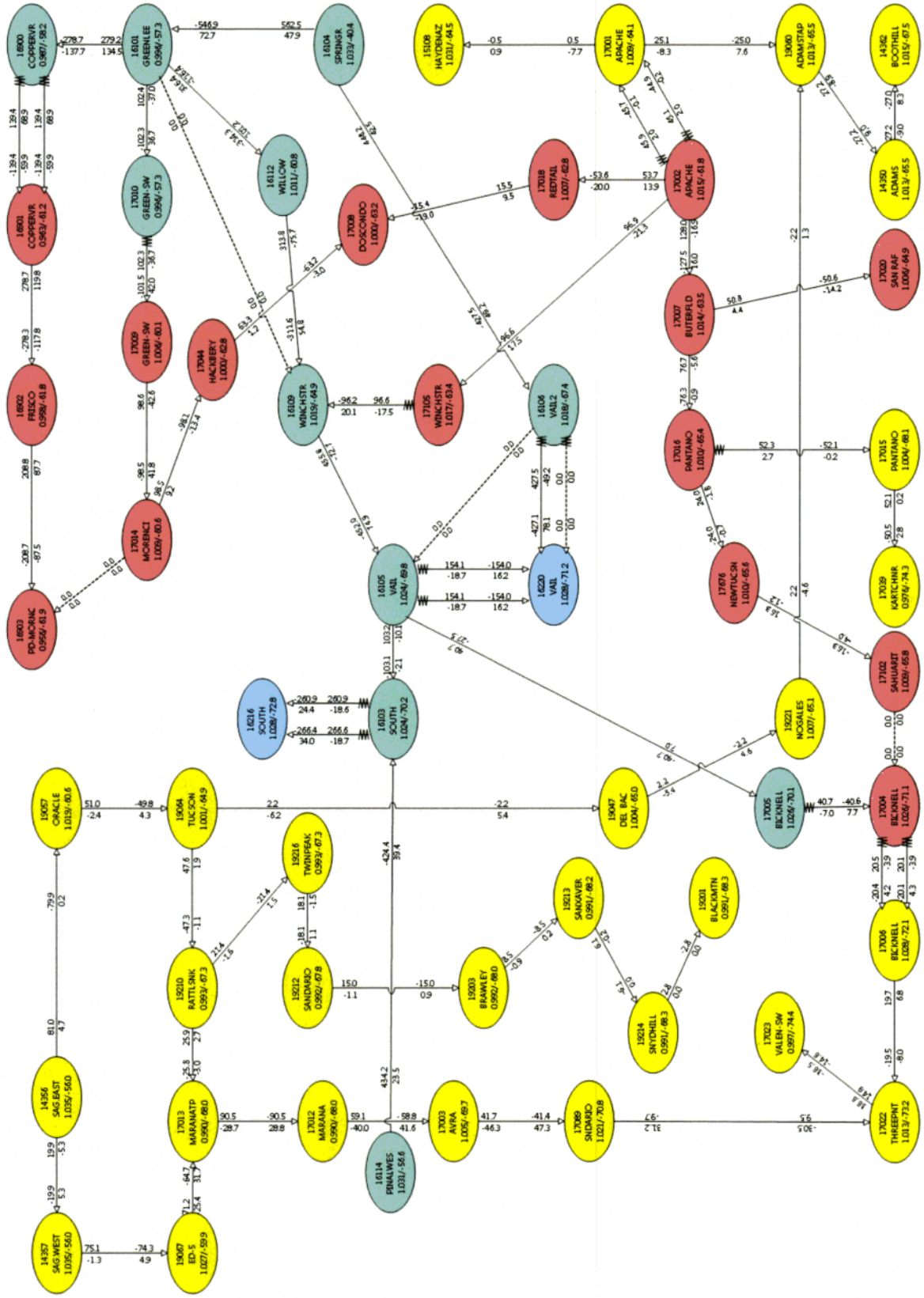
2018HS AEPCO System with Pantano to New Tucson 230 kV Line out of service



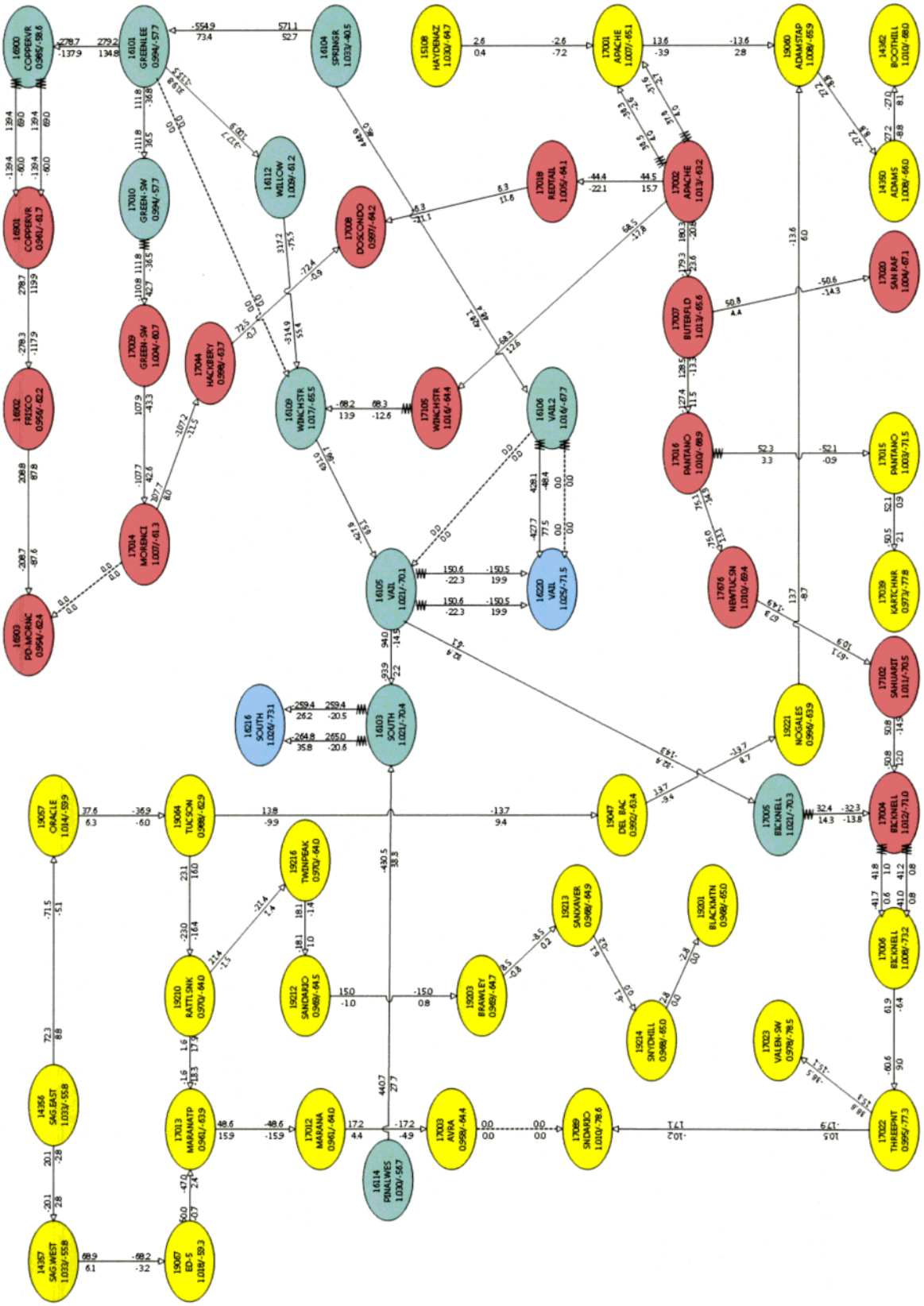
2018HS AEPCO System with Redtail to Dos Condados 230 kV Line out of service



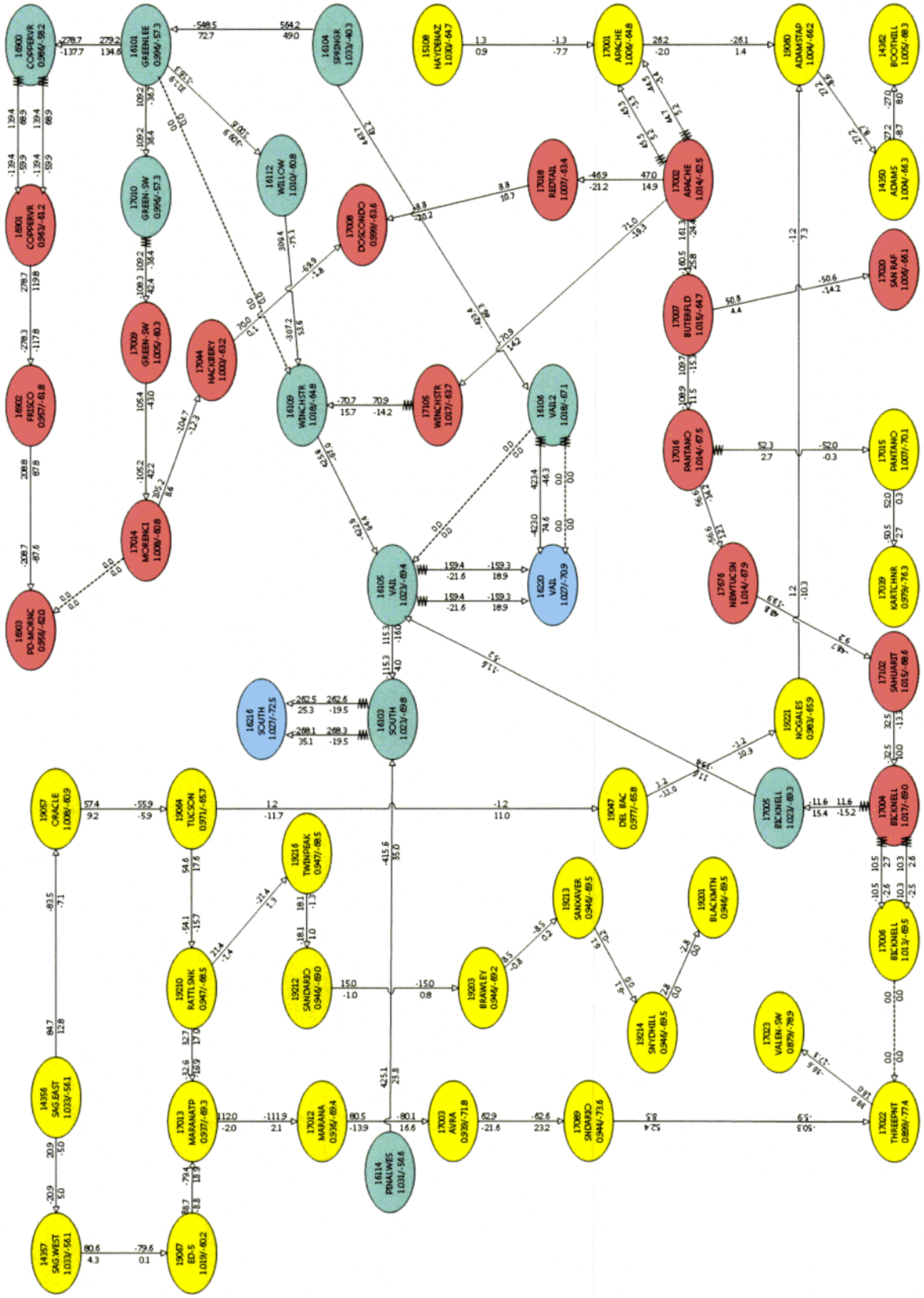
2018HS AEPCO System with Sahuarita to Bicknell 230 kV Line out of service



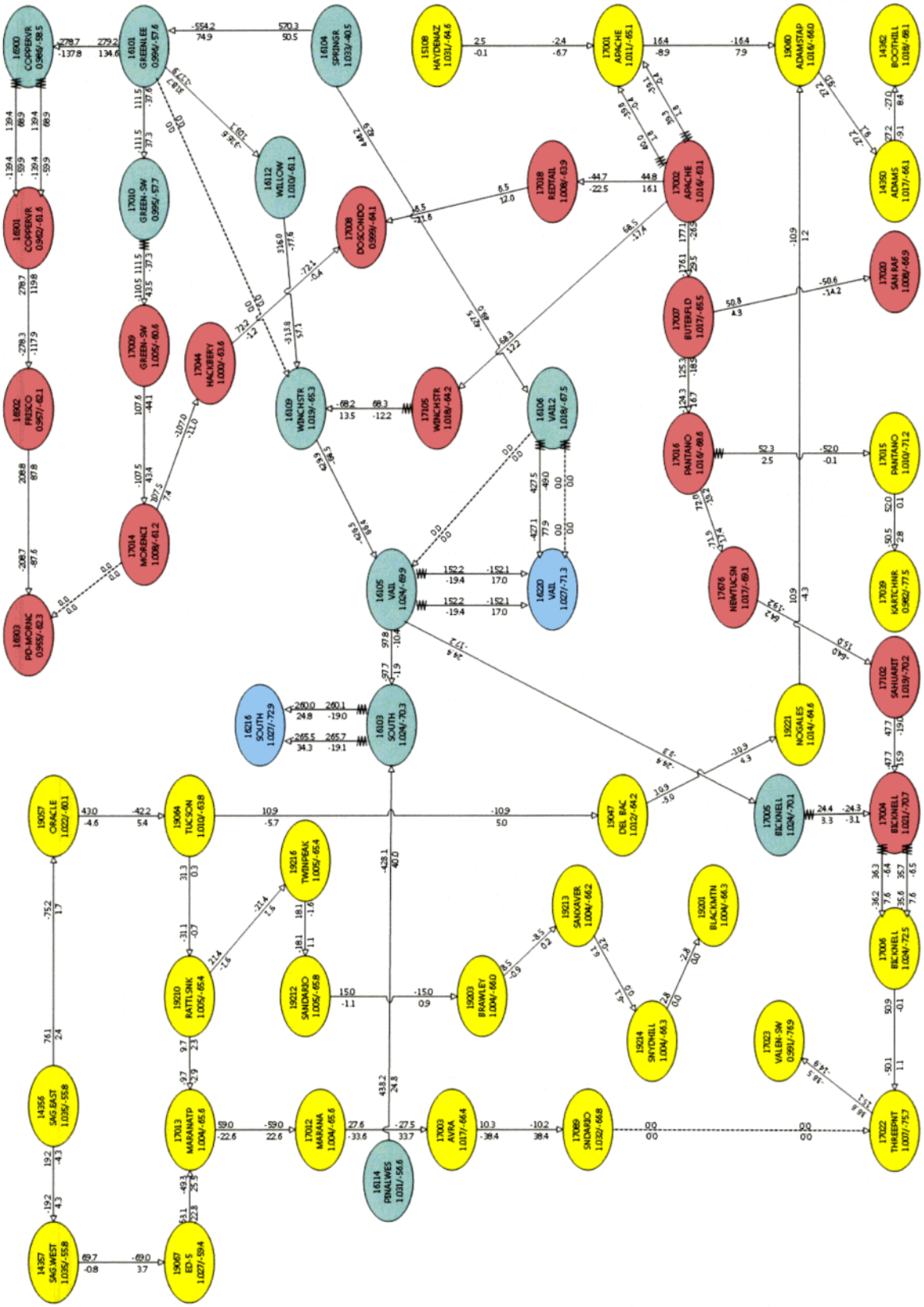
2018HS AEPCO System with Avra to Sandario 115 kV Line out of service



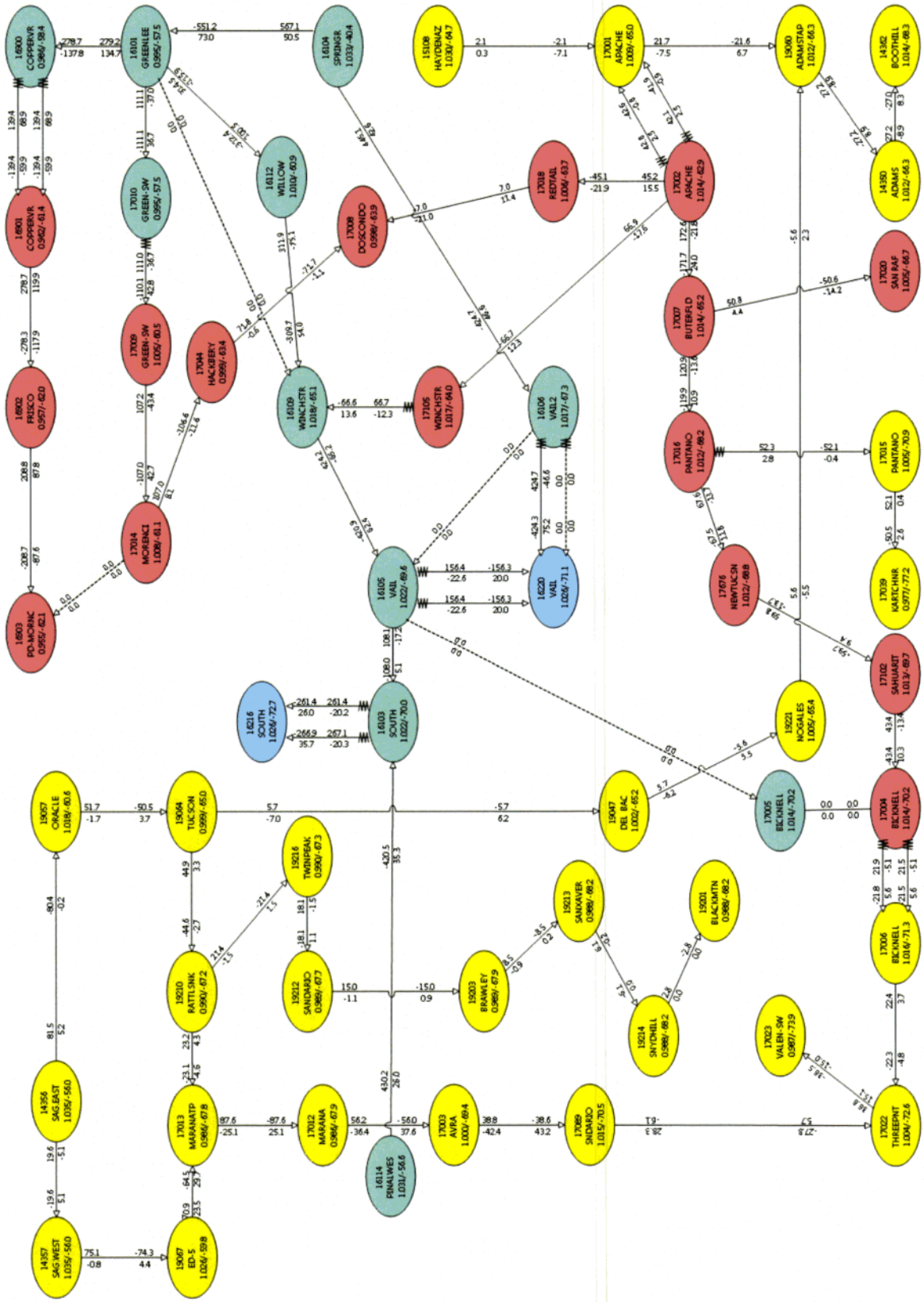
2018HS AEPCO System with Bicknell to Three Points 115 kV Line out of service



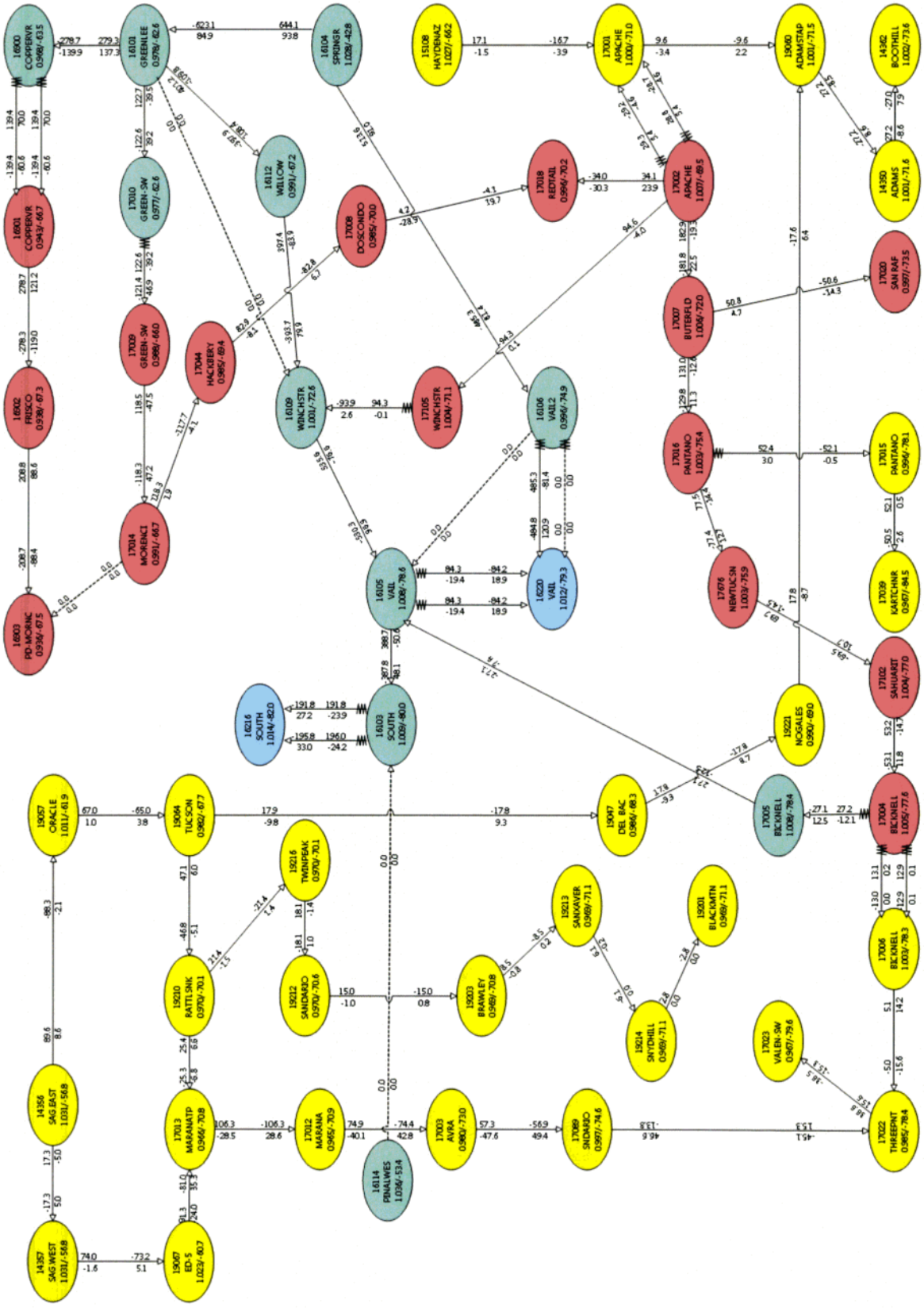
2018HS AEPCO System with Three Points to Sandario 115 kV Line out of service



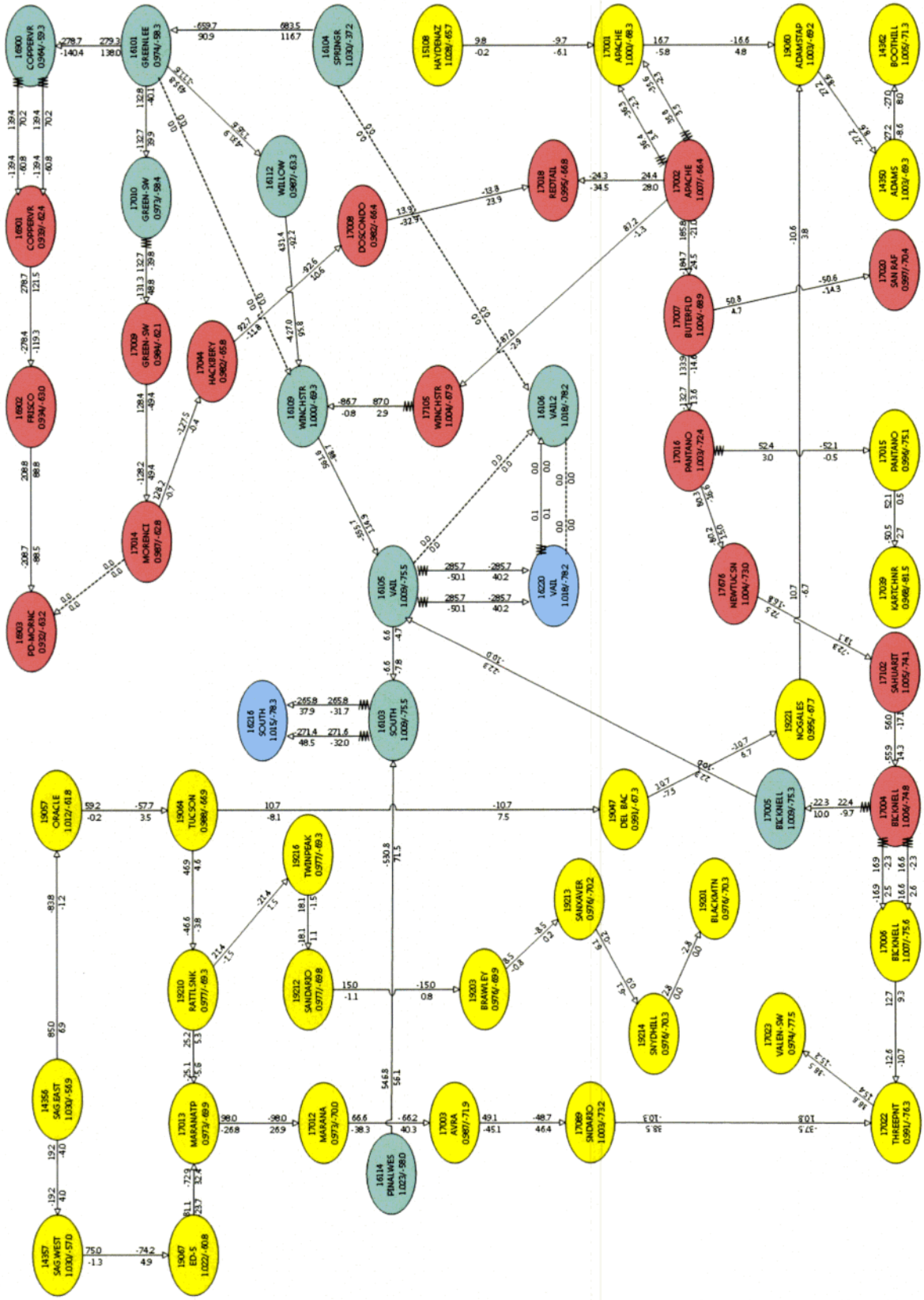
2018HS AEPCO System with Bicknell to Vail 345 kV Line out of service



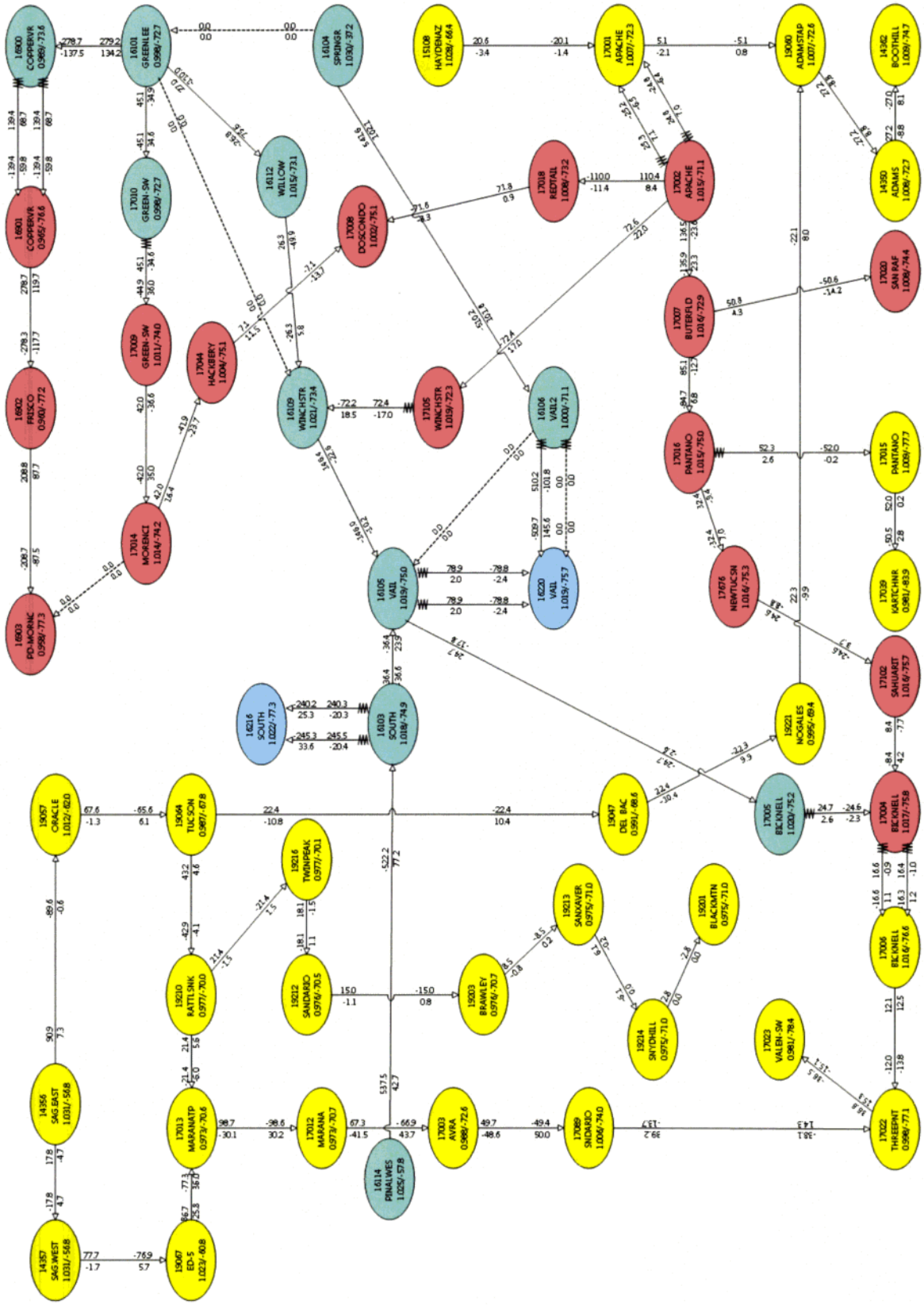
2018HS AEPCO System with Pinal West to South 345 kV Line out of service



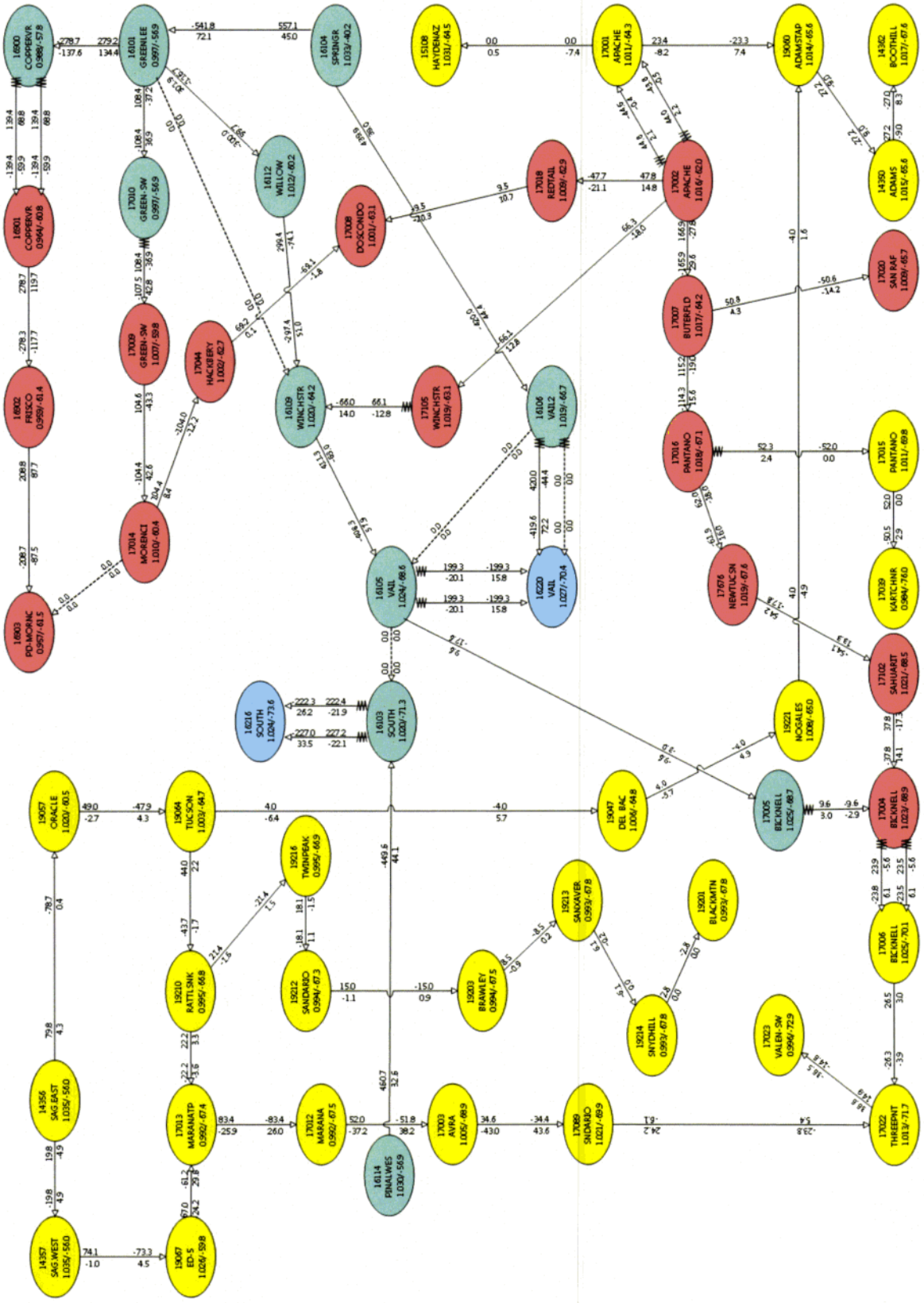
2018HS AEPCO System with Springerville to Vail2 345 kV Line out of service



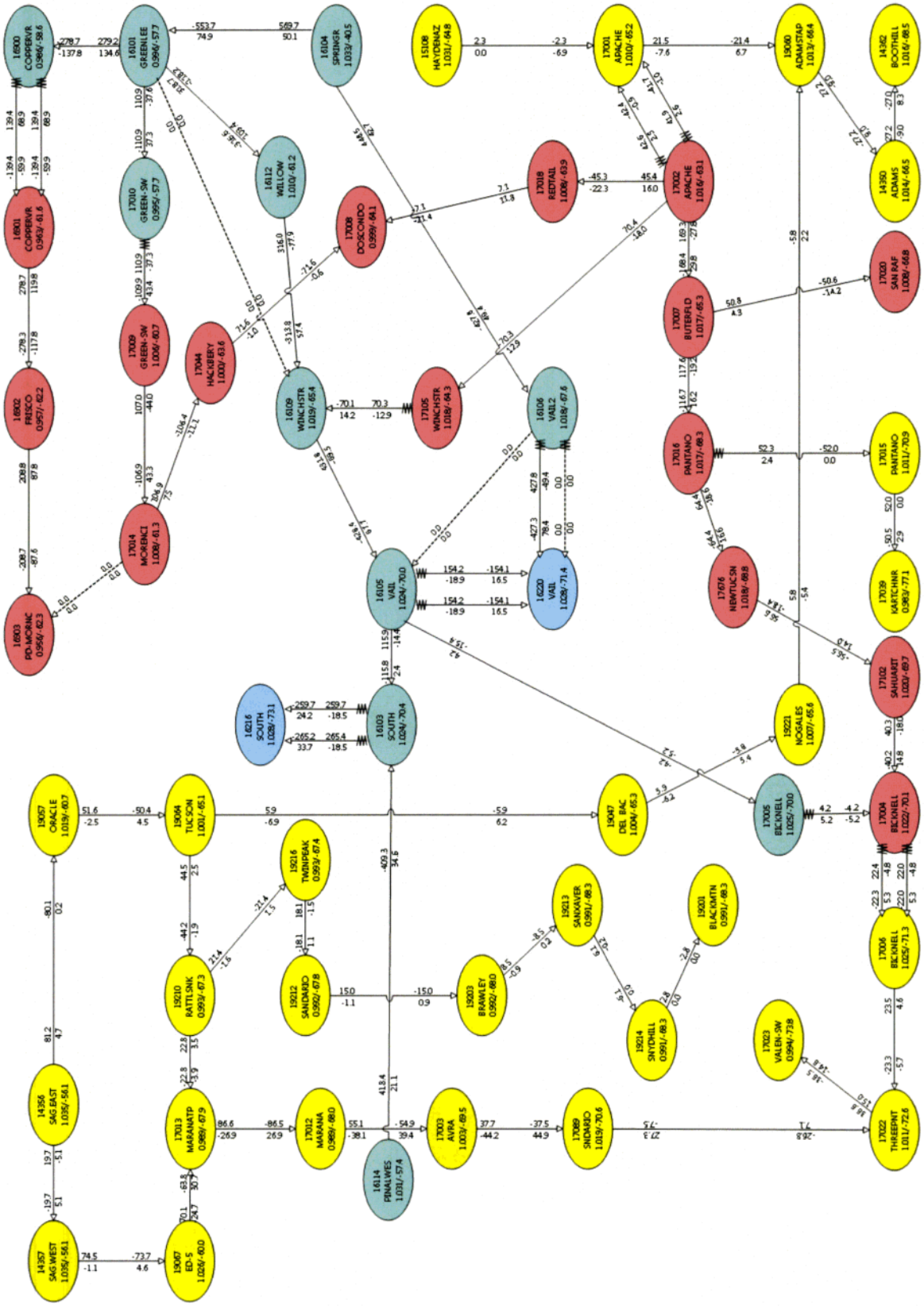
2018HS AEPCO System with Springerville to Greenlee 345 kV Line out of service



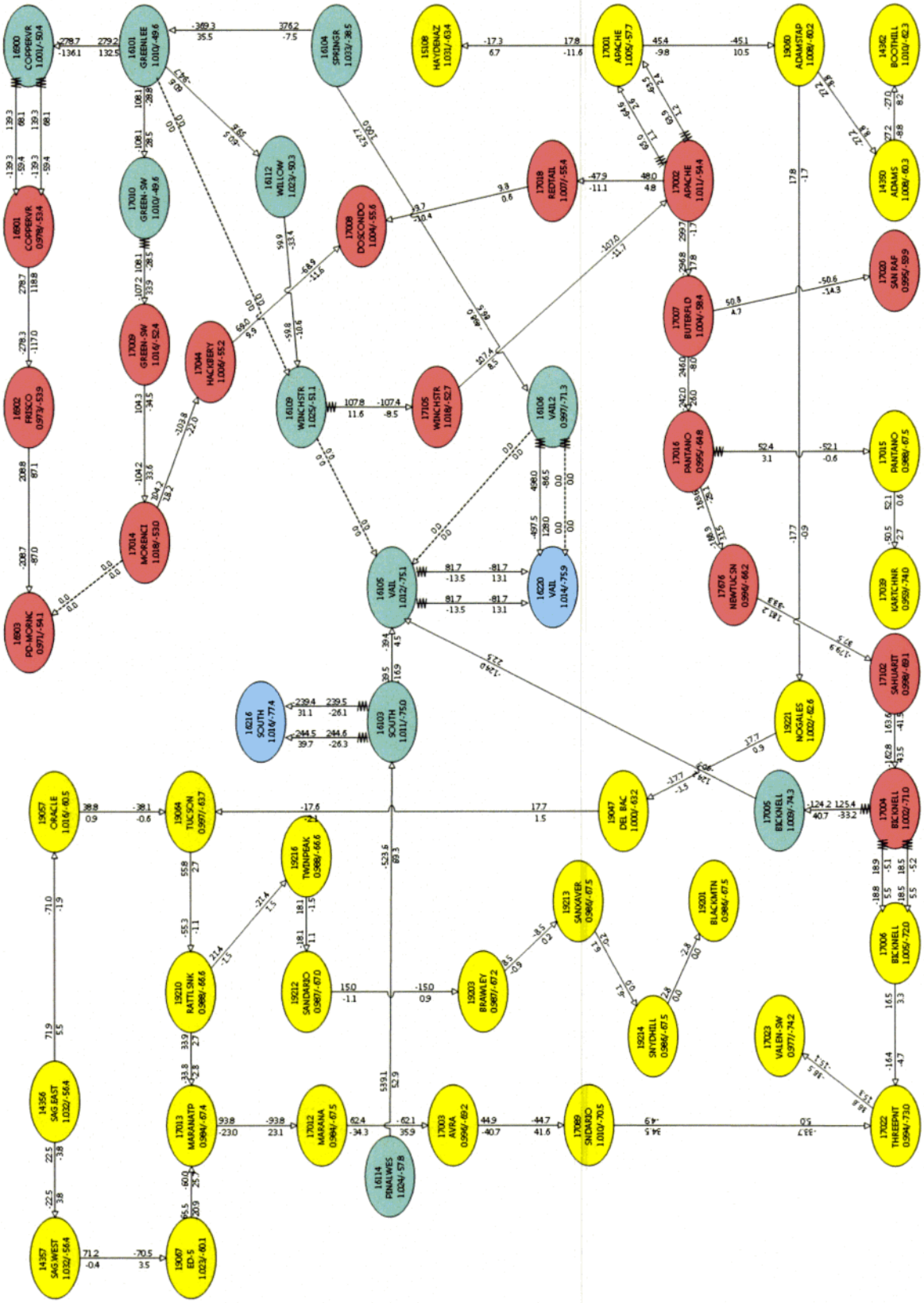
2018HS AEPCO System with Vail to South 345 kV Line out of service



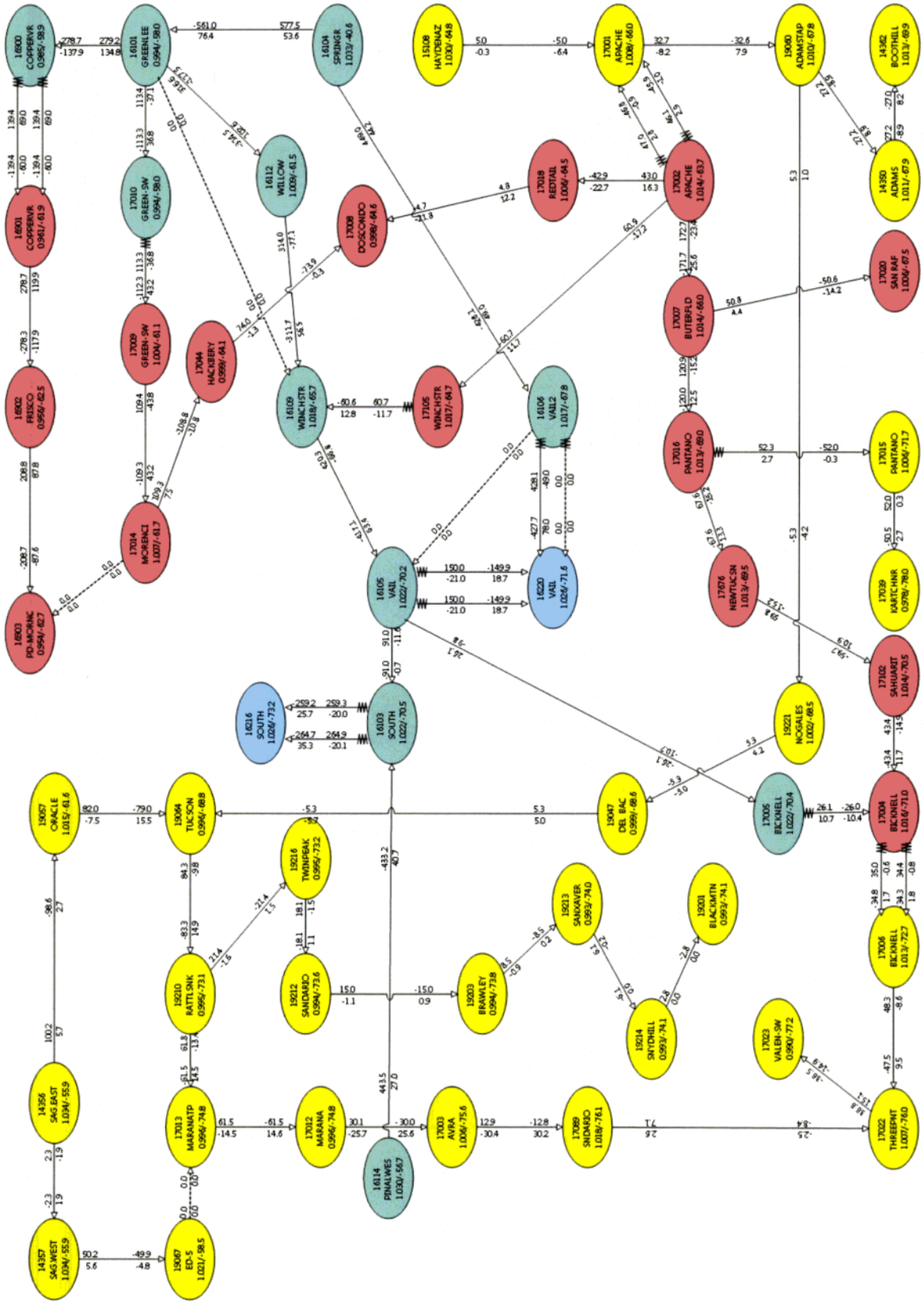
2018HS AEPCO System with Westwing to Pinal West 345 kV Line out of service



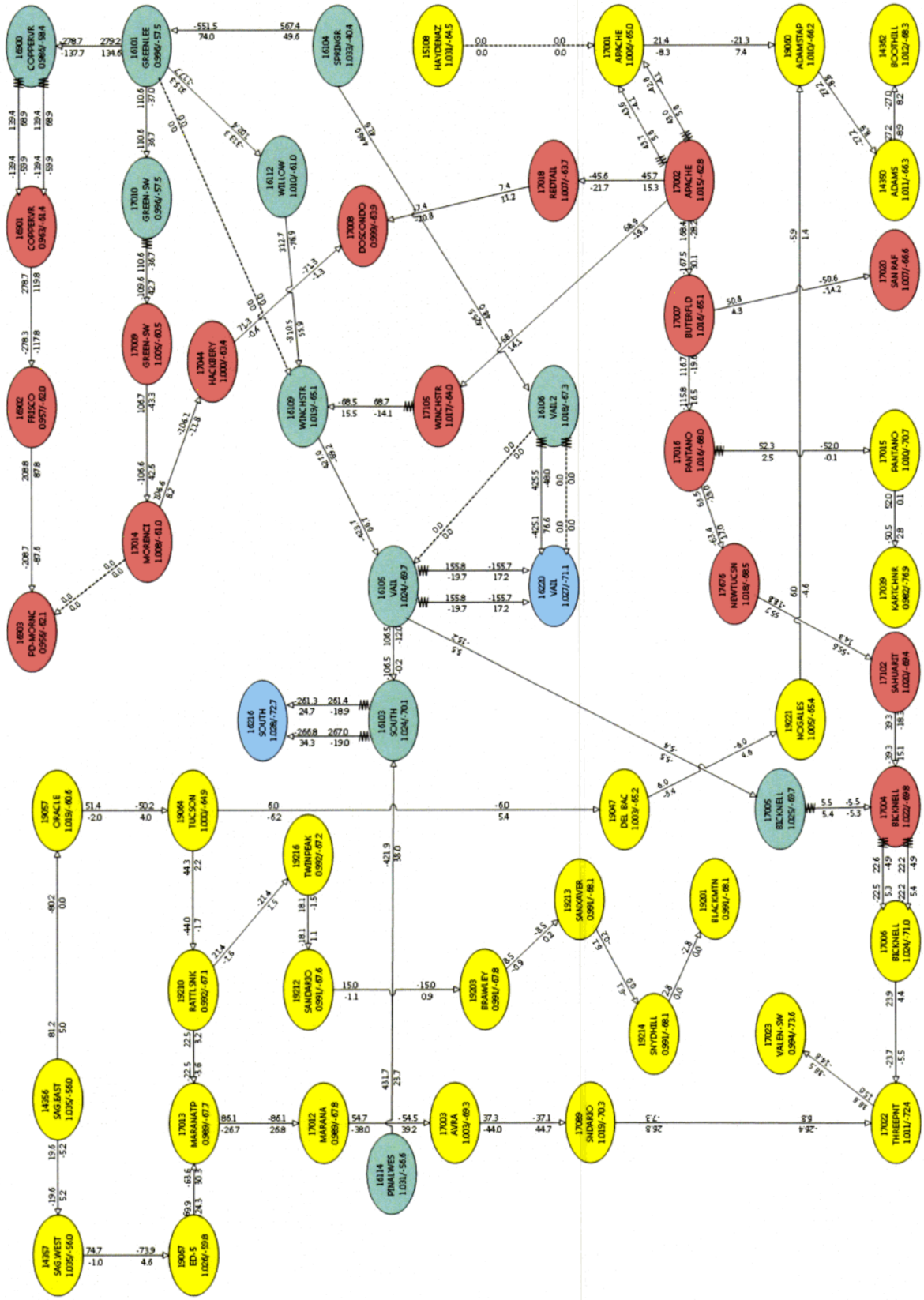
2018HS AEPCO System with Winchester to Vail 345 kV Line out of service



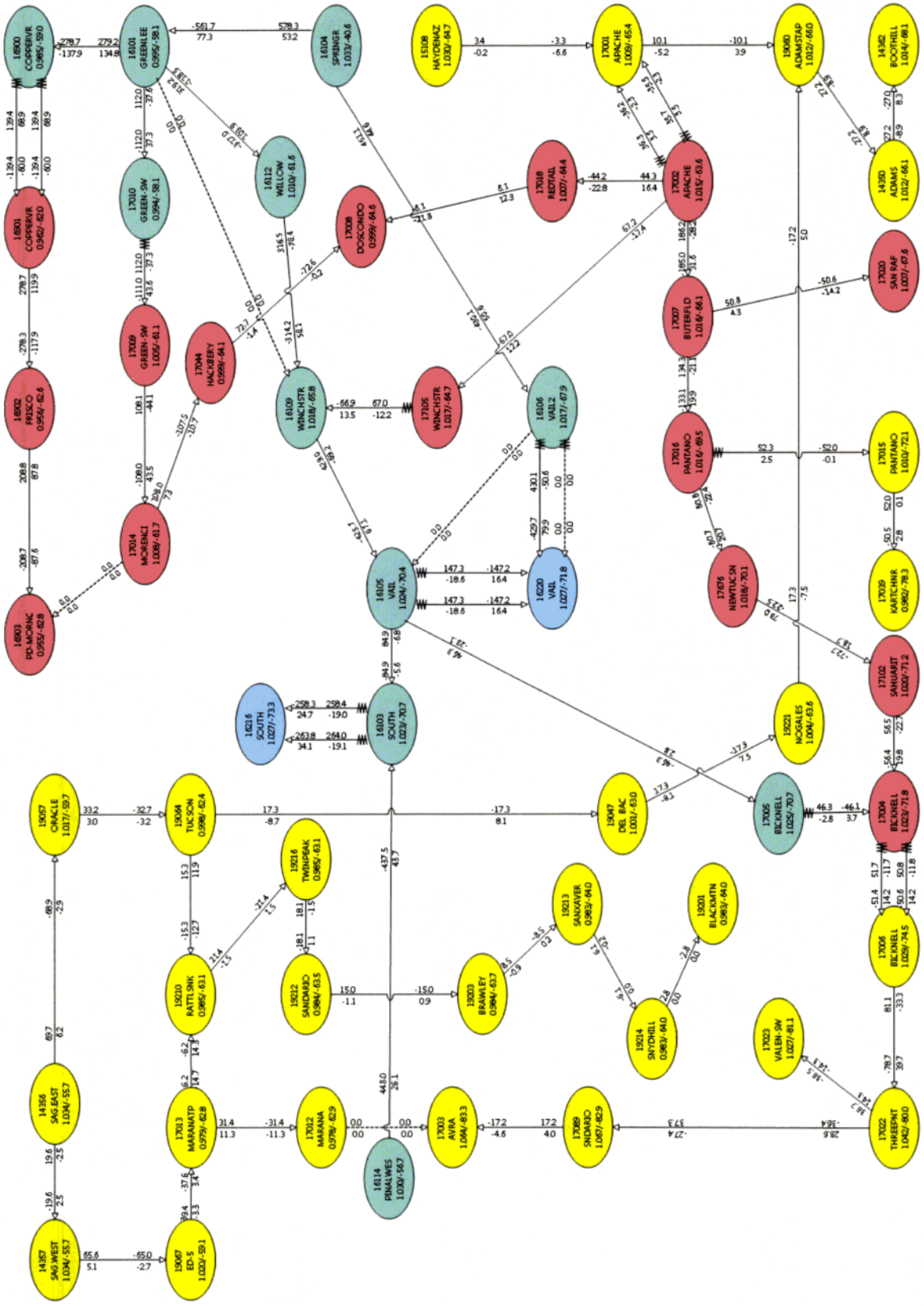
2018HS AEPCO System with ED-5 to Marana Tap 115 kV Line out of service



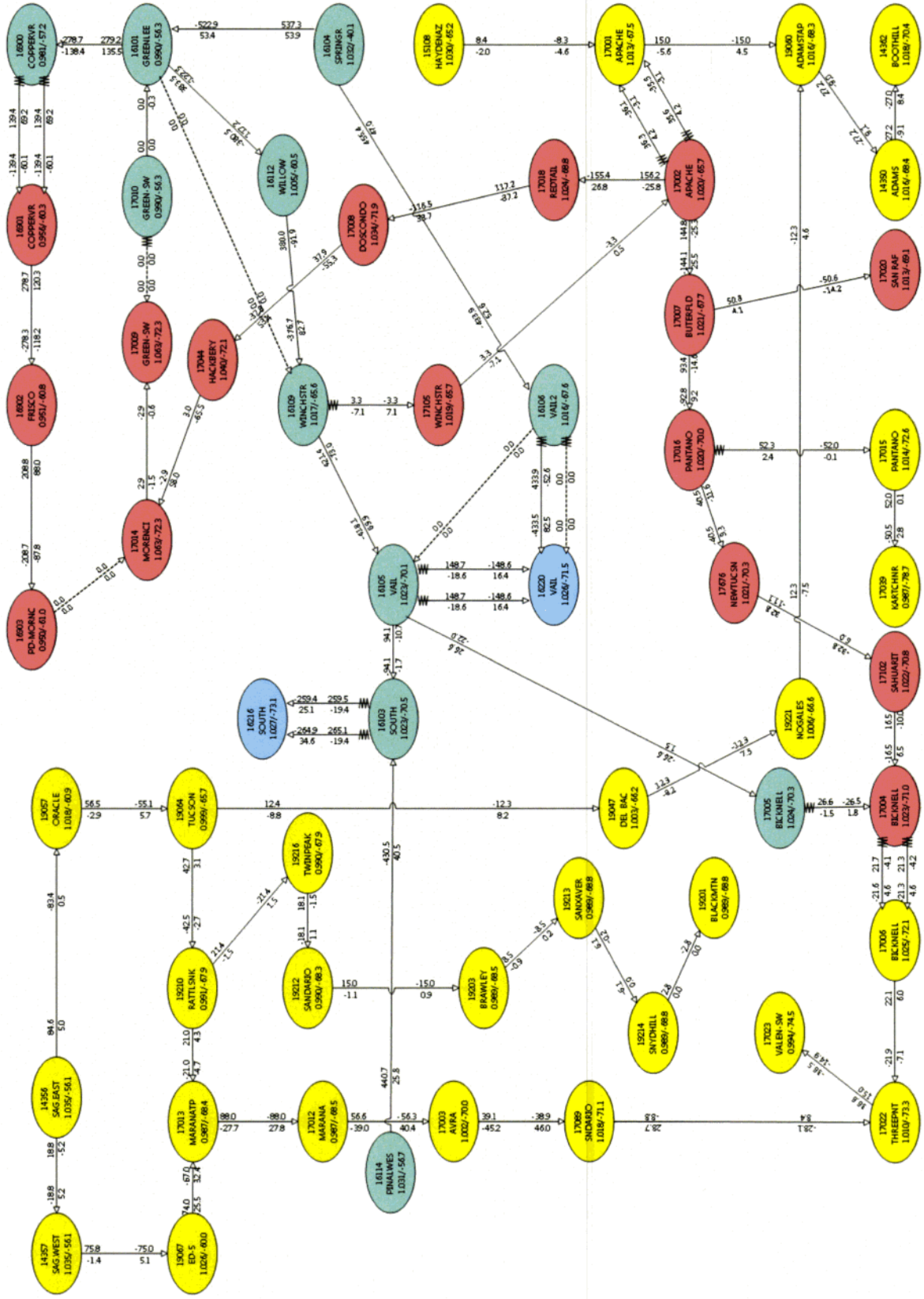
2018HS AEPCO System with Apache to Hayden 115 kV Line out of service



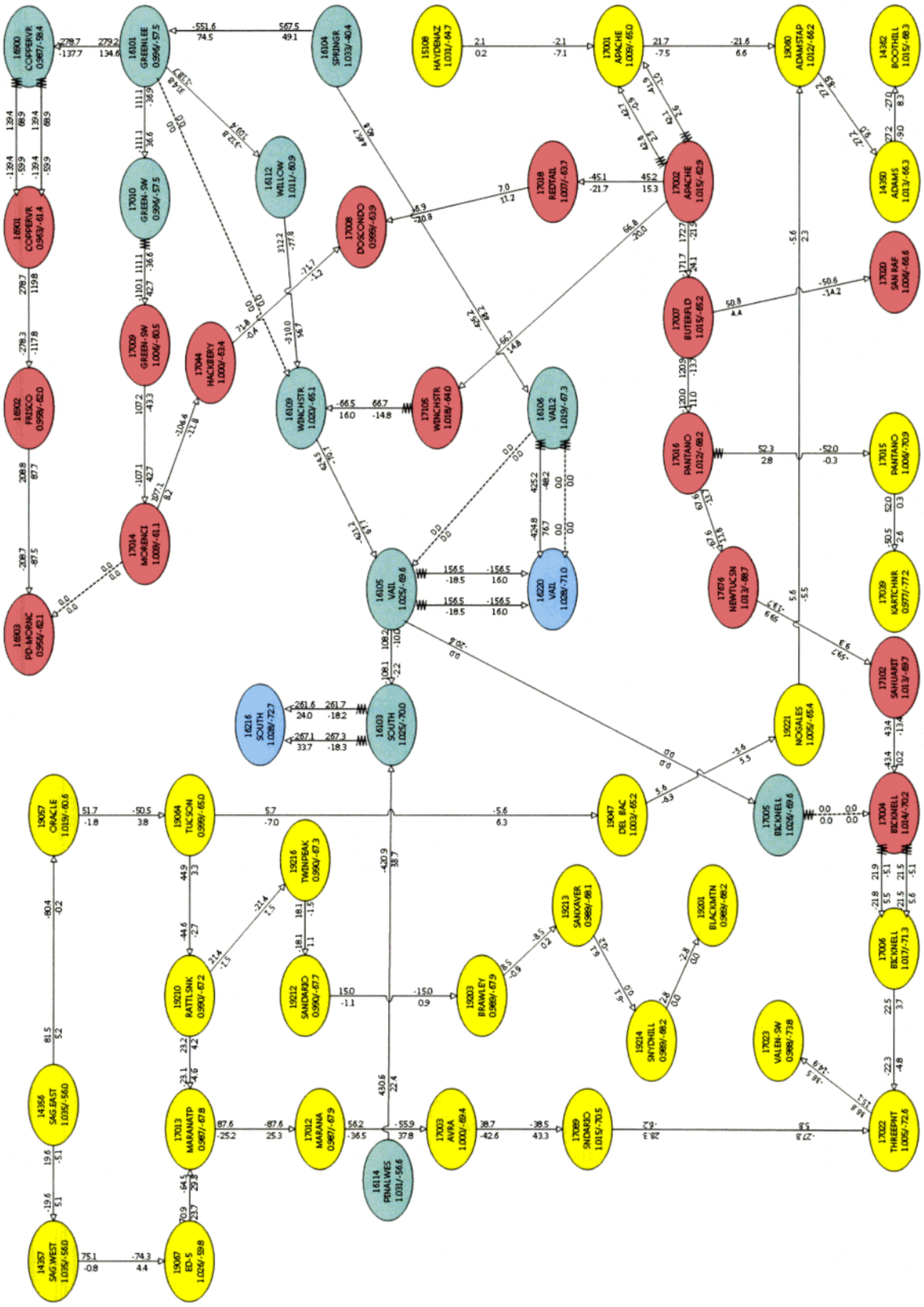
2018HS AEPCO System with Marana to Avra 115 kV Line out of service



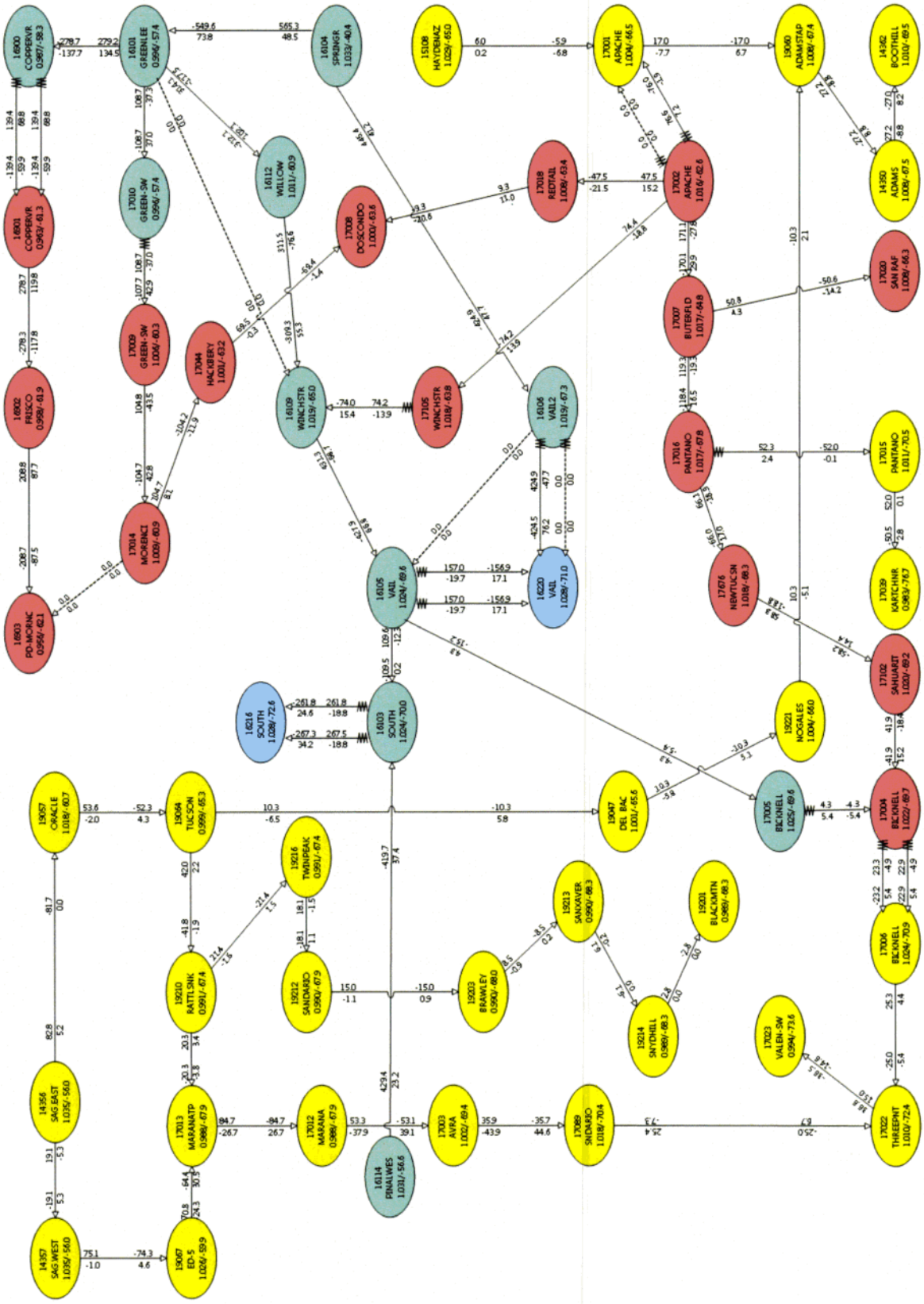
2018HS AEPCO System with Green-SW 345/230 kV Transformer out of service



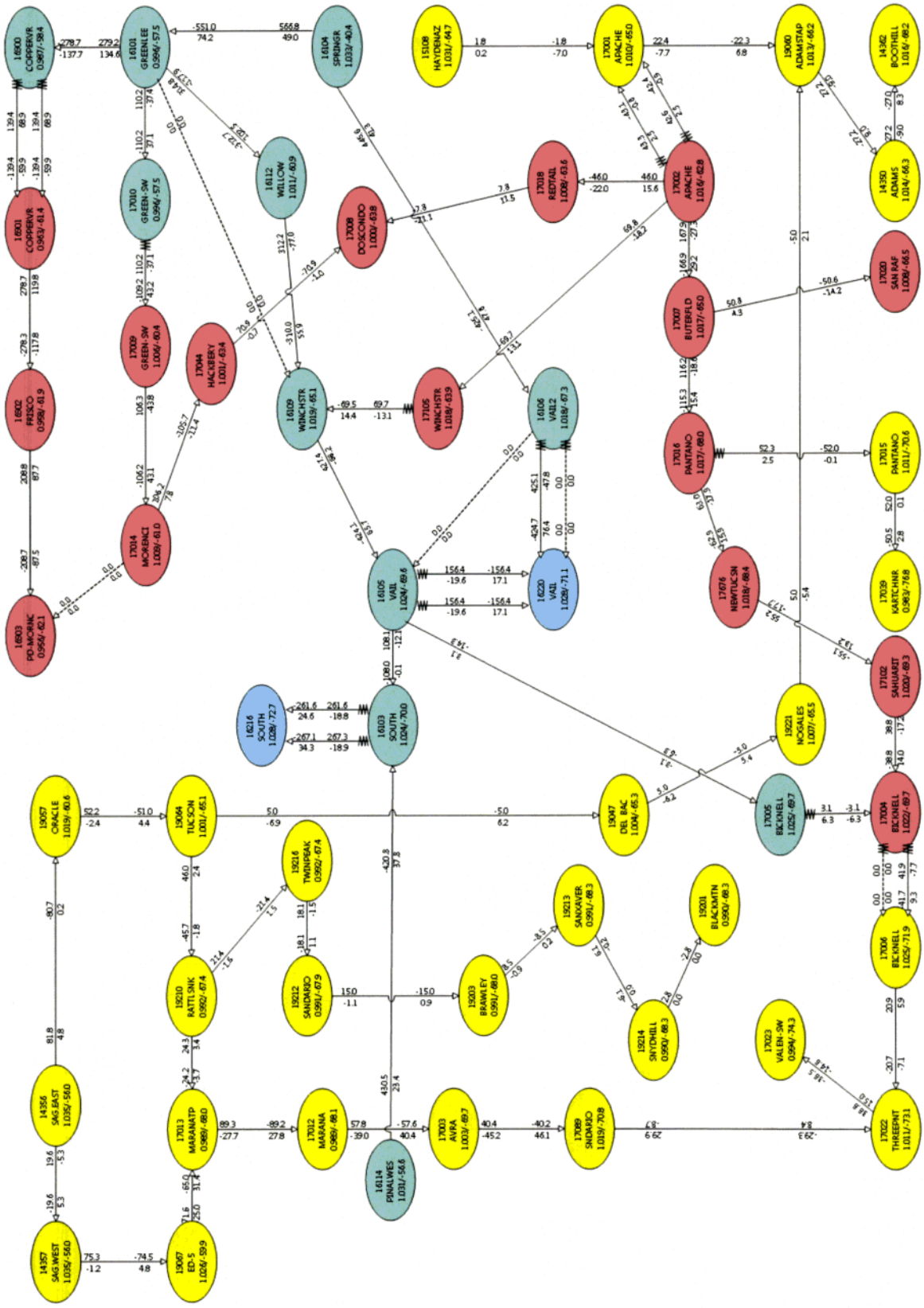
2018HS AEPCO System with Bicknell 345/230 kV Transformer out of service



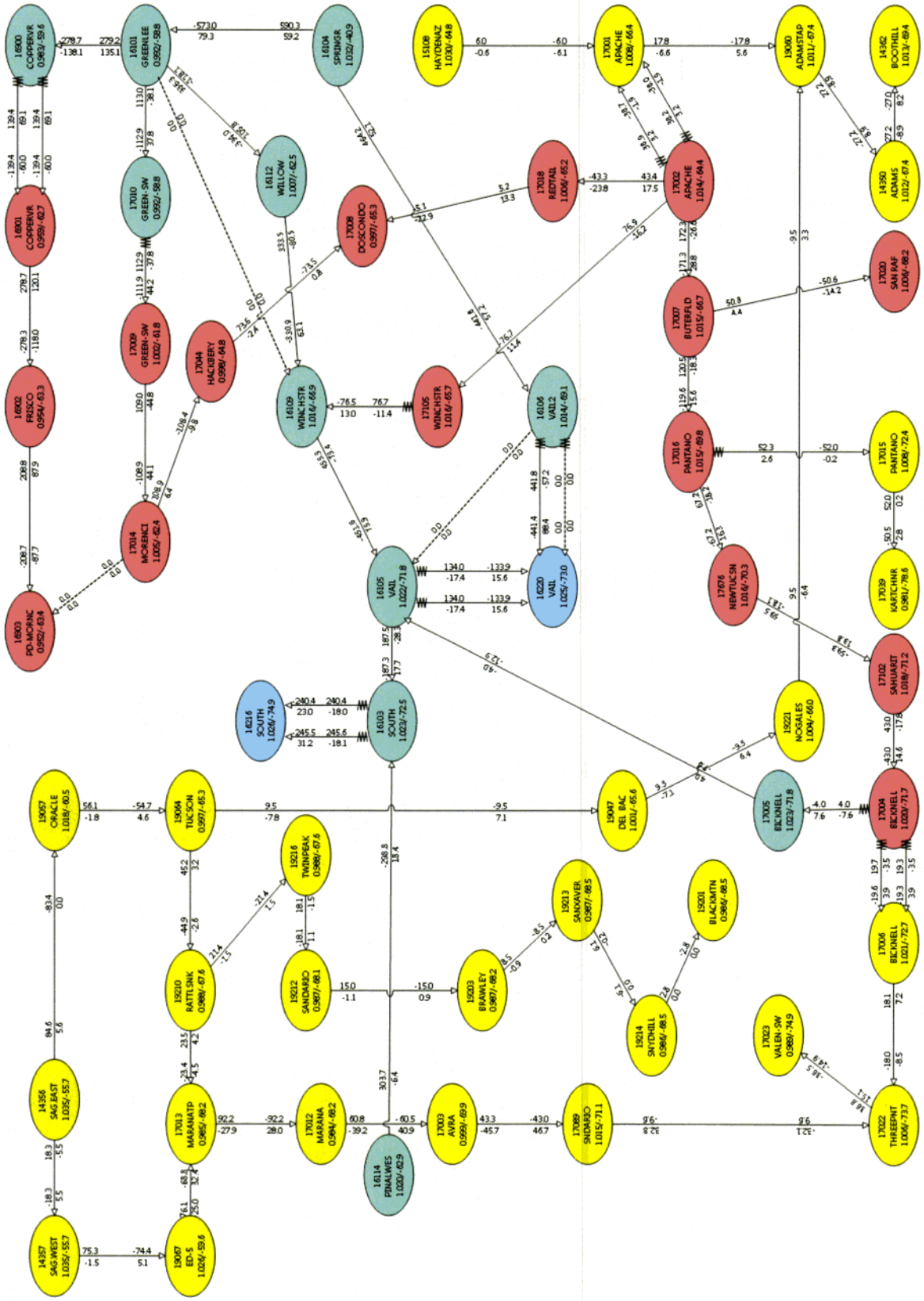
2018HS AEPCO System with one Apache 230/115 kV Transformer out of service



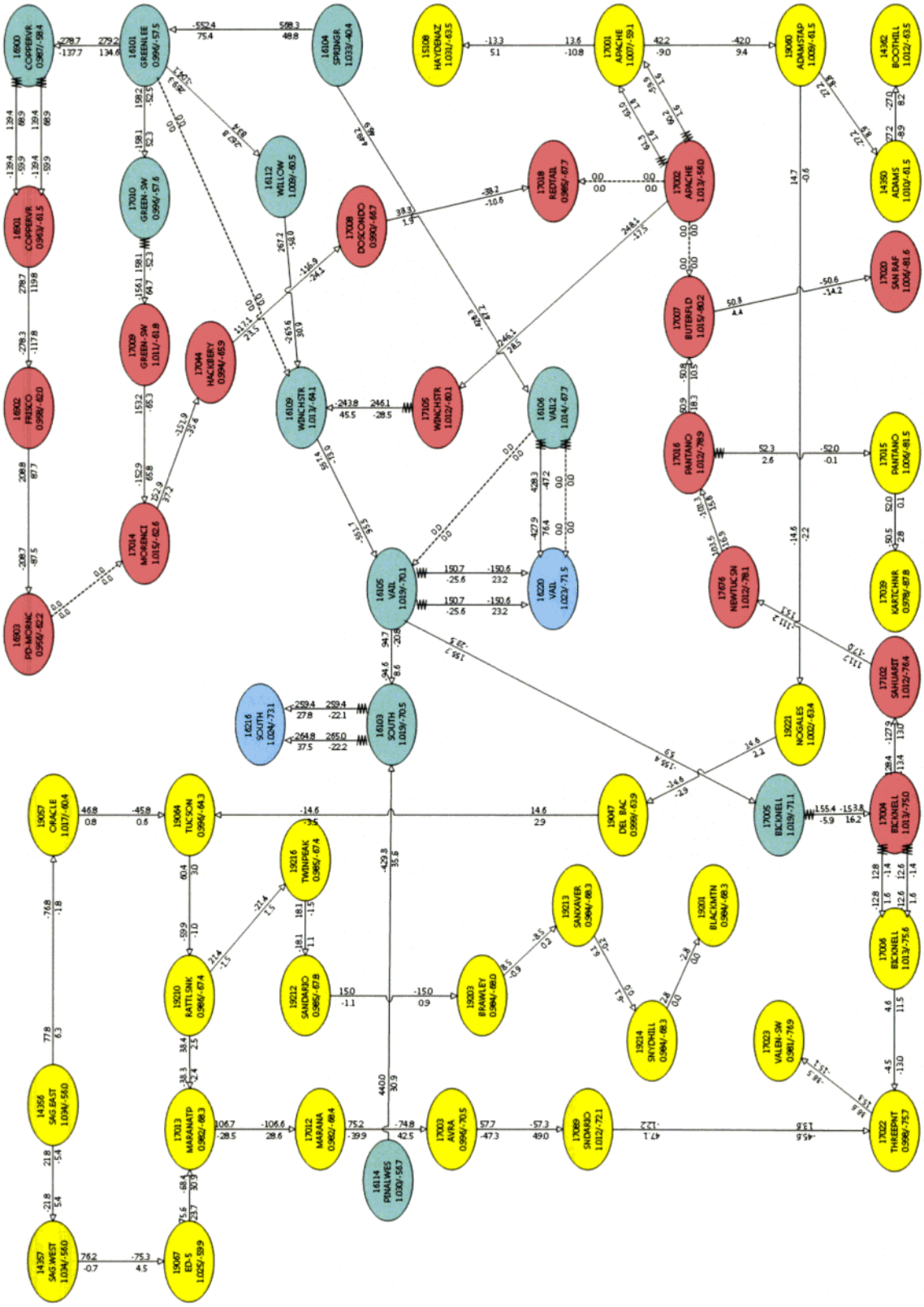
2018HS AEPCO System with one Bicknell 230/115 kV Transformer out of service



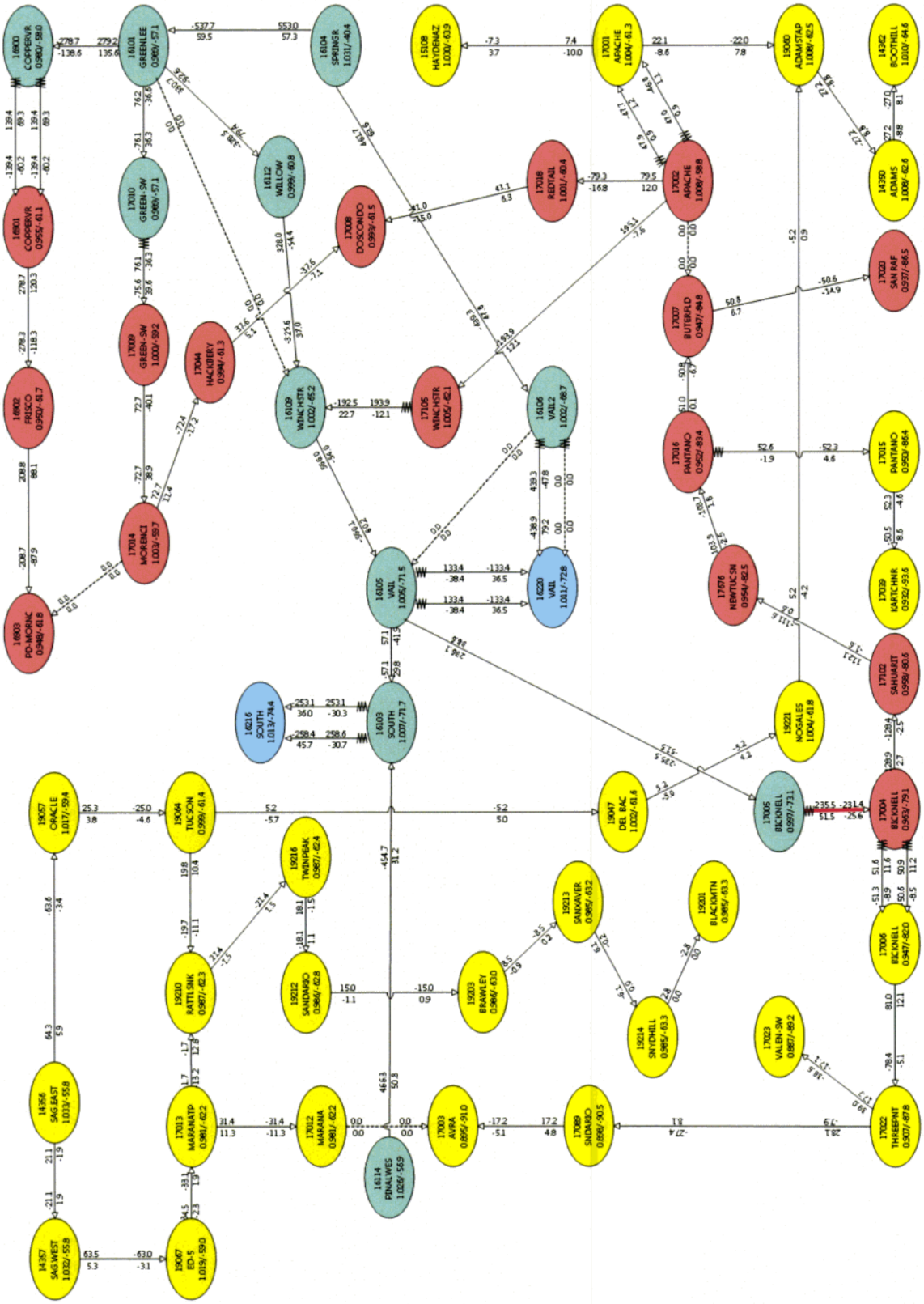
2018HS AEPCO System with Pinal West 500/345 kV Transformer out of service



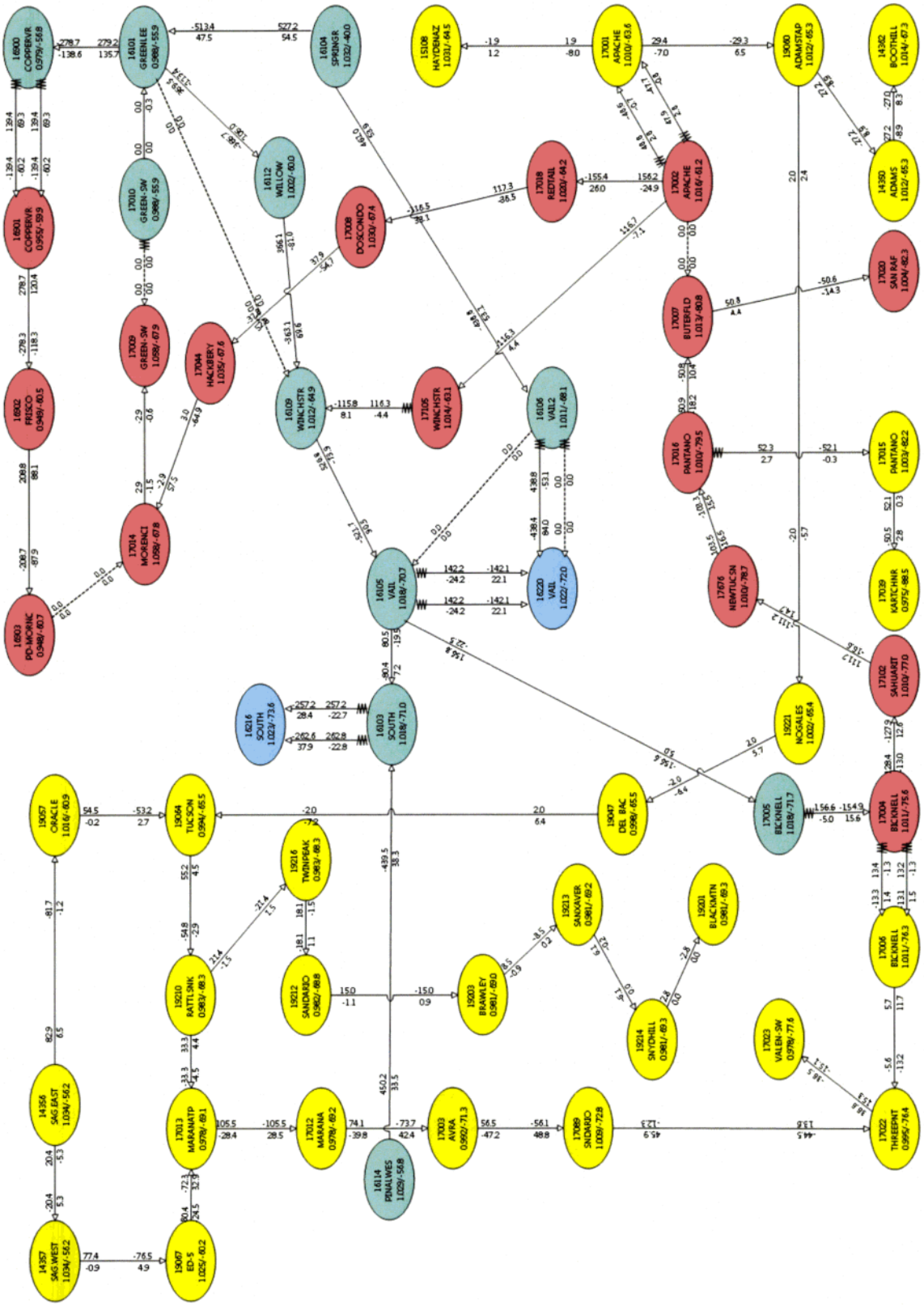
2018HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Apache to Redtail 230 kV Line out of service



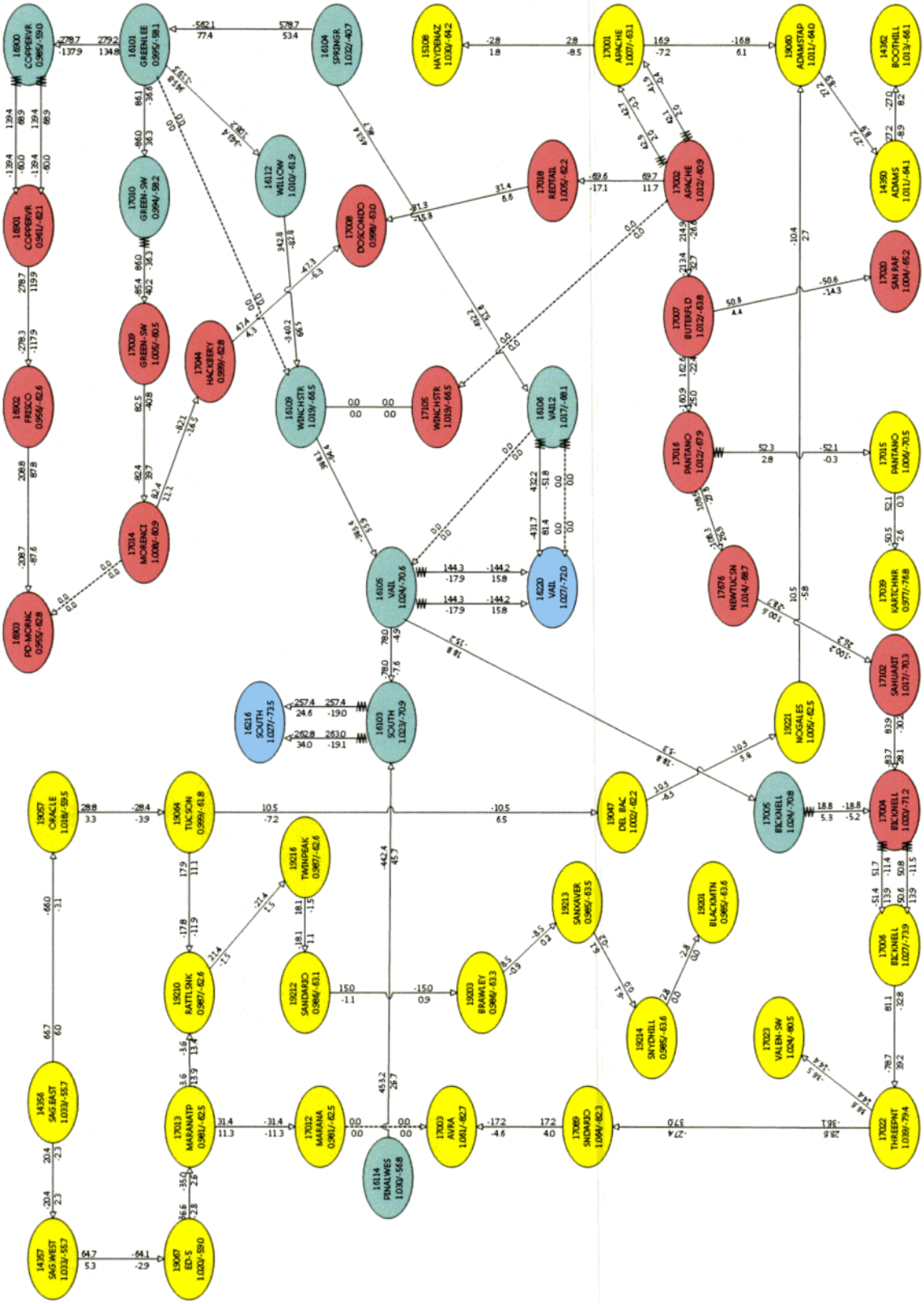
2018HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Marana to Avra 115 kV Line out of service



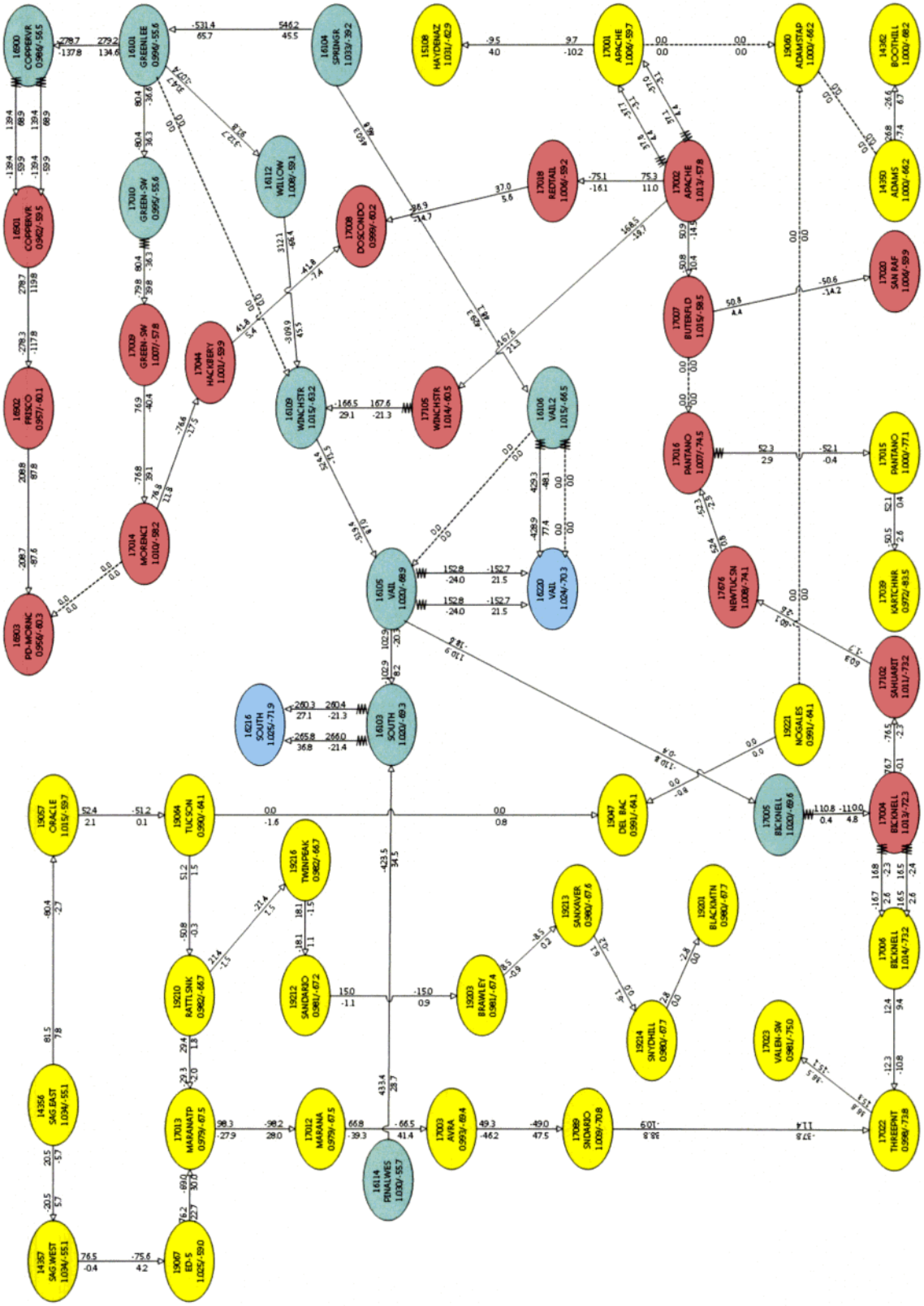
2018HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Green-SW 345/230 kV Transformer out of service



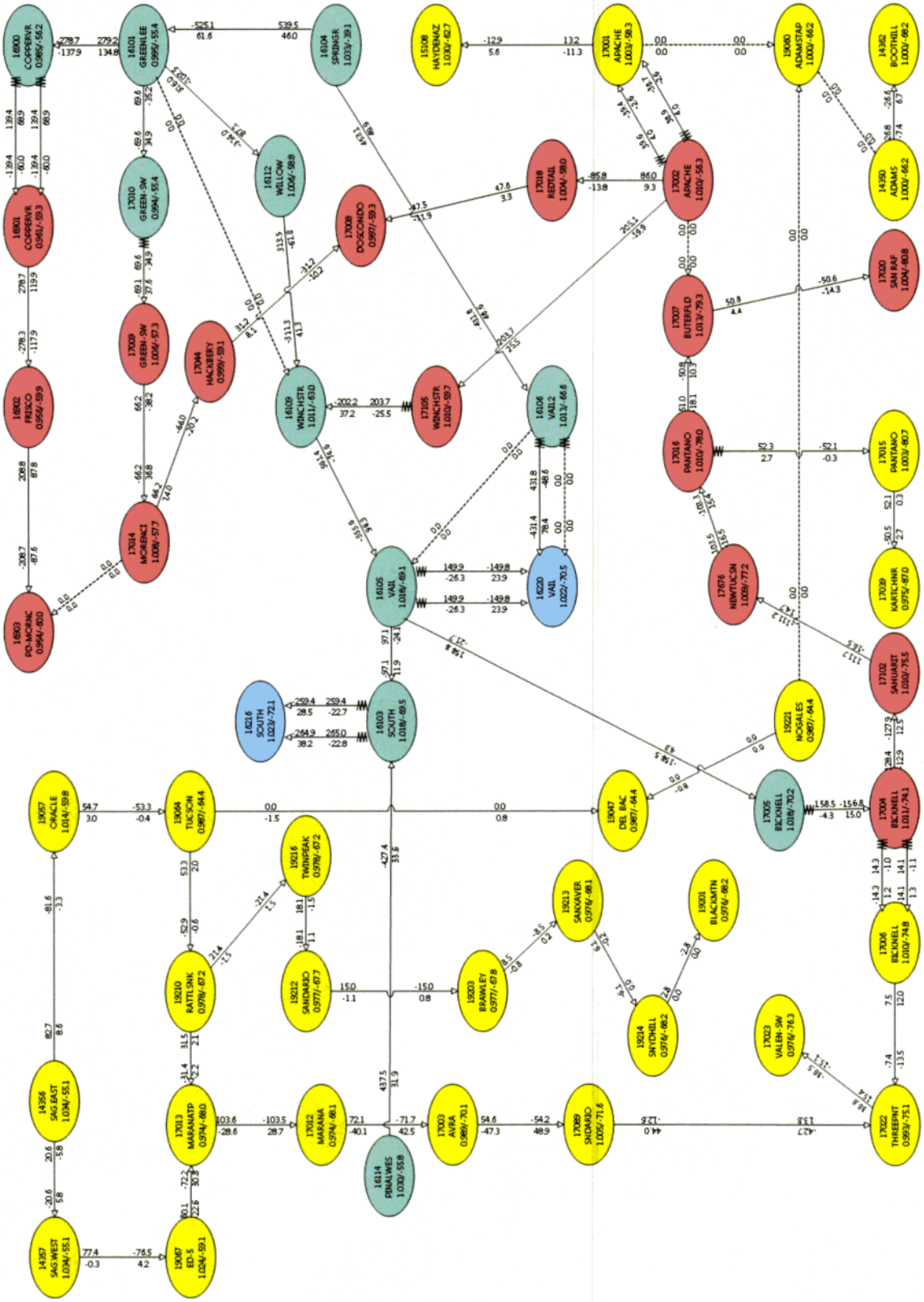
2018HS AEPCO System with Apache to Winchester 230 kV Line out followed by the Marana to Avra 115 kV Line out of service



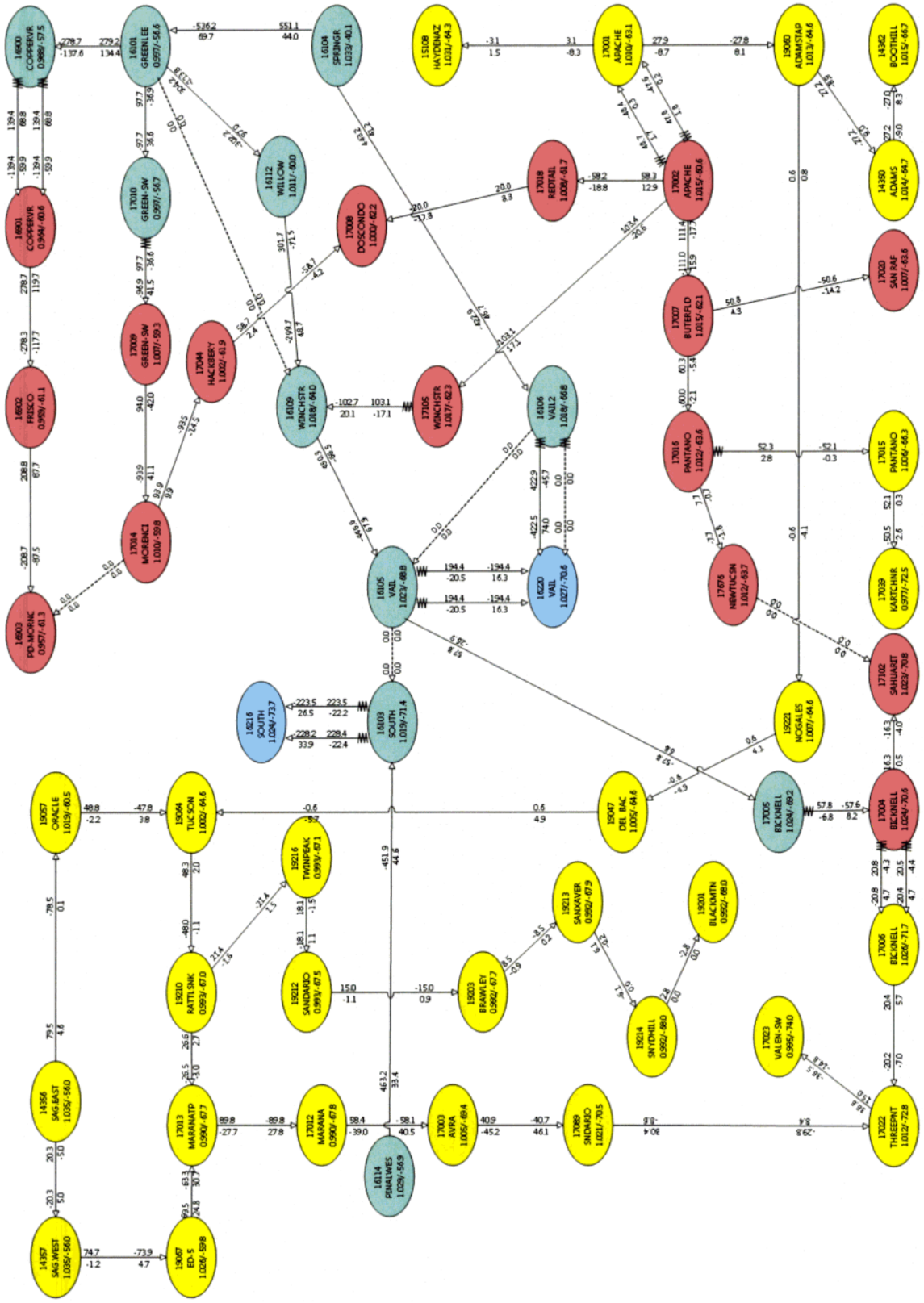
2018HS AEPCO System with Common Corridor outage of the Butterfield to Pantano 230 kV & Adams Tap to Apache 115 kV Lines



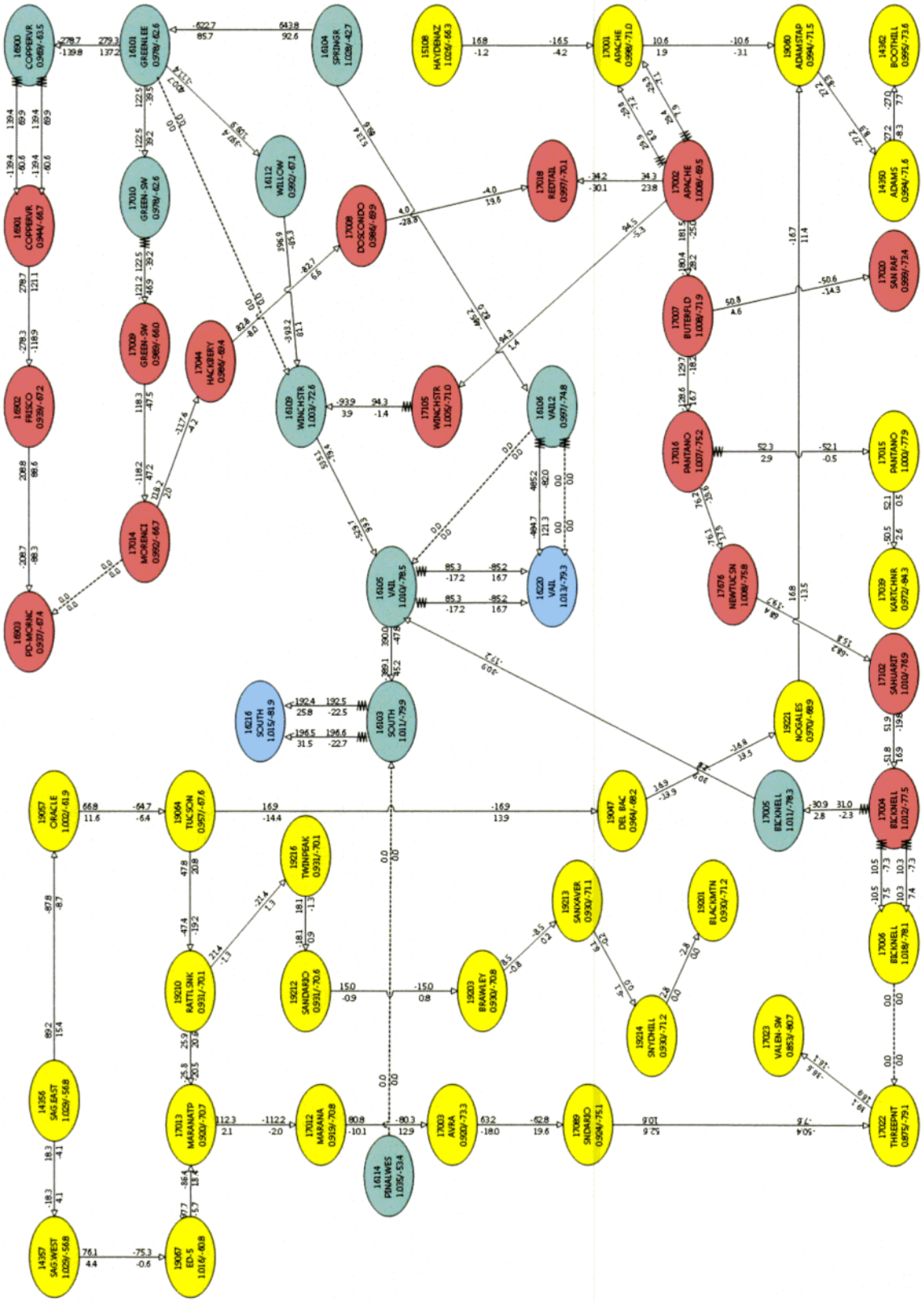
2018HS AEPCO System with Common Corridor outage of the Apache to Butterfield 230 kV & Adams Tap to Apache 115 kV Lines



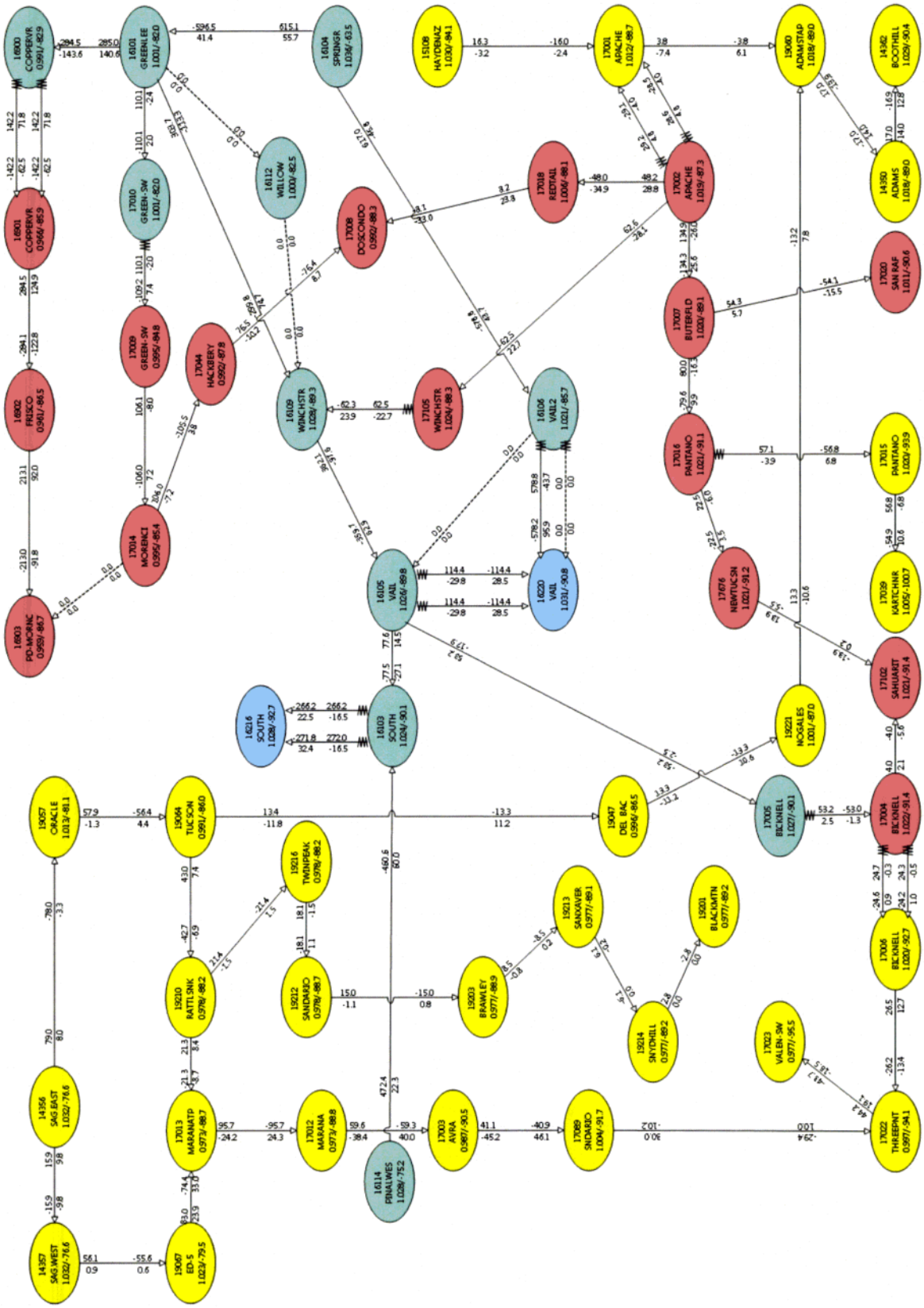
2018HS AEPCO System with Common Corridor outage of the Vail to South 345 kV & New Tucson to Sahuarita 230 kV Lines



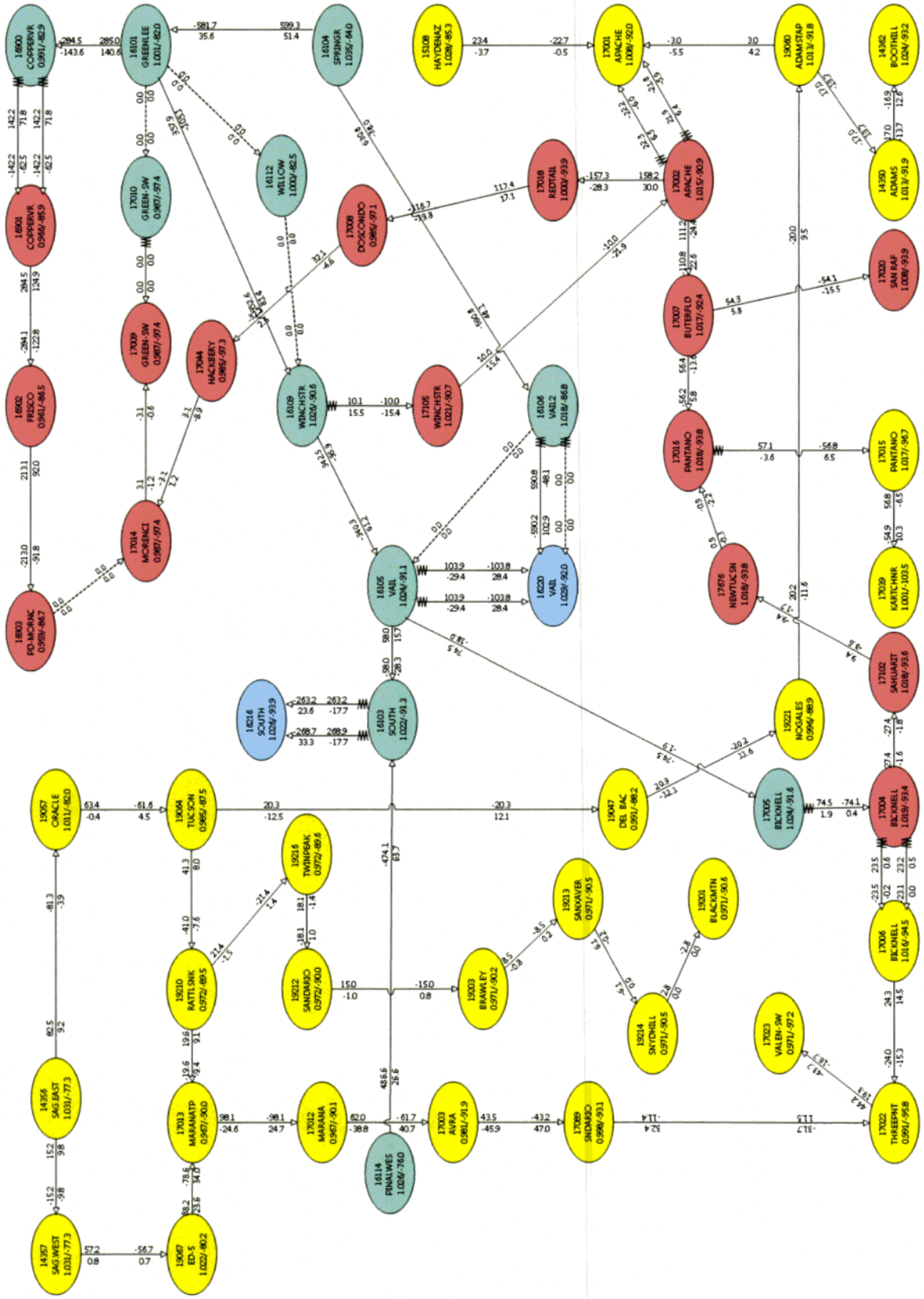
2018HS AEPCO System with Common Corridor outage of the Pinal West to South 345 kV and Bicknell to Three Points 115 kV Lines



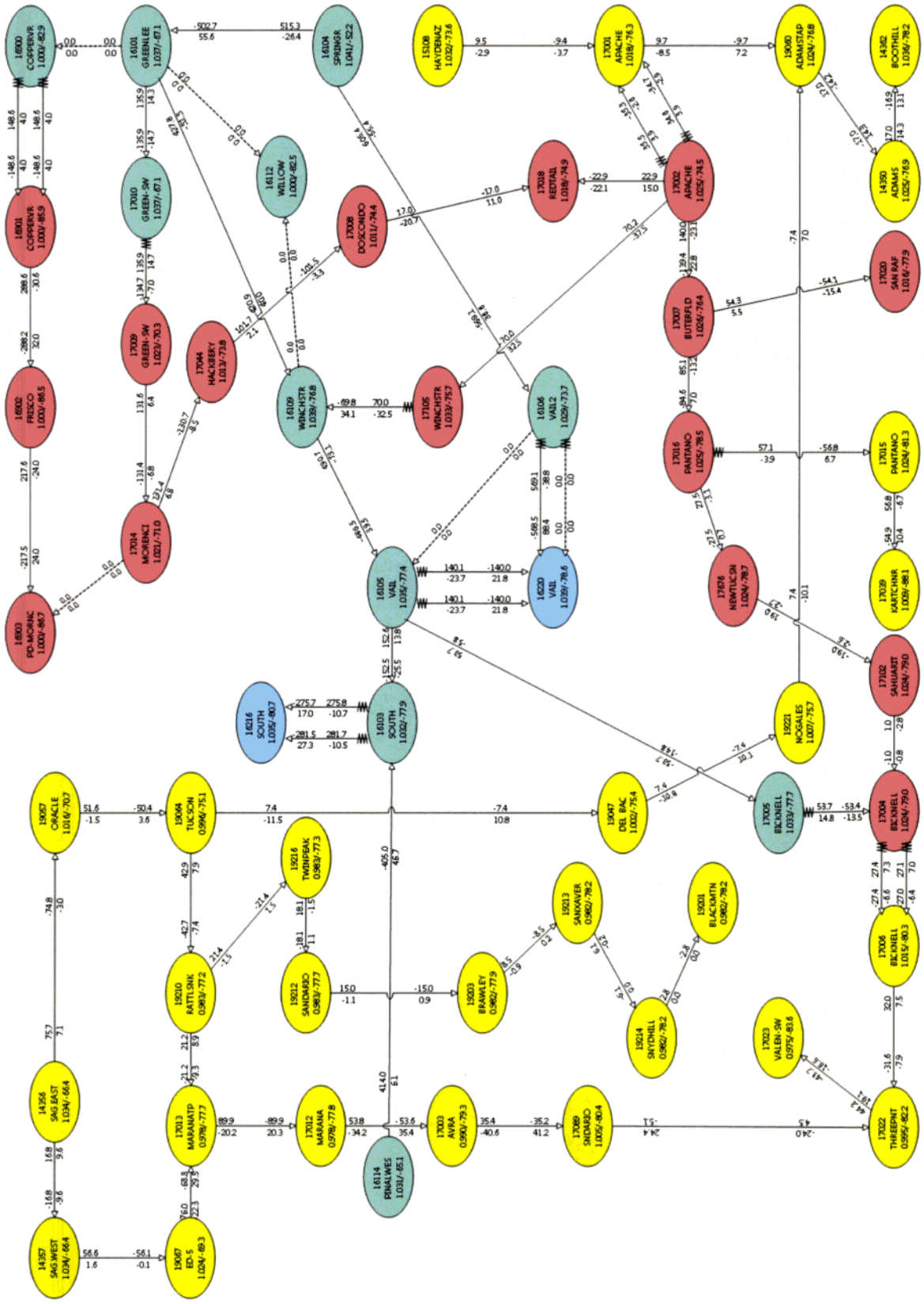
2021HS AEPCO System – All Lines in Service



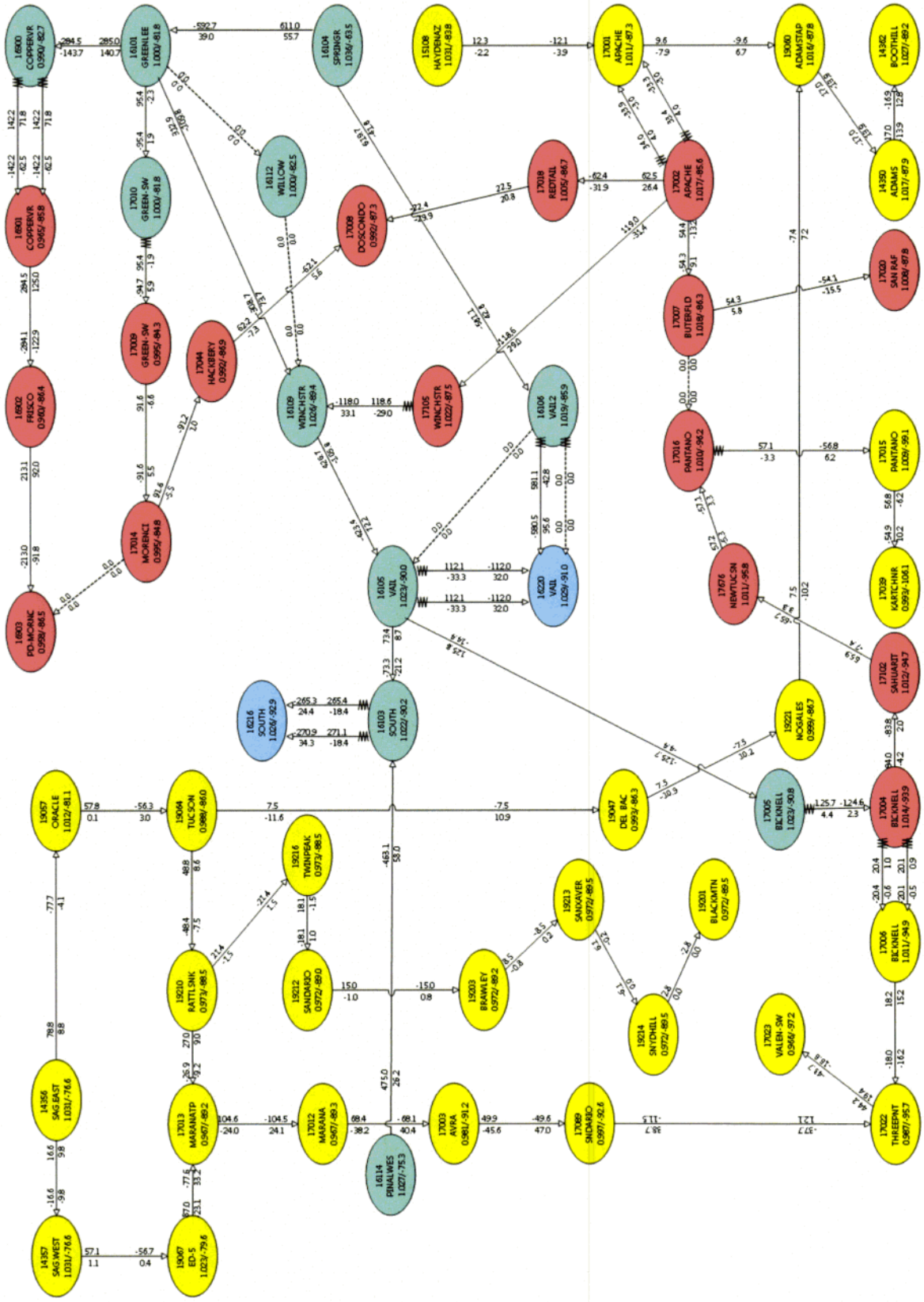
2021HS AEPCO System with Green-SW to Greenlee 345 kV Line out of service



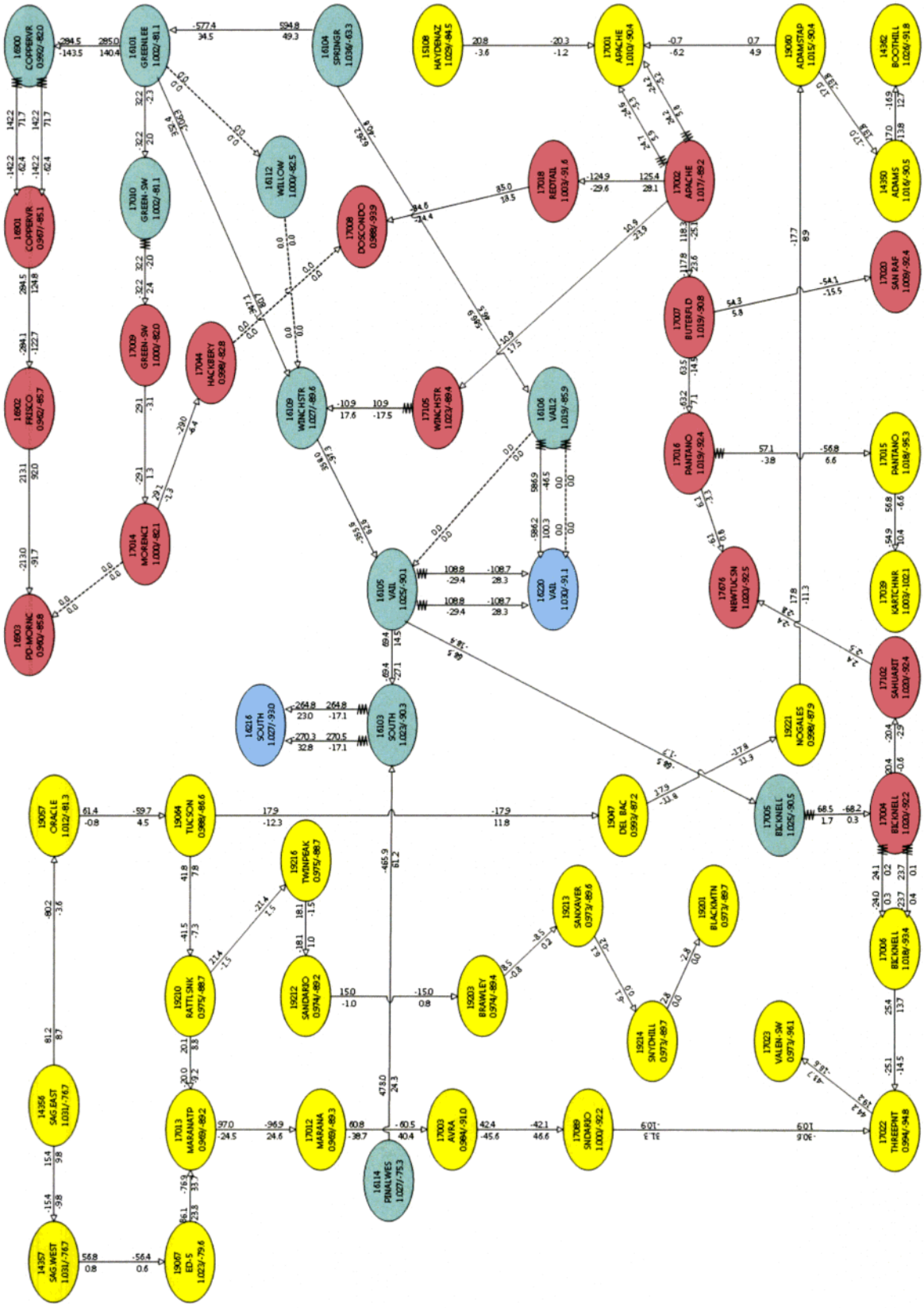
2021HS AEPCO System with Greenlee to Copper Verde 345 kV Line out of service



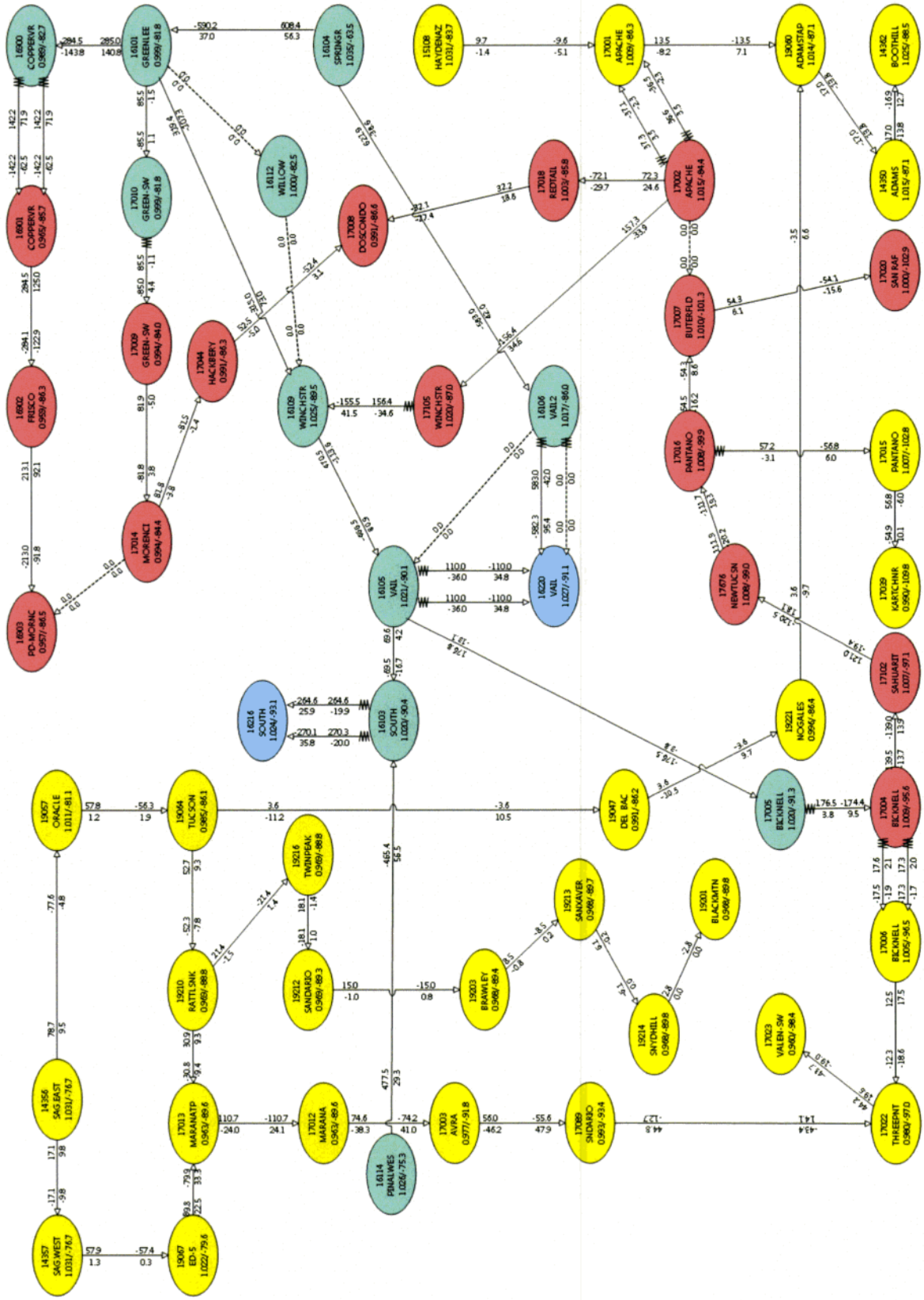
2021HS AEPCO System with Butterfield to Pantano 230 kV Line out of service



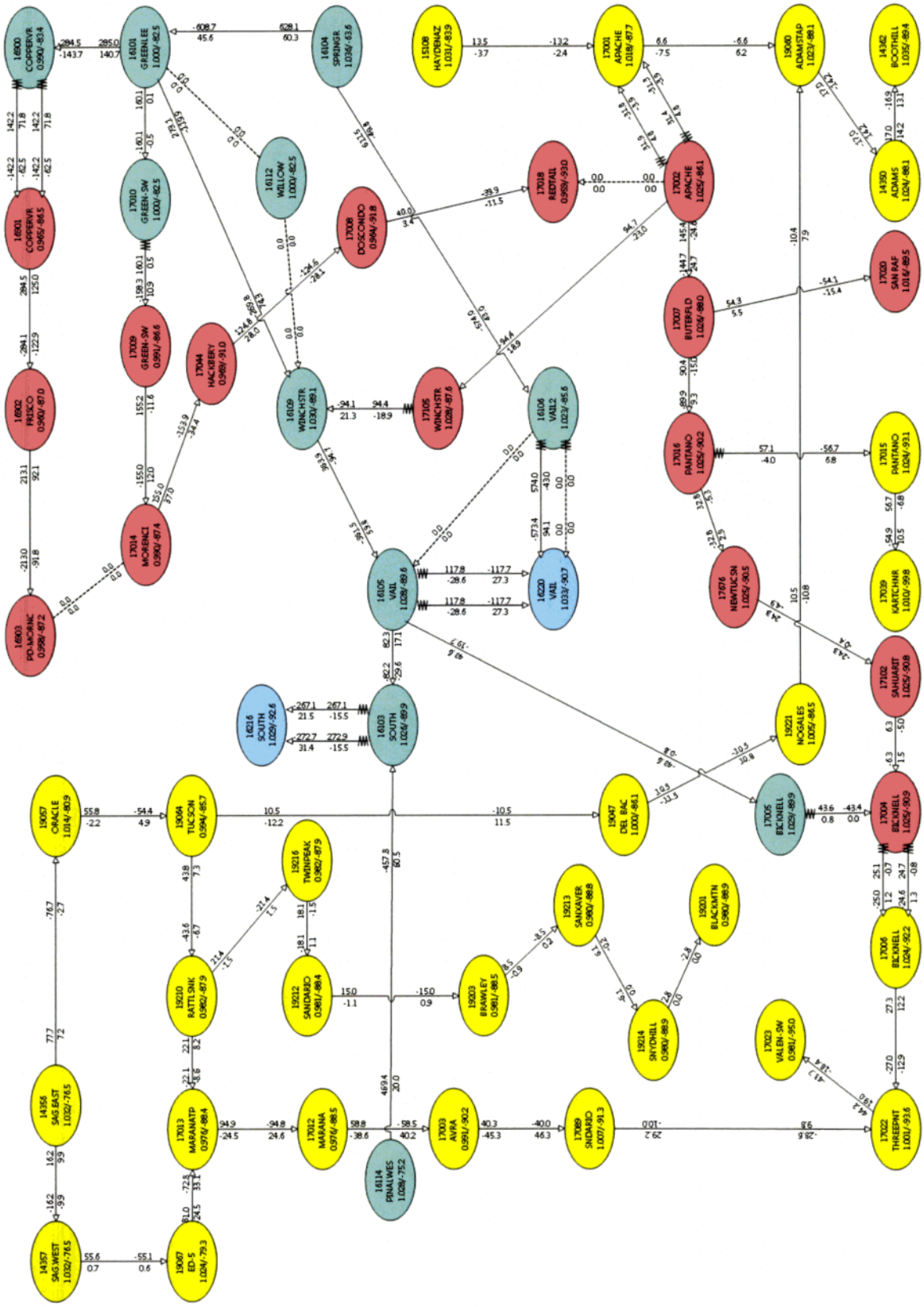
2021HS AEPCO System with Dos Condados to Hackberry 230 kV Line out of service



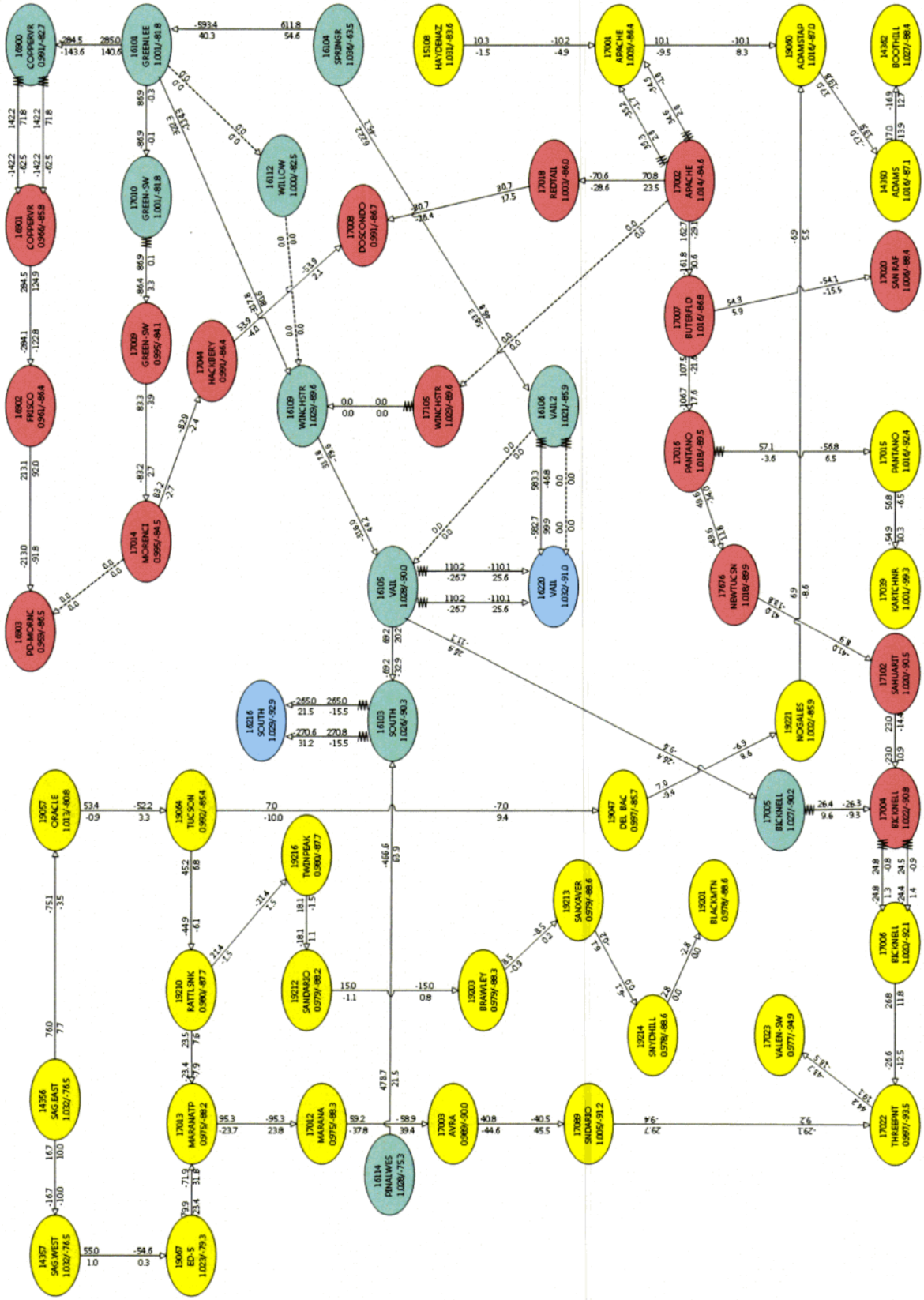
2021HS AEPCO System with Apache to Butterfield 230 kV Line out of service



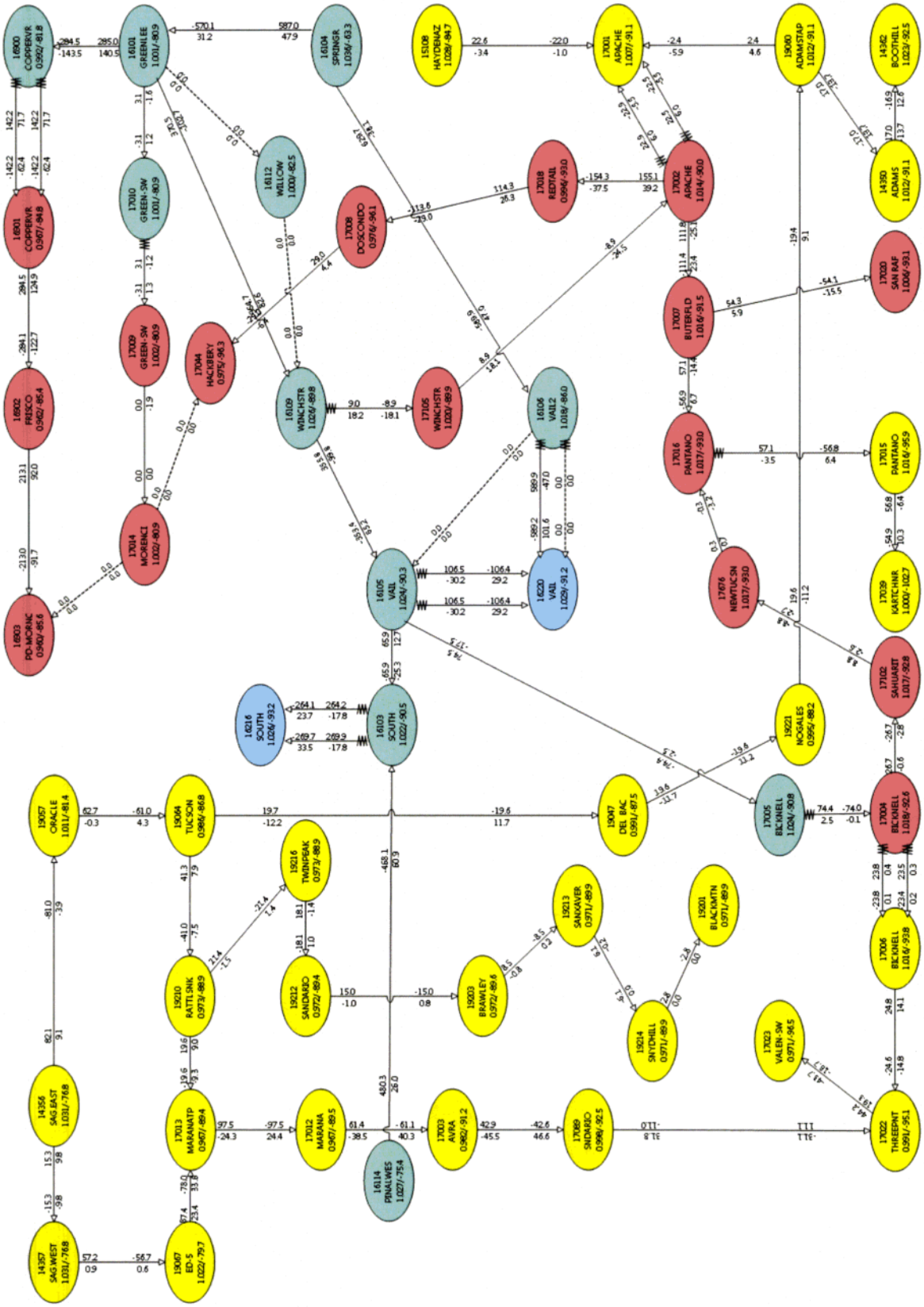
2021HS AEPCO System with Apache to Redtail 230 kV Line out of service



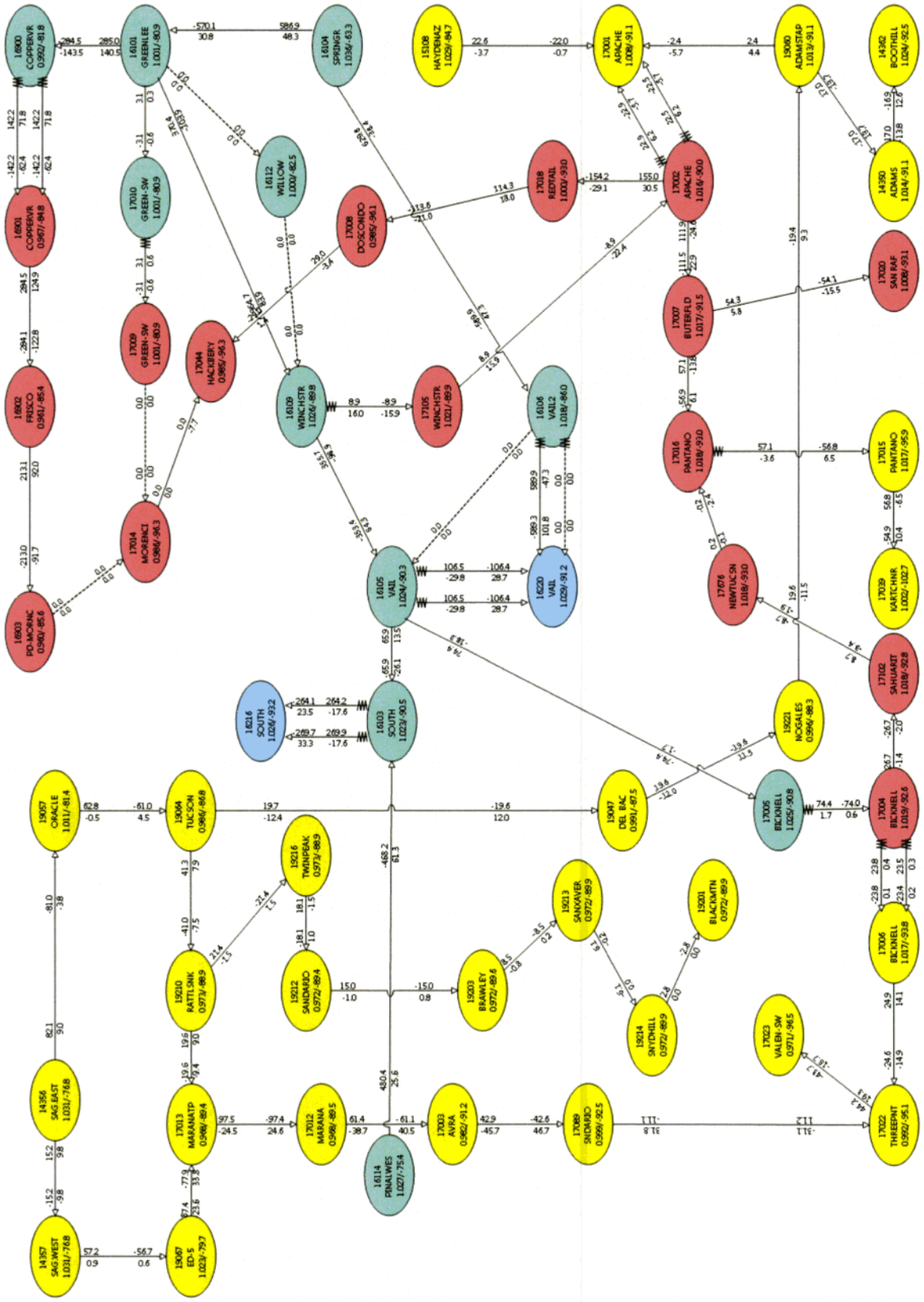
2021HS AEPCO System with Apache to Winchester 230 kV Line out of service



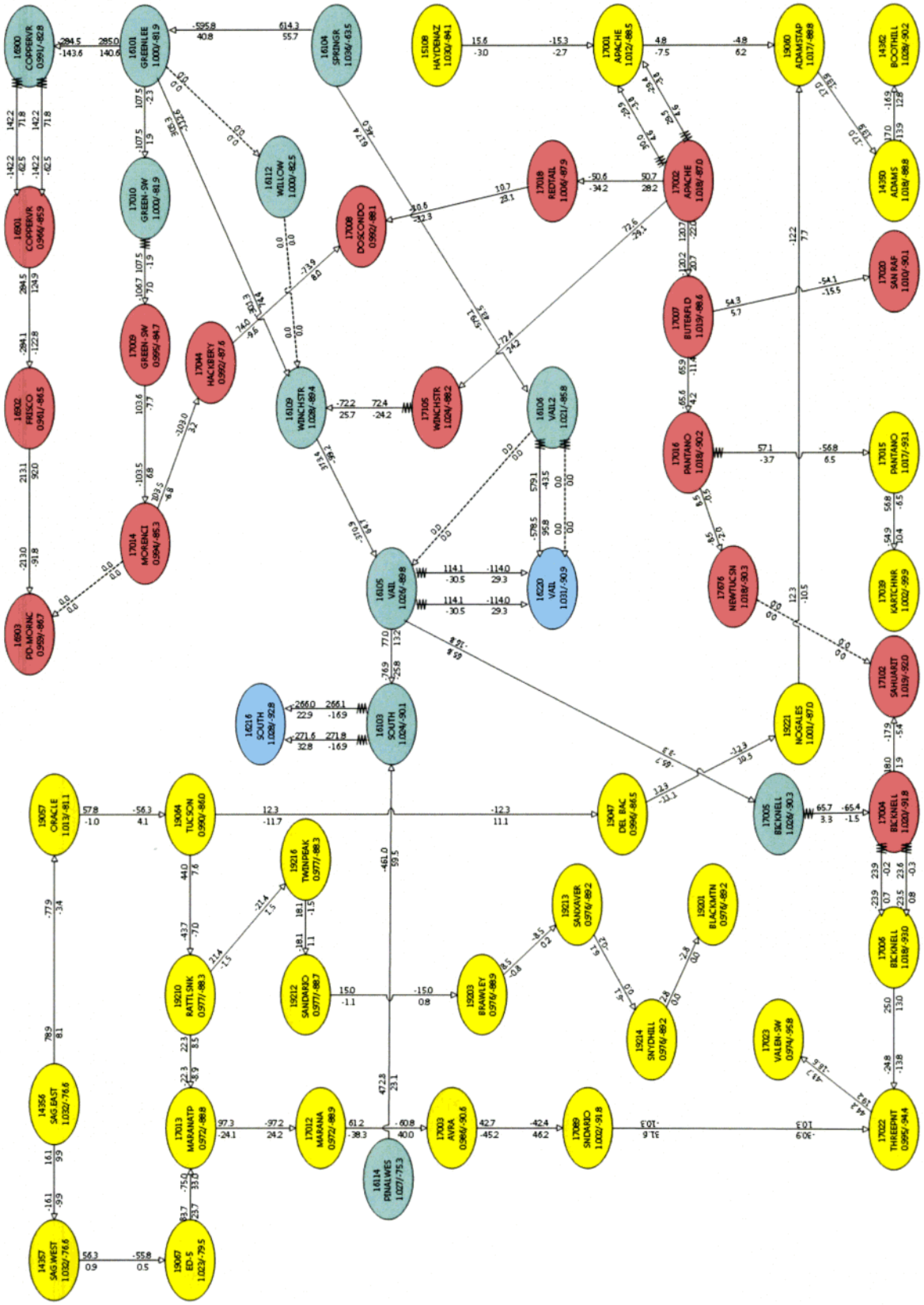
2021HS AEPCO System System with Hackberry to Morenci 230 kV Line out of service



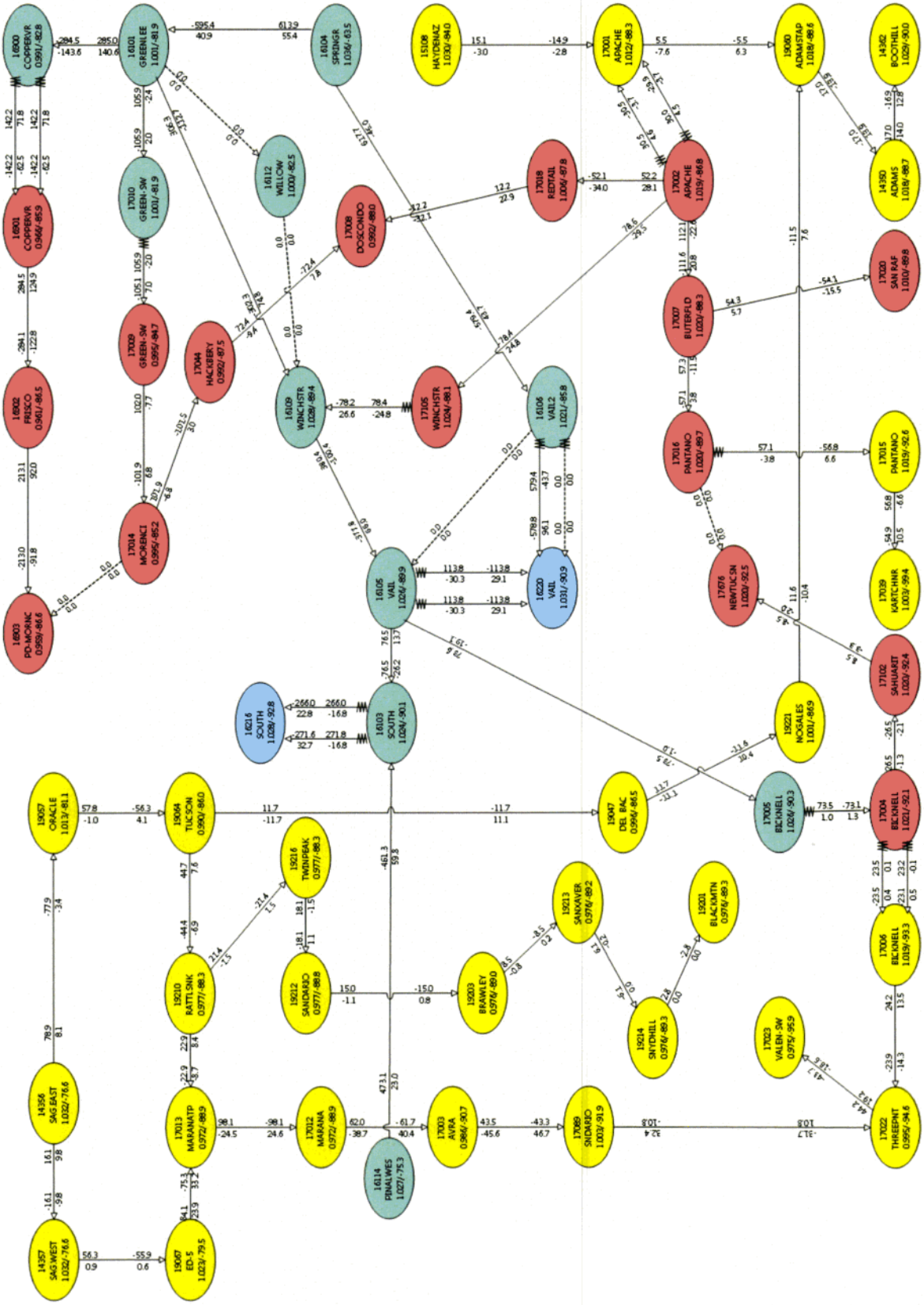
2021HS AEPCO System with Morenci to Green-SW 230 kV Line out of service



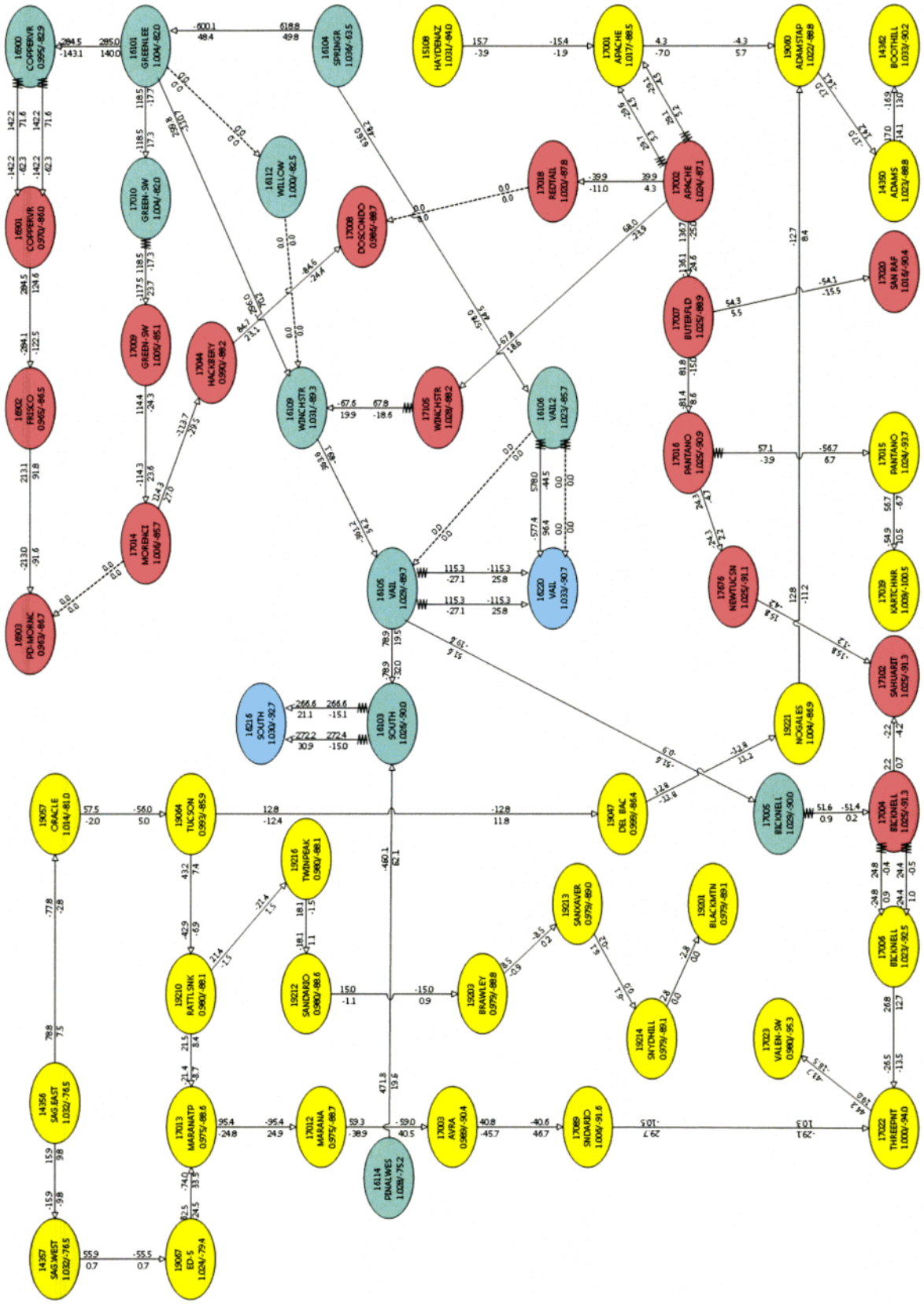
2021HS AEPCO System with New Tucson to Sahuarita 230 kV Line out of service



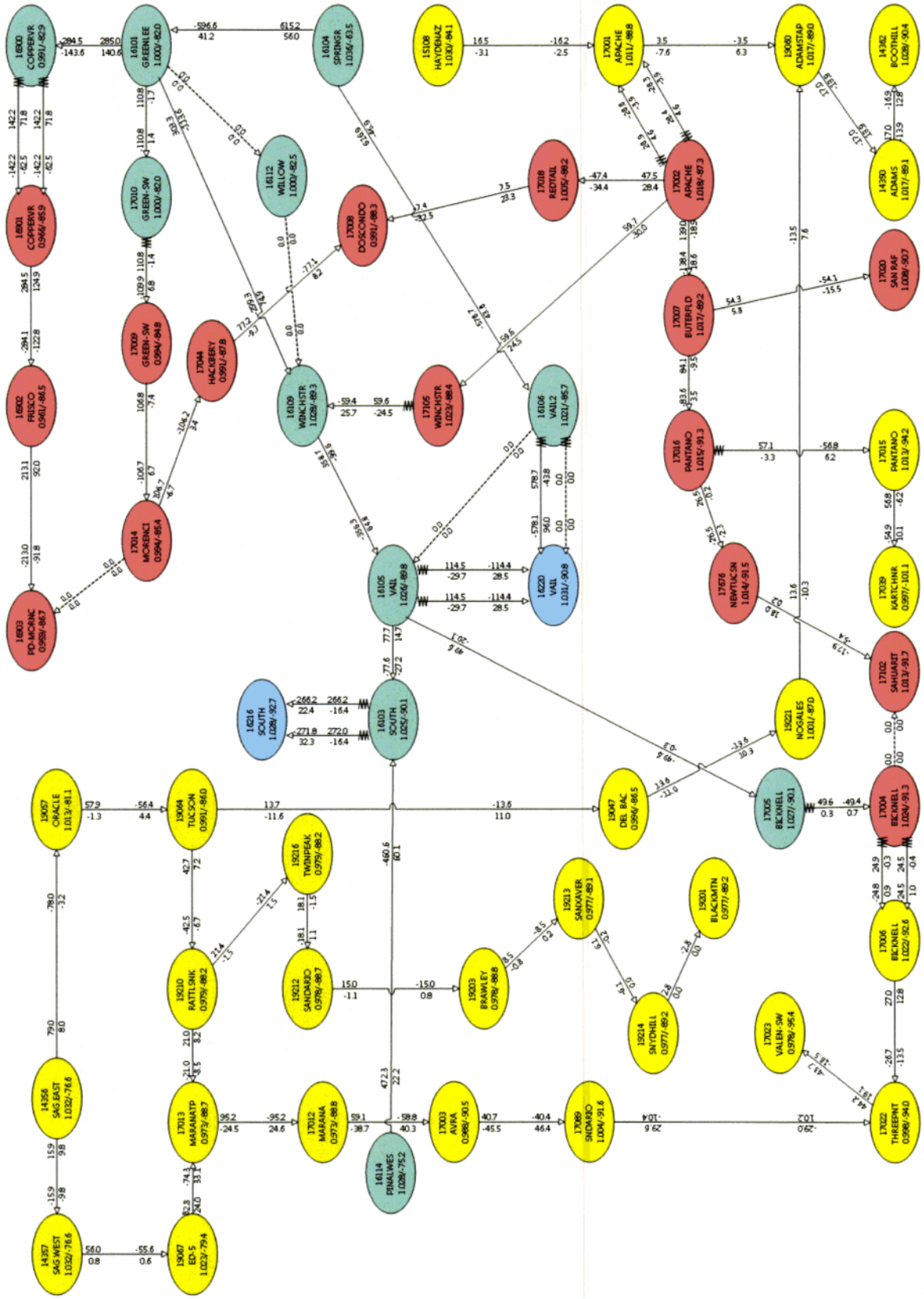
2021HS AEPCO System with Pantano to New Tucson 230 kV Line out of service



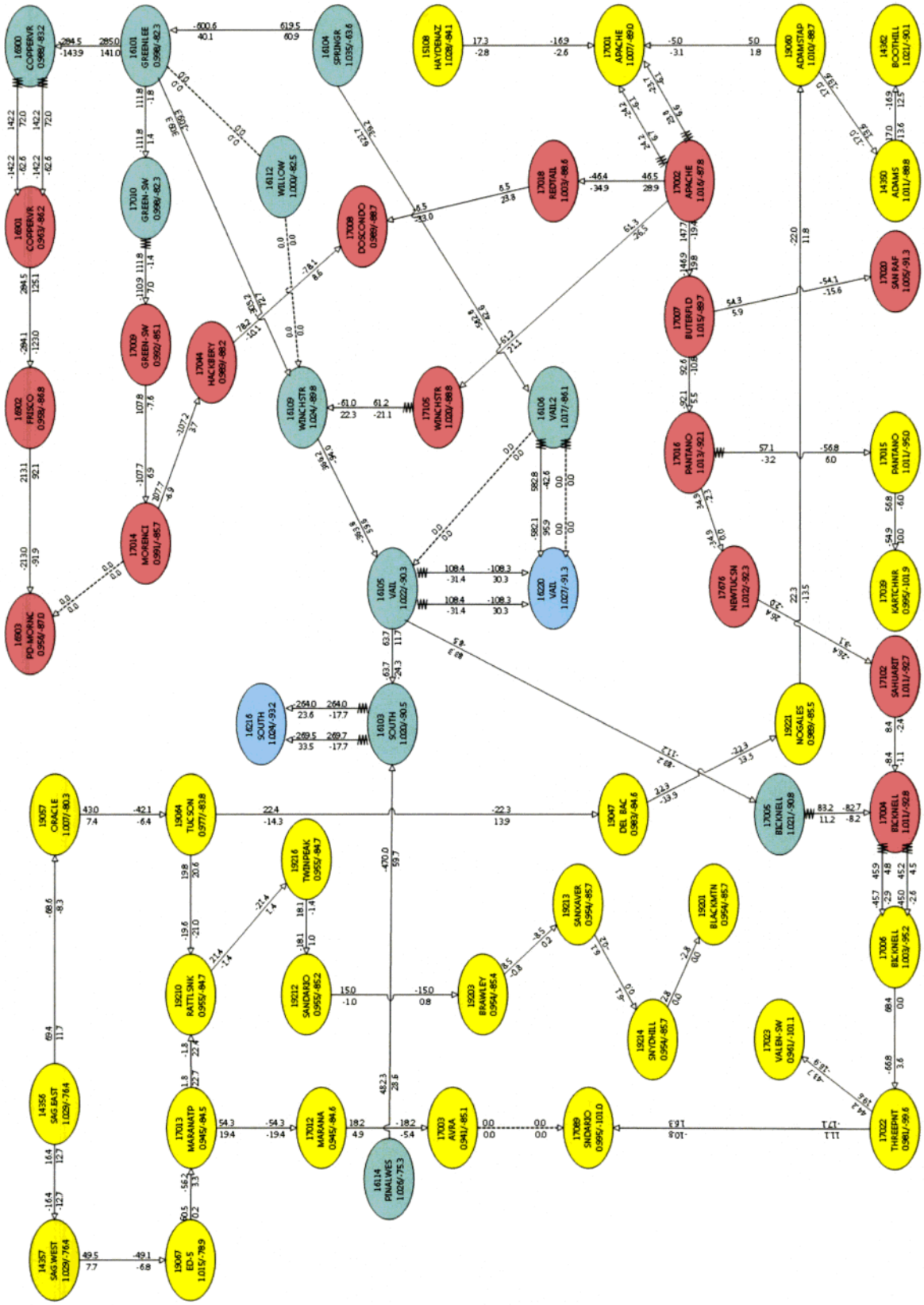
2021HS AEPCO System with Redtail to Dos Condados 230 kV Line out of service



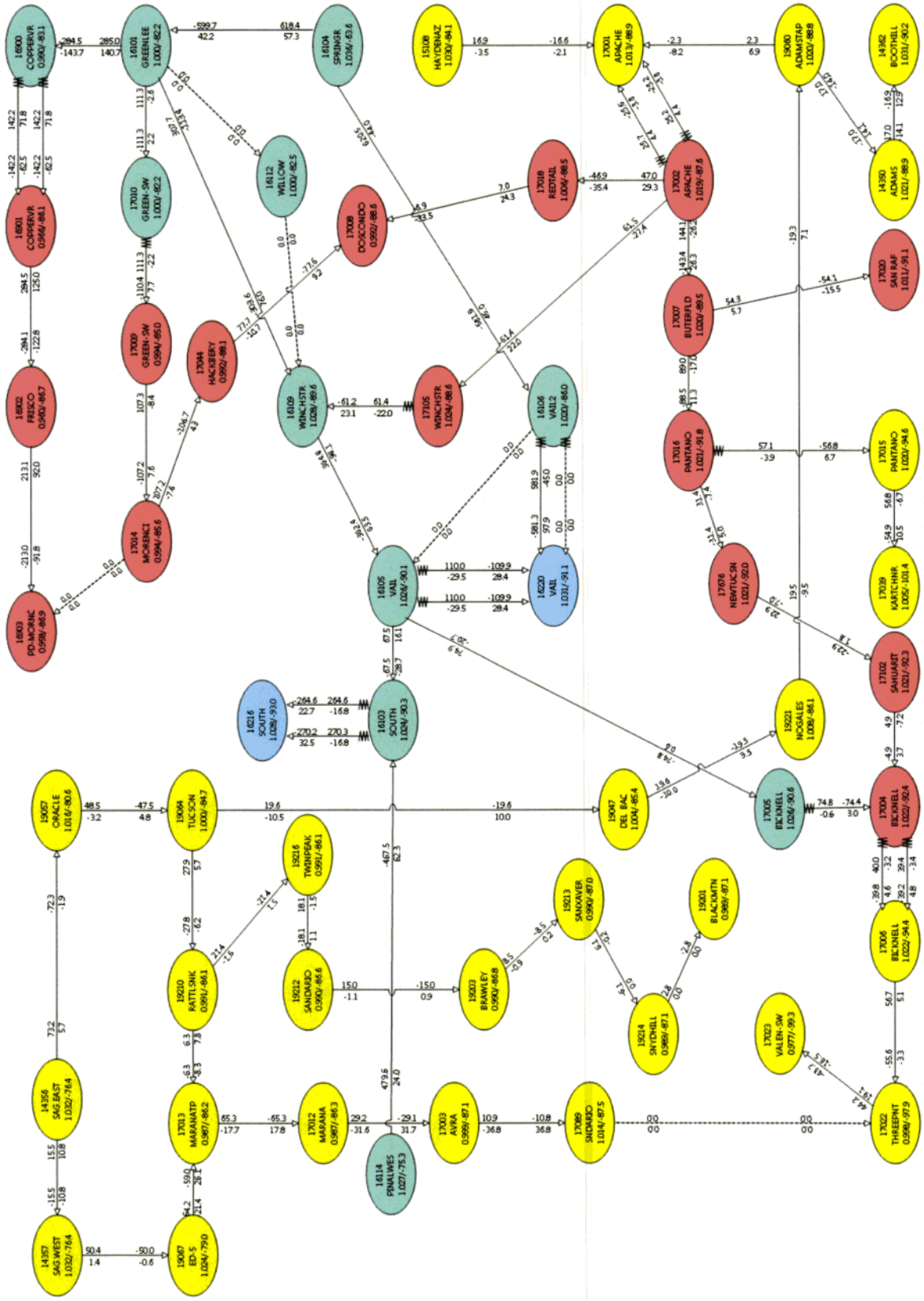
2021HS AEPCO System with Sahuarita to Bicknell 230 kV Line out of service



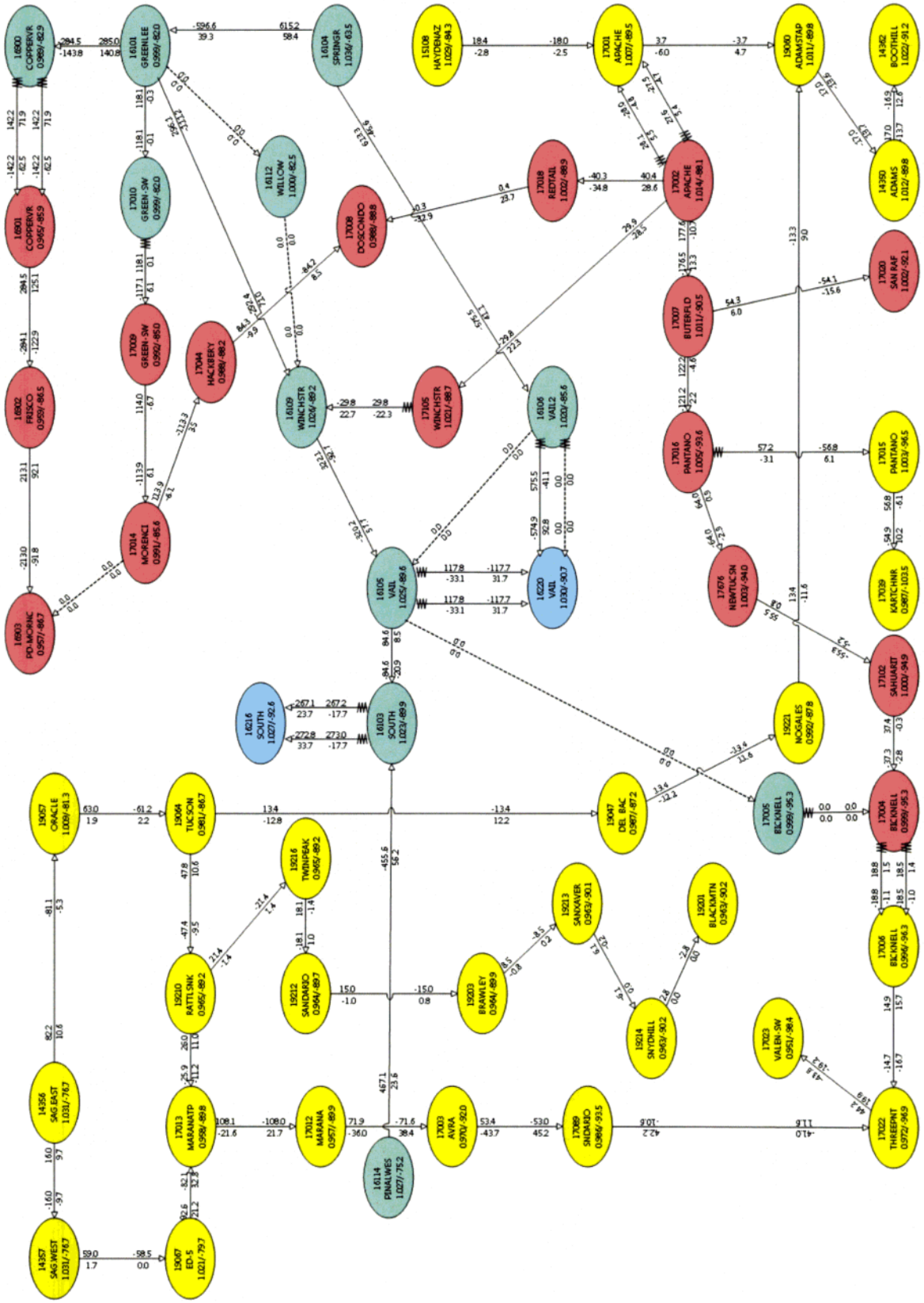
2021HS AEPCO System with Avra to Sandario 115 kV Line out of service



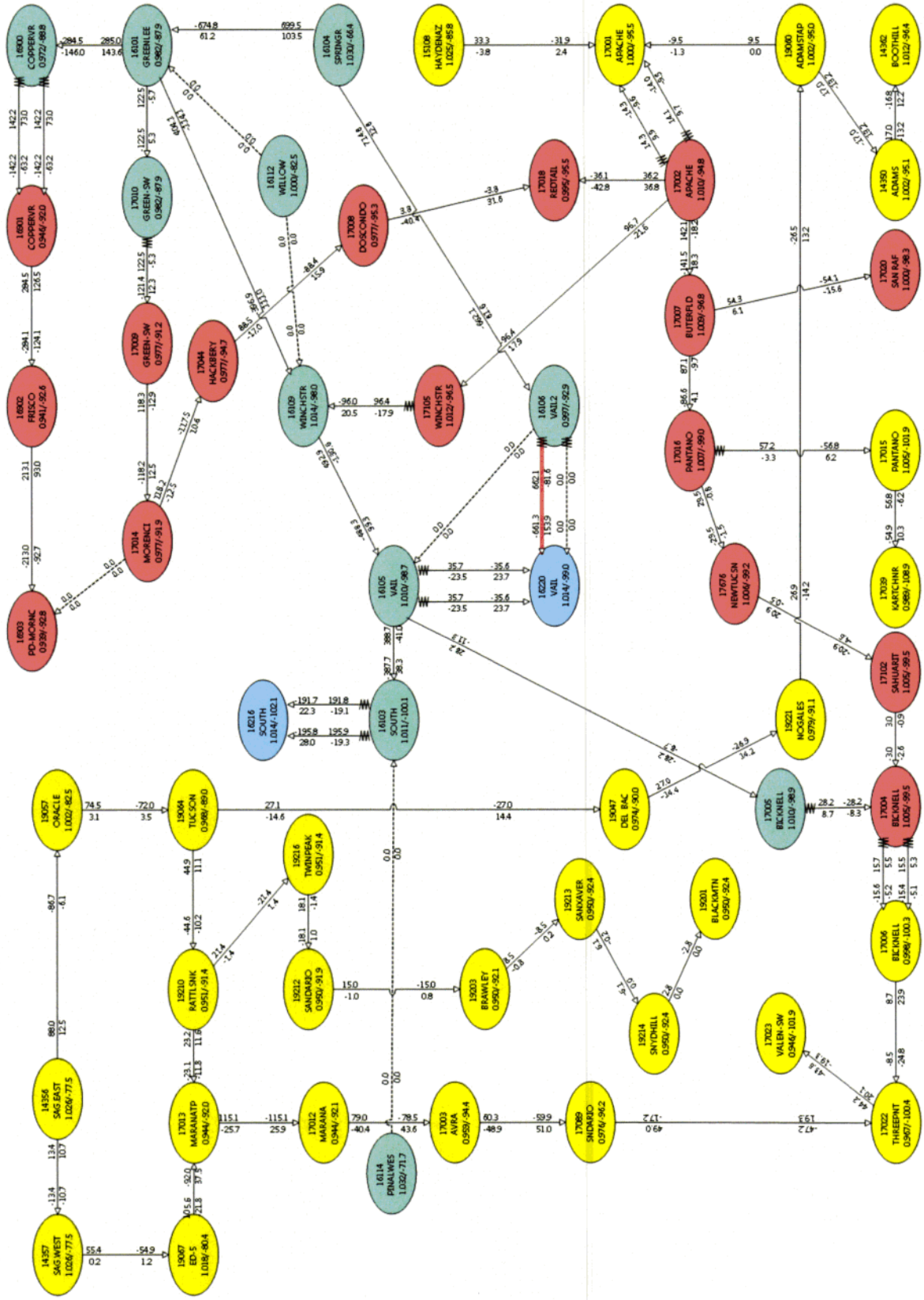
2021HS AEPCO System with Three Points to Sandario 115 kV Line out of service



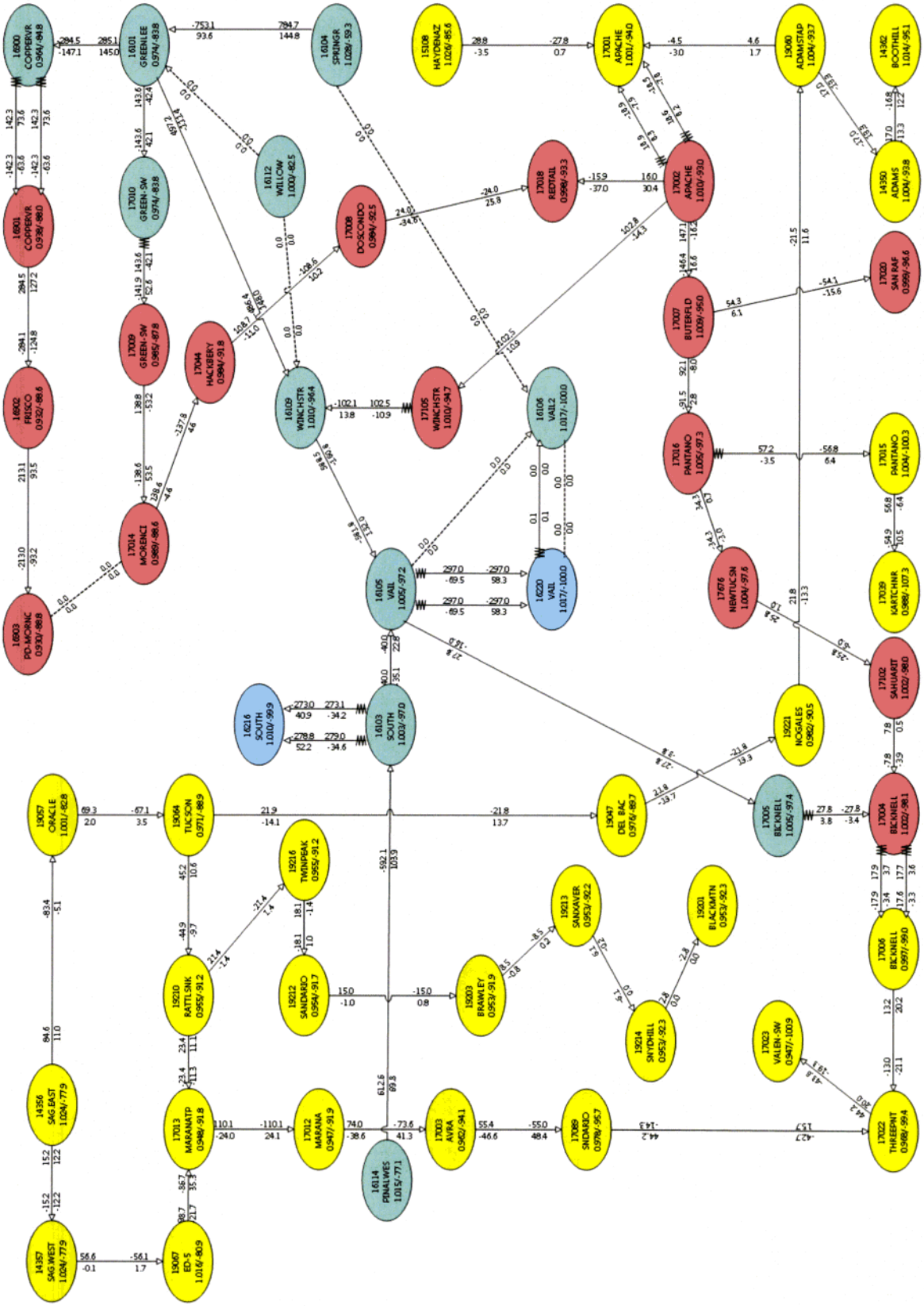
2021HS AEPCO System with Bicknell to Vail 345 kV Line out of service



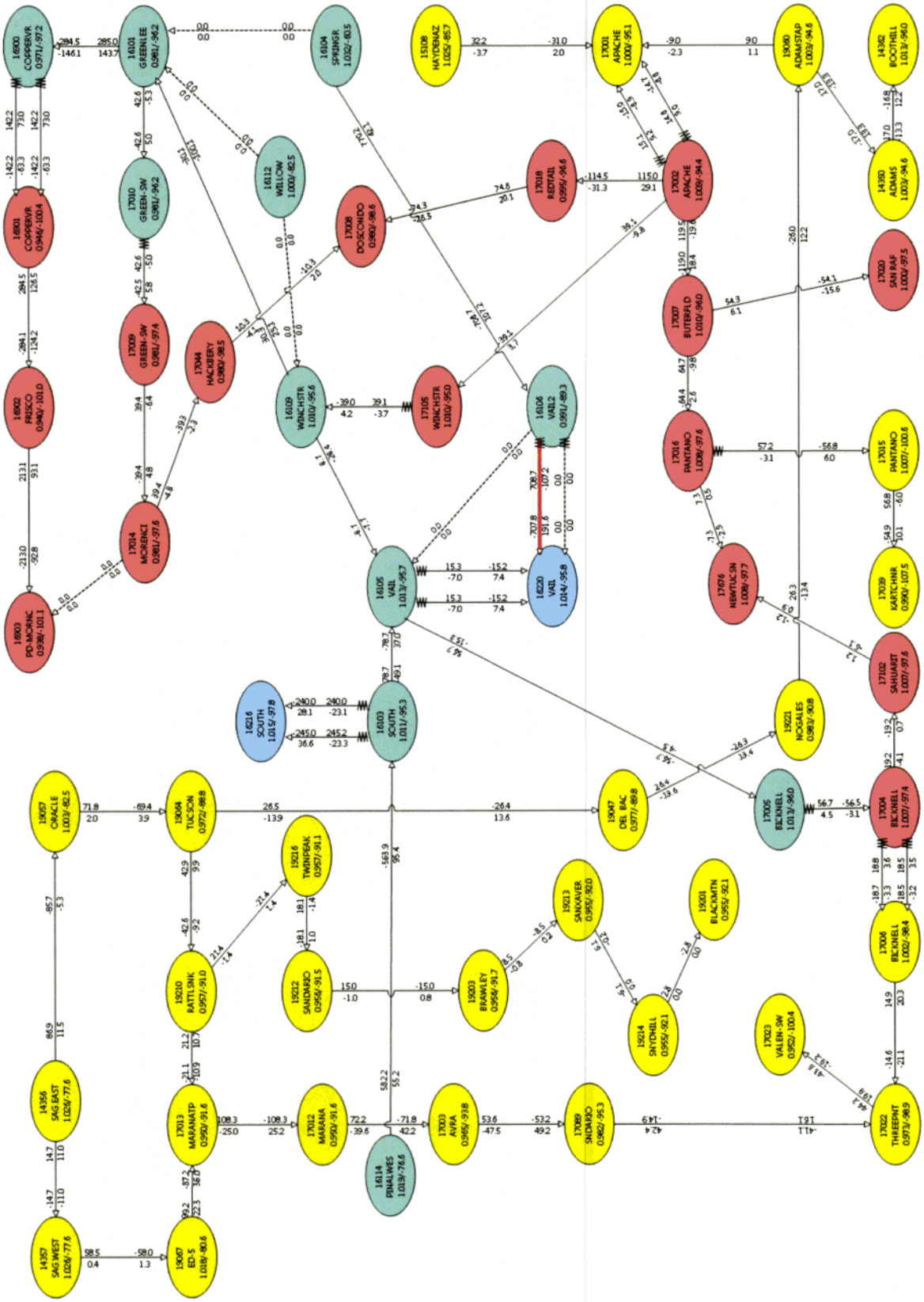
2021HS AEPCO System with Pinal West to South 345 kV Line out of service



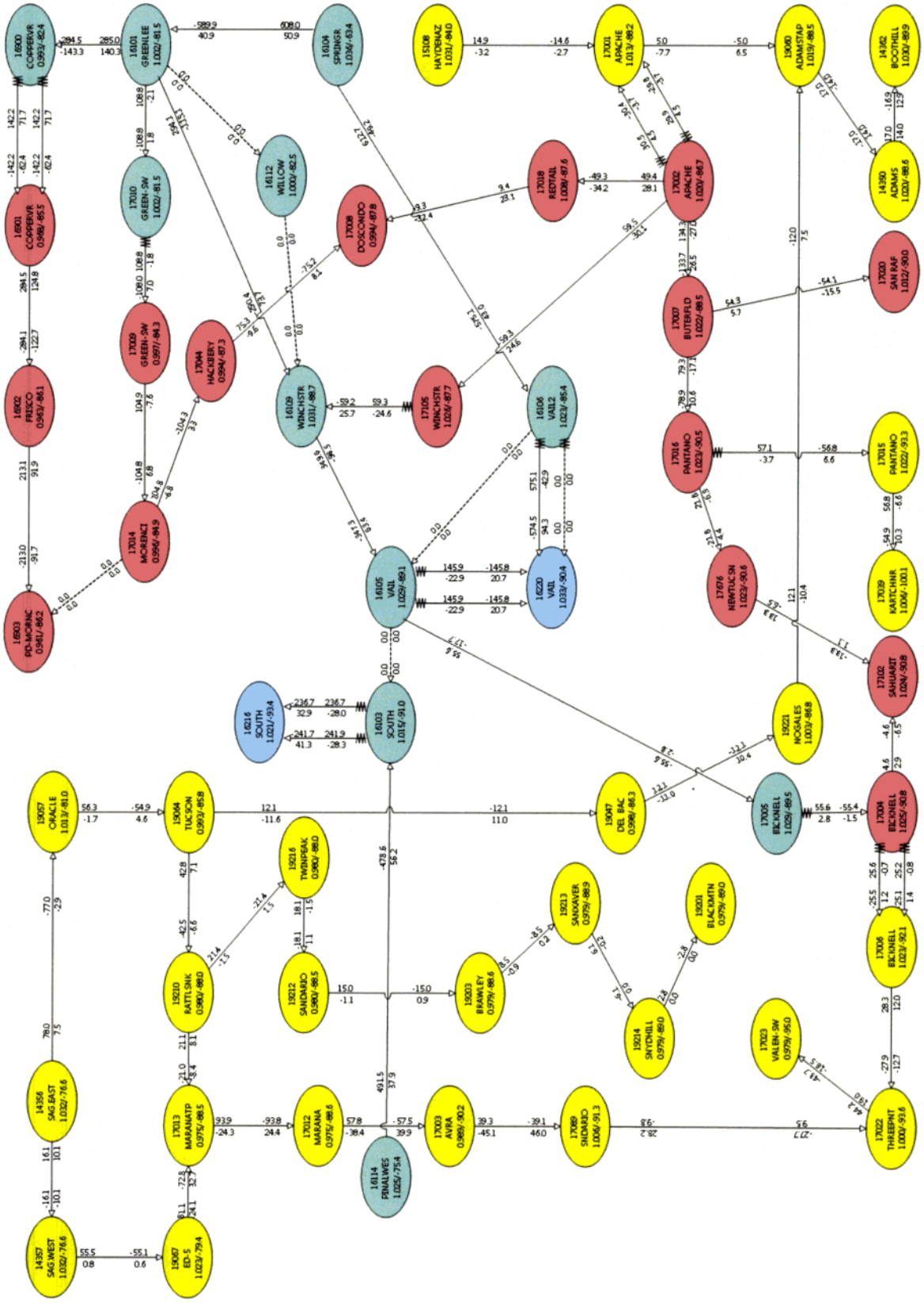
2021HS AEPCO System with Springerville to Vail2 345 kV Line out of service



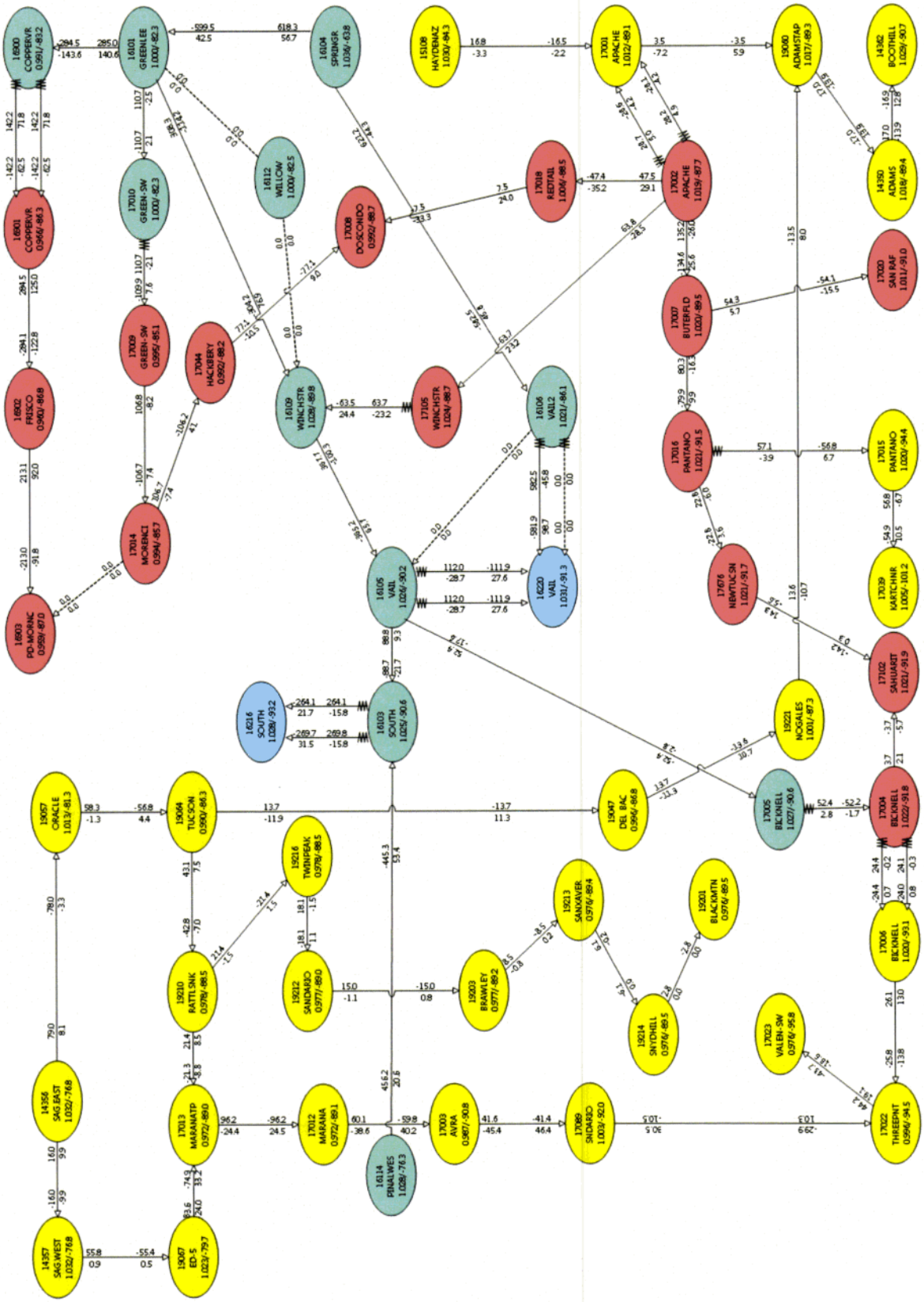
2021HS AEPCO System with Springerville to Greenlee 345 kV Line out of service



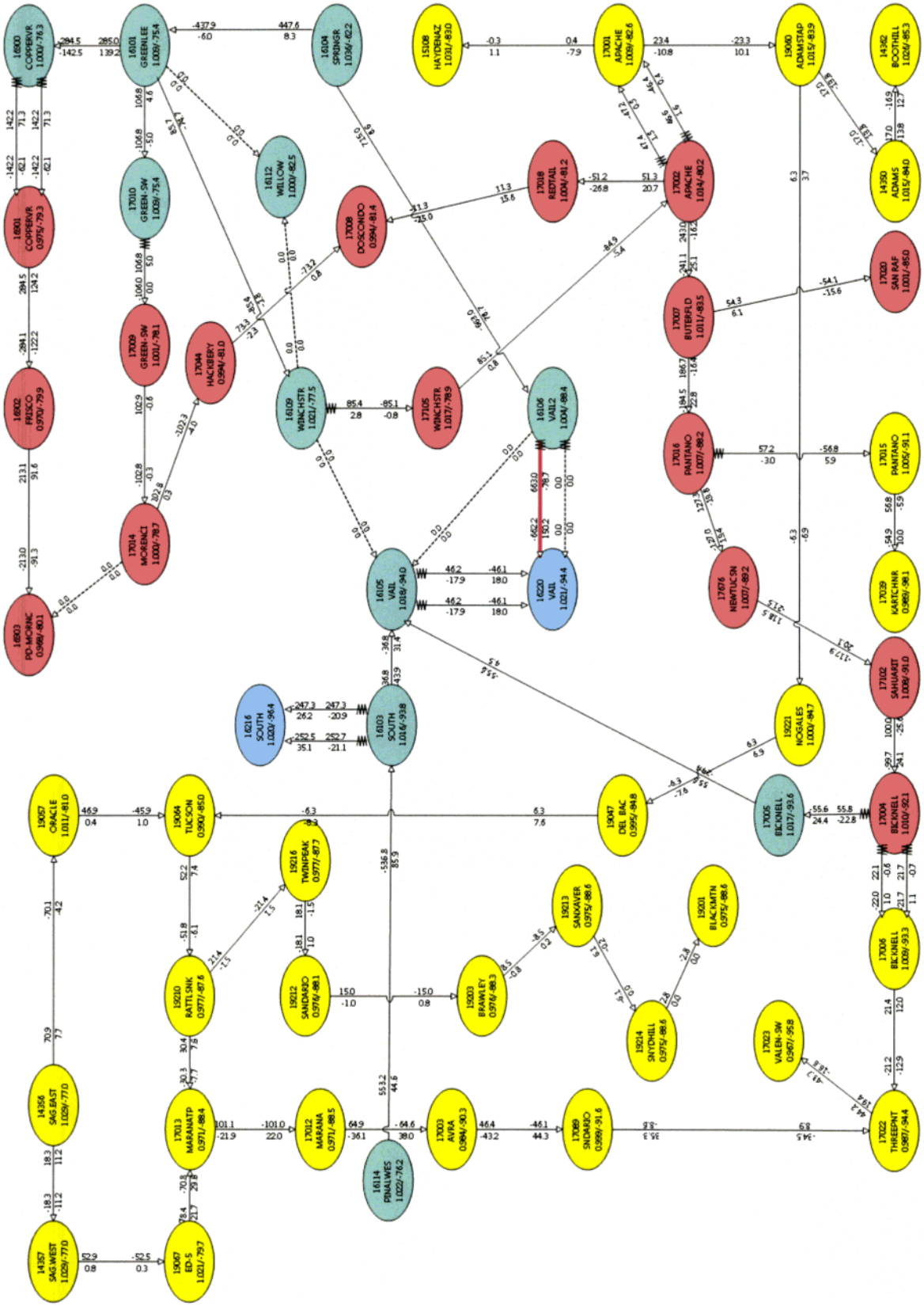
2021HS AEPCO System with Vail to South 345 kV Line out of service



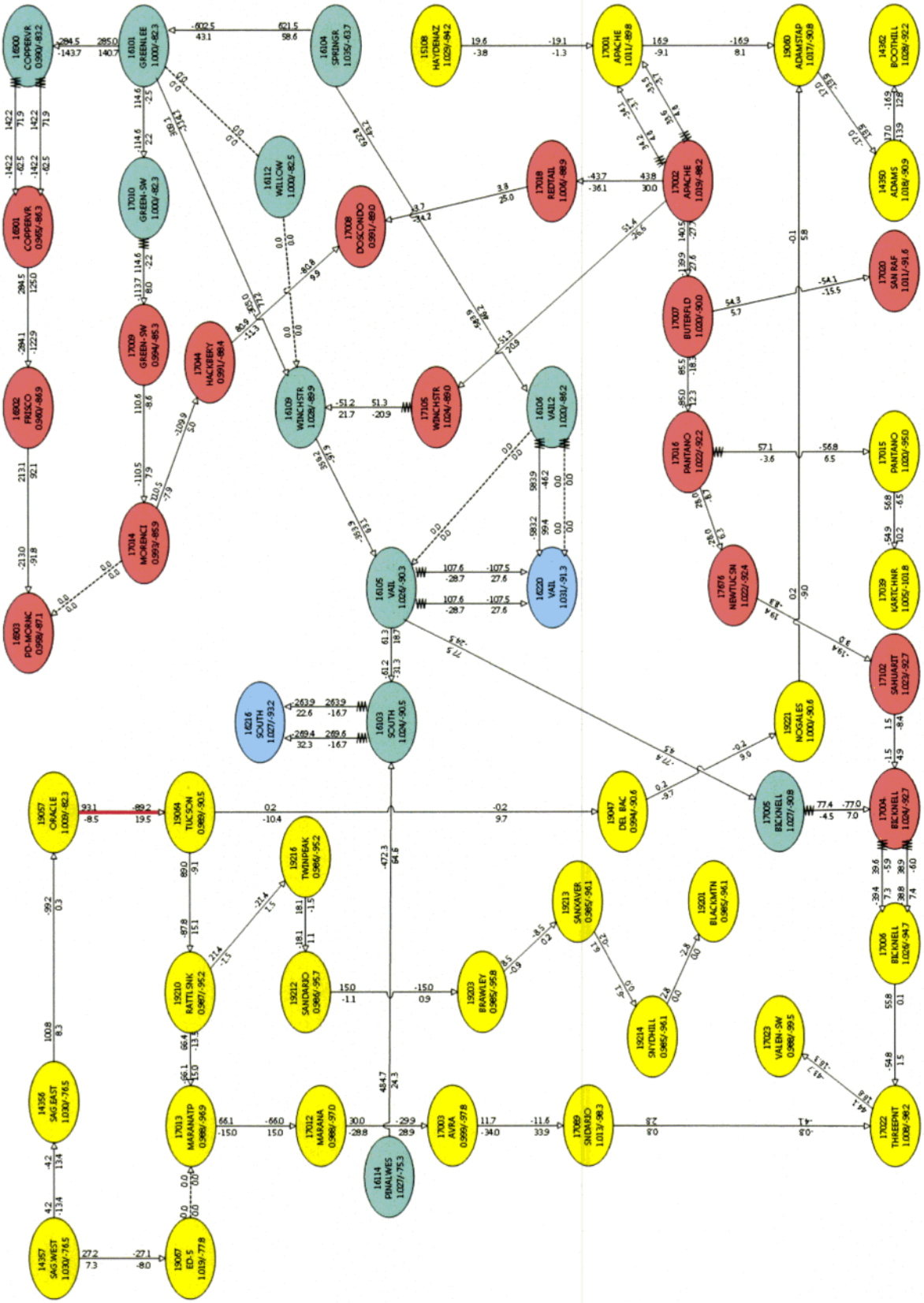
2021HS AEPCO System with Westwing to Pinal West 345 kV Line out of service



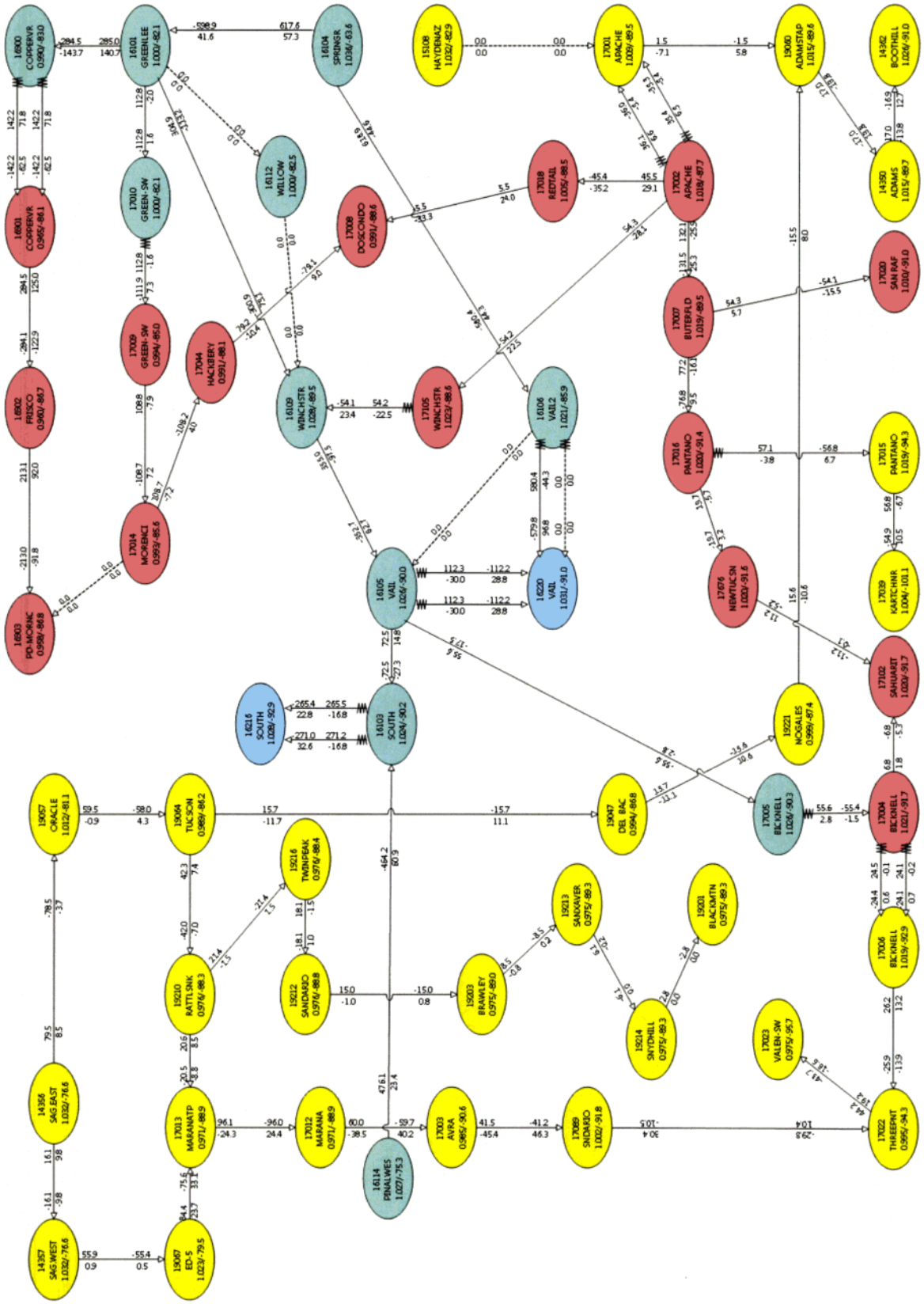
2021HS AEPCO System with Winchester to Vail 345 kV Line out of service



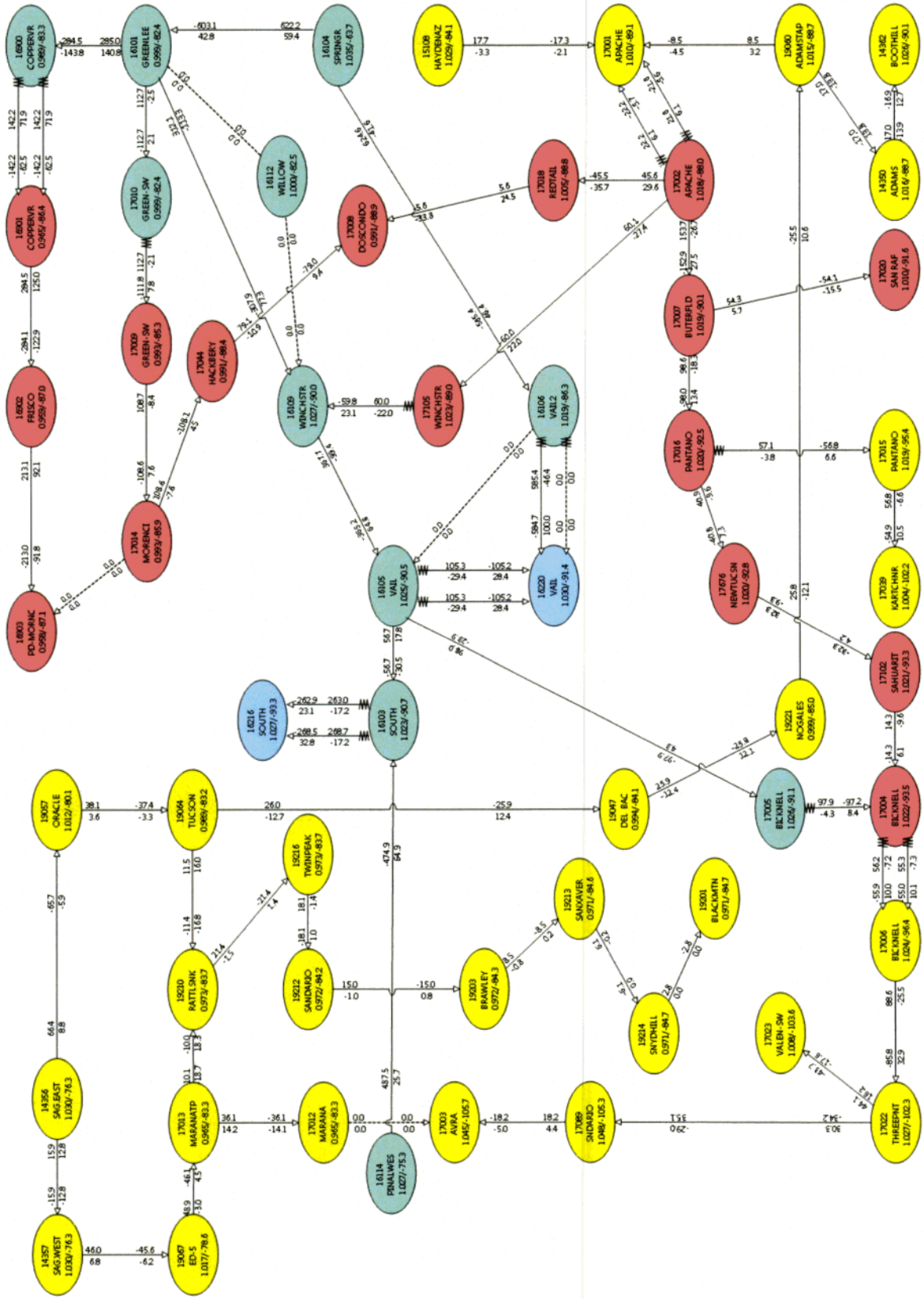
2021HS AEPCO System with ED-5 to Marana Tap 115 kV Line out of service



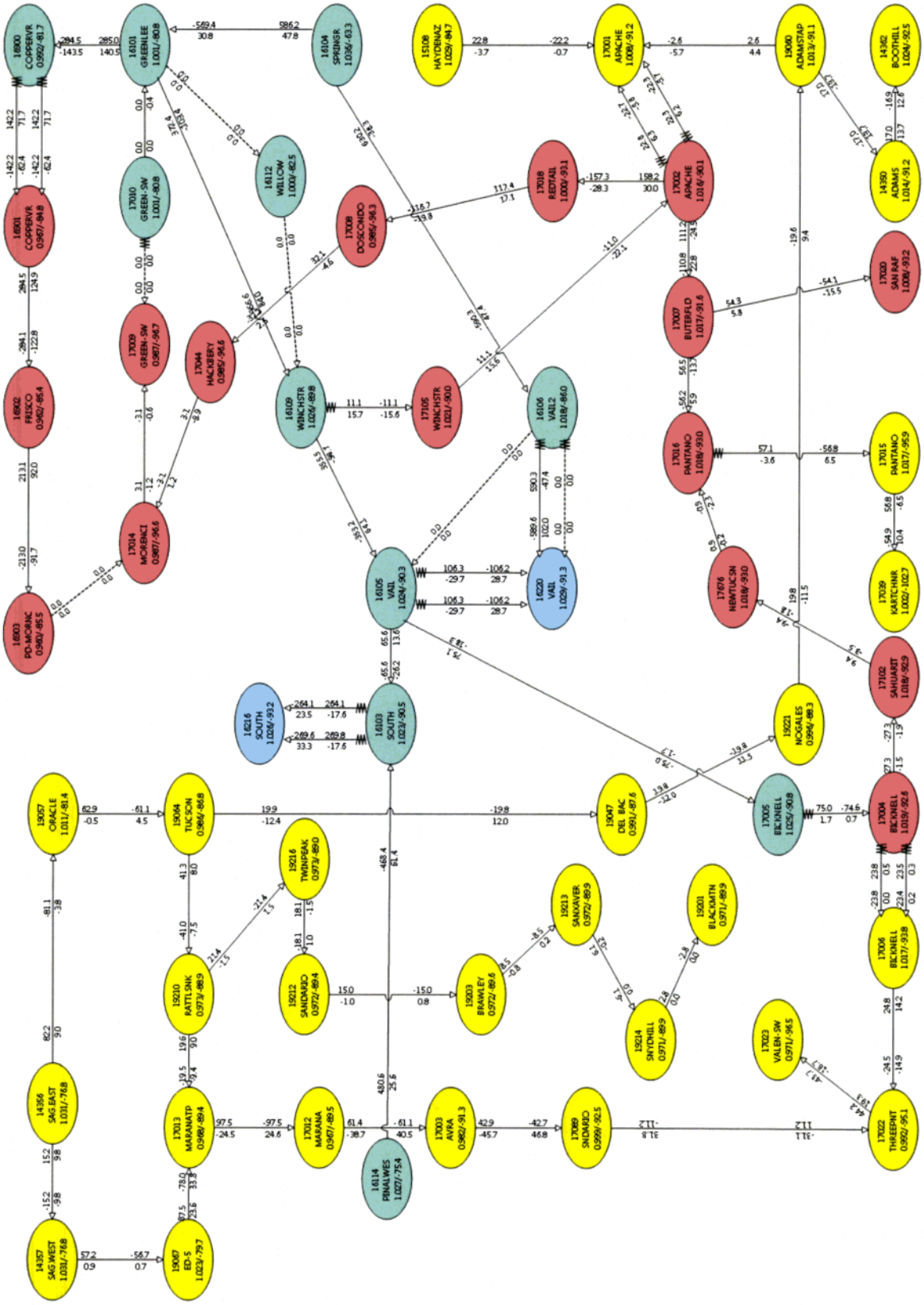
2021HS AEPCO System with Apache to Hayden 115 kV Line out of service



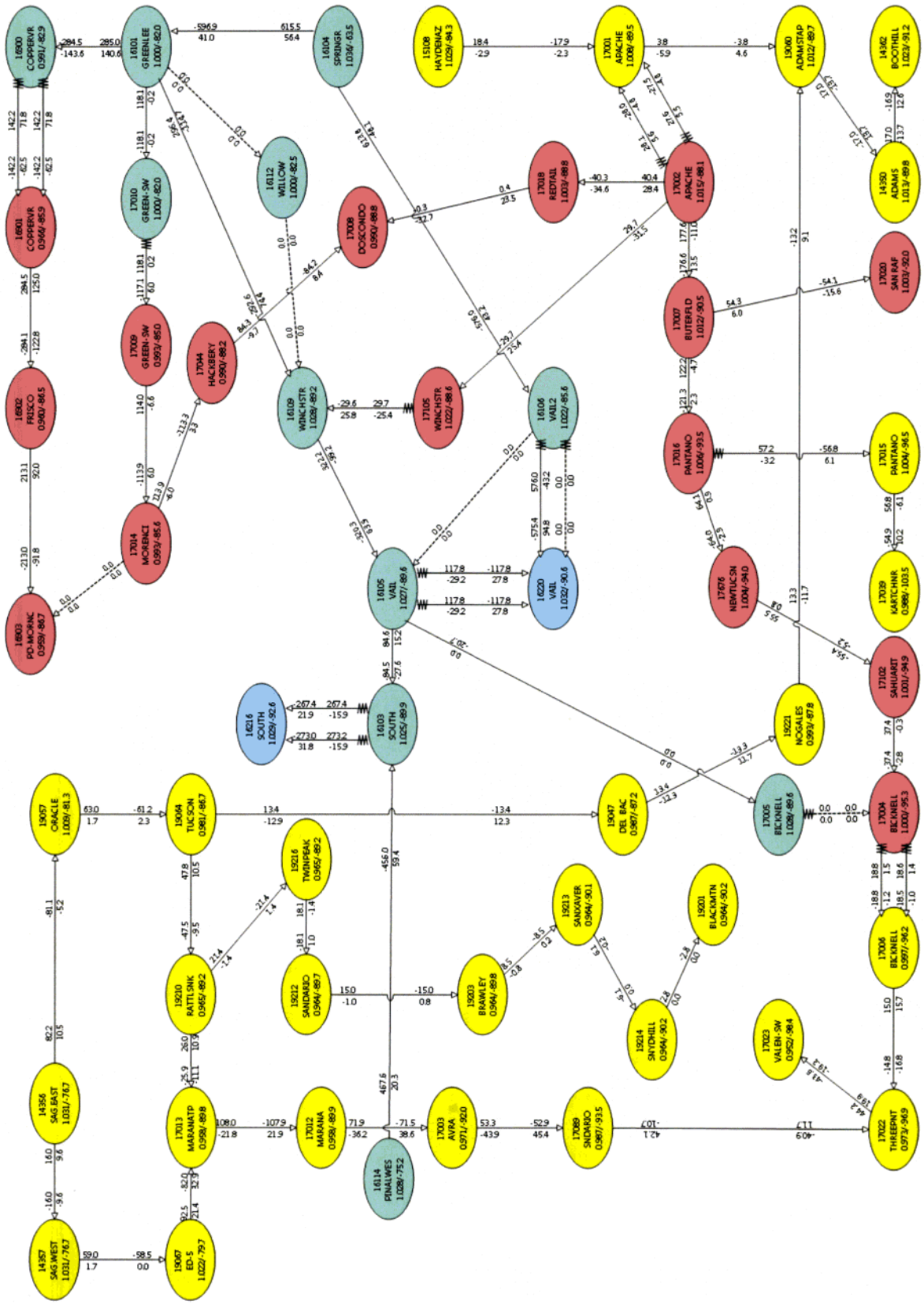
2021HS AEPCO System with Marana to Avra 115 kV Line out of service



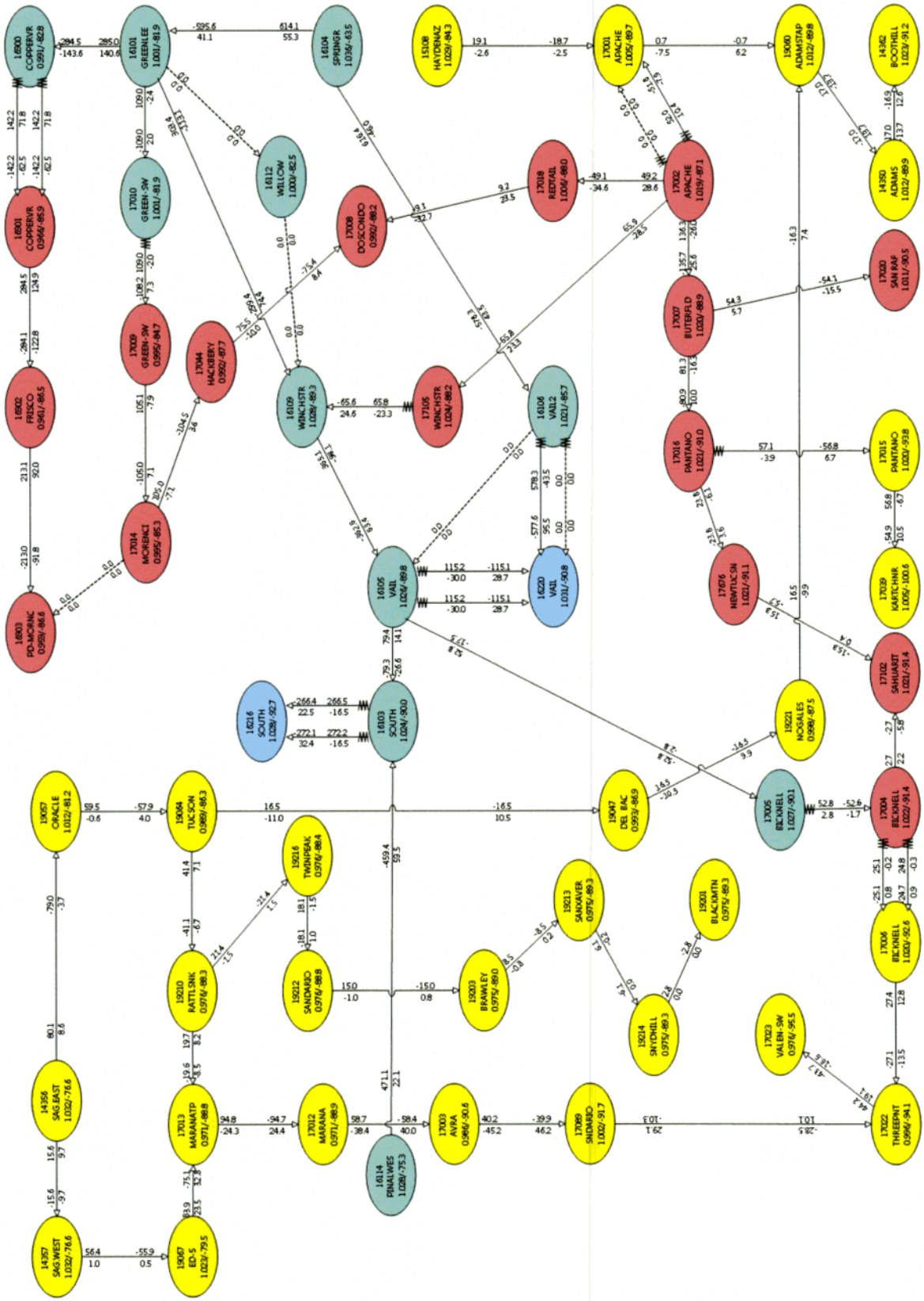
2021HS AEPCO System with Green-SW 345/230 kV Transformer out of service



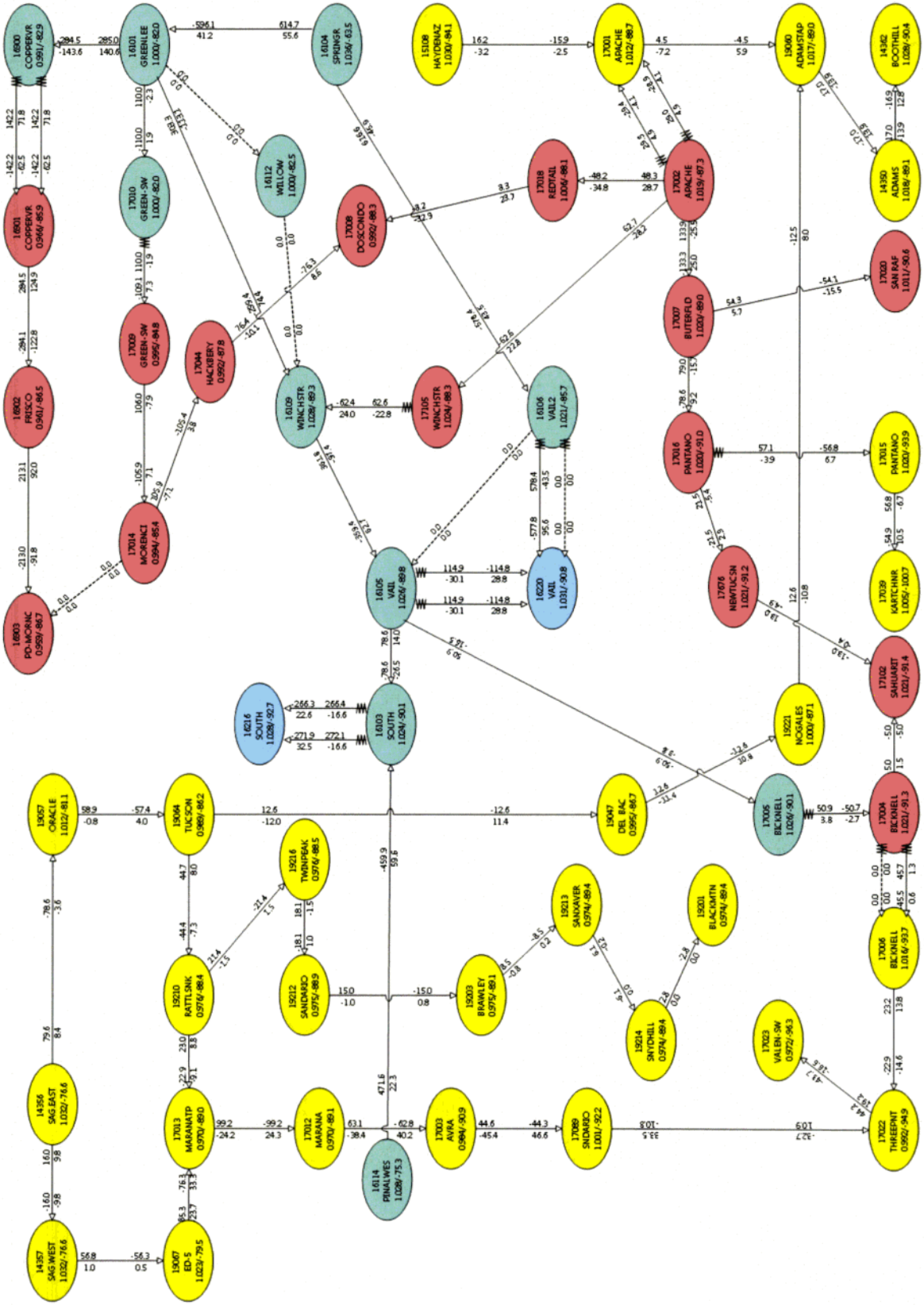
2021HS AEPCO System with Bicknell 345/230 kV Transformer out of service



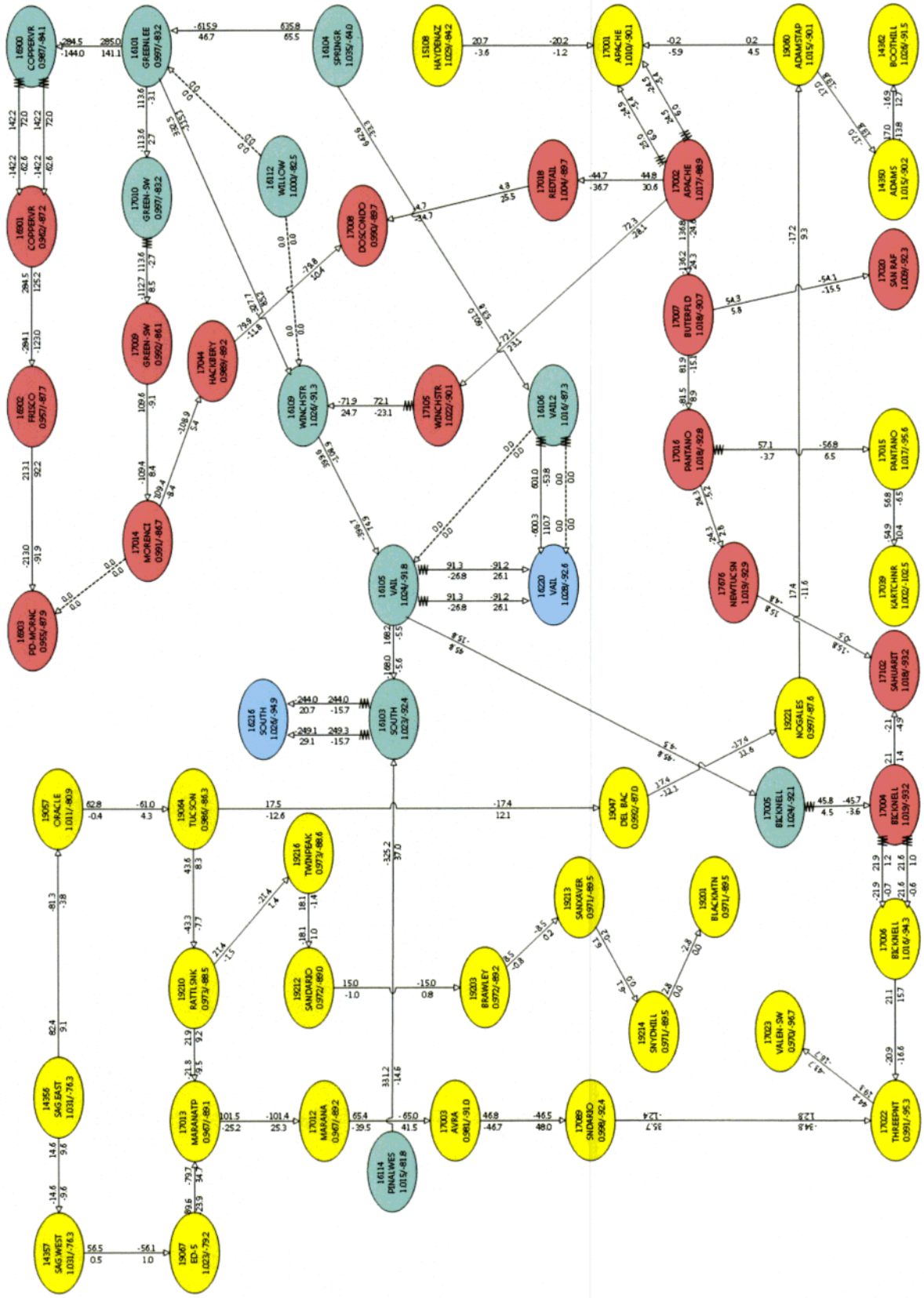
2021HS AEPCO System with one Apache 230/115 kV Transformer out of service



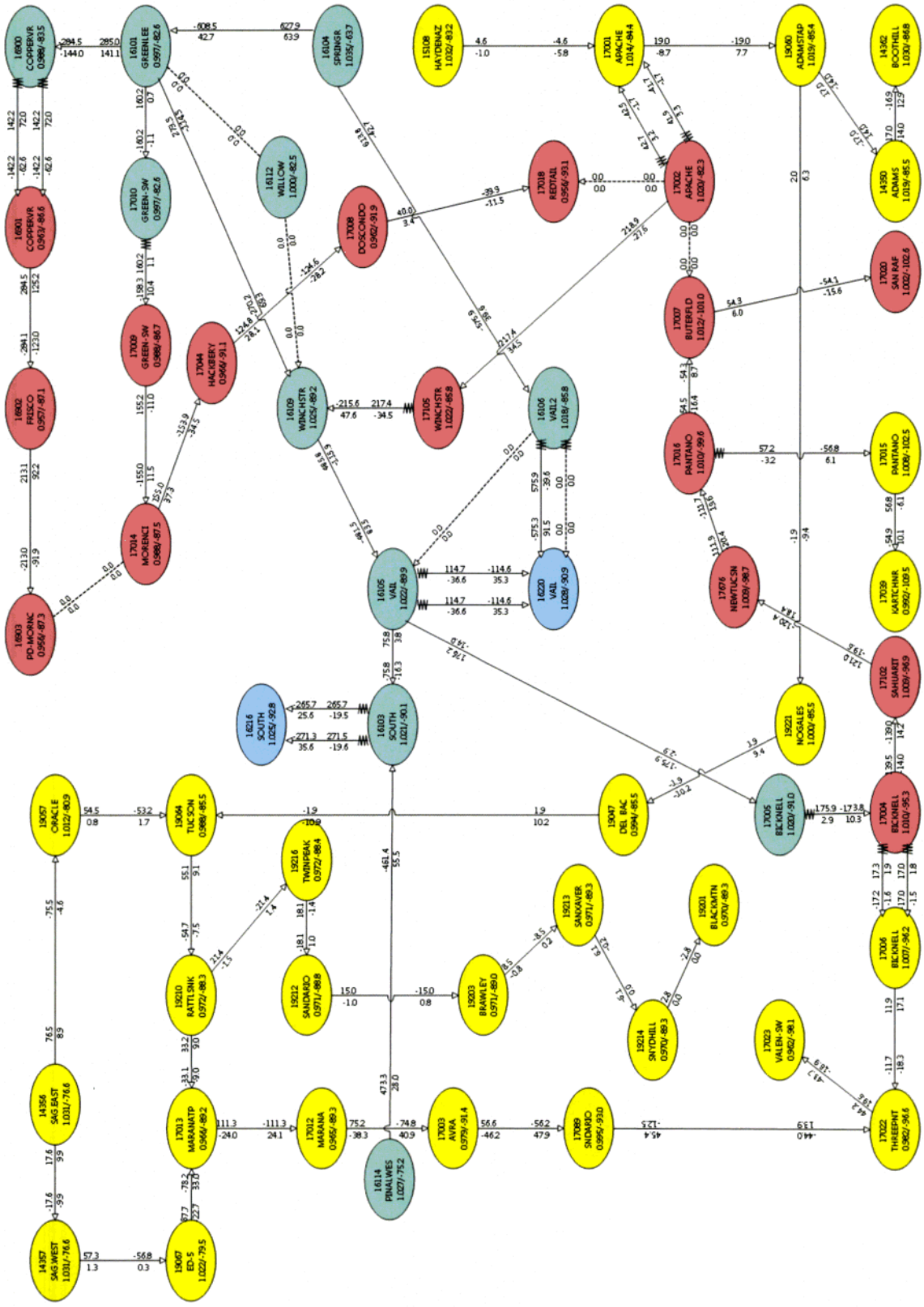
2021HS AEPCO System with one Bicknell 230/115 kV Transformer out of service



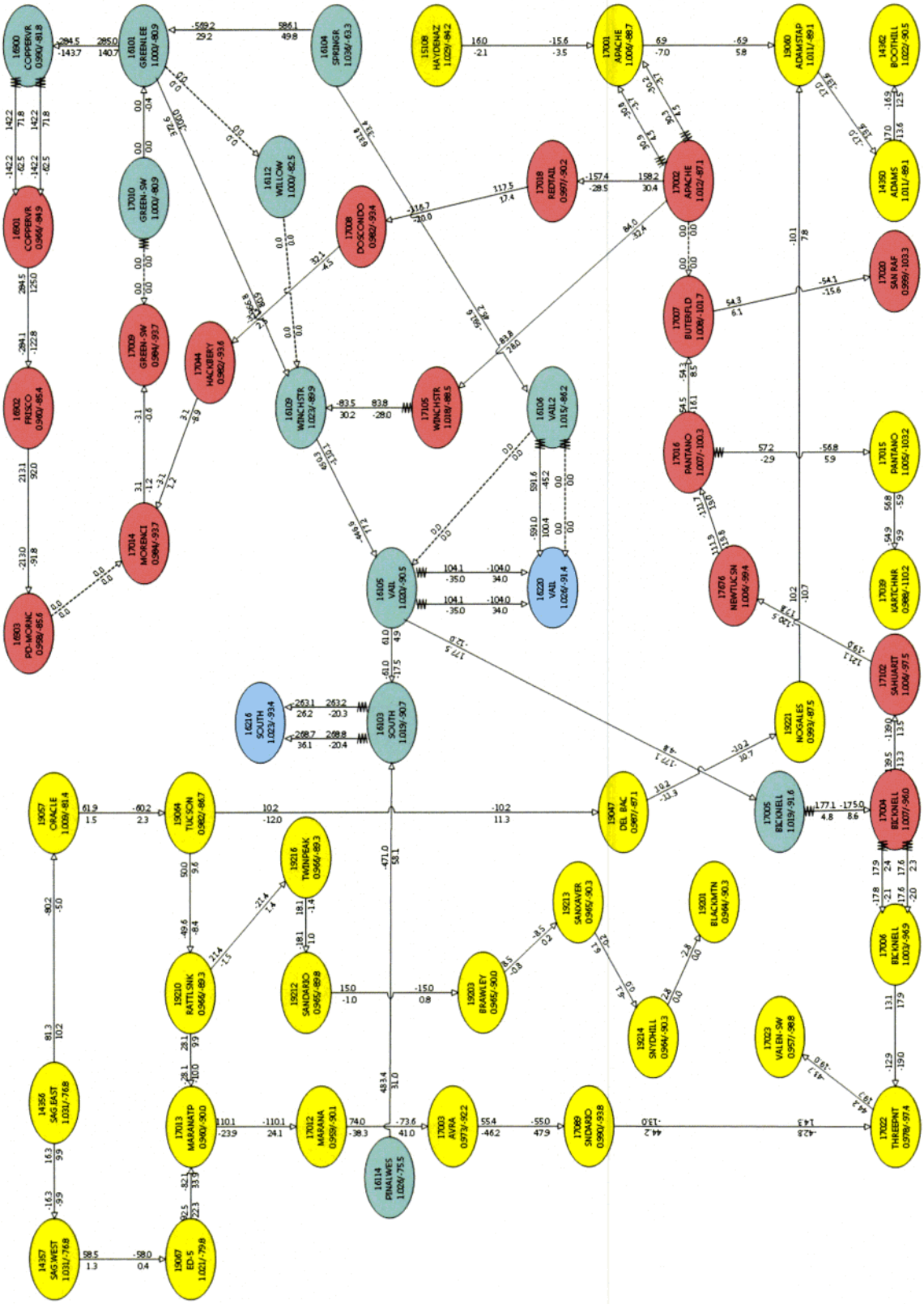
2021HS AEPCO System with Pinal West 500/345 kV Transformer out of service



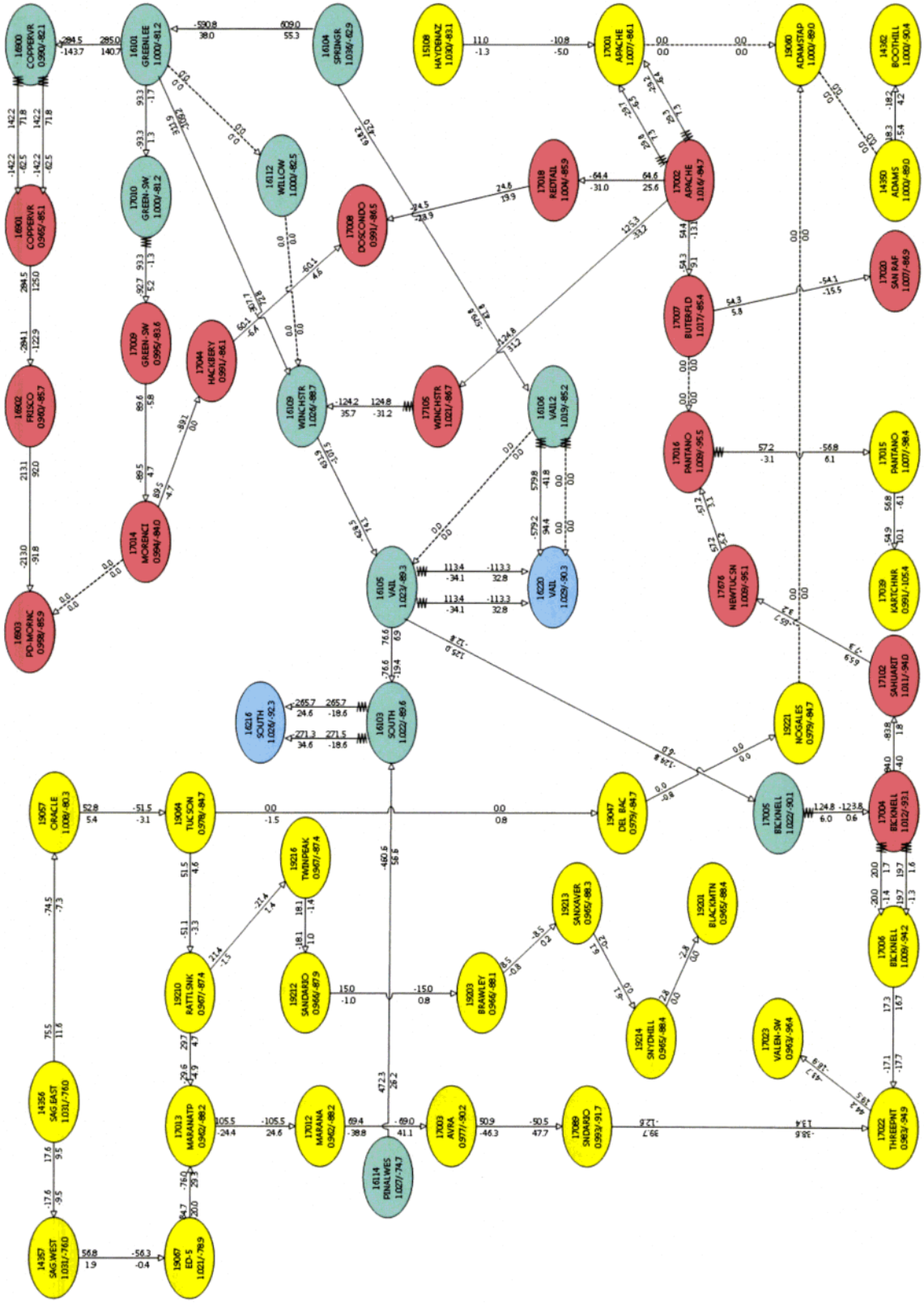
2021HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Apache to Redtail 230 kV Line out of service



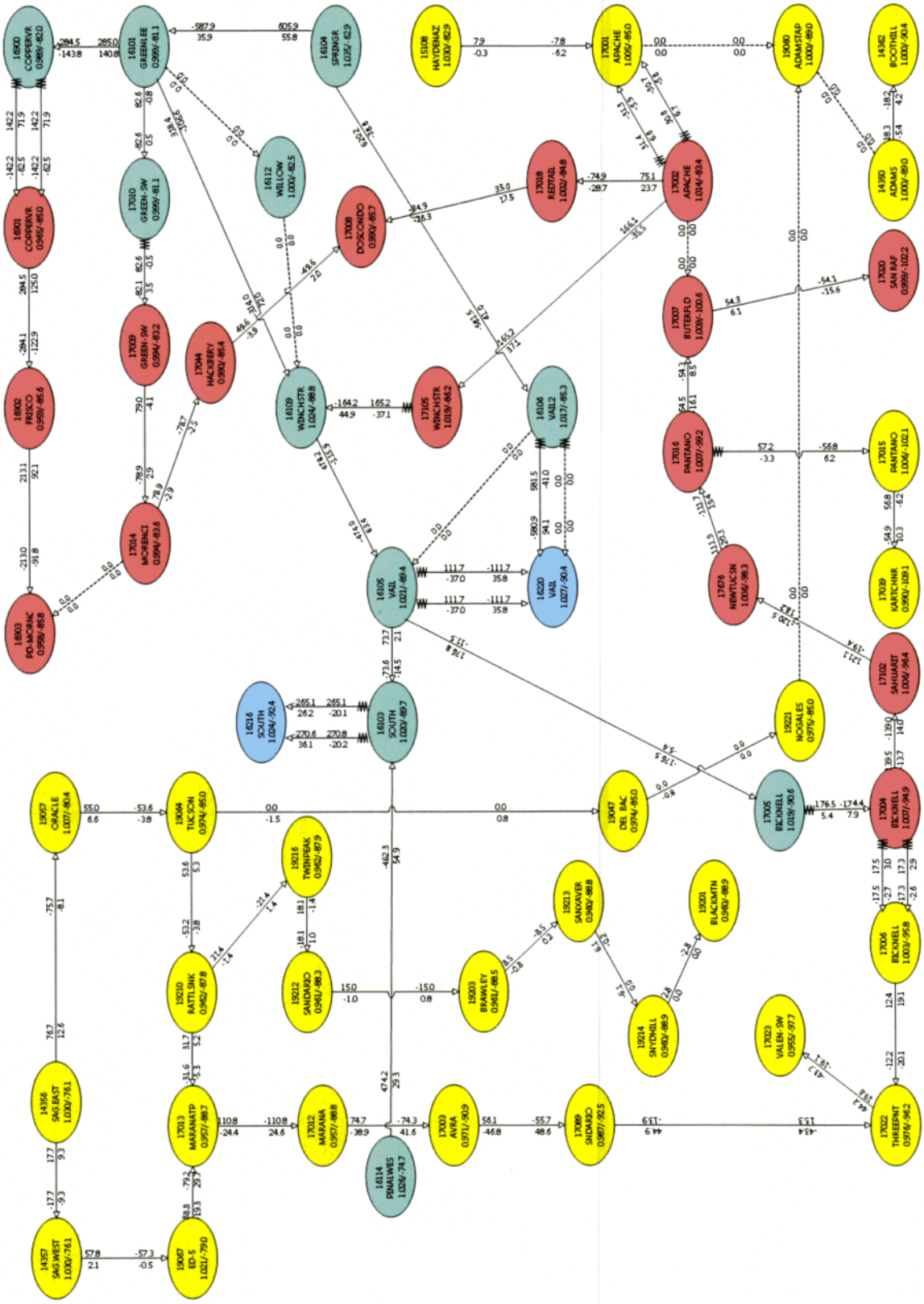
2021HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Green-SW 345/230 kV Transformer out of service



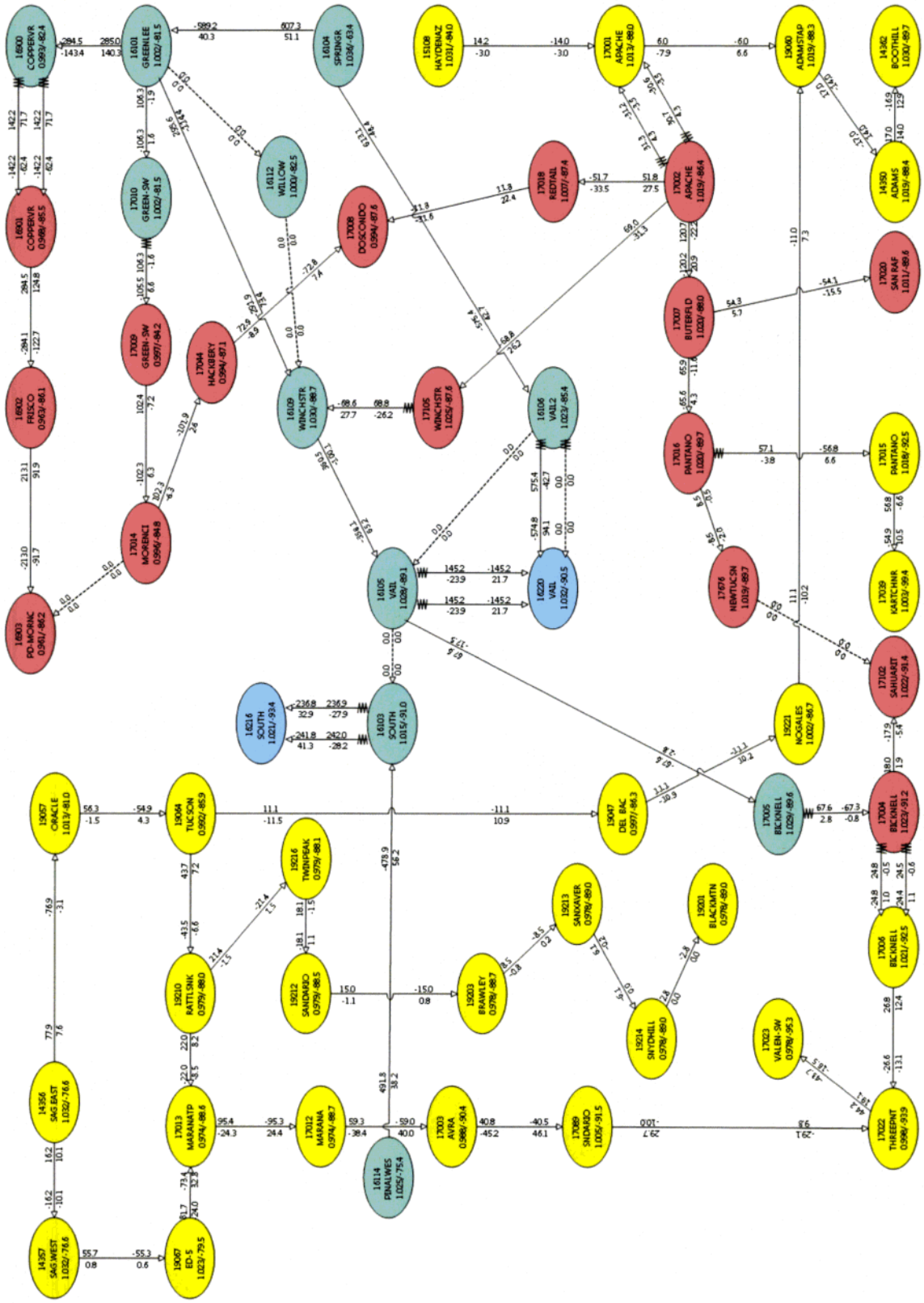
2021HS AEPCO System with Common Corridor outage of Butterfield to Pantano 230 kV & Adams Tap to Apache 115 kV Lines



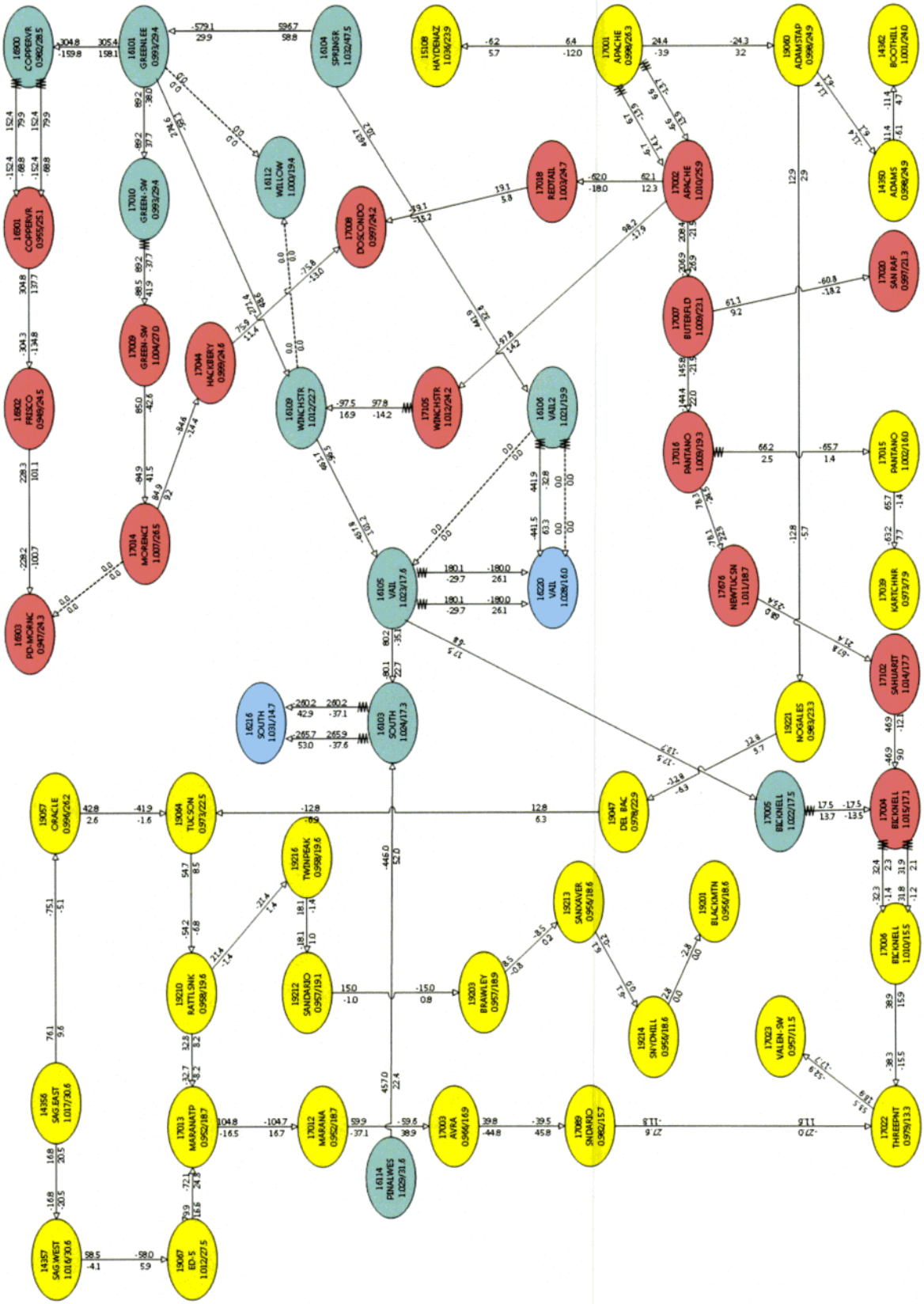
2021HS AEPCO System with Common Corridor outage of Apache to Butterfield 230 kV & Adams Tap to Apache 115 kV Lines



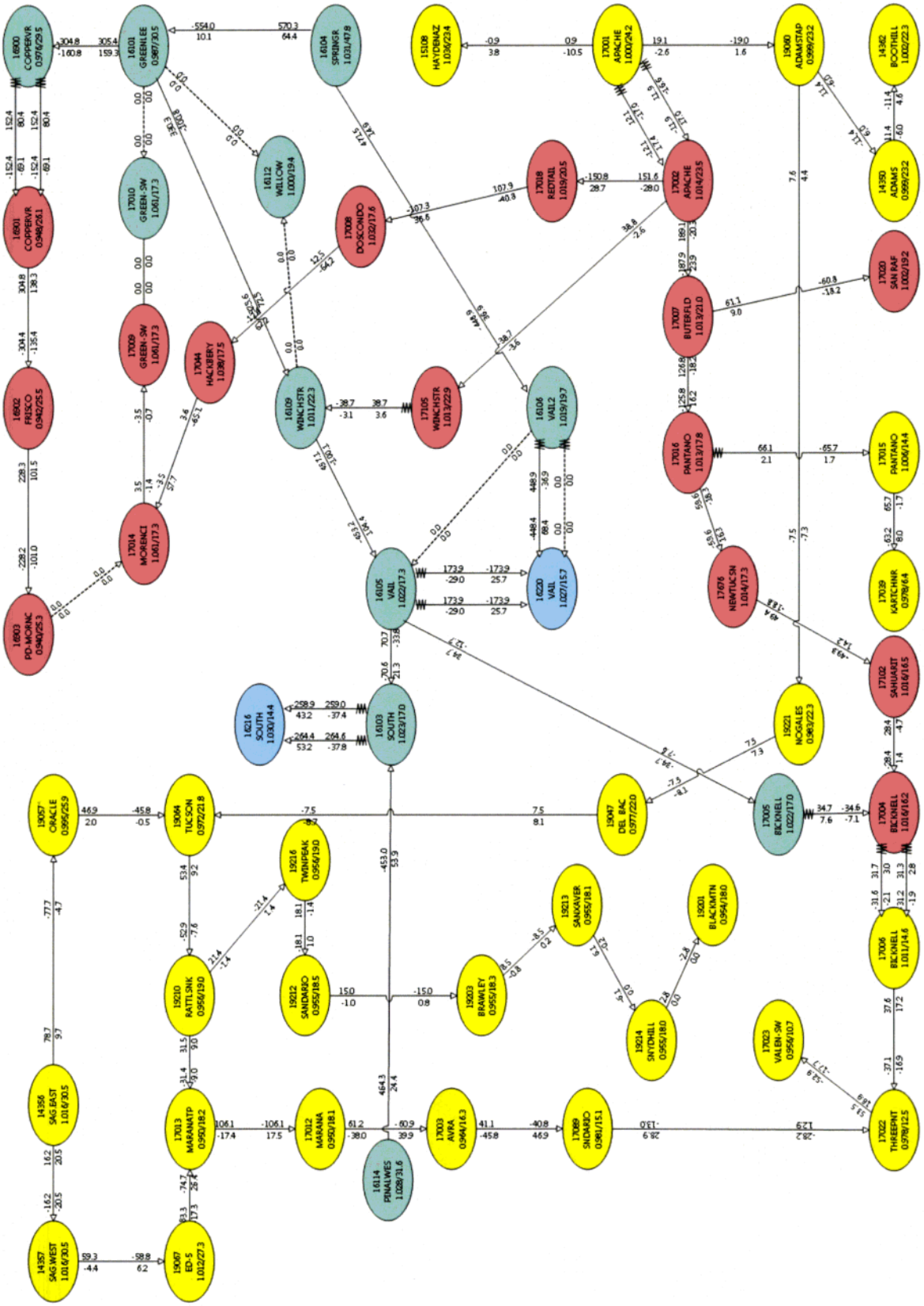
2021HS AEPCO System with Common Corridor outage of Vail to South 345 kV & New Tucson to Sahuarita 230 kV Lines



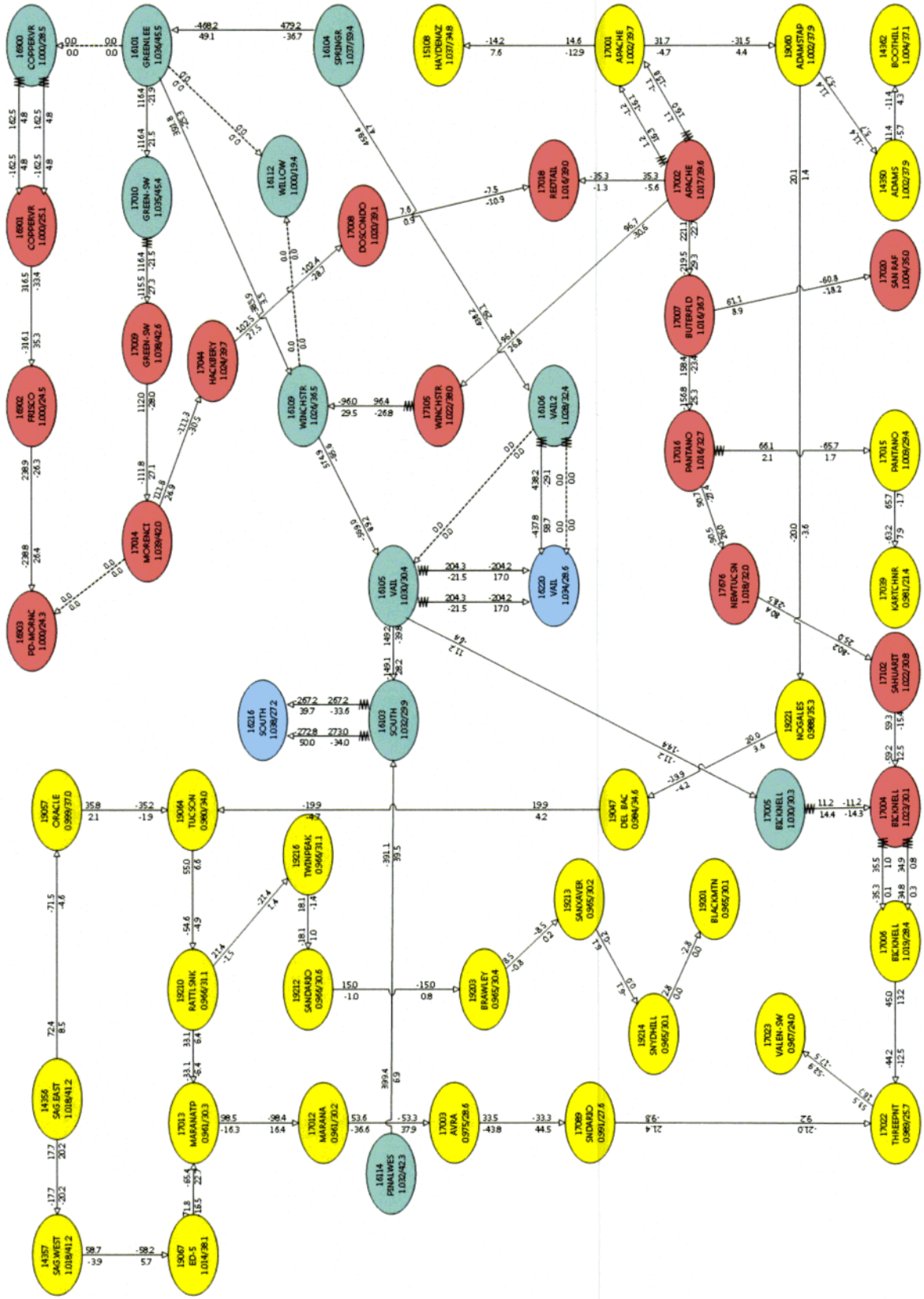
2026HS AEPCO System – All Lines in Service



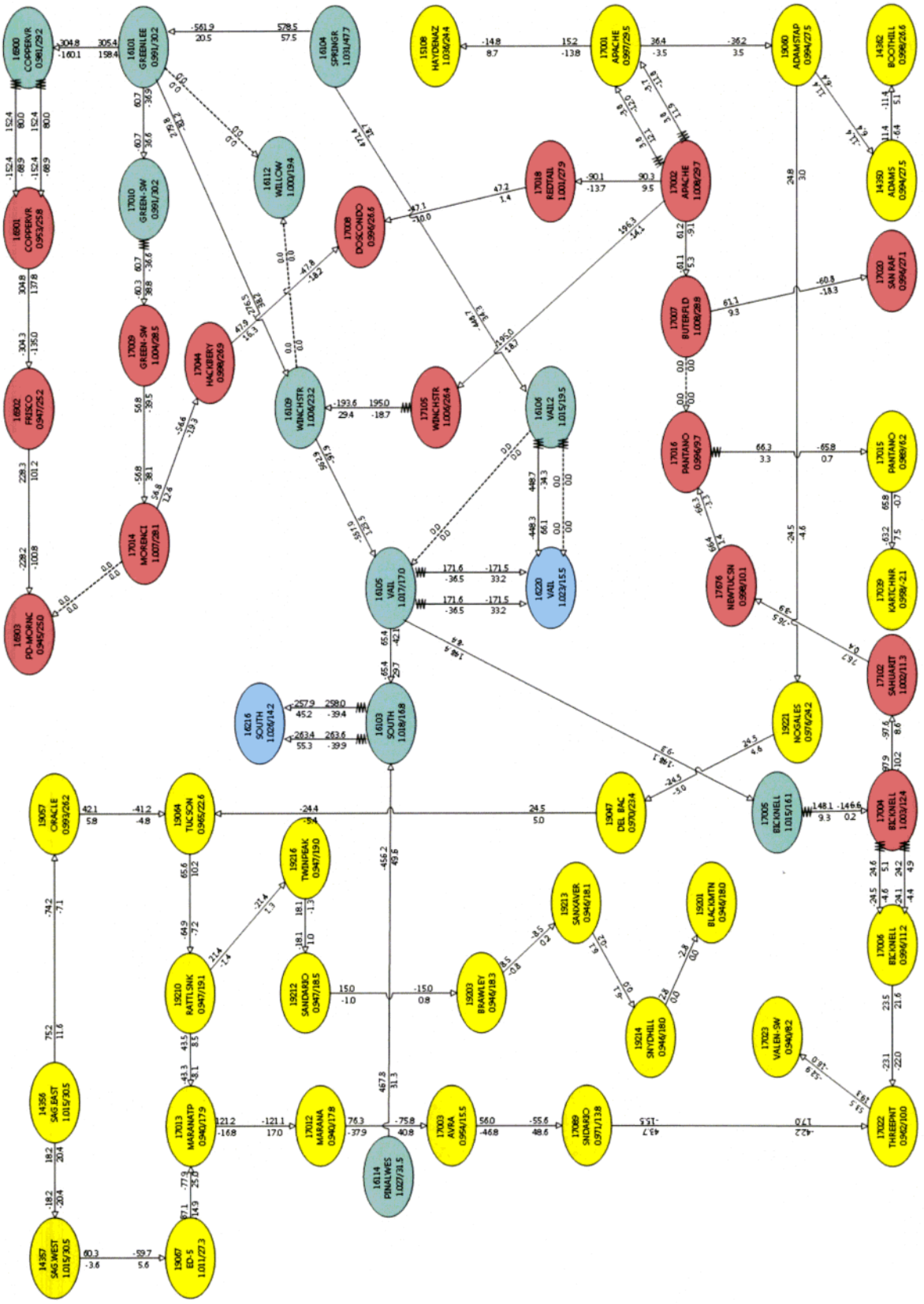
2026HS AEPCO System with Green-SW to Greenlee 345 kV Line out of service



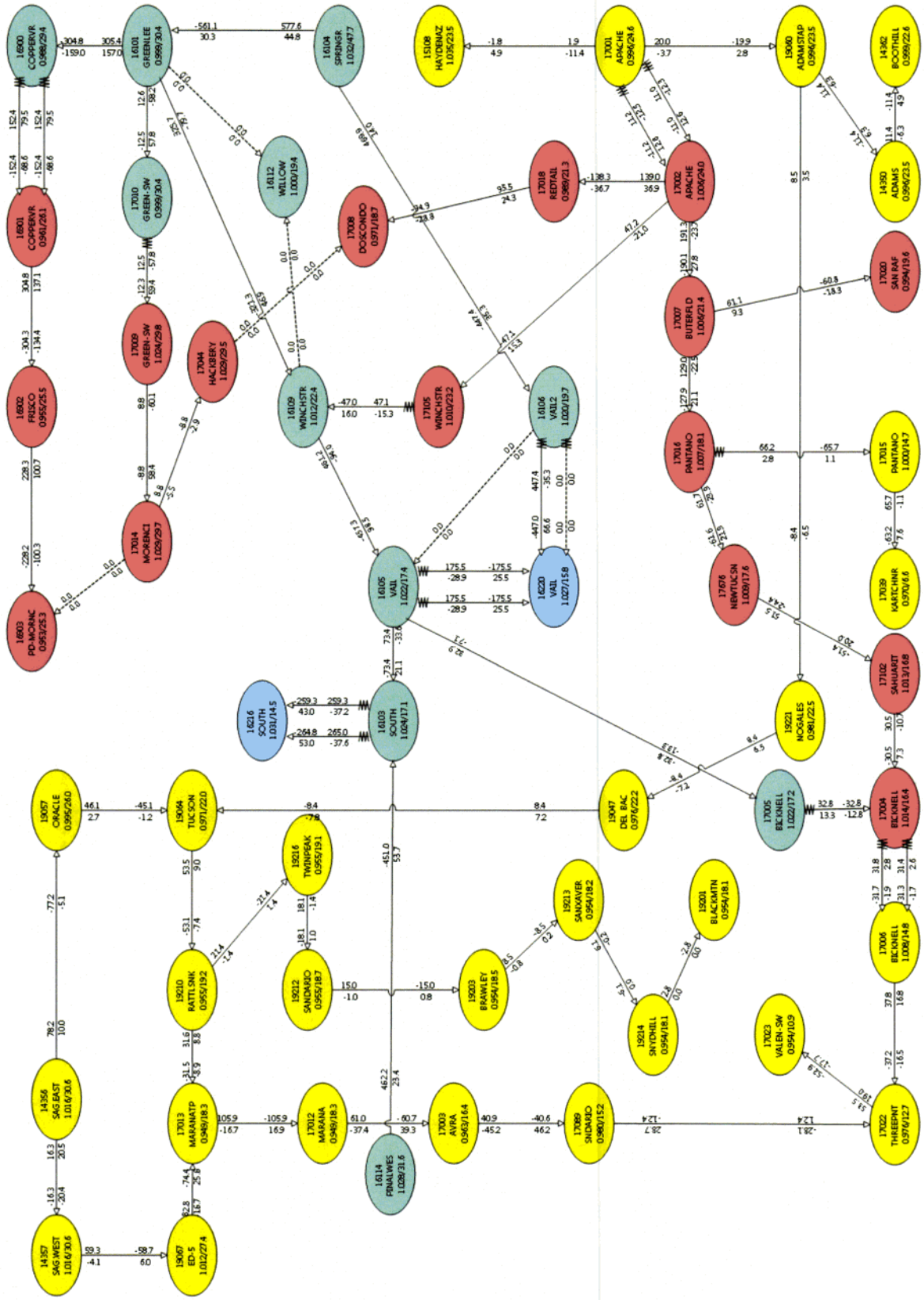
2026HS AEPCO System with Greenlee to Copper Verde 345 kV Line out of service



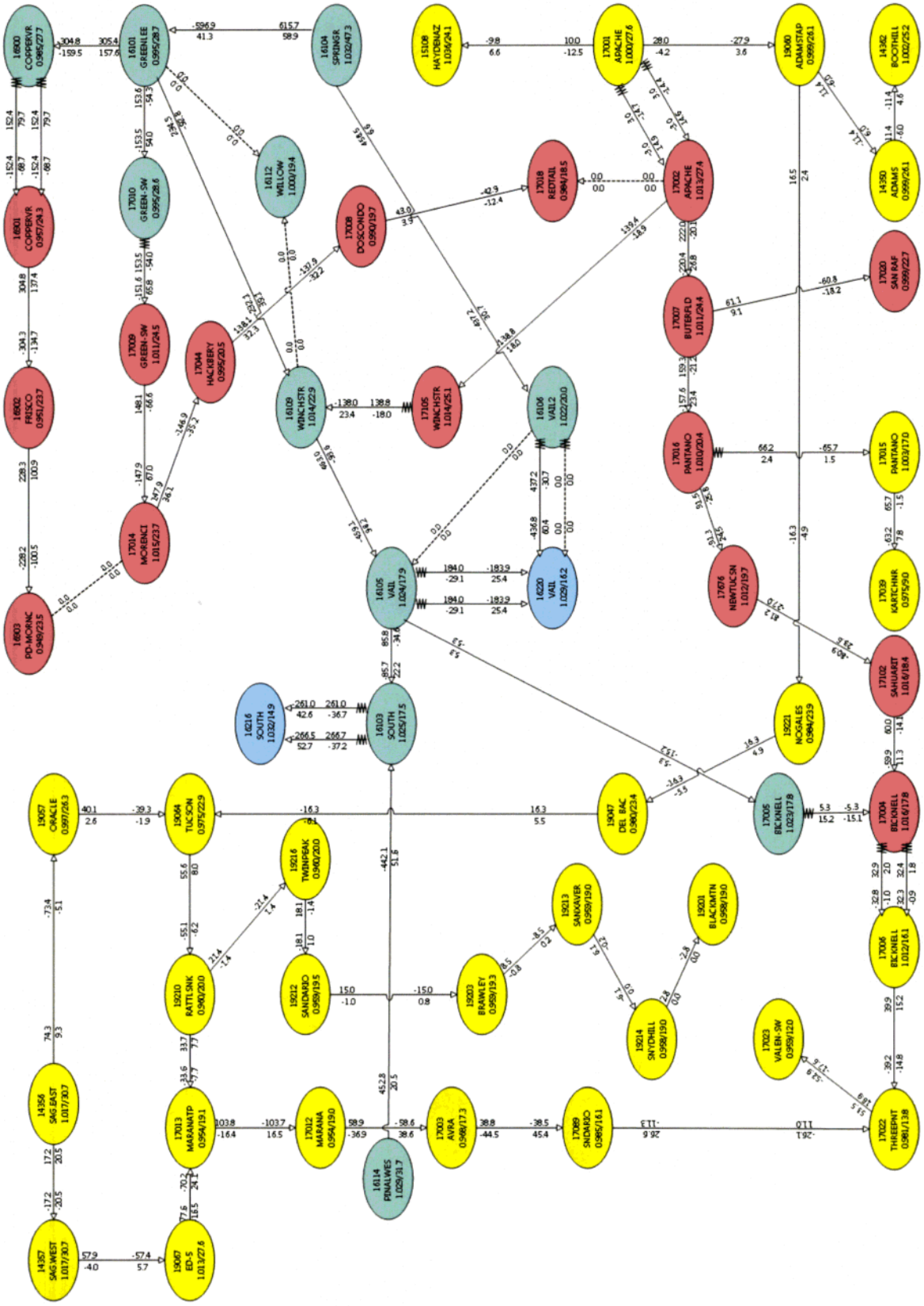
2026HS AEPCO System with Butterfield to Pantano 230 kV Line out of service



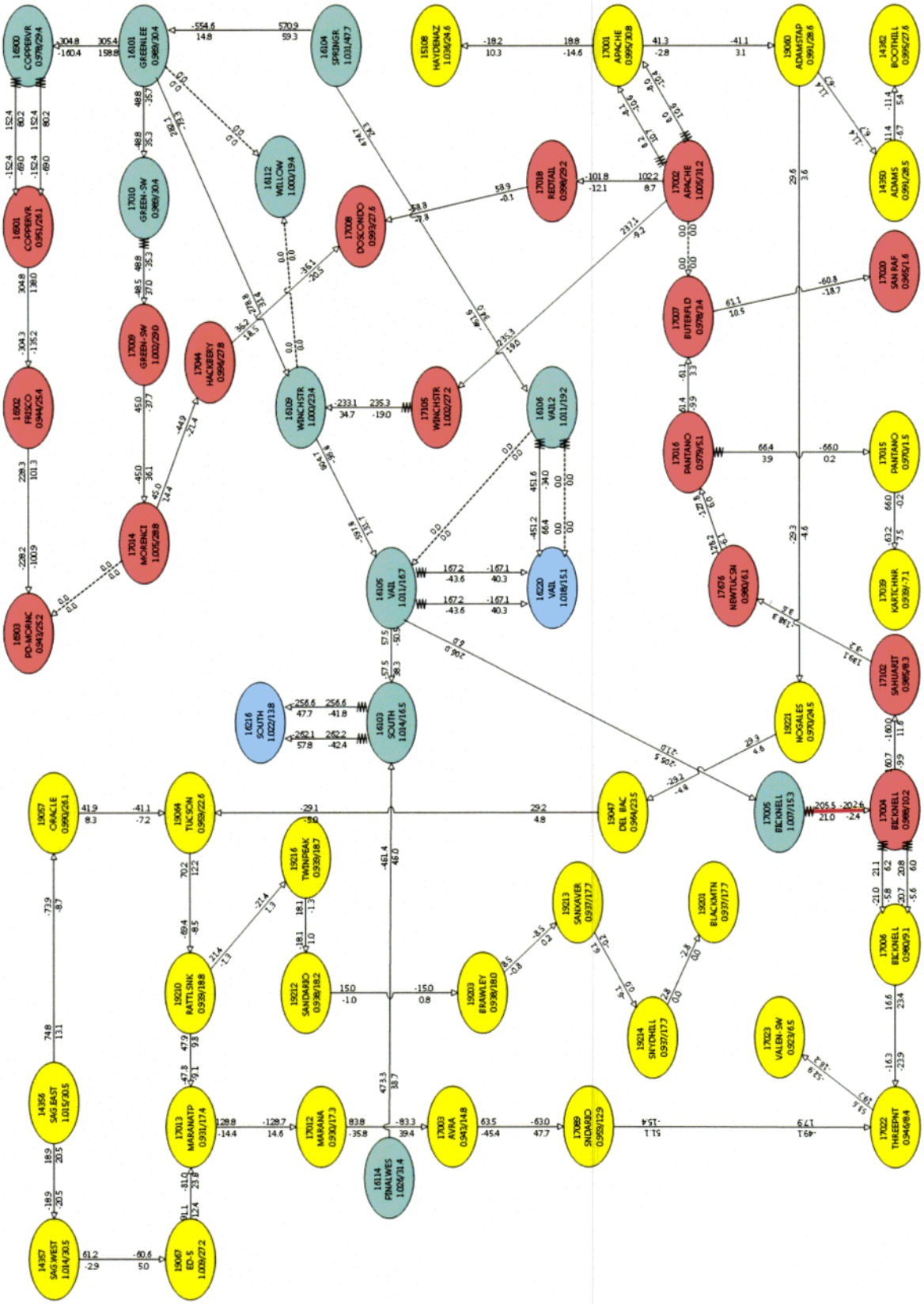
2026HS AEPCO System with Dos Condados to Hackberry 230 kV Line out of service



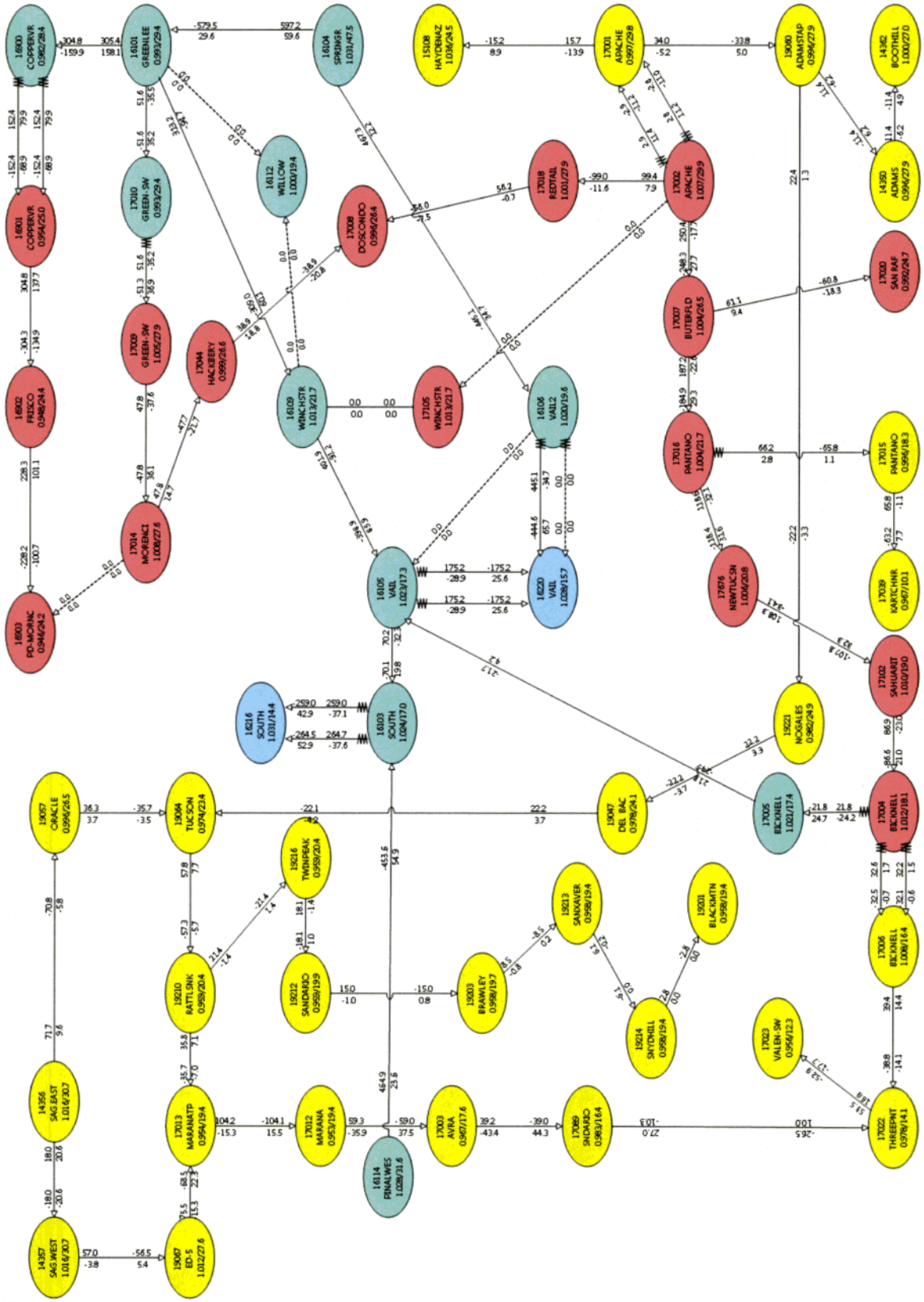
2026HS AEPCO System with Apache to Redtail 230 kV Line out of service



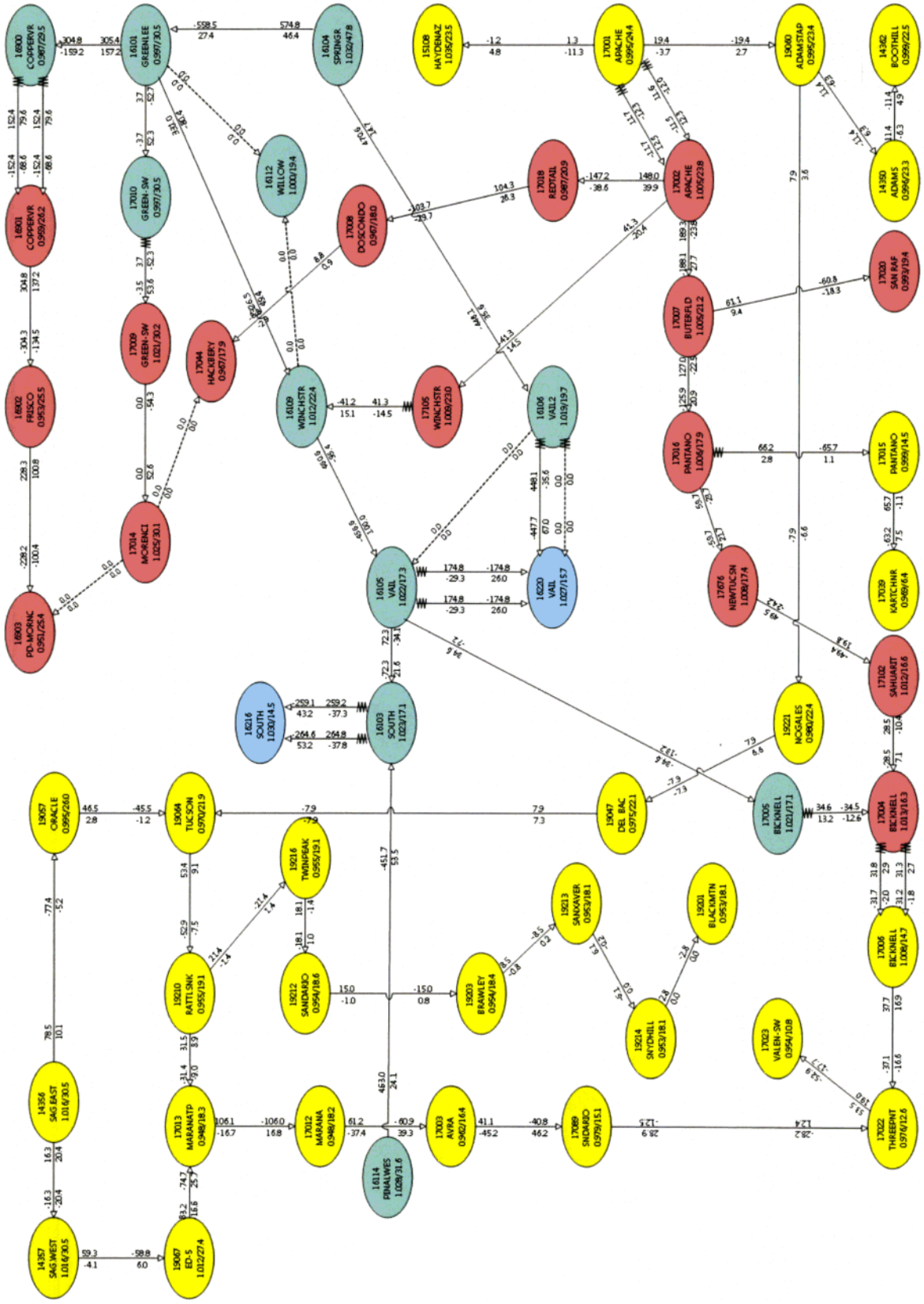
2026HS AEPCO System with Apache to Butterfield 230 kV Line out of service



2026HS AEPCO System with Apache to Winchester 230 kV Line out of service



2026HS AEPCO System with Hackberry to Morenci 230 kV Line out of service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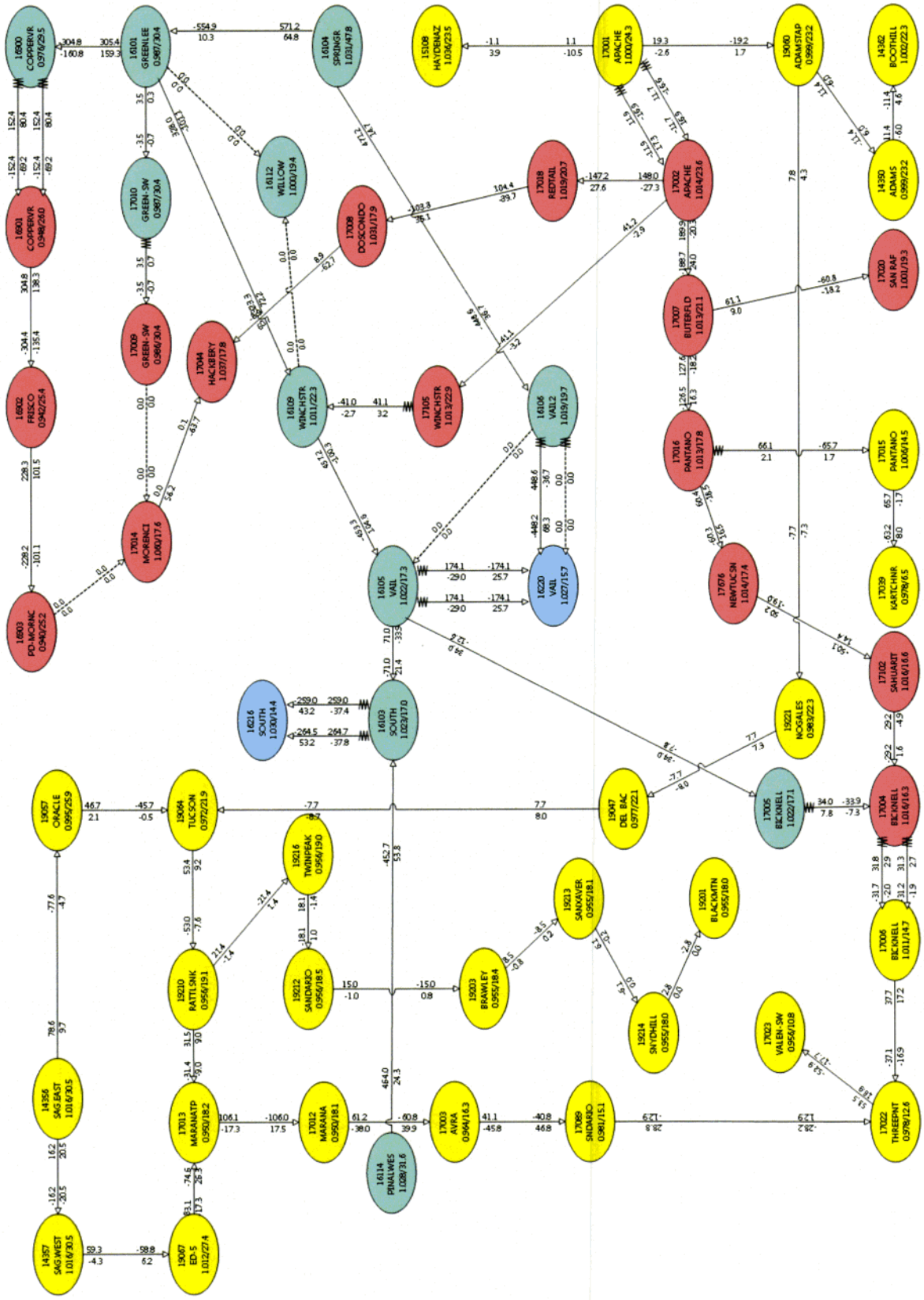
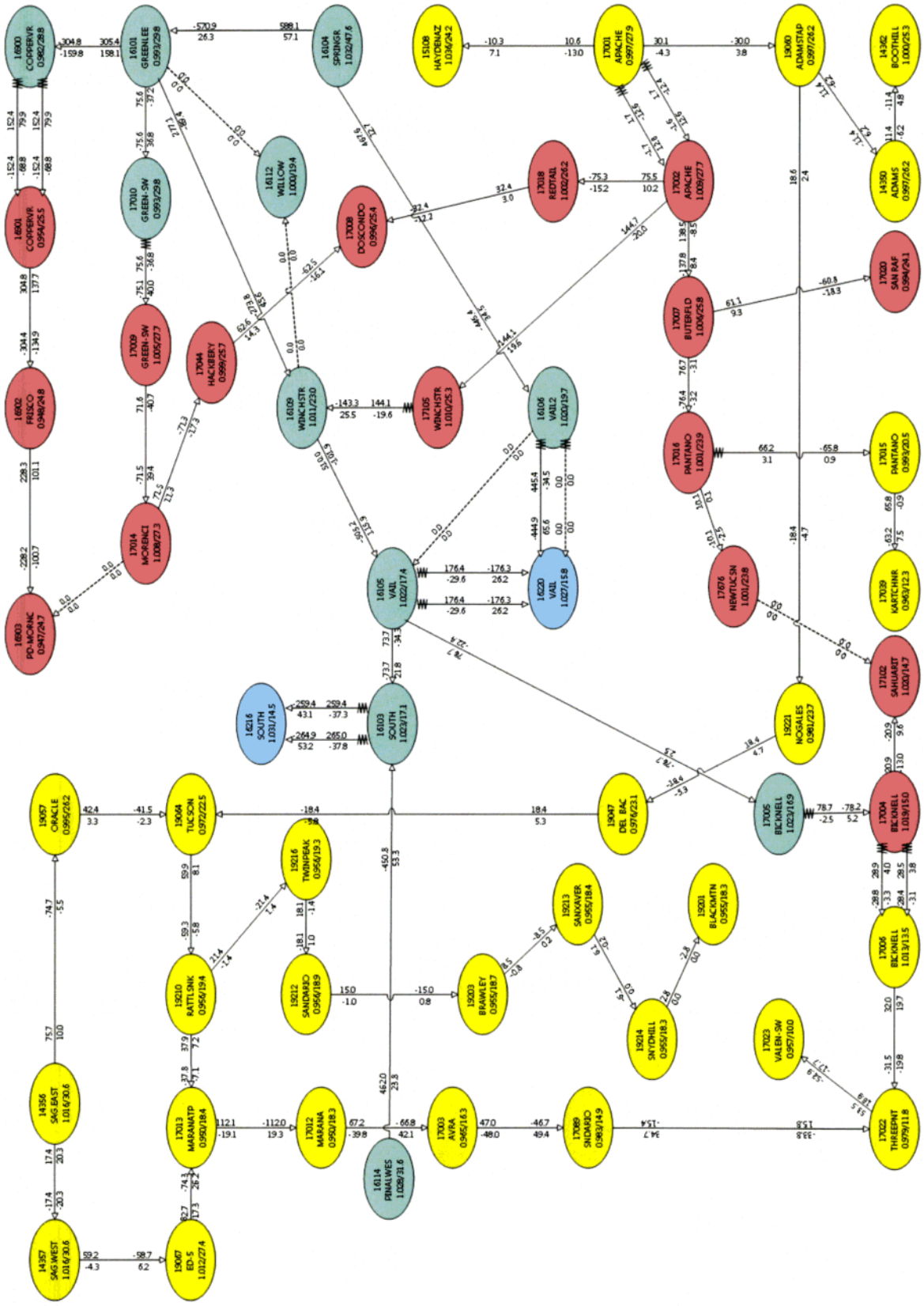
16101 GREENLEE 0.997/30.5
16104 SPRINGR 1.032/47.8
15108 HAYDENAZ 1.035/23.5
17001 APACHE 0.995/24.4
19060 ADAMSTAP 0.995/23.4
14362 BOOTHILL 0.999/22.5
16801 COPPERVR 0.999/28.2
17010 GREEN-SW 0.997/30.5
16112 WILLOW 1.000/19.4
17008 DOSCONDO 0.967/18.0
17018 REDTAIL 0.967/20.9
17002 APACHE 1.005/23.8
14350 ADAMS 0.994/23.3
16802 FRISCO 0.953/25.5
17009 GREEN-SW 1.021/30.2
17044 HACKBERY 0.967/17.9
16109 WINCHSTR 1.012/22.4
17105 WINCHSTR 1.009/23.0
16106 VAIL2 1.019/19.7
17020 SAN RAF 0.993/19.4
17007 BUTTERFLD 1.005/21.2
17016 PANTANO 1.004/17.9
17015 PANTANO 0.999/14.5
16803 PD-MORNC 0.961/25.4
17014 MORENCI 1.025/30.1
16105 VAIL 1.022/17.3
16220 VAIL 1.027/15.7
17616 NEWTUCSN 1.008/17.4
17039 KARTCHNR 0.969/6.4
17102 SAHUARIT 1.012/16.6
16216 SOUTH 1.030/14.5
16003 SOUTH 1.022/17.1
19221 NOGALES 0.980/22.4
19057 ORACLE 0.995/26.0
19064 TUCSON 0.970/21.9
19047 DEL BAC 0.975/22.1
17005 BICKNELL 1.022/17.1
17004 BICKNELL 1.013/16.3
19216 TWINPEAK 0.955/19.1
19213 SANXAVER 0.953/18.1
19001 BLACKMTN 0.953/18.1
17006 BICKNELL 1.006/14.7
19210 RATTLSNK 0.955/19.1
19212 SANDARIO 0.954/18.6
19203 BRAWLEY 0.954/18.4
19214 SNYDHILL 0.953/18.1
17023 VALEN-SW 0.954/10.8
14356 SAGEAST 1.016/30.5
17013 MARANATP 0.948/18.3
17012 MARANA 0.948/18.2
17003 AVRA 0.982/16.4
17089 SNDARIO 0.979/15.1
17022 THREEPNT 0.976/12.6
16114 PINALWES 1.028/31.6
14357 SAGWEST 1.016/30.5
19067 ED-5 1.012/27.4

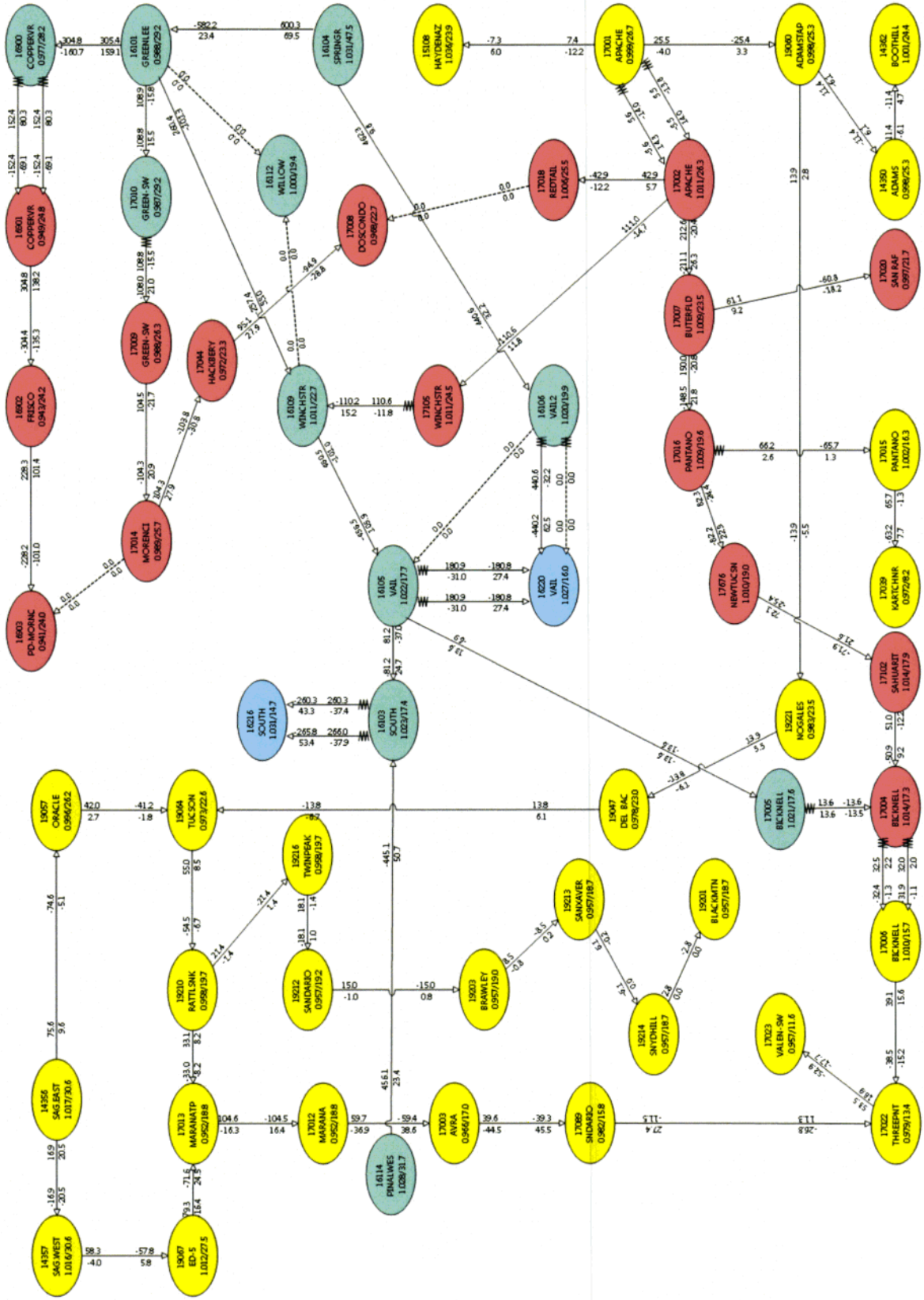
2026HS AEPCO System with Morenci to Green-SW 230 kV Line out of service



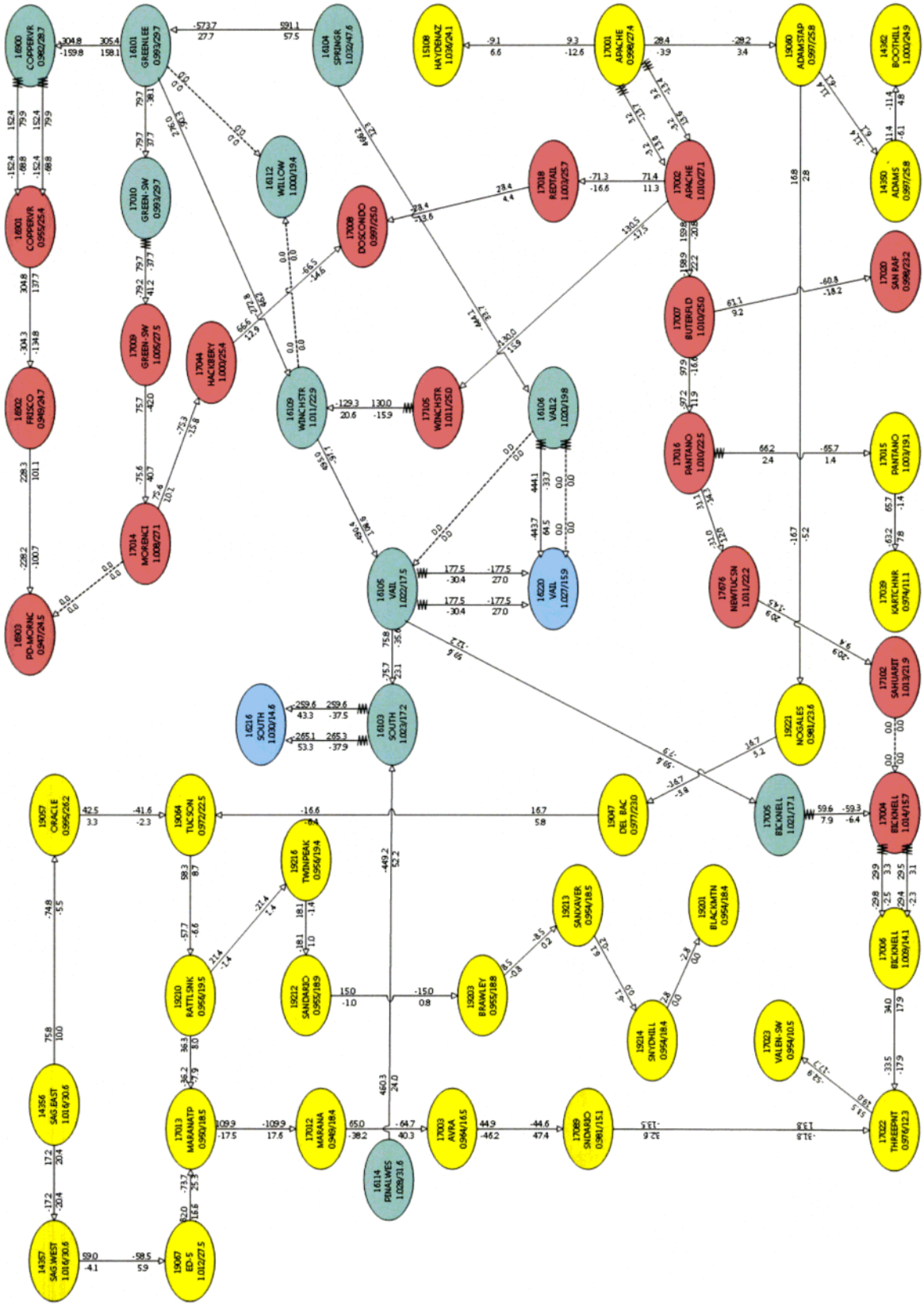
2026HS AEPCO System with New Tucson to Sahuarita 230 kV Line out of service



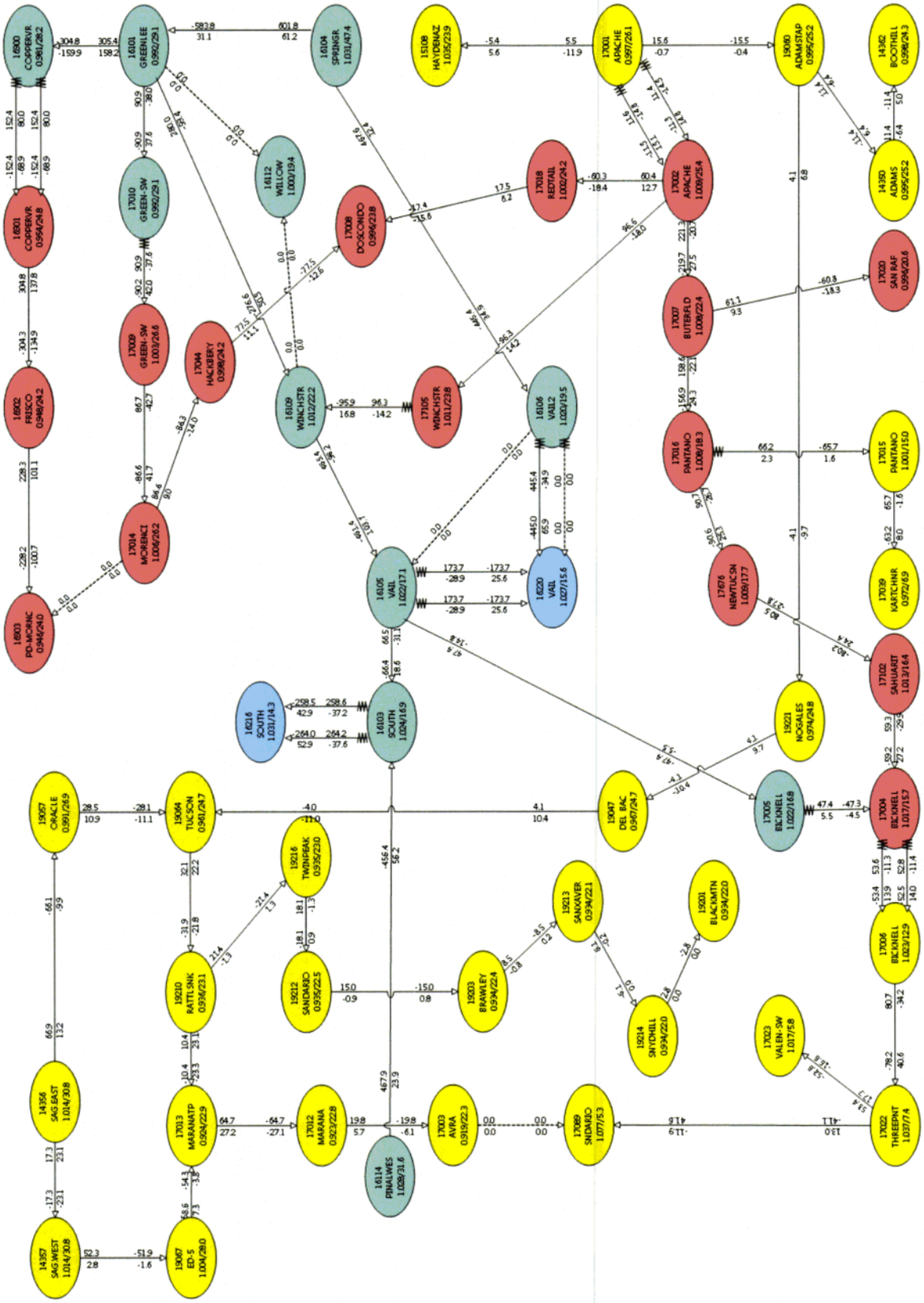
2026HS AEPCO System with Redtail to Dos Condados 230 kV Line out of service



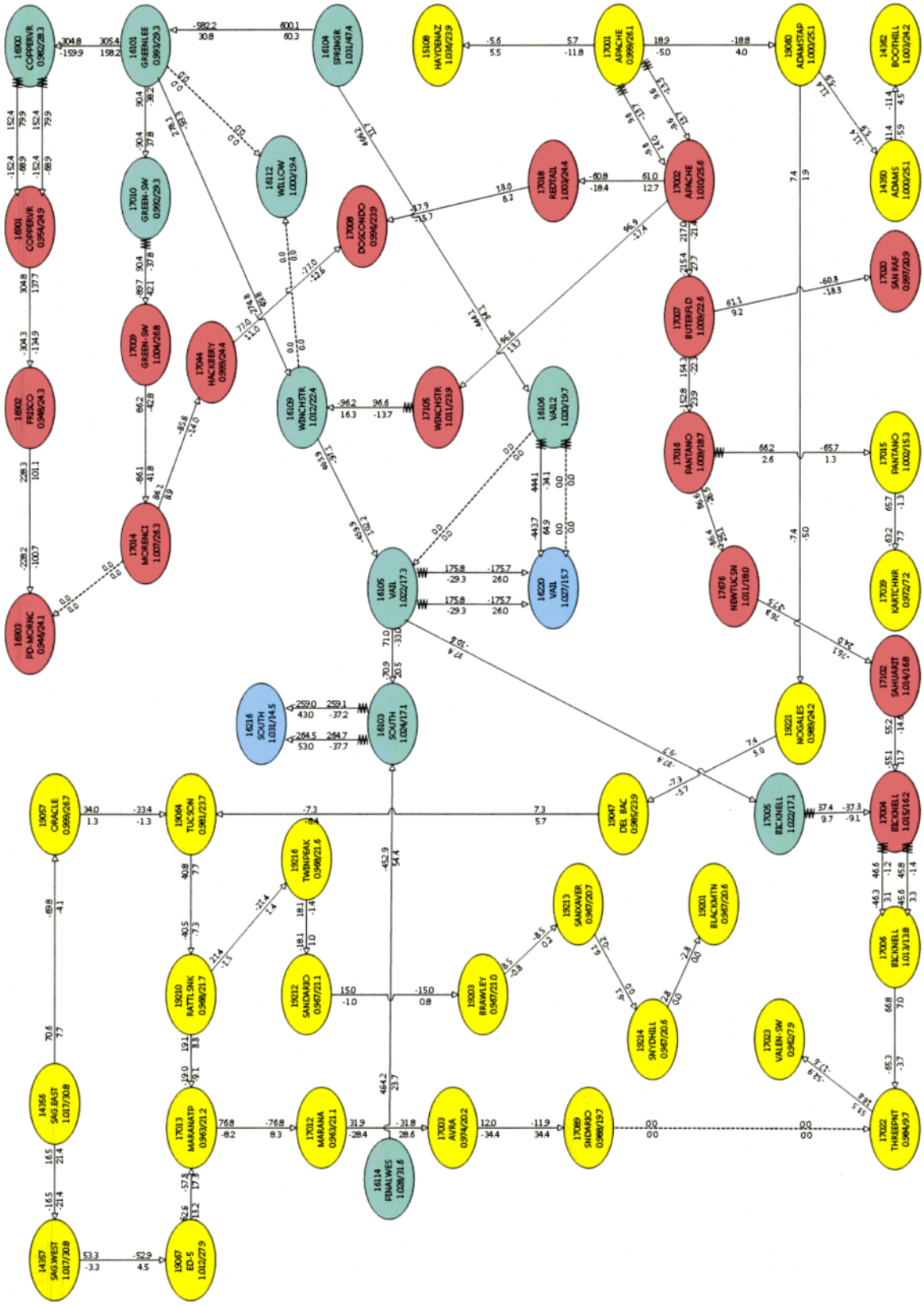
2026HS AEPCO System with Sahuarita to Bicknell 230 kV Line out of service



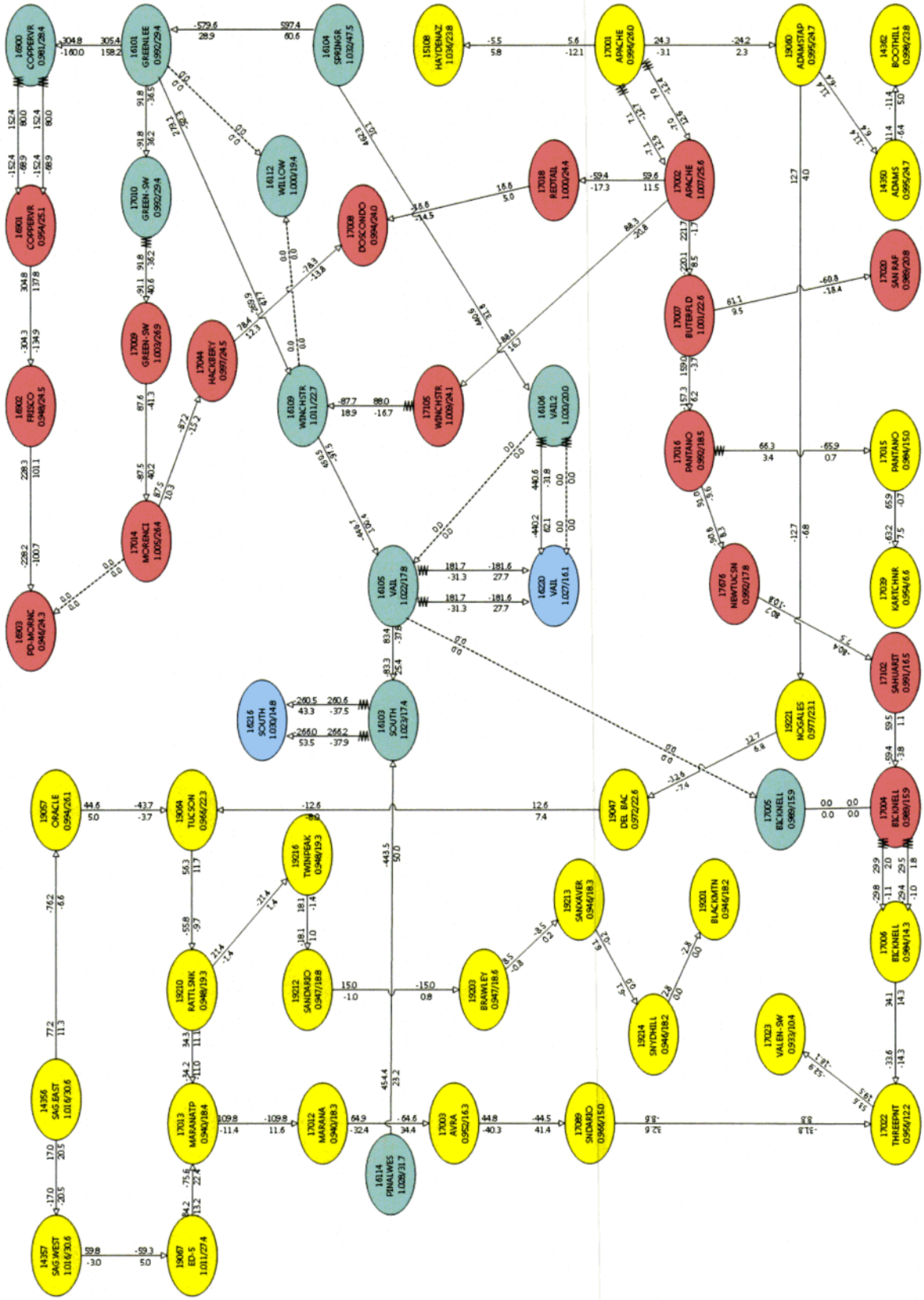
2026HS AEPCO System with Avra to Sandario 115 kV Line out of service



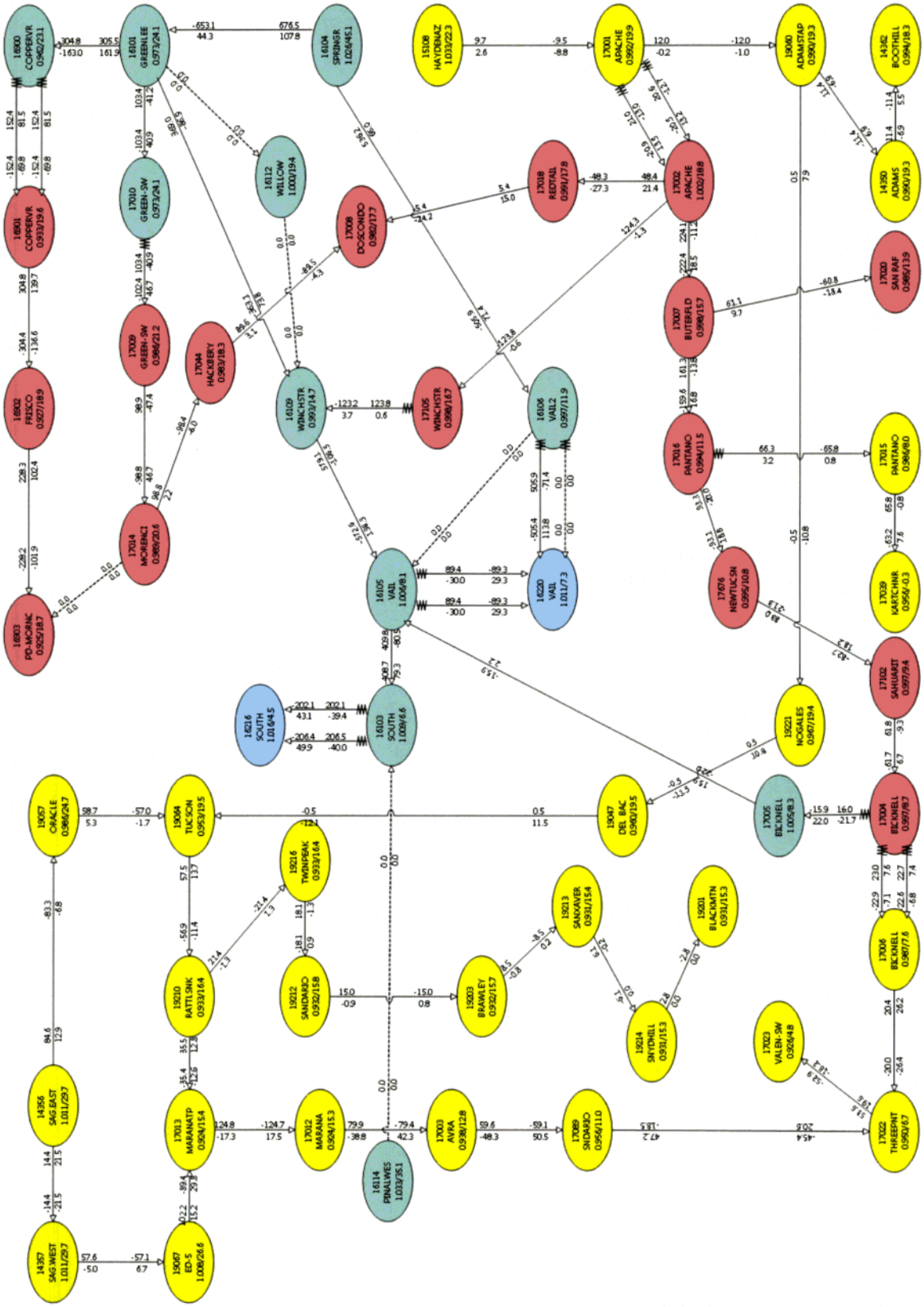
2026HS AEPCO System with Three Points to Sandario 115 kV Line out of service



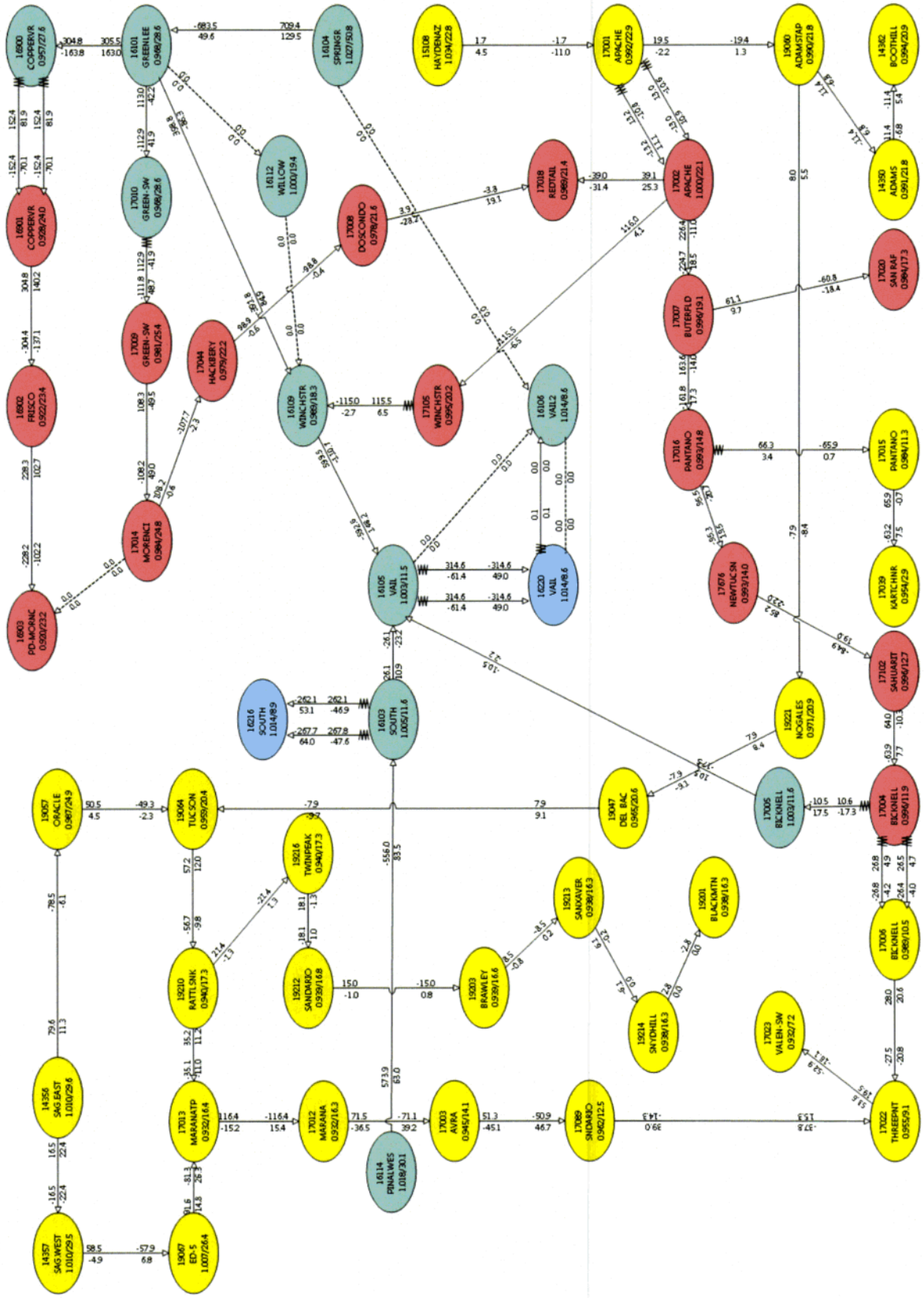
2026HS AEPCO System with Bicknell to Vail 345 kV Line out of service



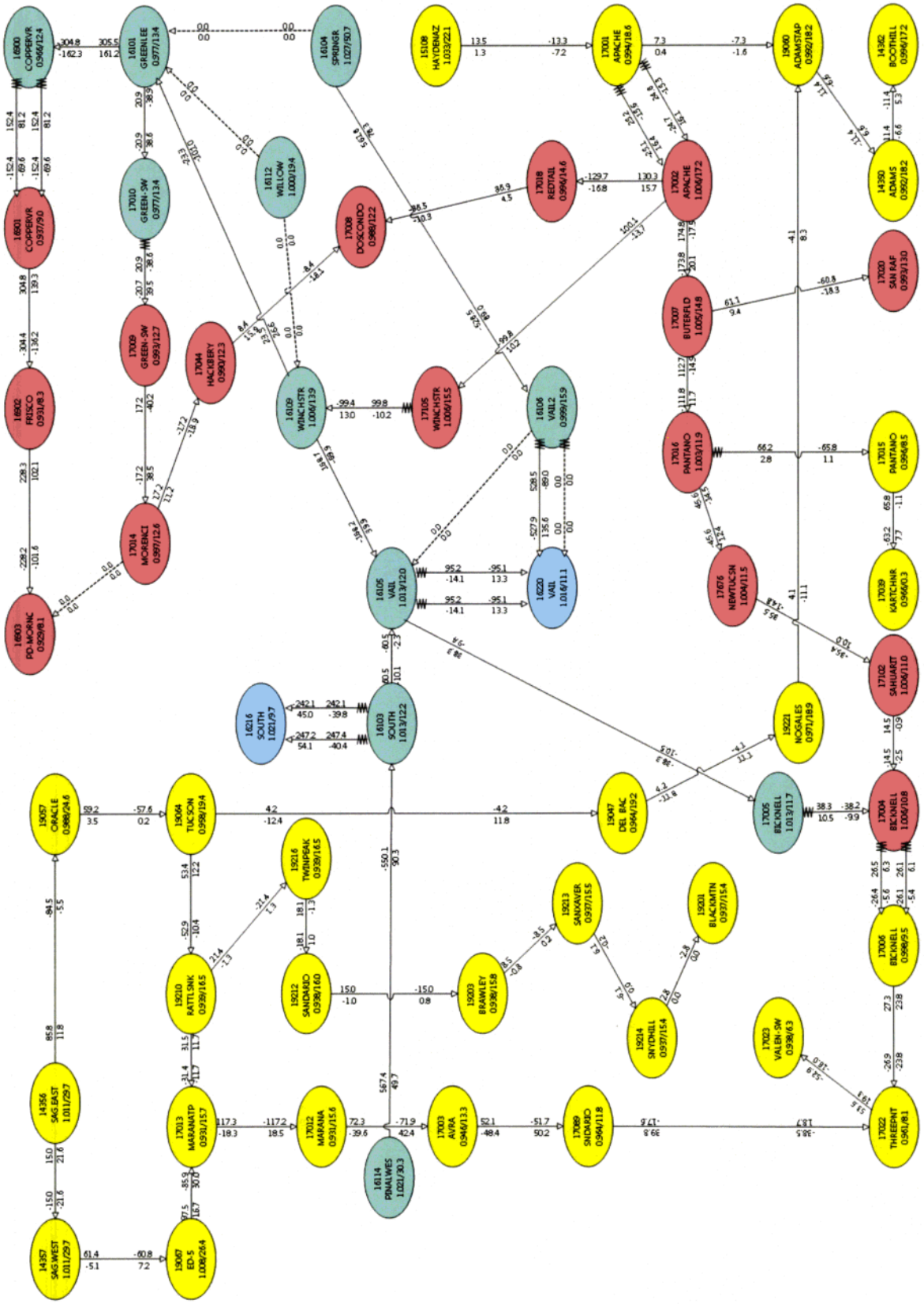
2026HS AEPCO System with Pinal West to South 345 kV Line out of service



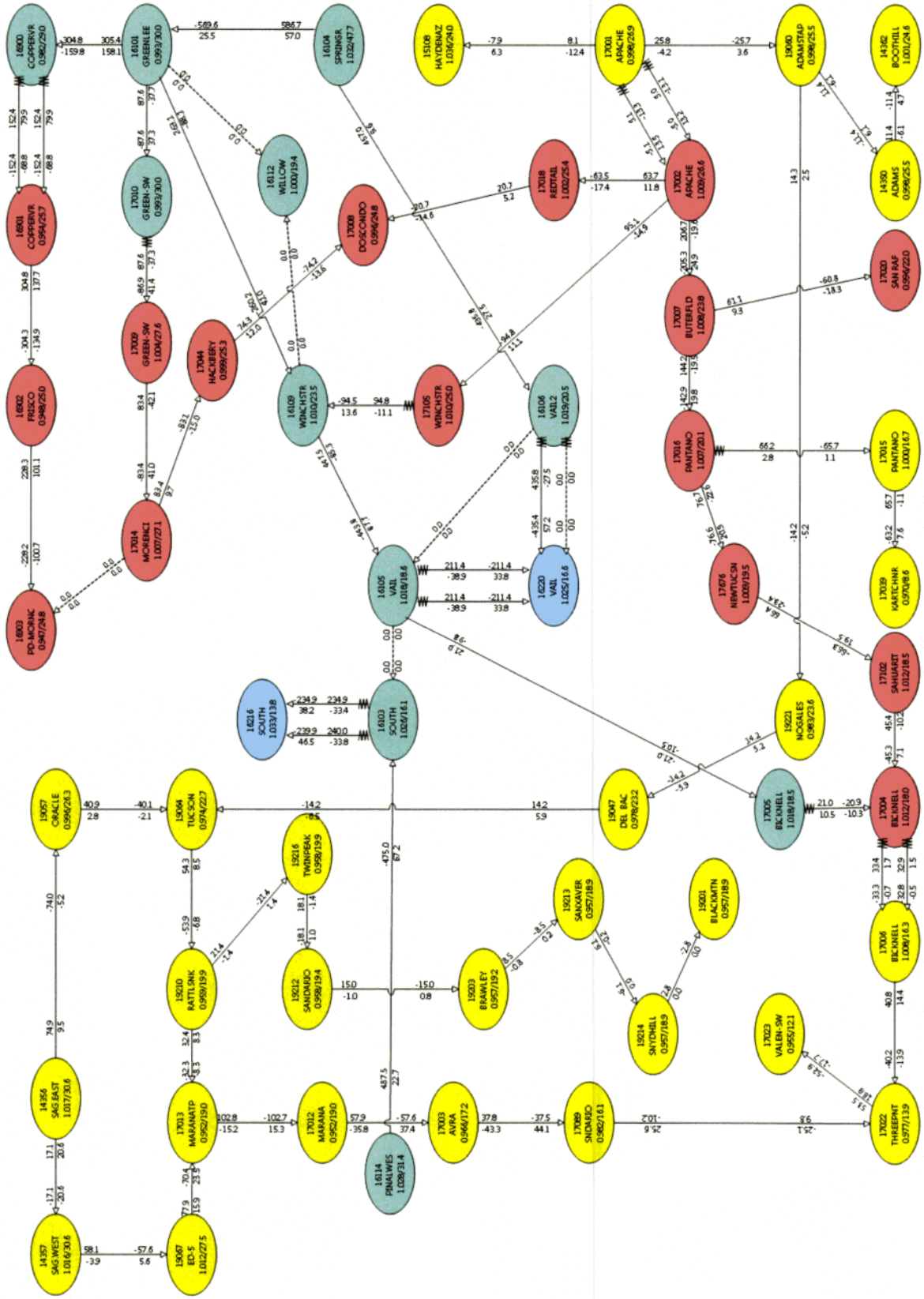
2026HS AEPCO System with Springerville to Vail2 345 kV Line out of service



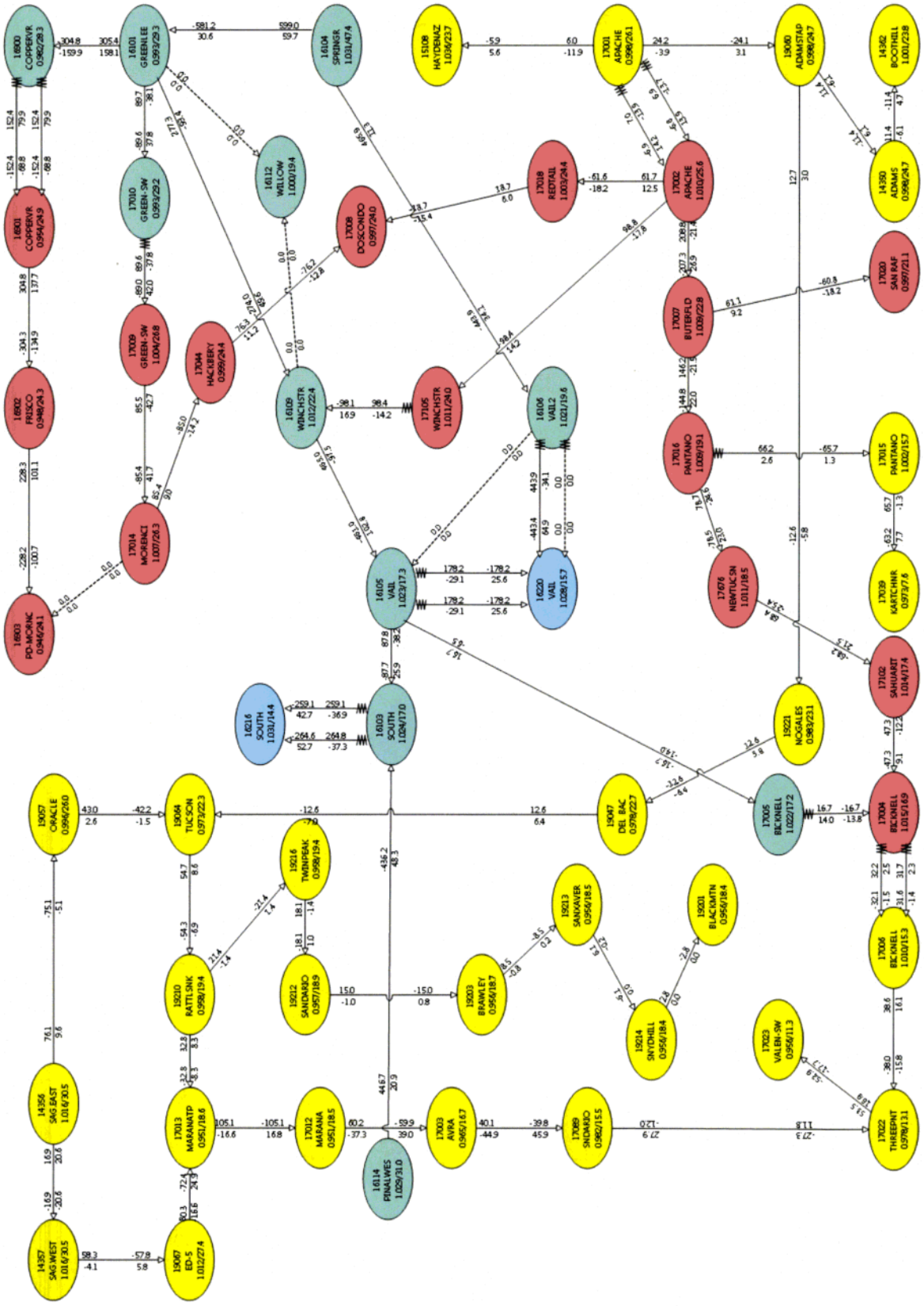
2026HS AEPCO System with Springerville to Greenlee 345 kV Line out of service



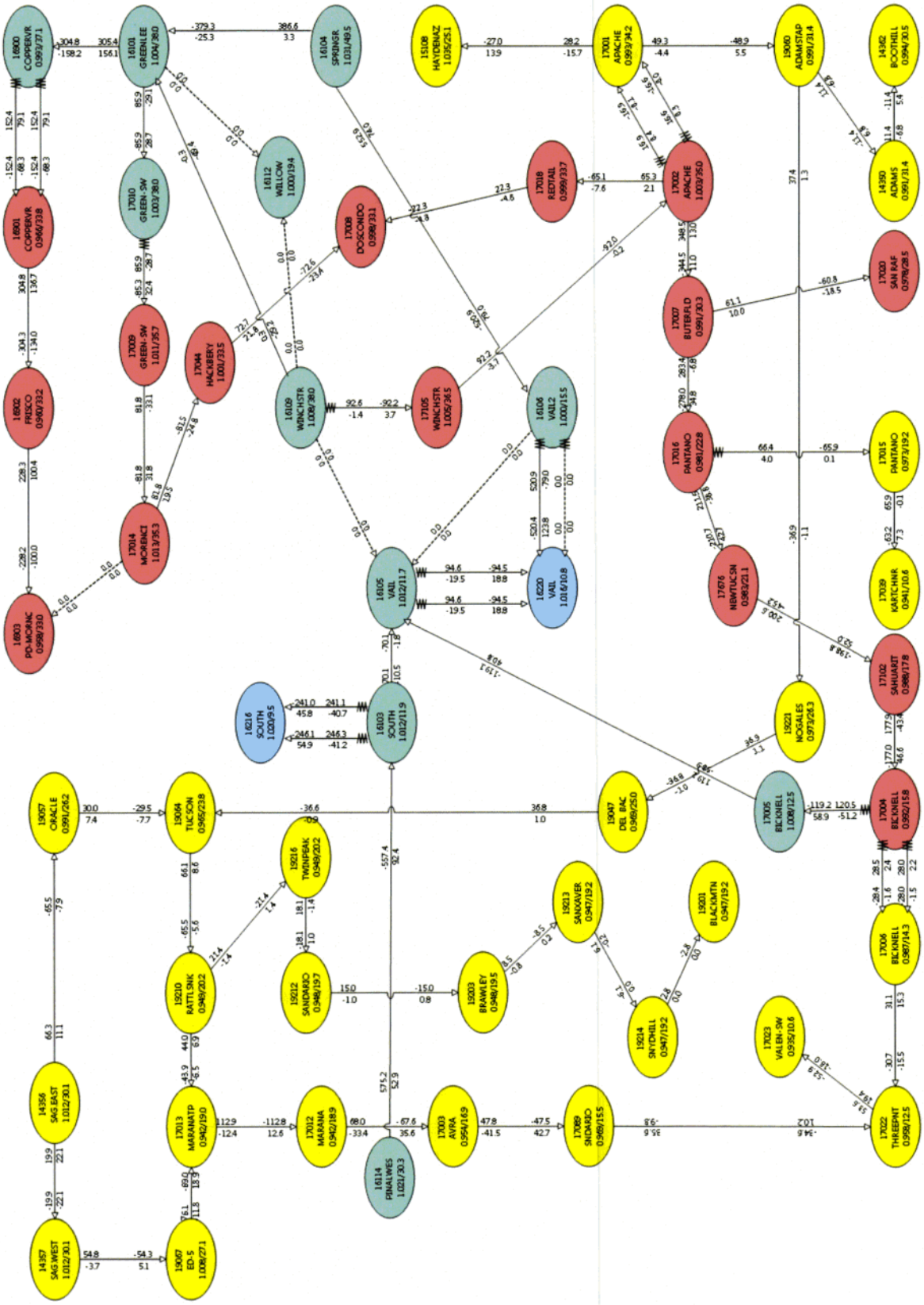
2026HS AEPCO System with Vail to South 345 kV Line out of service



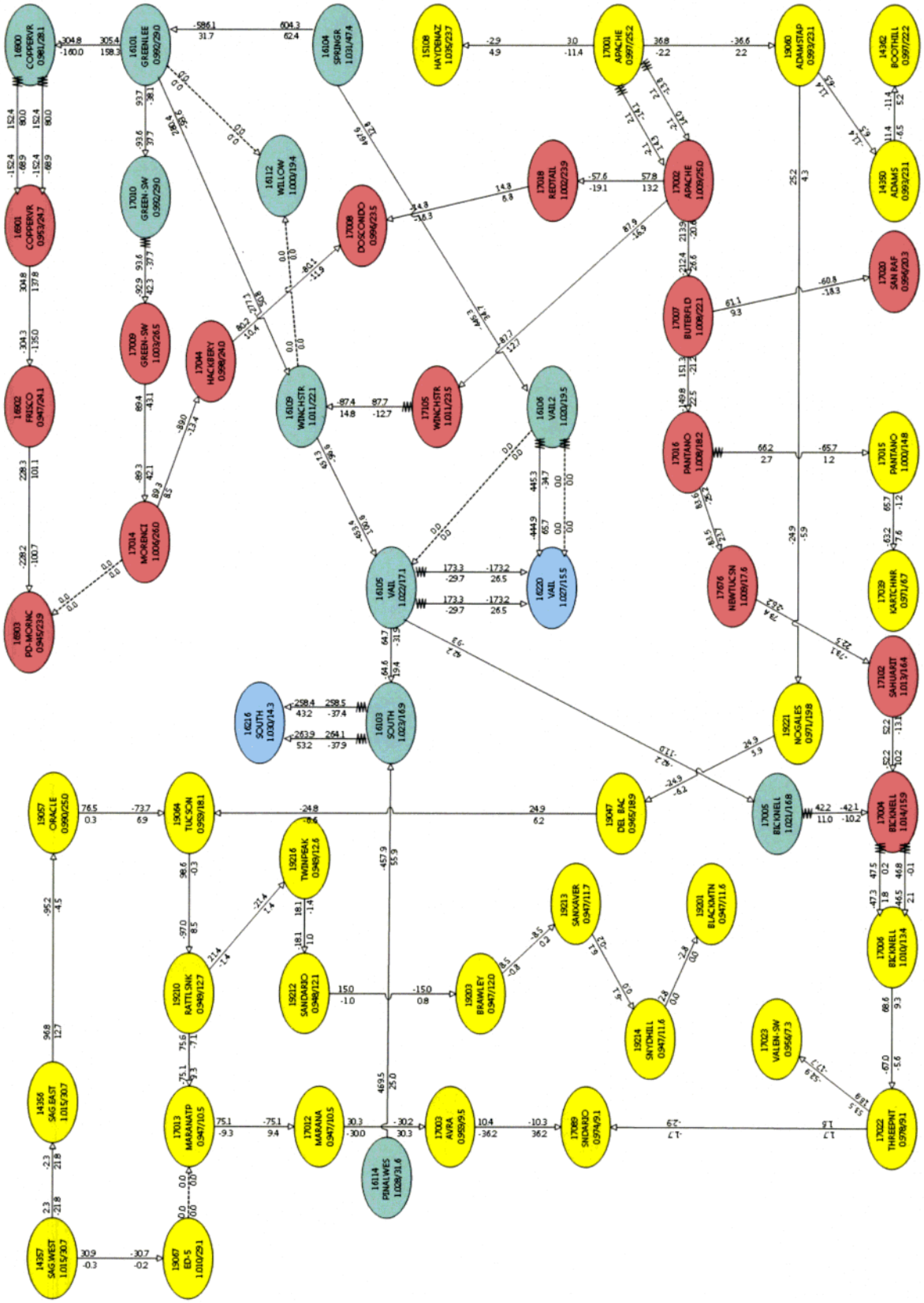
2026HS AEPCO System with Westwing to Pinal West 345 kV Line out of service



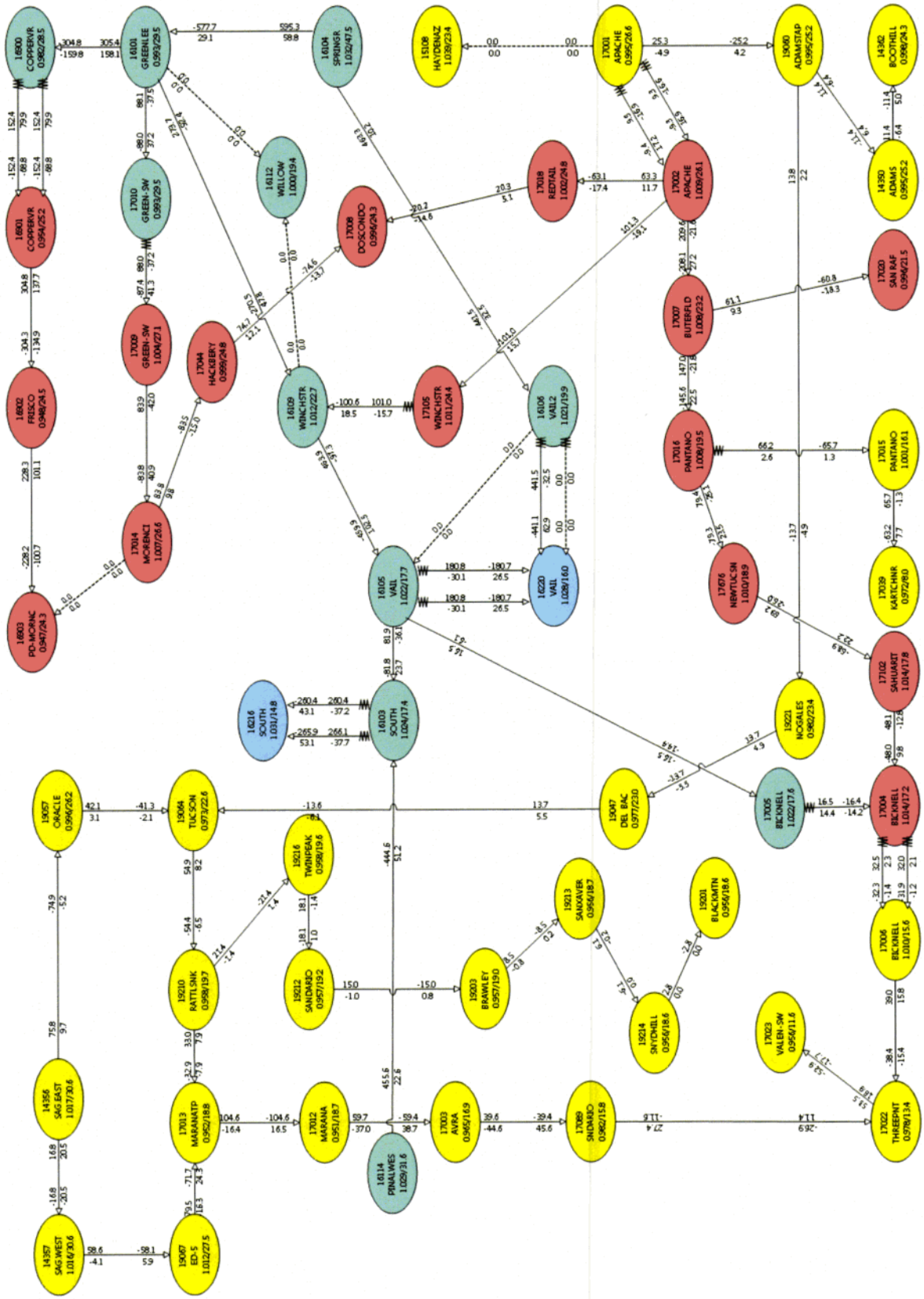
2026HS AEPCO System with Winchester to Vail 345 kV Line out of service



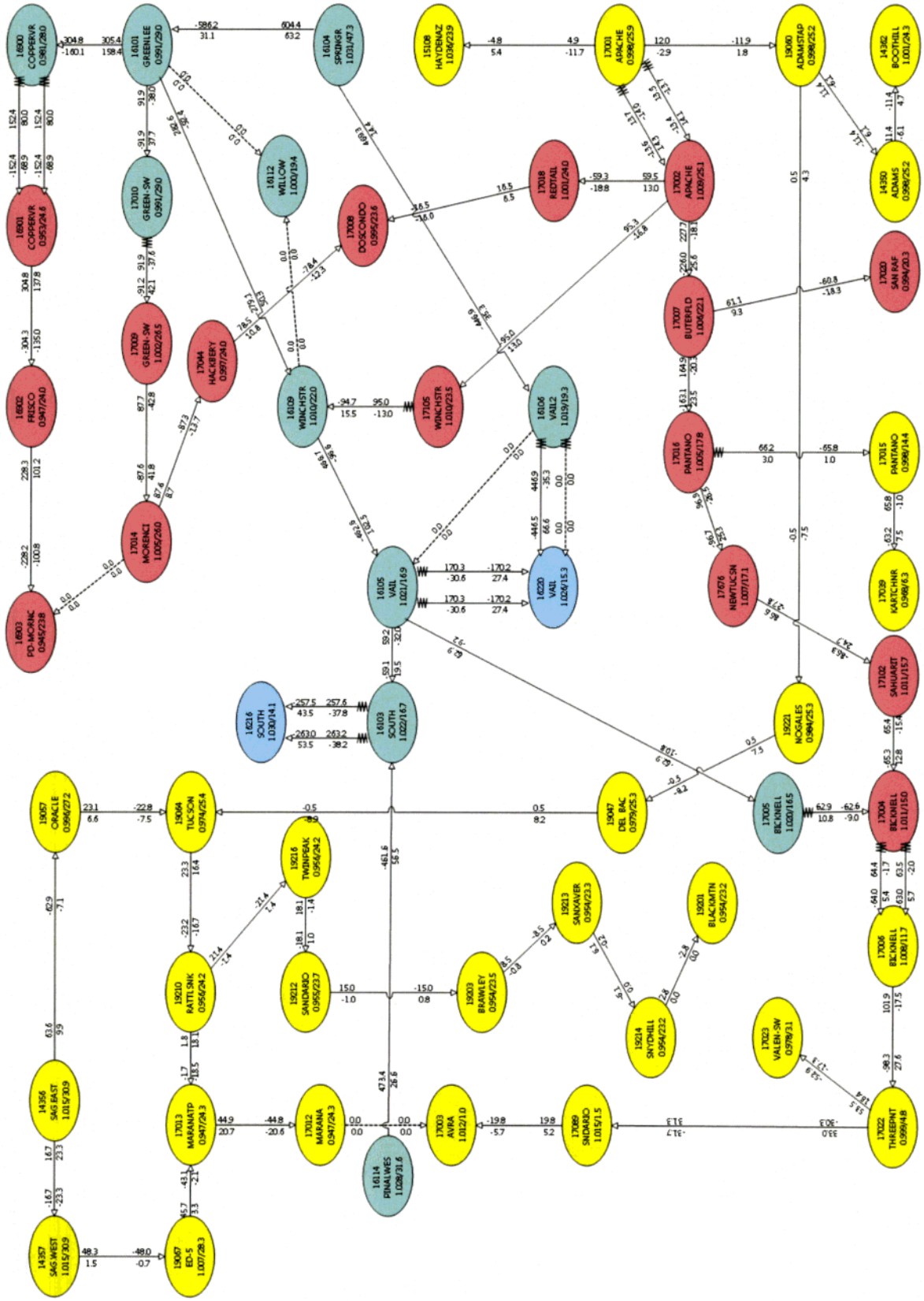
2026HS AEPCO System with ED-5 to Marana Tap 115 kV Line out of service



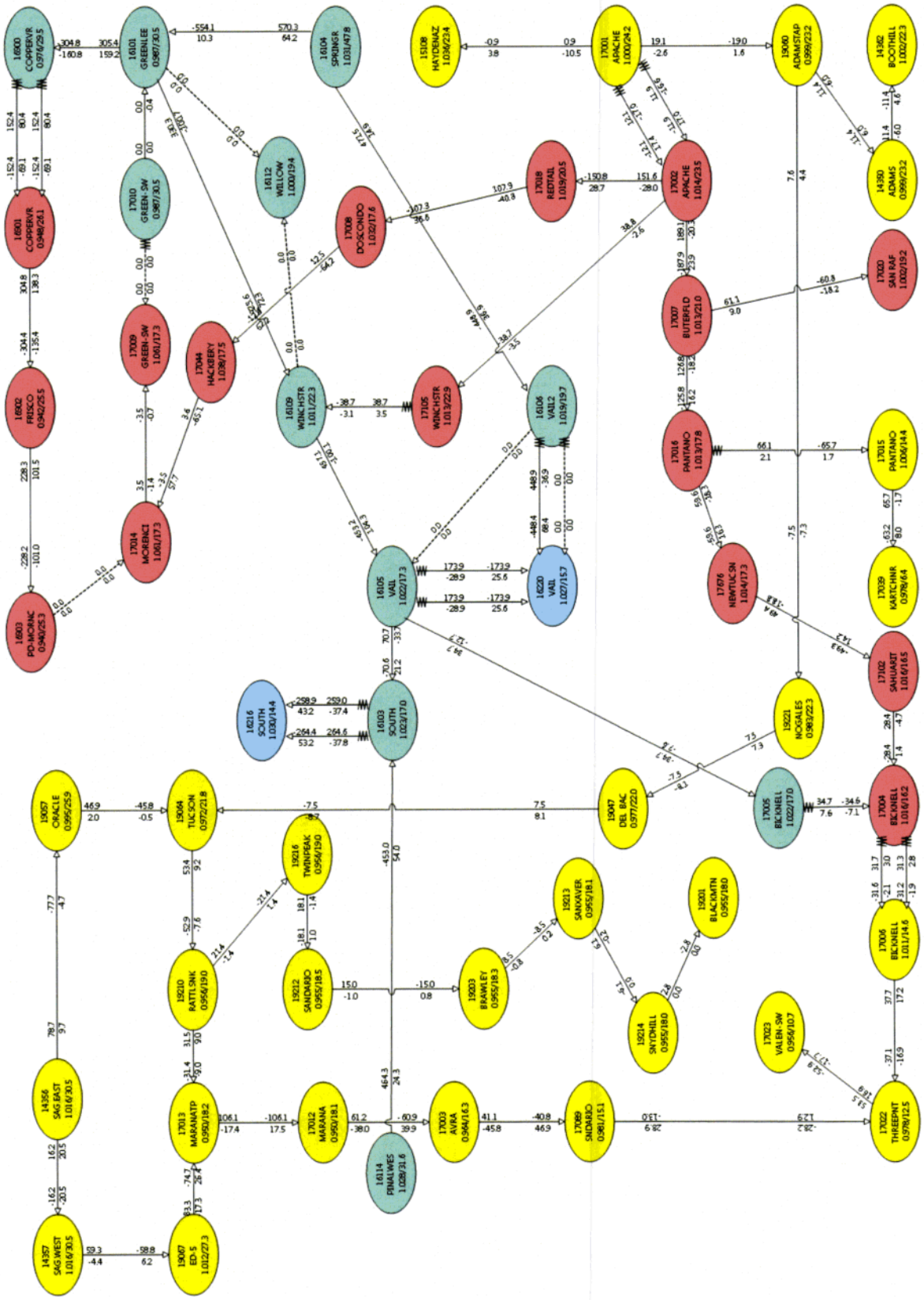
2026HS AEPCO System with Apache to Hayden 115 kV Line out of service



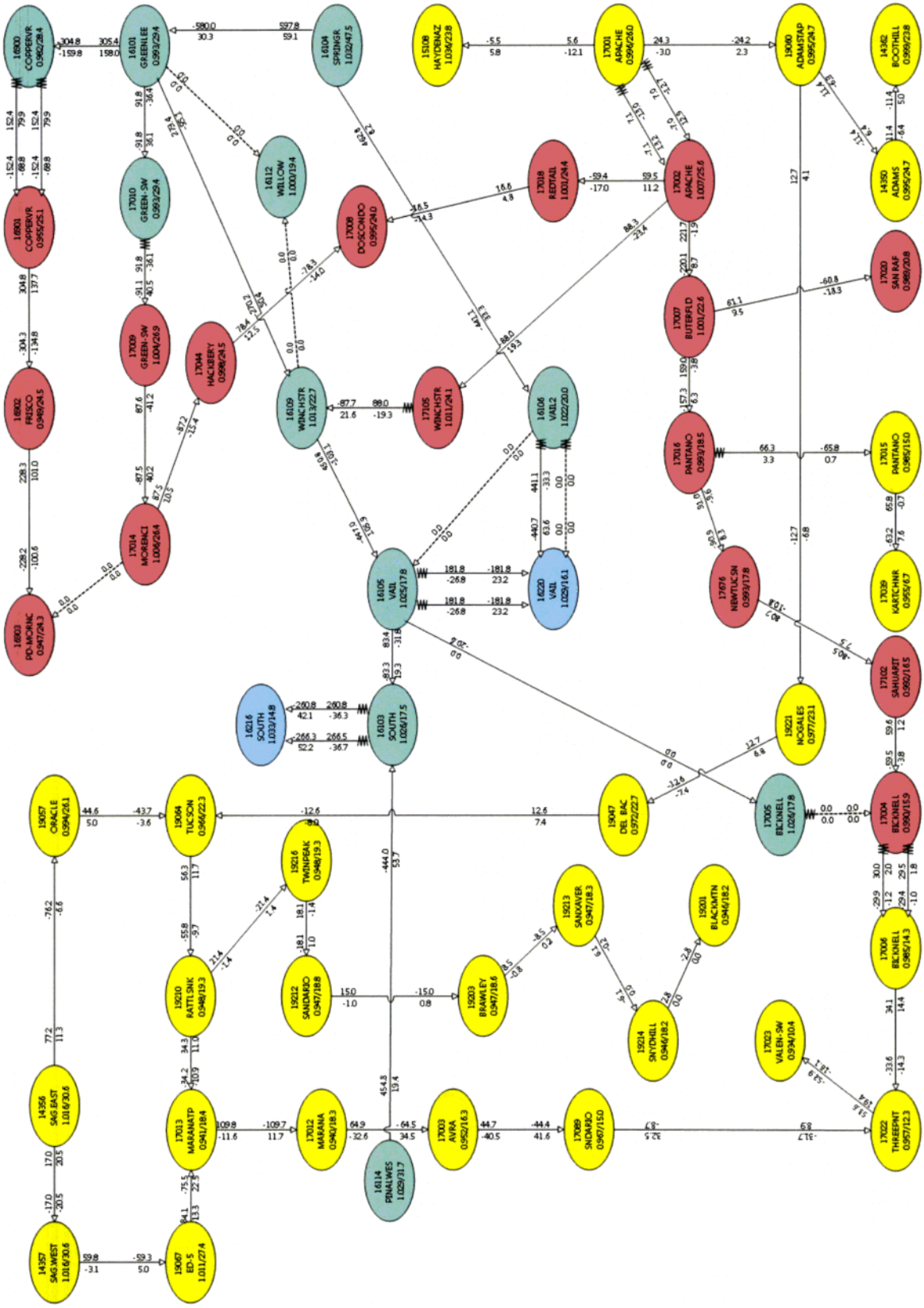
2026HS AEPCO System with Marana to Avra 115 kV Line out of service



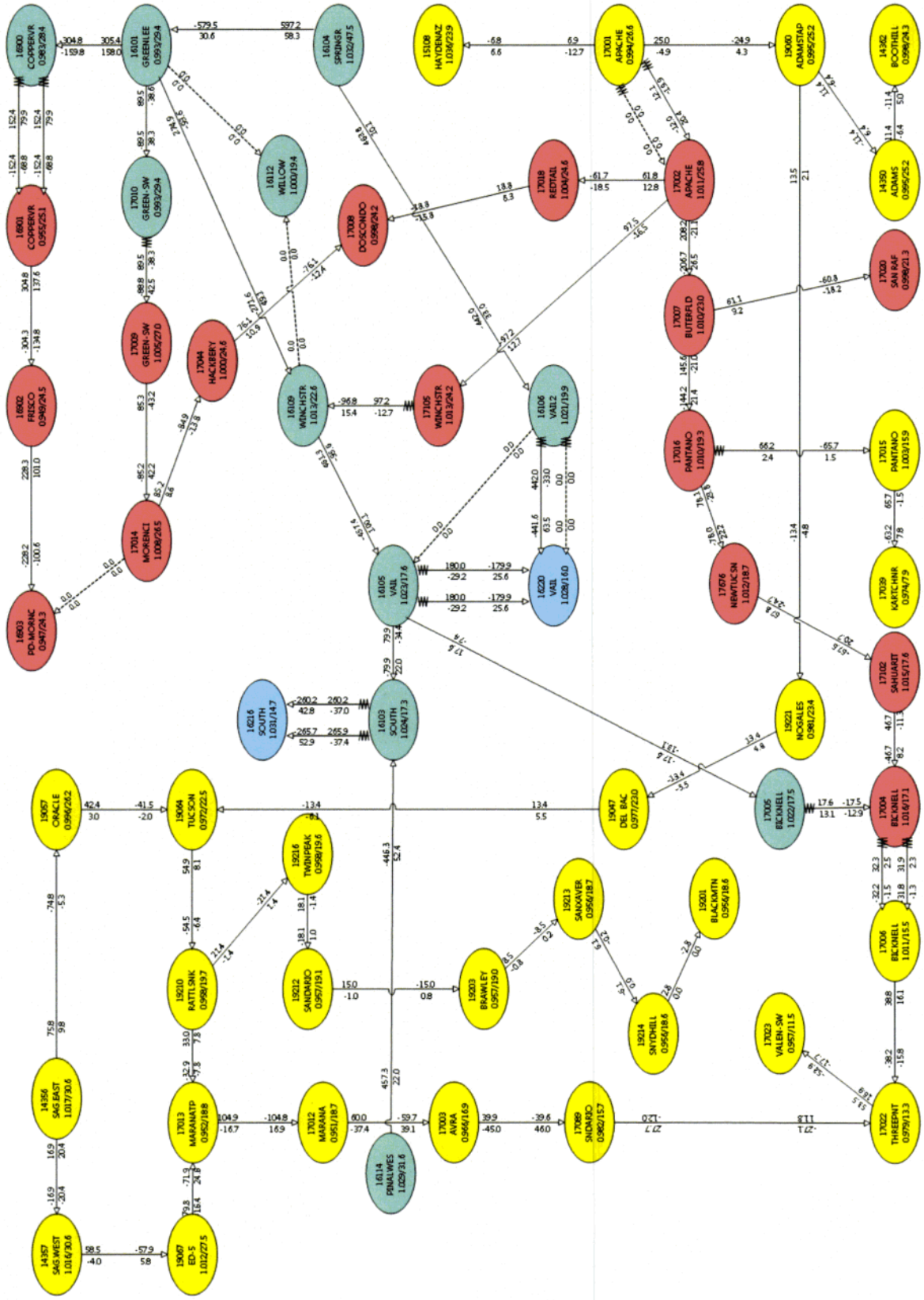
2026HS AEPCO System with Green-SW 345/230 kV Transformer out of service



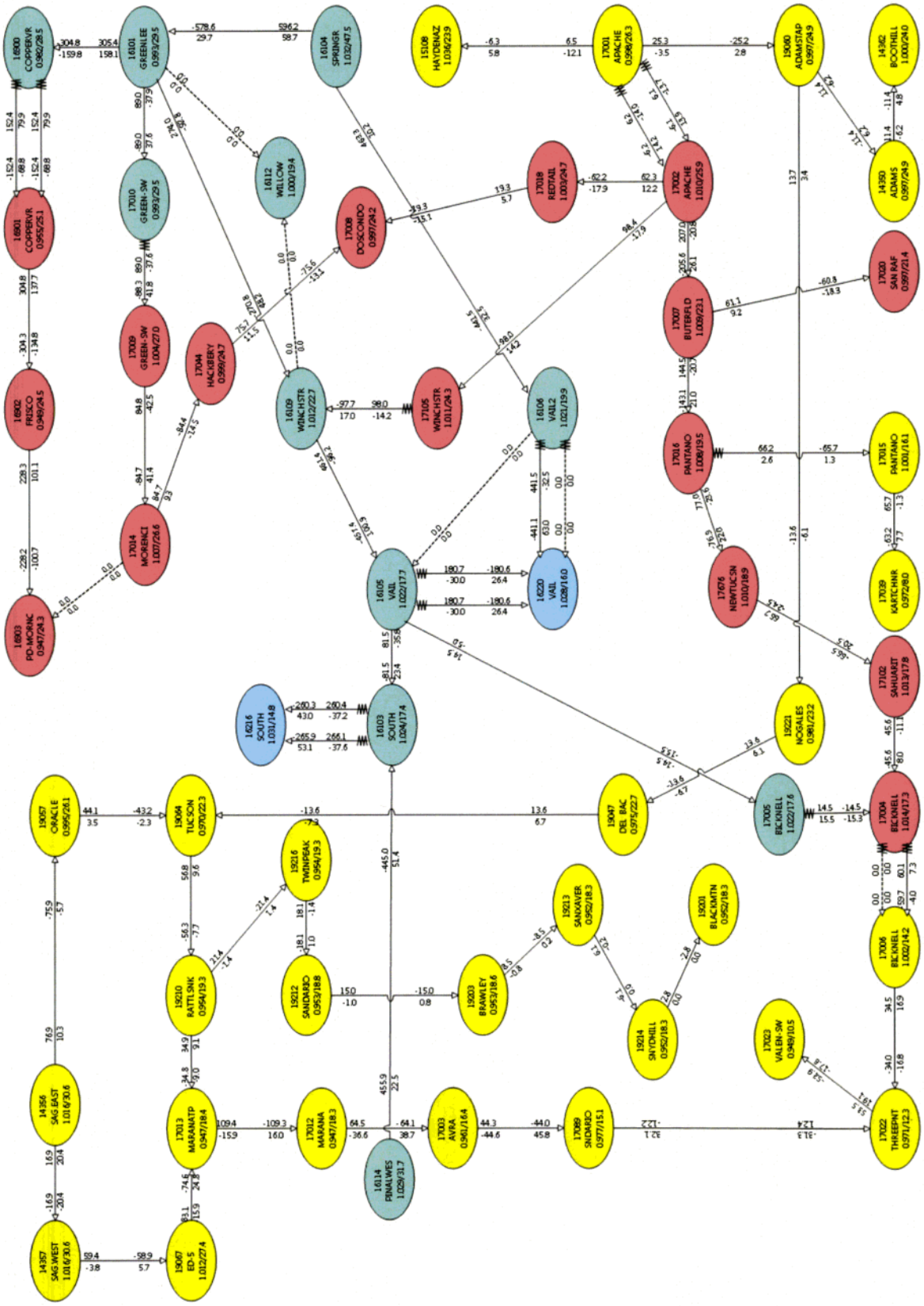
2026HS AEPCO System with Bicknell 345/230 kV Transformer out of service



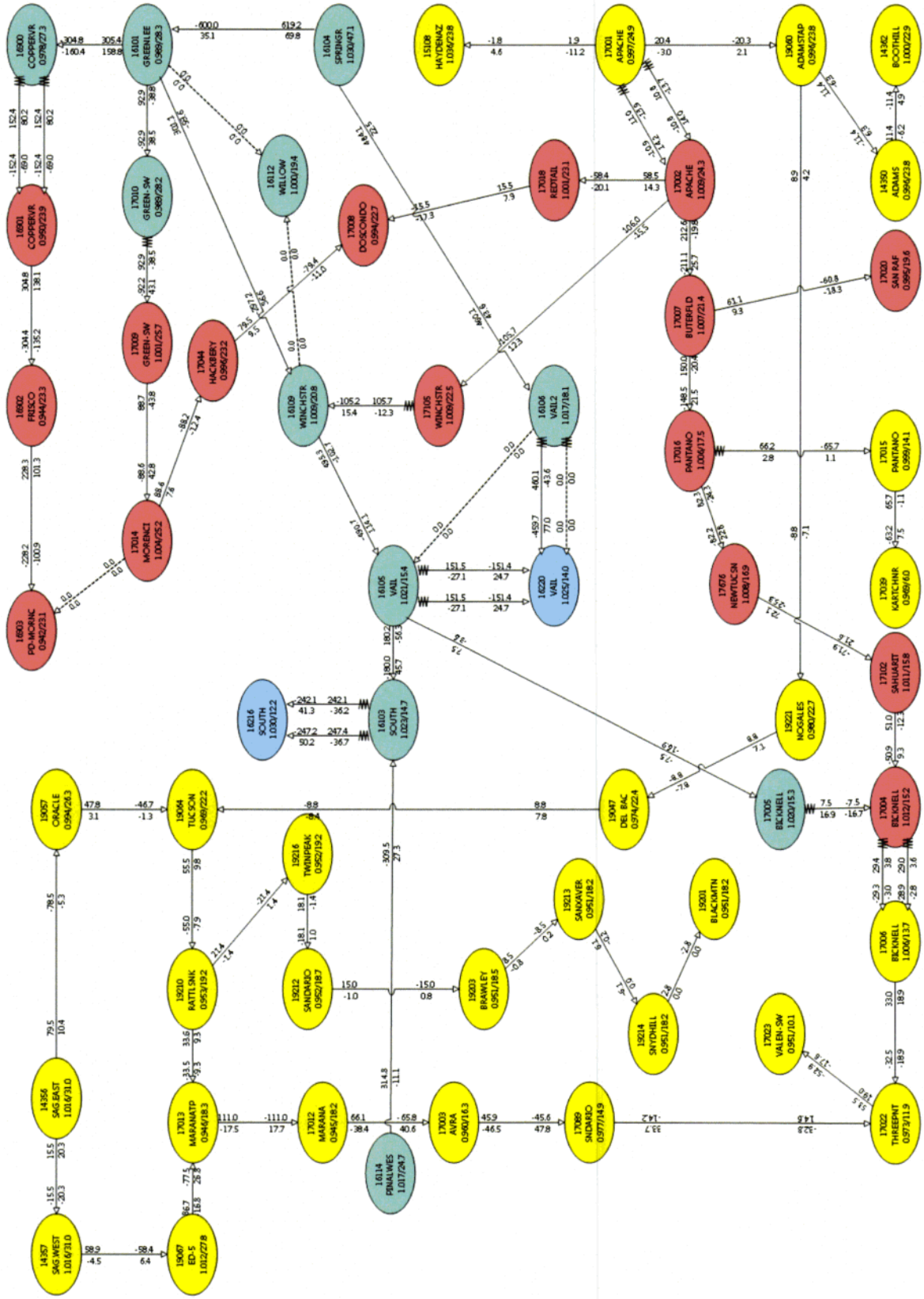
2026HS AEPCO System with one Apache 230/115 kV Transformer out of service



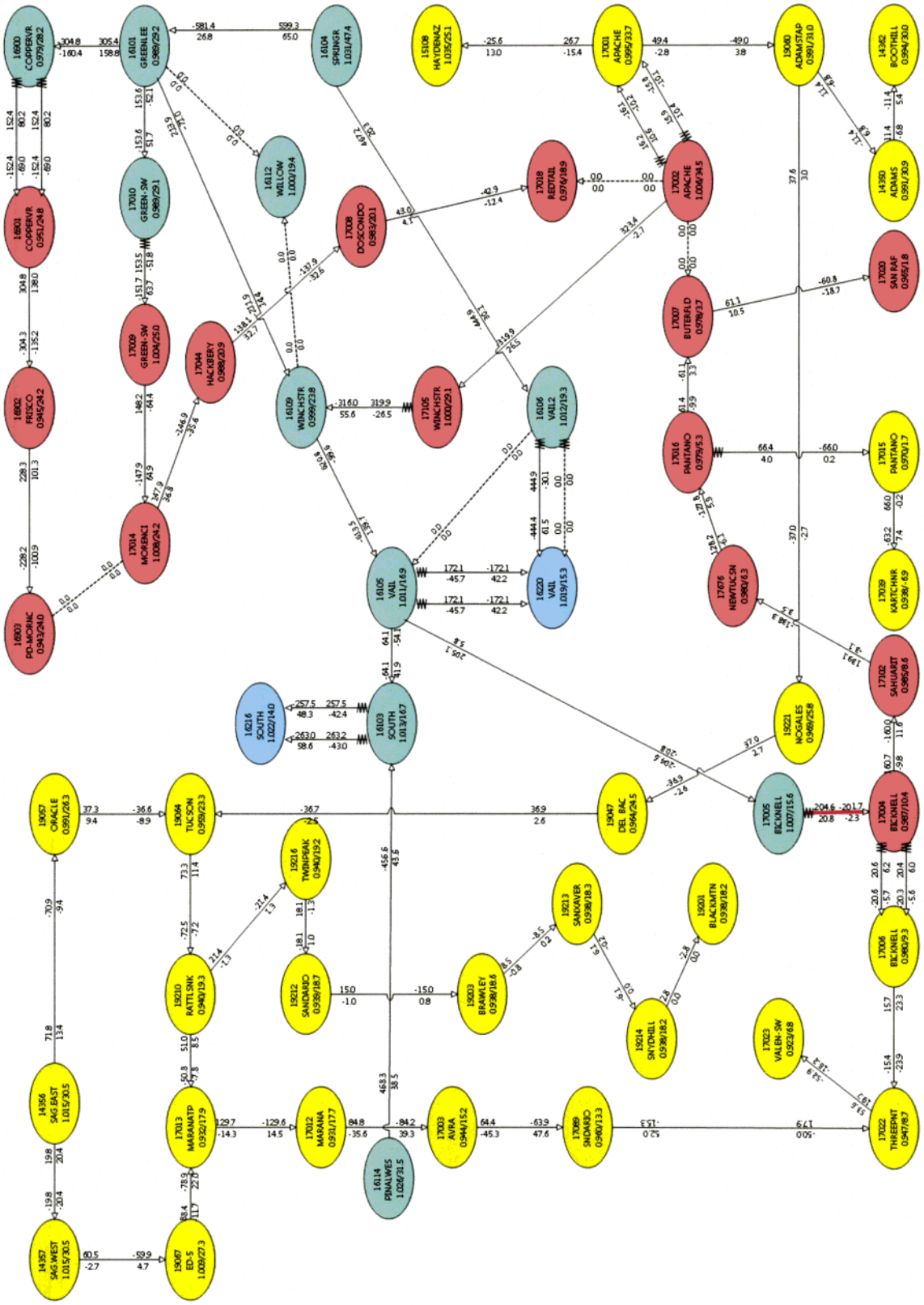
2026HS AEPCO System with one Bicknell 230/115 kV Transformer out of service



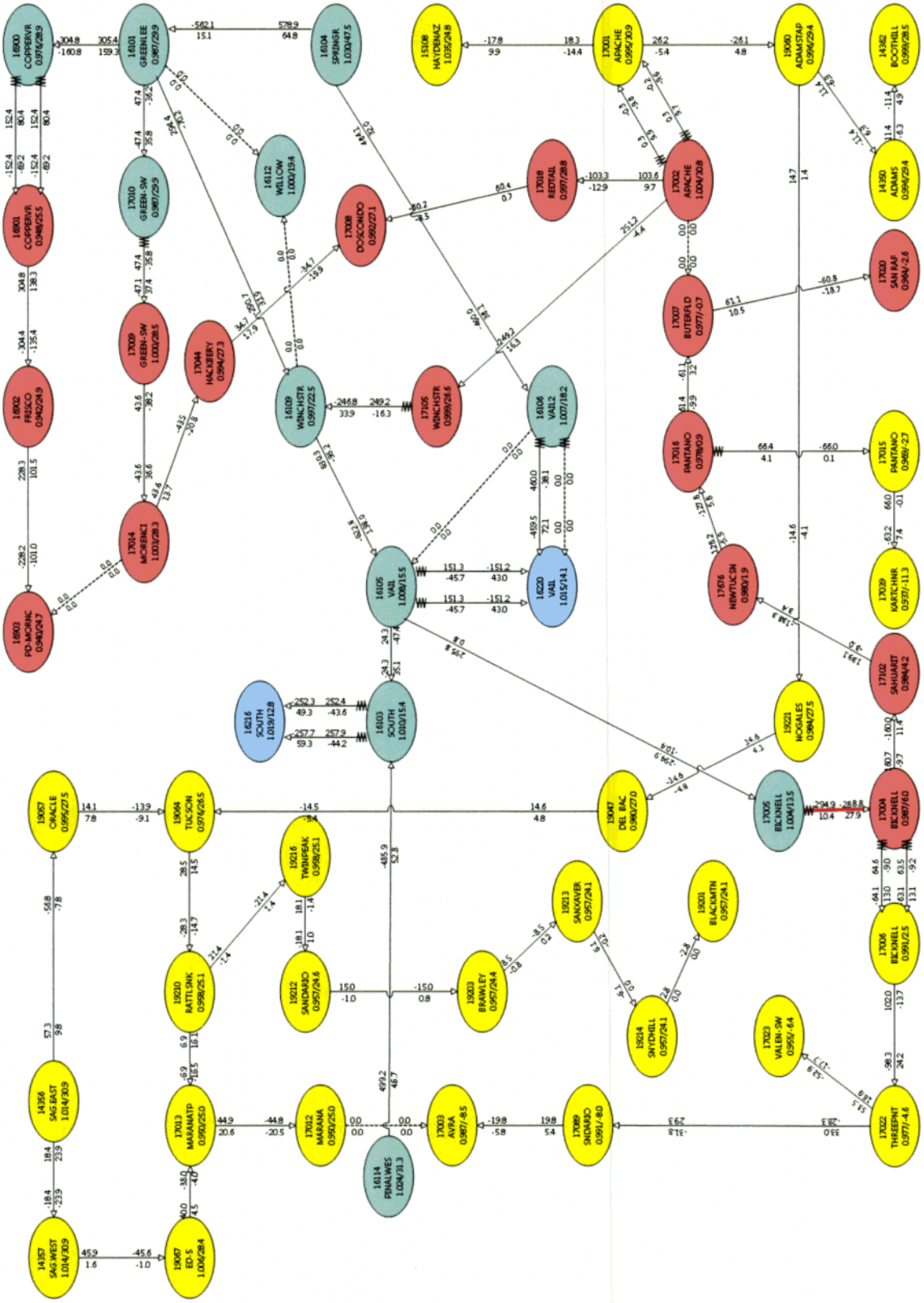
2026HS AEPCO System with Pinal West 500/345 kV Transformer out of service



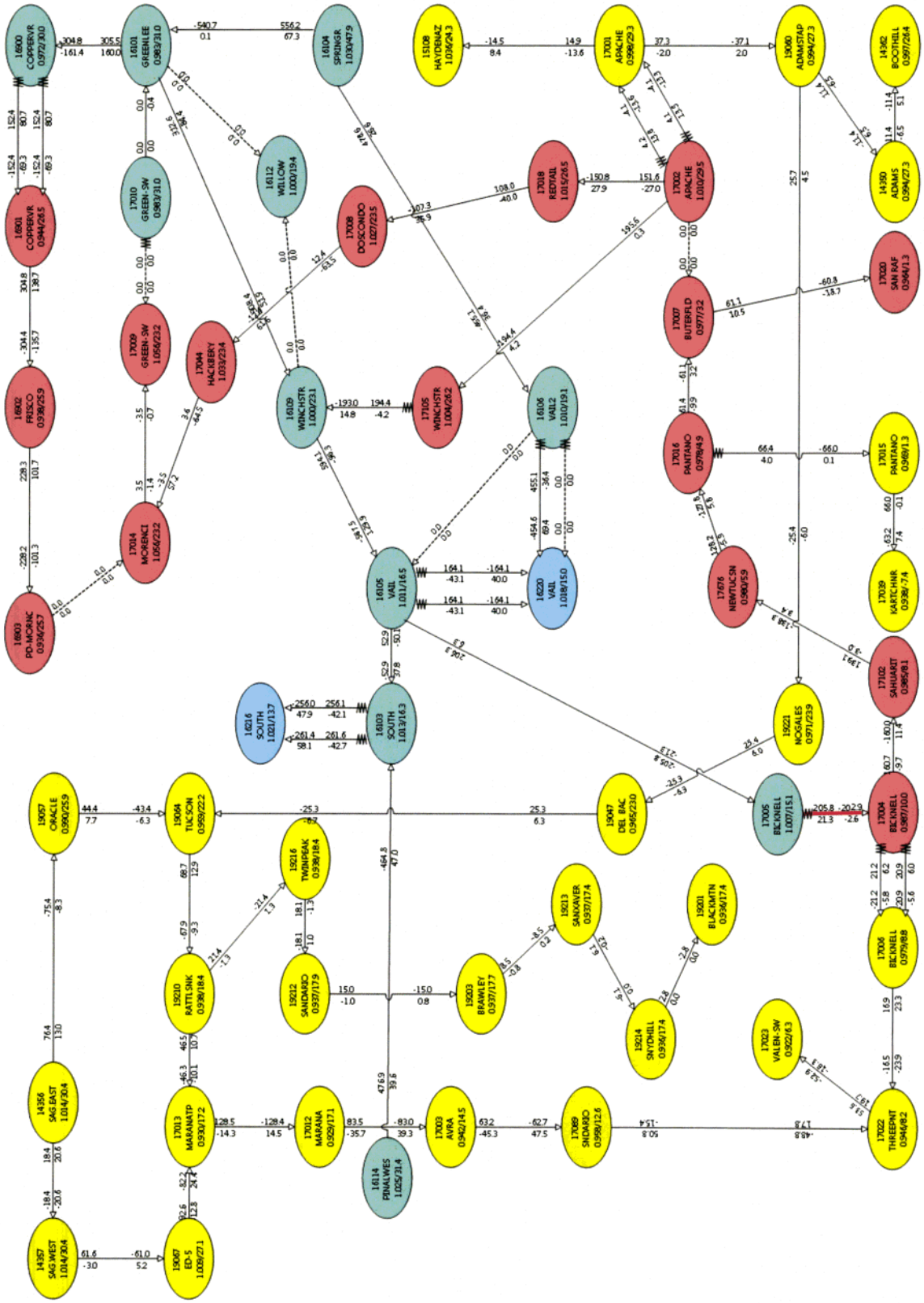
2026HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Apache to Red Tail 230 kV Line out of service



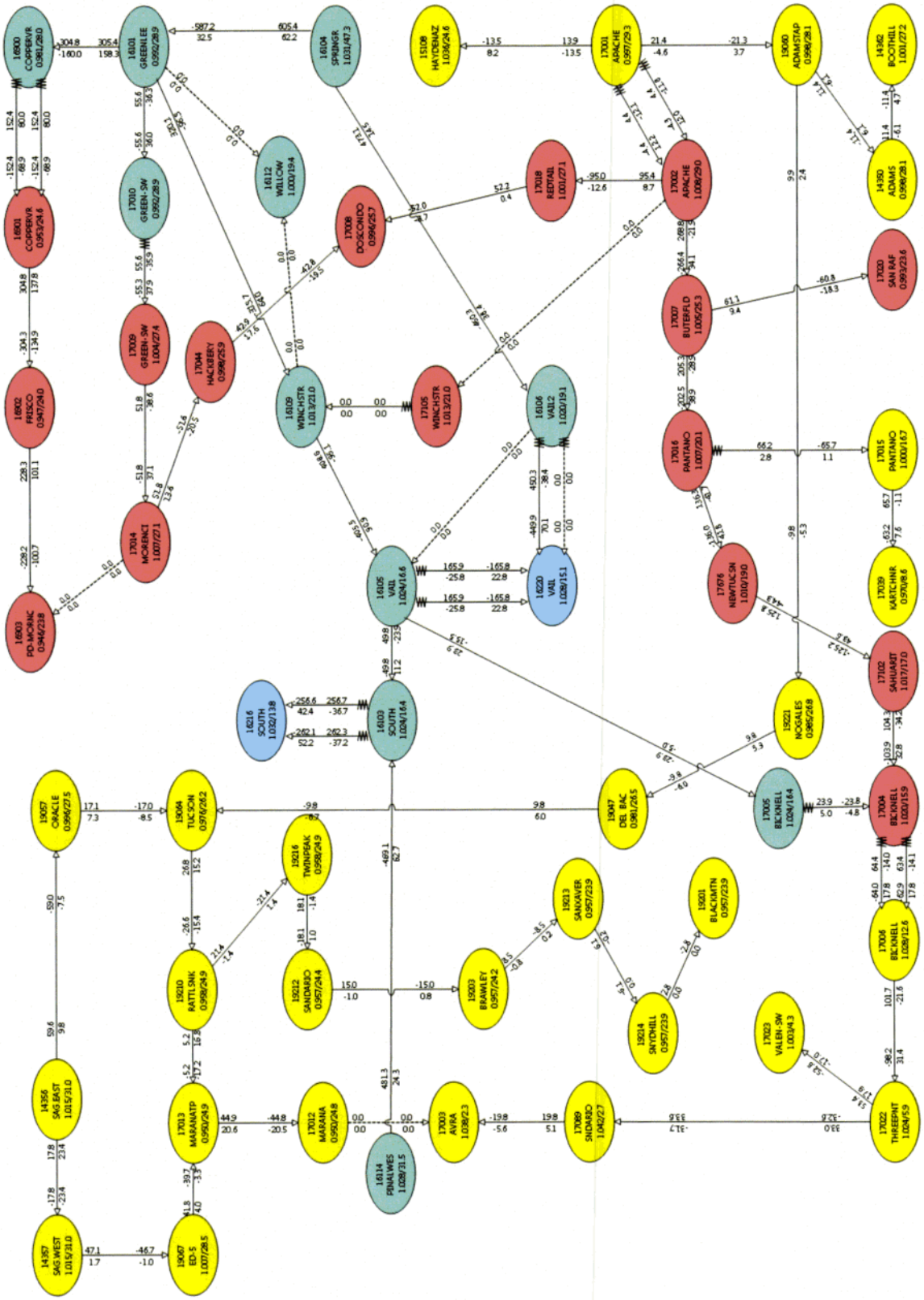
2026HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Marana to Avra 115 kV Line out of service



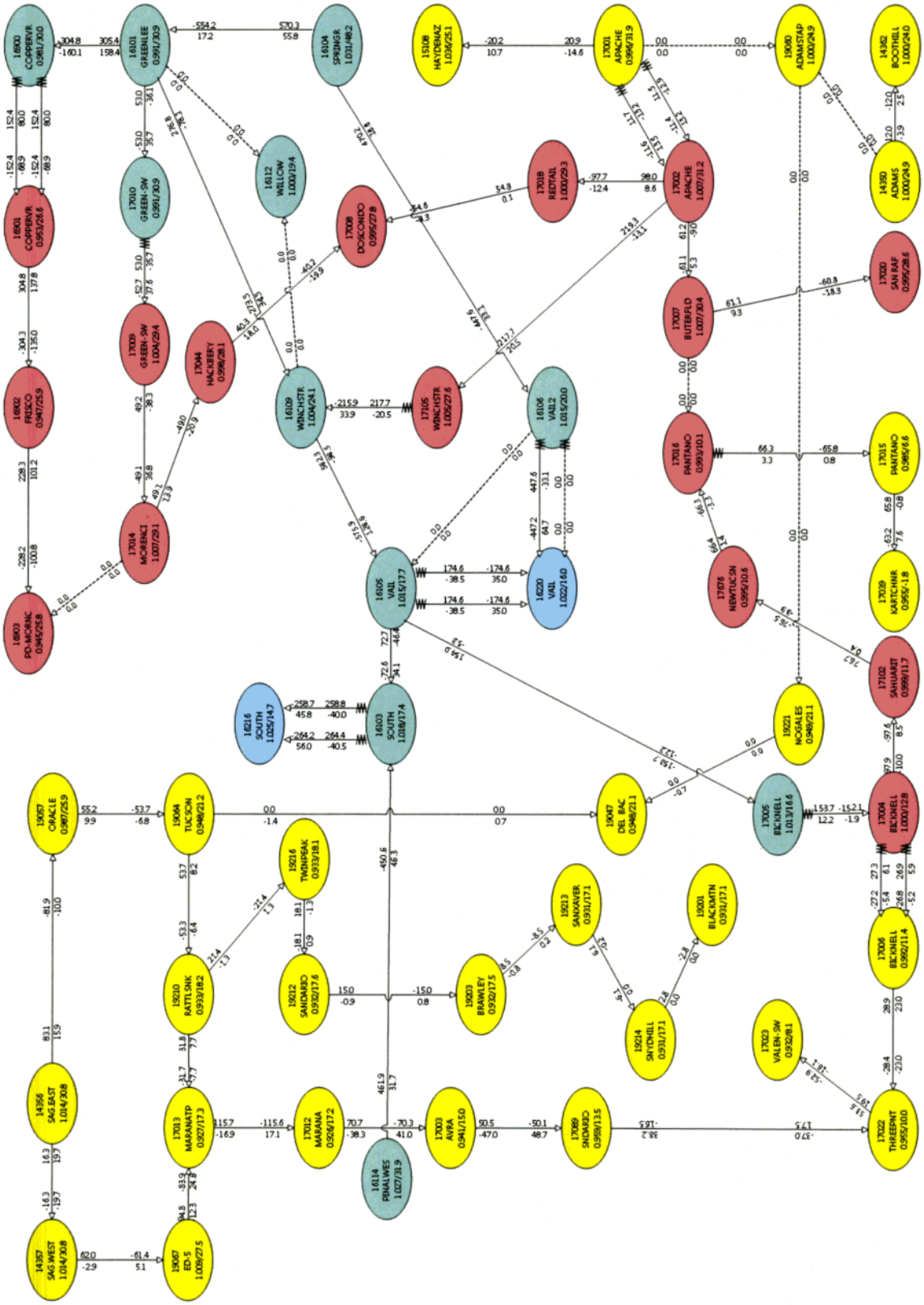
2026HS AEPCO System with Apache to Butterfield 230 kV Line out followed by the Green-SW 345/230 kV Transformer out of service



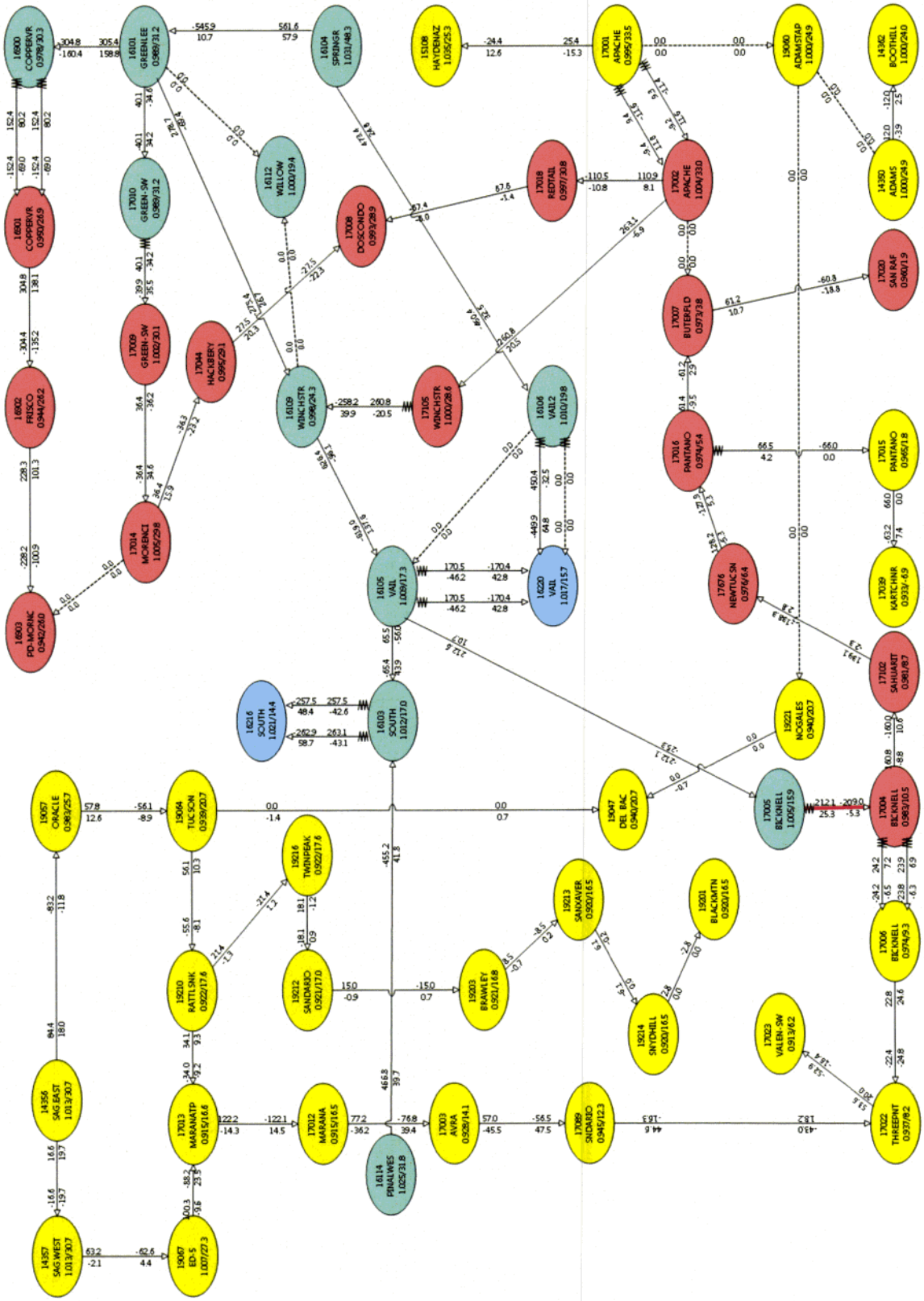
2026HS AEPCO System with Apache to Winchester 230 kV Line out followed by the Marana to Avra 115 kV Line out of service



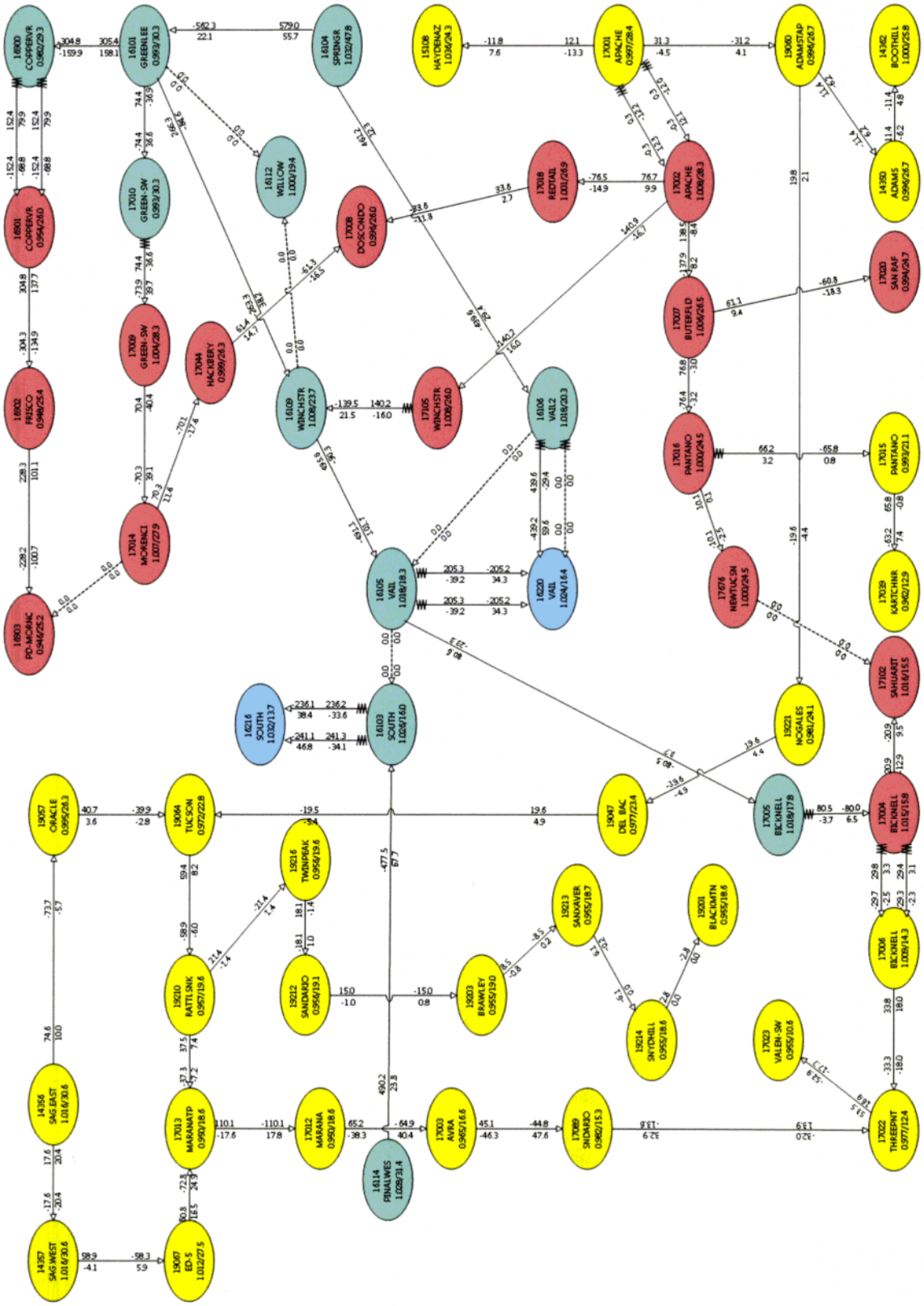
2026HS AEPCO System with Common Corridor outage of the Butterfield to Pantano 230 kV & Adams Tap to Apache 115 kV Lines



2021HS AEPCO System with Common Corridor outage of Apache to Butterfield 230 kV & Adams Tap to Apache 115 kV Lines



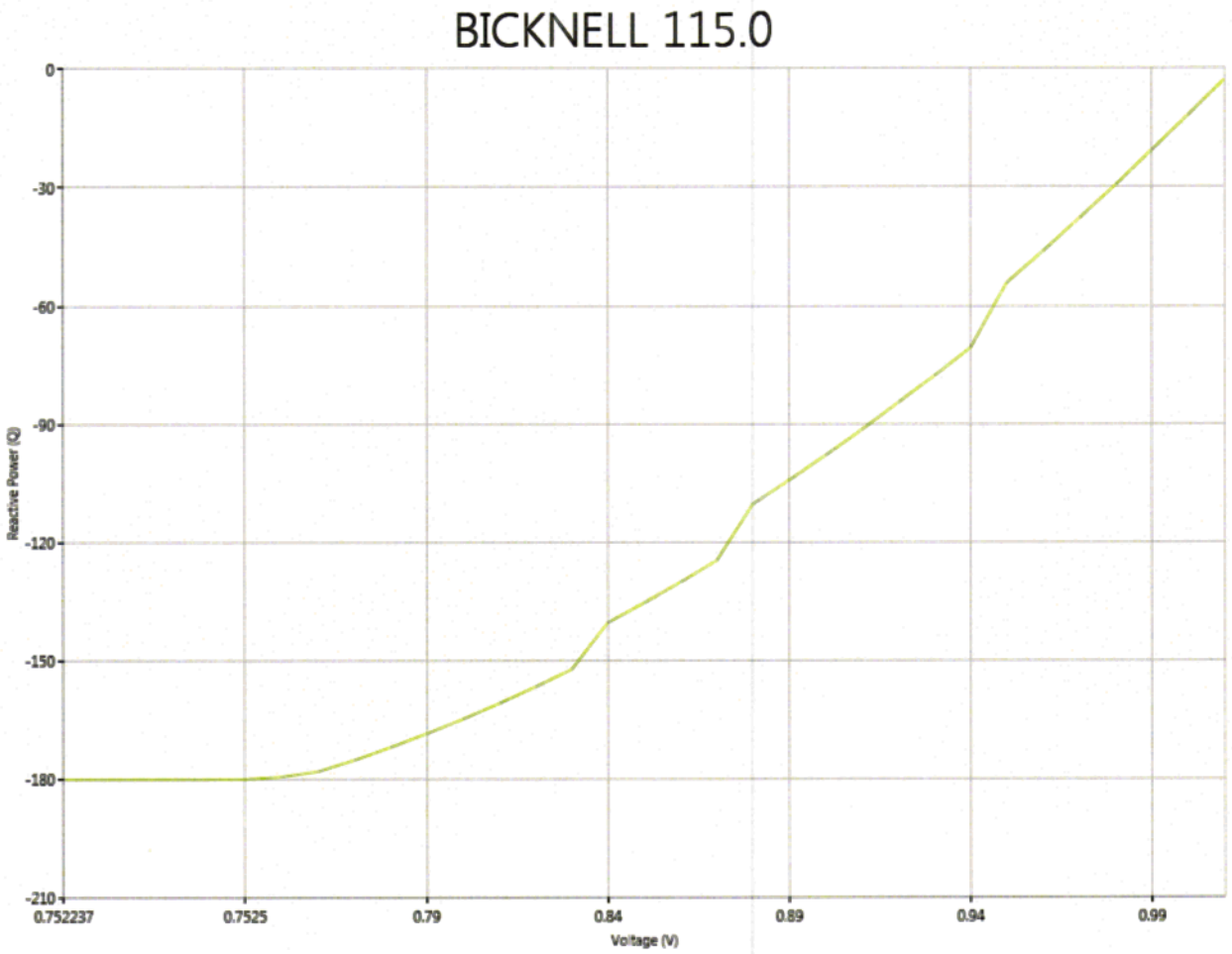
2026HS AEPCO System with Common Corridor outage of the Vail to South 345 kV & New Tucson to Sahuarita 230 kV Lines

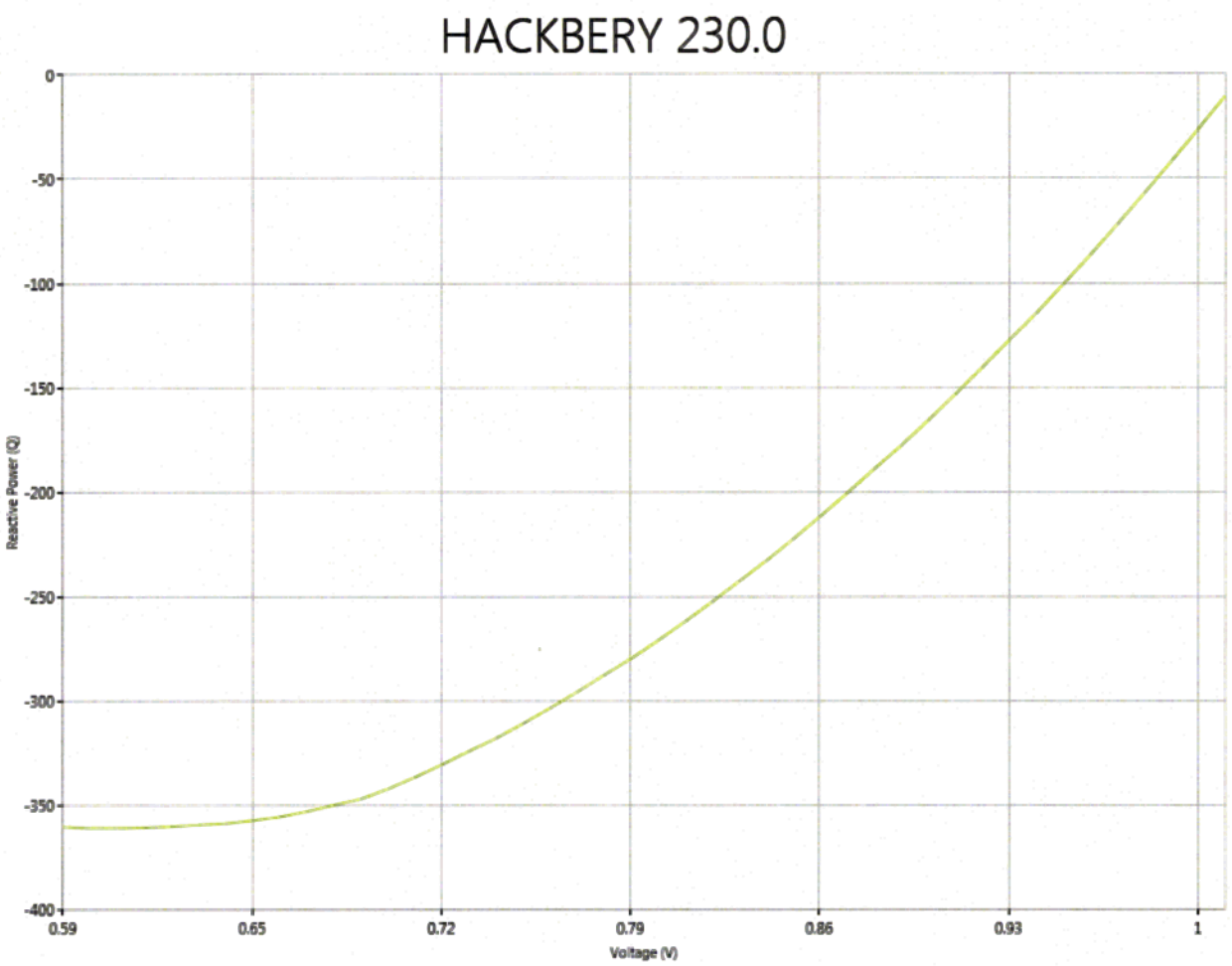


APPENDIX D: Reactive Margin Q-V Plots

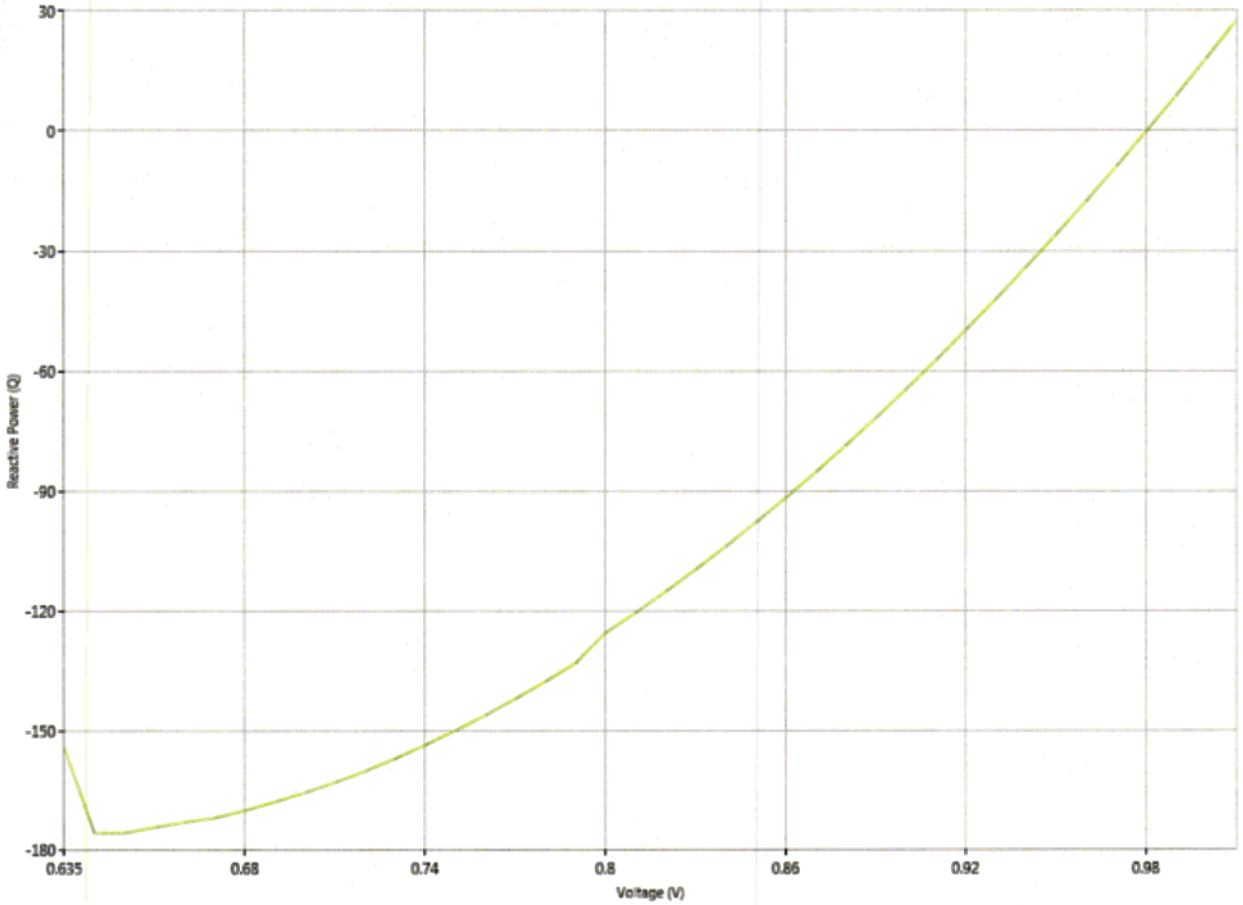
2018 HEAVY SUMMER

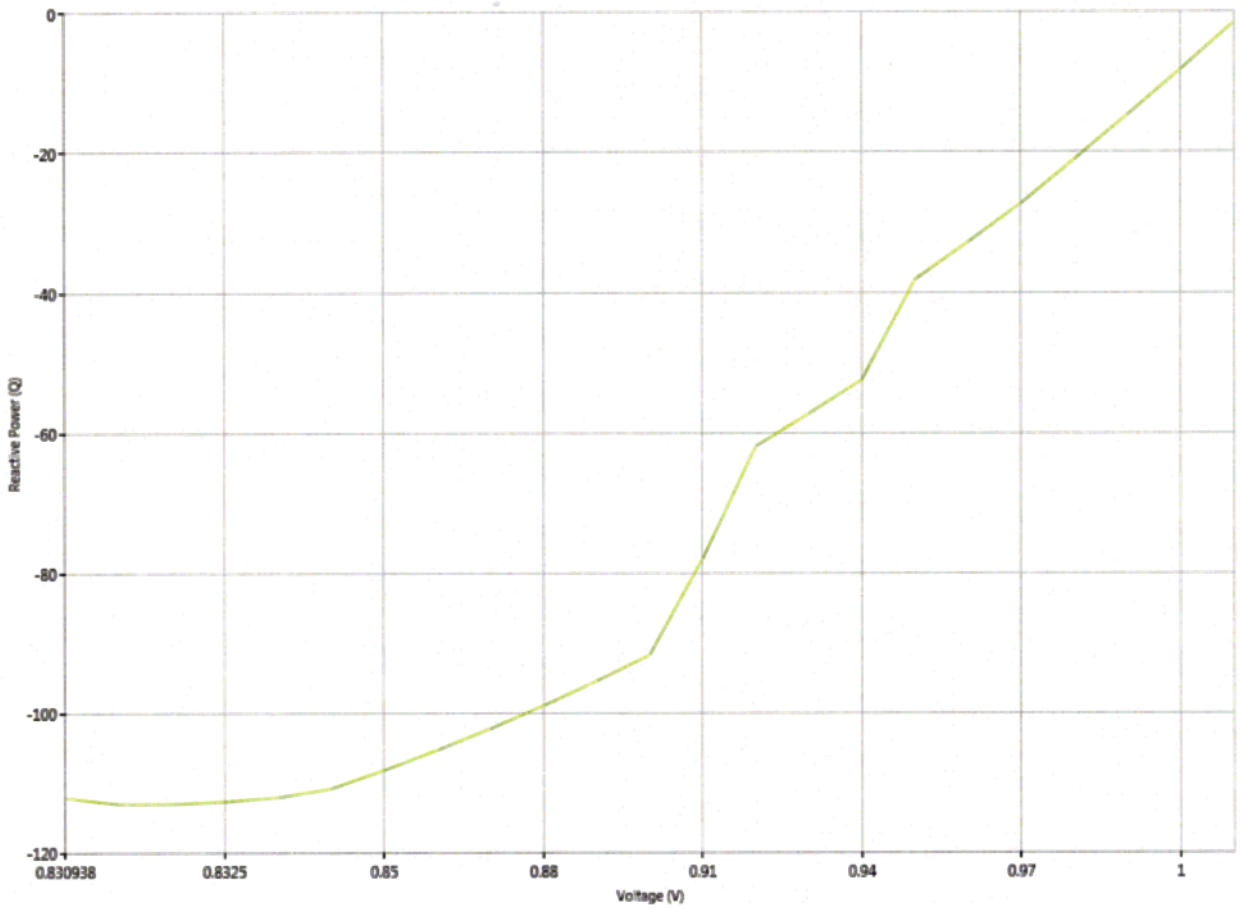
Apache to Butterfield 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

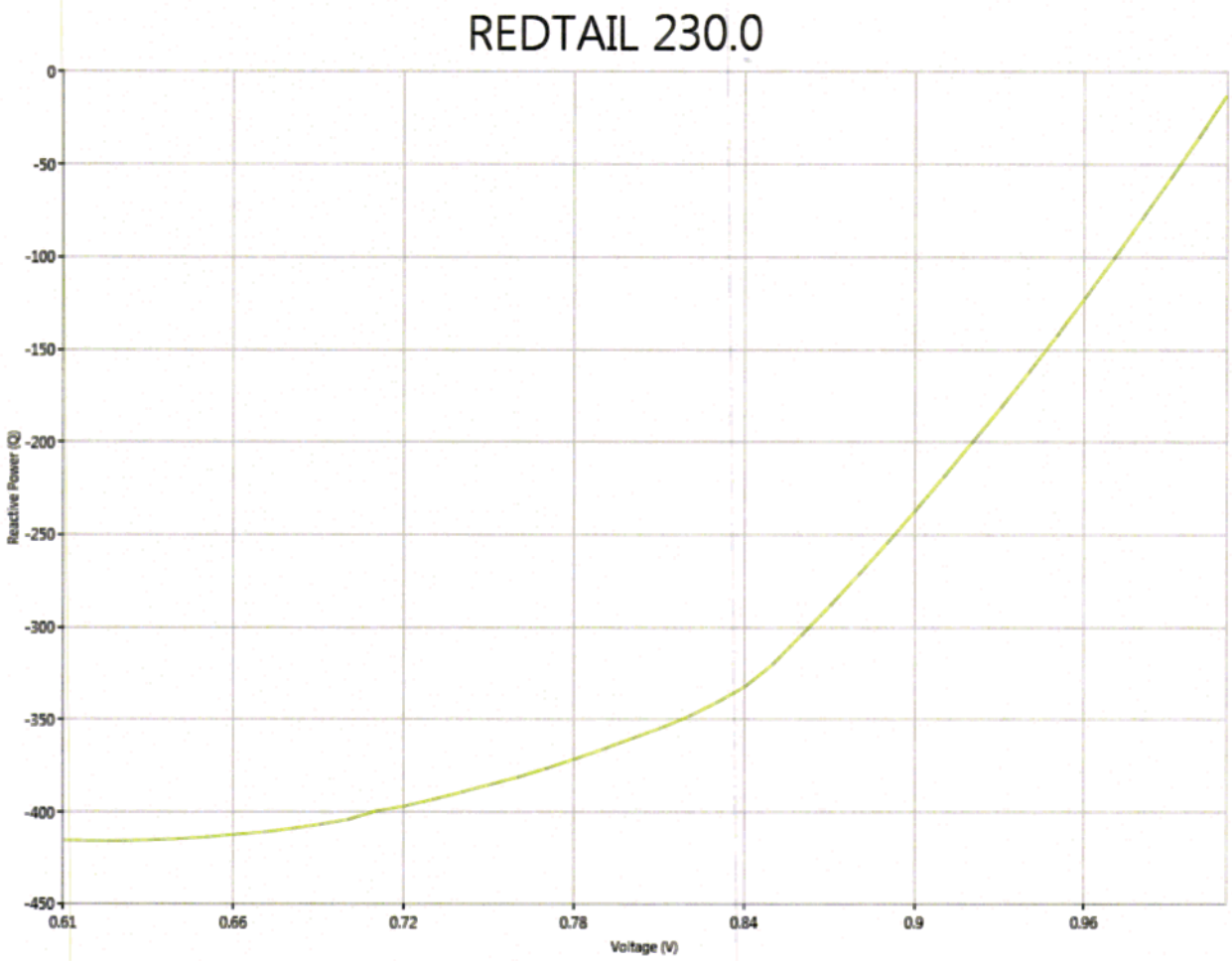



HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
Reactive Power (Q)
0.59
0.65
0.72
0.79
0.86
0.93
1
Voltage (V)

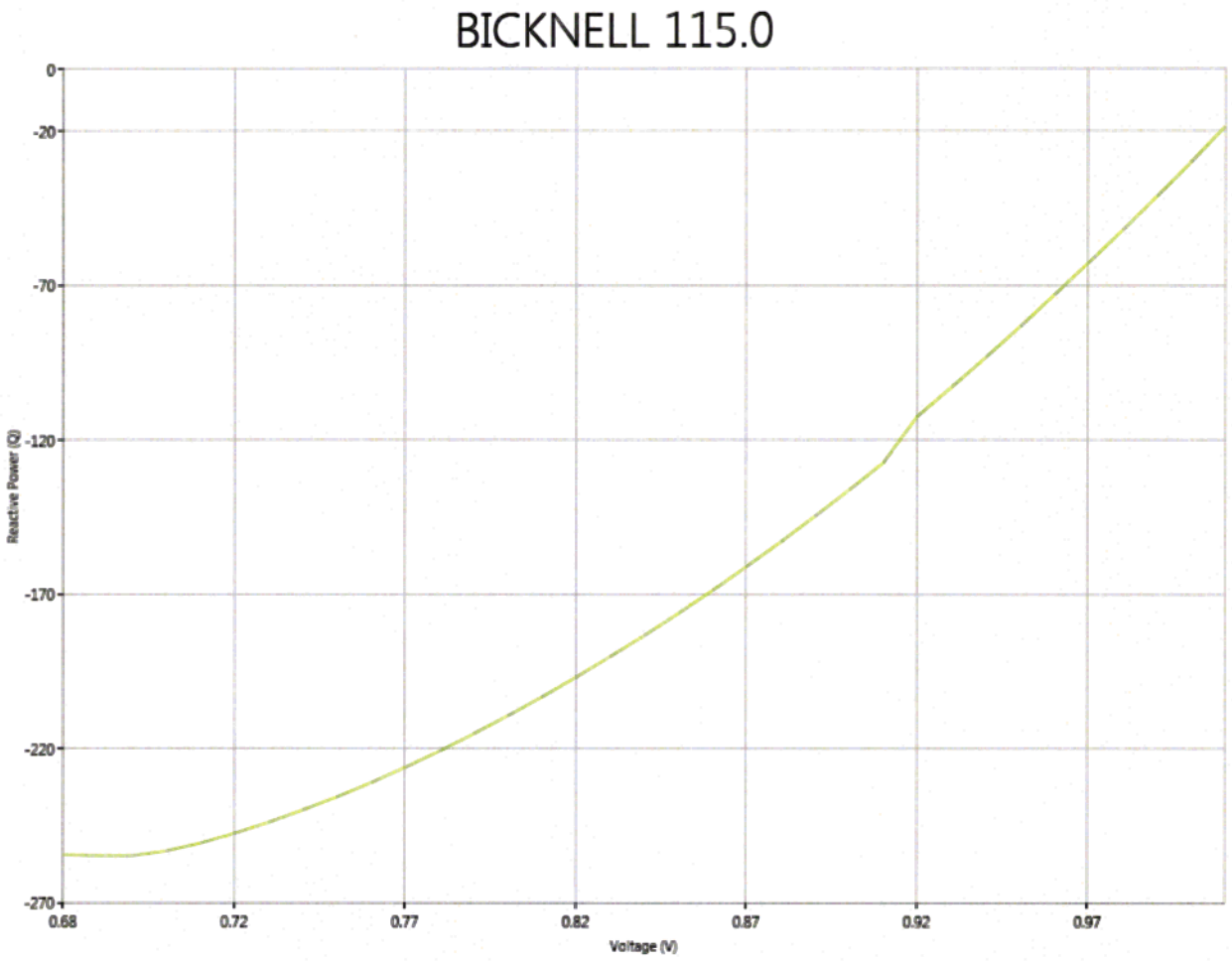
MARANA 115.0


30
0
-30
-60
-90
-120
-150
-180
Reactive Power (Q)
0.635
0.68
0.74
0.8
0.86
0.92
0.98
Voltage (V)

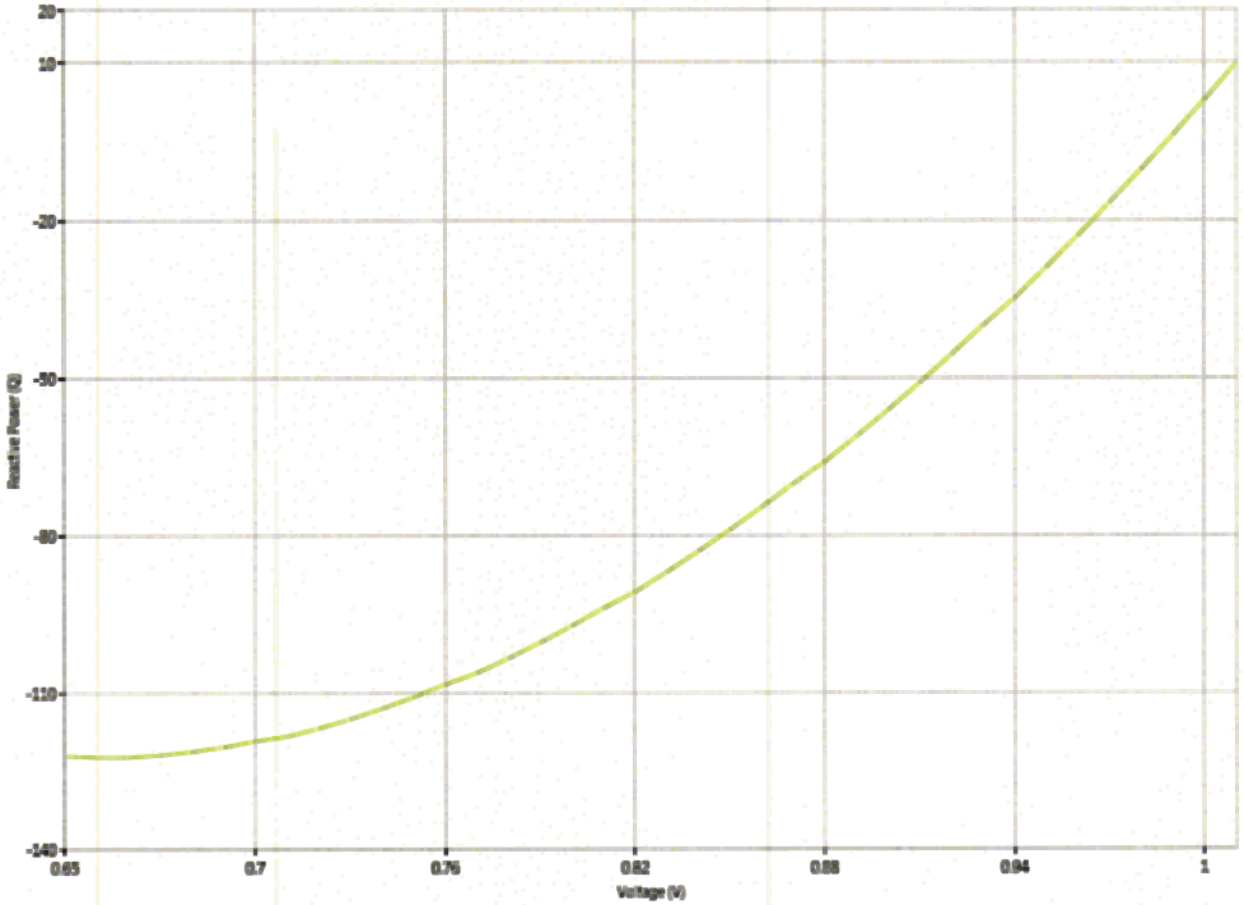

PANTANO 230.0
0
-20
-40
-60
-80
-100
-120
Reactive Power (Q)
0.830938
0.8325
0.85
0.88
0.91
0.94
0.97
1
Voltage (V)

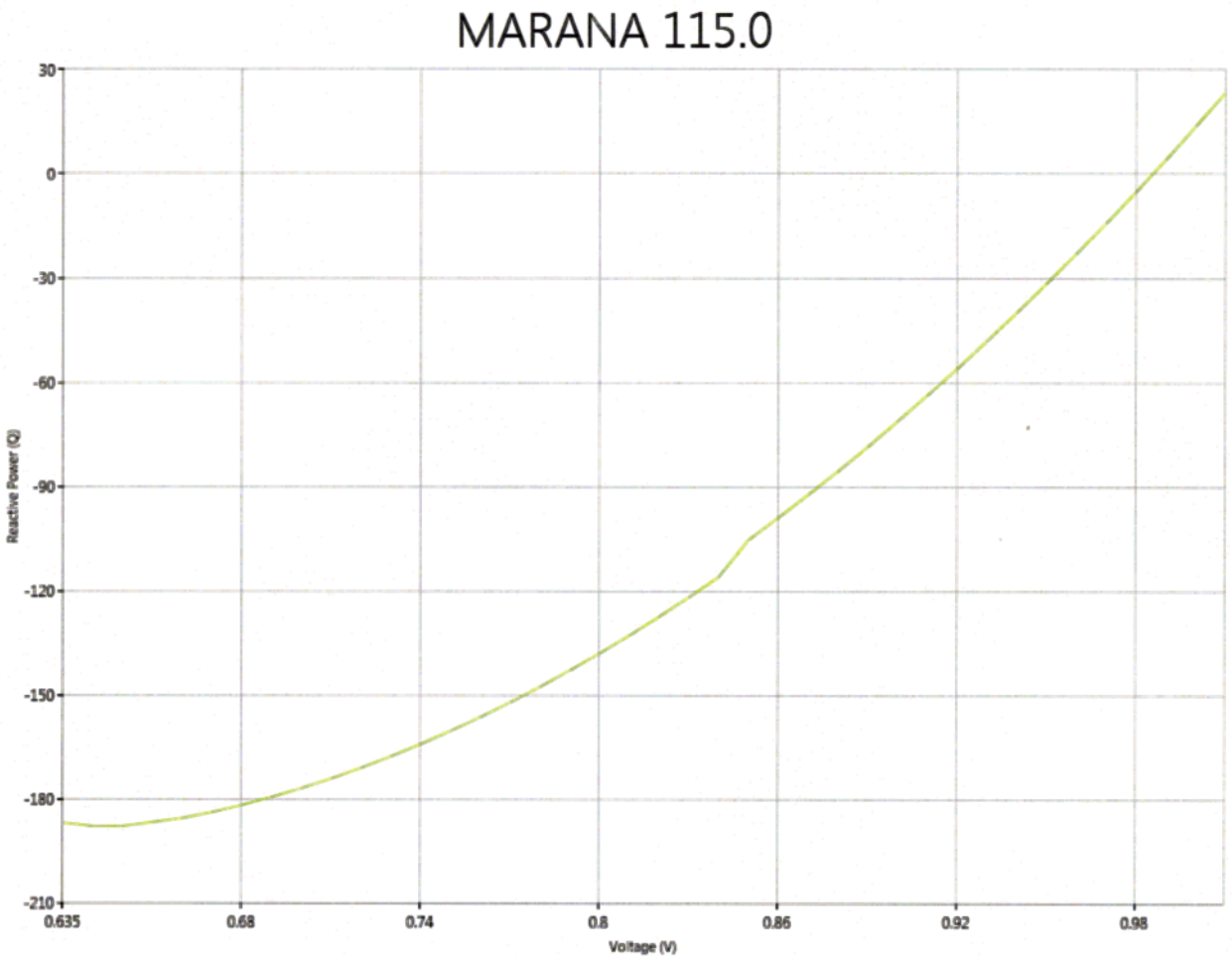

REDTAIL 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.61
0.66
0.72
0.78
0.84
0.9
0.96
Voltage (V)

Apache to Redtail 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

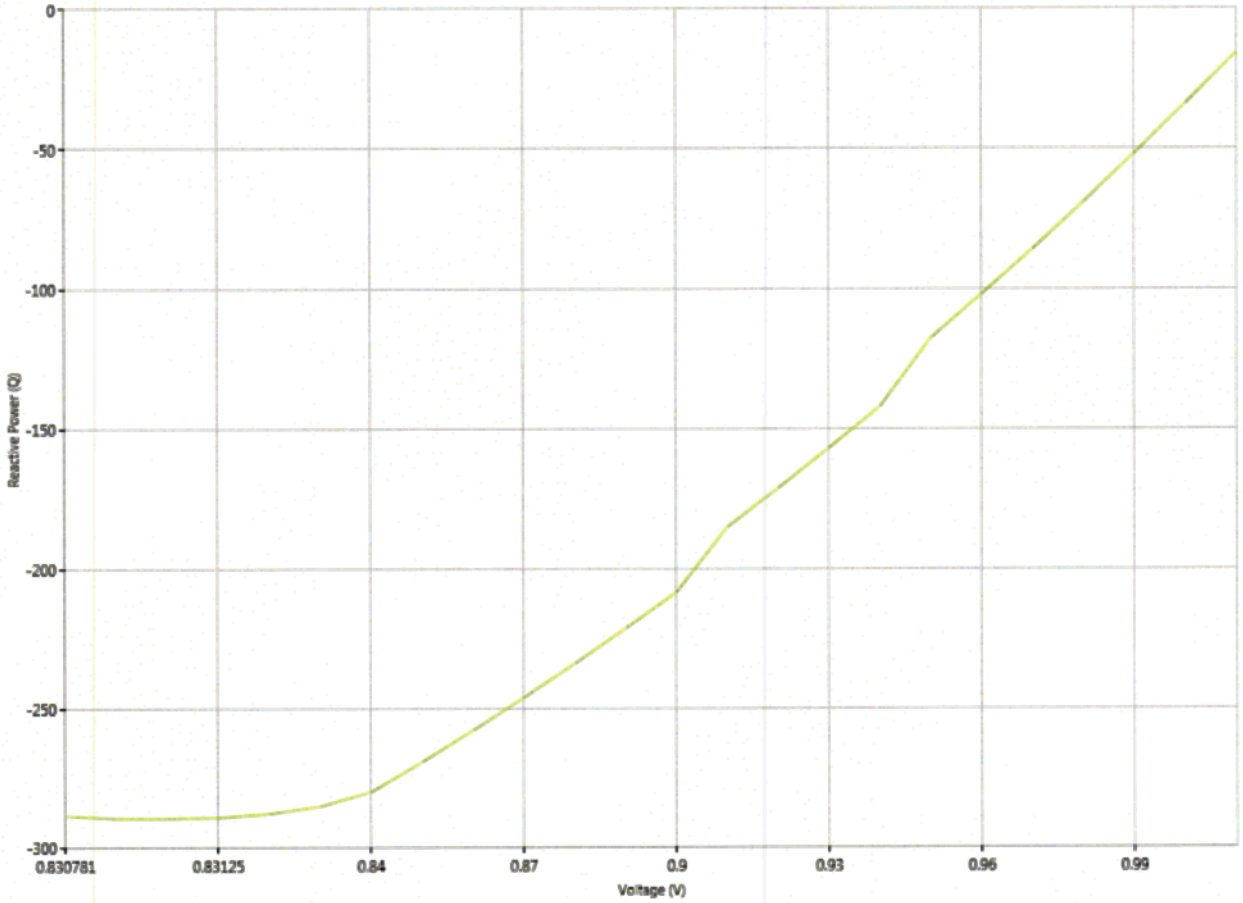


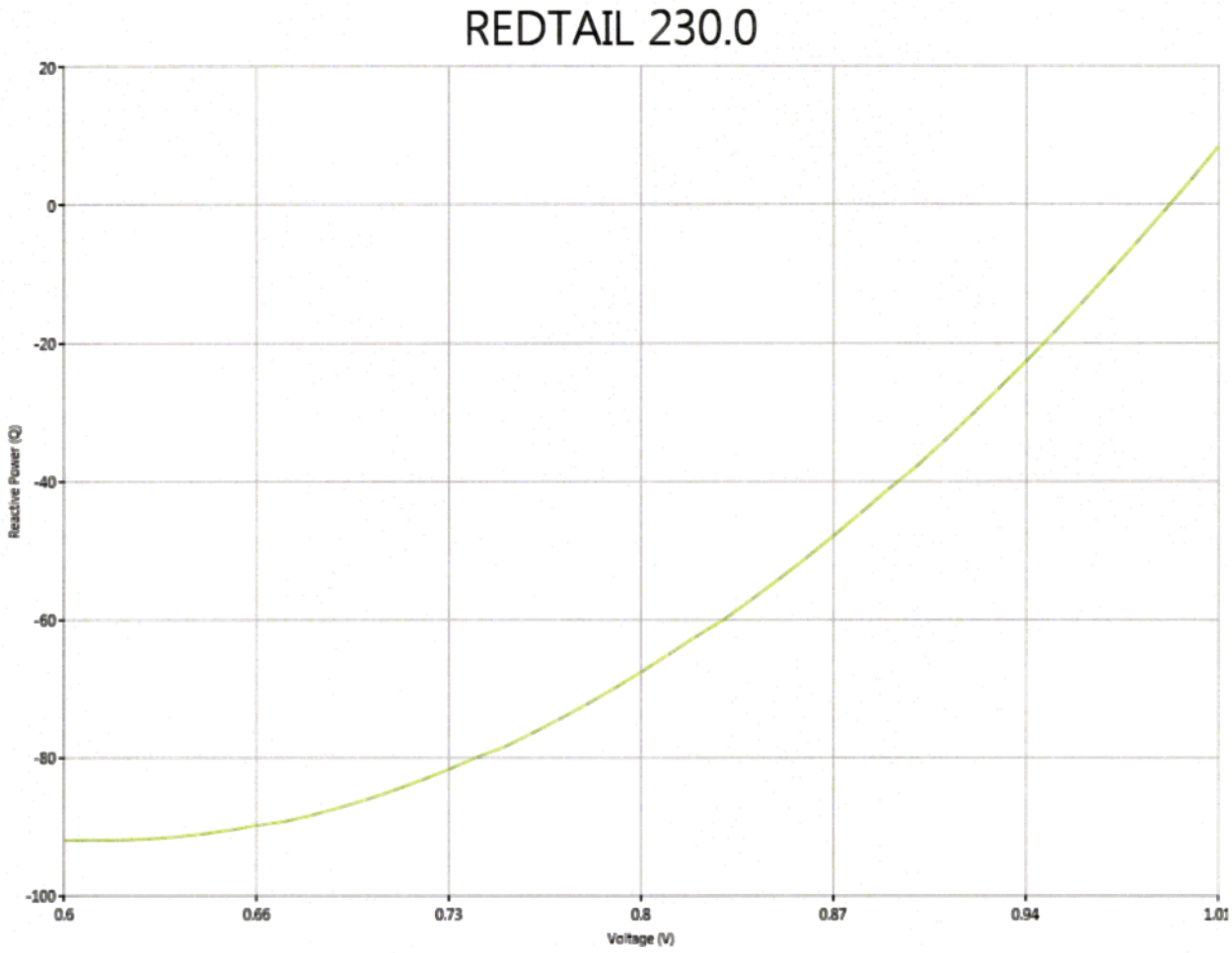
HACKBERY 230.0



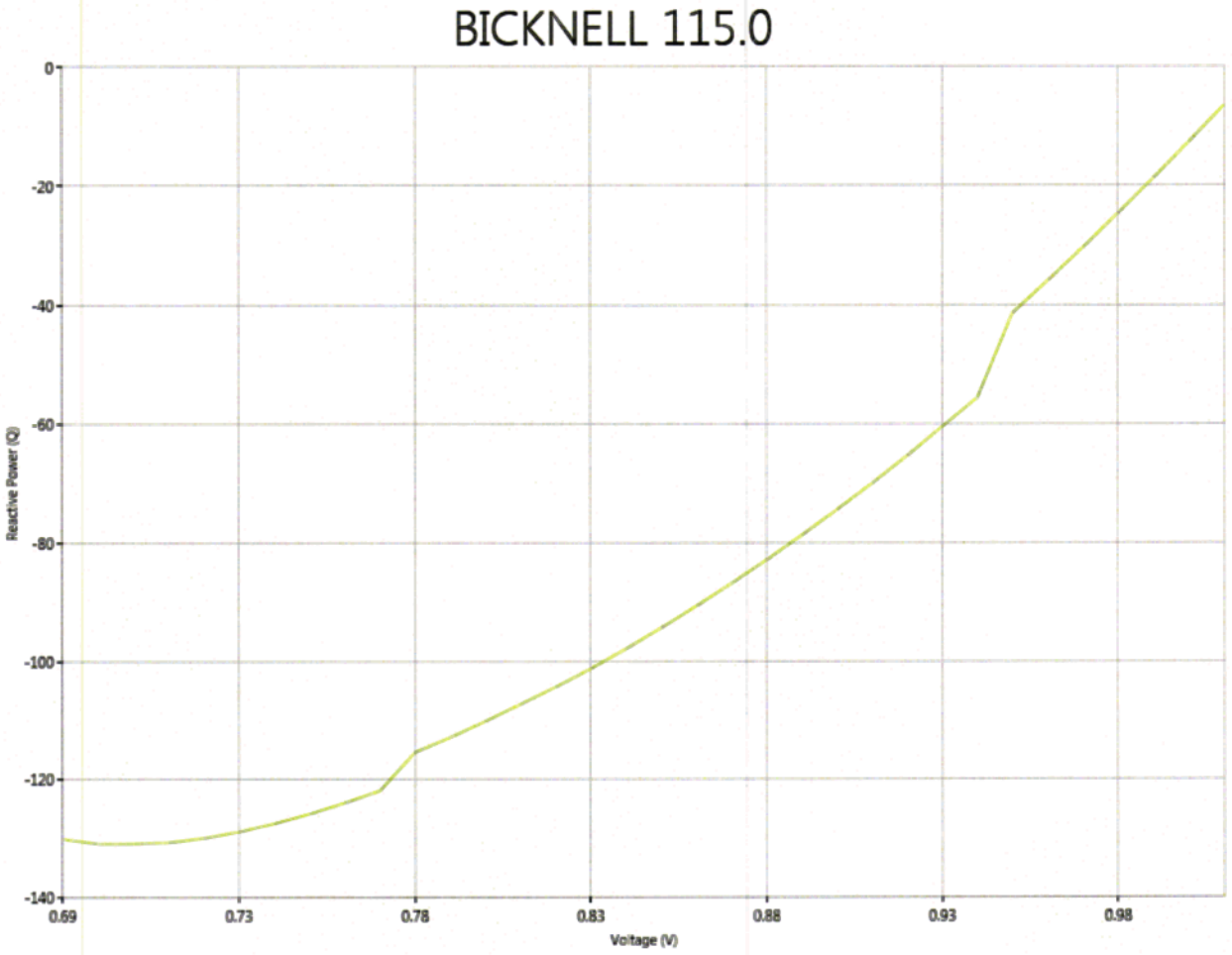

MARANA 115.0
30
0
-30
-60
-90
-120
-150
-180
-210
Reactive Power (Q)
0.635
0.68
0.74
0.8
0.86
0.92
0.98
Voltage (V)

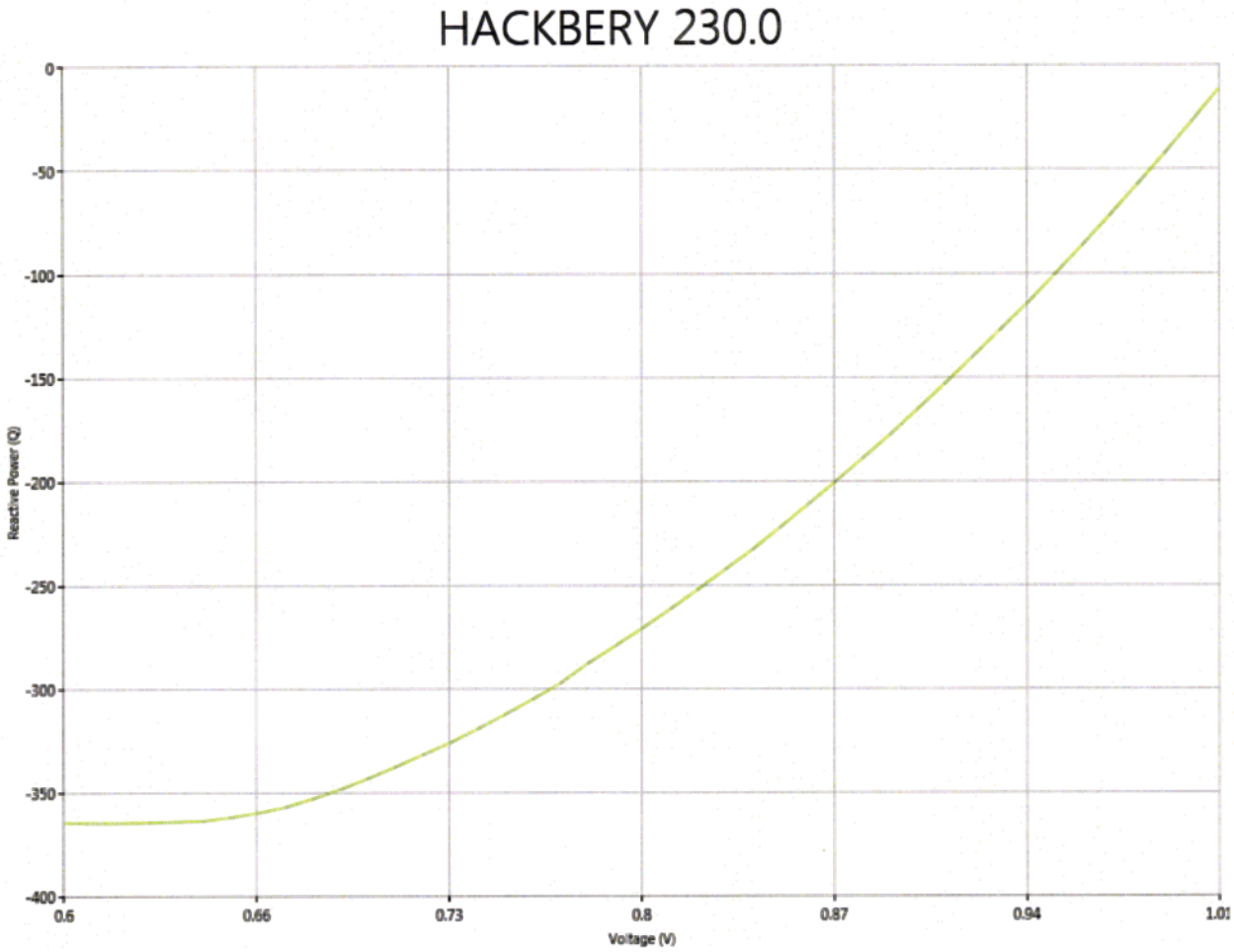
PANTANO 230.0

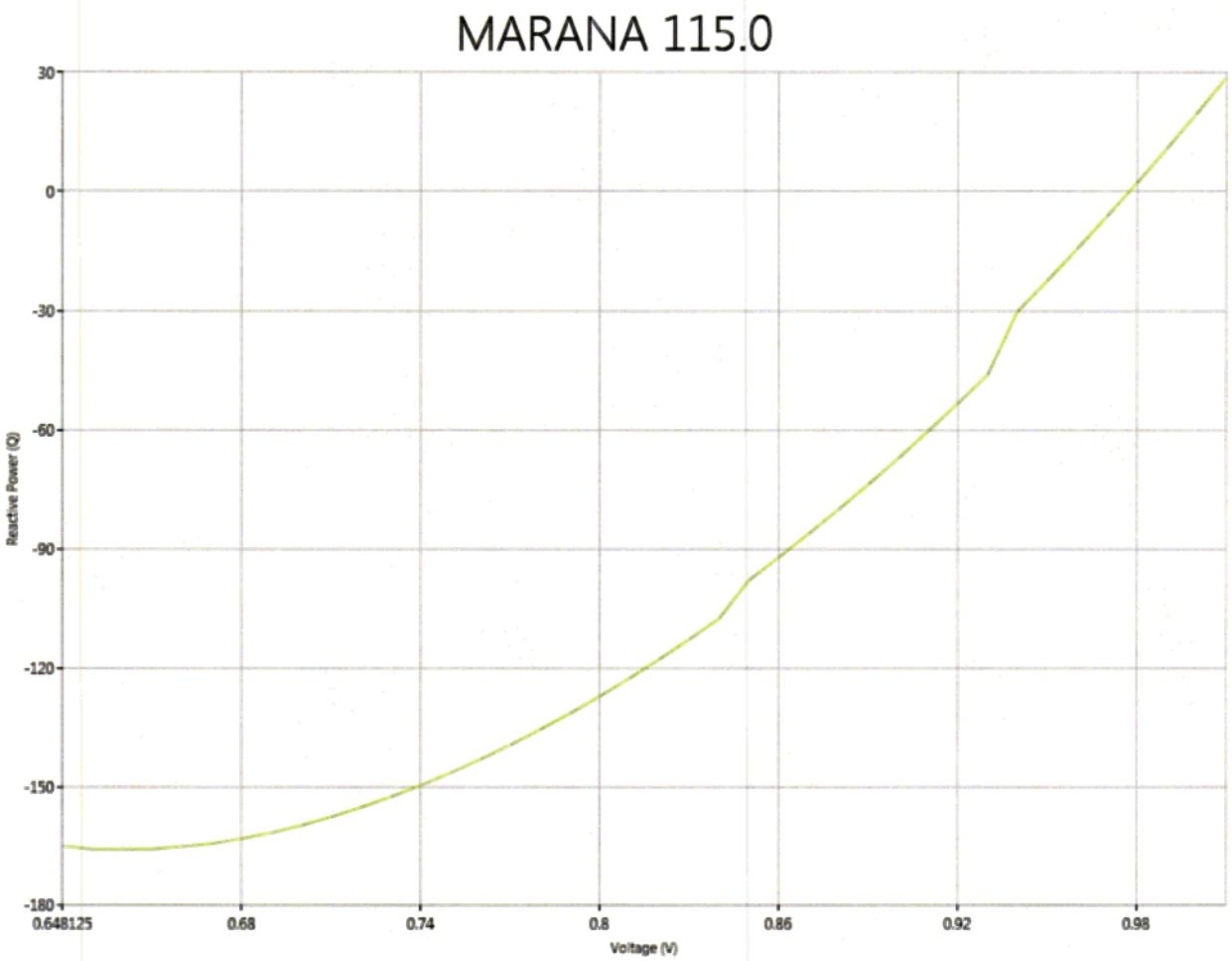


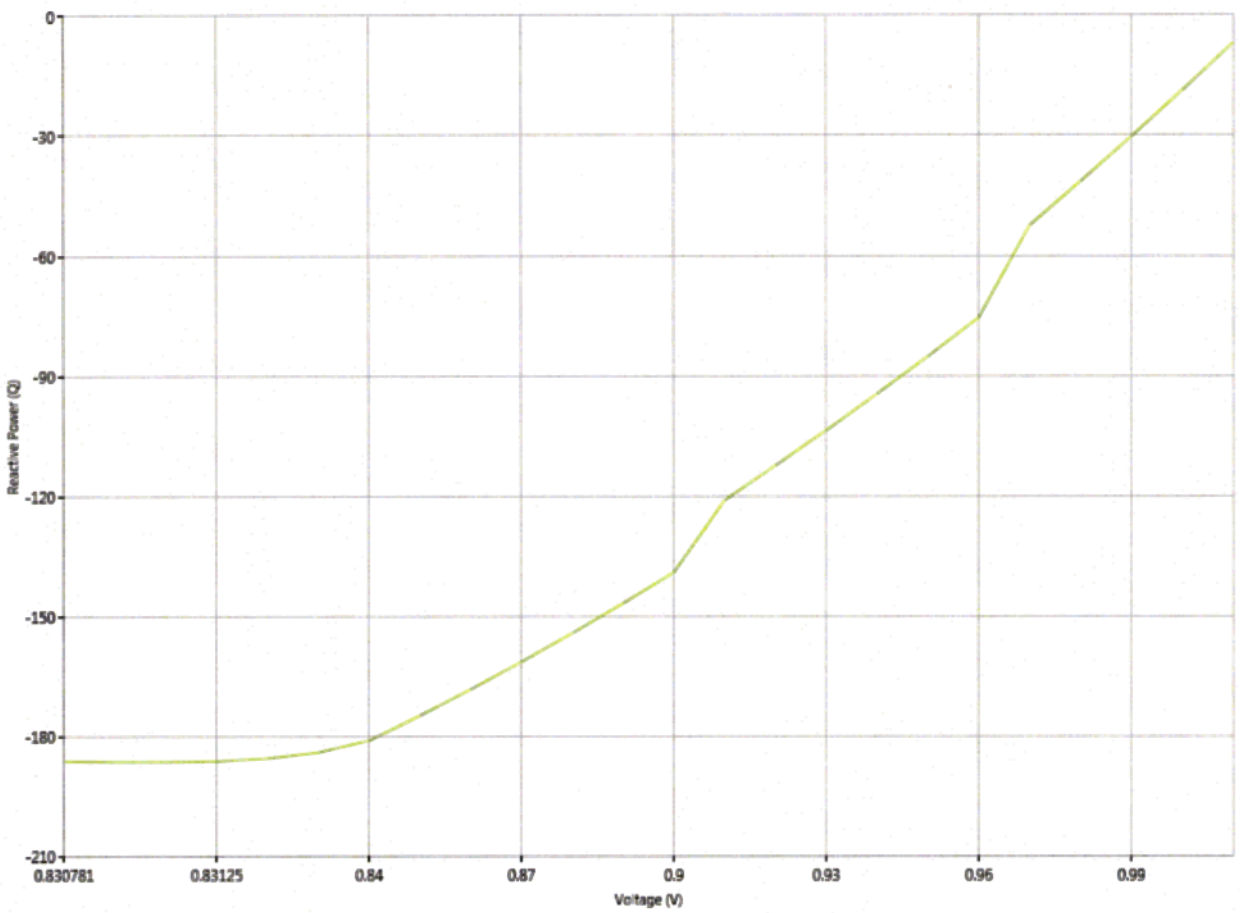

REDTAIL 230.0
20
0
-20
-40
-60
-80
-100
Reactive Power (Q)
0.6
0.66
0.73
0.8
0.87
0.94
1.01
Voltage (V)

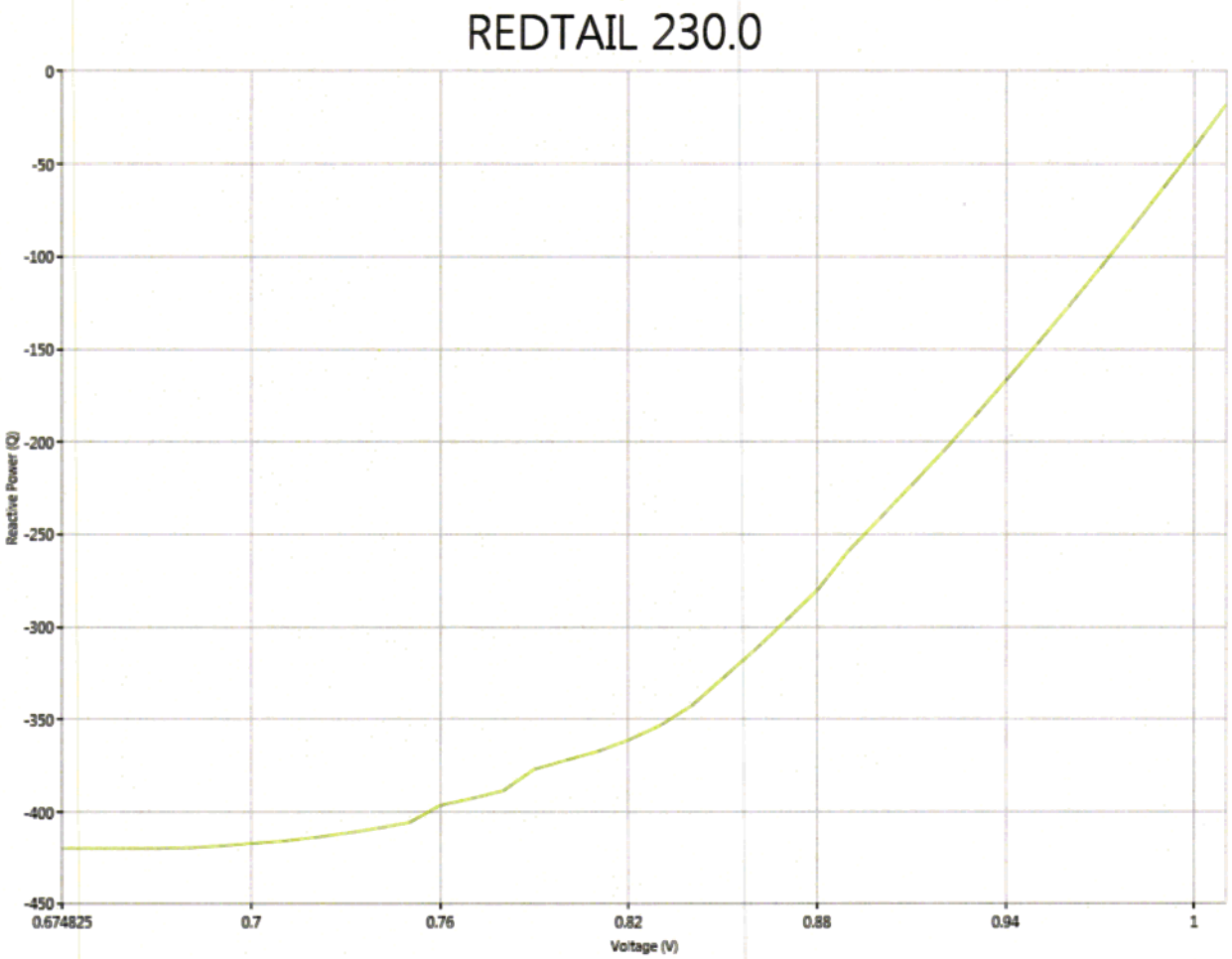
Bicknell to Vail 345 kV outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses



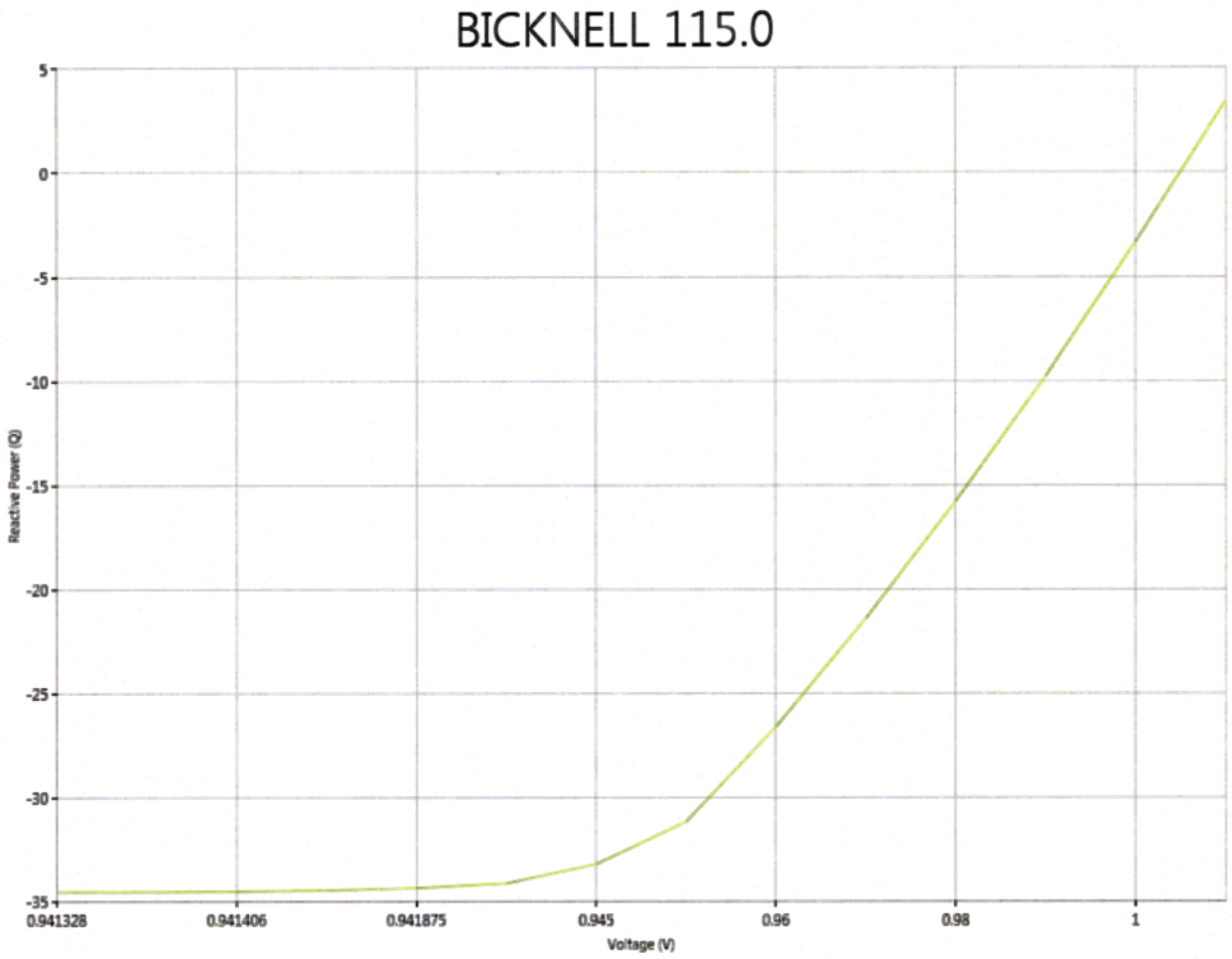

HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
Reactive Power (Q)
0.6
0.66
0.73
0.8
0.87
0.94
1.01
Voltage (V)


MARANA 115.0
30
0
-30
-60
-90
-120
-150
-180
Reactive Power (Q)
0.648125
0.68
0.74
0.8
0.86
0.92
0.98
Voltage (V)


PANTANO 230.0
0
-30
-60
-90
-120
-150
-180
-210
Reactive Power (Q)
0.830781
0.83125
0.84
0.87
0.9
0.93
0.96
0.99
Voltage (V)

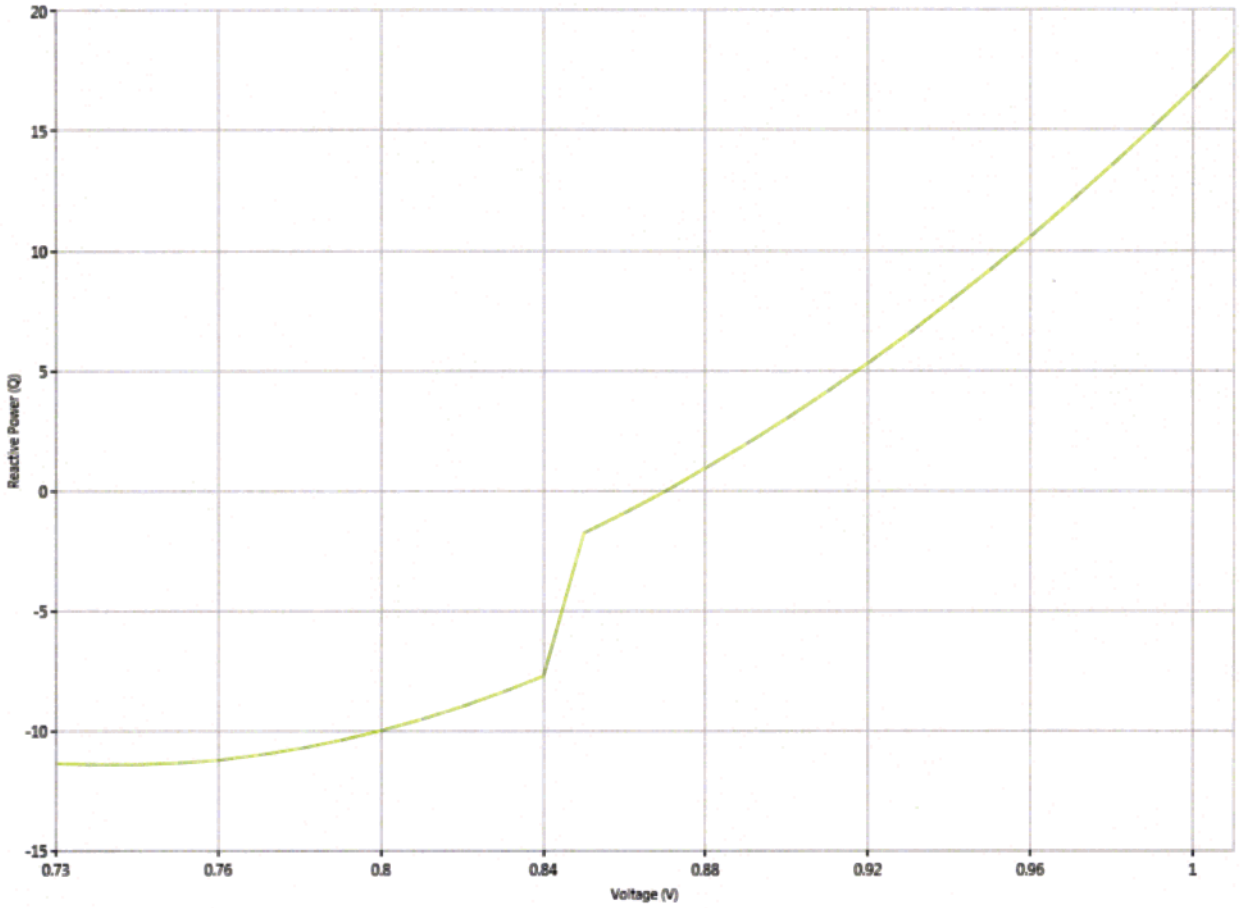

REDTAIL 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.674825
0.7
0.76
0.82
0.88
0.94
1
Voltage (V)

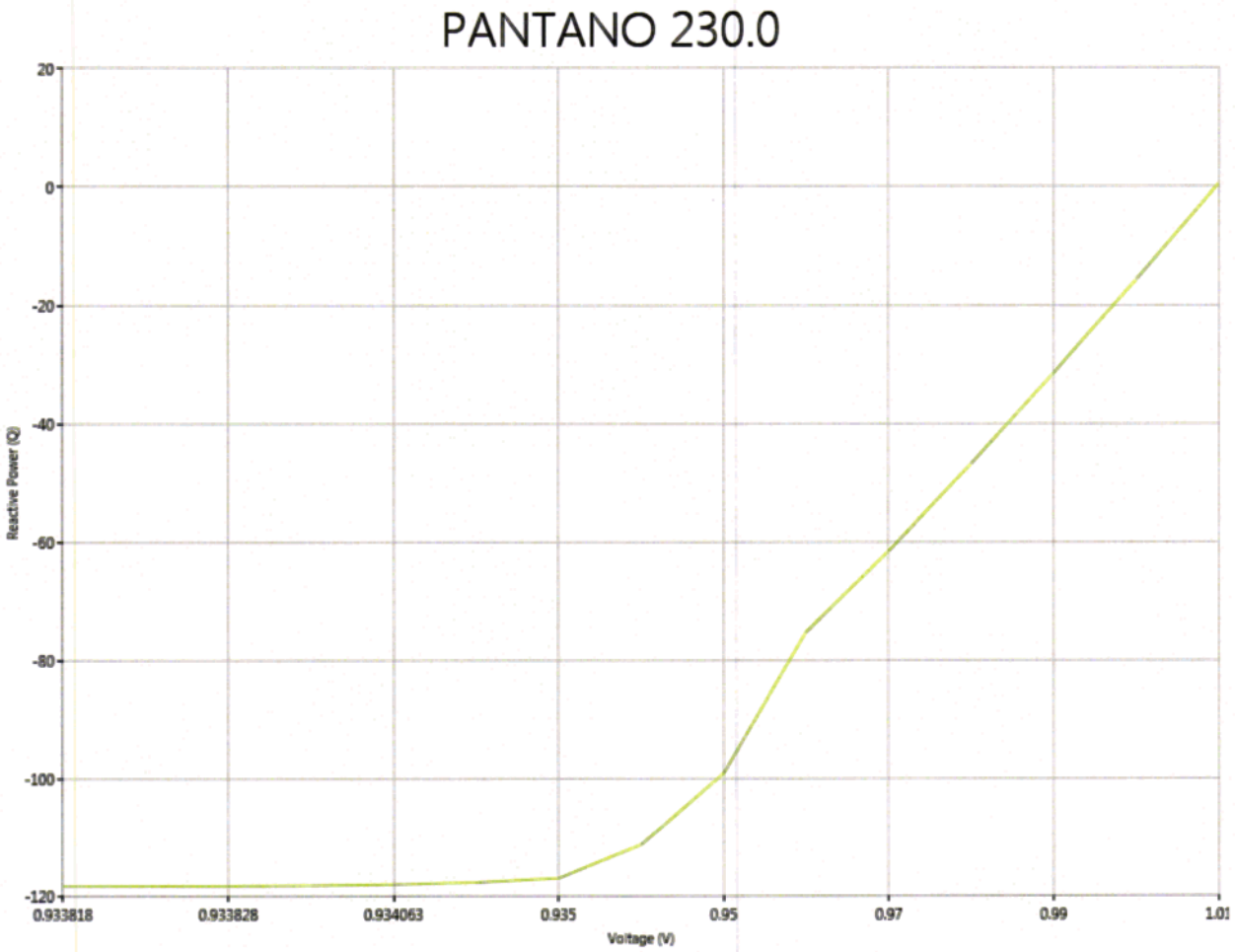
Marana Group Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

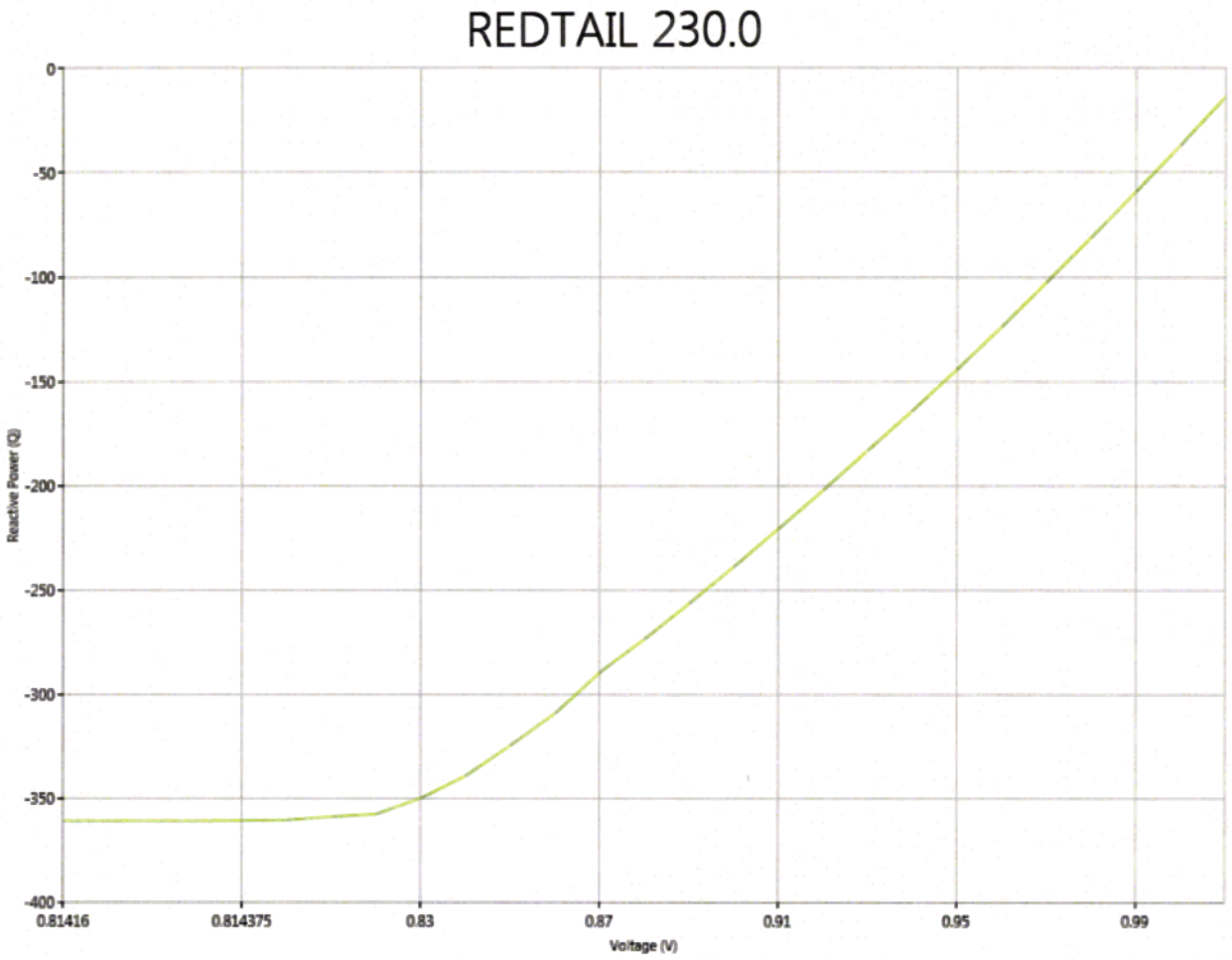



HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
Reactive Power (Q)
0.67
0.7
0.76
0.82
0.88
0.94
1
Voltage (V)

MARANA 115.0

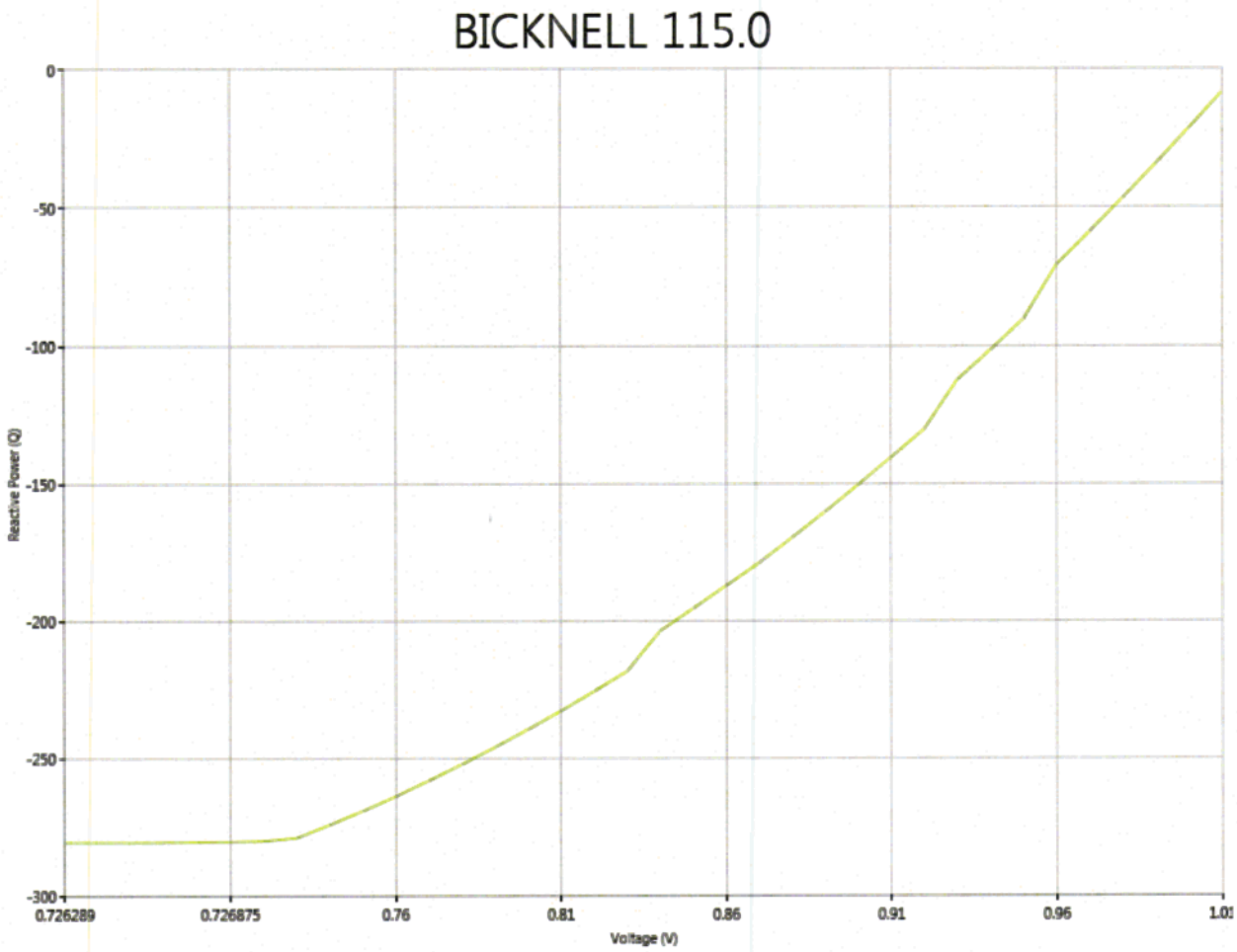

20
15
10
5
0
-5
-10
-15
Reactive Power (Q)
0.73
0.76
0.8
0.84
0.88
0.92
0.96
1
Voltage (V)


PANTANO 230.0
20
0
-20
-40
-60
-80
-100
-120
Reactive Power (Q)
0.933818
0.933828
0.934063
0.935
0.95
0.97
0.99
1.01
Voltage (V)

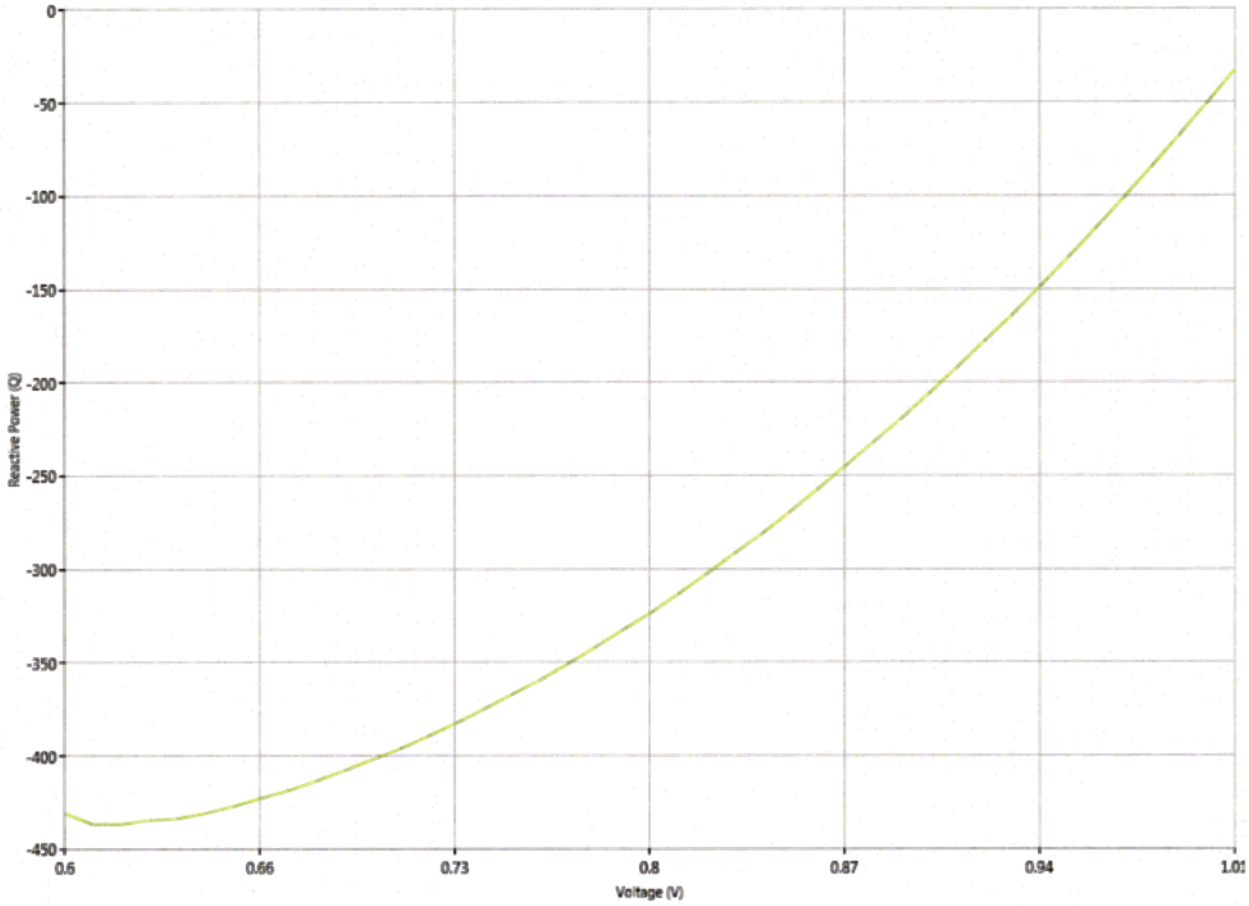

REDTAIL 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
Reactive Power (Q)
0.81416
0.814375
0.83
0.87
0.91
0.95
0.99
Voltage (V)

2021 HEAVY SUMMER

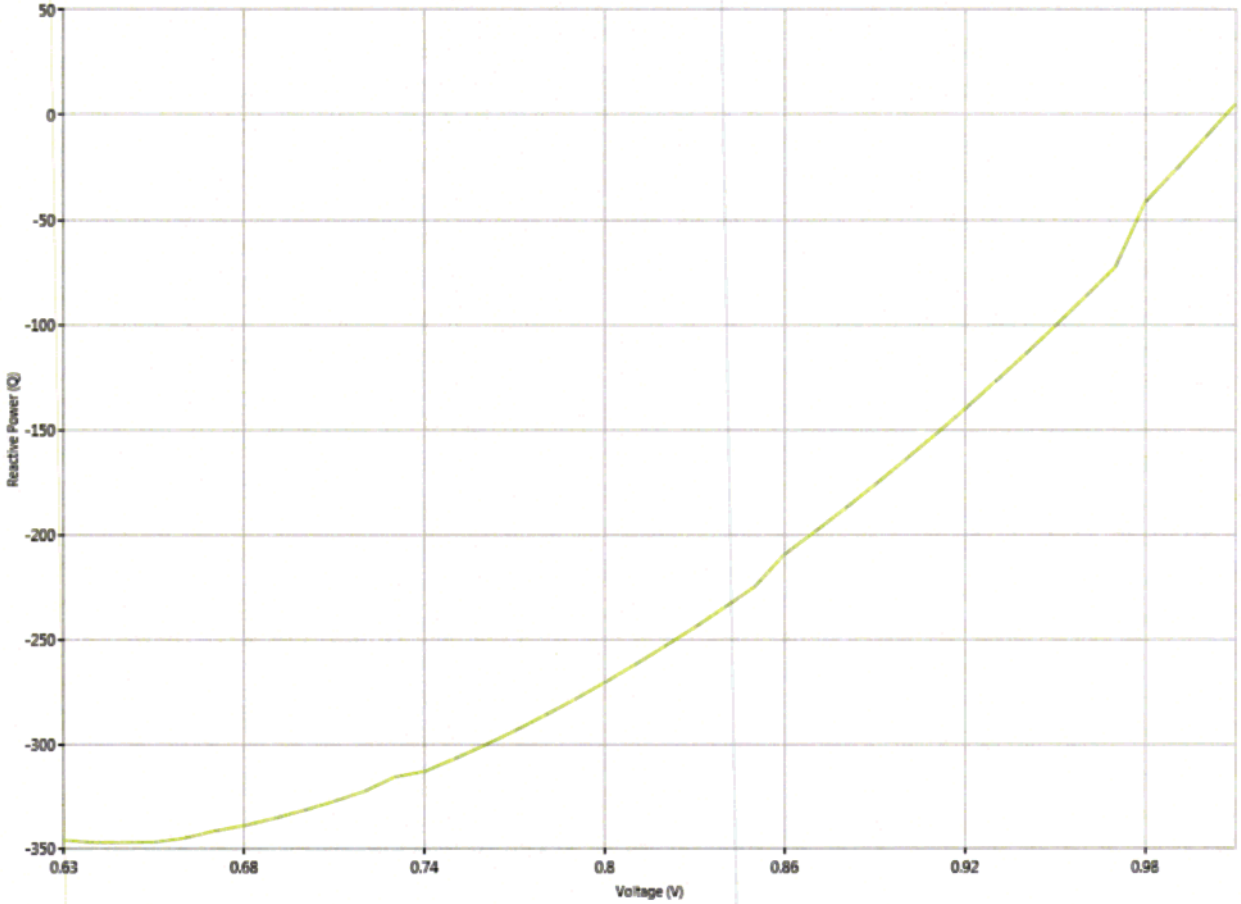
Apache to Butterfield 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

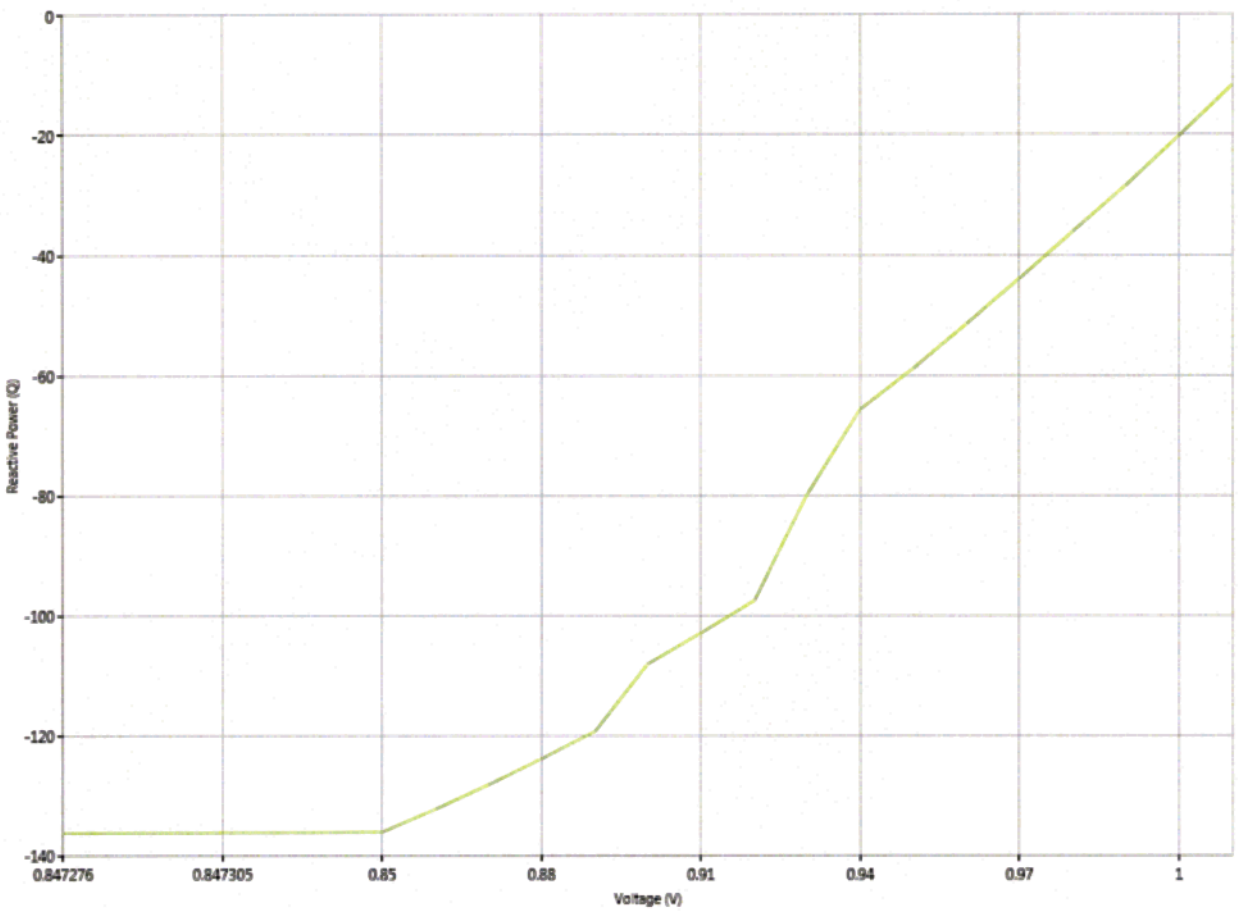


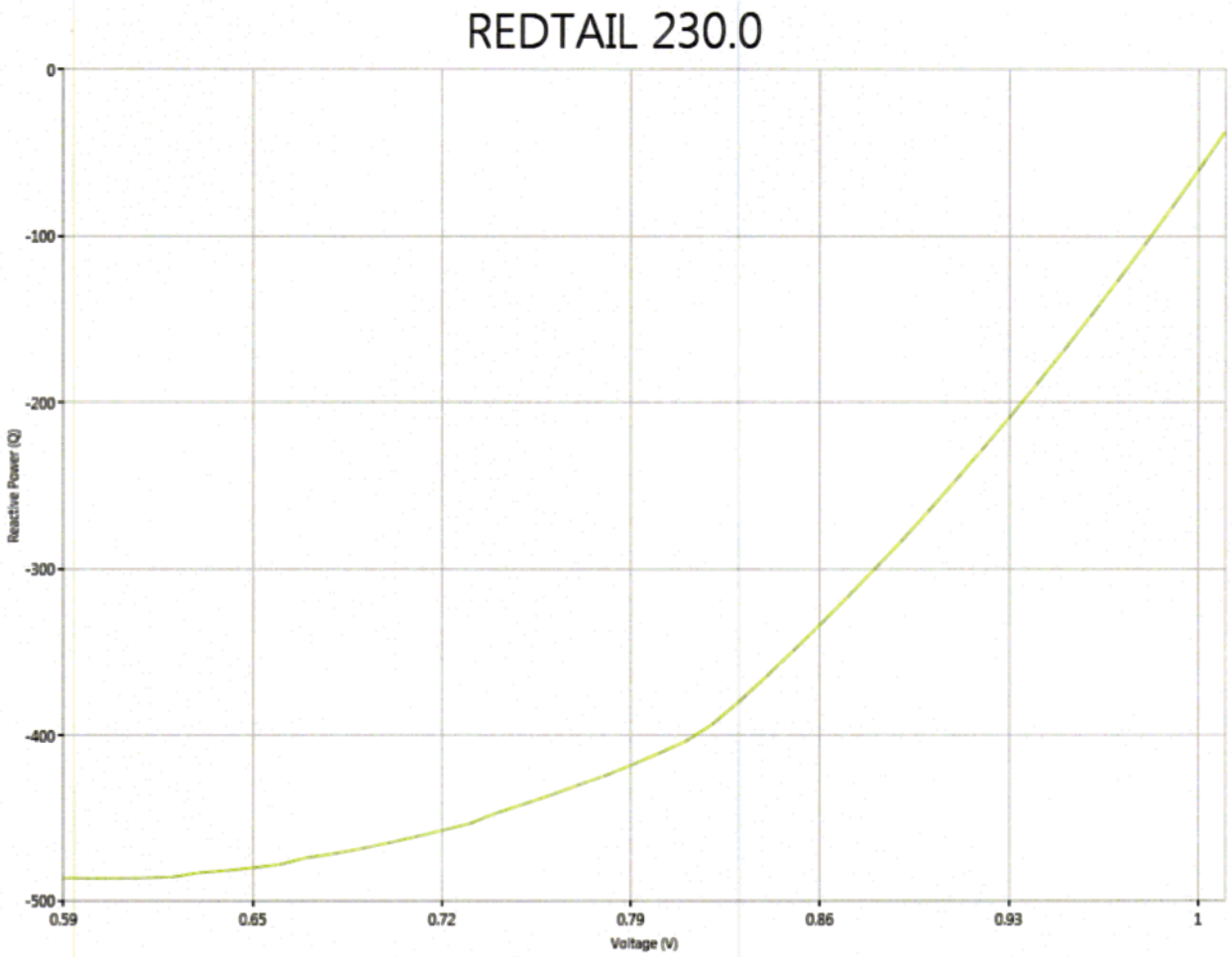
HACKBERY 230.0



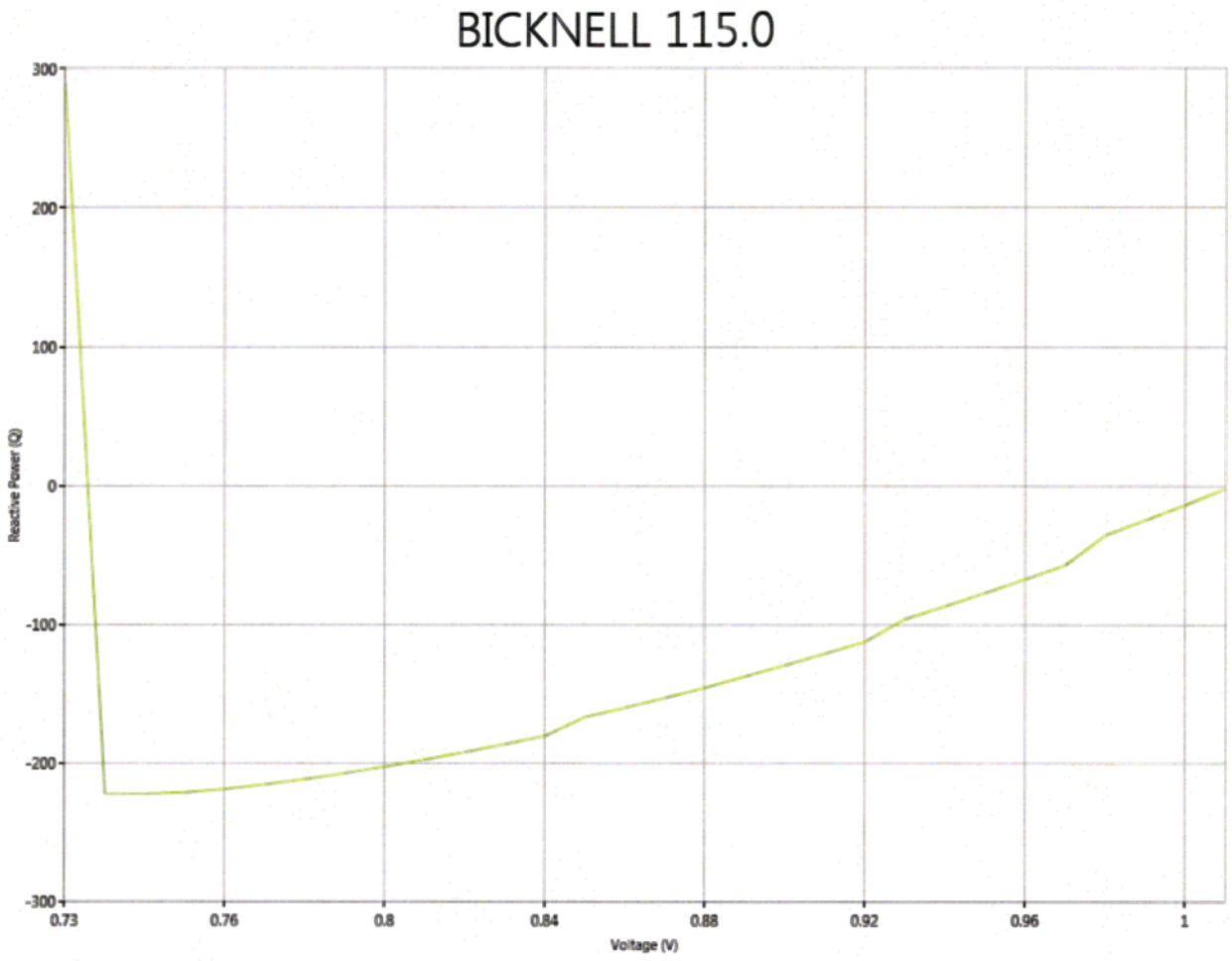
MARANA 115.0

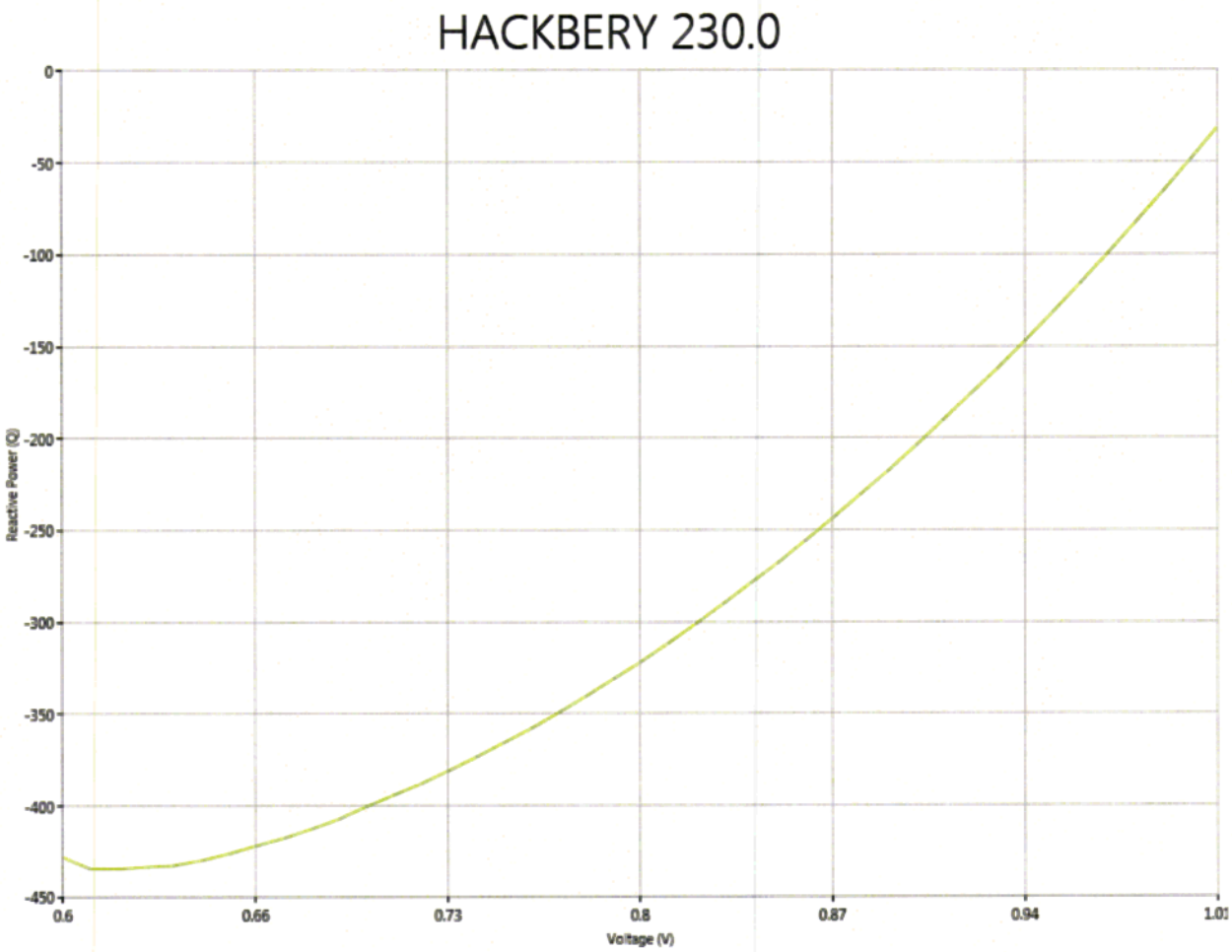

50
0
-50
-100
-150
-200
-250
-300
-350
Reactive Power (Q)
0.63
0.68
0.74
0.8
0.86
0.92
0.98
Voltage (V)


PANTANO 230.0
0
-20
-40
-60
-80
-100
-120
-140
Reactive Power (Q)
0.847276
0.847305
0.85
0.88
0.91
0.94
0.97
1
Voltage (V)

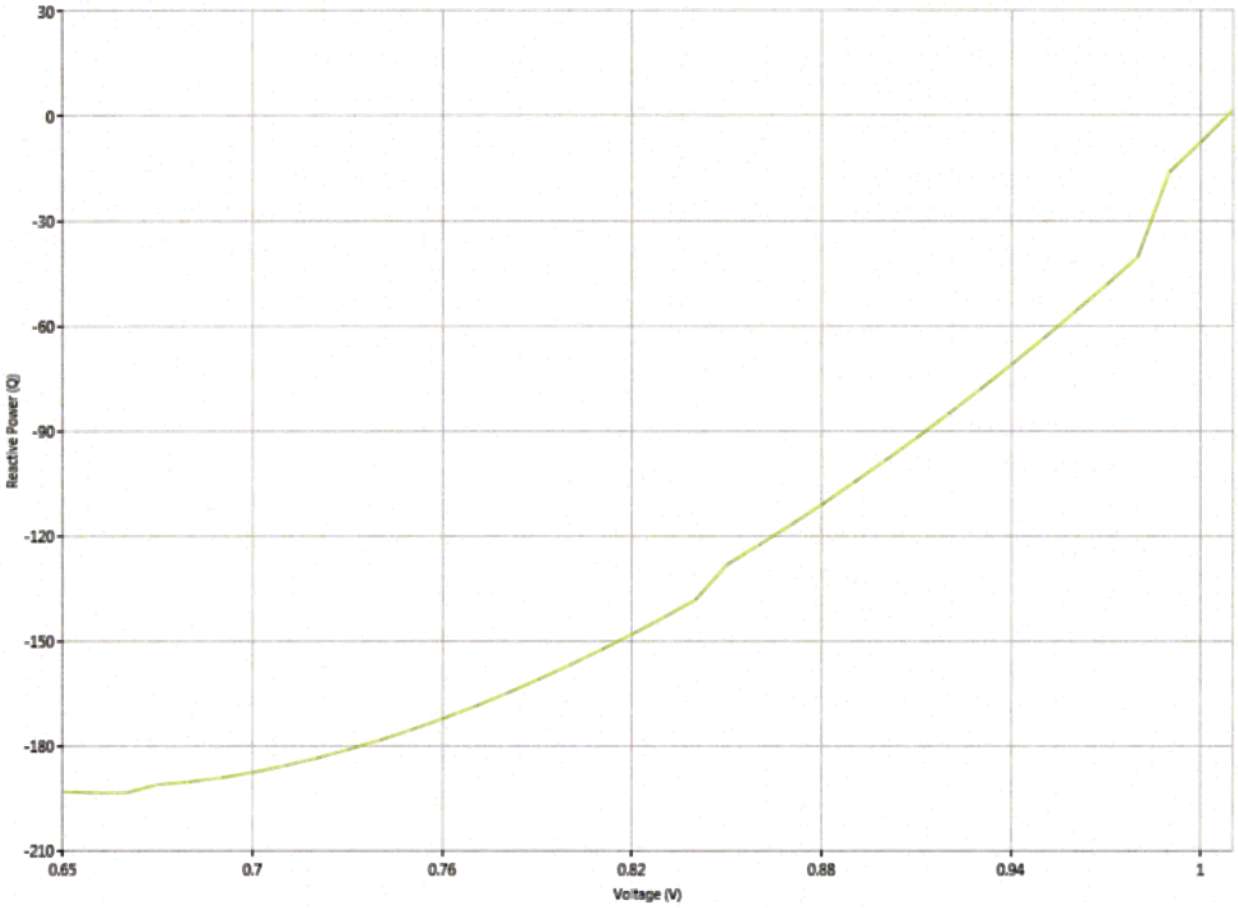

REDTAIL 230.0
0
-100
-200
-300
-400
-500
Reactive Power (Q)
0.59
0.65
0.72
0.79
0.86
0.93
1
Voltage (V)

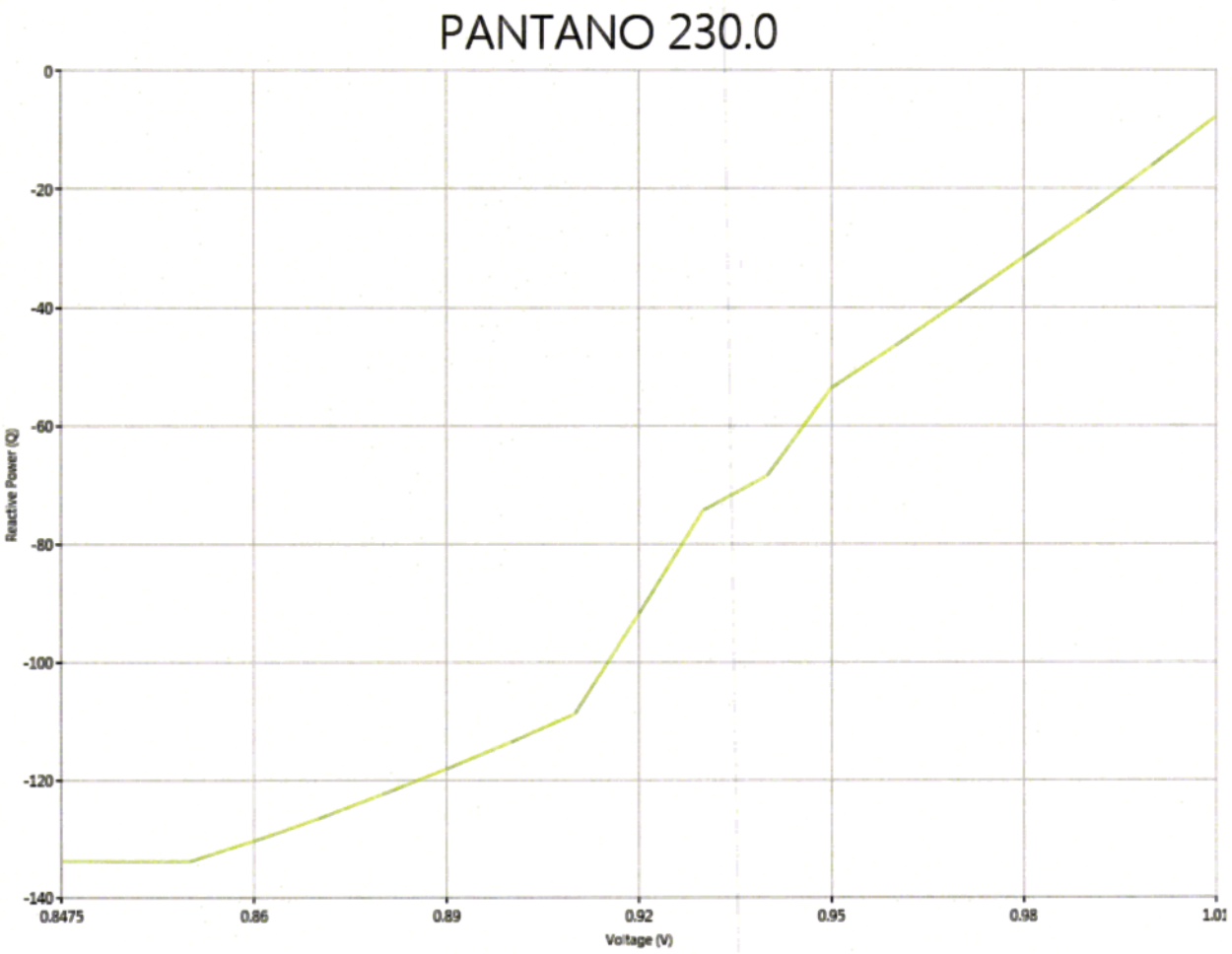
Apache to Butterfield 230 kV and Marana Group Outages
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

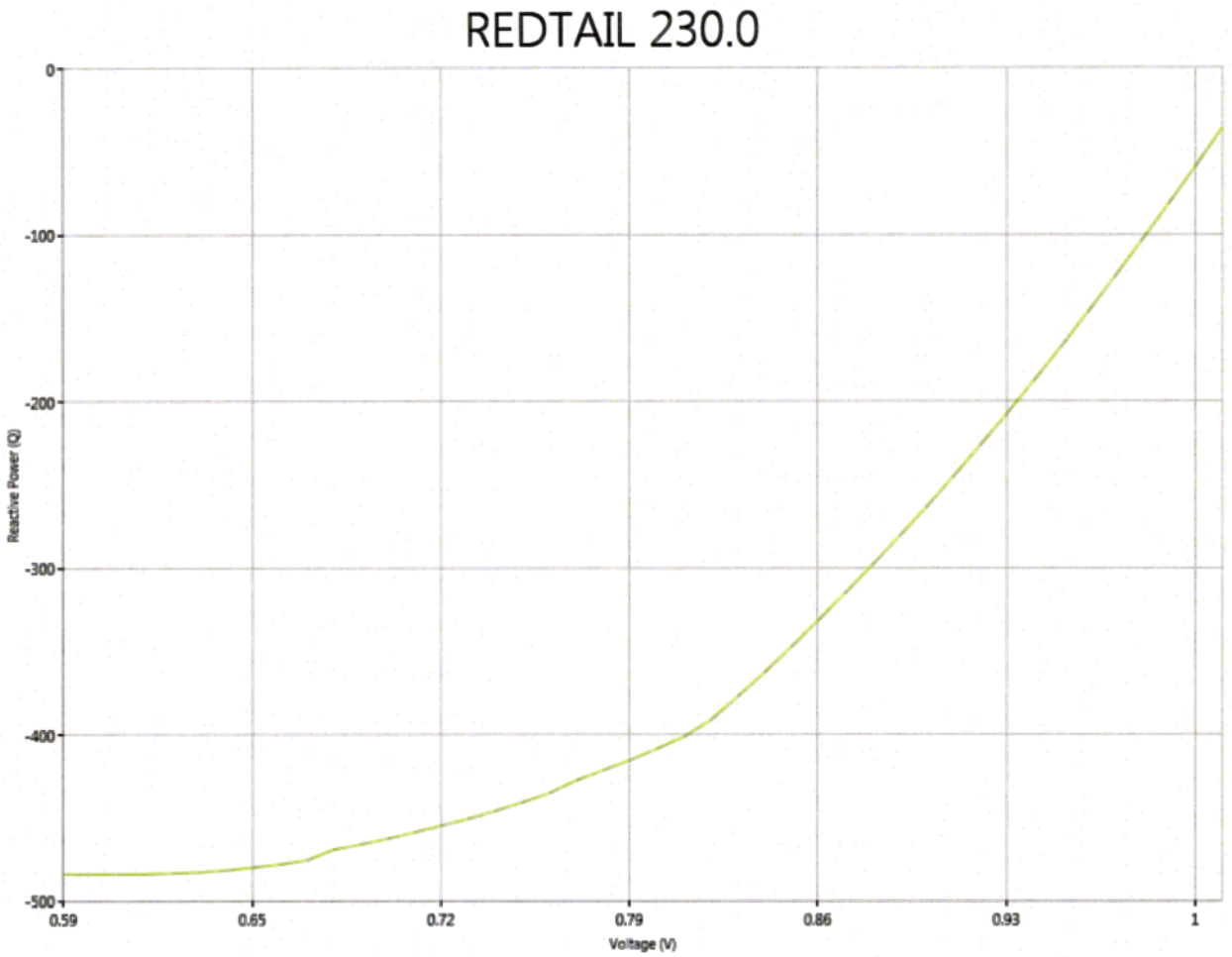



HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.6
0.66
0.73
0.8
0.87
0.94
1.01
Voltage (V)

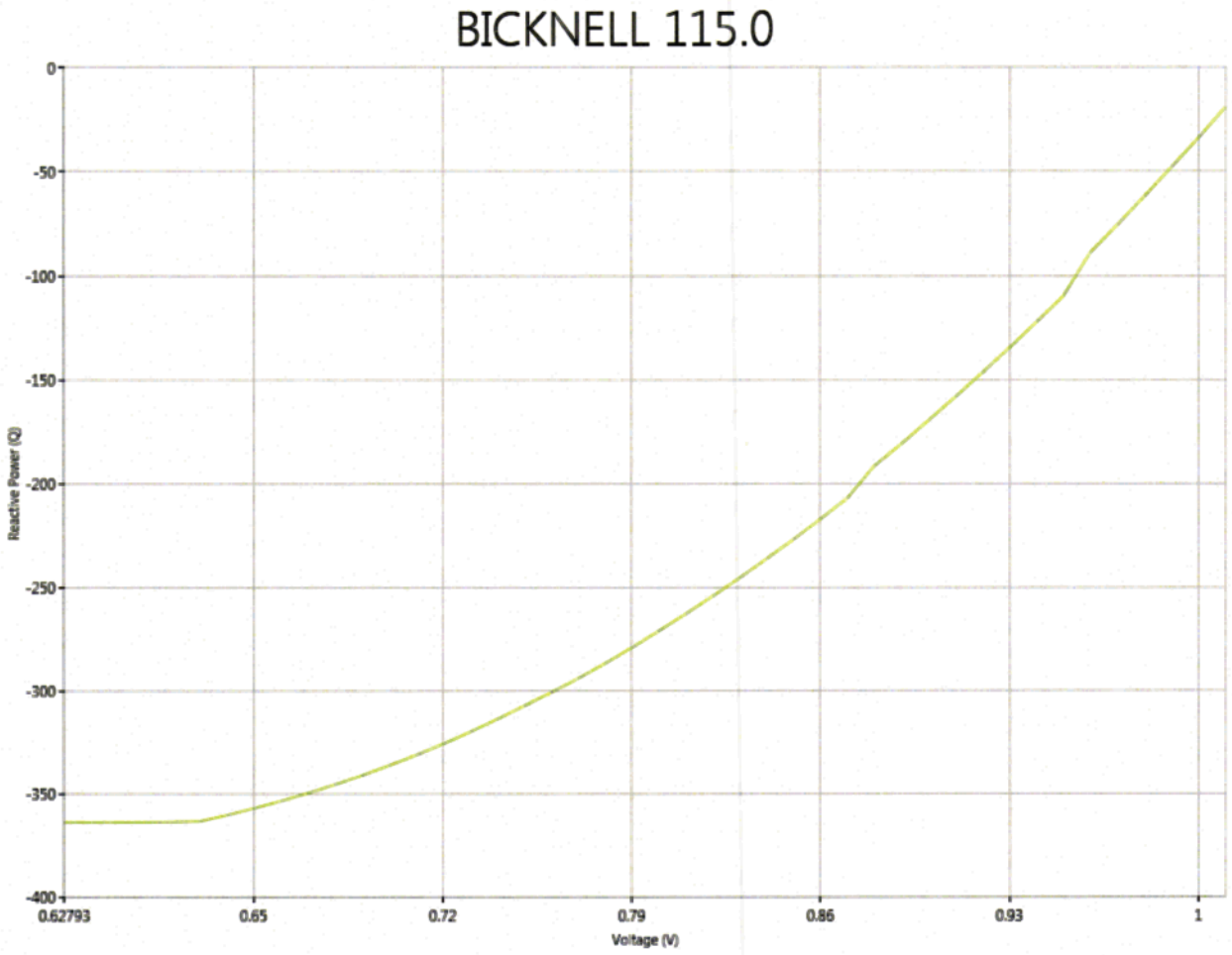
MARANA 115.0

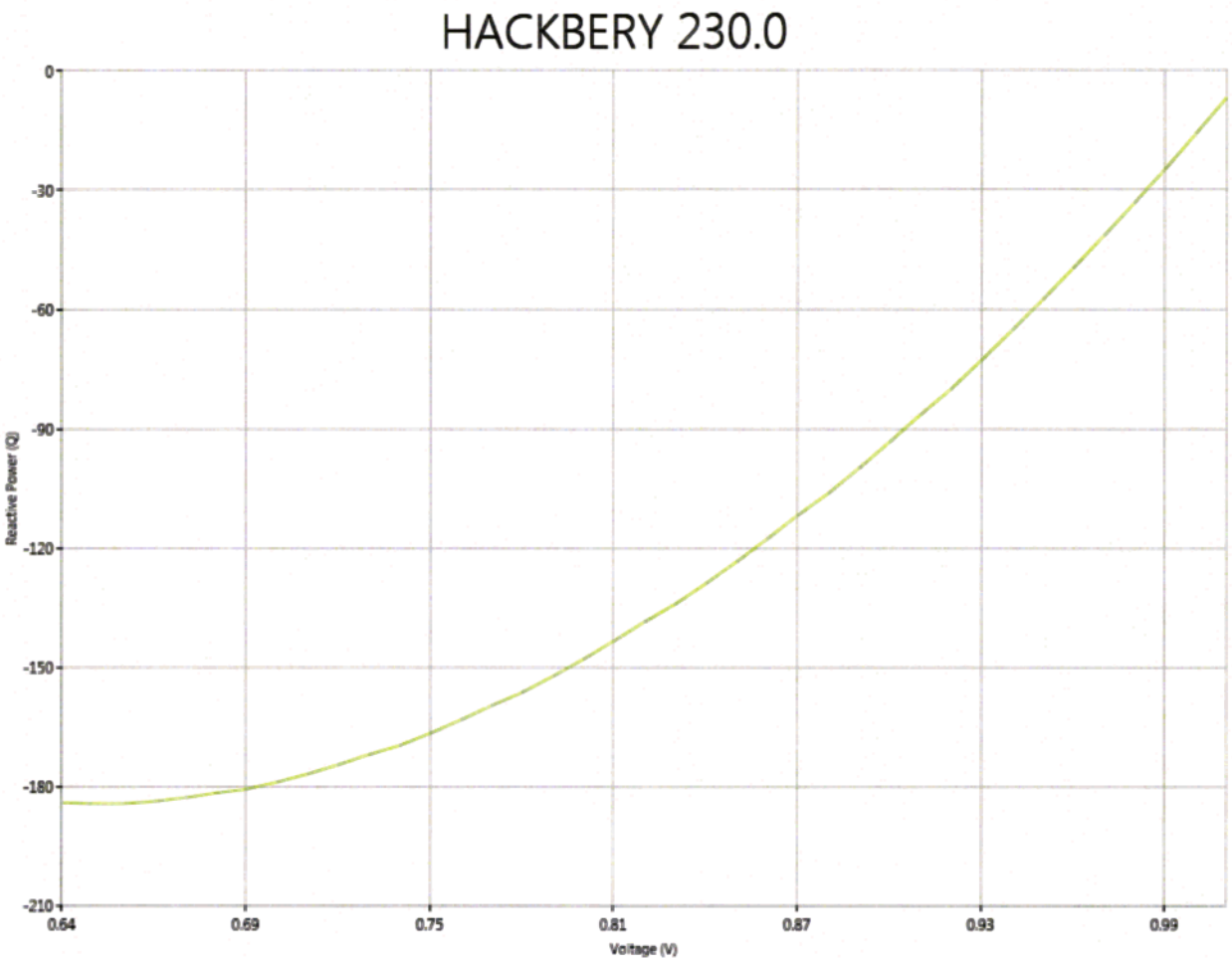

30
0
-30
-60
-90
-120
-150
-180
-210
Reactive Power (Q)
0.65
0.7
0.76
0.82
0.88
0.94
1
Voltage (V)


PANTANO 230.0
0
-20
-40
-60
-80
-100
-120
-140
Reactive Power (Q)
0.8475
0.86
0.89
0.92
0.95
0.98
1.01
Voltage (V)

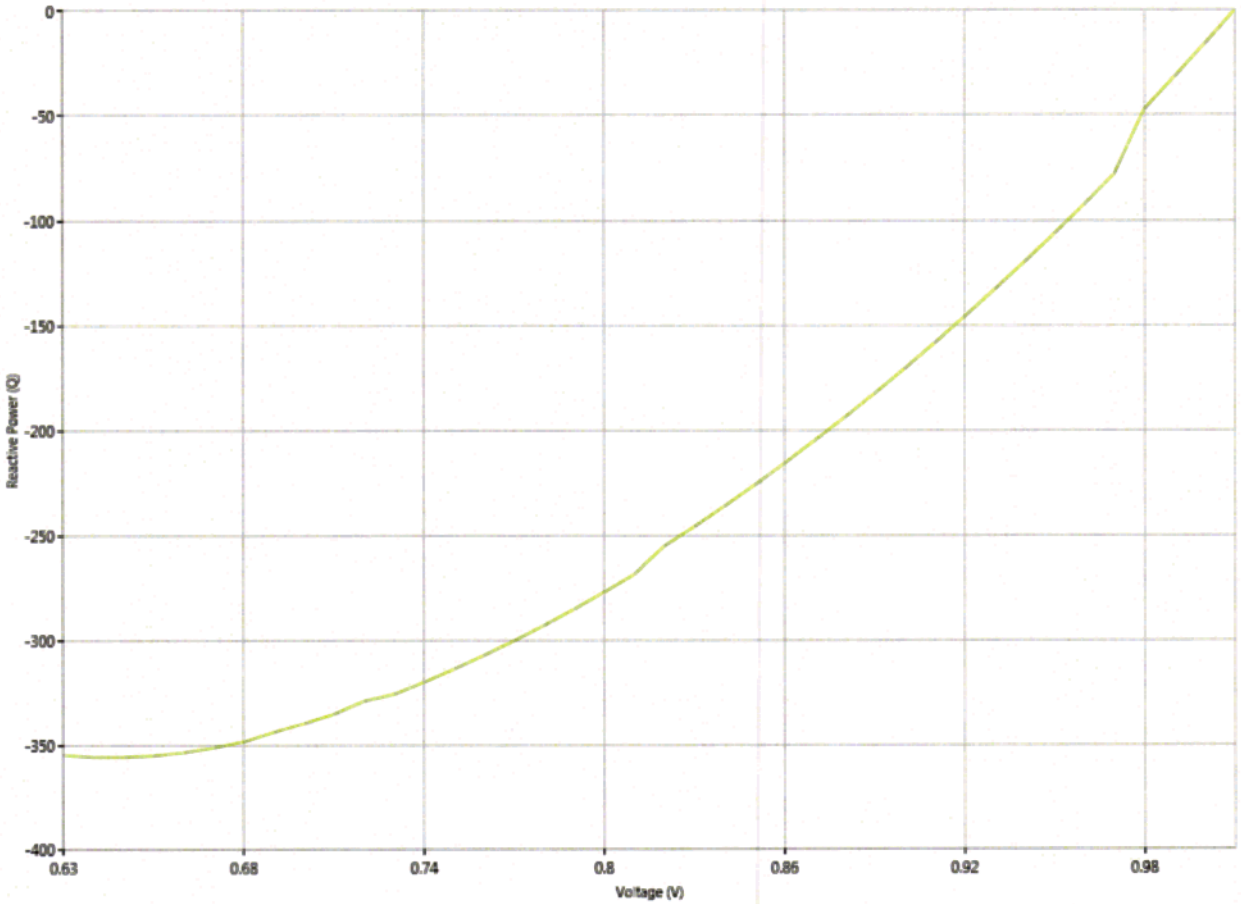

REDTAIL 230.0
0
-100
-200
-300
-400
-500
Reactive Power (Q)
0.59
0.65
0.72
0.79
0.86
0.93
1
Voltage (V)

Apache to Redtail 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

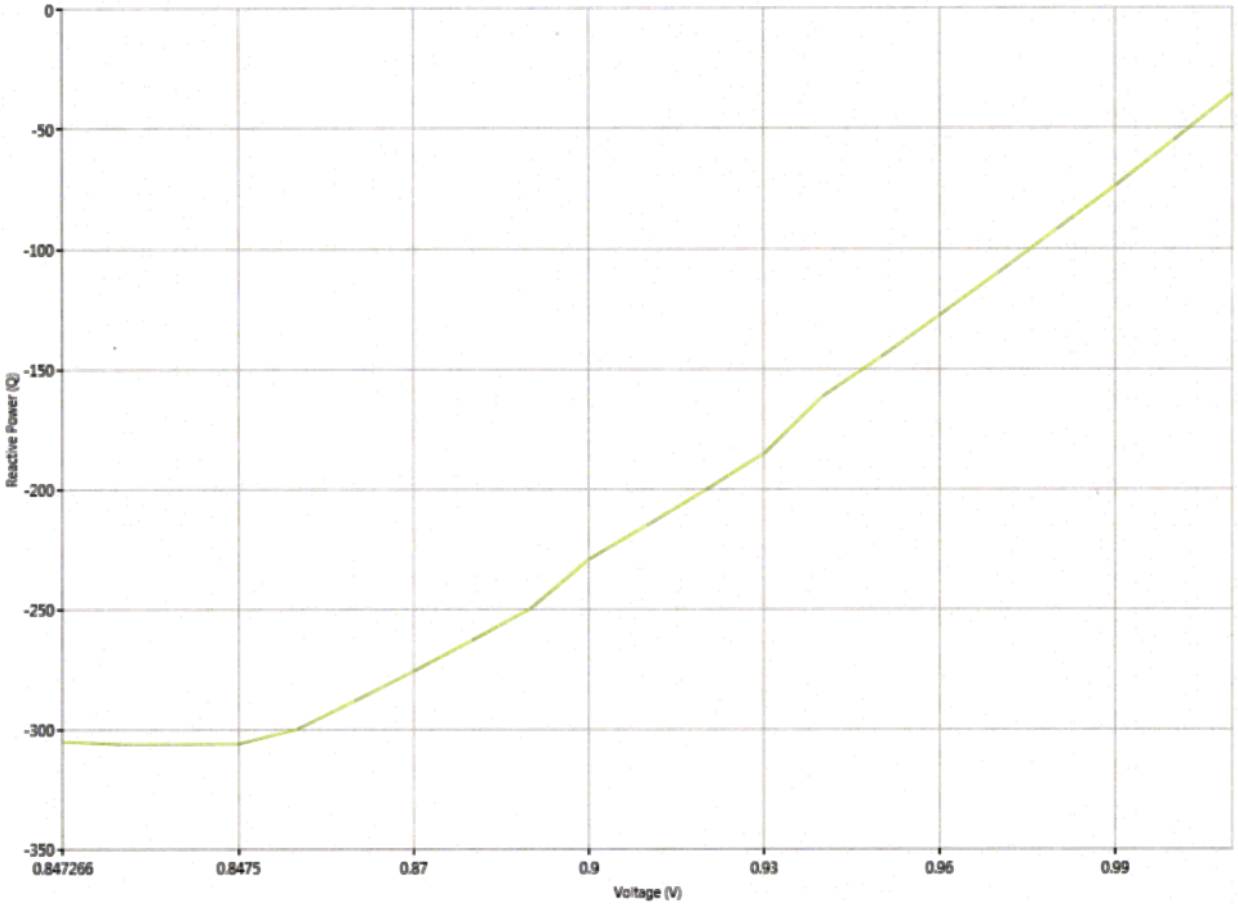


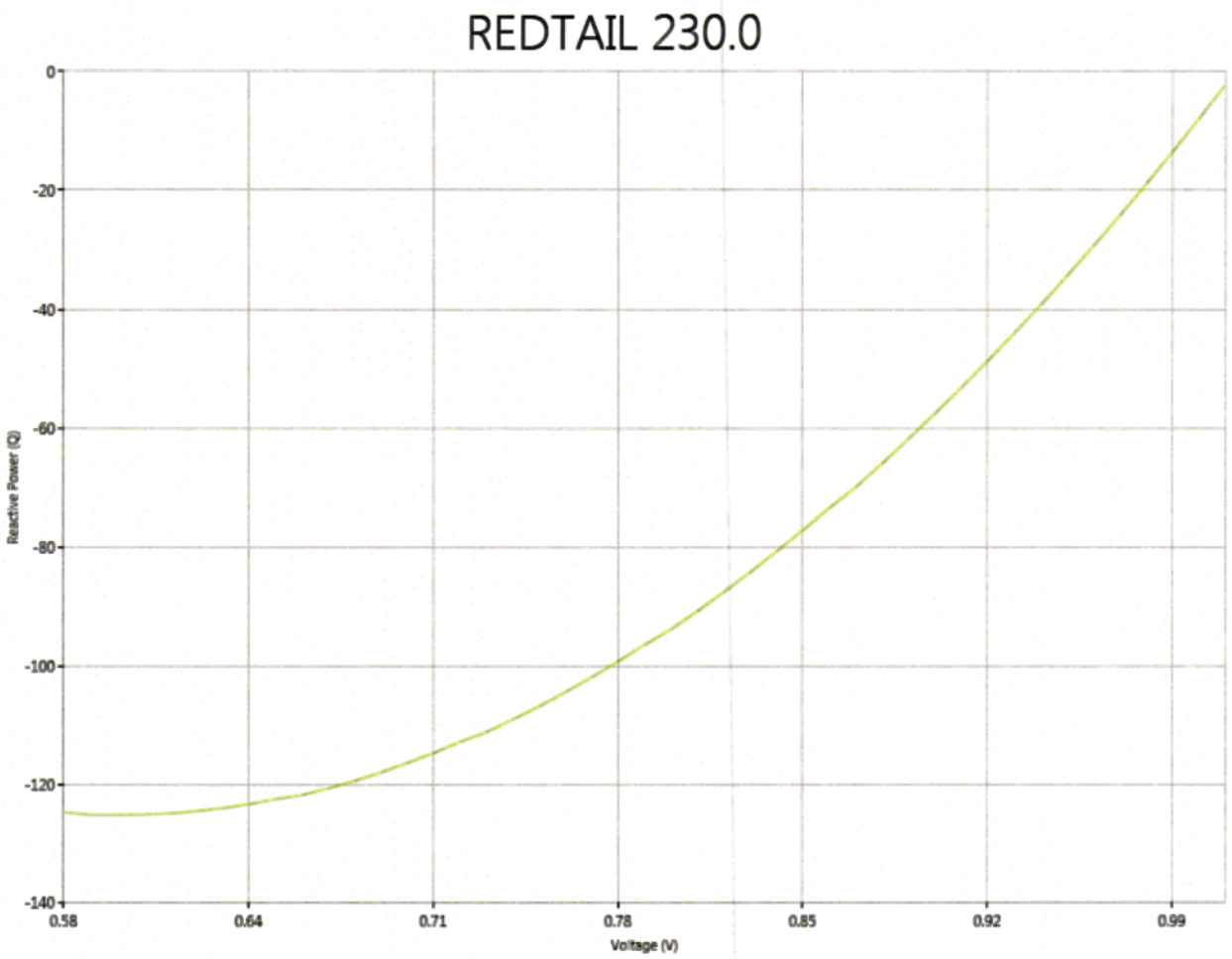

HACKBERY 230.0
0
-30
-60
-90
-120
-150
-180
-210
Reactive Power (Q)
0.64
0.69
0.75
0.81
0.87
0.93
0.99
Voltage (V)

MARANA 115.0

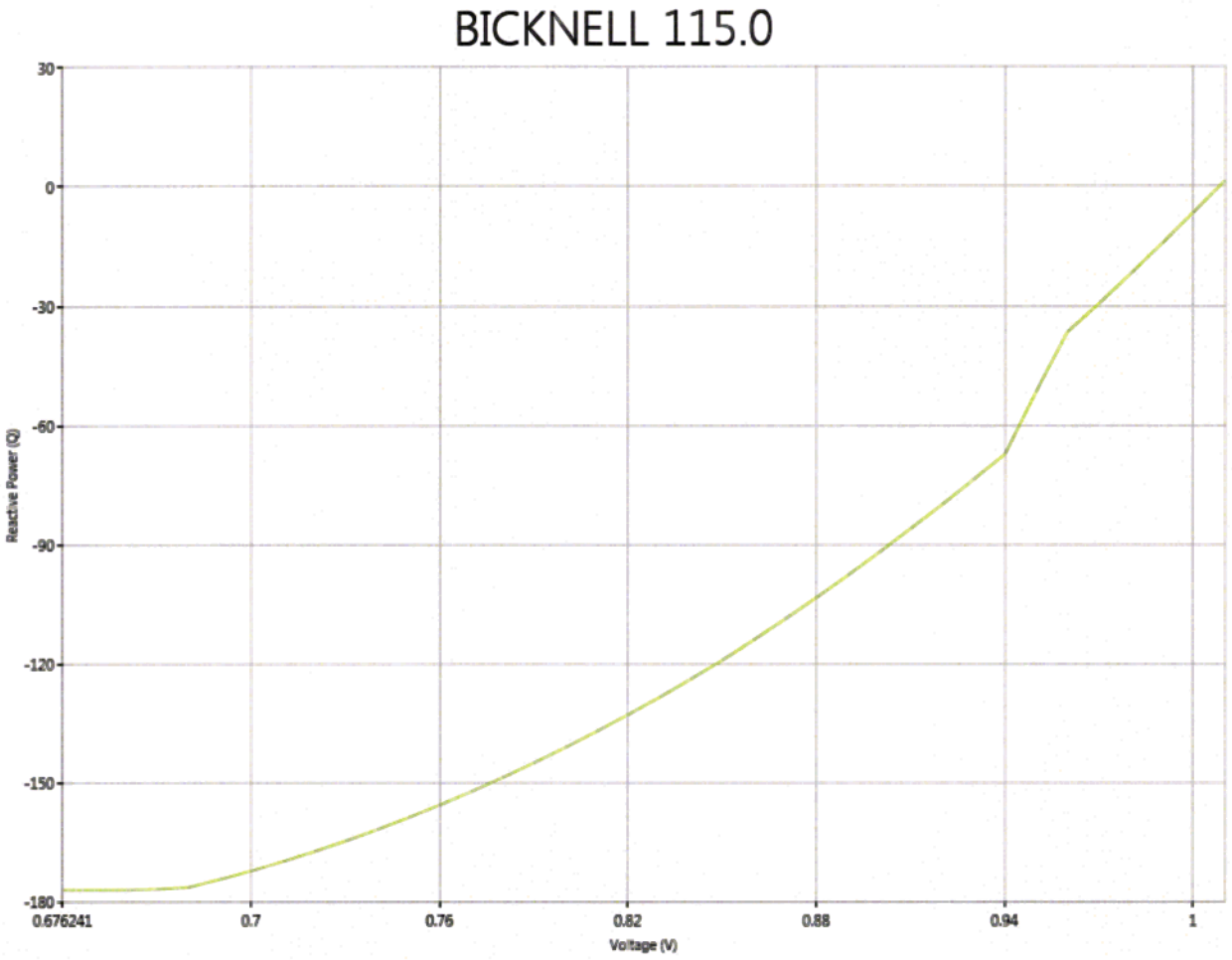

0
-50
-100
-150
-200
-250
-300
-350
-400
Reactive Power (Q)
0.63
0.68
0.74
0.8
0.86
0.92
0.98
Voltage (V)

PANTANO 230.0

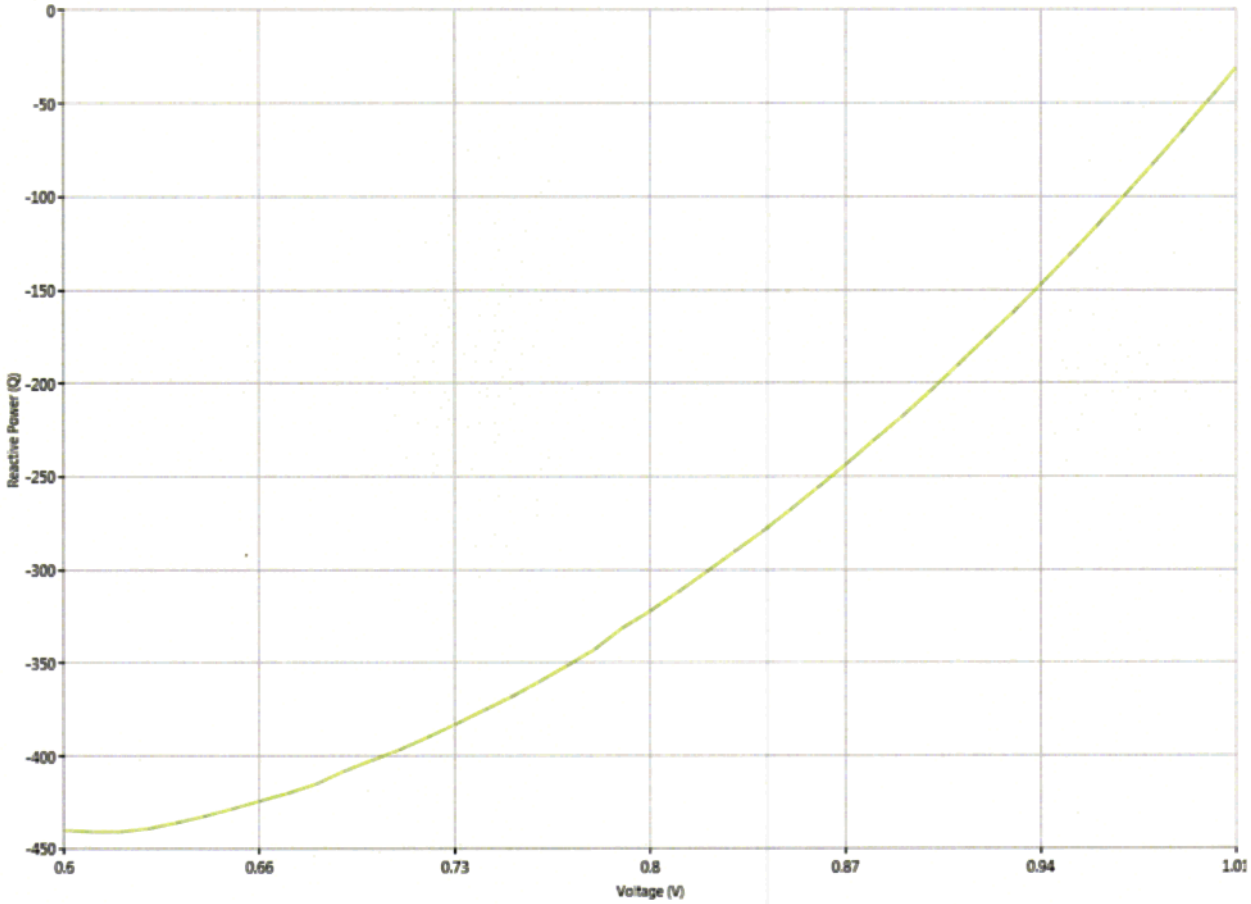



REDTAIL 230.0
0
-20
-40
-60
-80
-100
-120
-140
Reactive Power (Q)
0.58
0.64
0.71
0.78
0.85
0.92
0.99
Voltage (V)

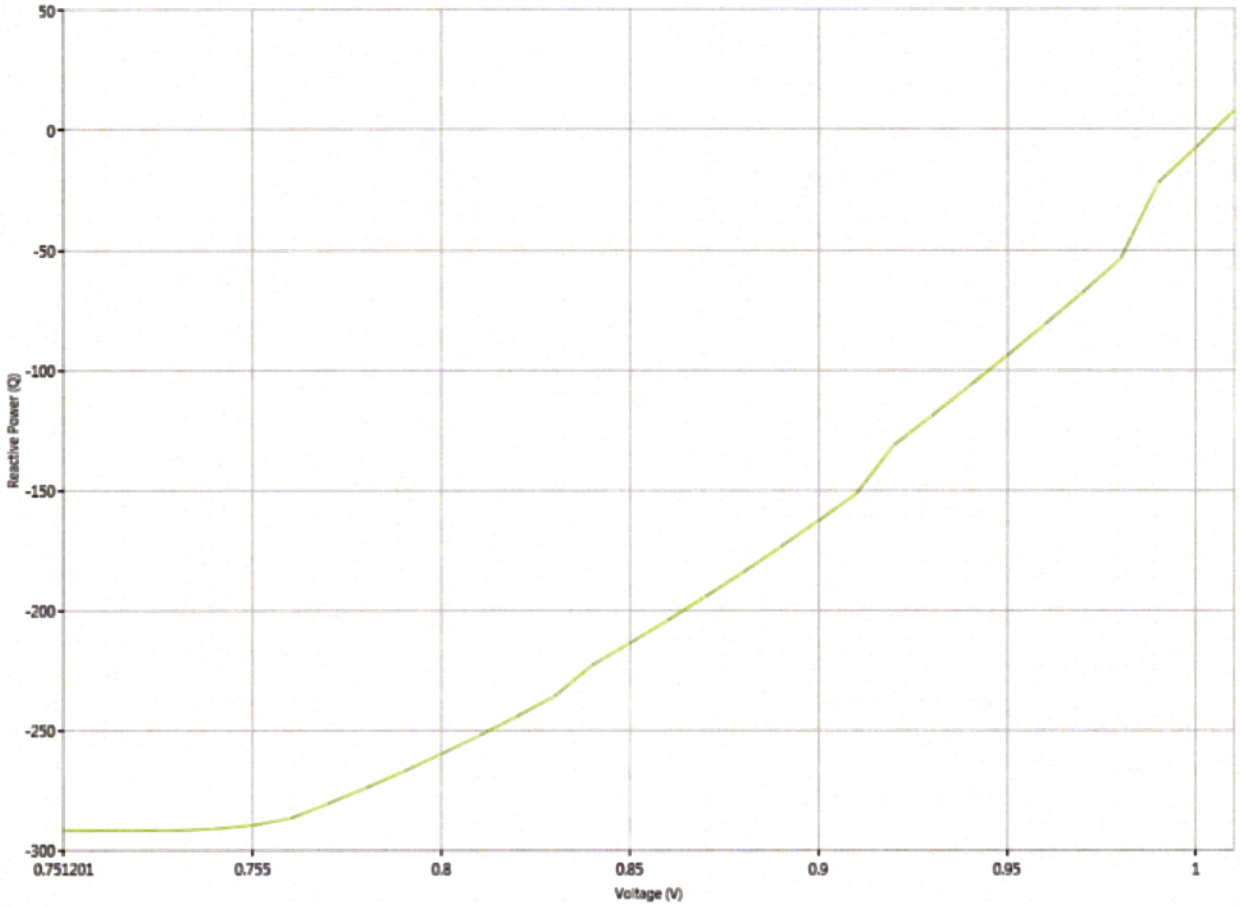
Bicknell to Vail 345 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses



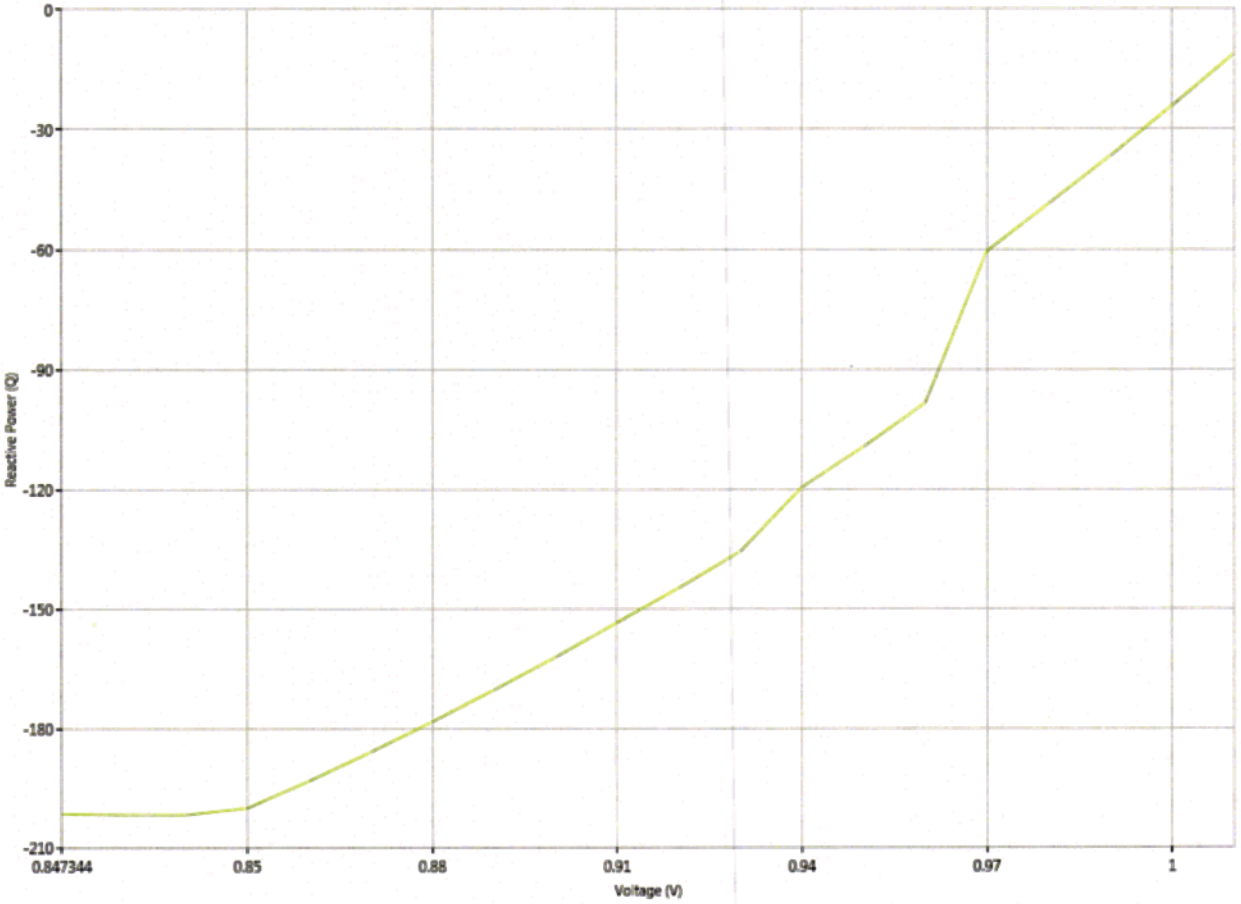
HACKBERY 230.0

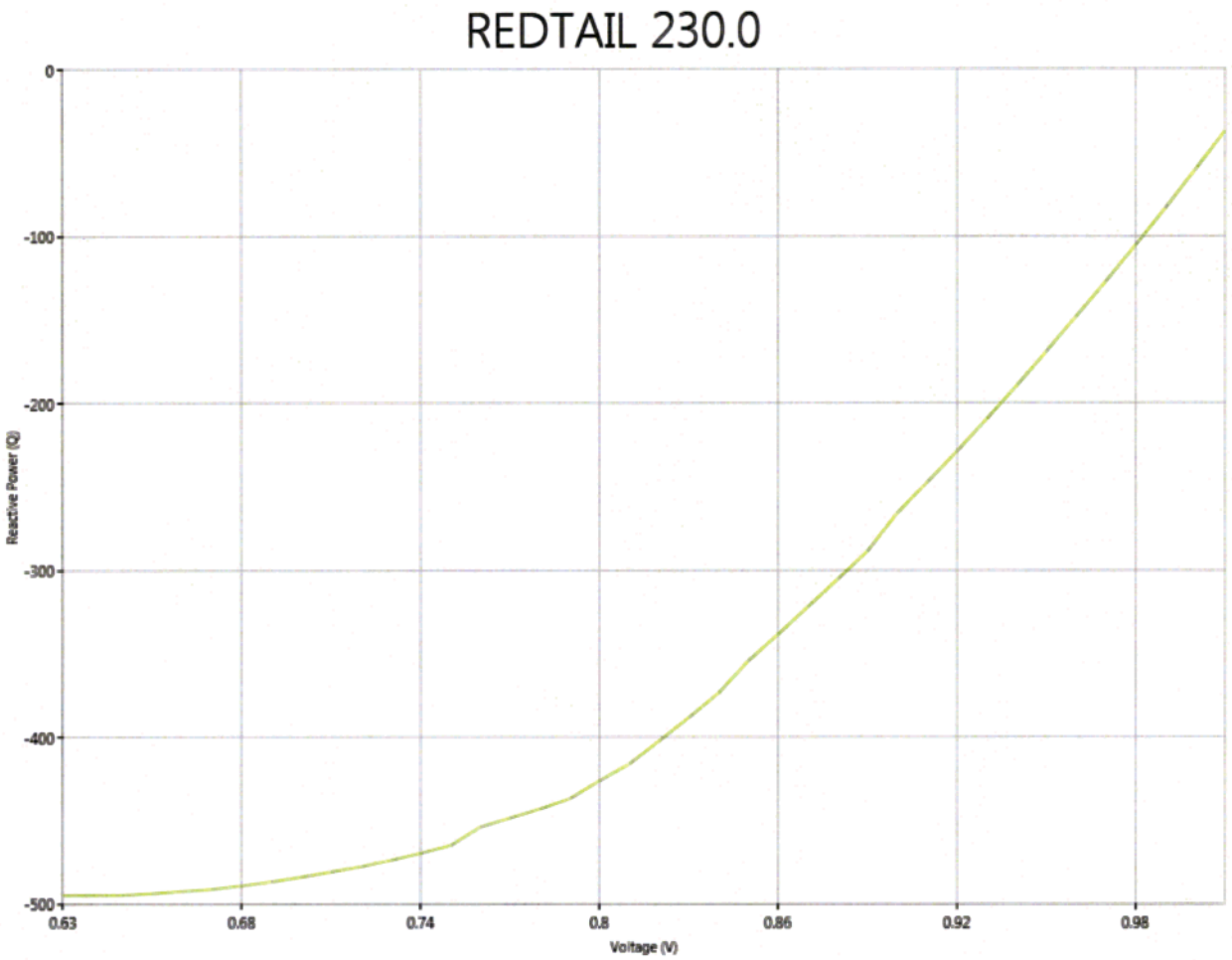


MARANA 115.0

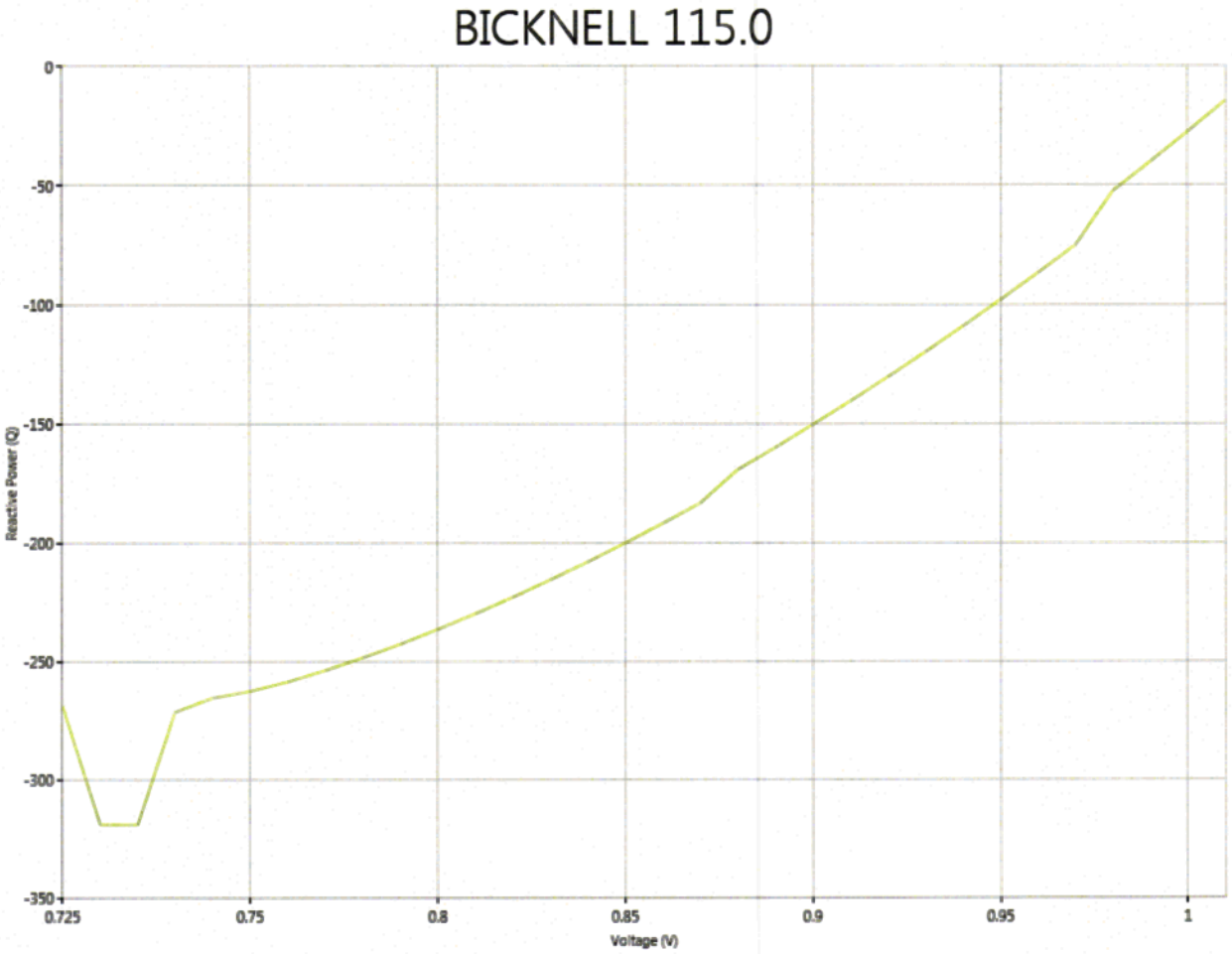

50
0
-50
-100
-150
-200
-250
-300
Reactive Power (Q)
0.751201
0.755
0.8
0.85
0.9
0.95
1
Voltage (V)

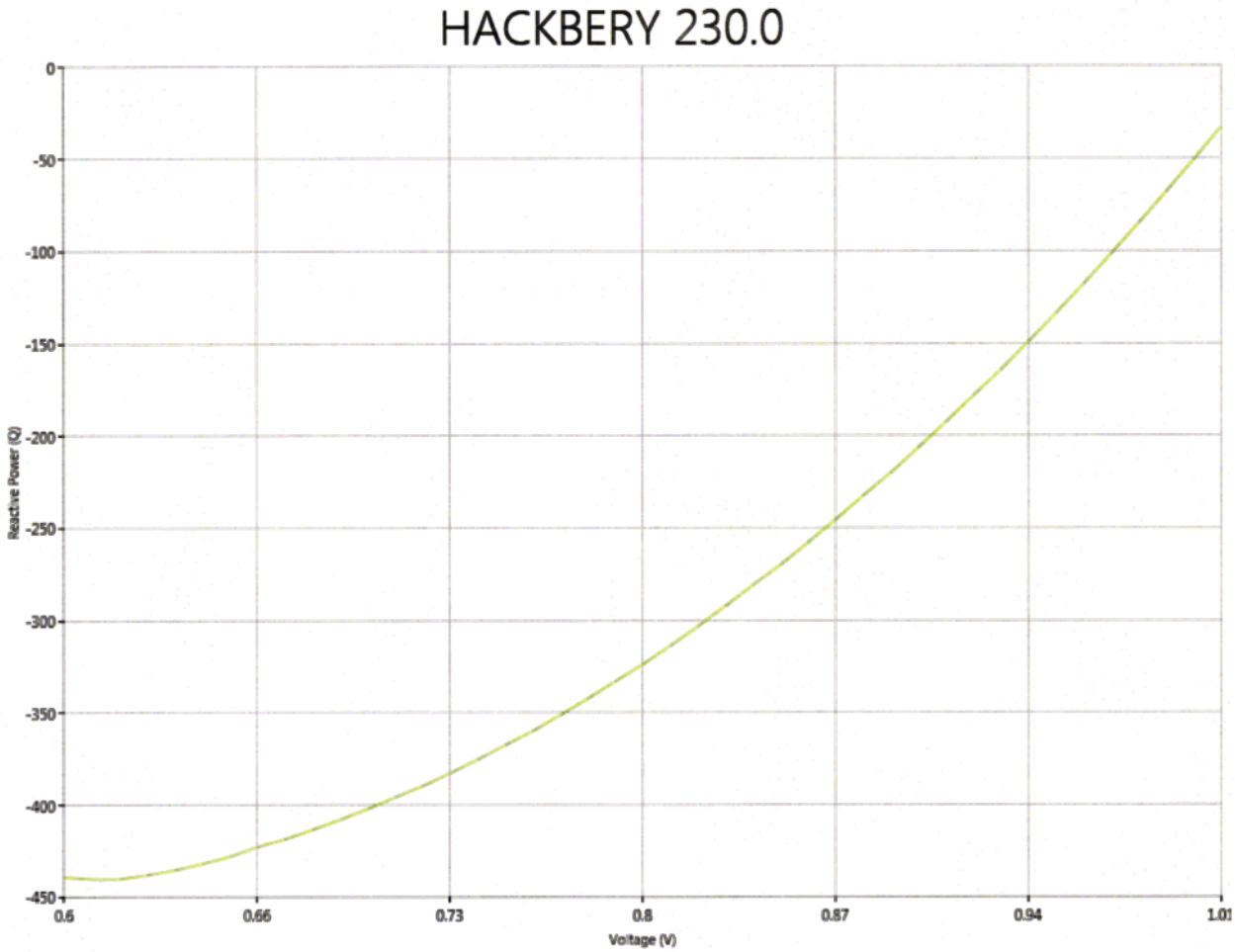
PANTANO 230.0

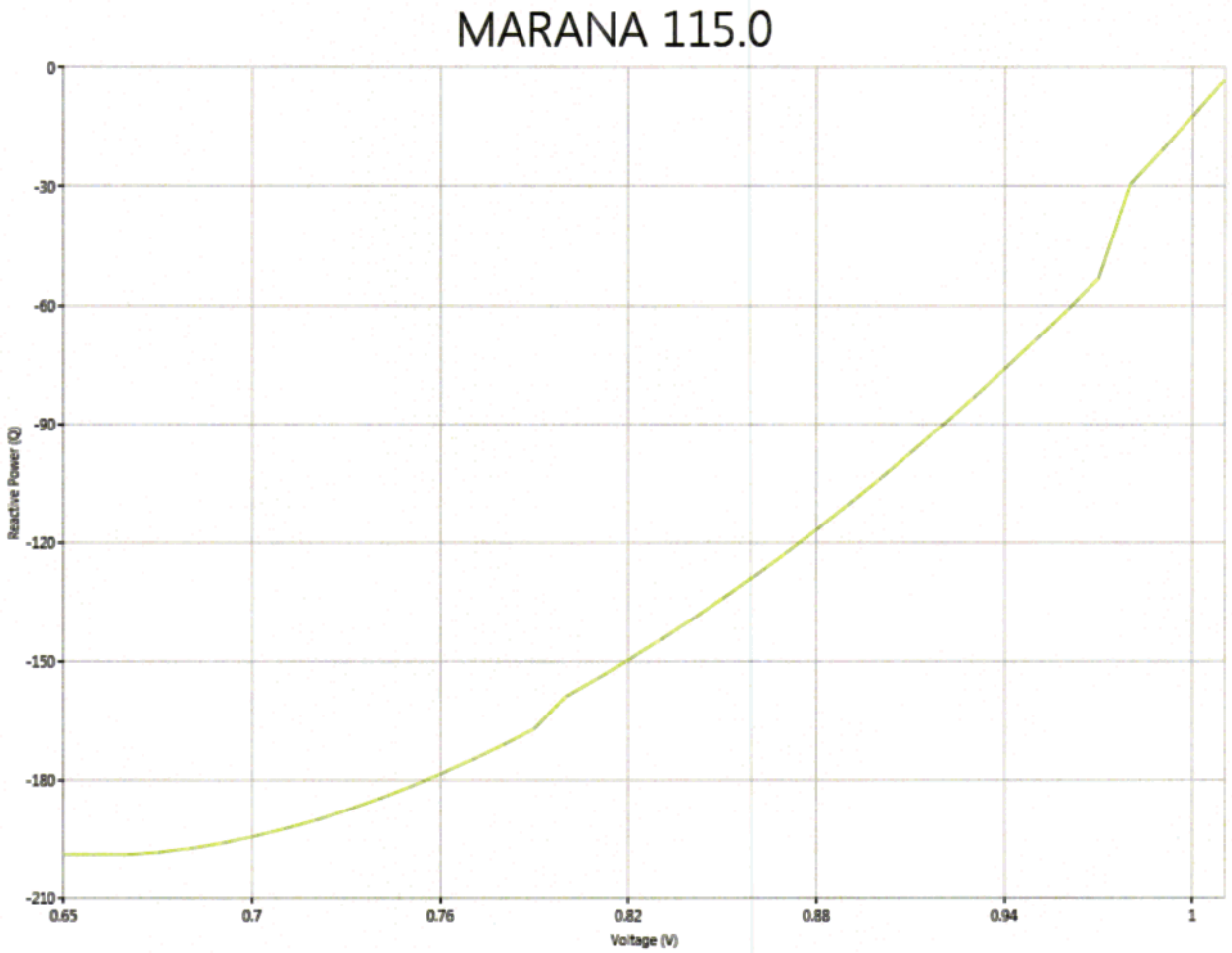


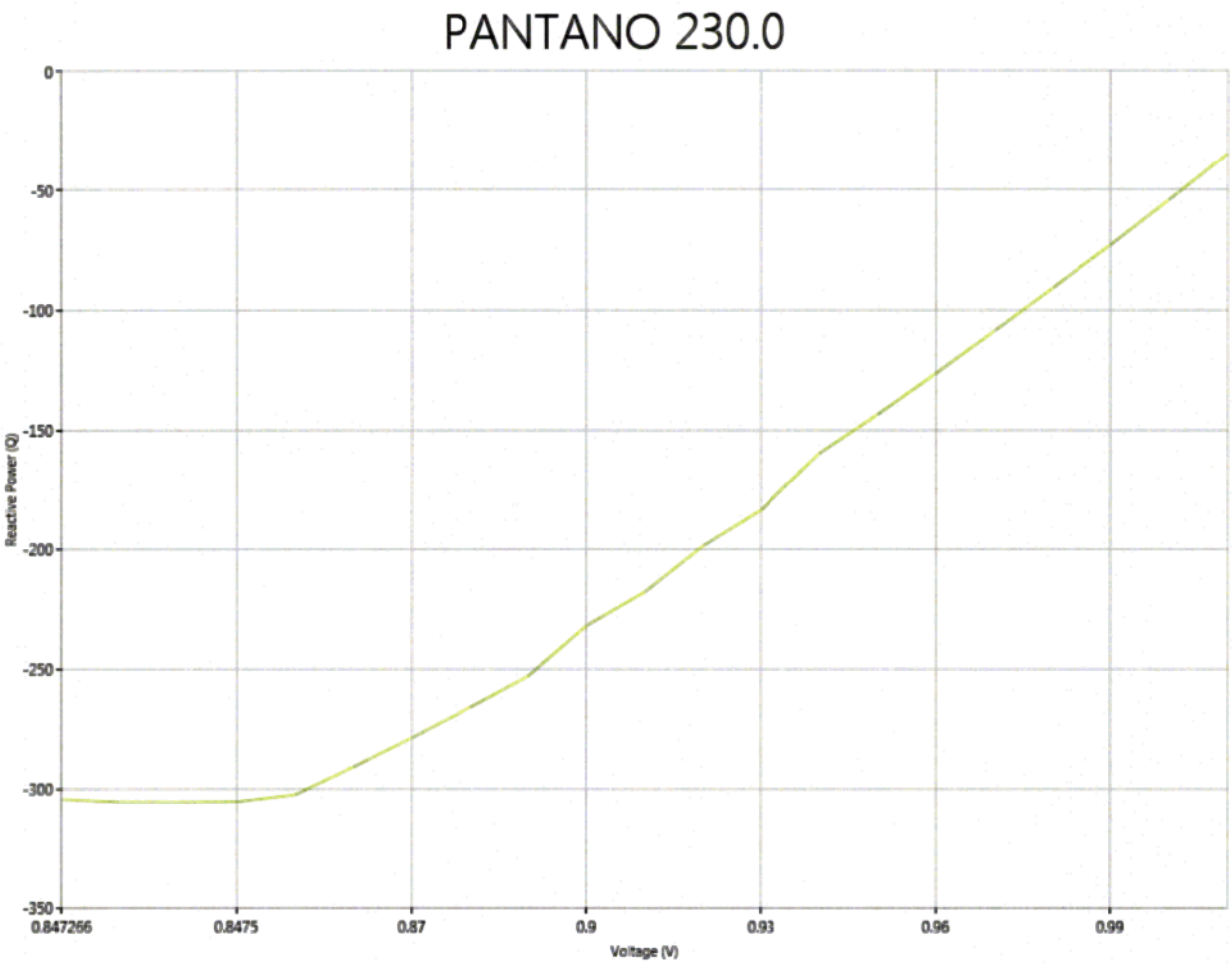

REDTAIL 230.0
0
-100
-200
-300
-400
-500
Reactive Power (Q)
0.63
0.68
0.74
0.8
0.86
0.92
0.98
Voltage (V)

Marana Group 115 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

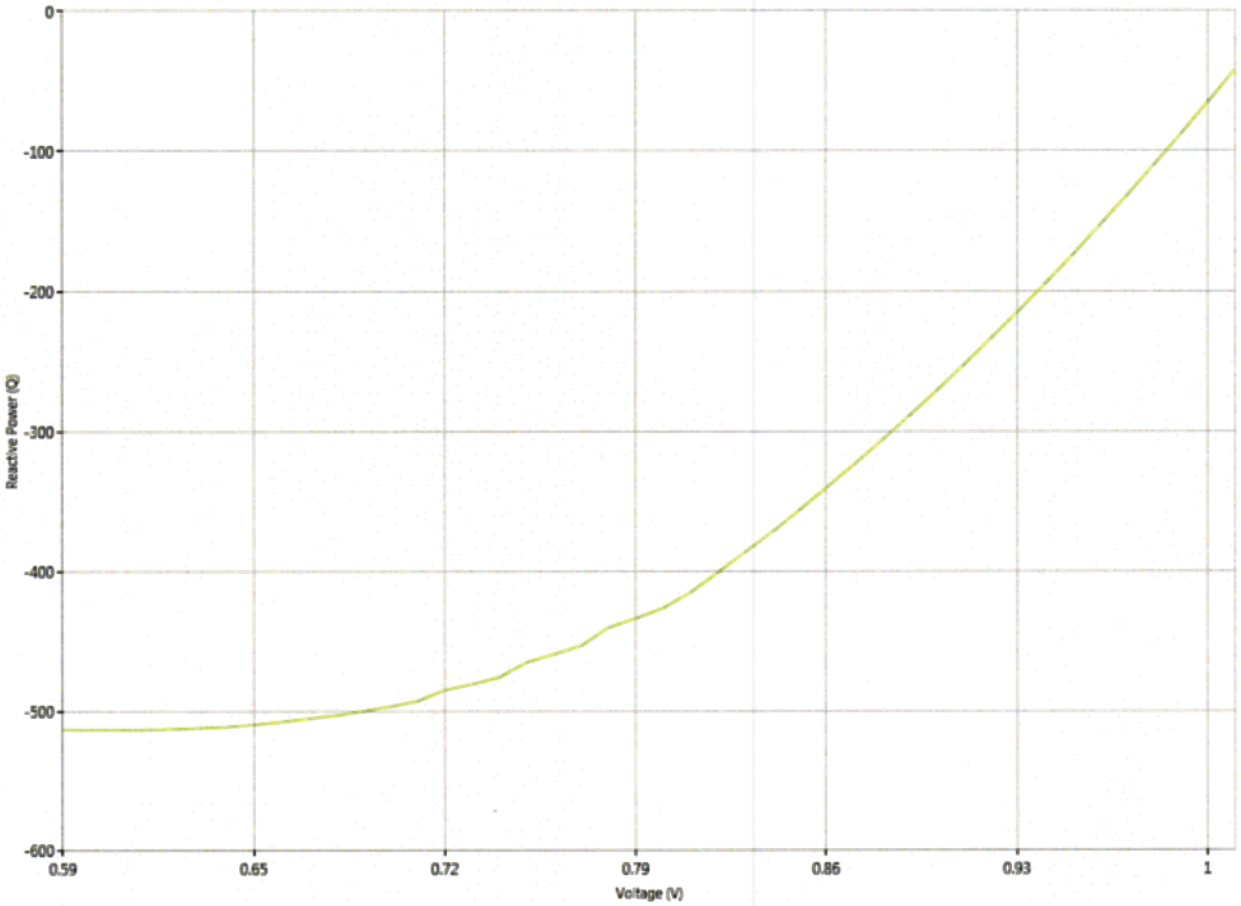



HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.6
0.66
0.73
0.8
0.87
0.94
1.01
Voltage (V)


MARANA 115.0
0
-30
-60
-90
-120
-150
-180
-210
Reactive Power (Q)
0.65
0.7
0.76
0.82
0.88
0.94
1
Voltage (V)

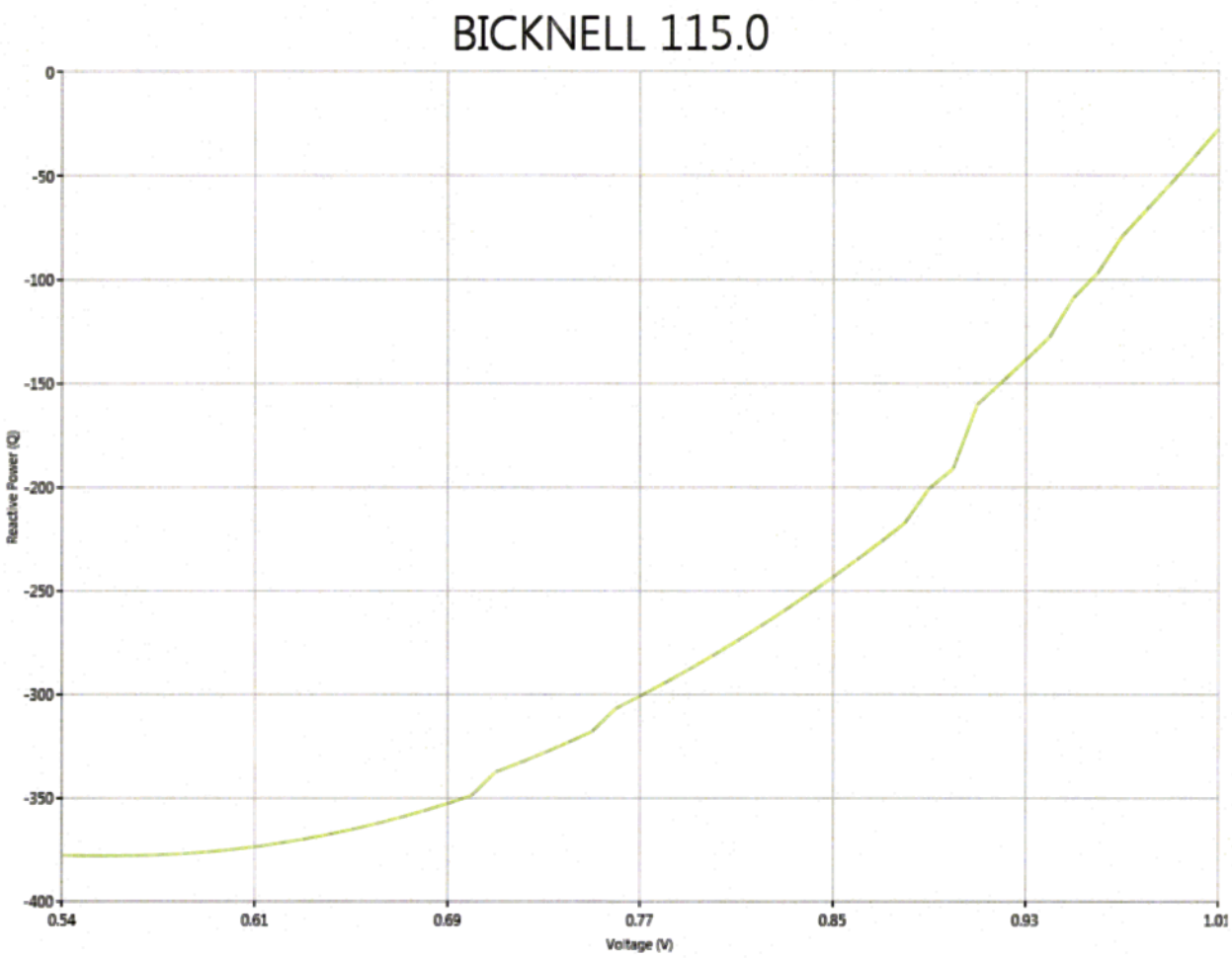

PANTANO 230.0
0
-50
-100
-150
-200
-250
-300
-350
Reactive Power (Q)
0.847266
0.8475
0.87
0.9
0.93
0.96
0.99
Voltage (V)

REDTAIL 230.0

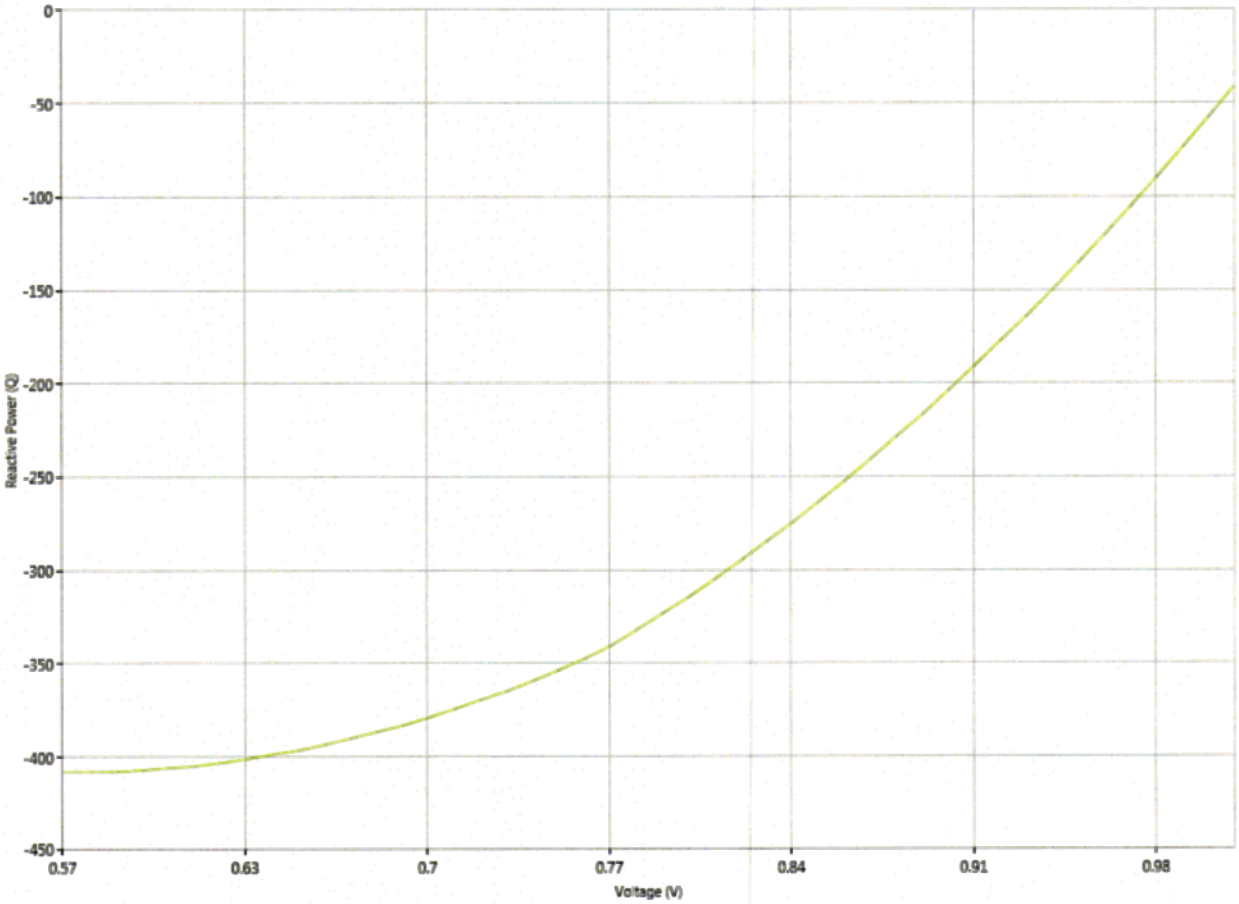


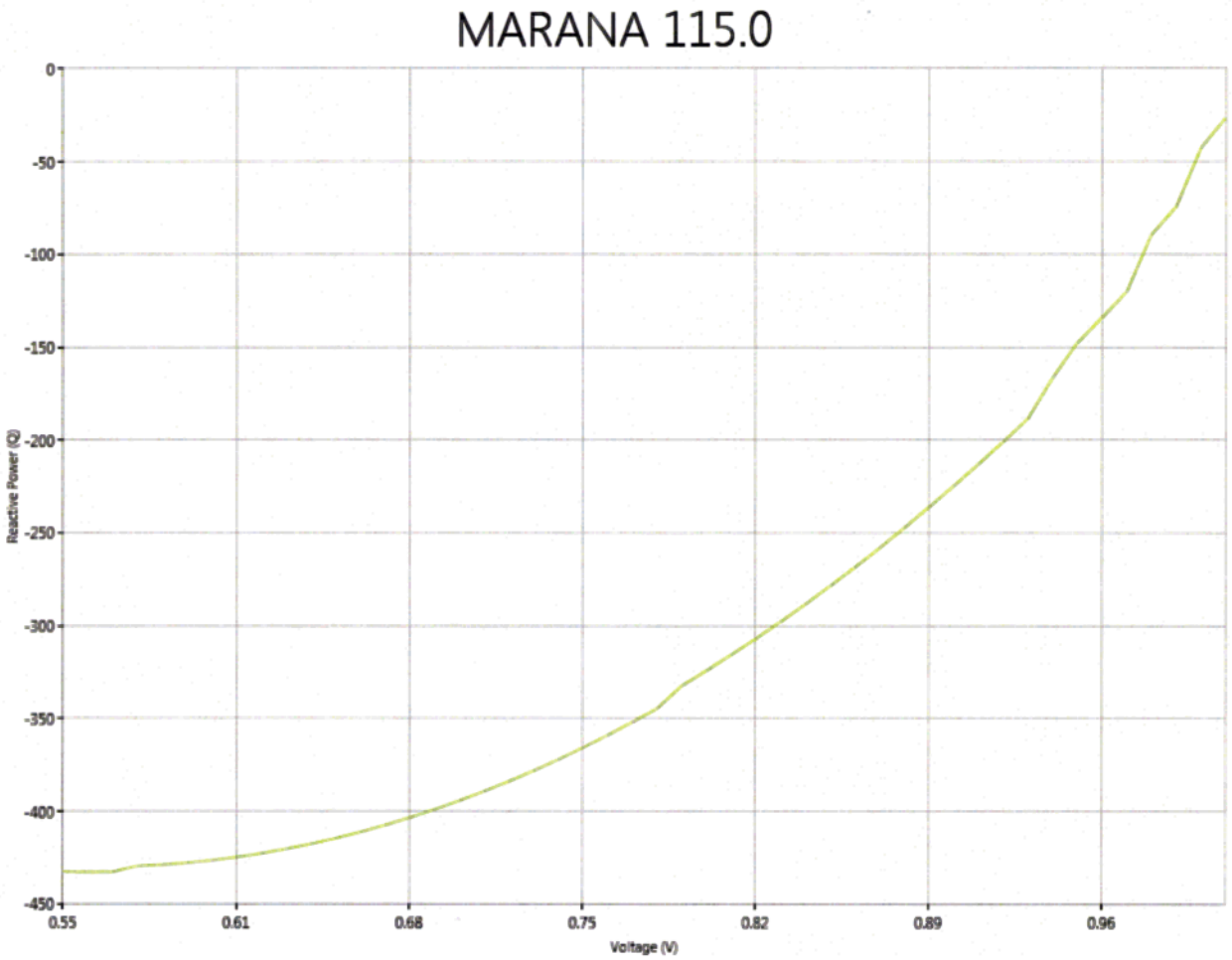
2021 HEAVY WINTER

Apache to Butterfield 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

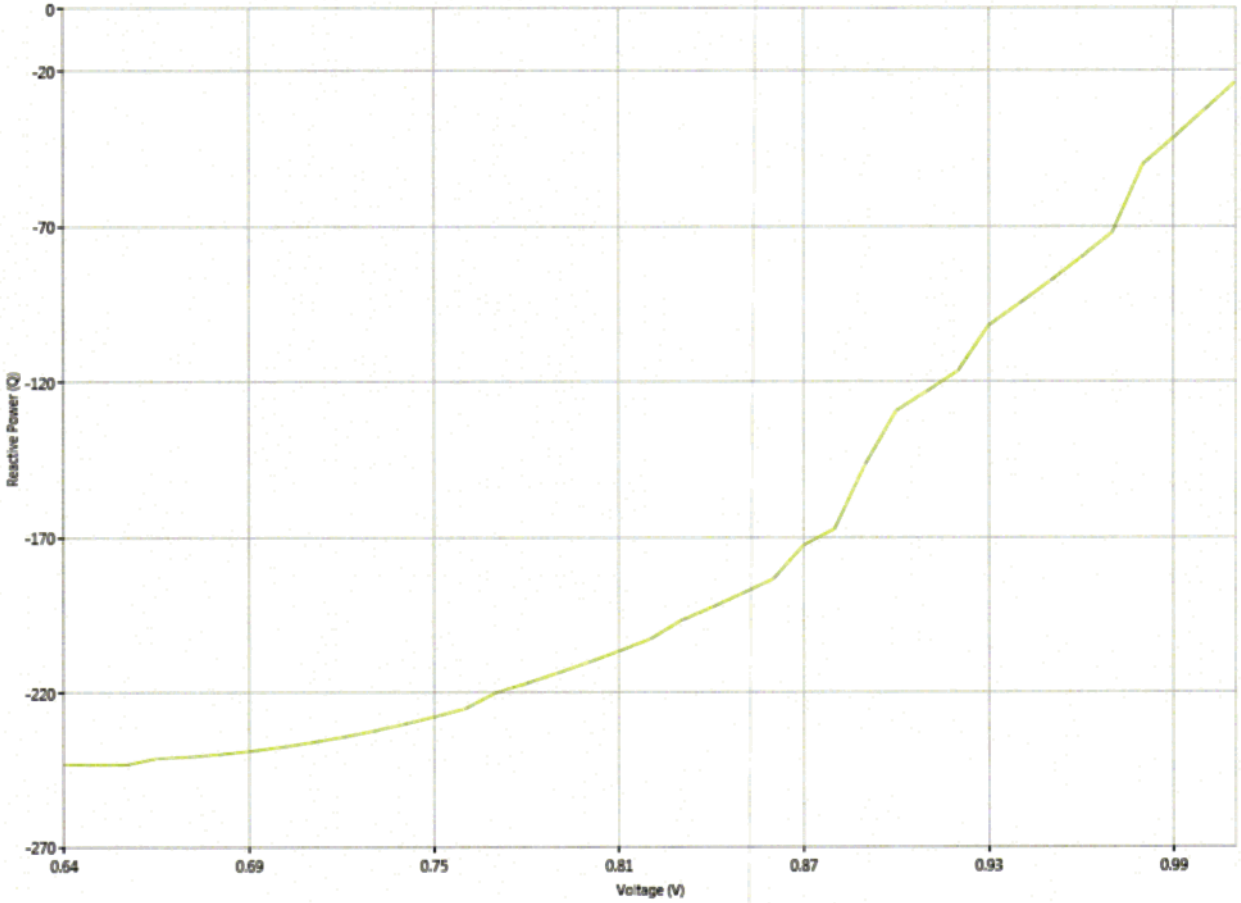


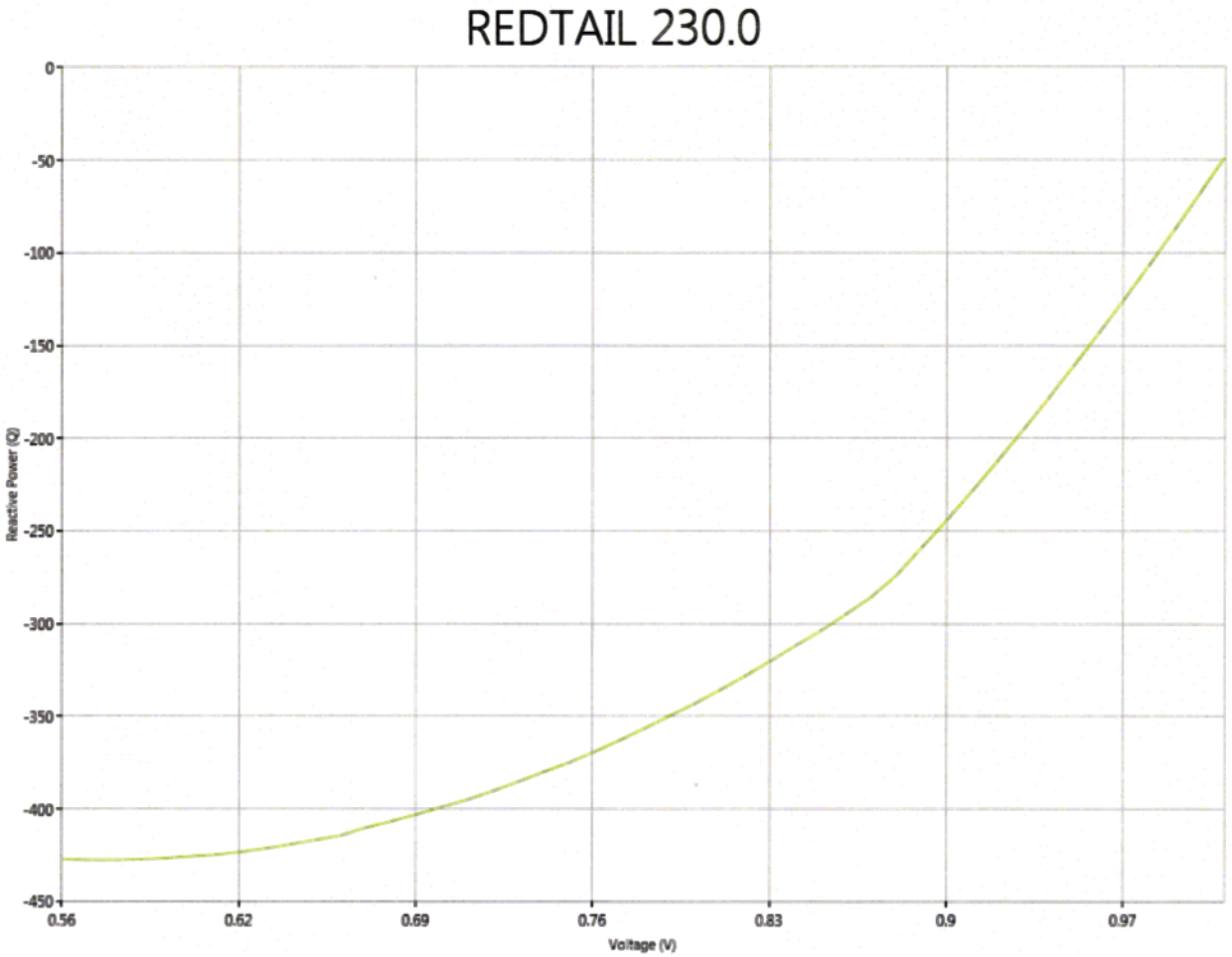
HACKBERY 230.0



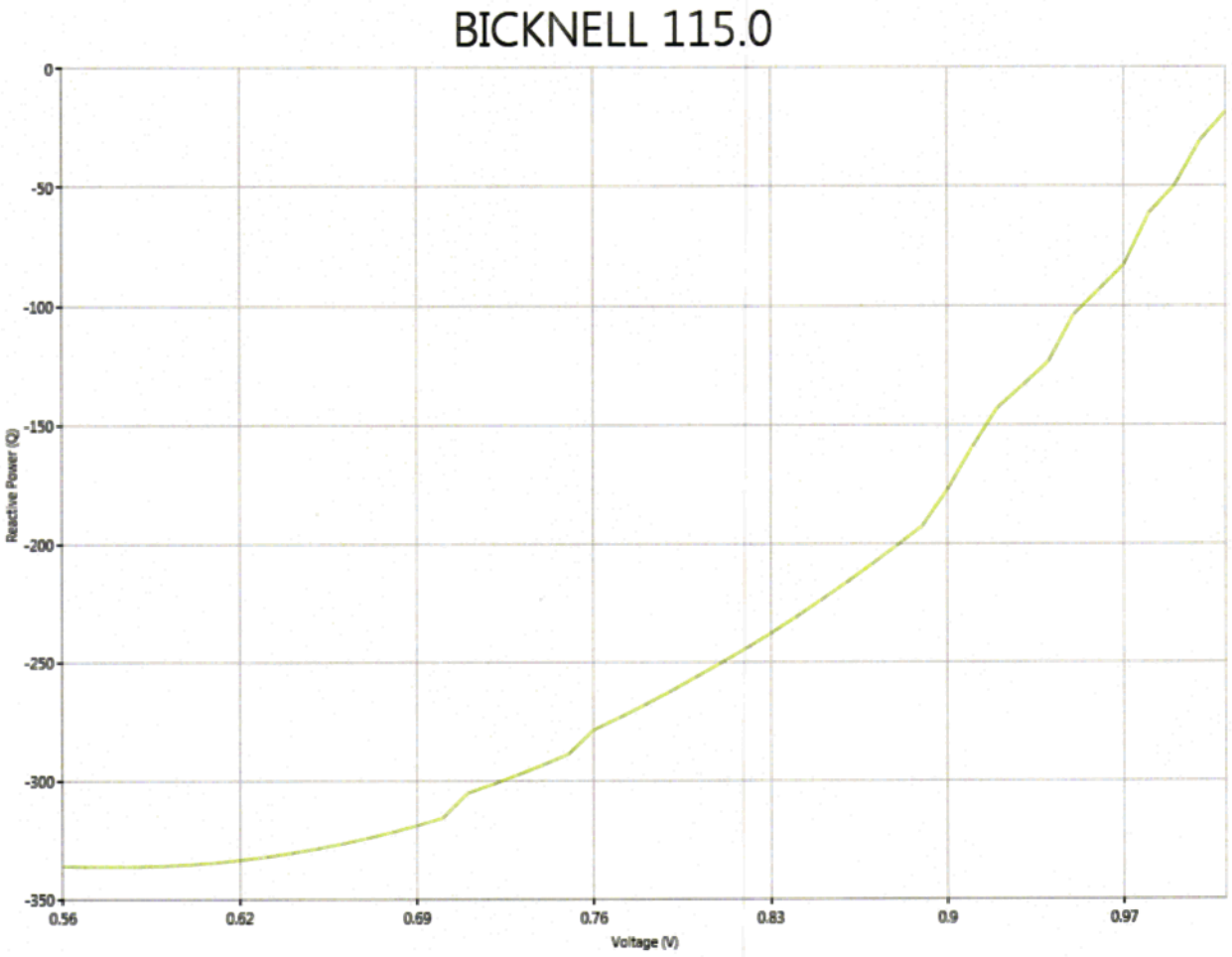

MARANA 115.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.55
0.61
0.68
0.75
0.82
0.89
0.96
Voltage (V)

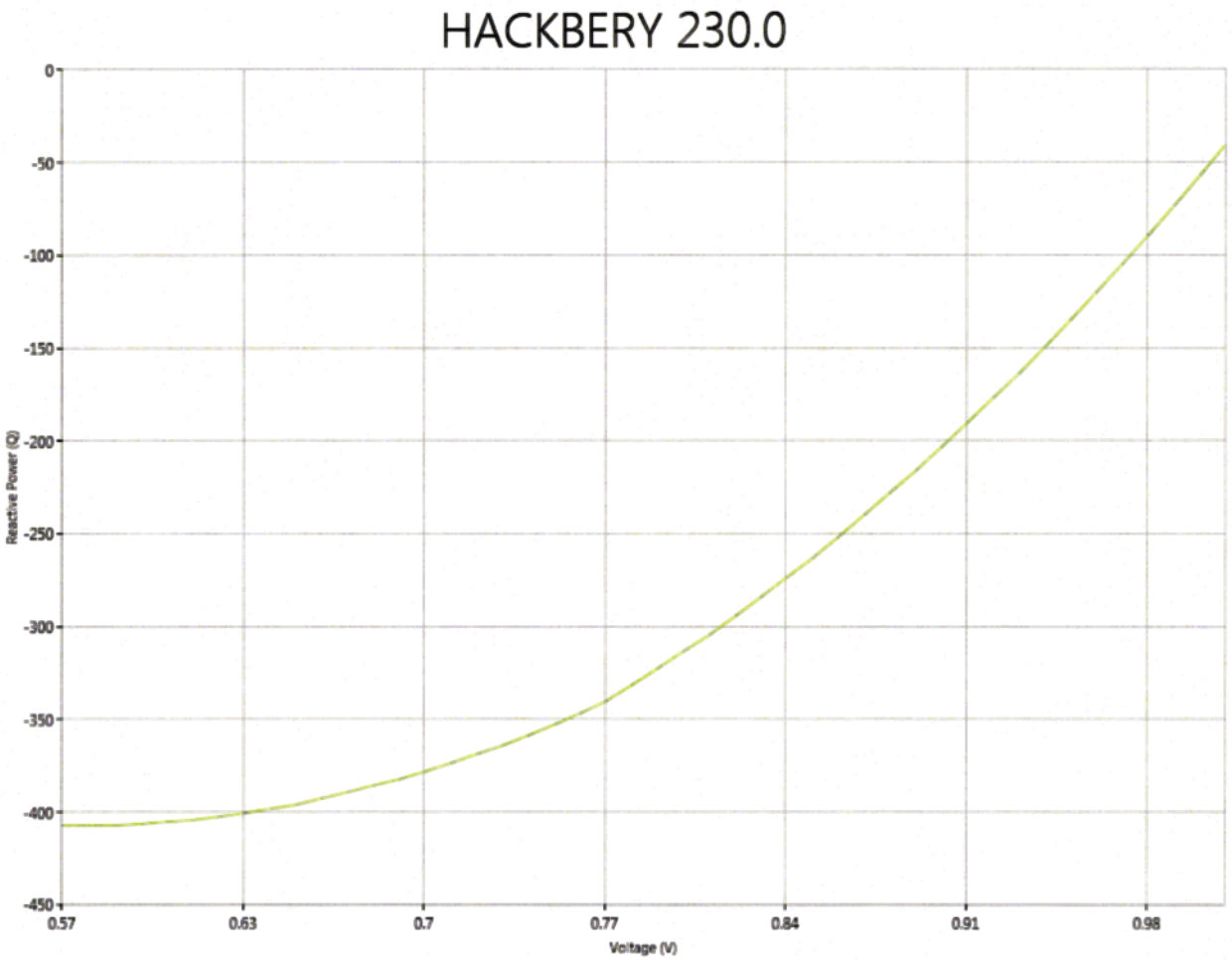
PANTANO 230.0



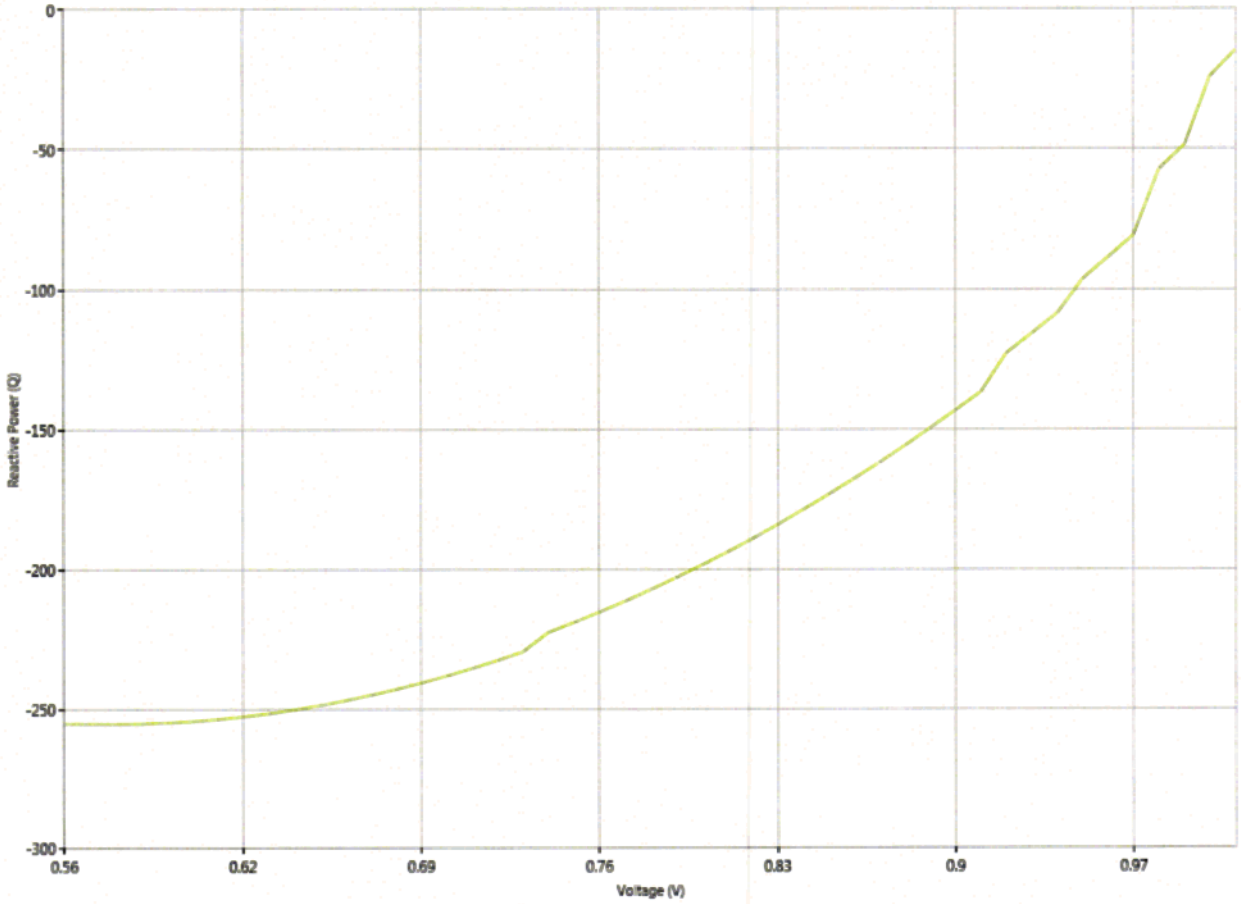

REDTAIL 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)

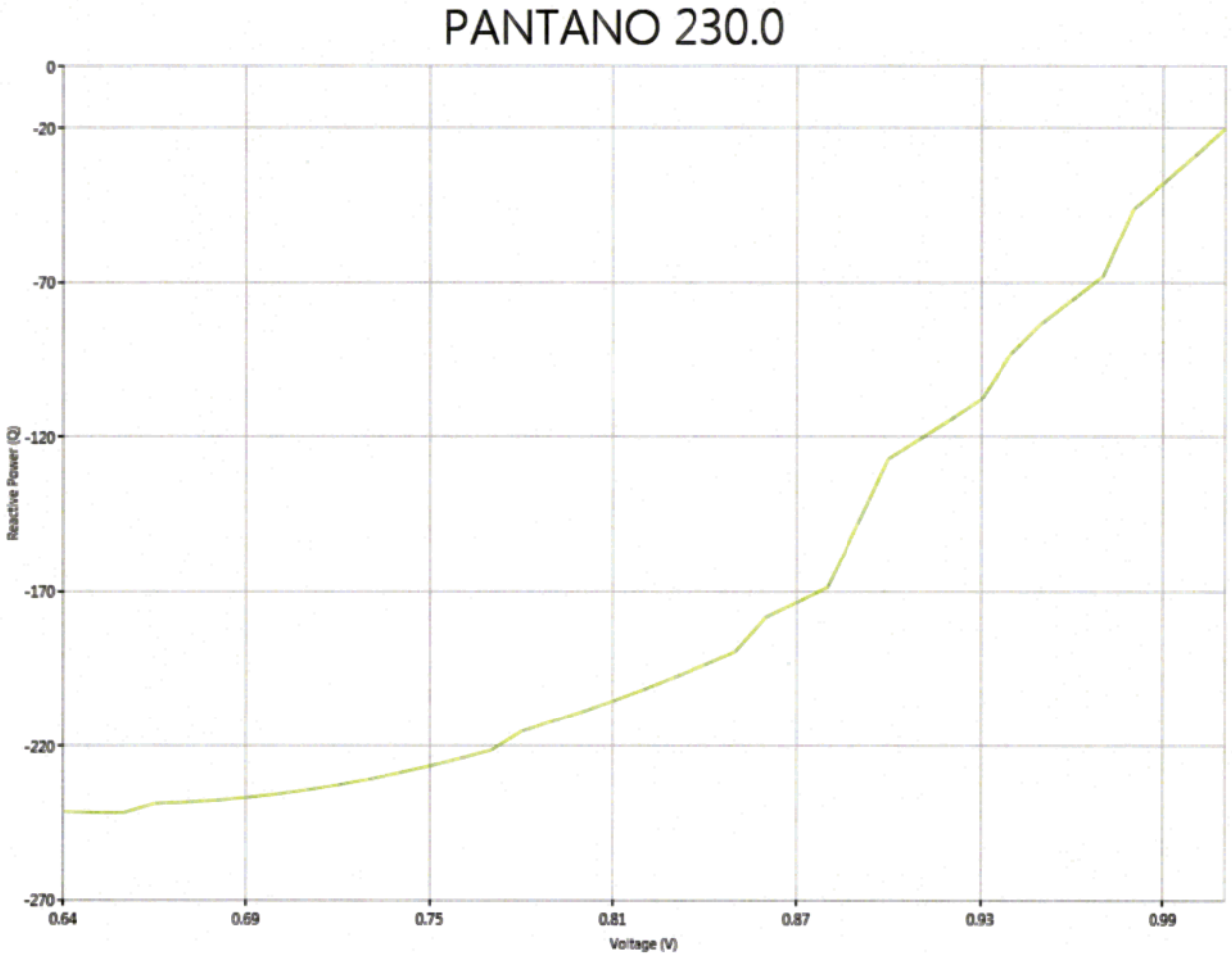
Apache to Butterfield 230 kV and Marana Group Outages
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

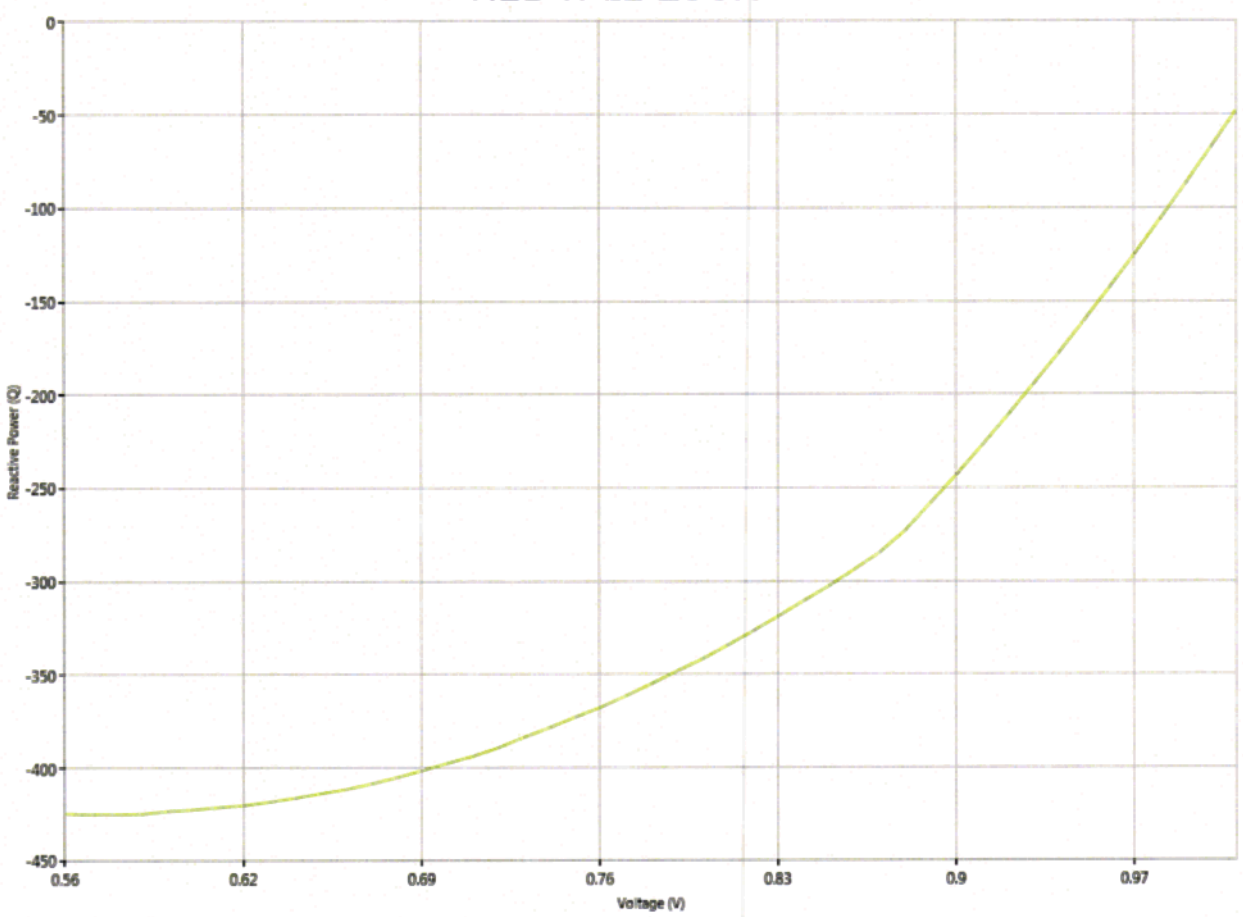



HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.57
0.63
0.7
0.77
0.84
0.91
0.98
Voltage (V)

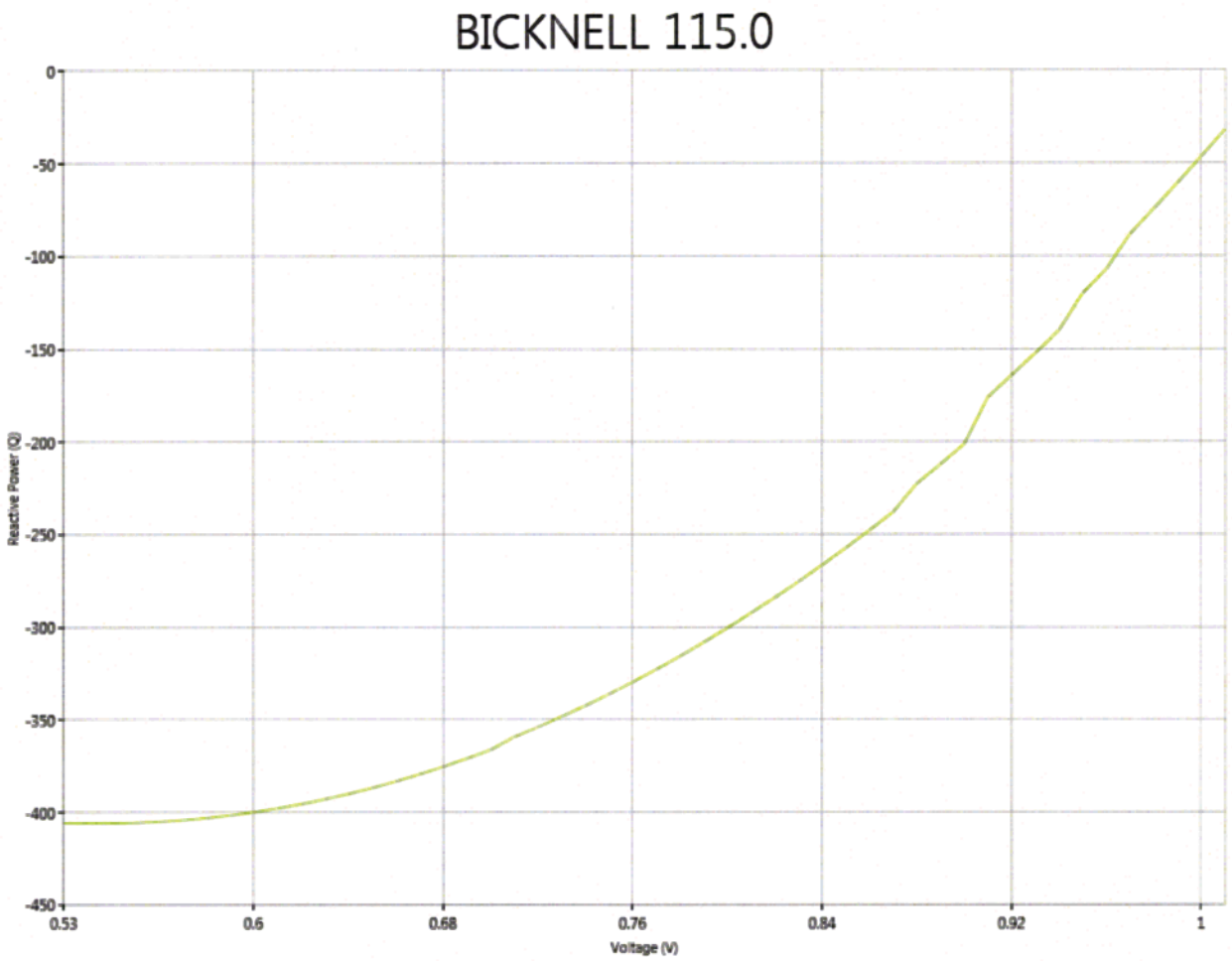
MARANA 115.0


0
-50
-100
-150
-200
-250
-300
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)

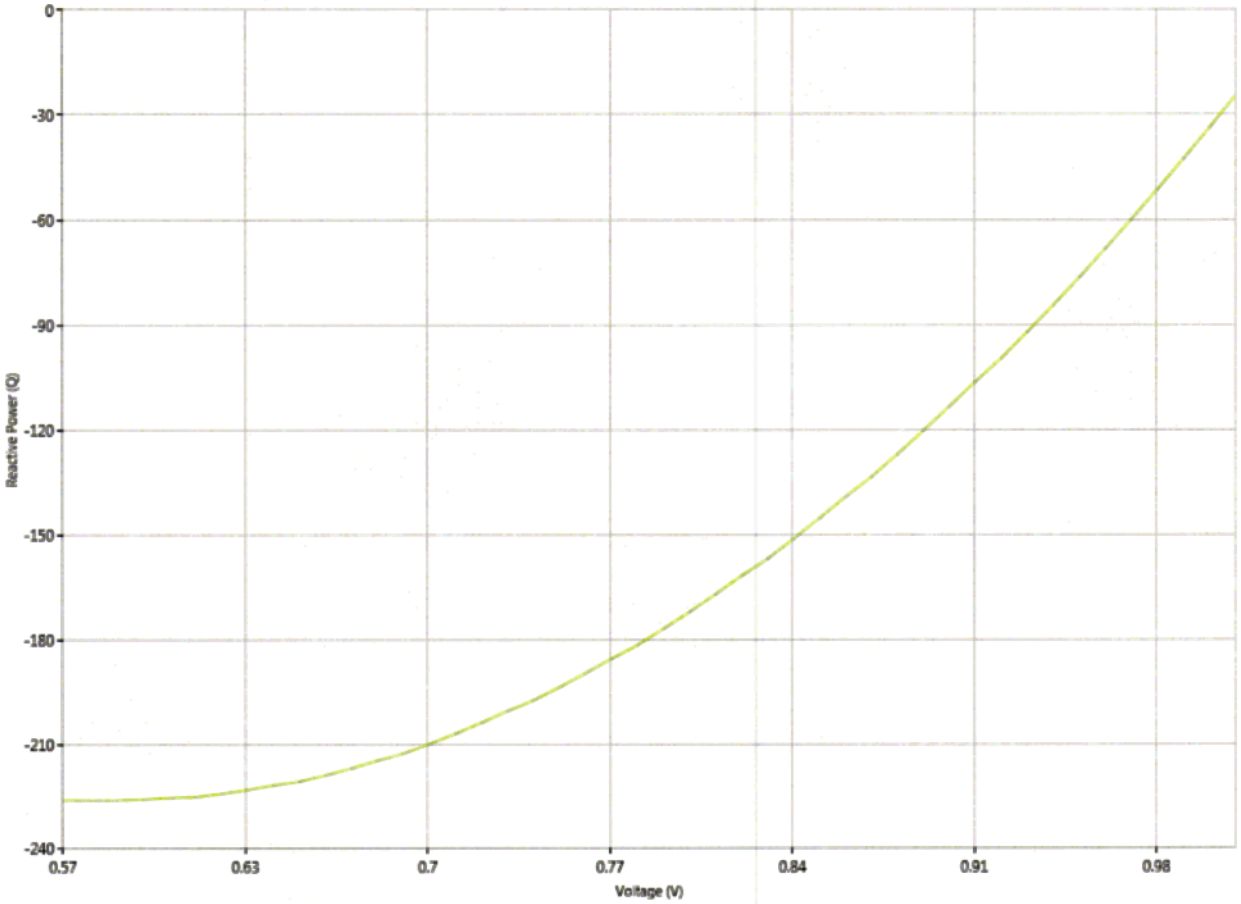

PANTANO 230.0
0
-20
-70
-120
-170
-220
-270
Reactive Power (Q)
0.64
0.69
0.75
0.81
0.87
0.93
0.99
Voltage (V)


REDTAIL 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)

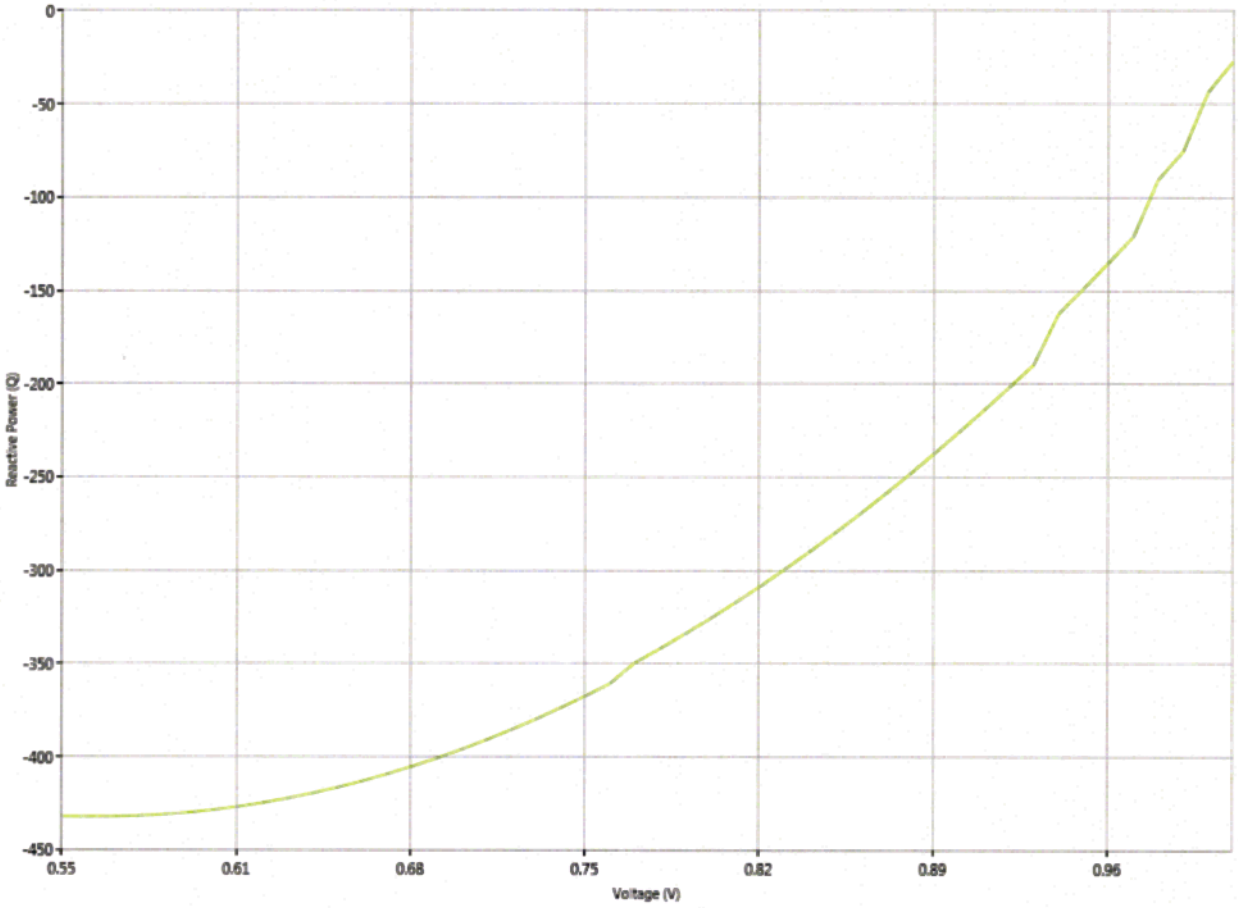
Apache to Redtail 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses



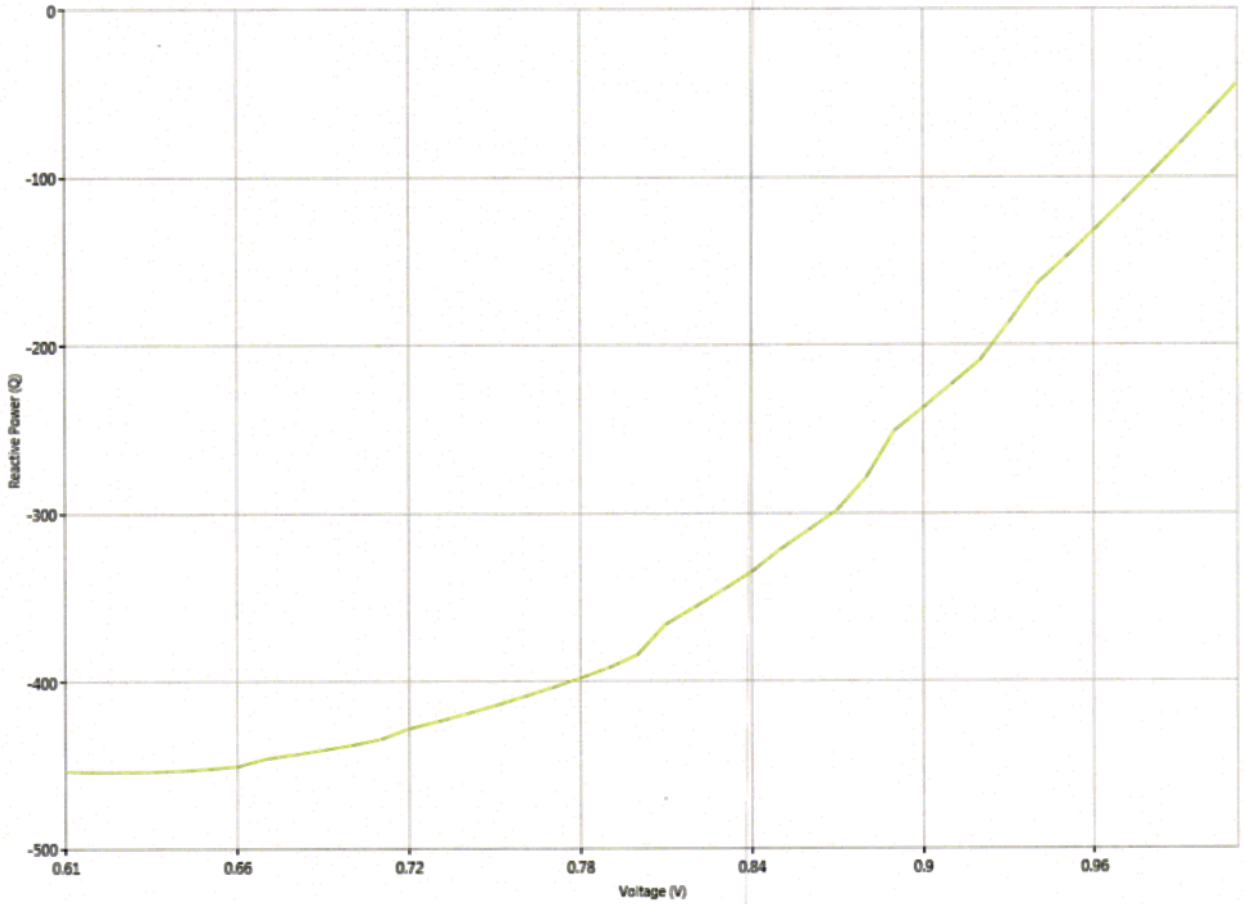
HACKBERY 230.0

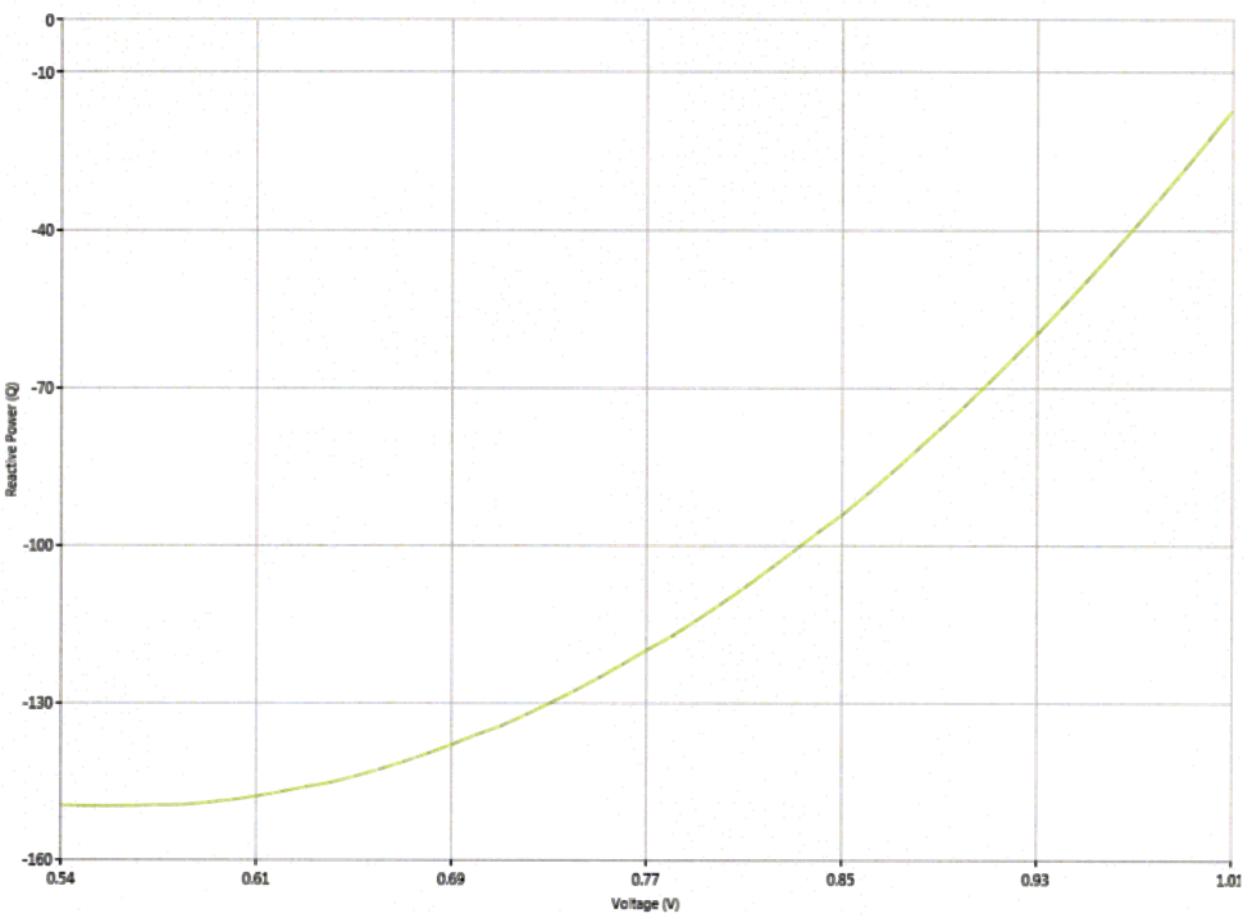


MARANA 115.0

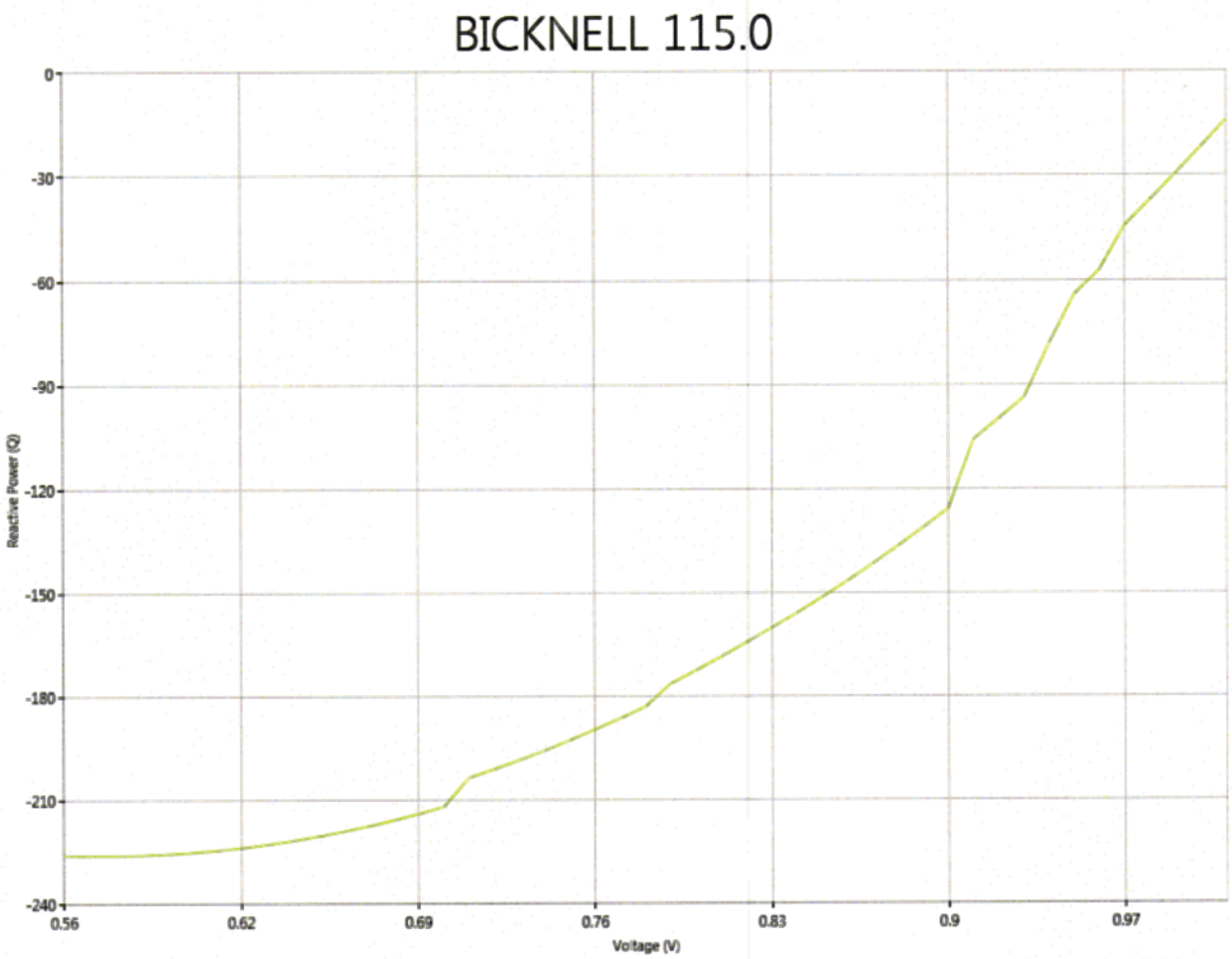

0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.55
0.61
0.68
0.75
0.82
0.89
0.96
Voltage (V)

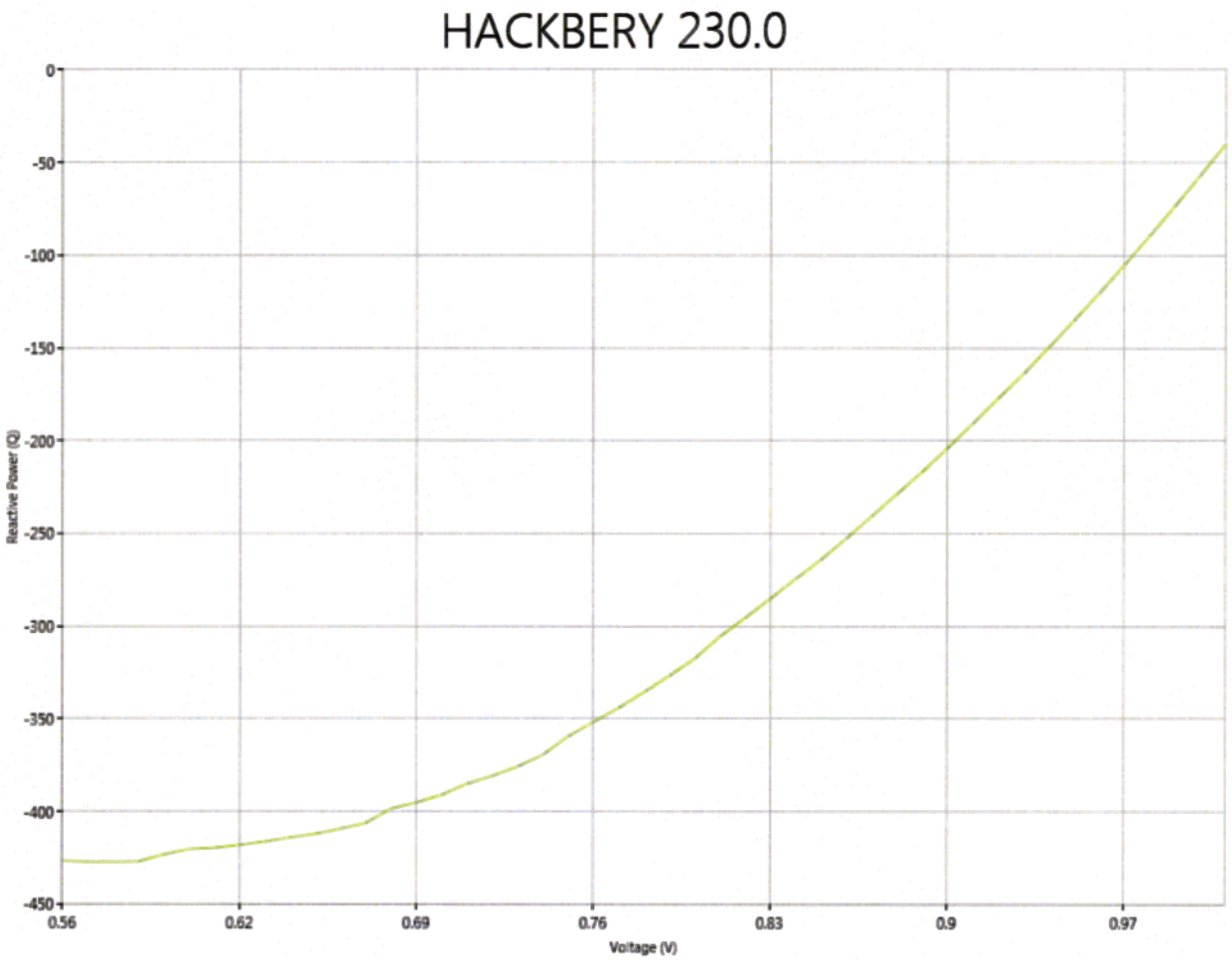
PANTANO 230.0



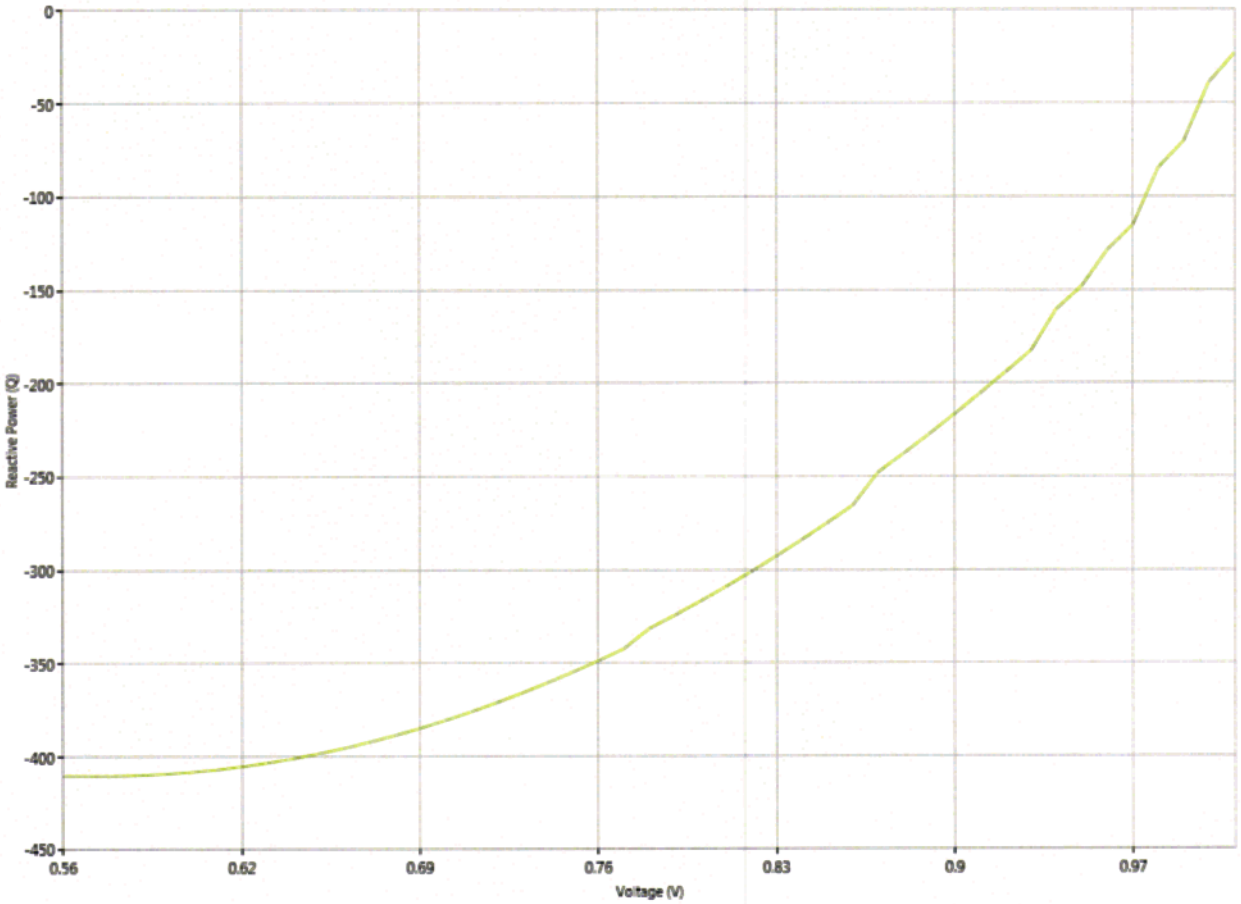

REDTAIL 230.0
0
-10
-40
-70
-100
-130
-160
Reactive Power (Q)
0.54
0.61
0.69
0.77
0.85
0.93
1.01
Voltage (V)

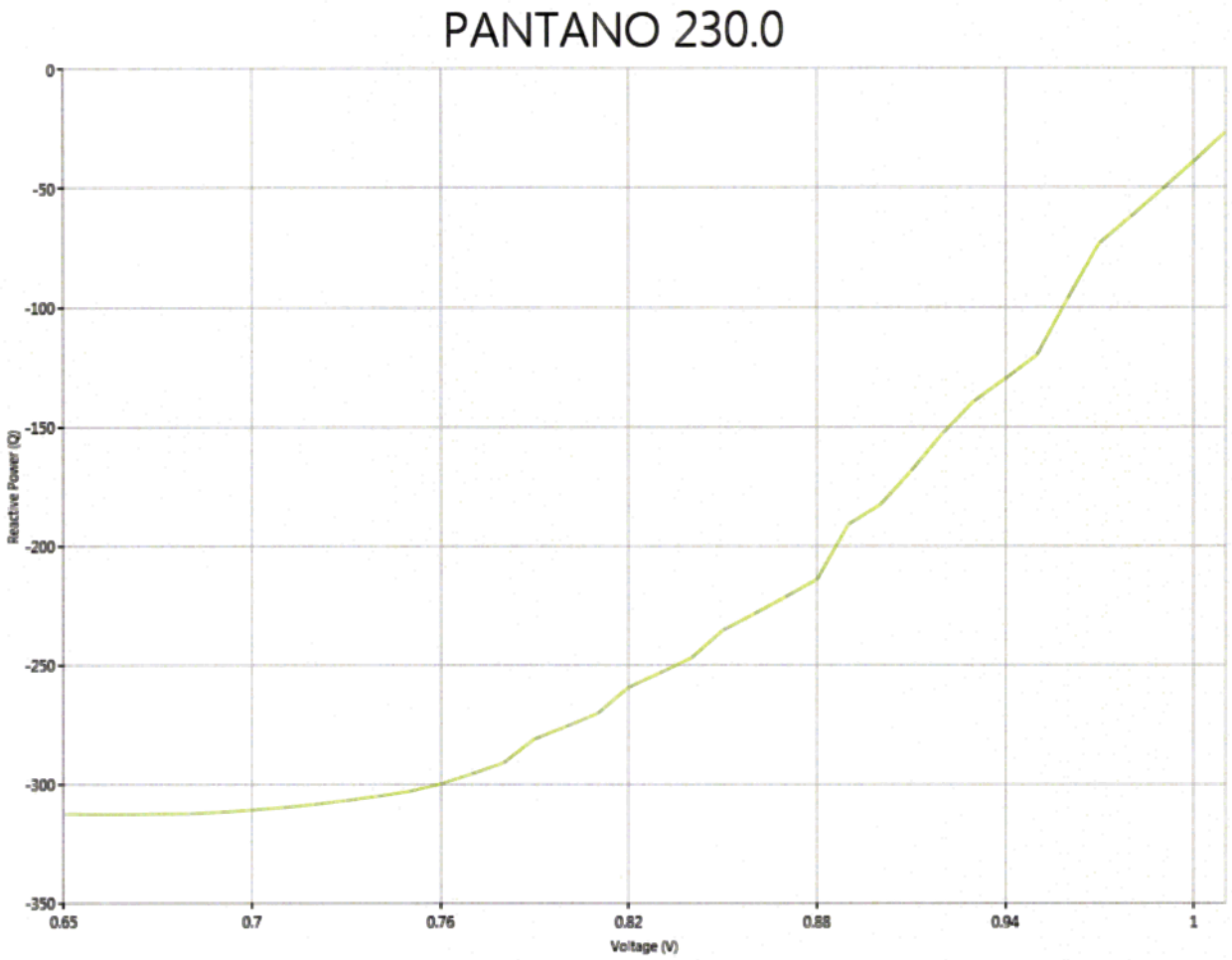
Bicknell to Vail 345 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

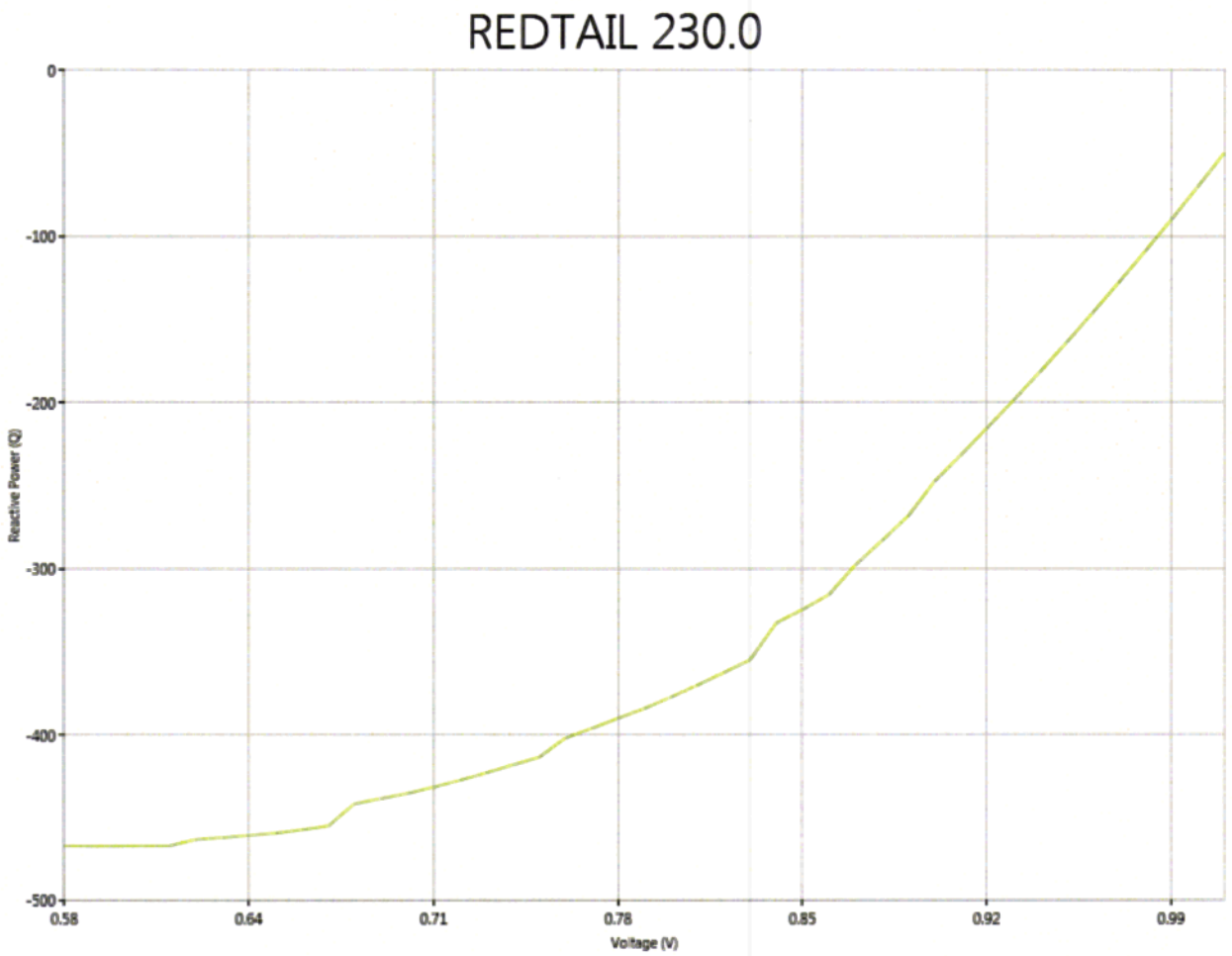



HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)

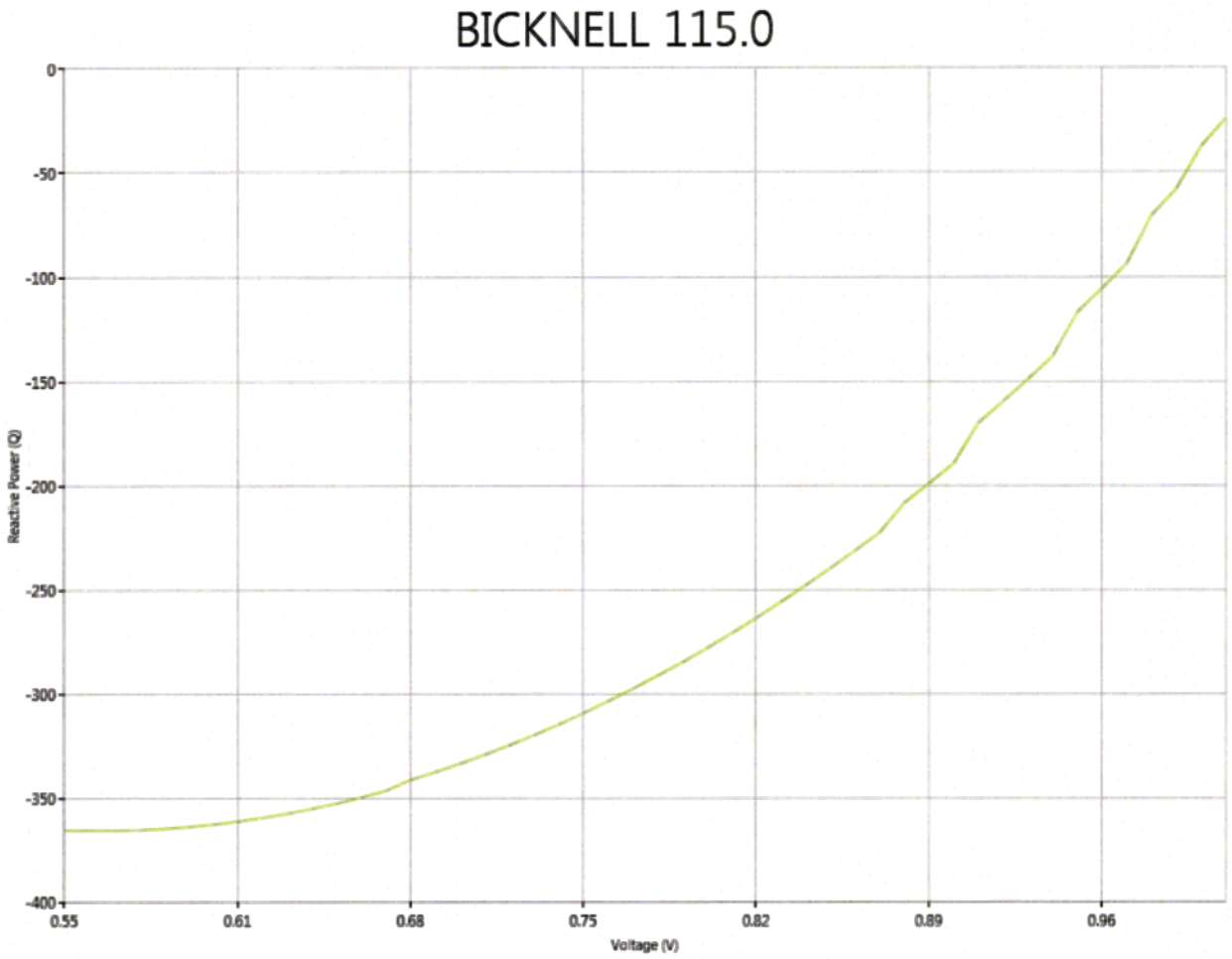
MARANA 115.0


0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)

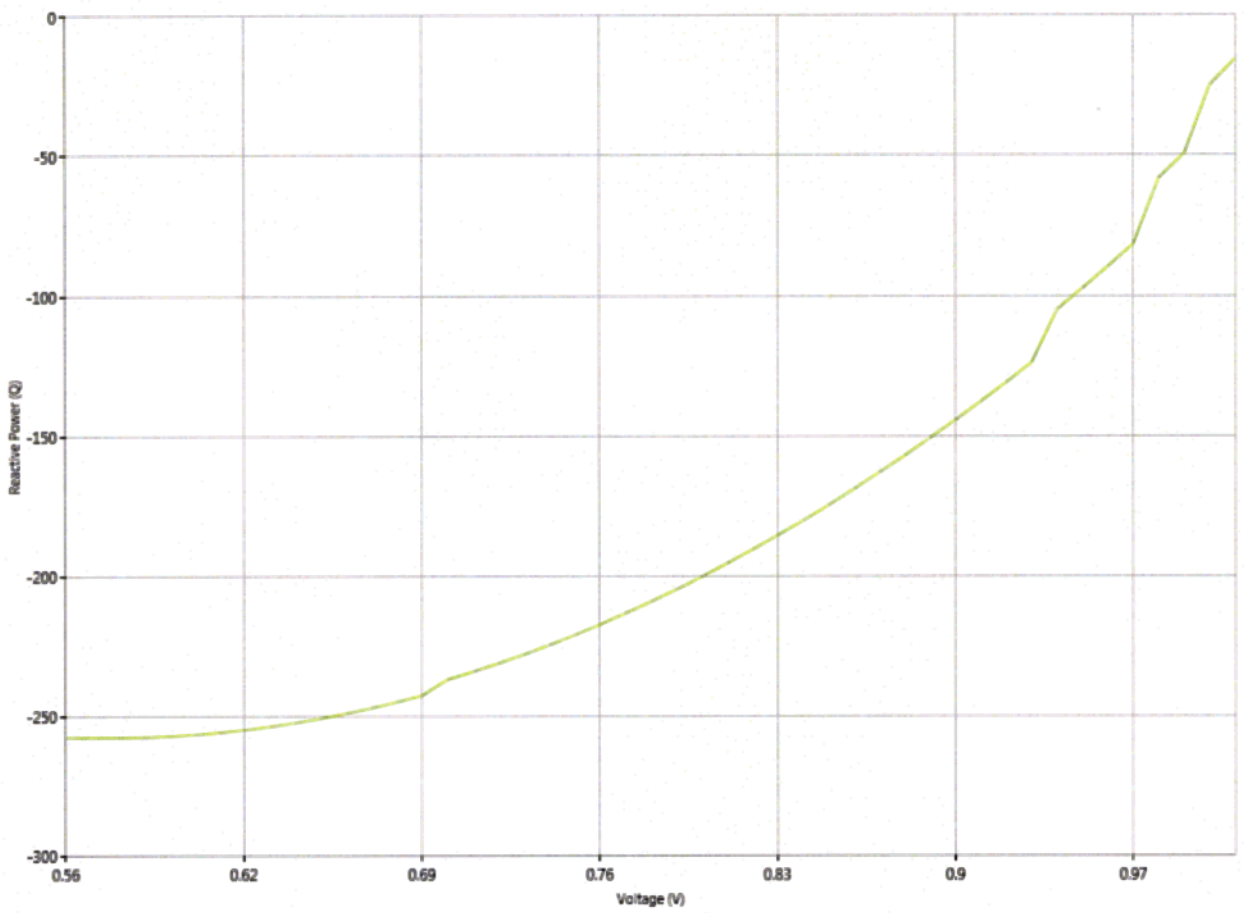

PANTANO 230.0
0
-50
-100
-150
-200
-250
-300
-350
Reactive Power (Q)
0.65
0.7
0.76
0.82
0.88
0.94
1
Voltage (V)

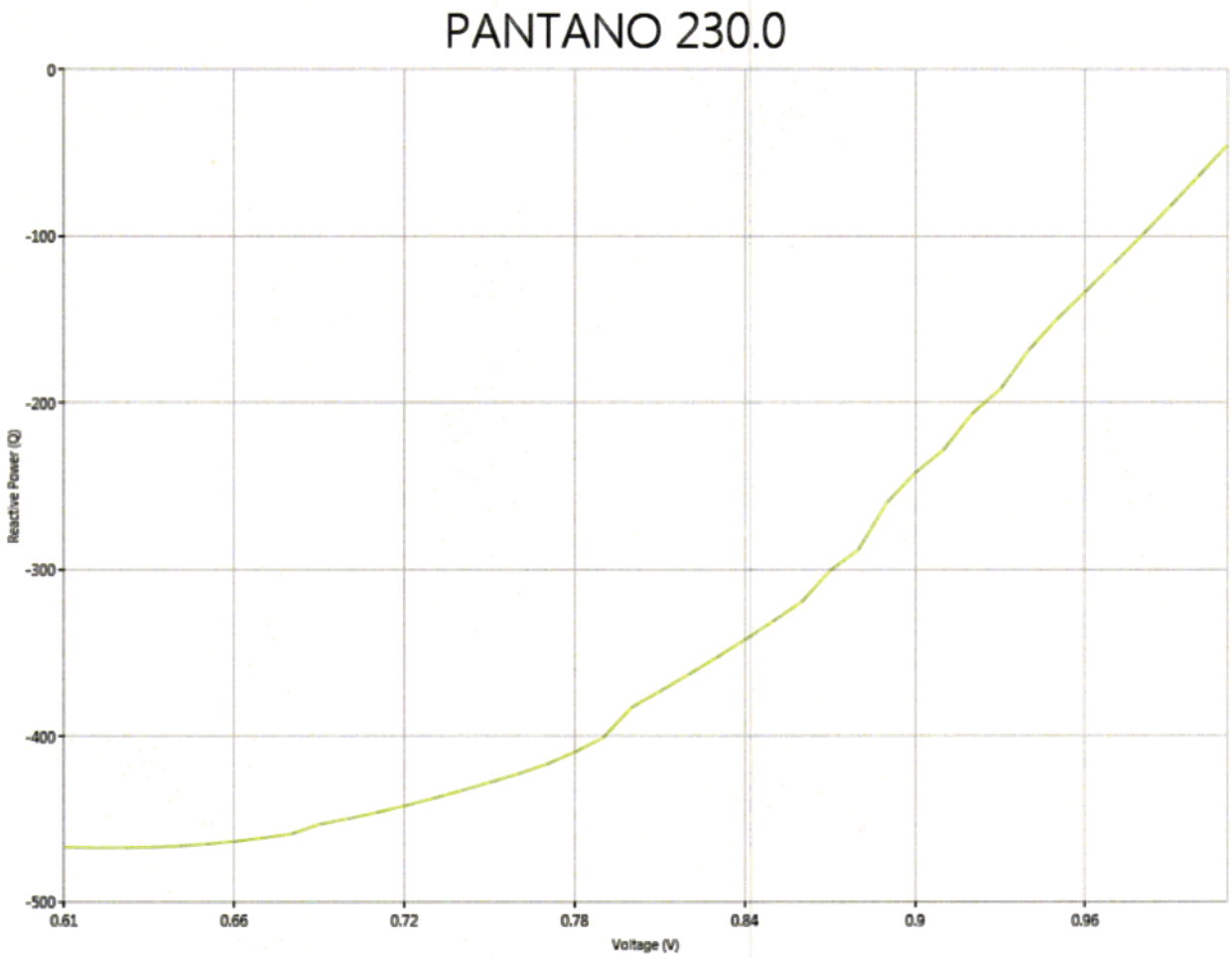

REDTAIL 230.0
0
-100
-200
-300
-400
-500
Reactive Power (Q)
0.58
0.64
0.71
0.78
0.85
0.92
0.99
Voltage (V)

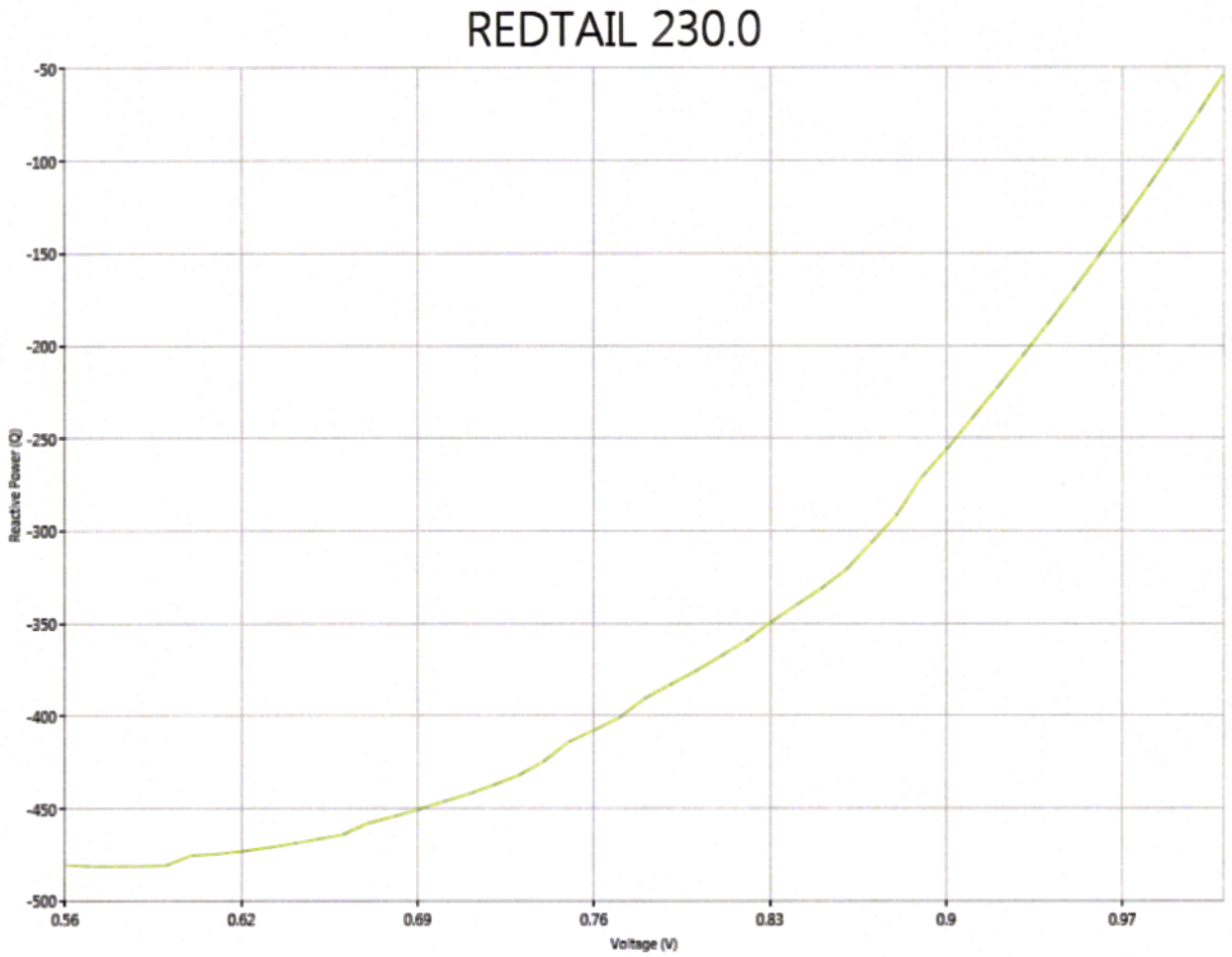
Marana Group 115 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses




HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)

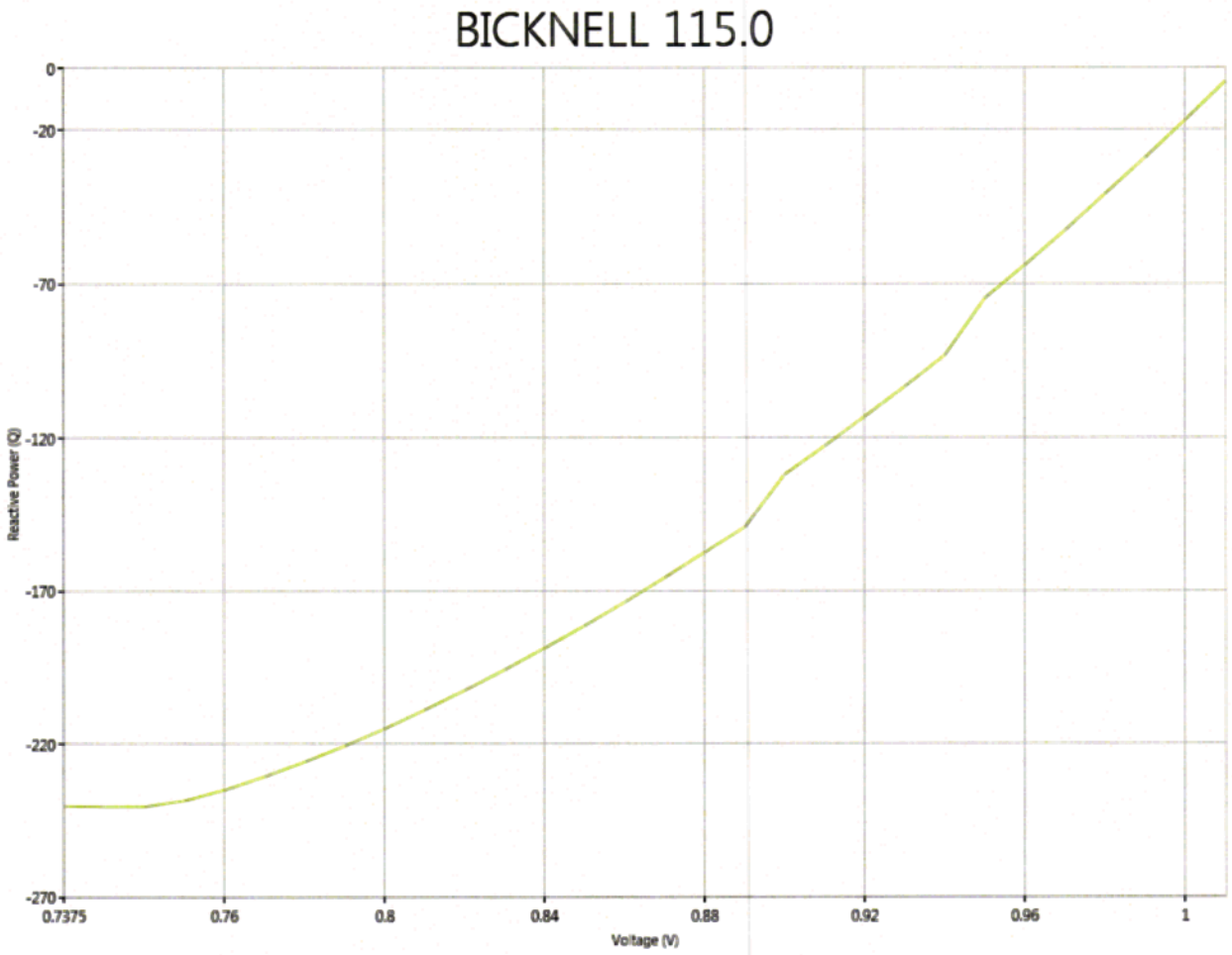

MARANA 115.0
0
-50
-100
-150
-200
-250
-300
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)


PANTANO 230.0
0
-100
-200
-300
-400
-500
Reactive Power (Q)
0.61
0.66
0.72
0.78
0.84
0.9
0.96
Voltage (V)


REDTAIL 230.0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
Reactive Power (Q)
0.56
0.62
0.69
0.76
0.83
0.9
0.97
Voltage (V)

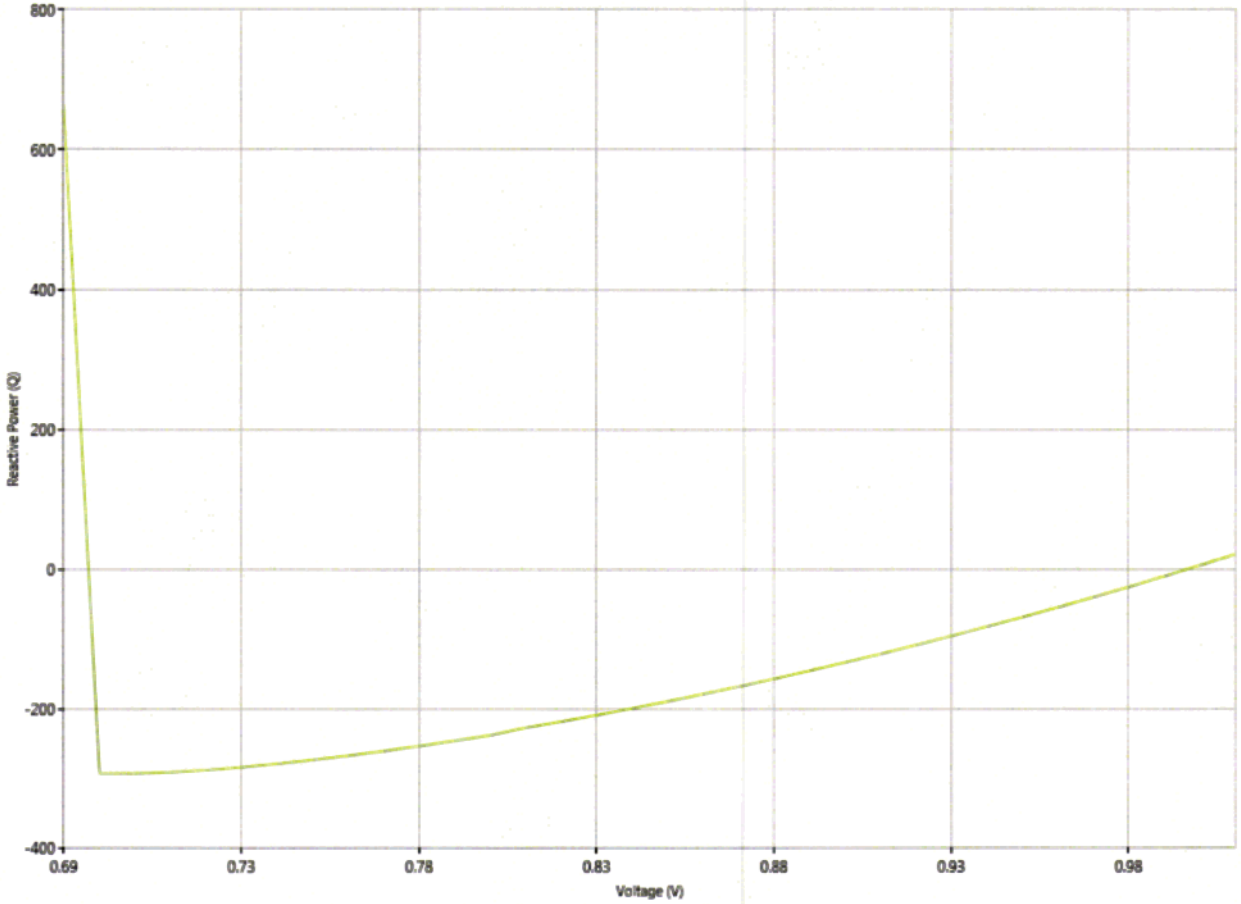
2026 HEAVY SUMMER

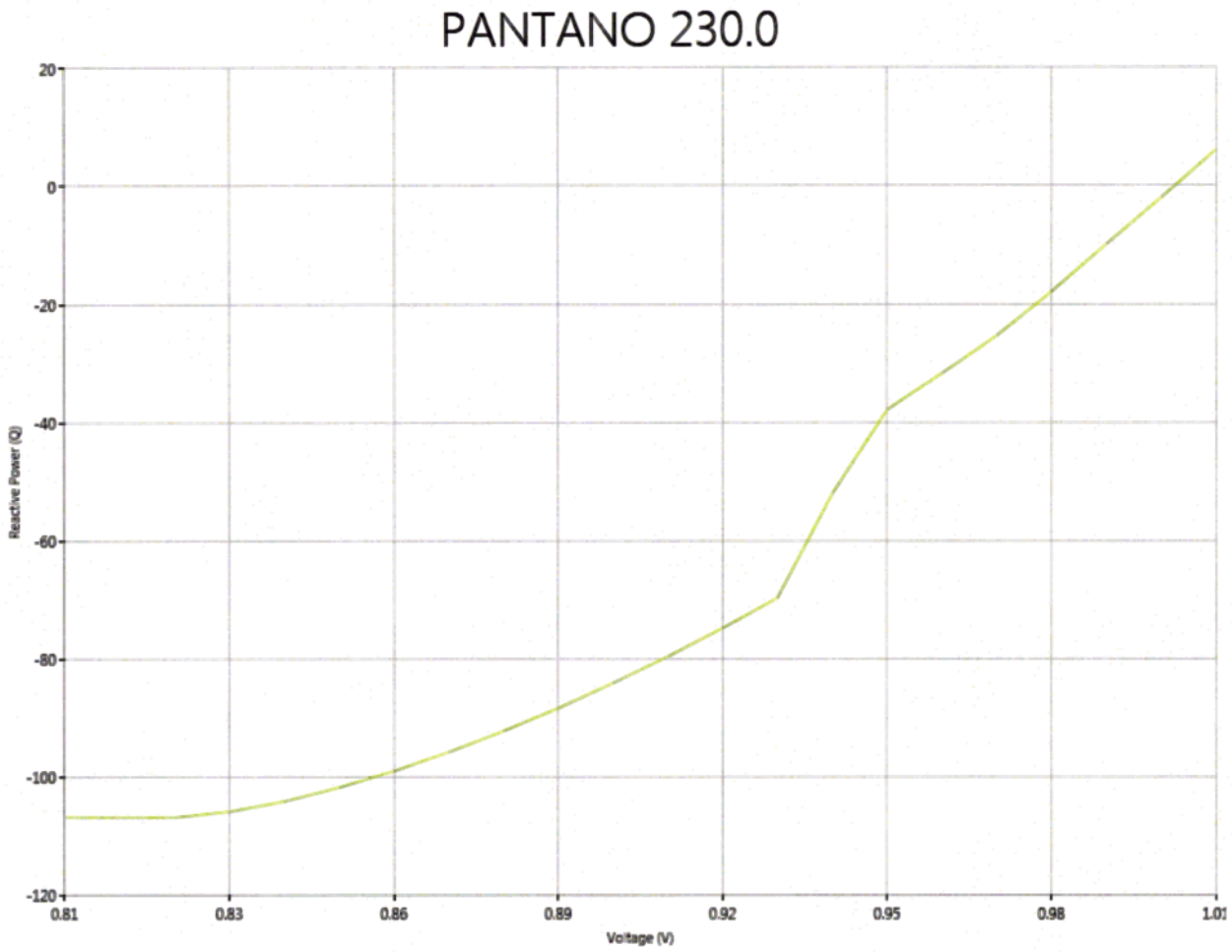
Apache to Butterfield 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses

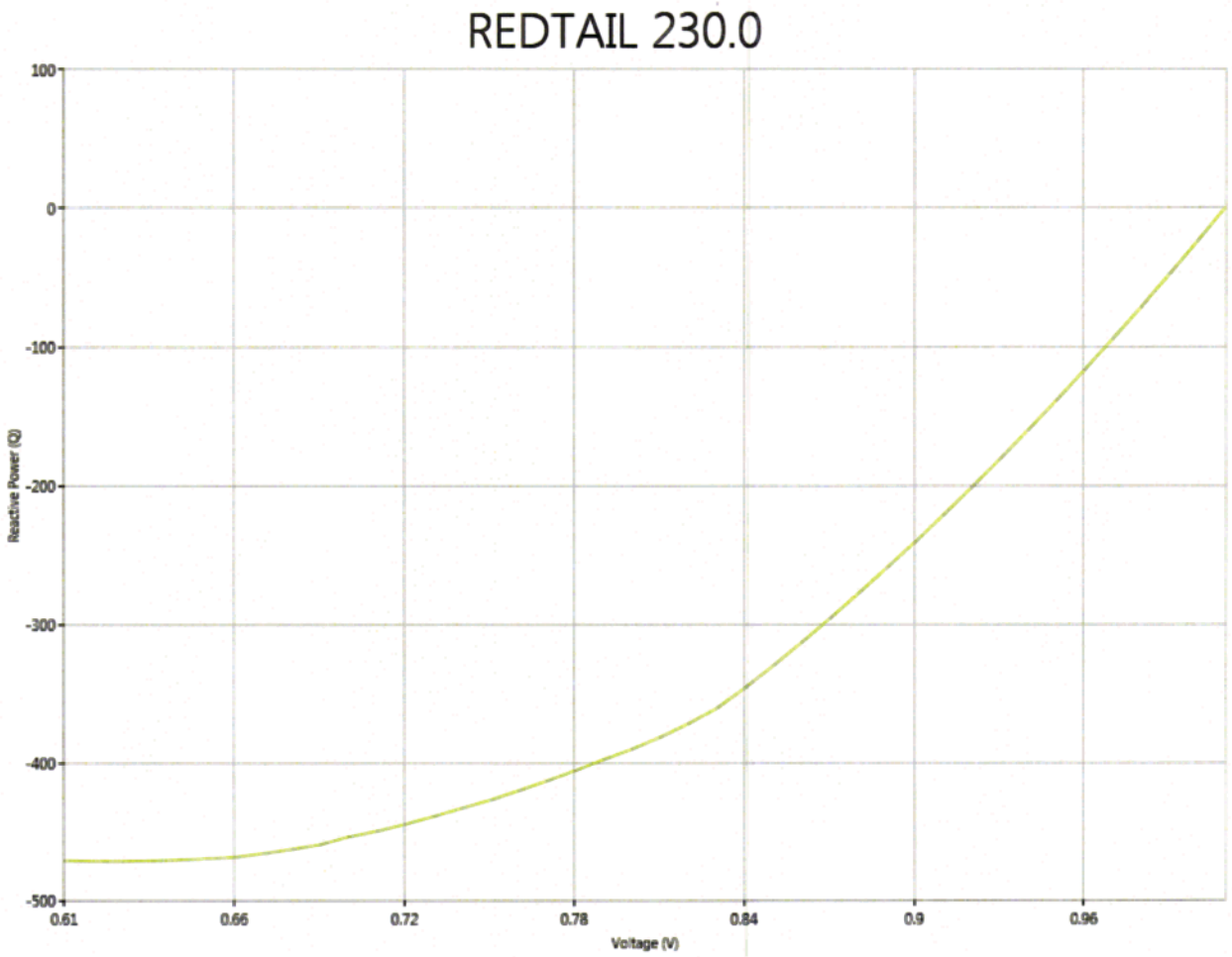



HACKBERY 230.0
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
Reactive Power (Q)
0.57
0.63
0.7
0.77
0.84
0.91
0.98
Voltage (V)

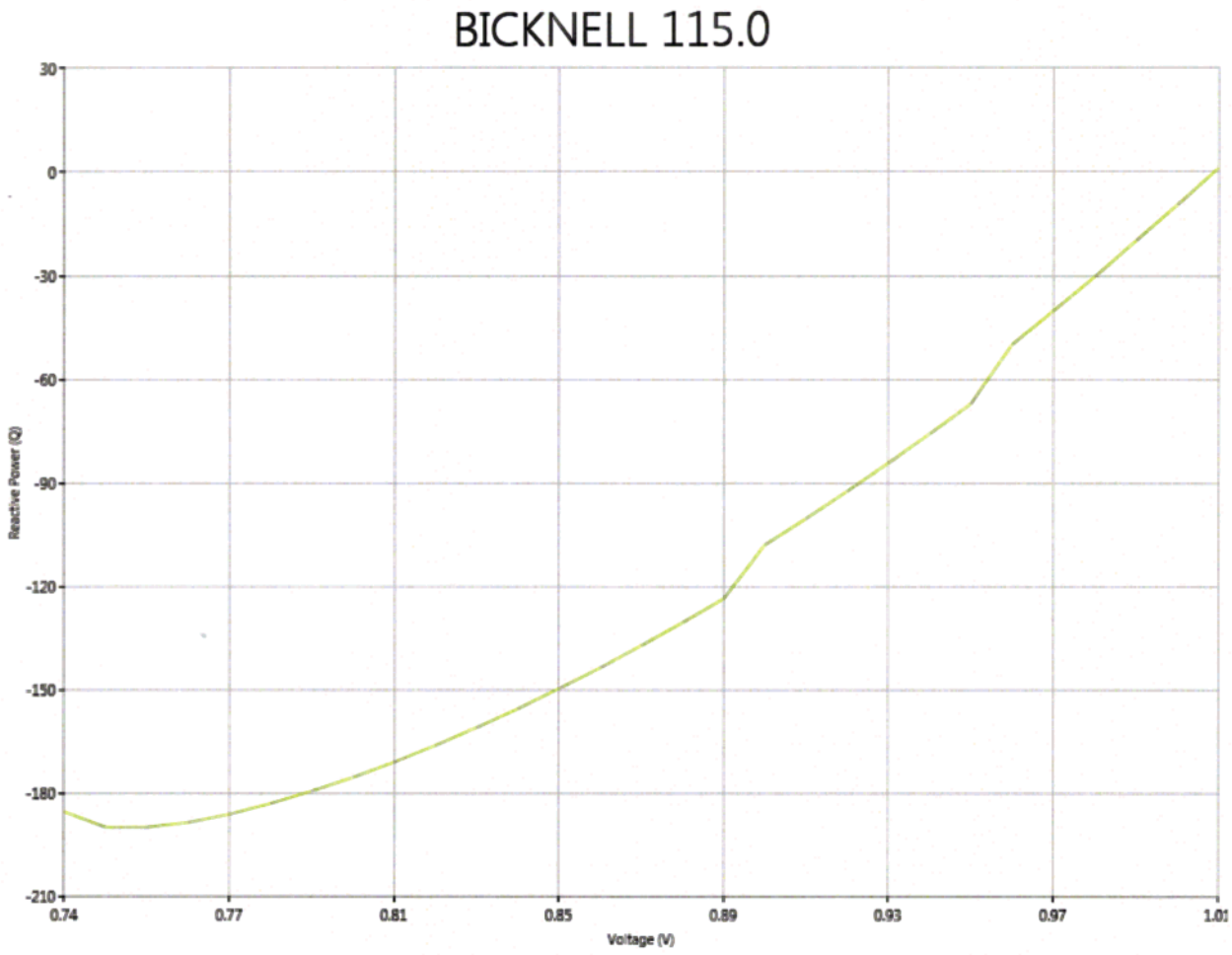
MARANA 115.0


800
600
400
200
0
-200
-400
Reactive Power (Q)
0.69
0.73
0.78
0.83
0.88
0.93
0.98
Voltage (V)

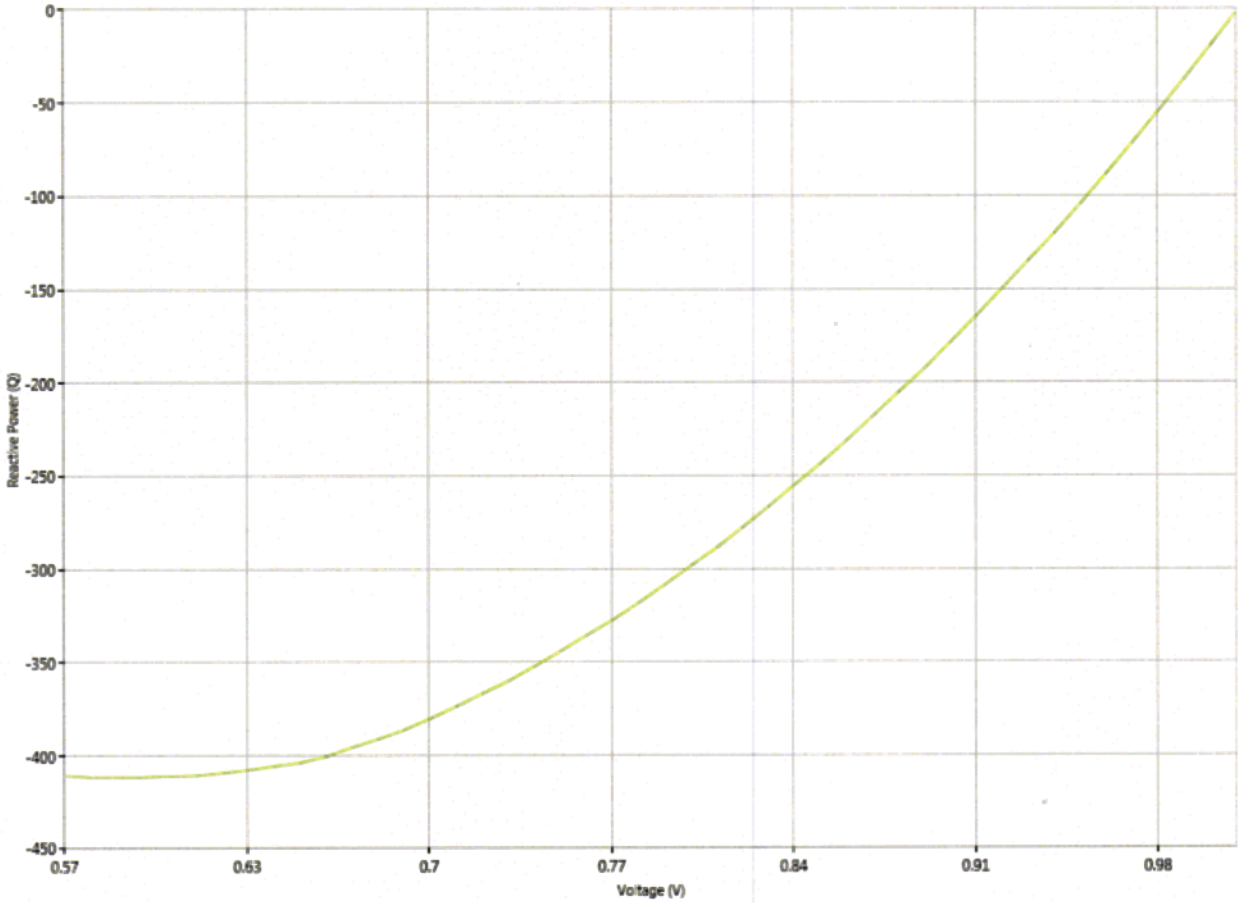

PANTANO 230.0
20
0
-20
-40
-60
-80
-100
-120
Reactive Power (Q)
0.81
0.83
0.86
0.89
0.92
0.95
0.98
1.01
Voltage (V)


REDTAIL 230.0
100
0
-100
-200
-300
-400
-500
Reactive Power (Q)
0.61
0.66
0.72
0.78
0.84
0.9
0.96
Voltage (V)

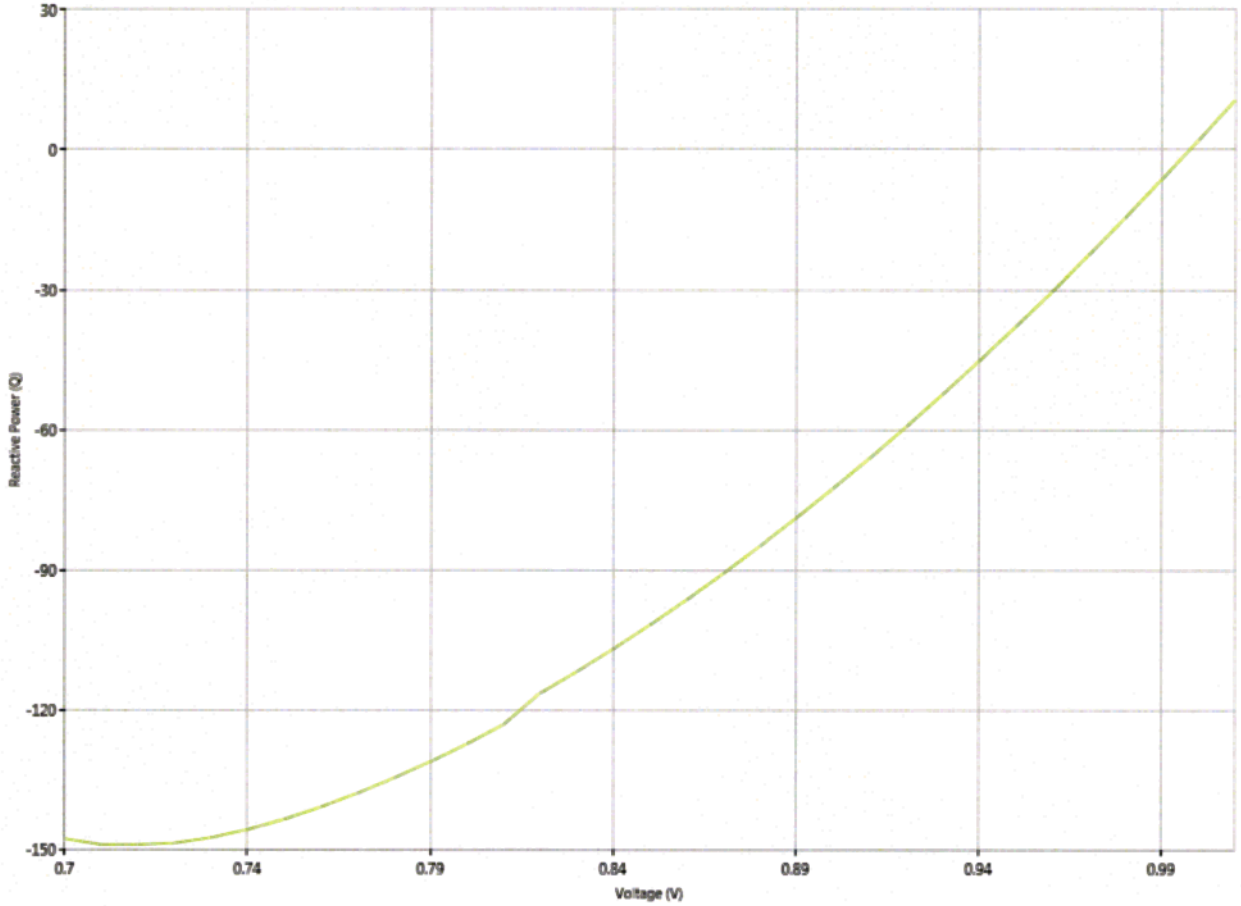
Apache to Butterfield 230 kV and Marana Group Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses



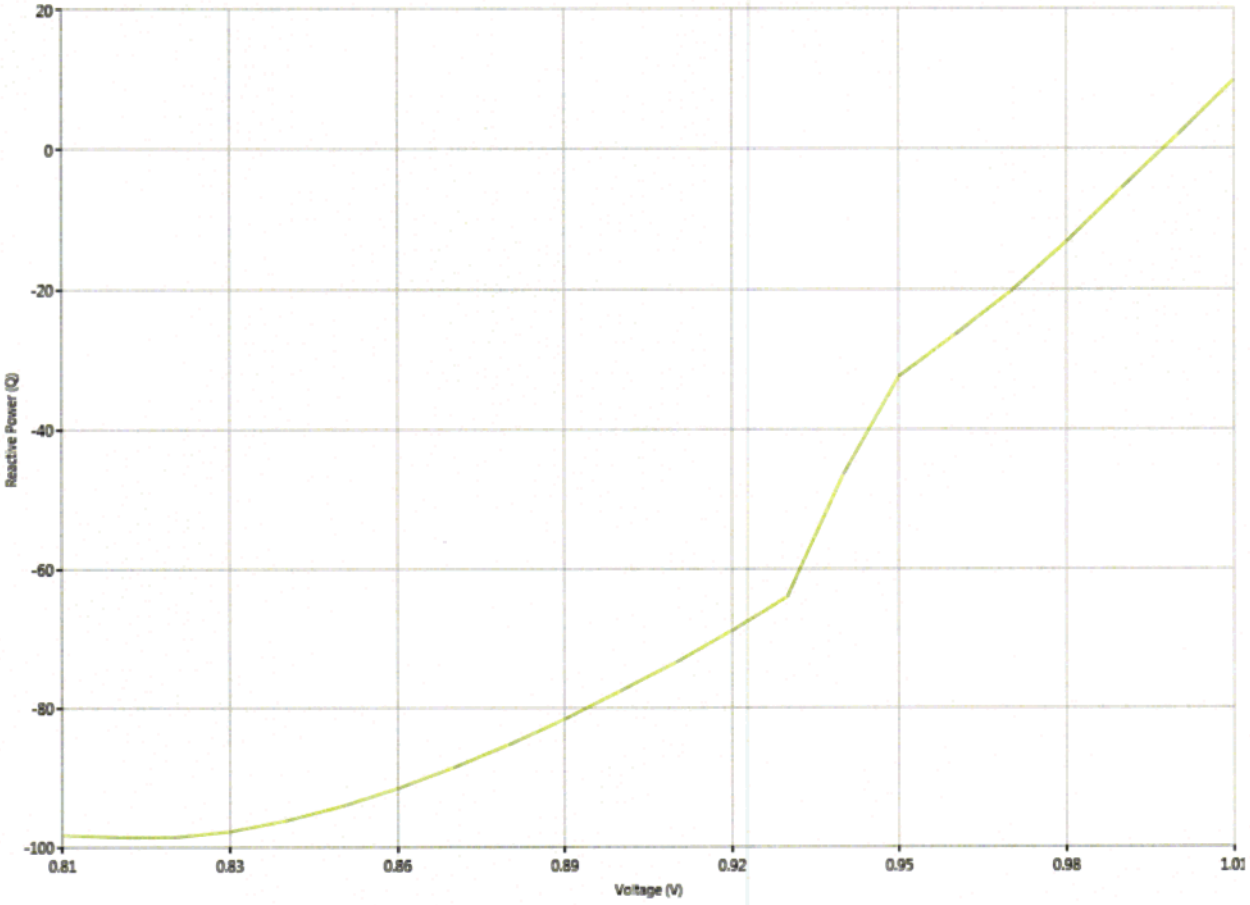
HACKBERY 230.0

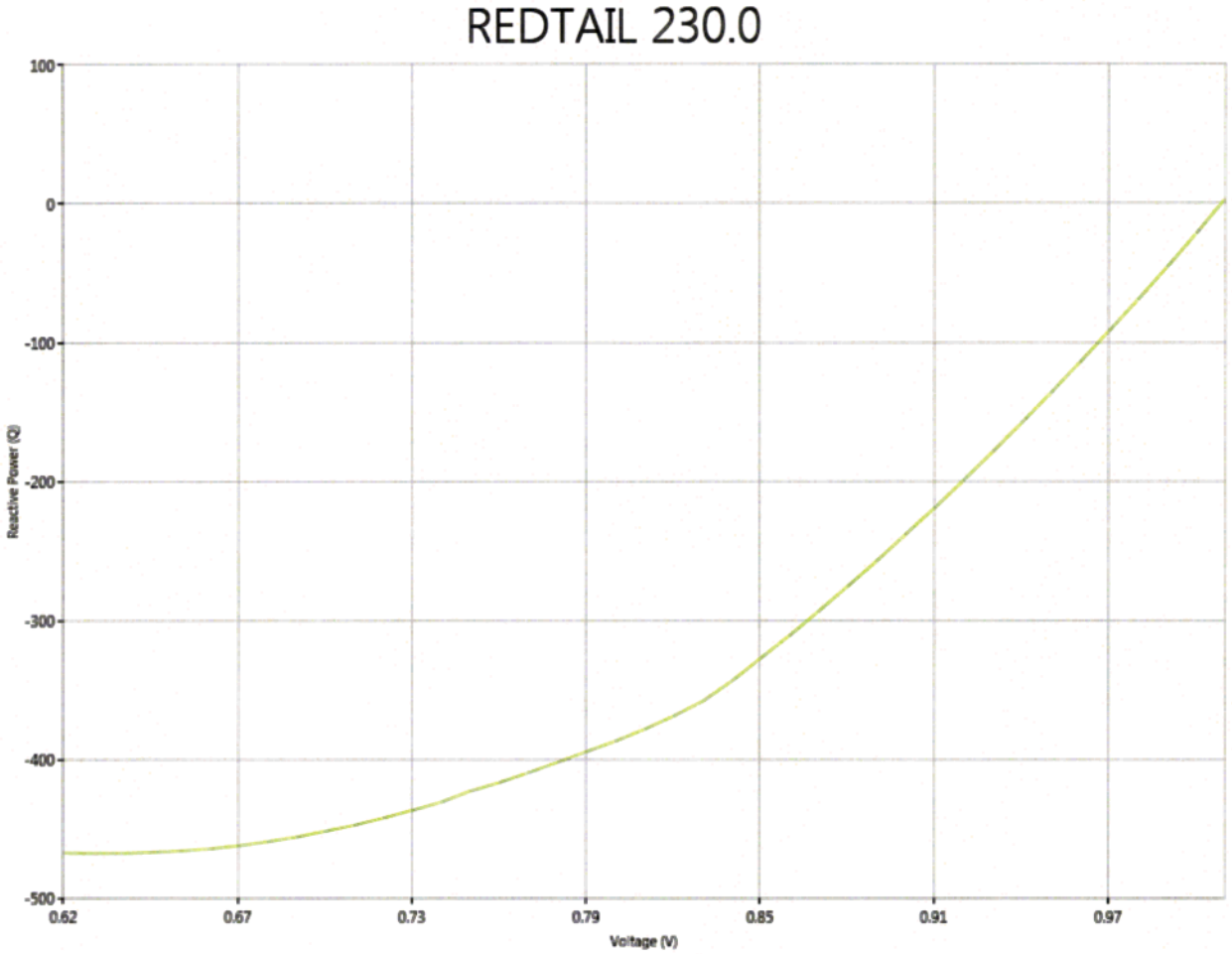


MARANA 115.0

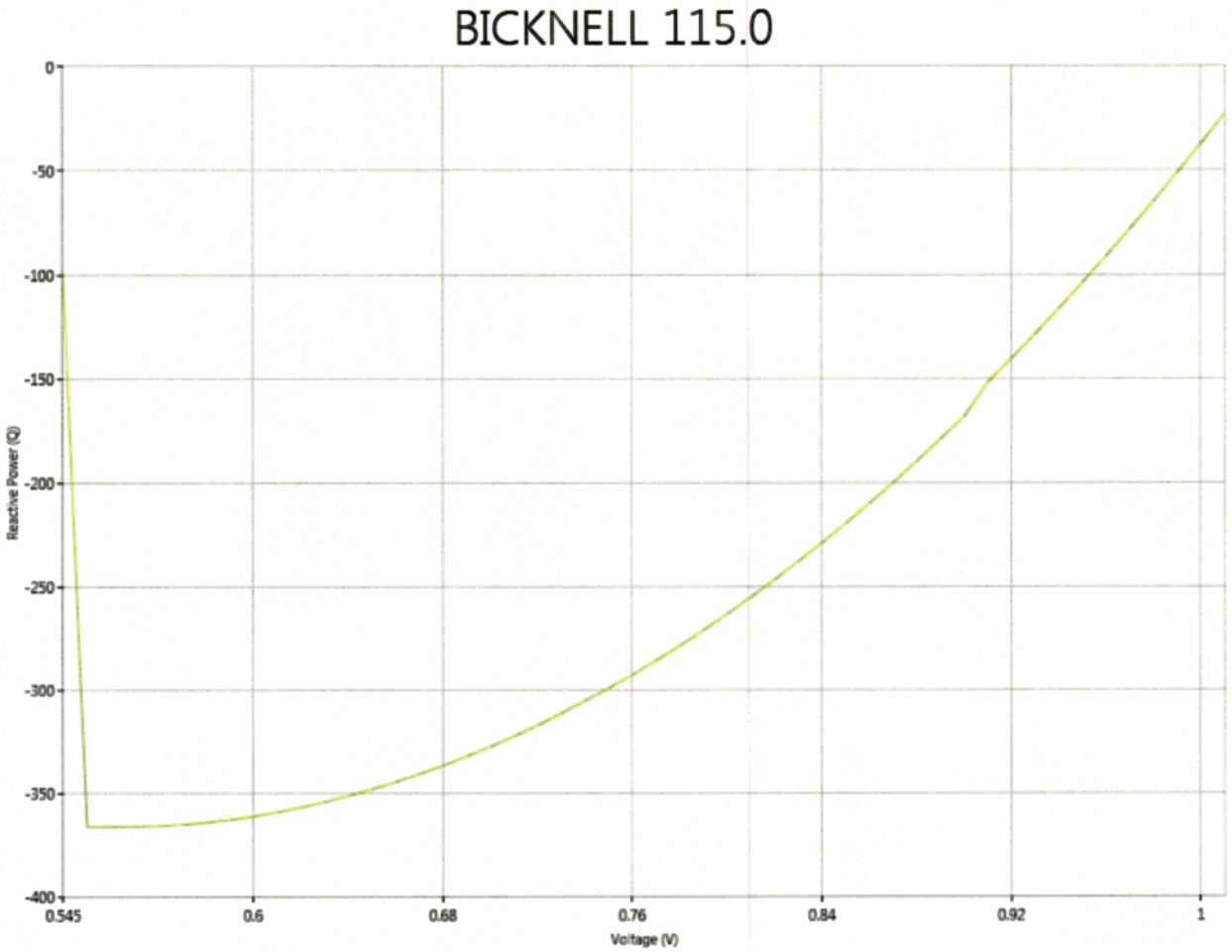

30
0
-30
-60
-90
-120
-150
Reactive Power (Q)
0.7
0.74
0.79
0.84
0.89
0.94
0.99
Voltage (V)

PANTANO 230.0

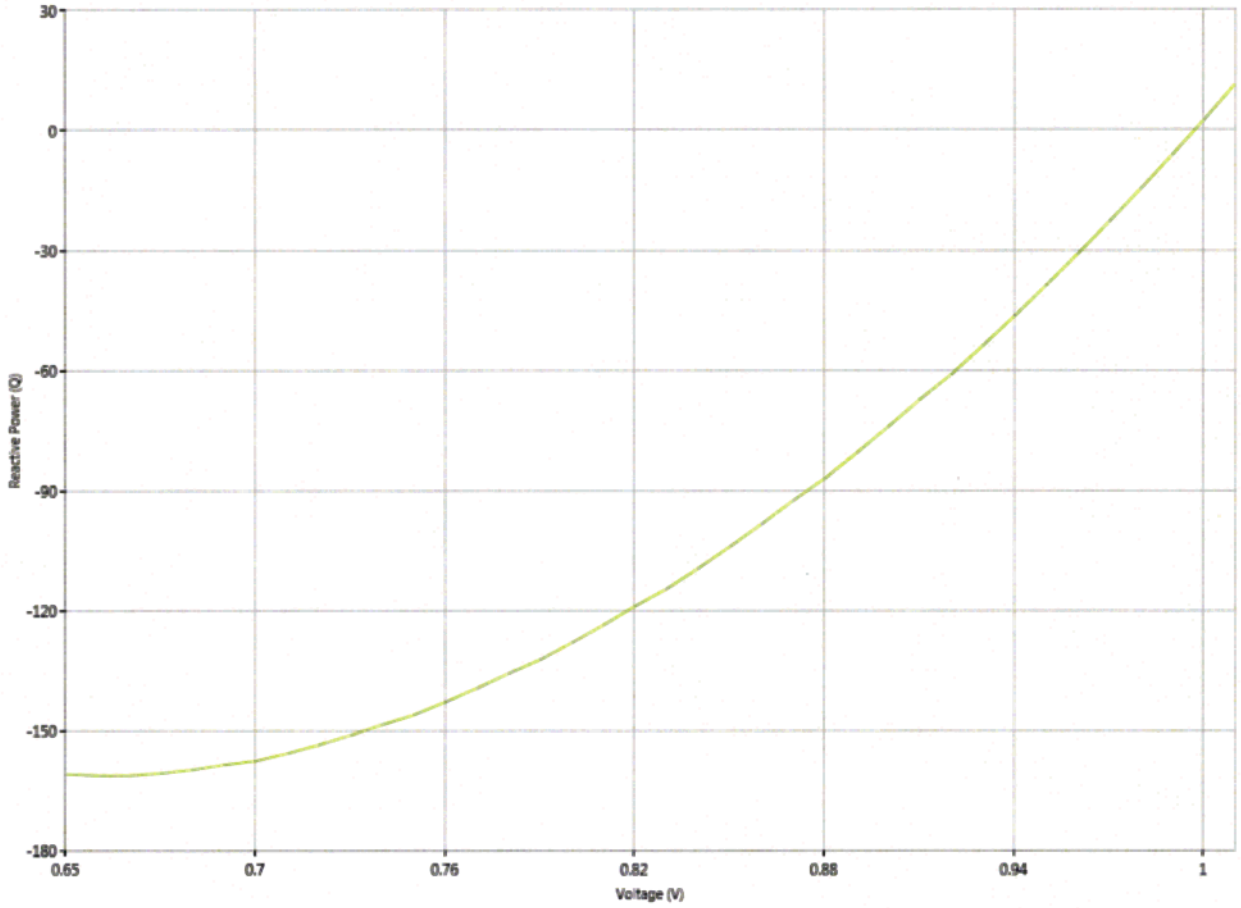



REDTAIL 230.0
100
0
-100
-200
-300
-400
-500
Reactive Power (Q)
0.62
0.67
0.73
0.79
0.85
0.91
0.97
Voltage (V)

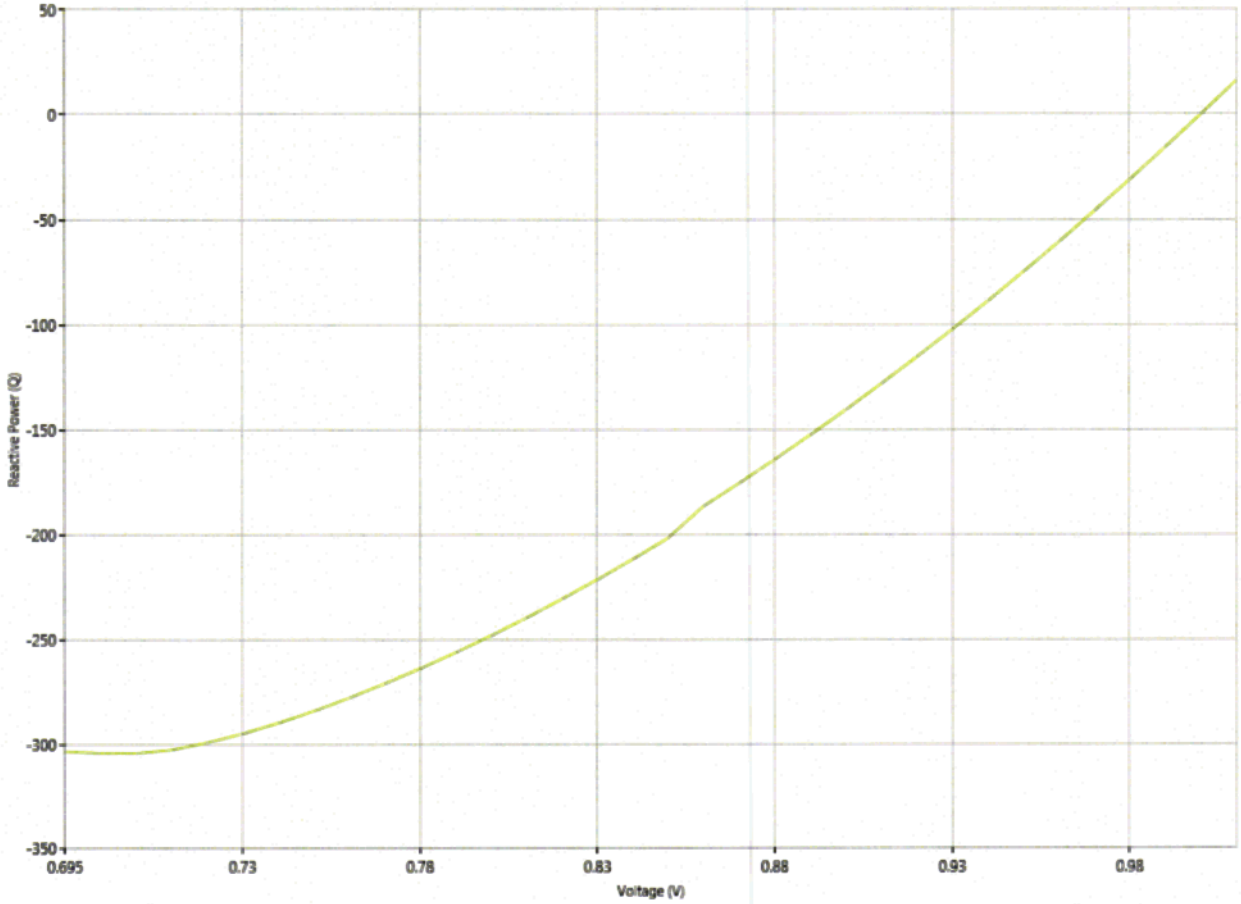
Apache to Redtail 230 kV Outage
With plots of Bicknell 115 kV, Hackberry 230 kV, Marana 115 kV, Pantano 230 kV and Redtail 230 kV buses



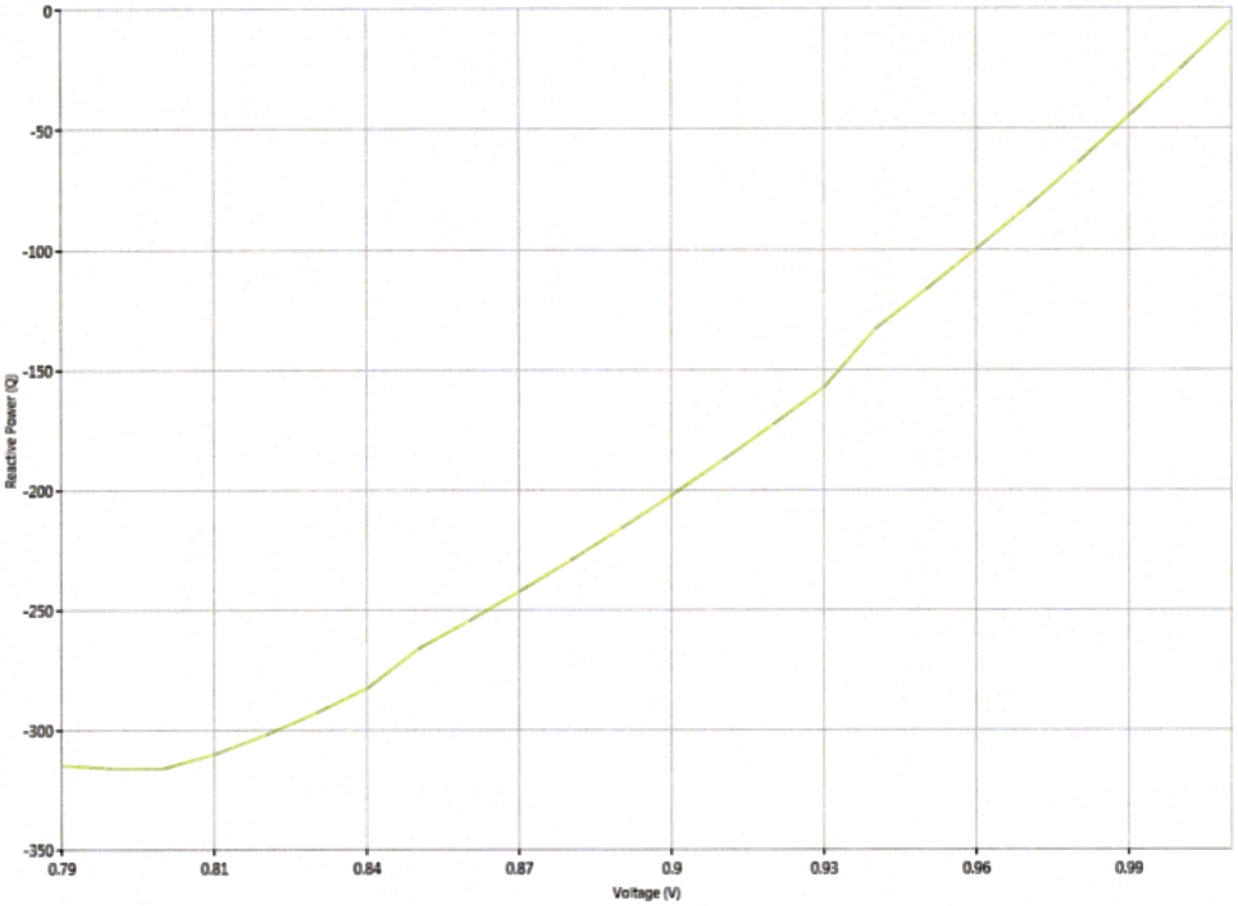
HACKBERY 230.0

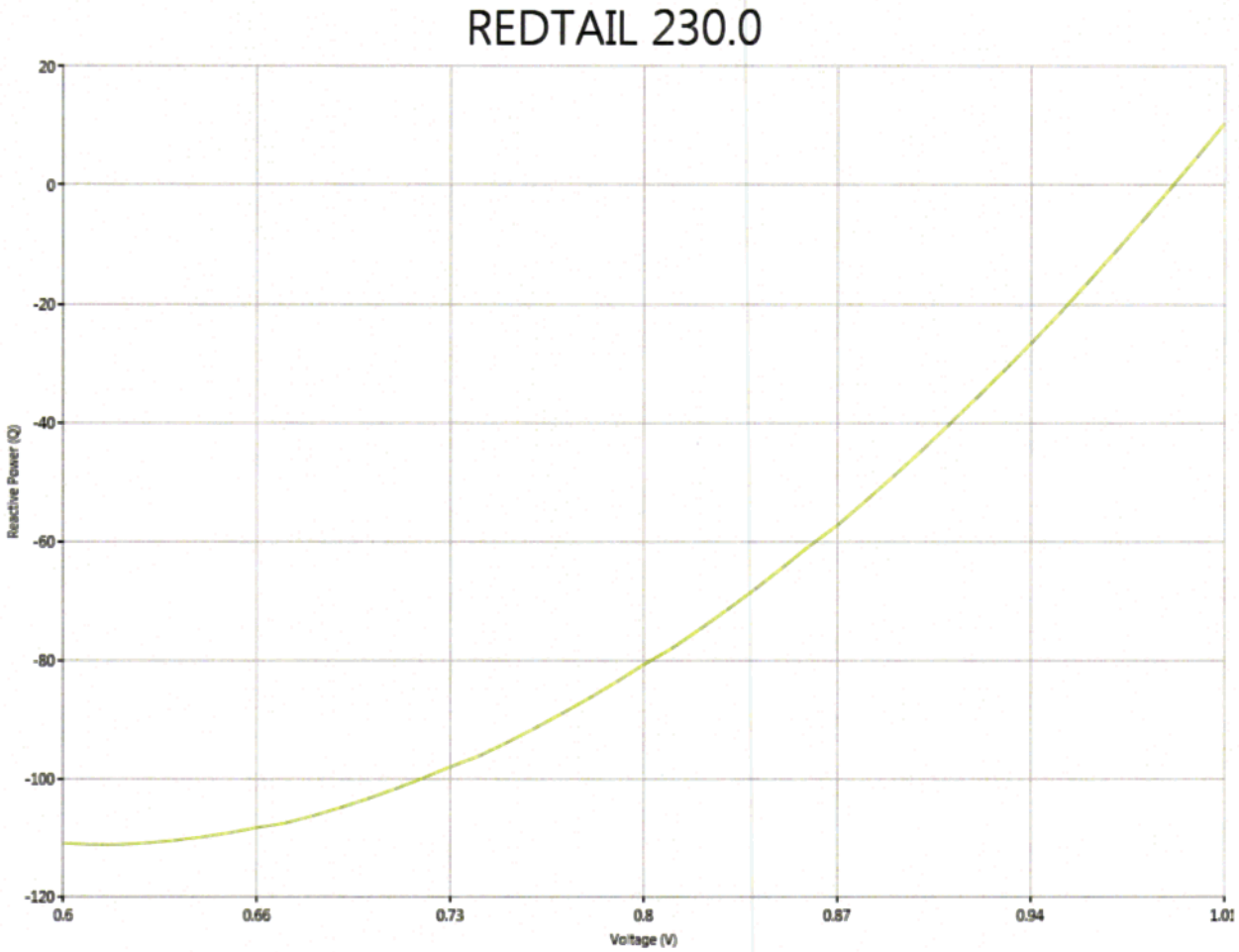


MARANA 115.0


50
0
-50
-100
-150
-200
-250
-300
-350
Reactive Power (Q)
0.695
0.73
0.78
0.83
0.88
0.93
0.98
Voltage (V)

PANTANO 230.0

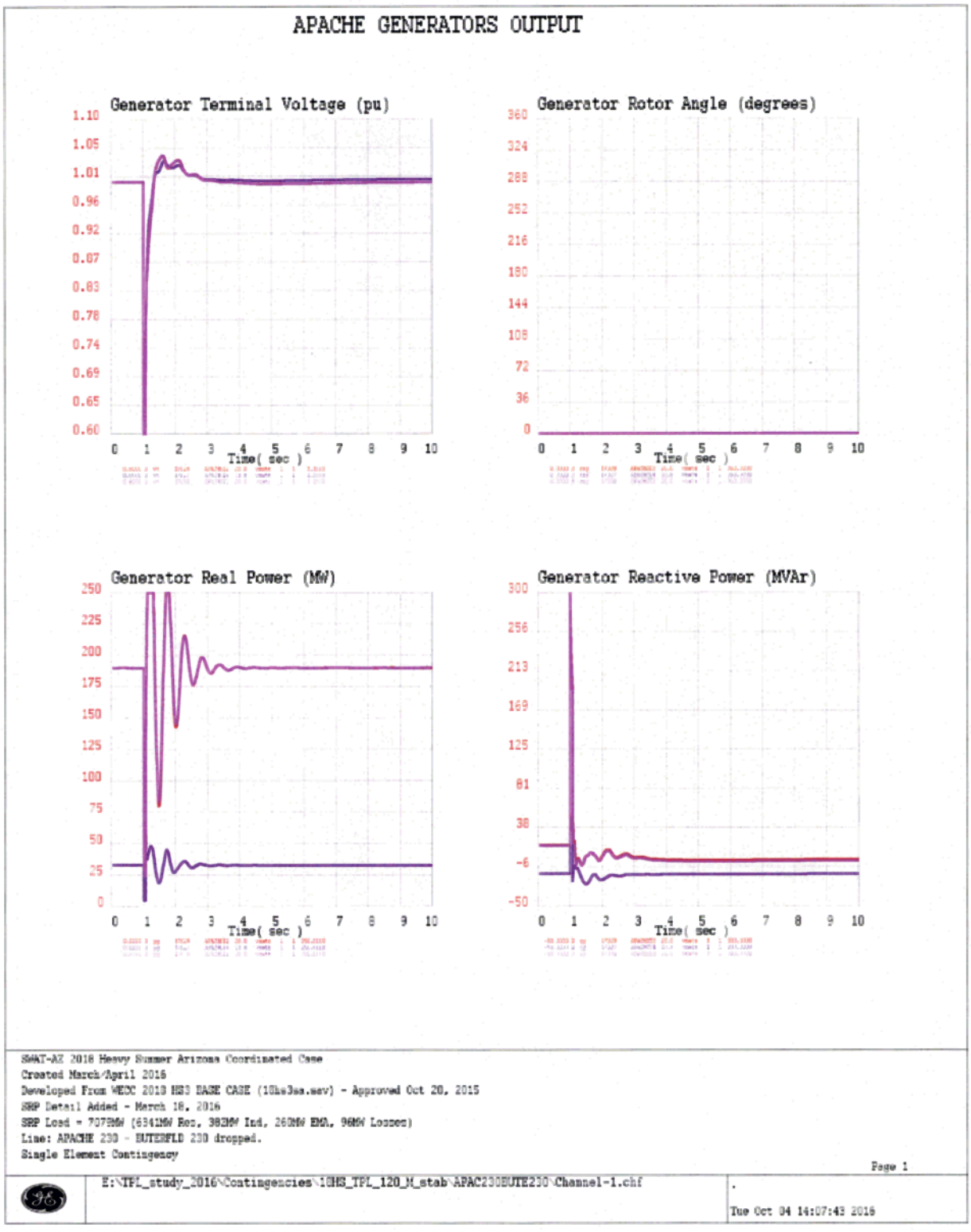



REDTAIL 230.0
20
0
-20
-40
-60
-80
-100
-120
Reactive Power (Q)
0.6
0.66
0.73
0.8
0.87
0.94
1.01
Voltage (V)

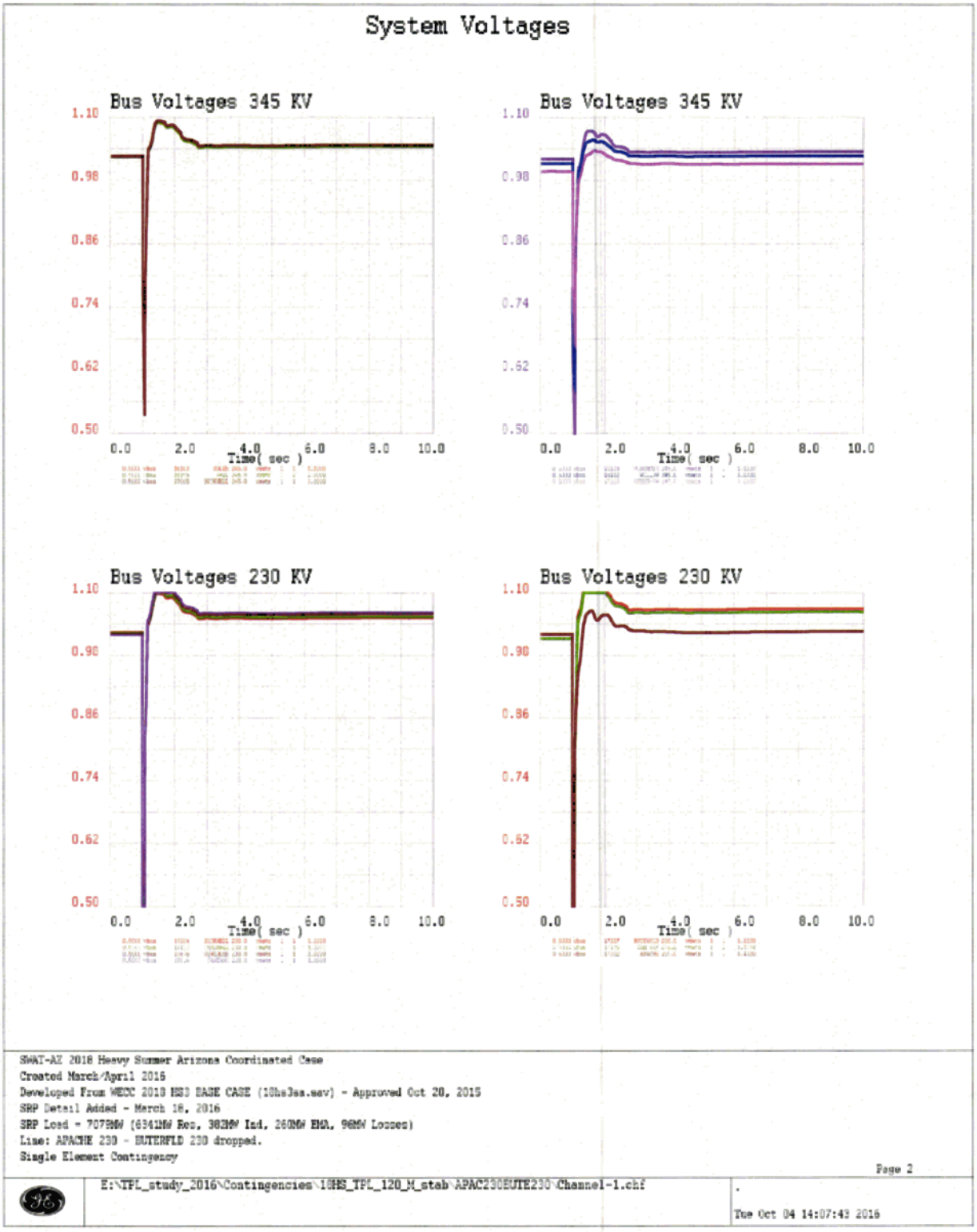
APPENDIX E: Transient Stability Plots

2018 HEAVY SUMMER P1 Contingencies

2018 HS - Apache to Butterfield 230 kV Line Outage
Apache Generators Output

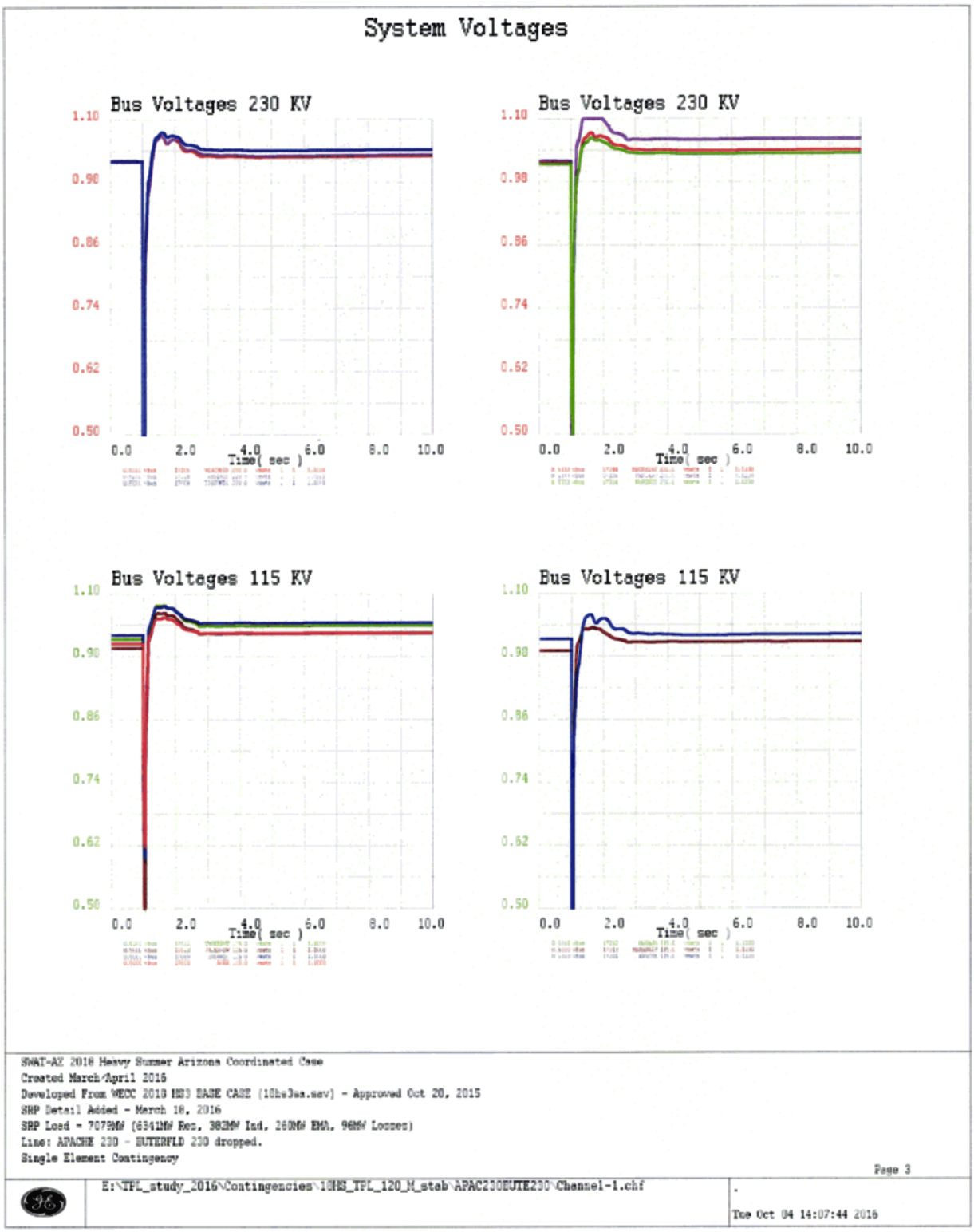


2018 HS – Apache to Butterfield 230 kV Line Outage
345 kV & 230 kV System Voltages

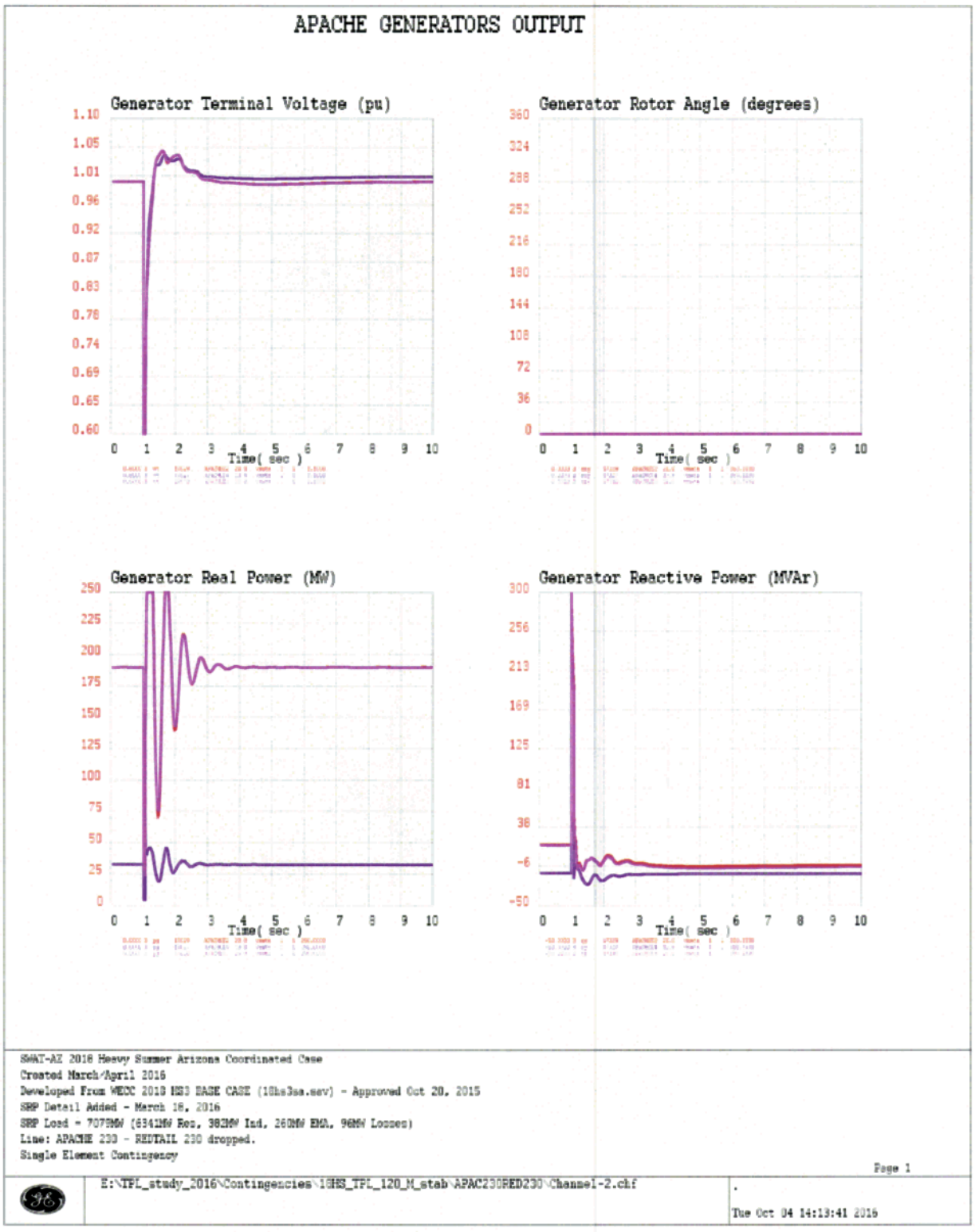


2018 Heavy Summer – Apache to Butterfield 230 kV Line Outage

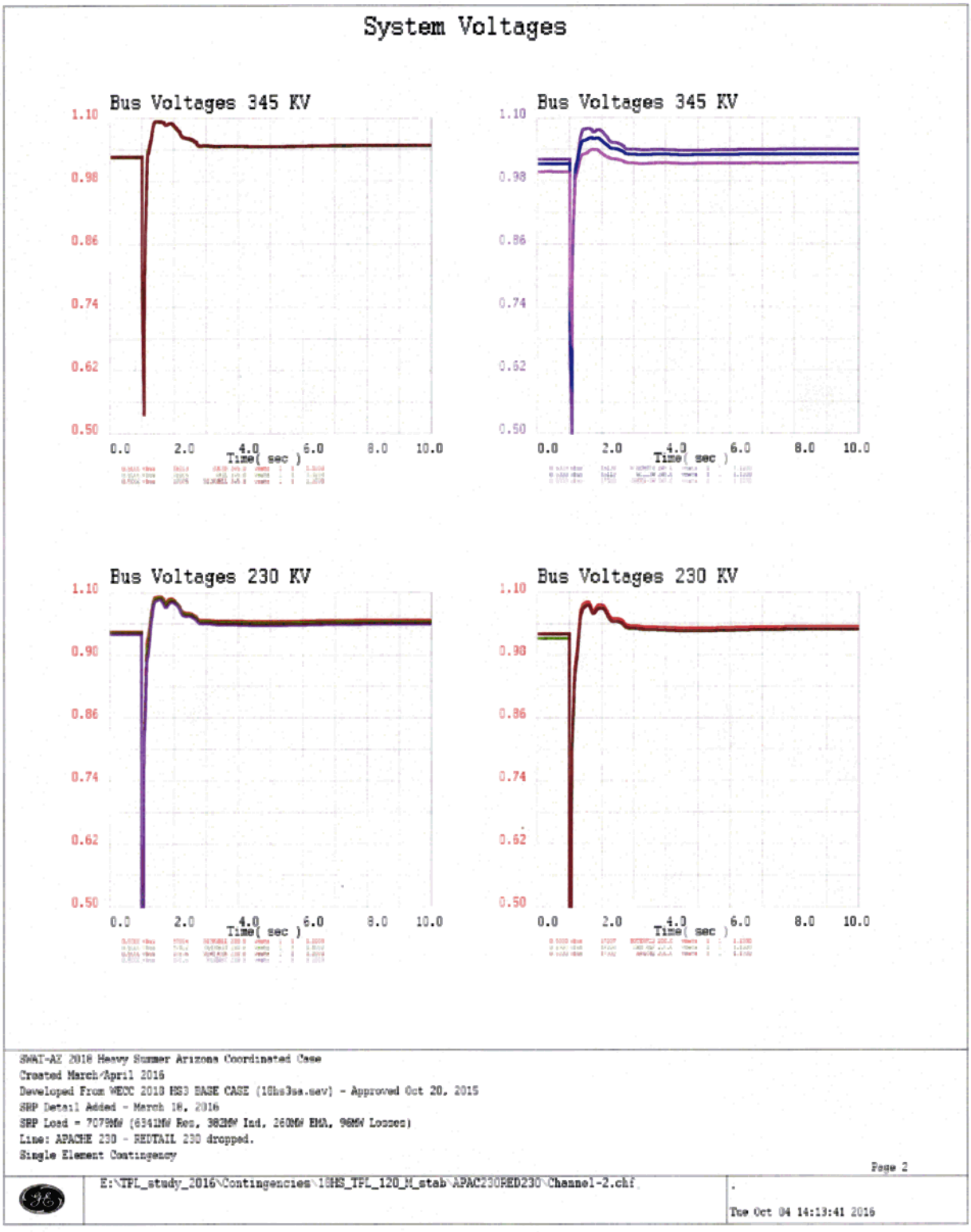
230 kV & 115 kV System Voltages



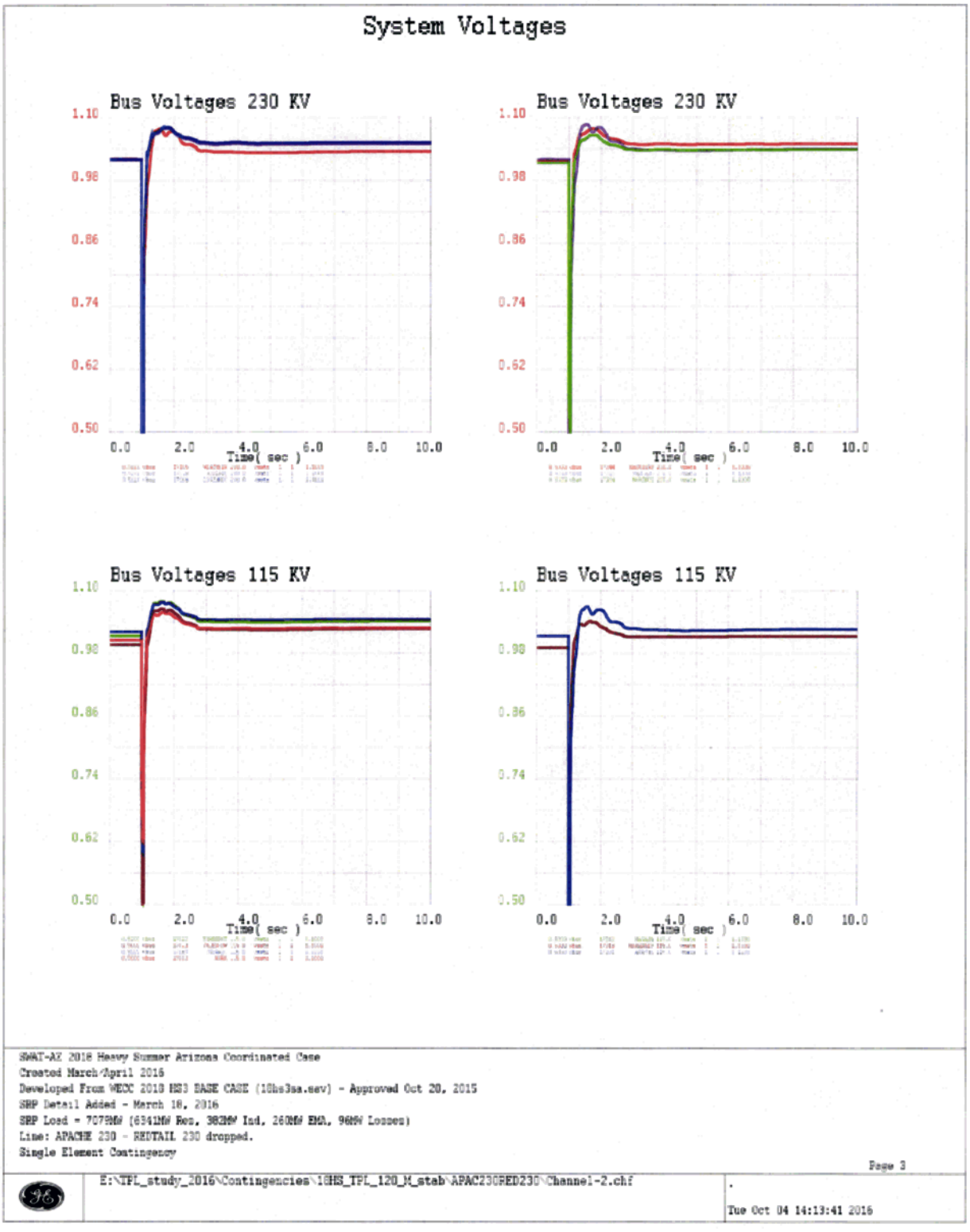
2018 HS – Apache to Redtail 230 kV Line Outage
Apache Generators Output



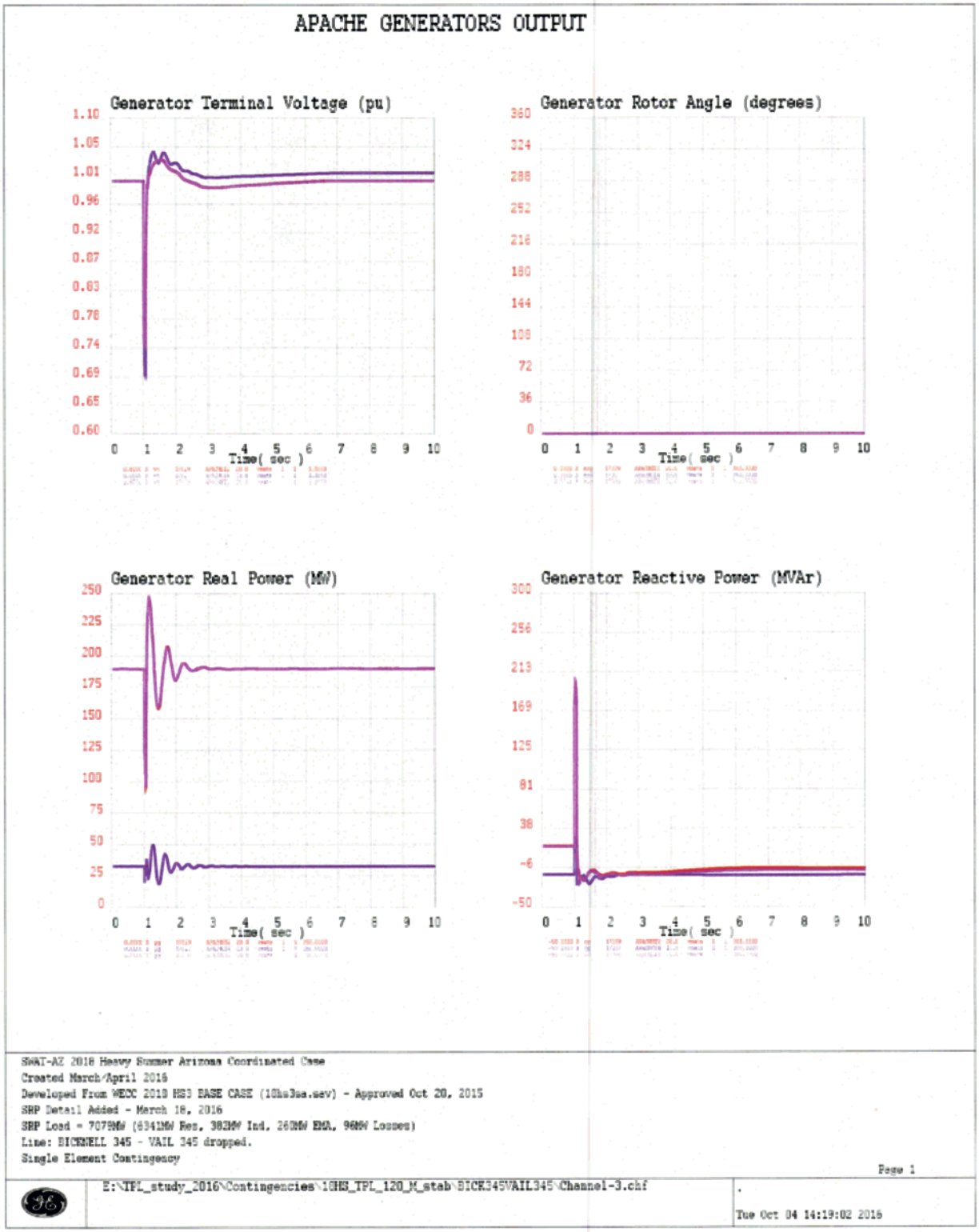
2018 HS – Apache to Redtail 230 kV Line Outage
345 kV & 230 kV System Voltages



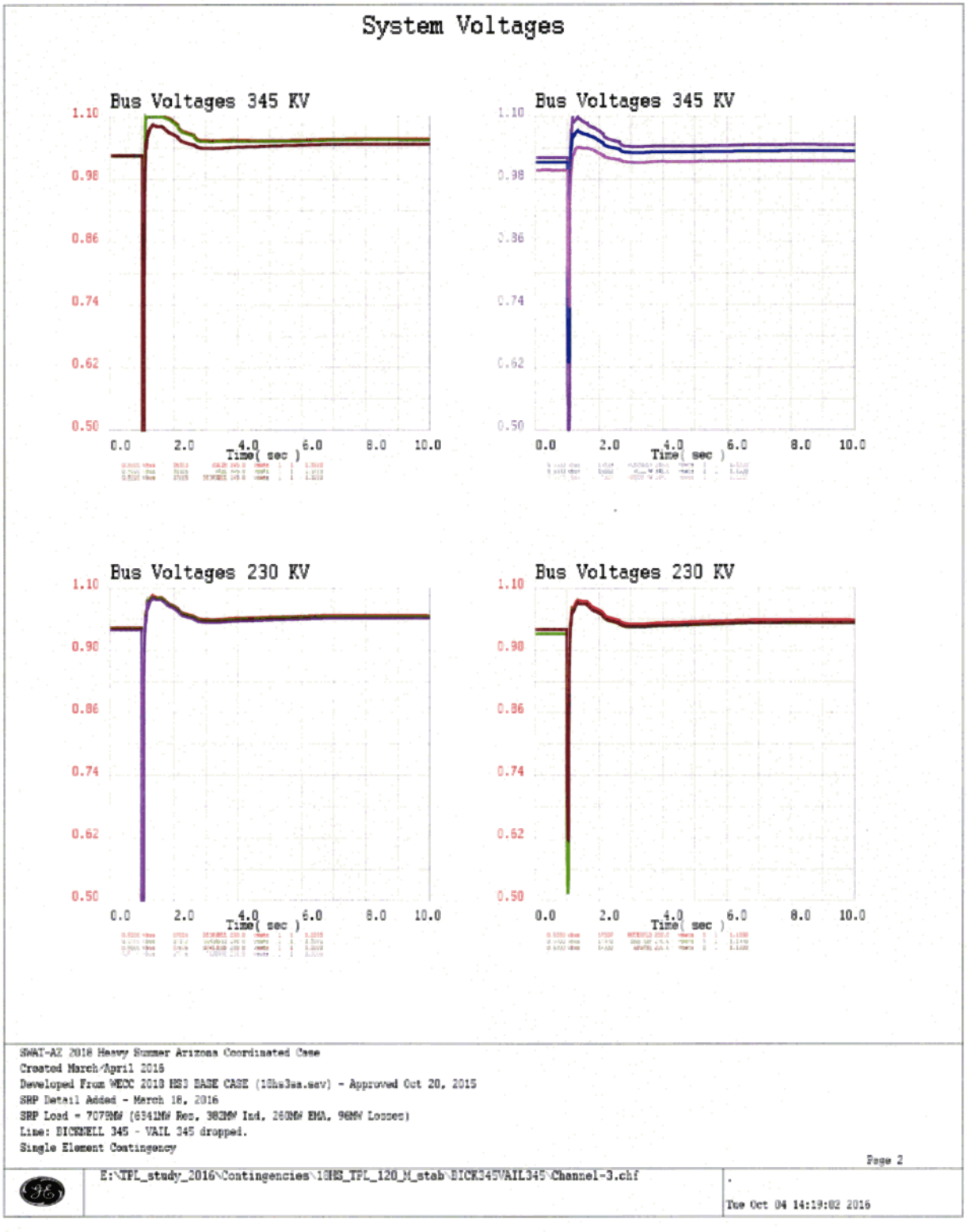
2018 HS – Apache to Redtail 230 kV Line Outage
230 kV & 115 kV System Voltages



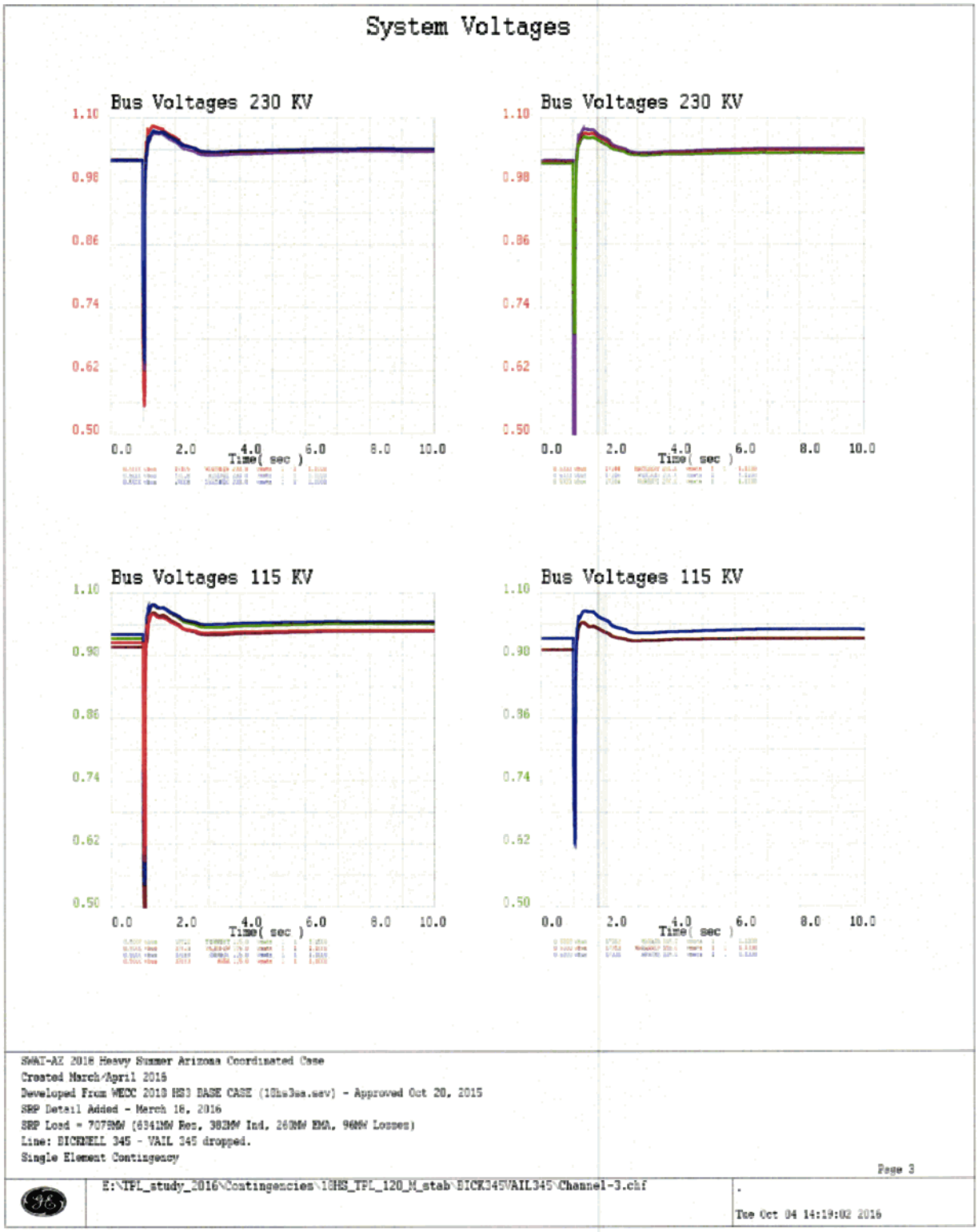
2018 HS – Bicknell to Vail 345 kV Line Outage
Apache Generators Output



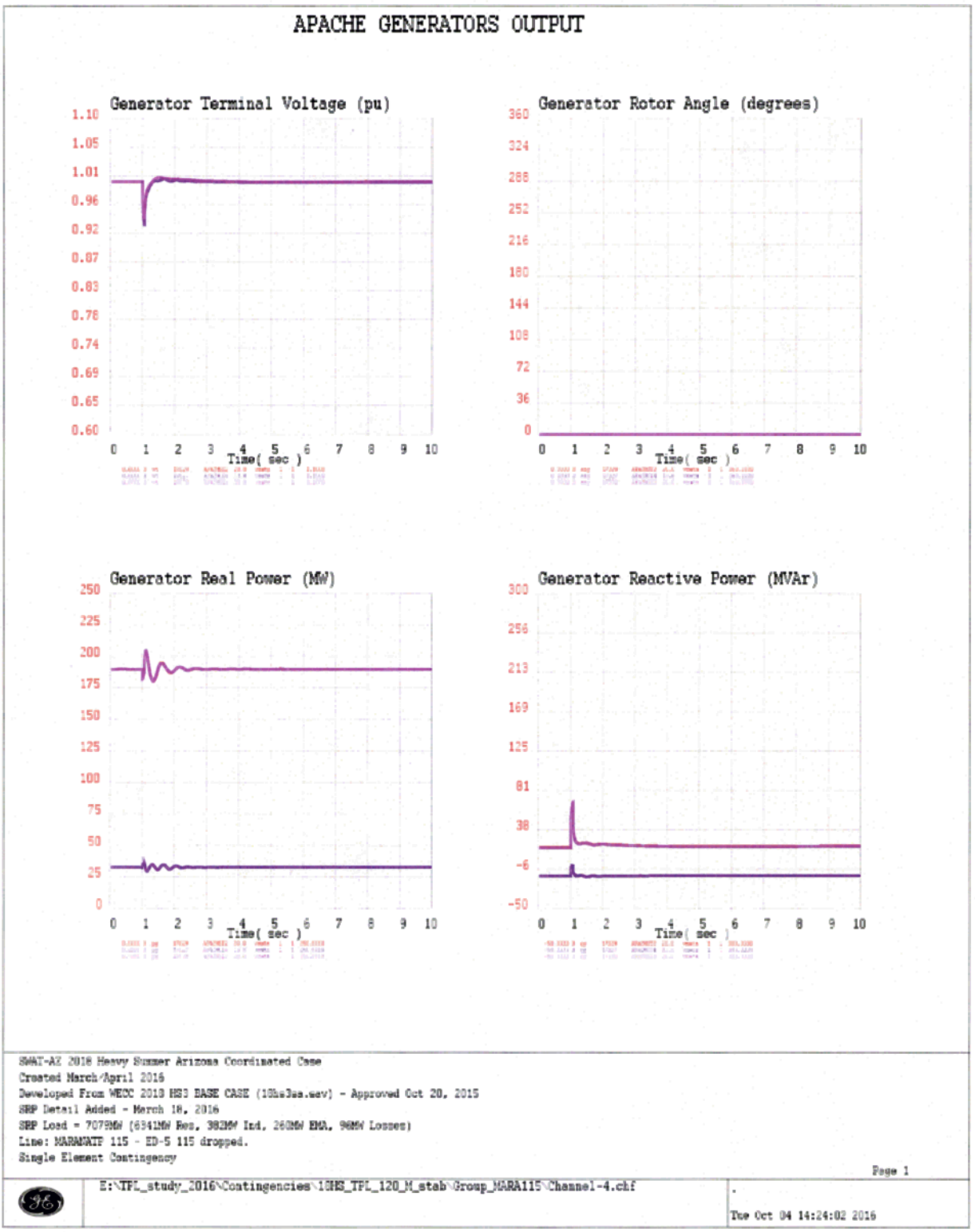
2018 HS – Bicknell to Vail 345 kV Line Outage
345 kV & 230 kV System Voltages



2018 HS – Bicknell to Vail 345 kV Line Outage
230 kV & 115 kV System Voltages

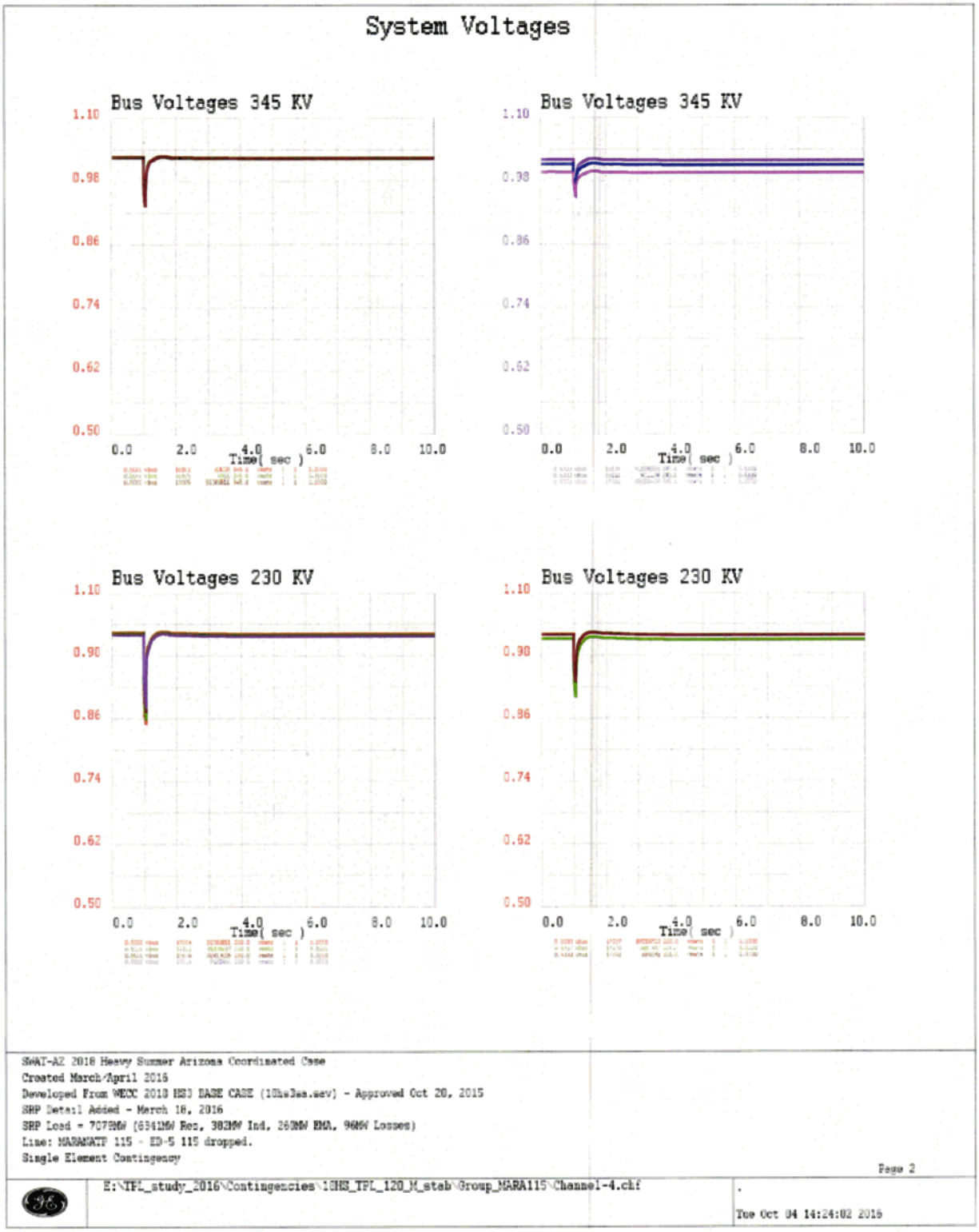


2018 HS – Marana Group 115 kV Line Outage
Apache Generators Output

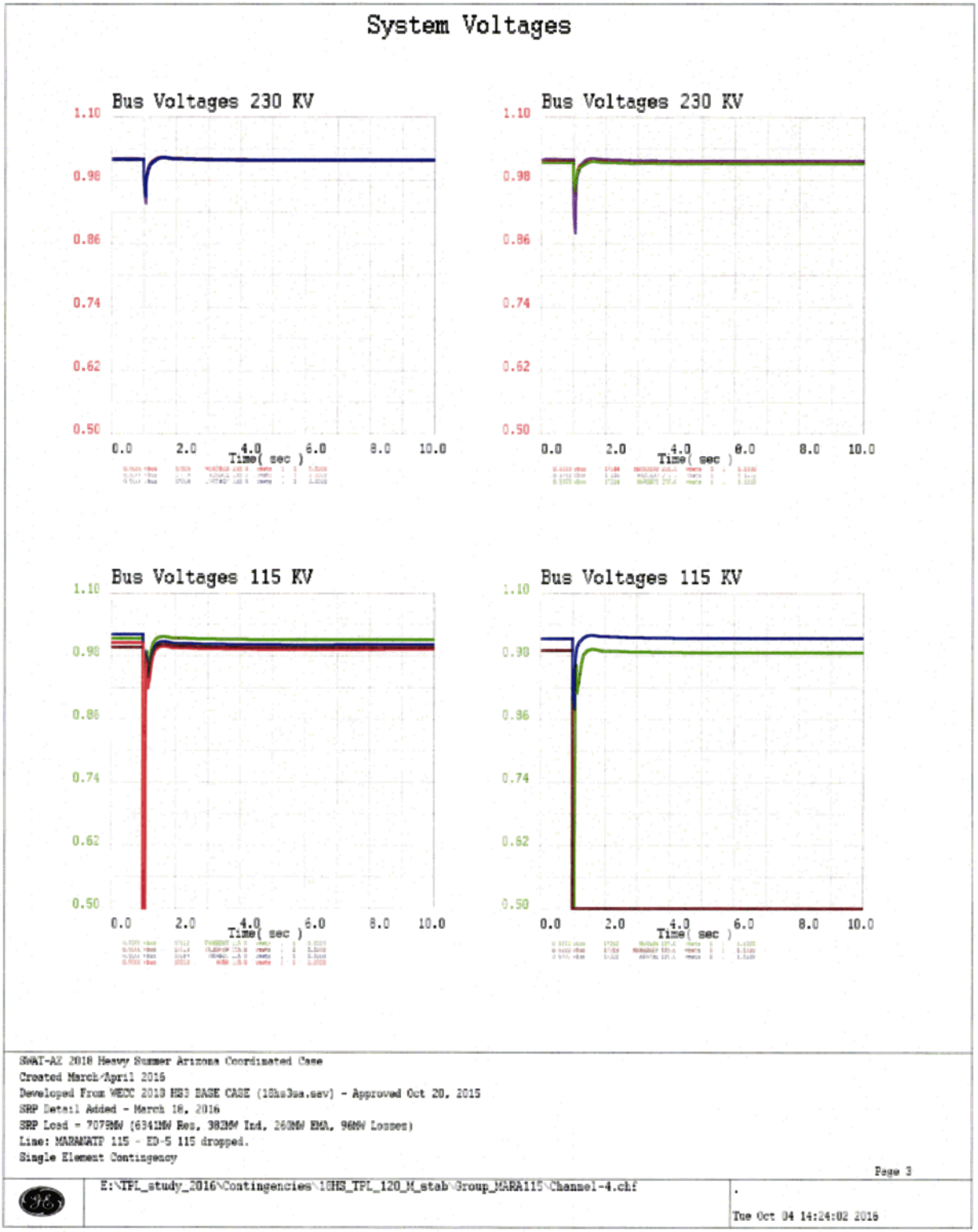


2018 HS – Marana Group 115 kV Line Outage

345 kV & 230 kV System Voltages

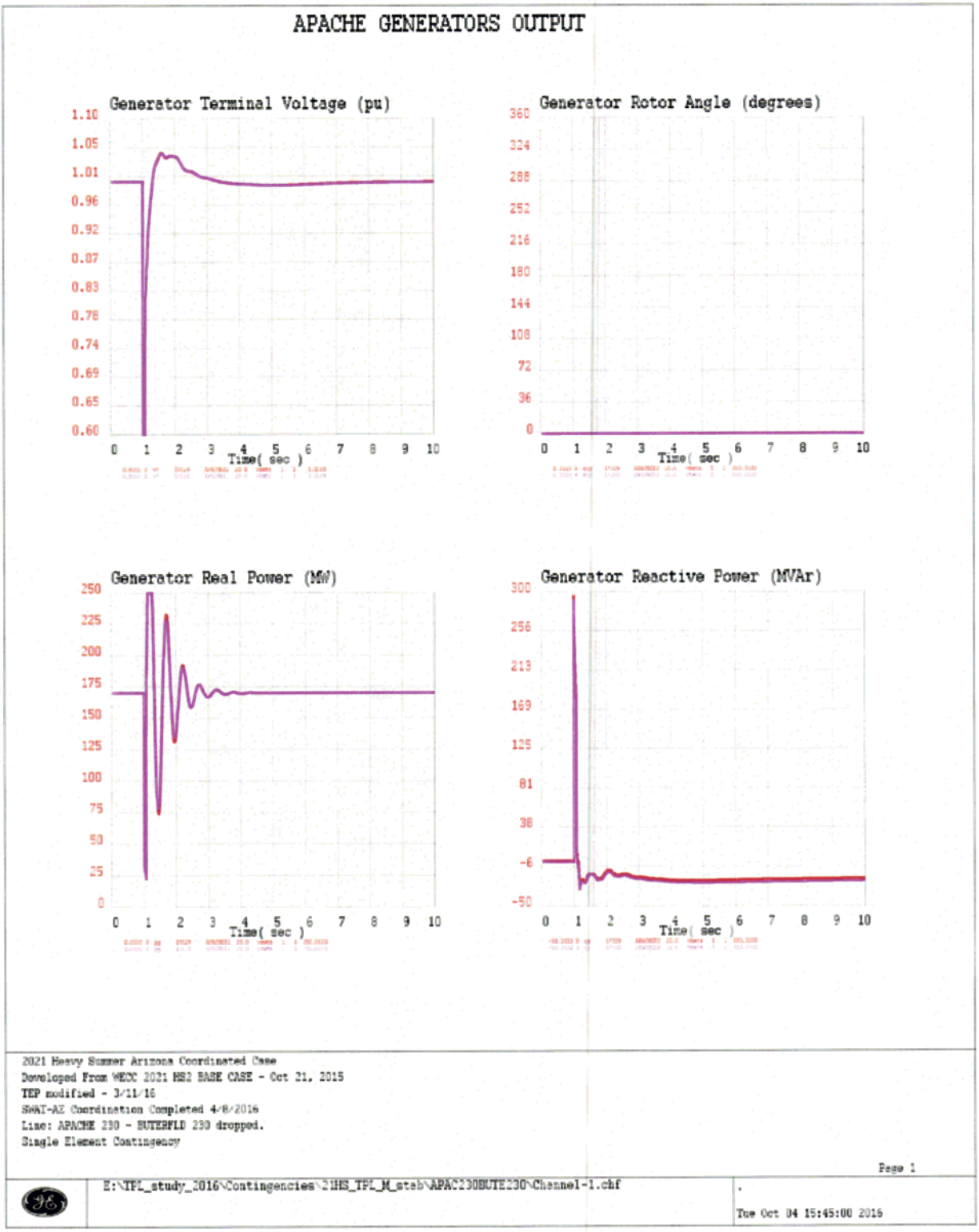


2018 HS – Marana Group 115 kV Line Outage
230 kV & 115 kV System Voltages

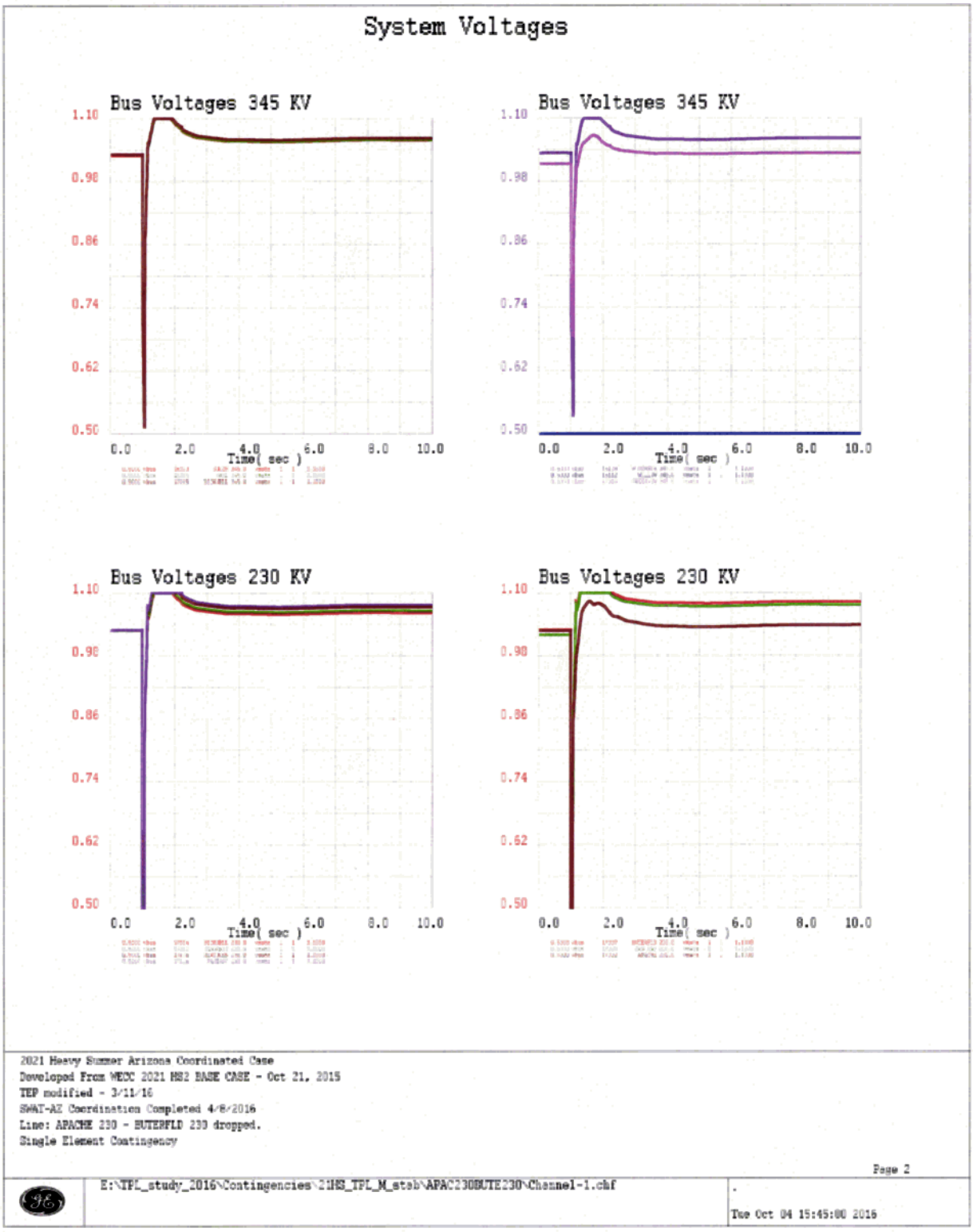


2021 HEAVY SUMMER P1 Contingencies

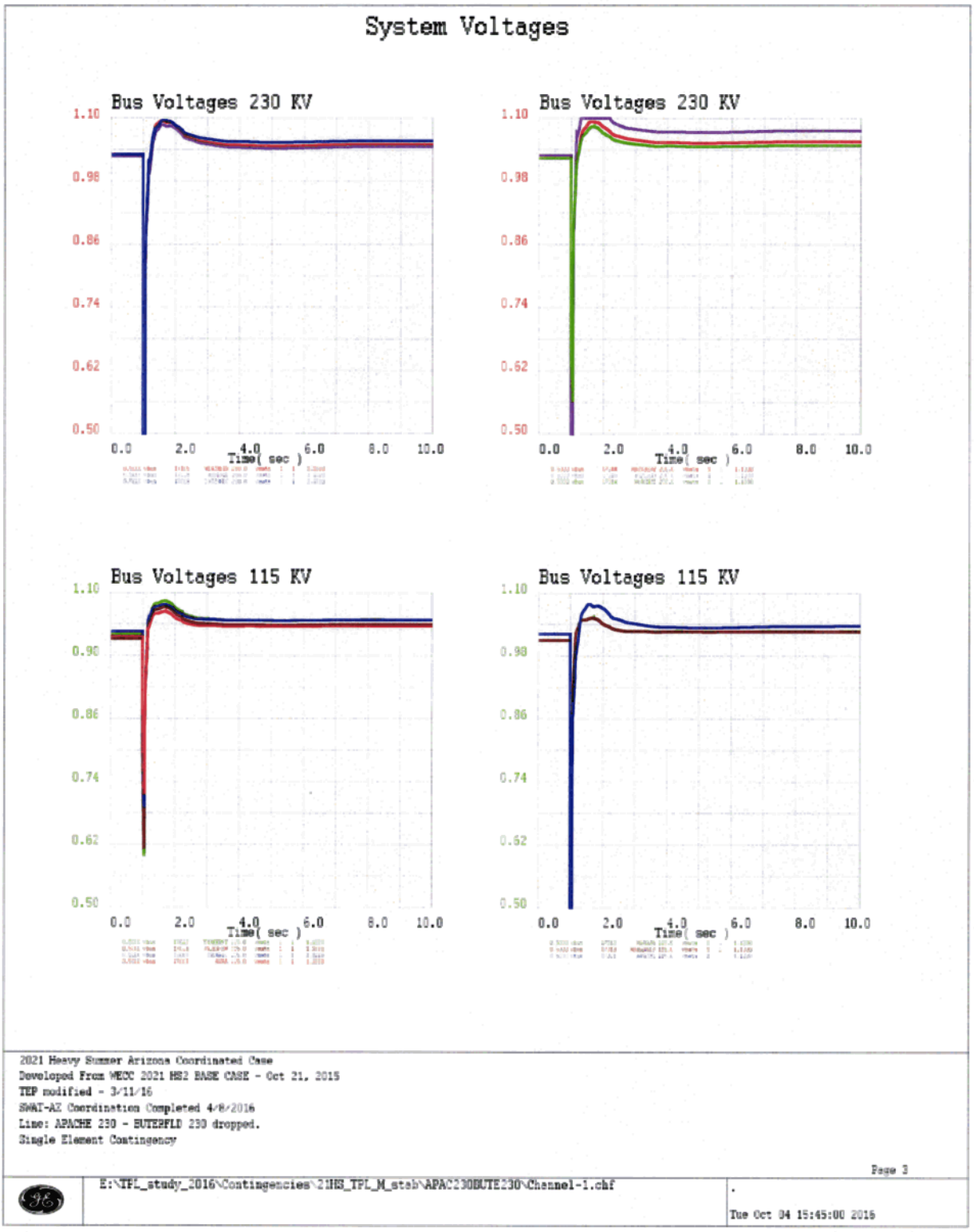
2021 HS – Apache to Butterfield 230 kV Line Outage
Apache Generators Output



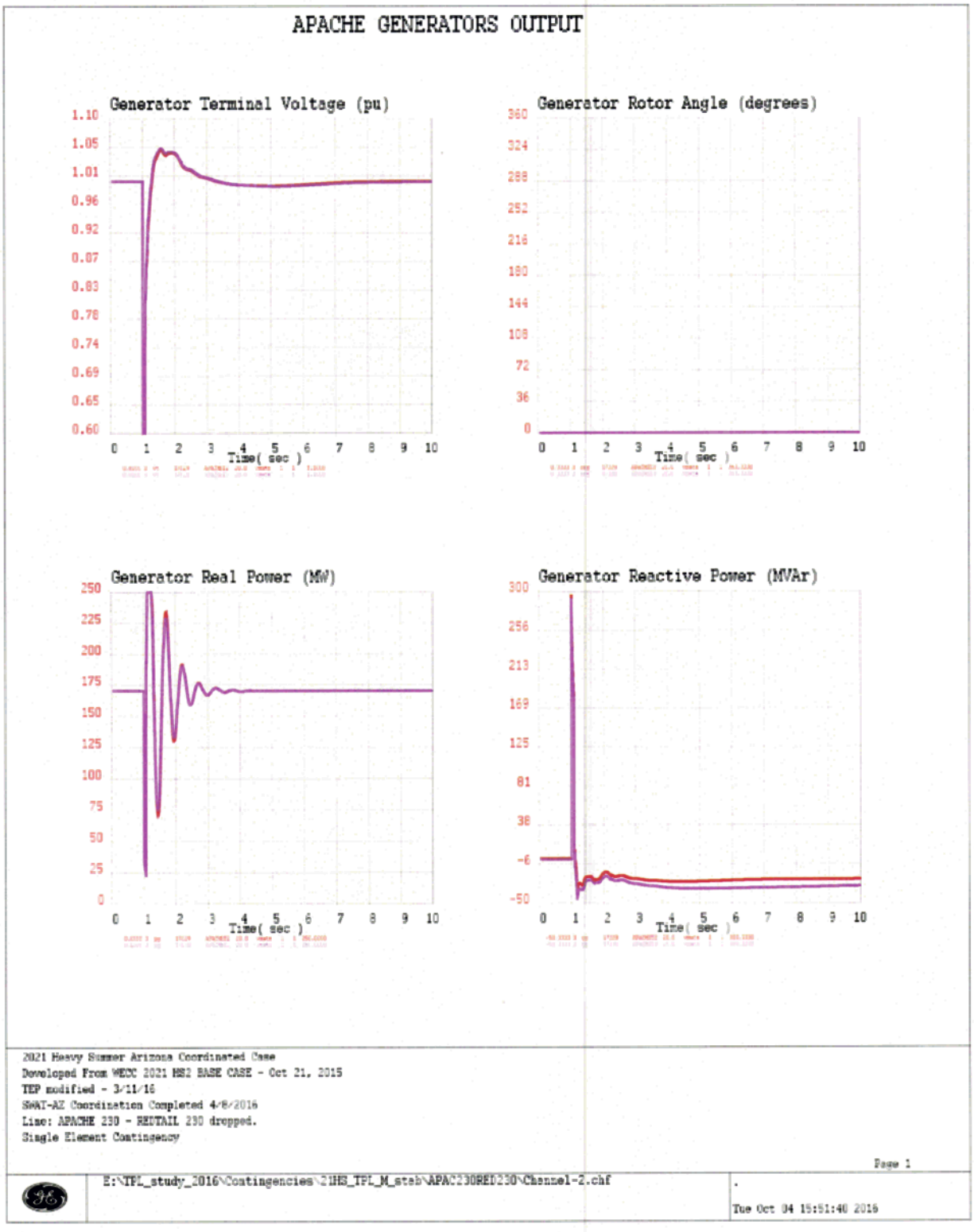
2021 HS– Apache to Butterfield 230 kV Line Outage
345 kV & 230 kV System Voltages



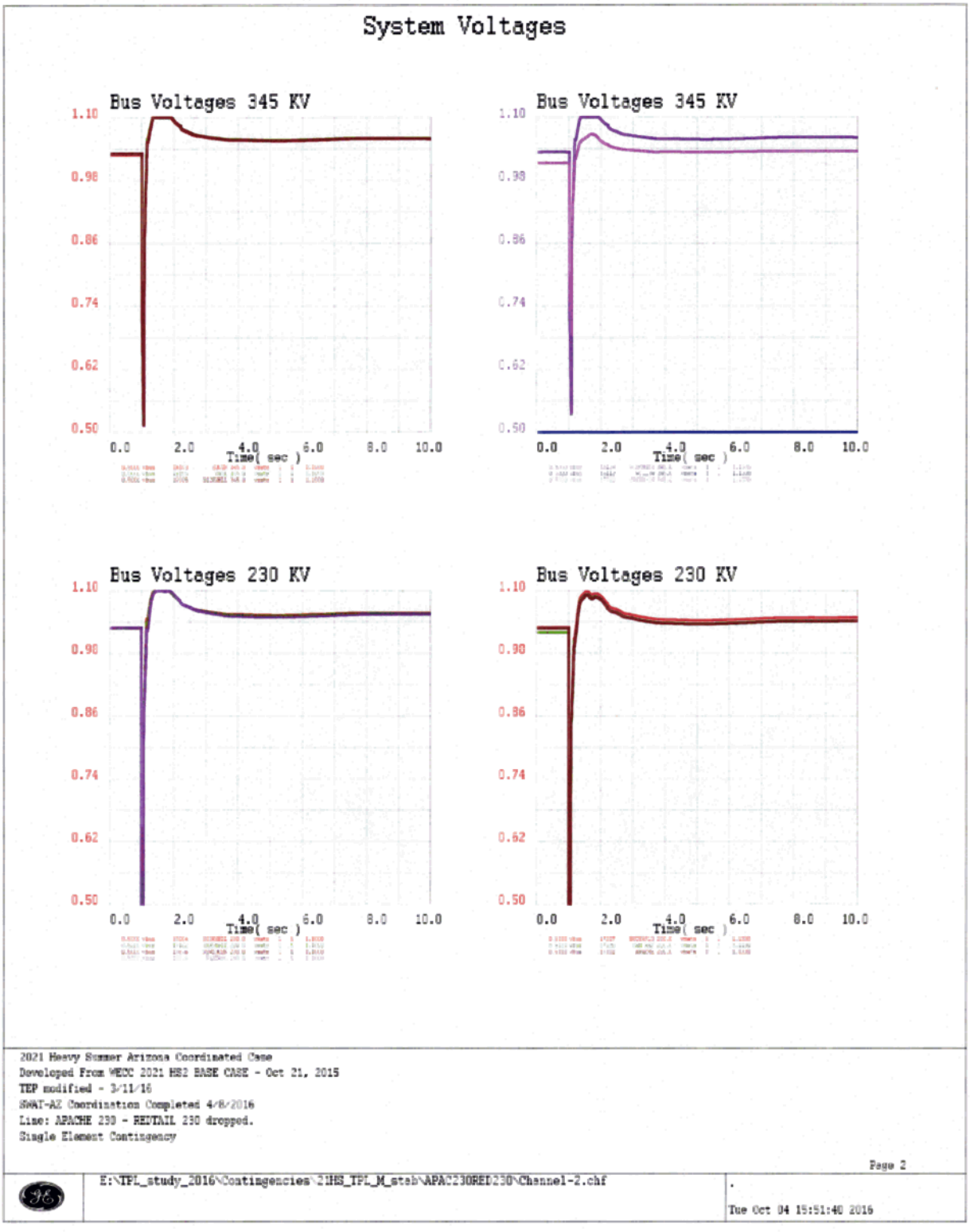
2021 HS – Apache to Butterfield 230 kV Line Outage
230 kV & 115 kV System Voltages



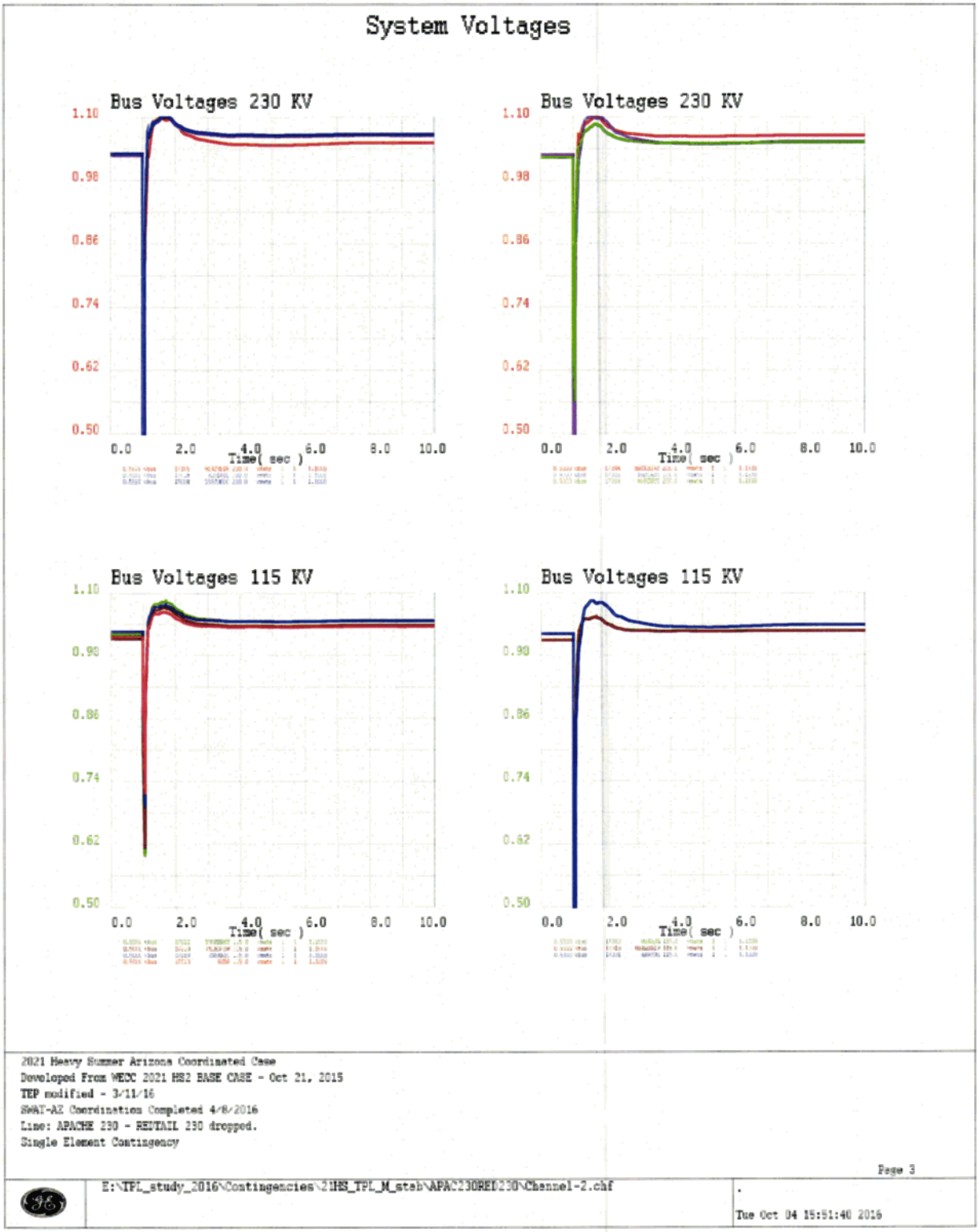
2021 HS – Apache to Redtail 230 kV Line Outage
Apache Generators Output



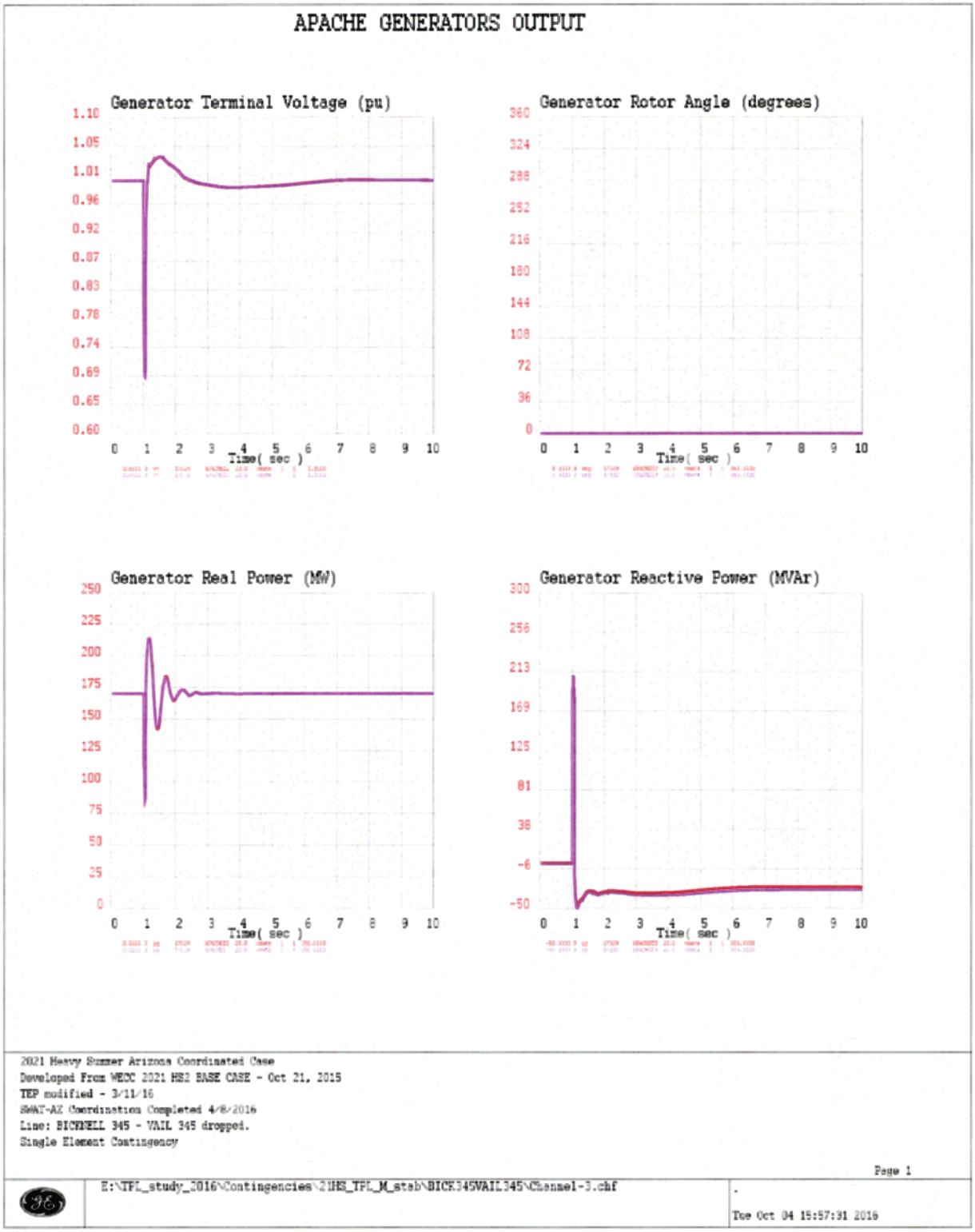
2021 HS – Apache to Redtail 230 kV Line Outage
345 kV & 230 kV System Voltages



2021 HS – Apache to Redtail 230 kV Line Outage
230 kV & 115 kV System Voltages

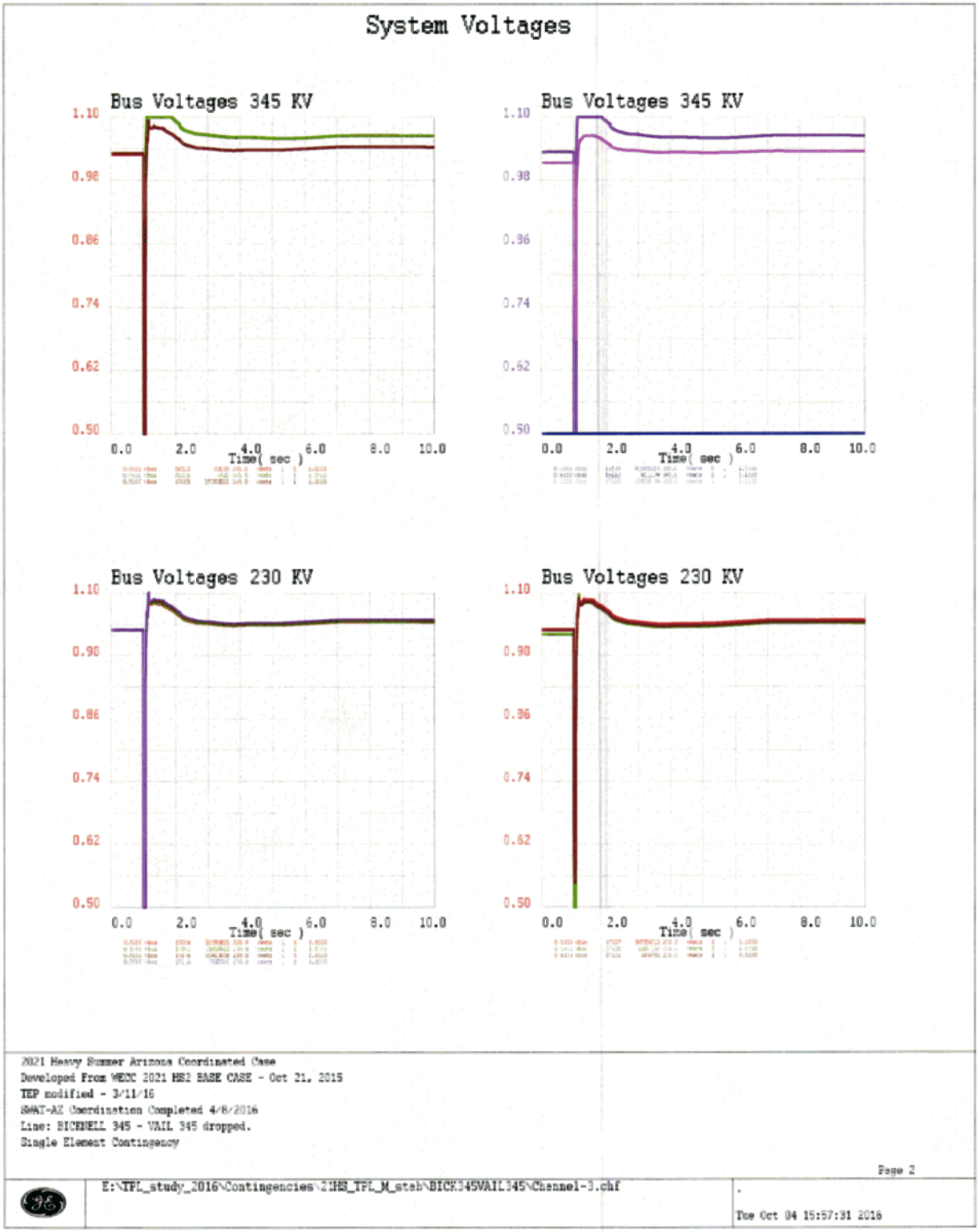


2021 HS– Bicknell to Vail 345 kV Line Outage
Apache Generators Output

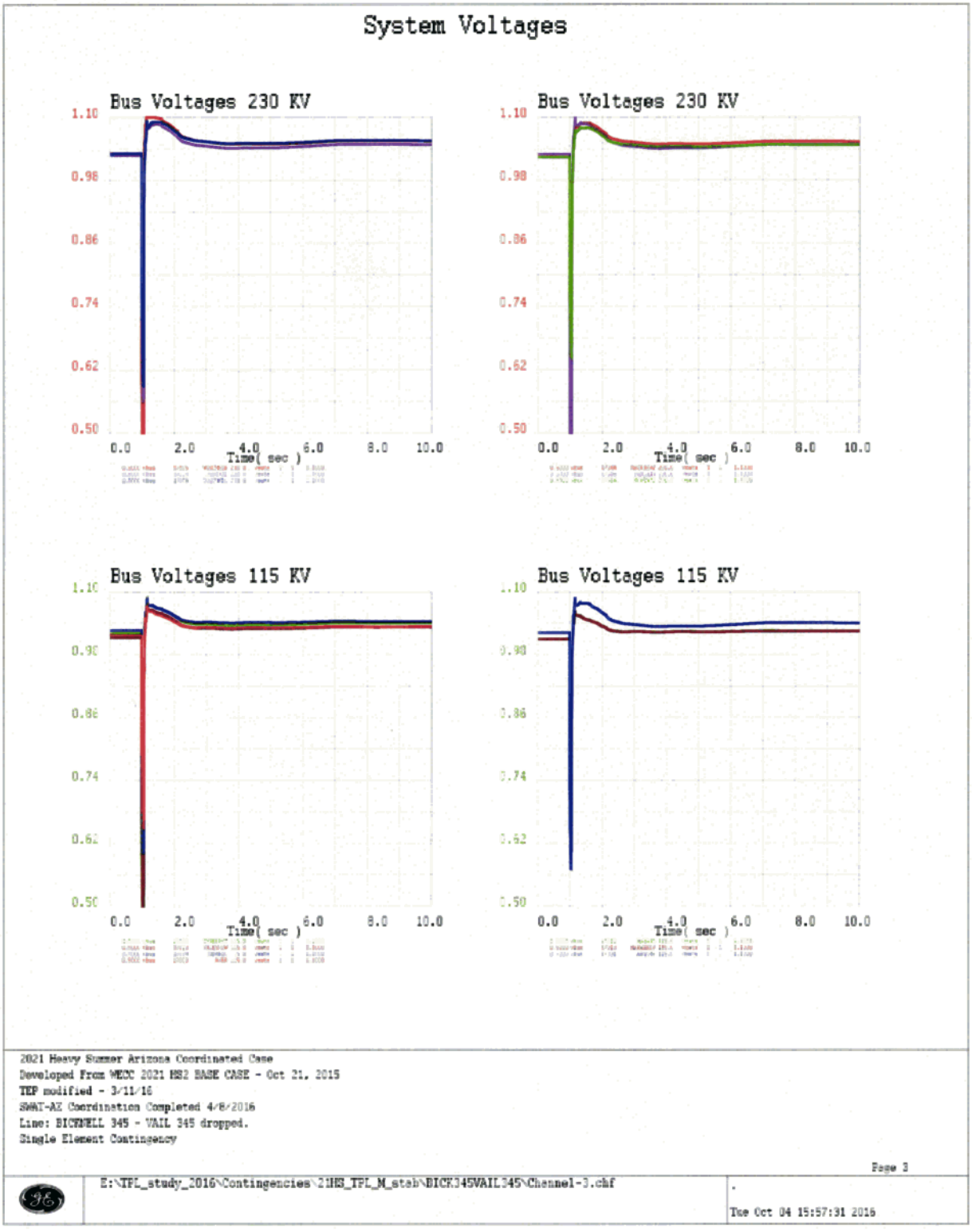


2021 HS – Bicknell to Vail 345 kV Line Outage

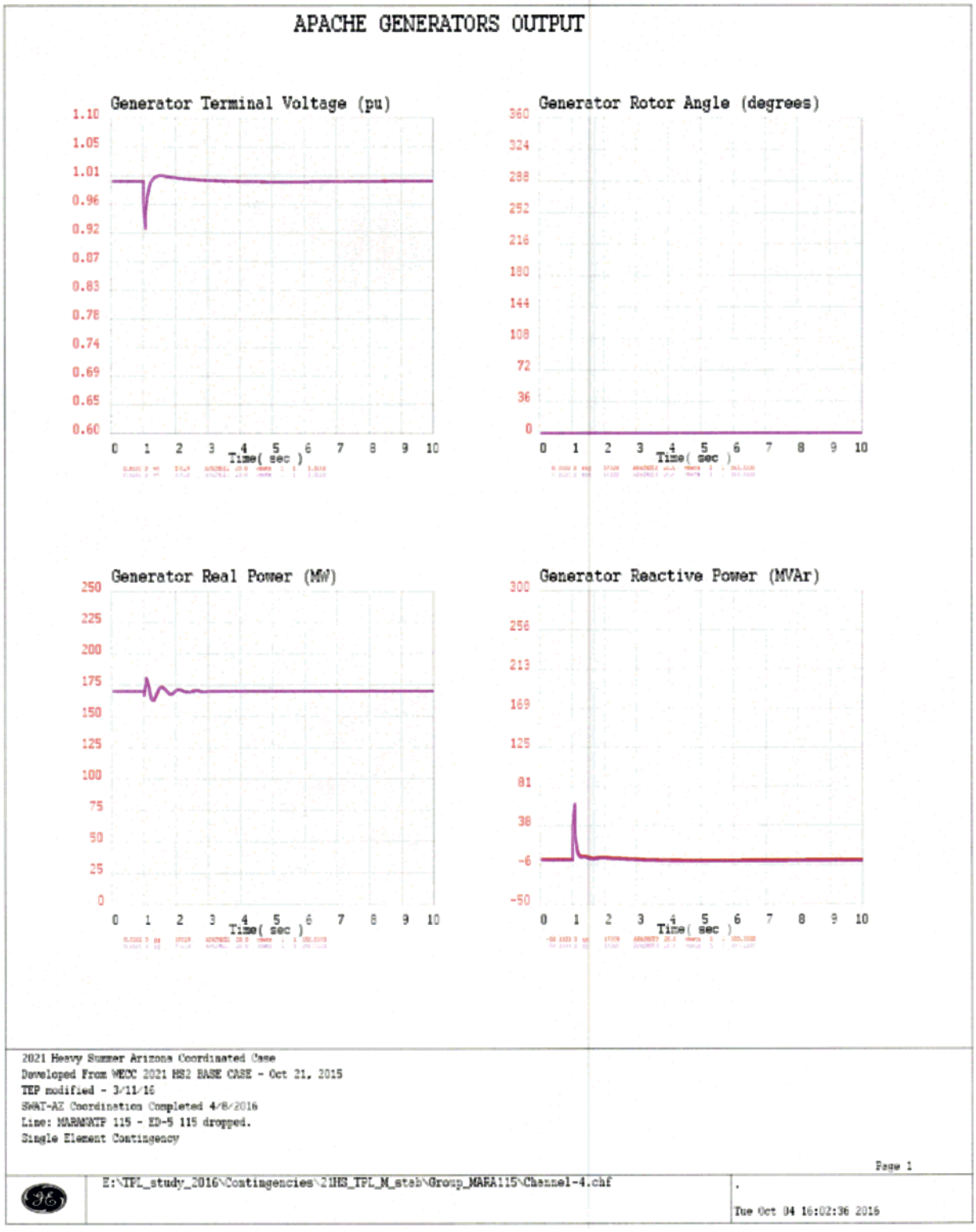
345 kV & 230 kV System Voltages



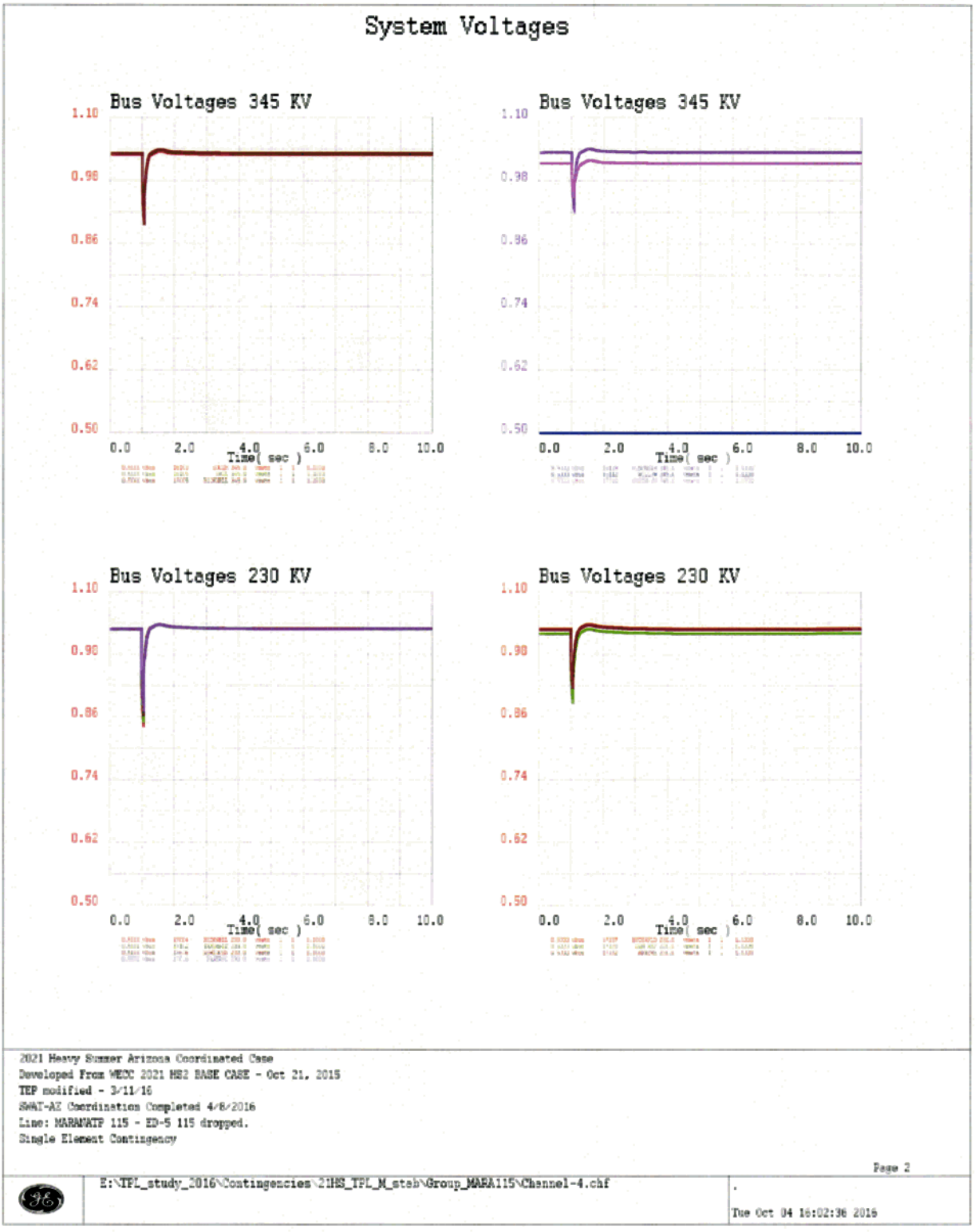
2021 HS – Bicknell to Vail 345 kV Line Outage
230 kV & 115 kV System Voltages



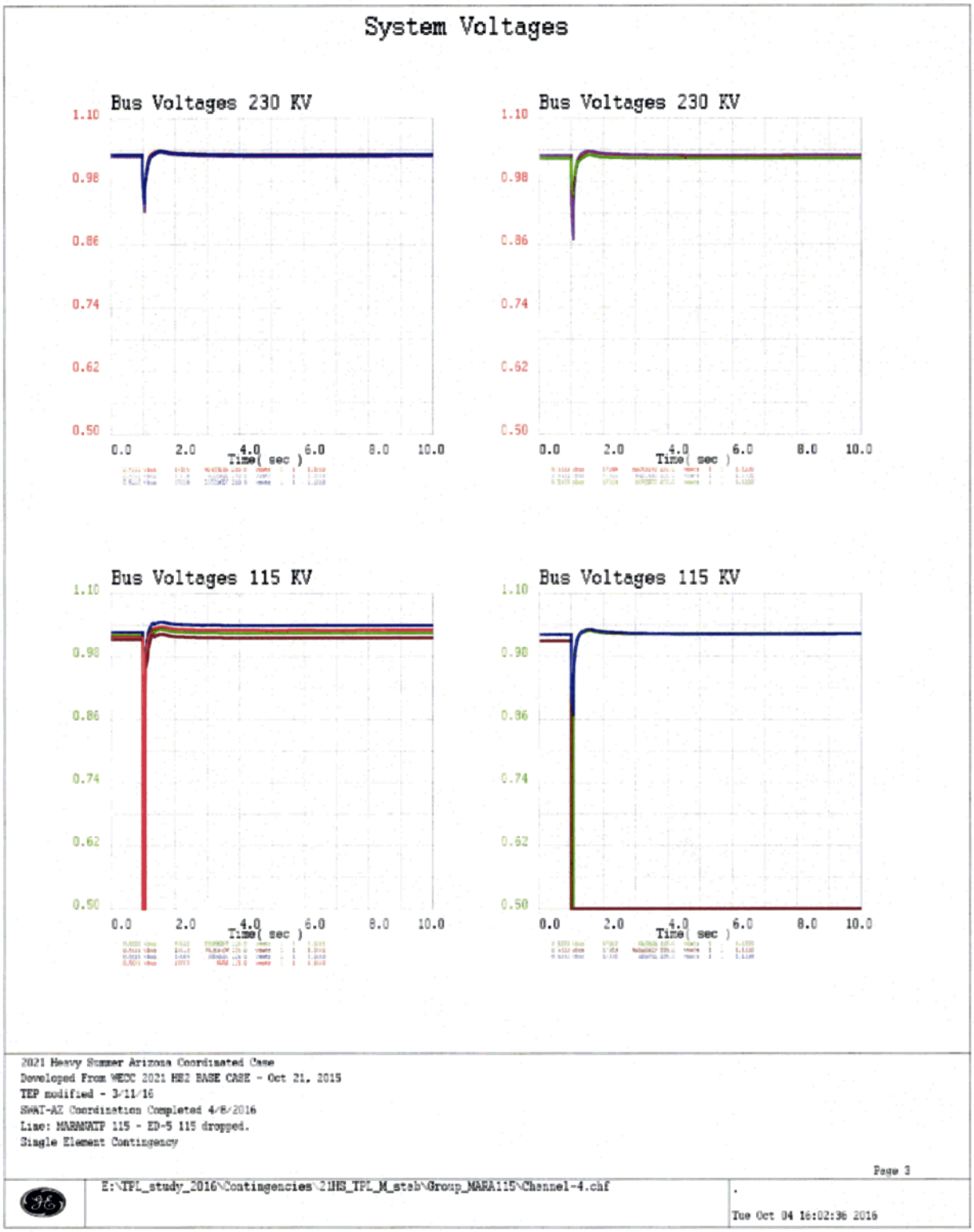
2021 HS – Marana Group 115 kV Line Outage
Apache Generators Output



2021 HS – Marana Group 115 kV Line Outage
345 kV & 230 kV System Voltages

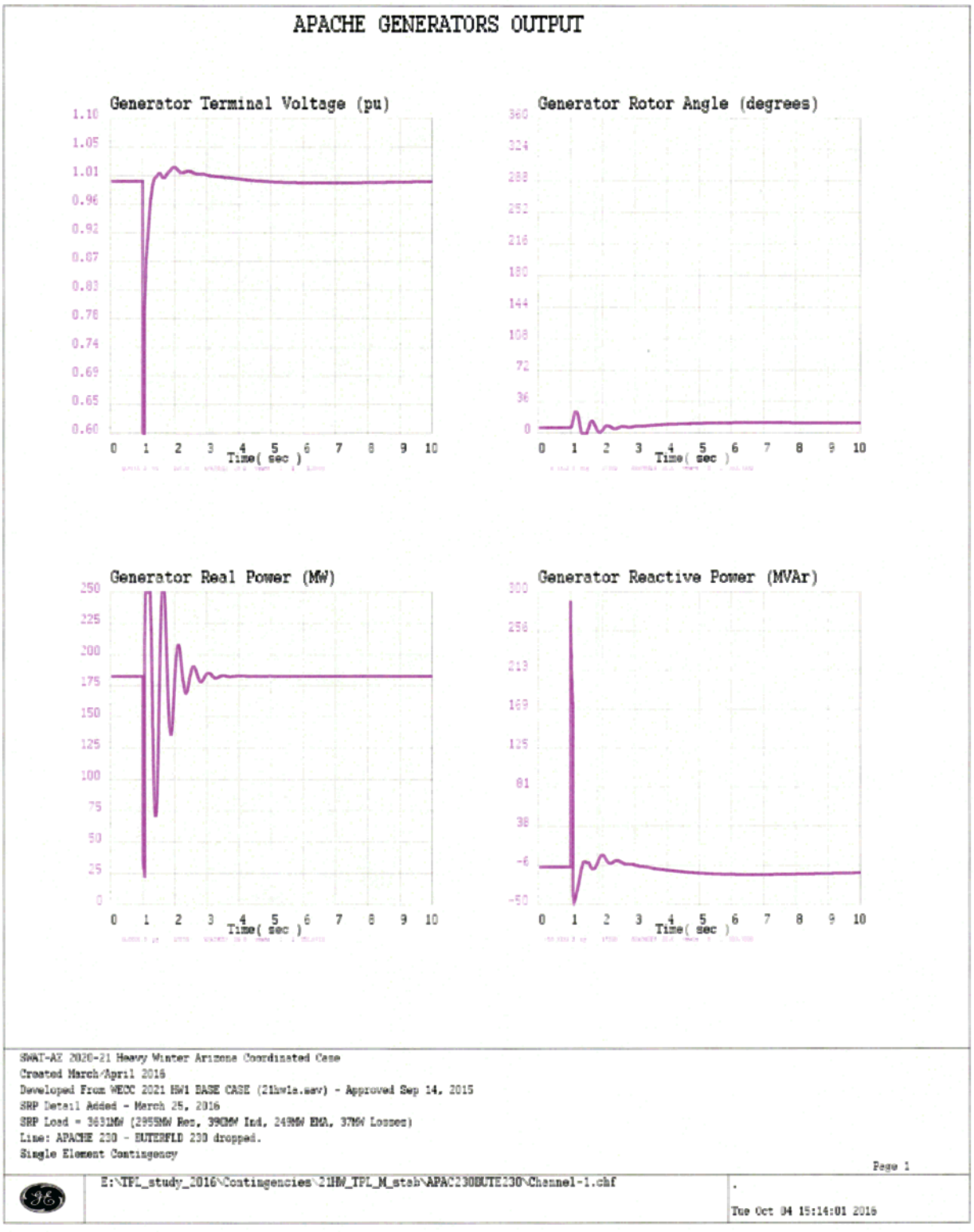


2021 HS – Marana Group 115 kV Line Outage
230 kV & 115 kV System Voltages

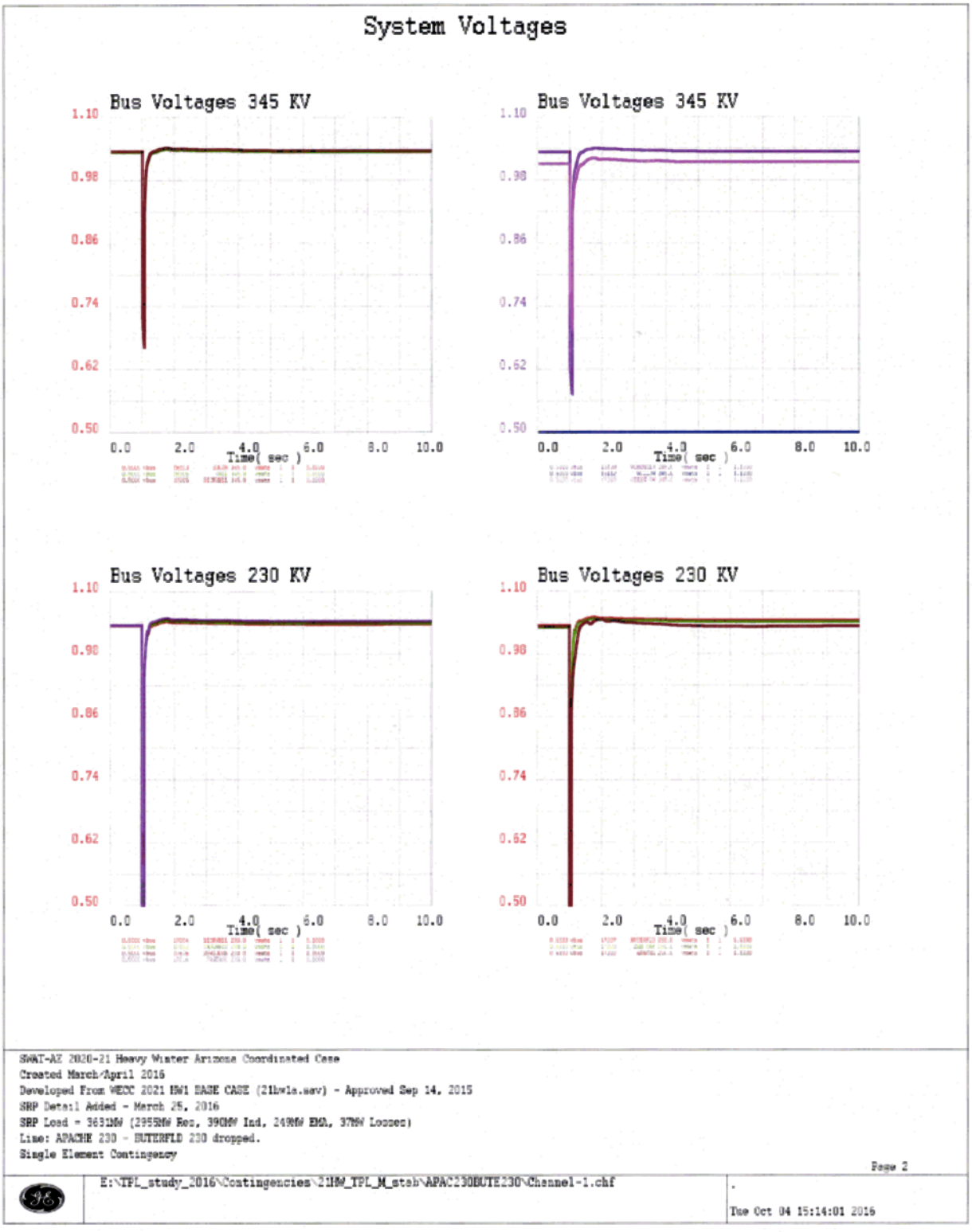


2021 HEAVY WINTER P1 Contingencies

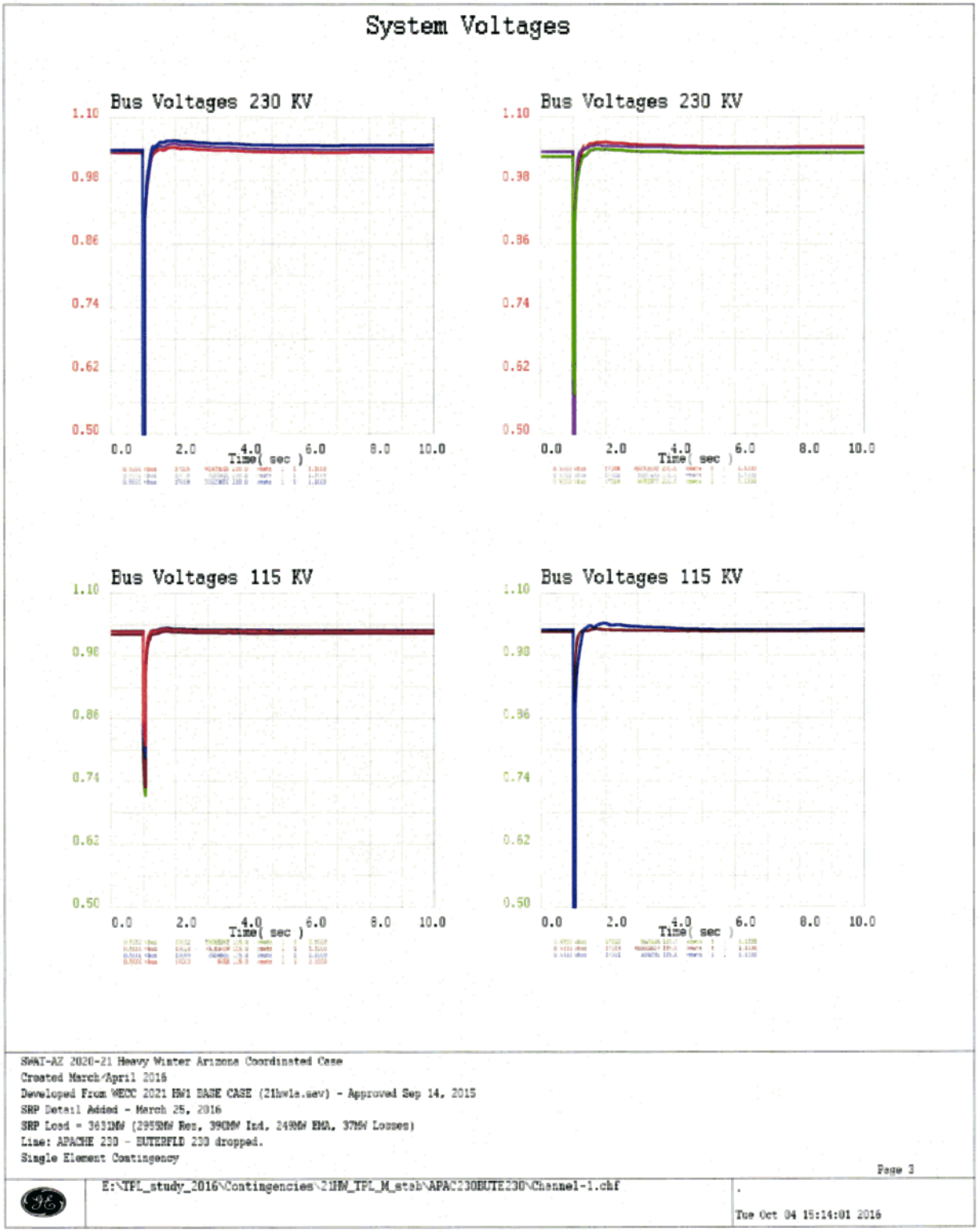
2021 HW – Apache to Butterfield 230 kV Line Outage
Apache Generators Output



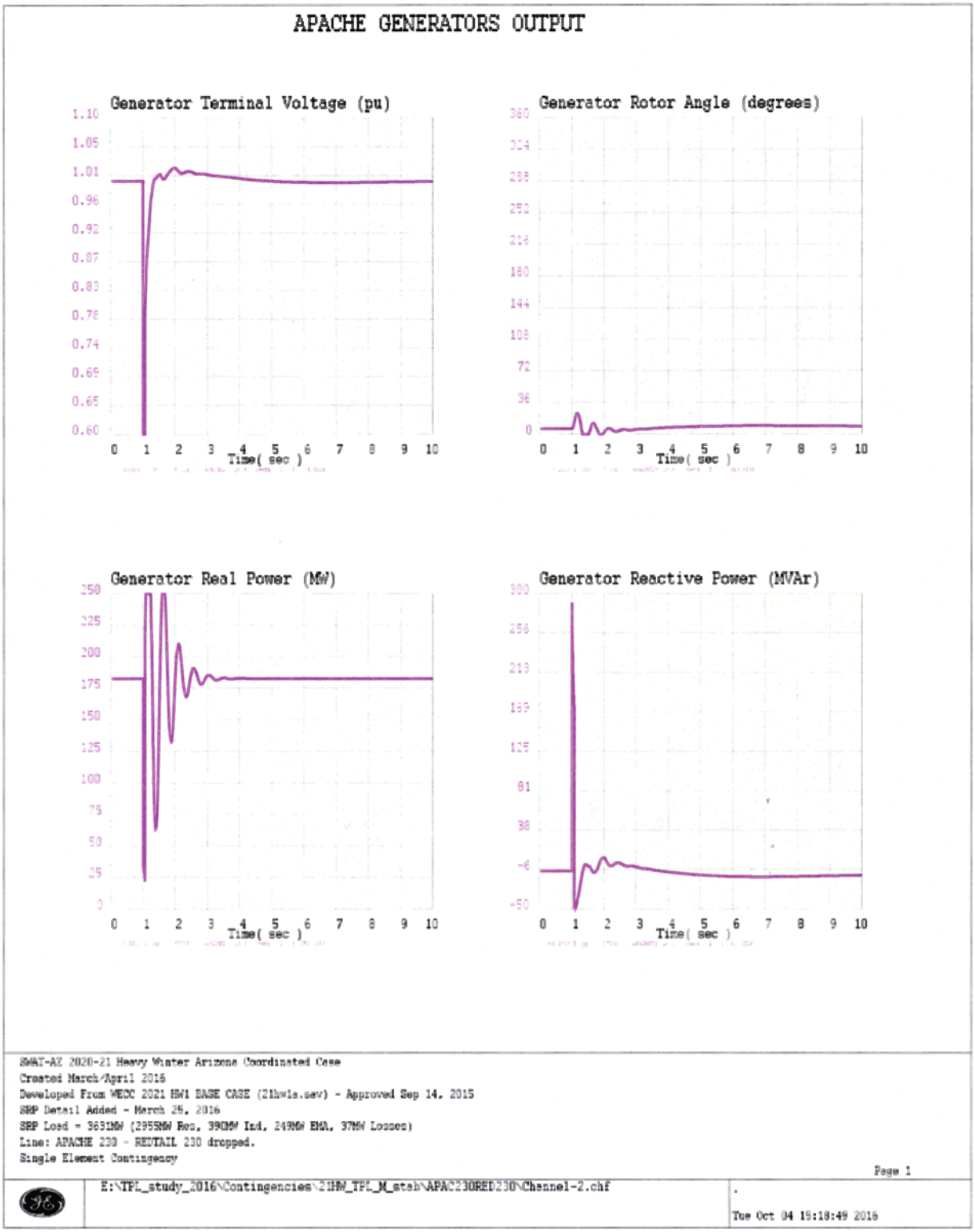
2021 HW – Apache to Butterfield 230 kV Line Outage
345 kV & 230 kV System Voltages



2021 HW– Apache to Butterfield 230 kV Line Outage
230 kV & 115 kV System Voltages

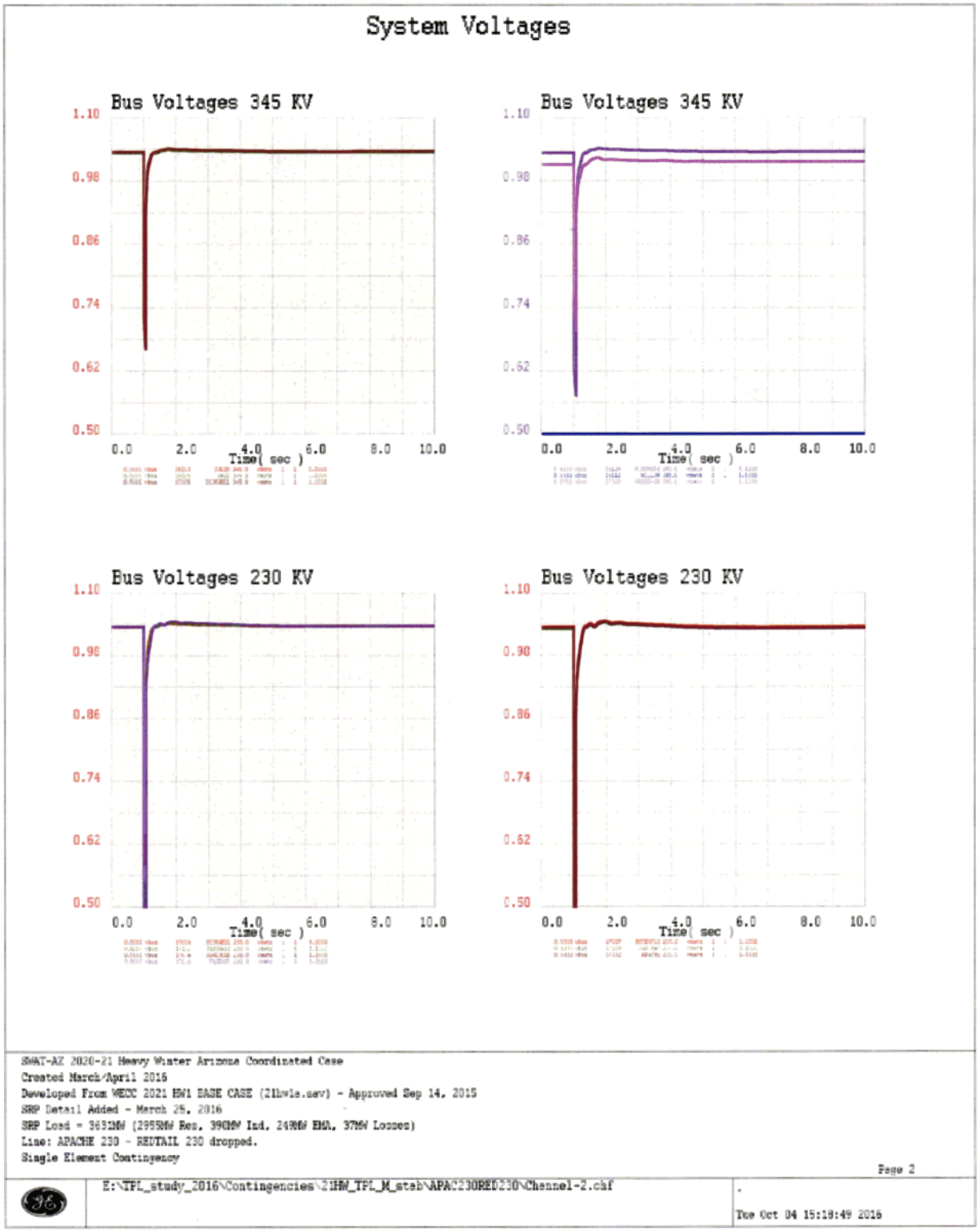


2021 HW – Apache to Redtail 230 kV Line Outage
Apache Generators Output

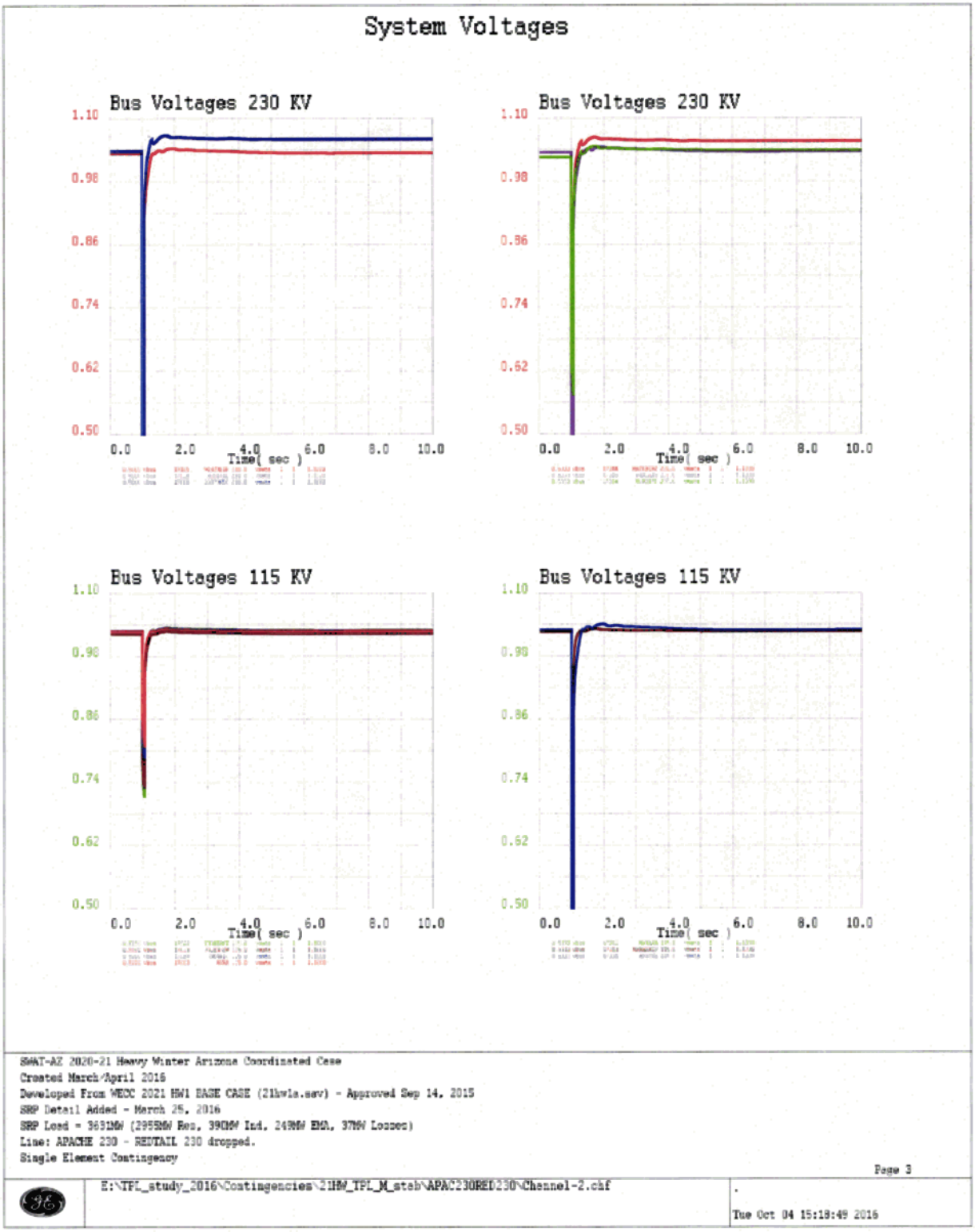


2021 HW – Apache to Redtail 230 kV Line Outage

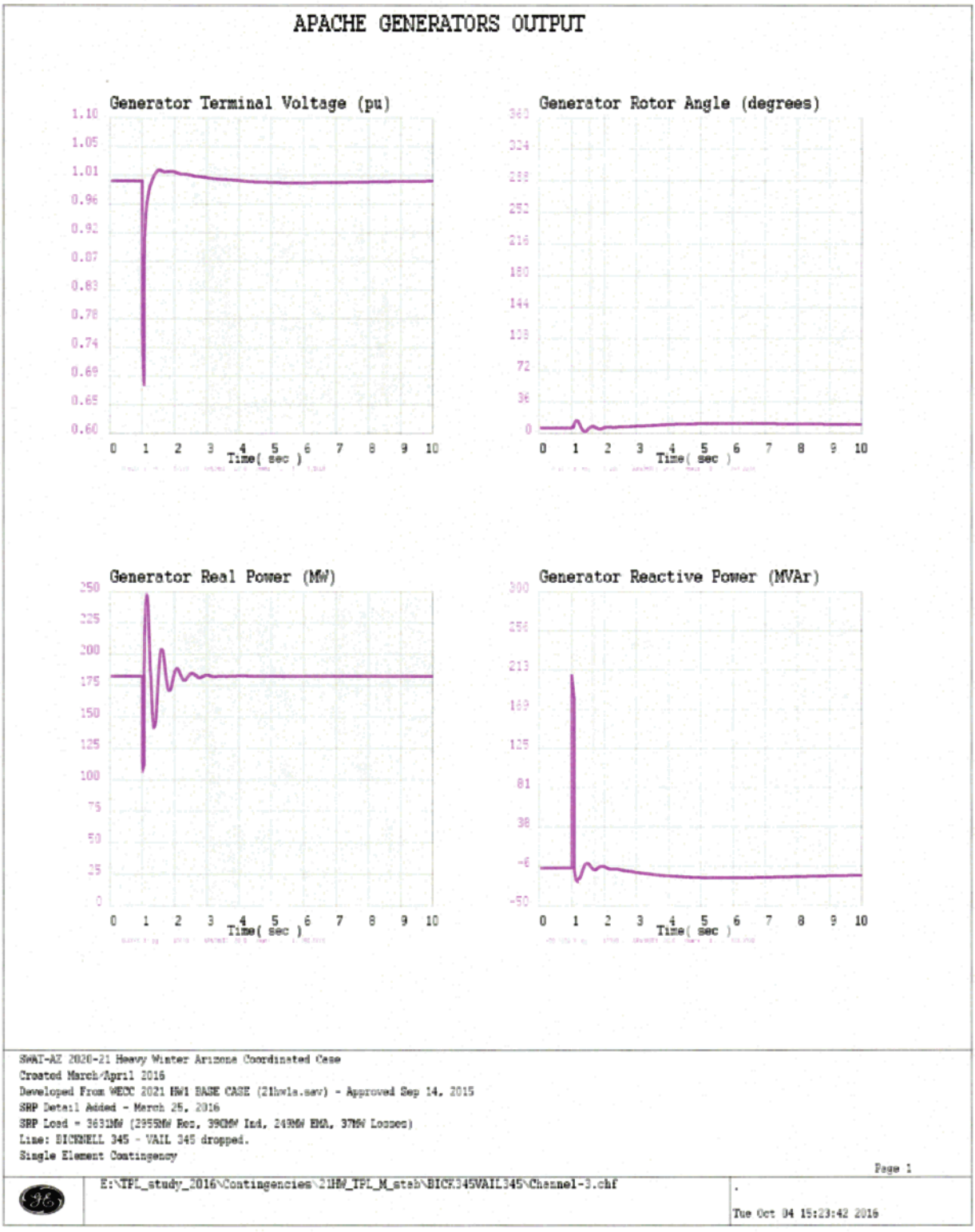
345 kV & 230 kV System Voltages



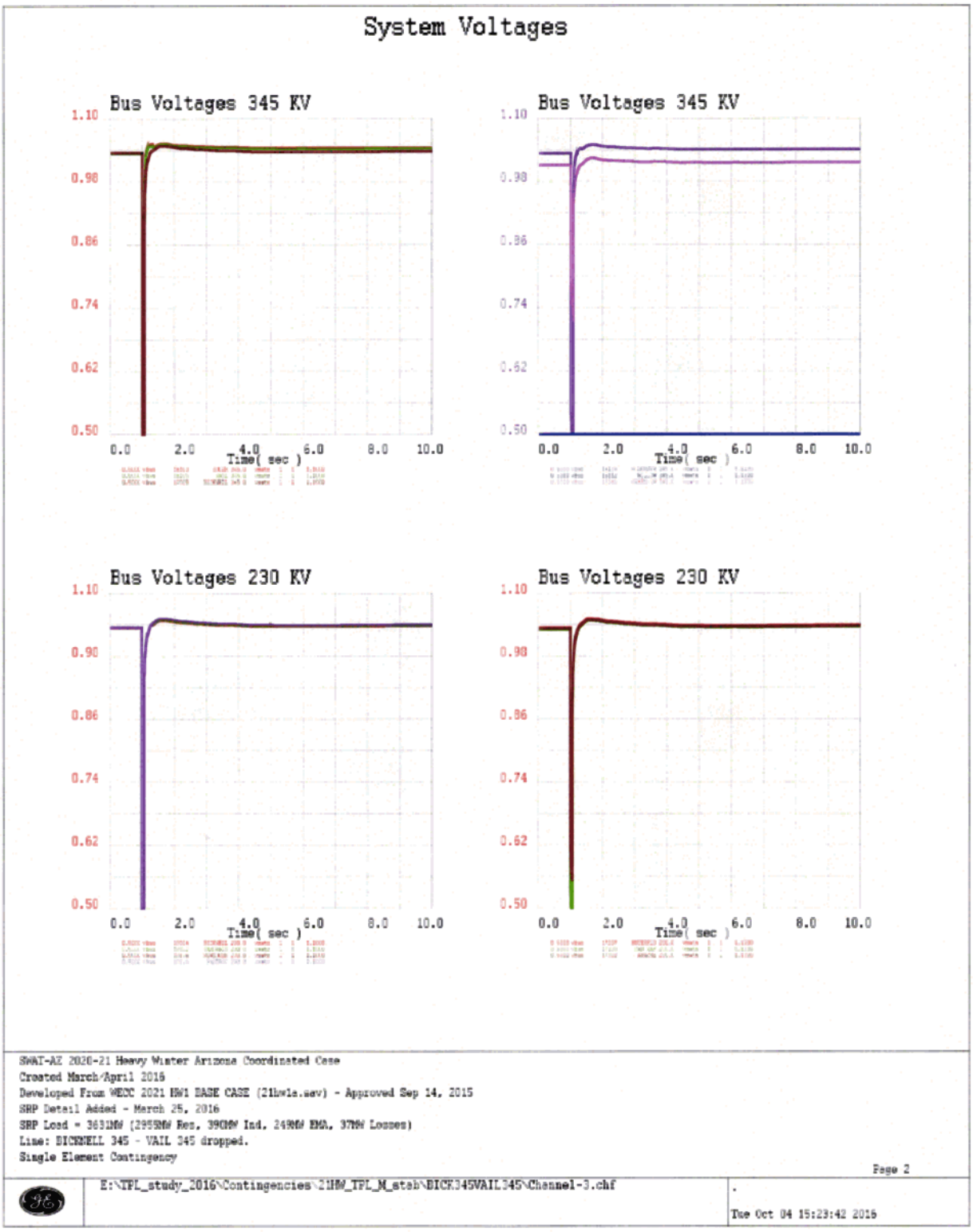
2021 HW – Apache to Redtail 230 kV Line Outage
230 kV & 115 kV System Outages



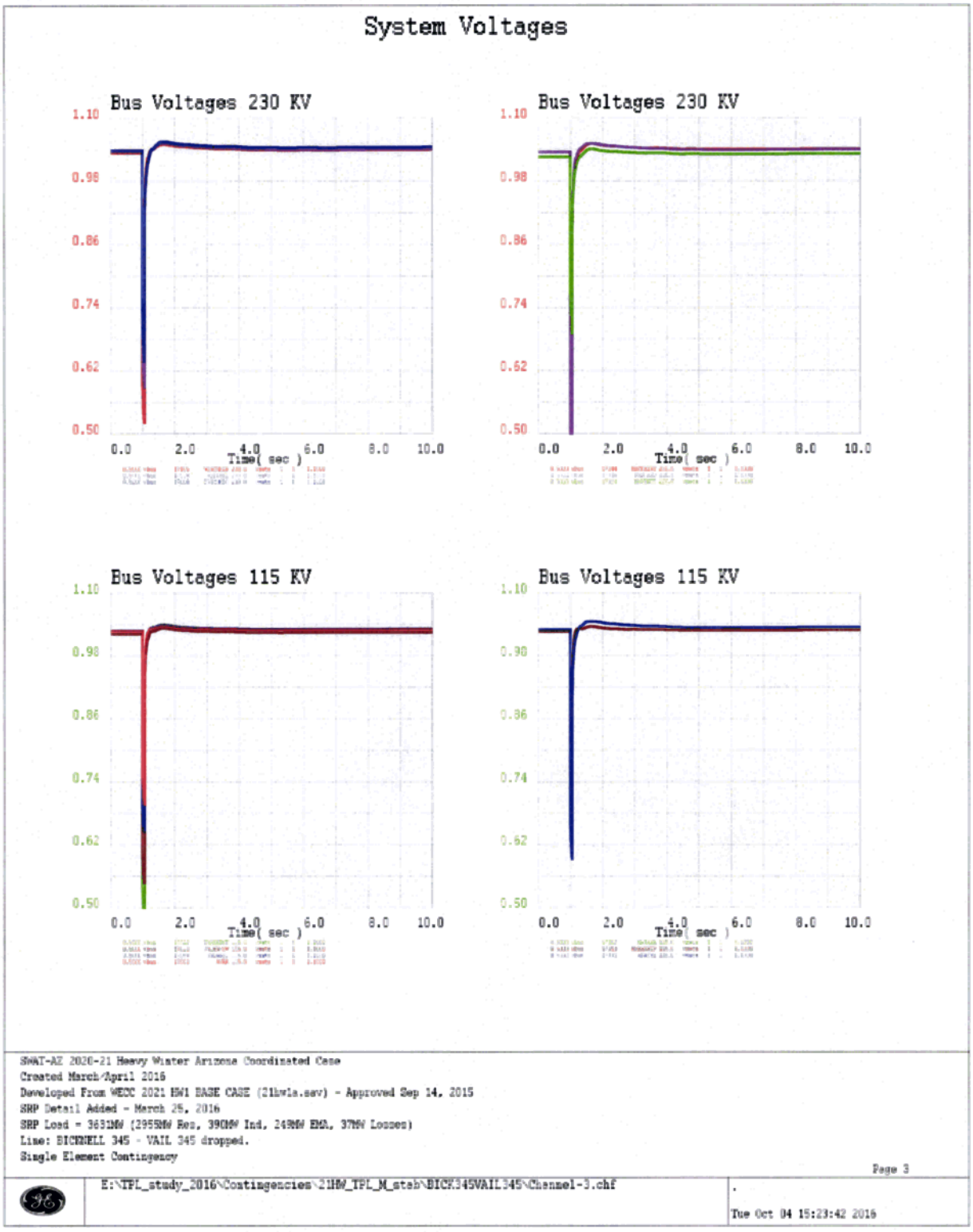
2021 HW – Bicknell to Vail 345 kV Line Outage
Apache Generators Output



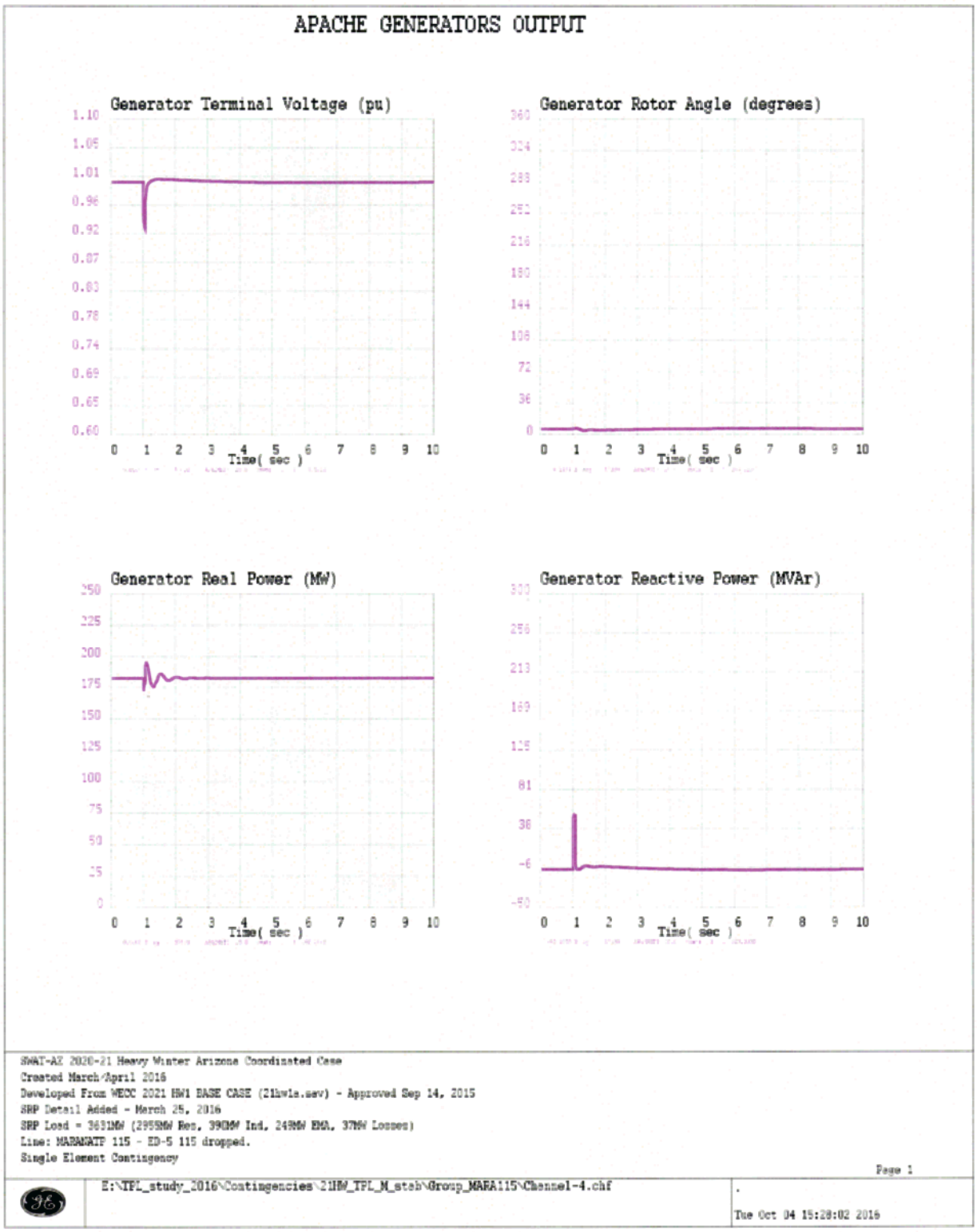
2021 HW – Bicknell to Vail 345 kV Line Outage
345 kV & 230 kV System Voltages



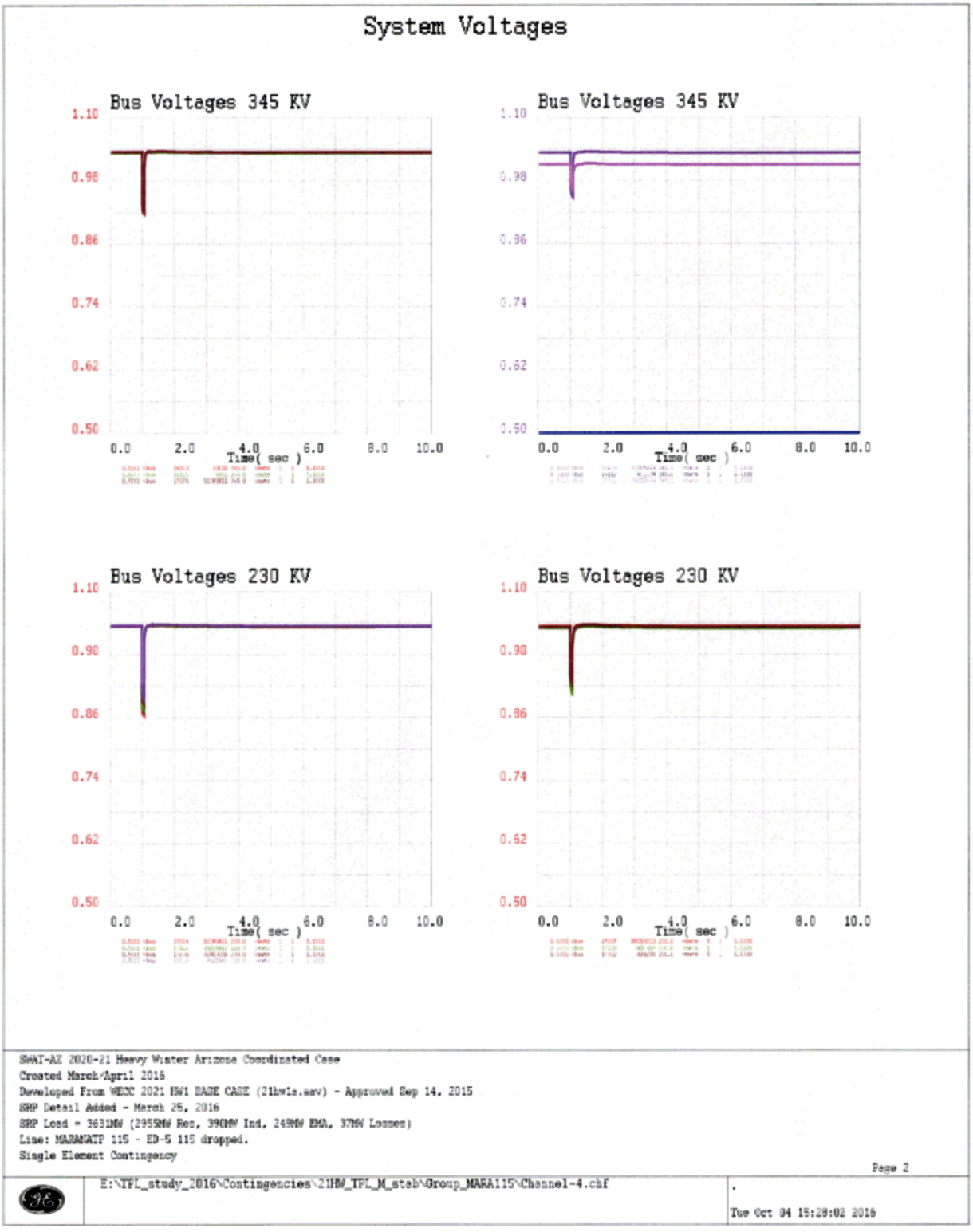
2021 HW – Bicknell to Vail 345 kV Line Outage
230 kV & 115 kV System Voltages



2021 HW – Marana Group 115 kV Line Outage
Apache Generators Output

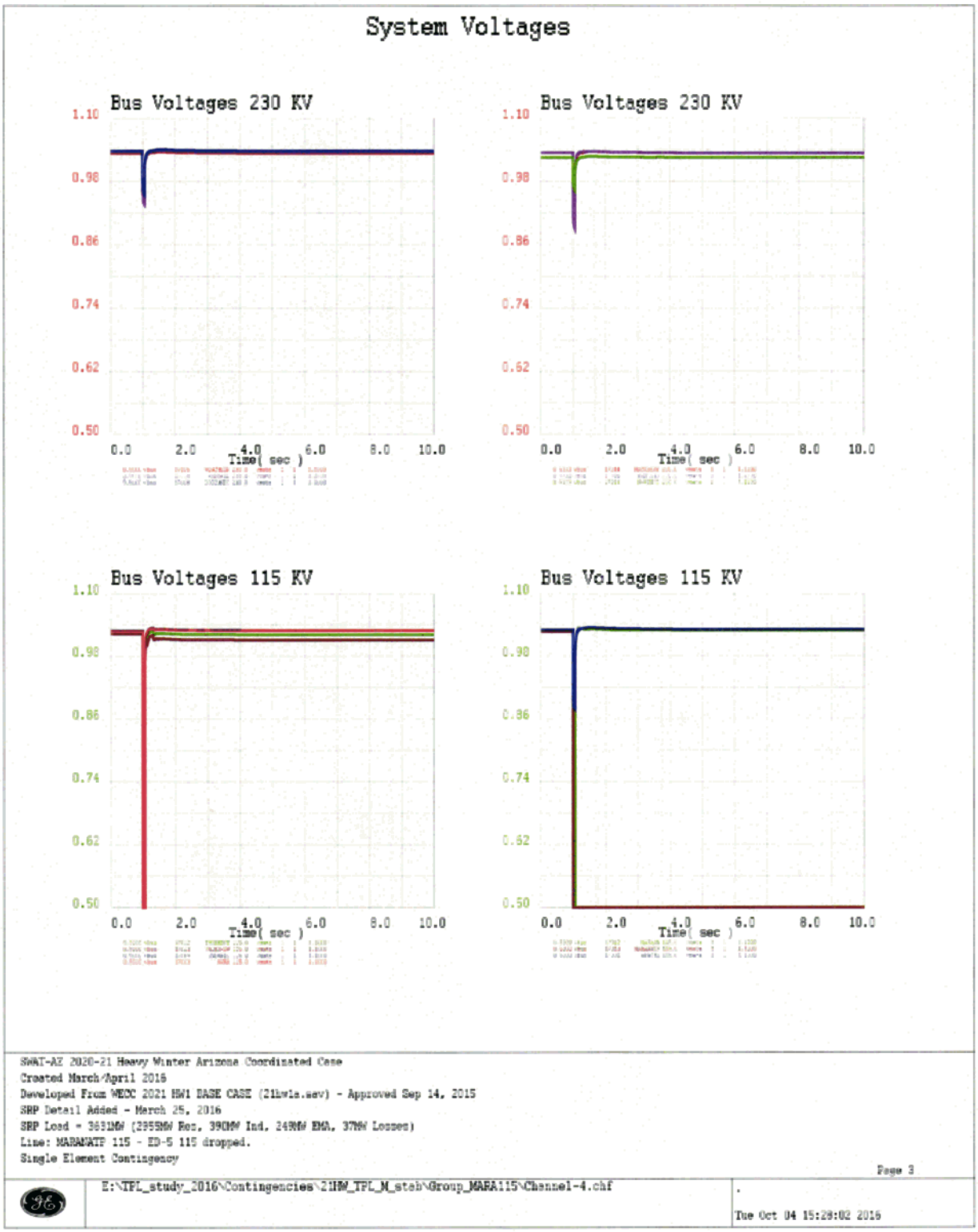


2021 HW – Marana Group 115 kV Line Outage
345 kV & 230 kV System Voltages



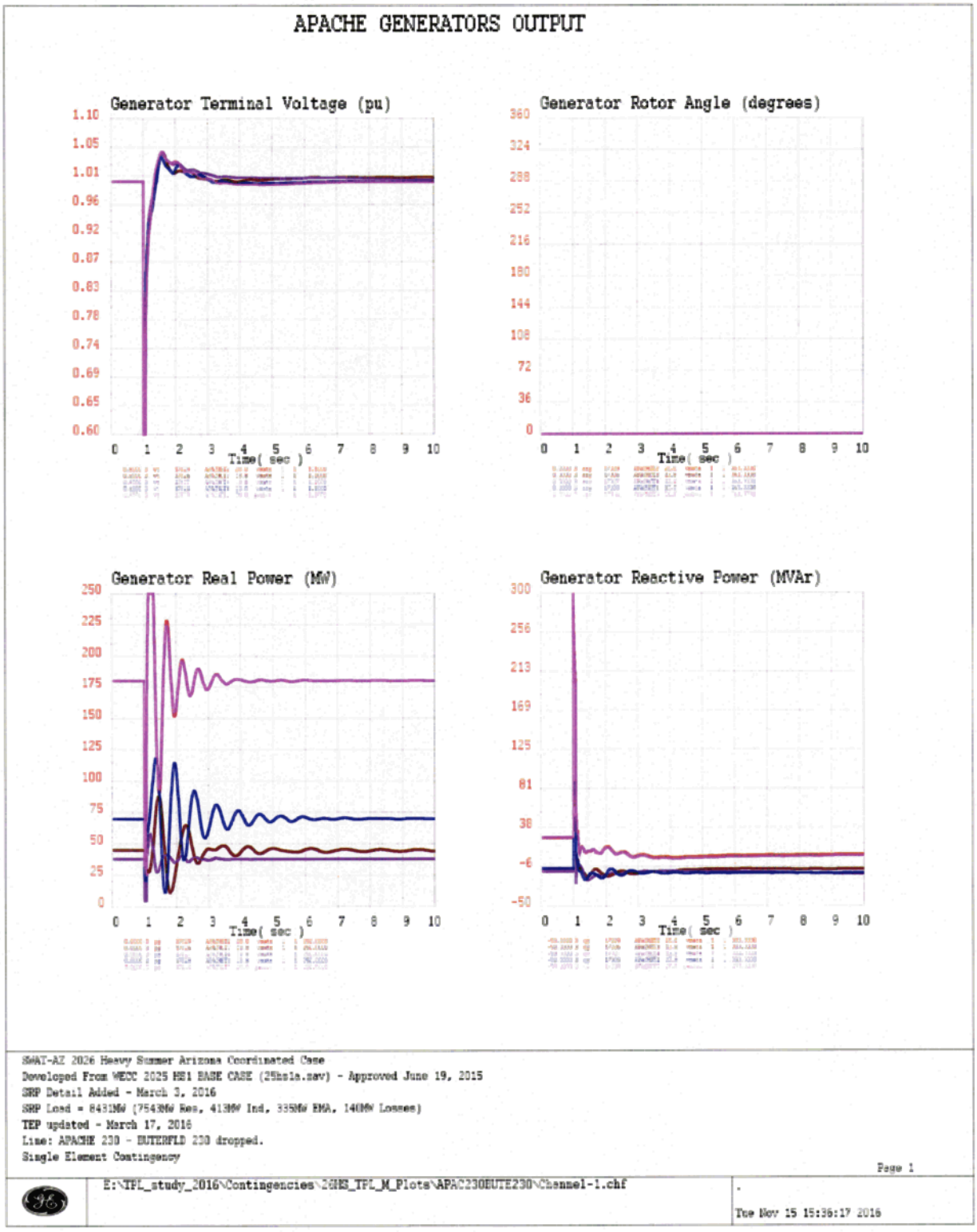
2021 HW – Marana Group 115 kV Line Outage

230 kV & 115 kV System Voltages

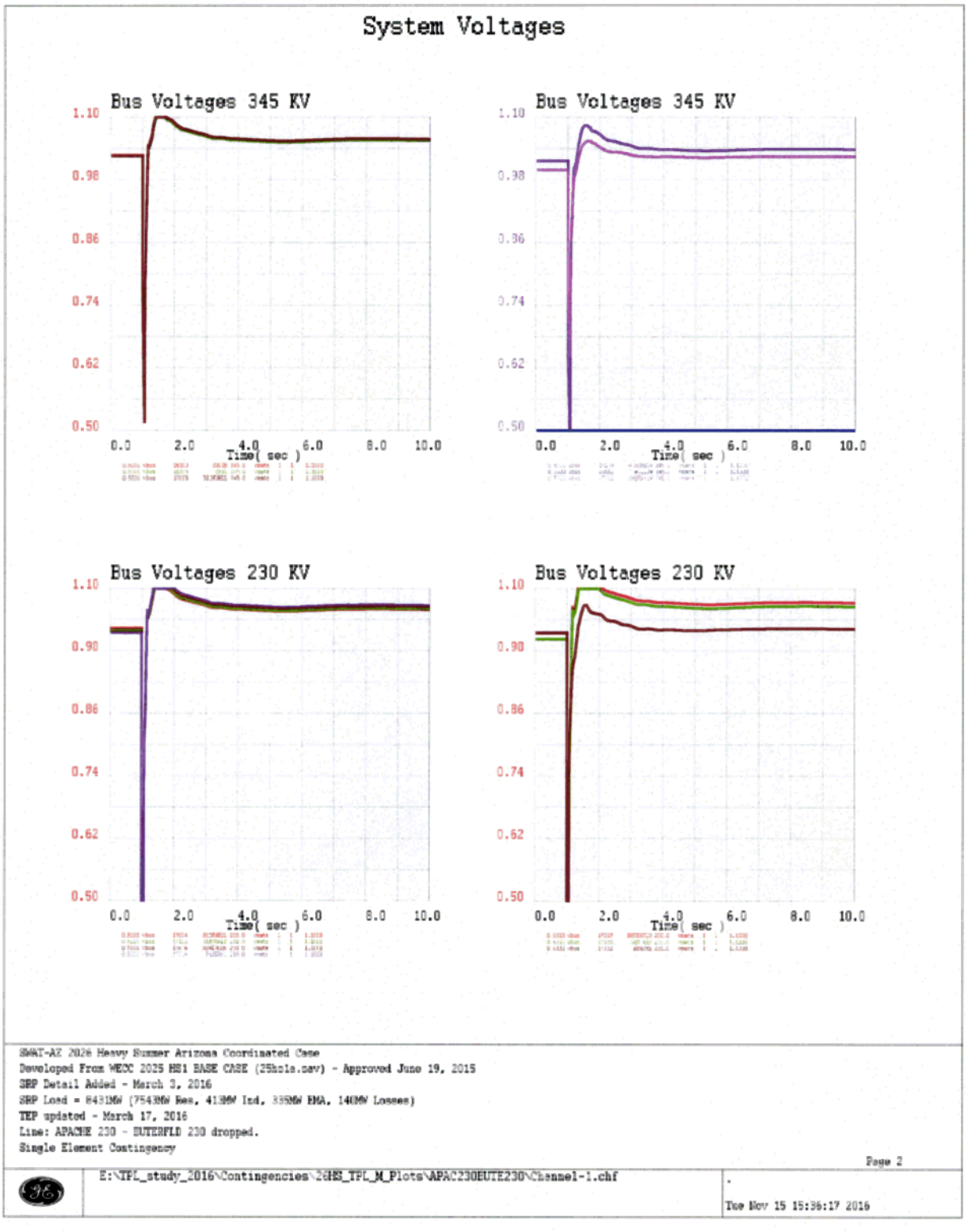


2026 HEAVY SUMMER P1 Contingencies

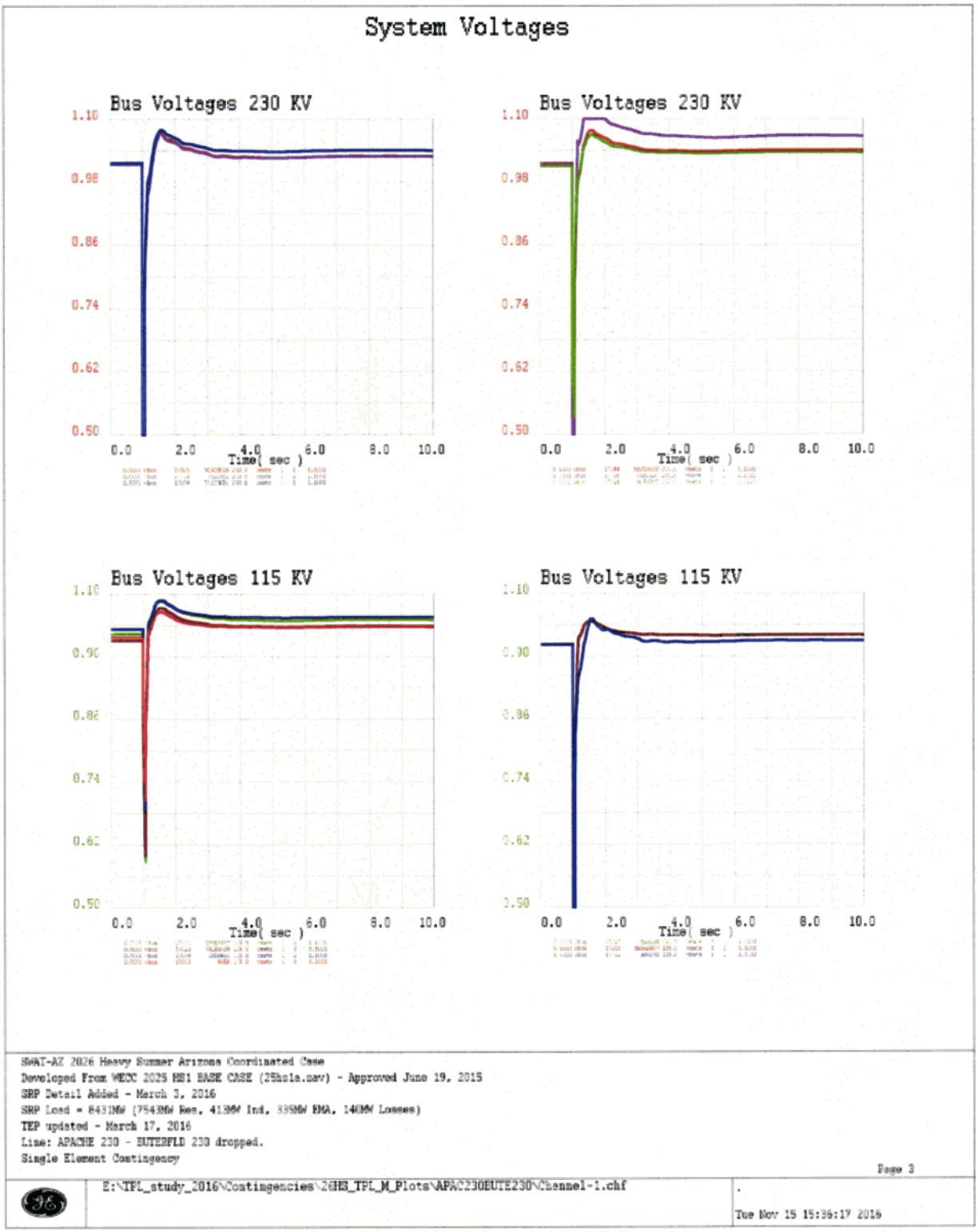
2026 HS – Apache to Butterfield 230 kV Line Outage
Apache Generators Output



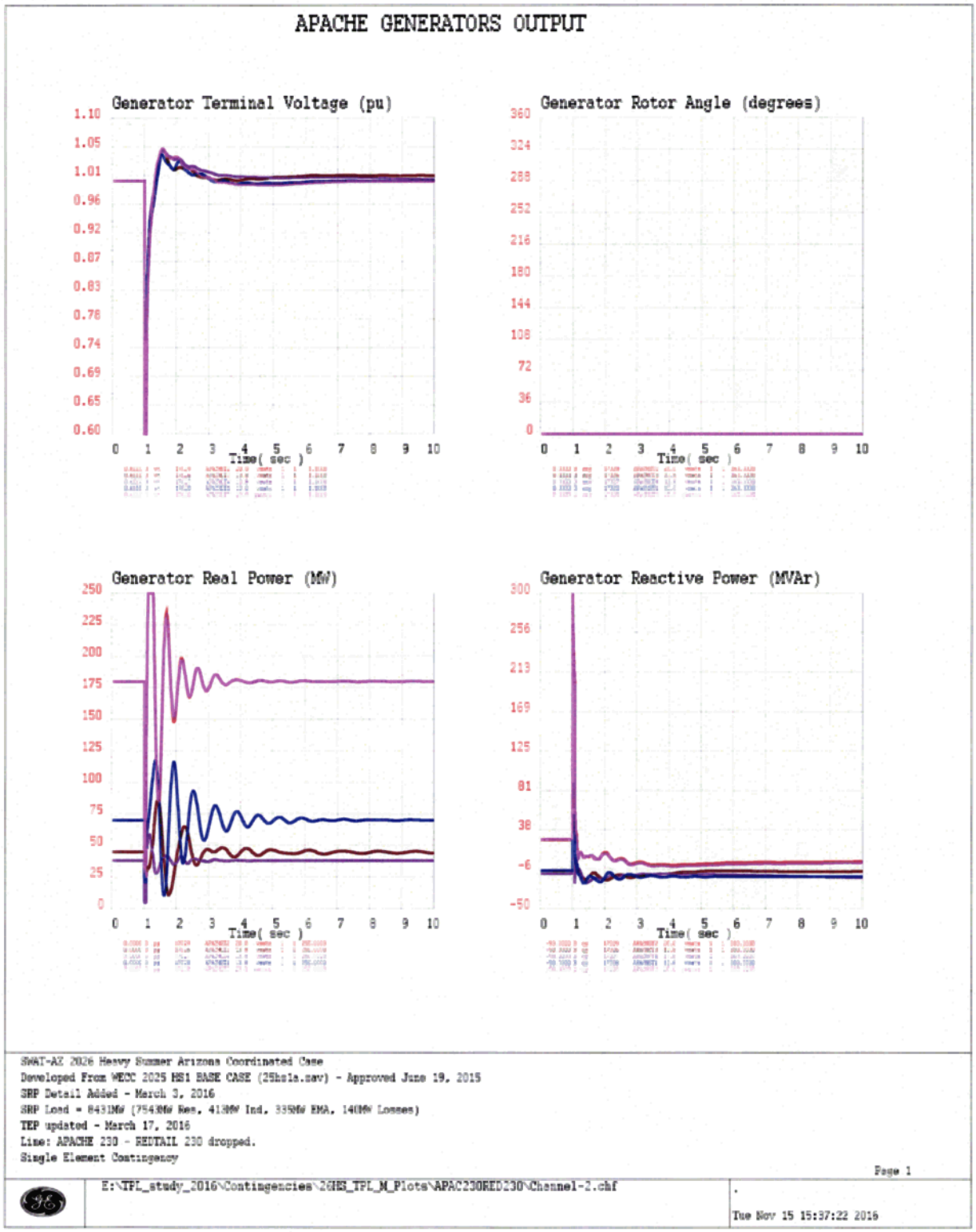
2026 HS – Apache to Butterfield 230 kV Line Outage
345 kV & 230 kV System Voltages



2026 HS– Apache to Butterfield 230 kV Line Outage
230 kV & 115 kV System Voltages

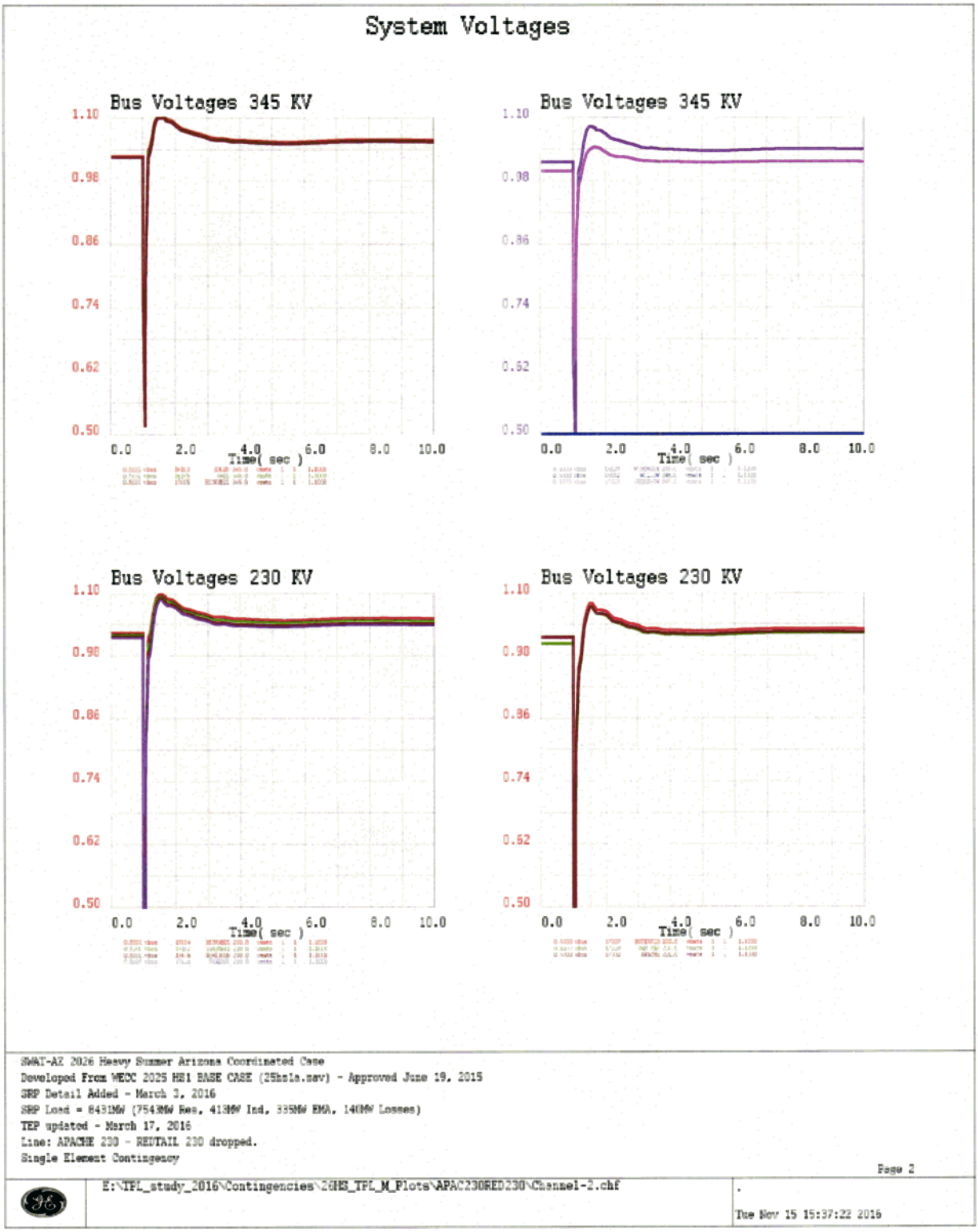


2026 HS – Apache to Redtail 230 kV Line Outage
Apache Generators Output

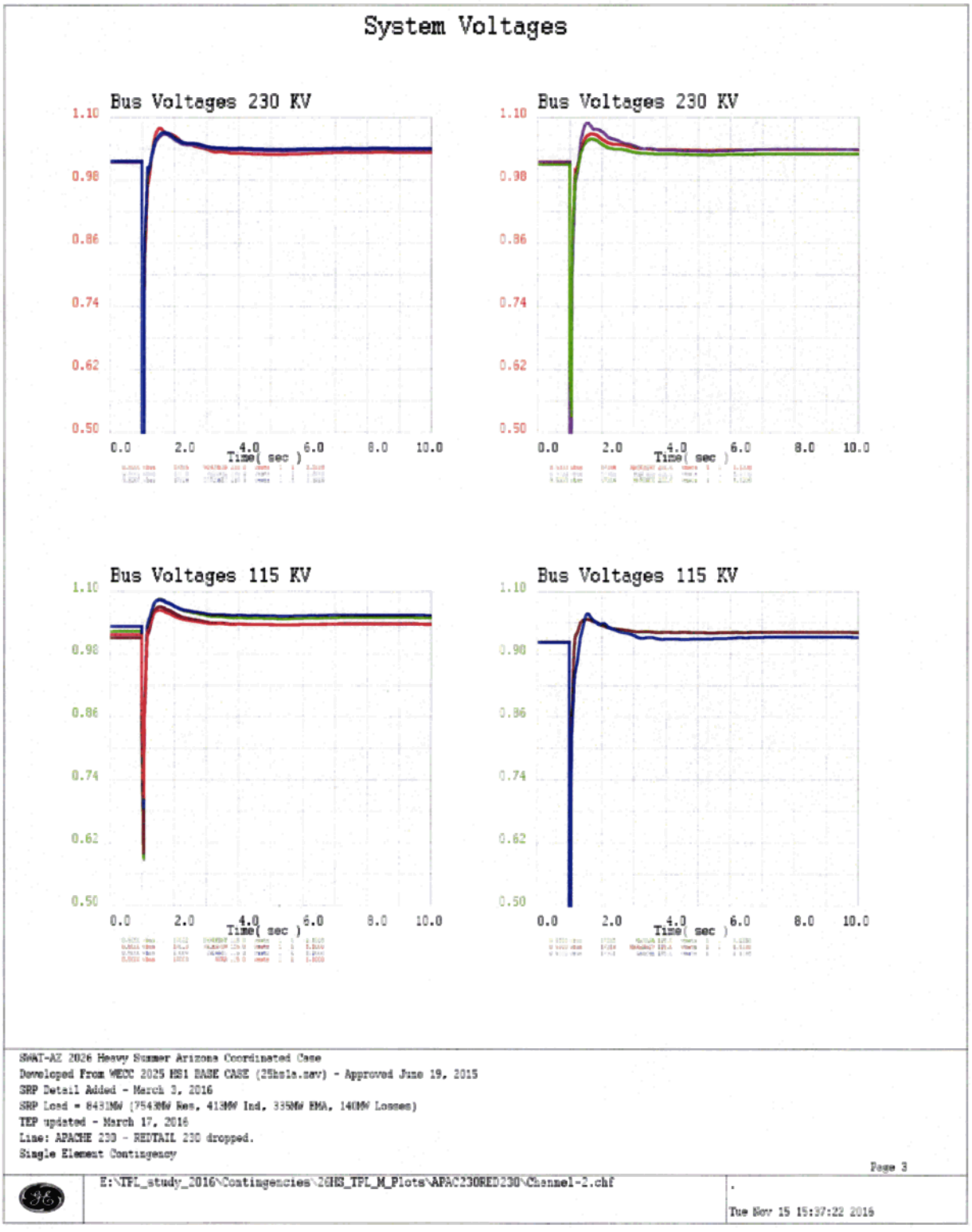


2026 HS – Apache to Redtail 230 kV Line Outage

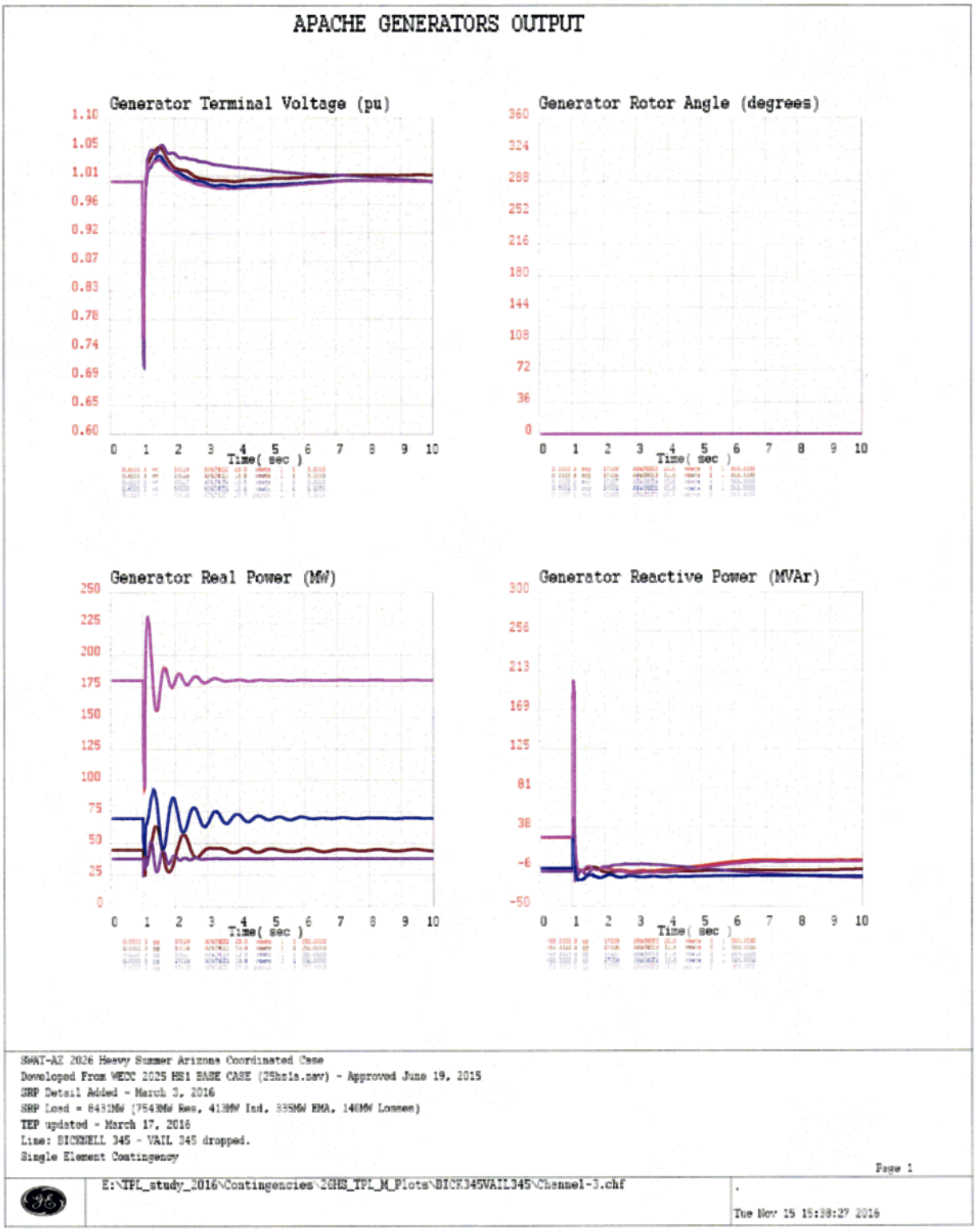
345 kV & 230 kV System Voltages



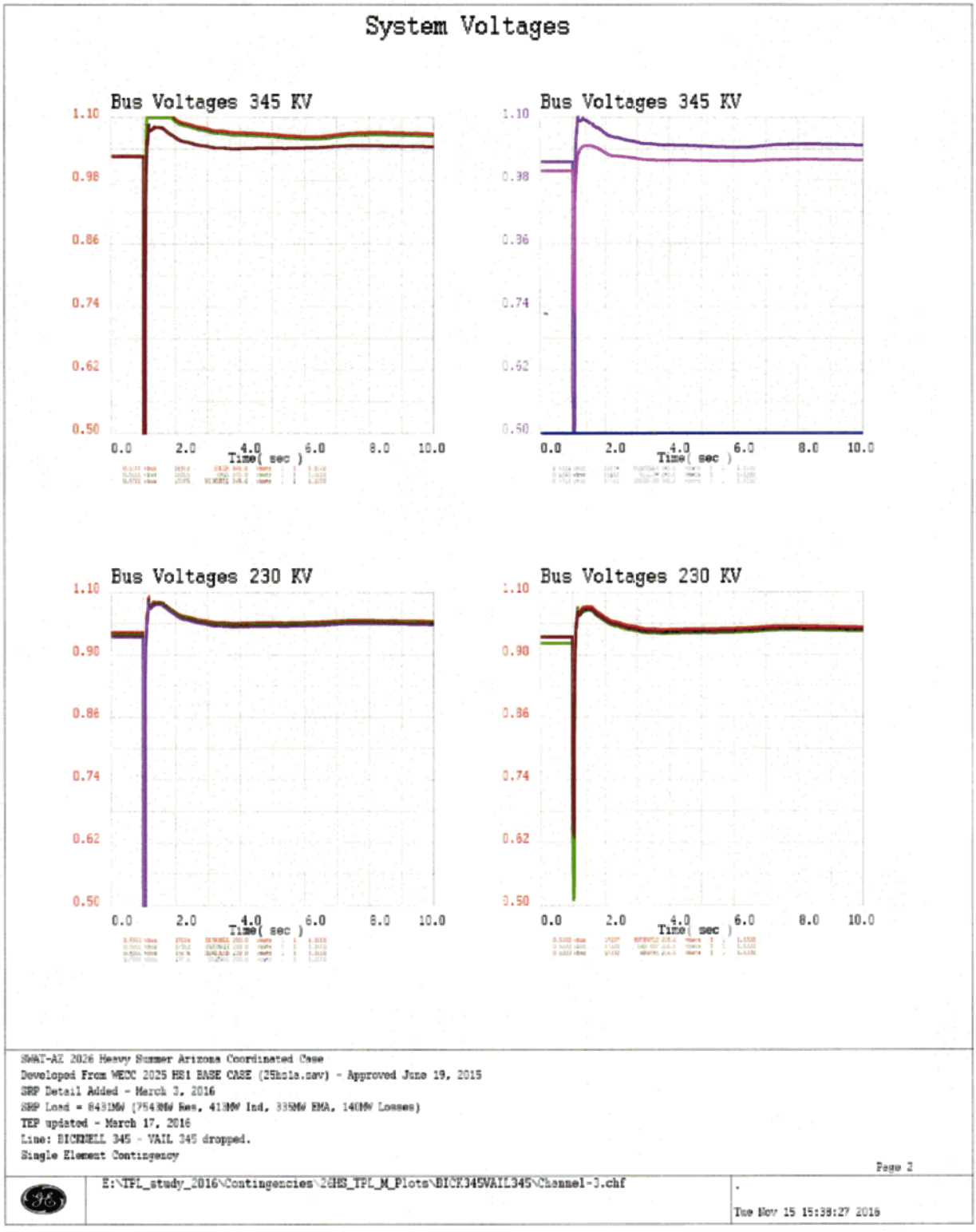
2026 HS – Apache to Redtail 230 kV Line Outage
230 kV & 115 kV System Outages



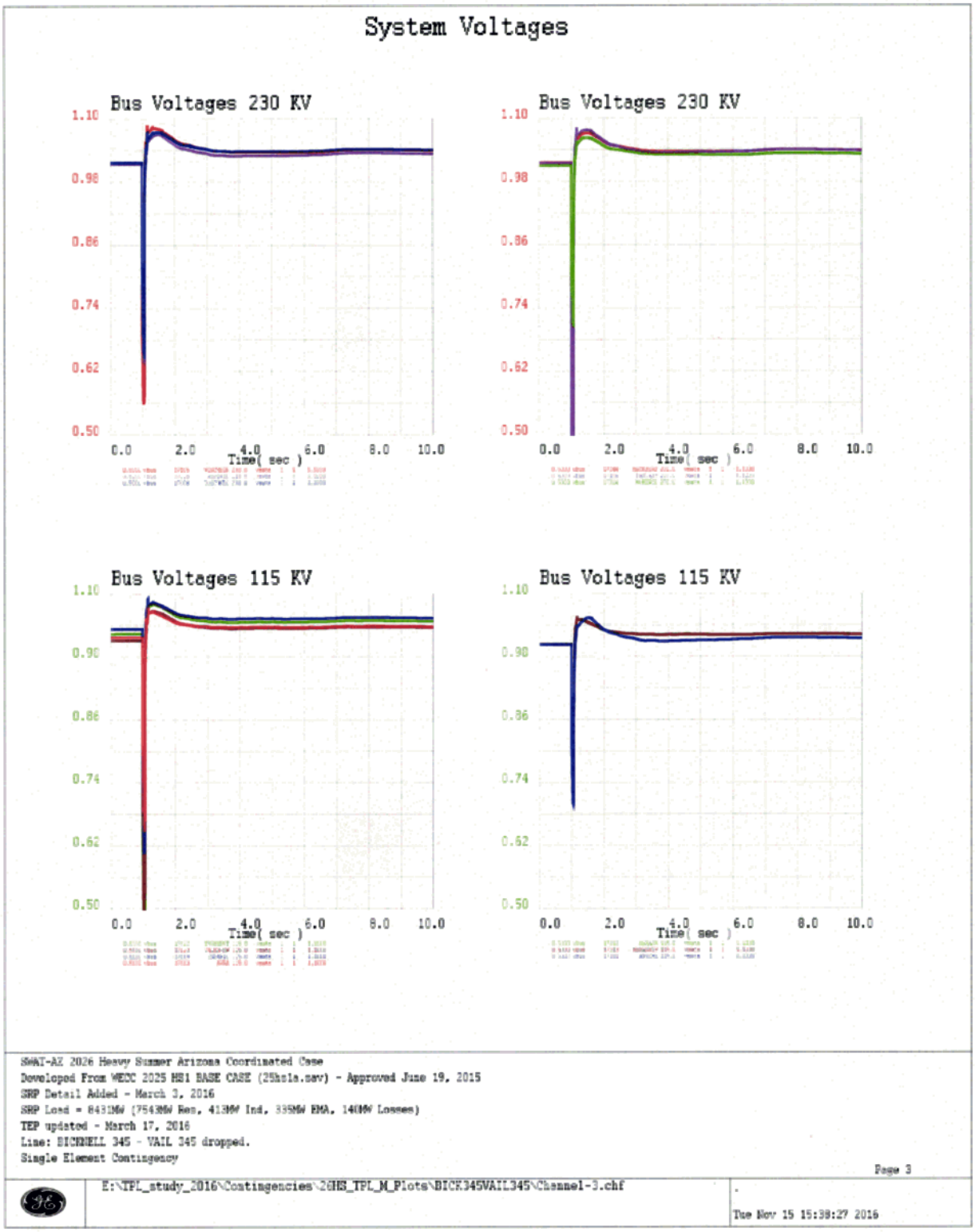
2026 HS – Bicknell to Vail 345 kV Line Outage
Apache Generators Output



2026 HS – Bicknell to Vail 345 kV Line Outage
345 kV & 230 kV System Voltages

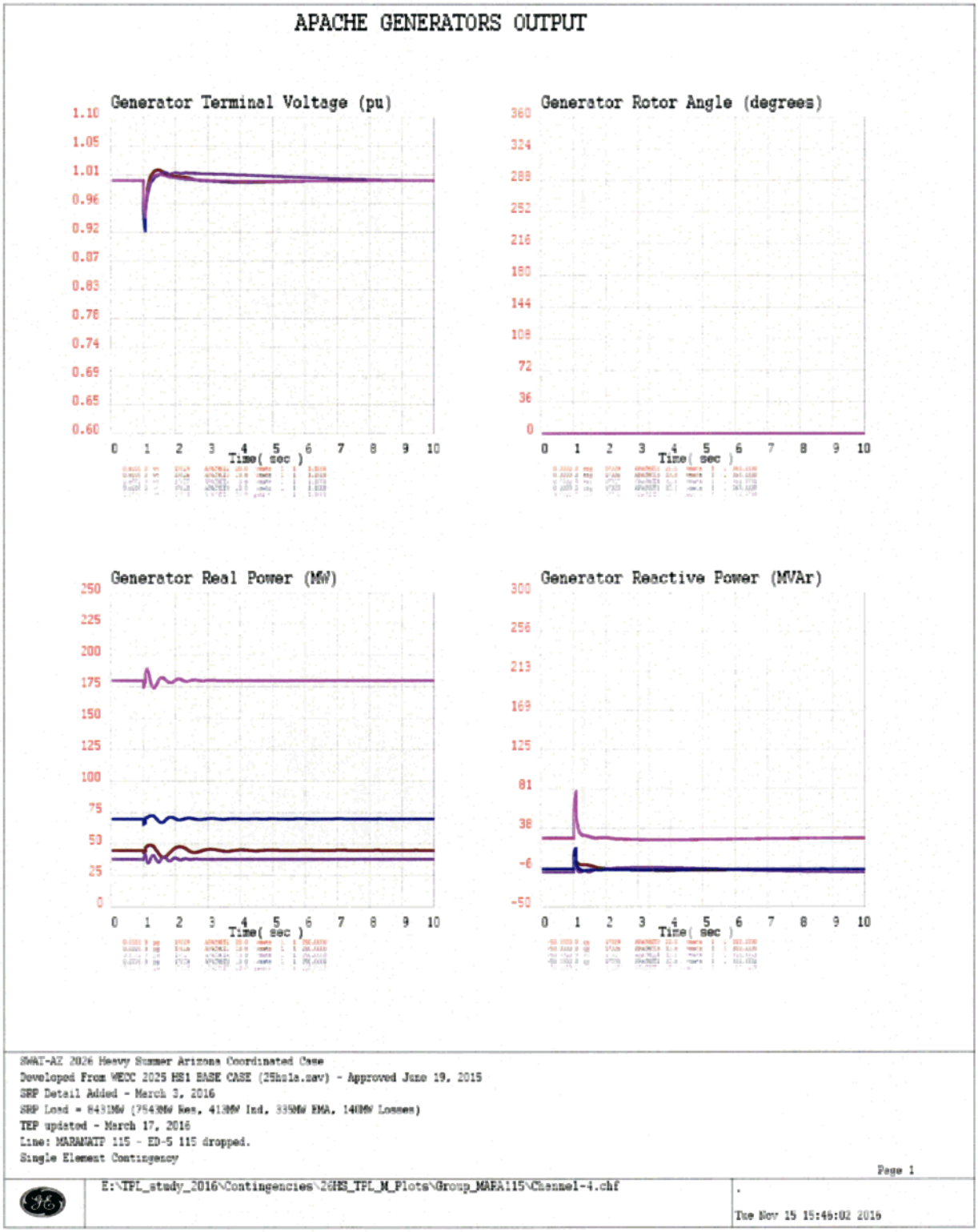


2026 HS – Bicknell to Vail 345 kV Line Outage
230 kV & 115 kV System Voltages

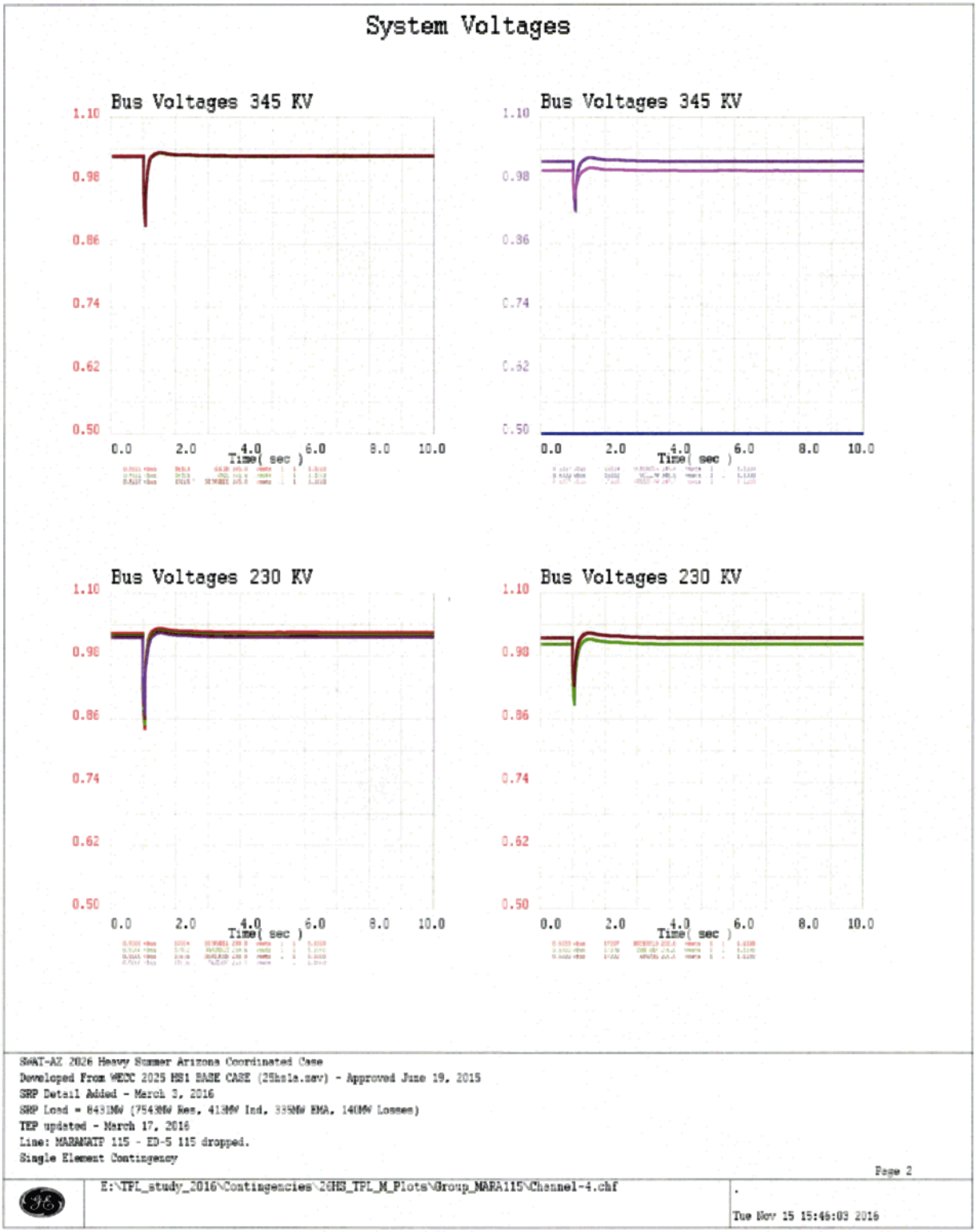


2026 HS – Marana Group 115 kV Line Outage

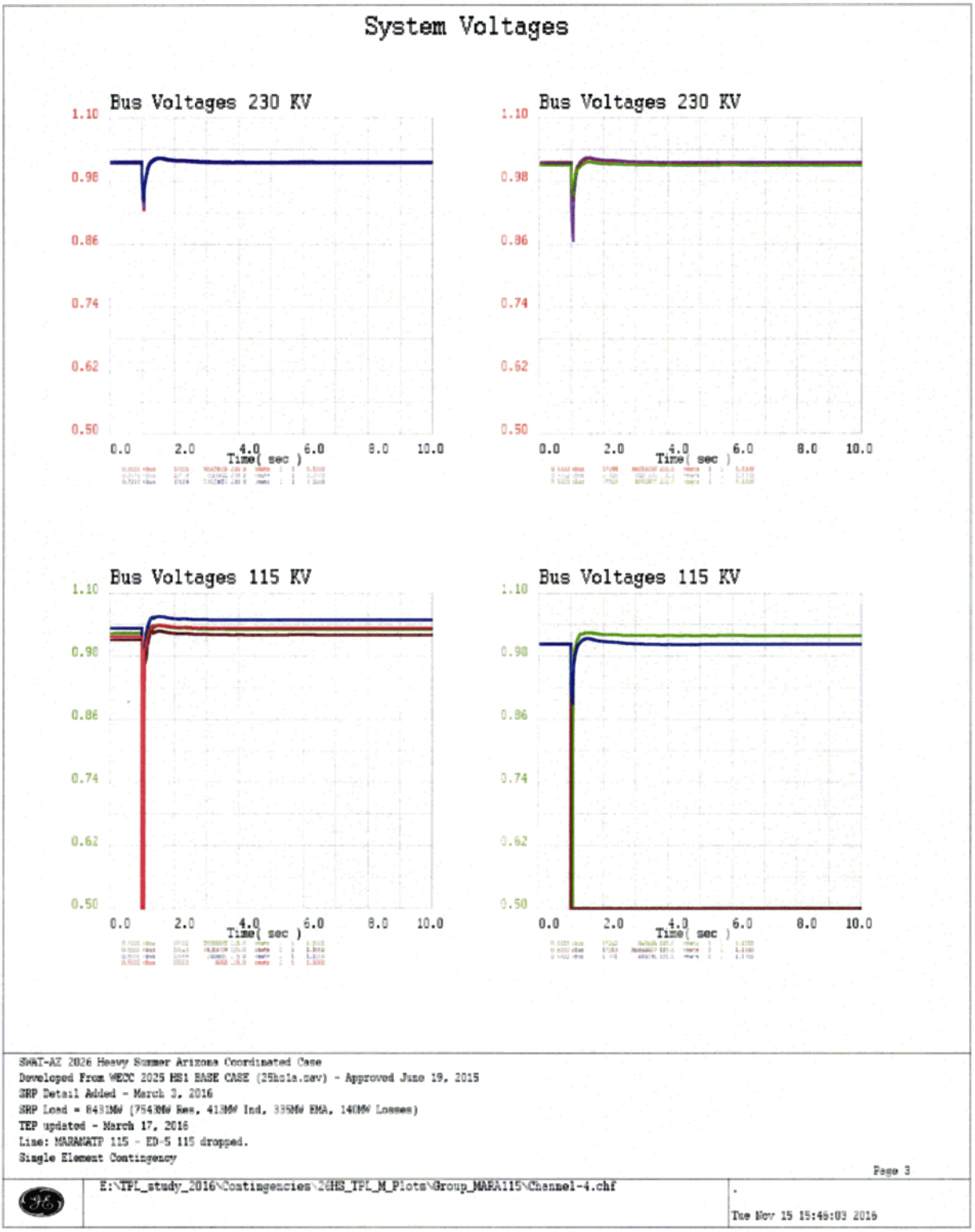
Apache Generators Output



2026 HS – Marana Group 115 kV Line Outage
345 kV & 230 kV System Voltages

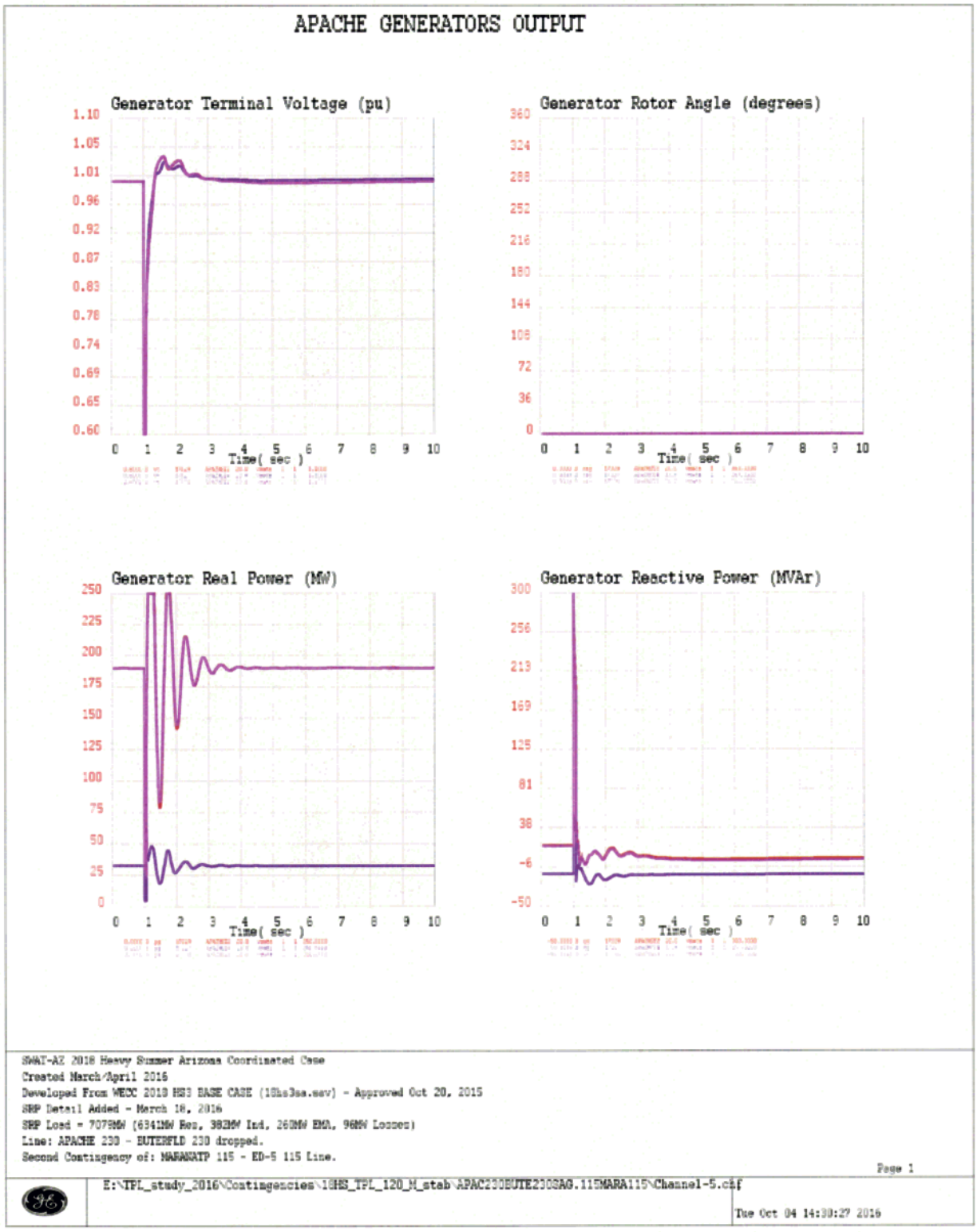


2026 HS – Marana Group 115 kV Line Outage
230 kV & 115 kV System Voltages

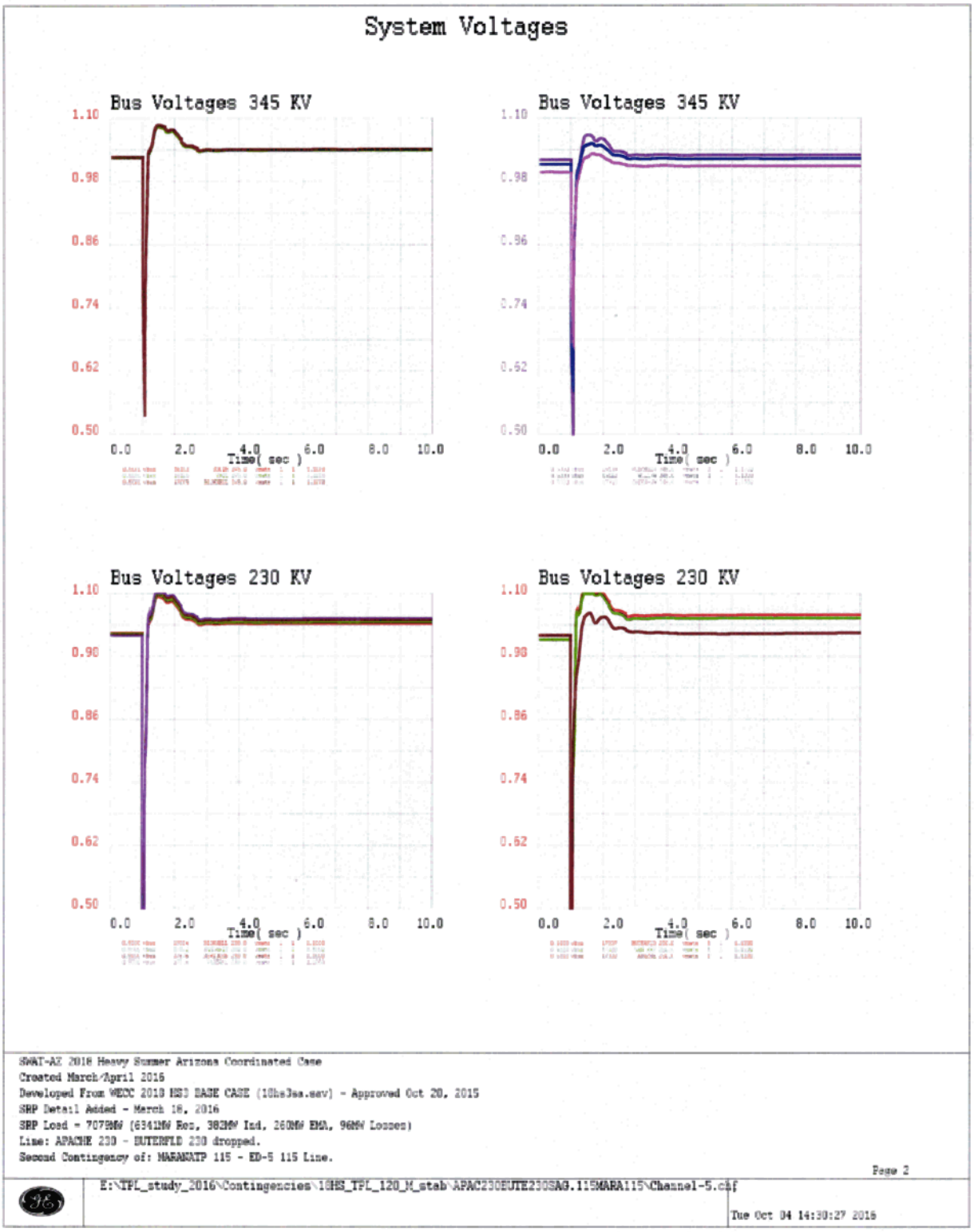


2018 HEAVY SUMMER P6 Contingencies

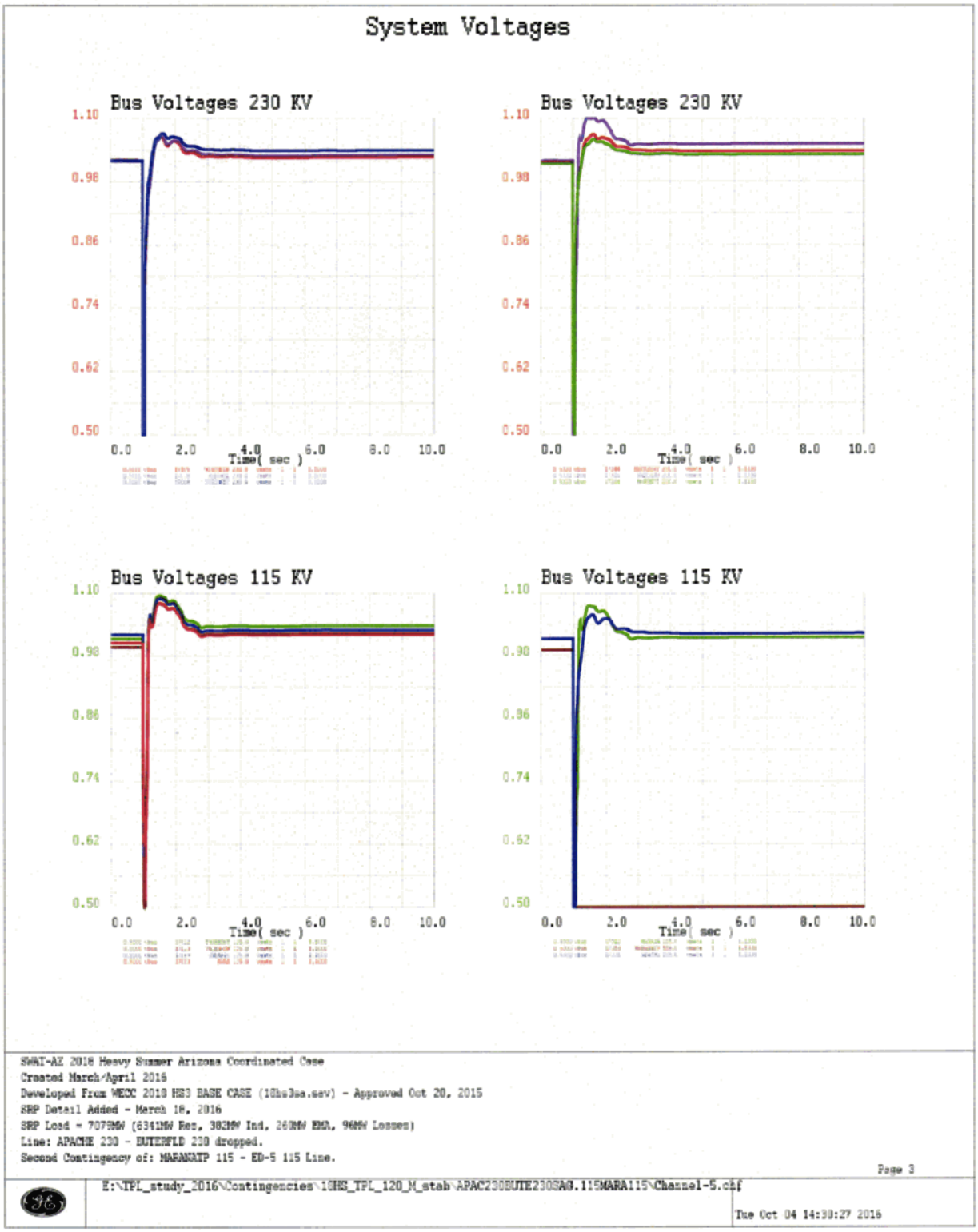
2018 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
Apache Generators Output



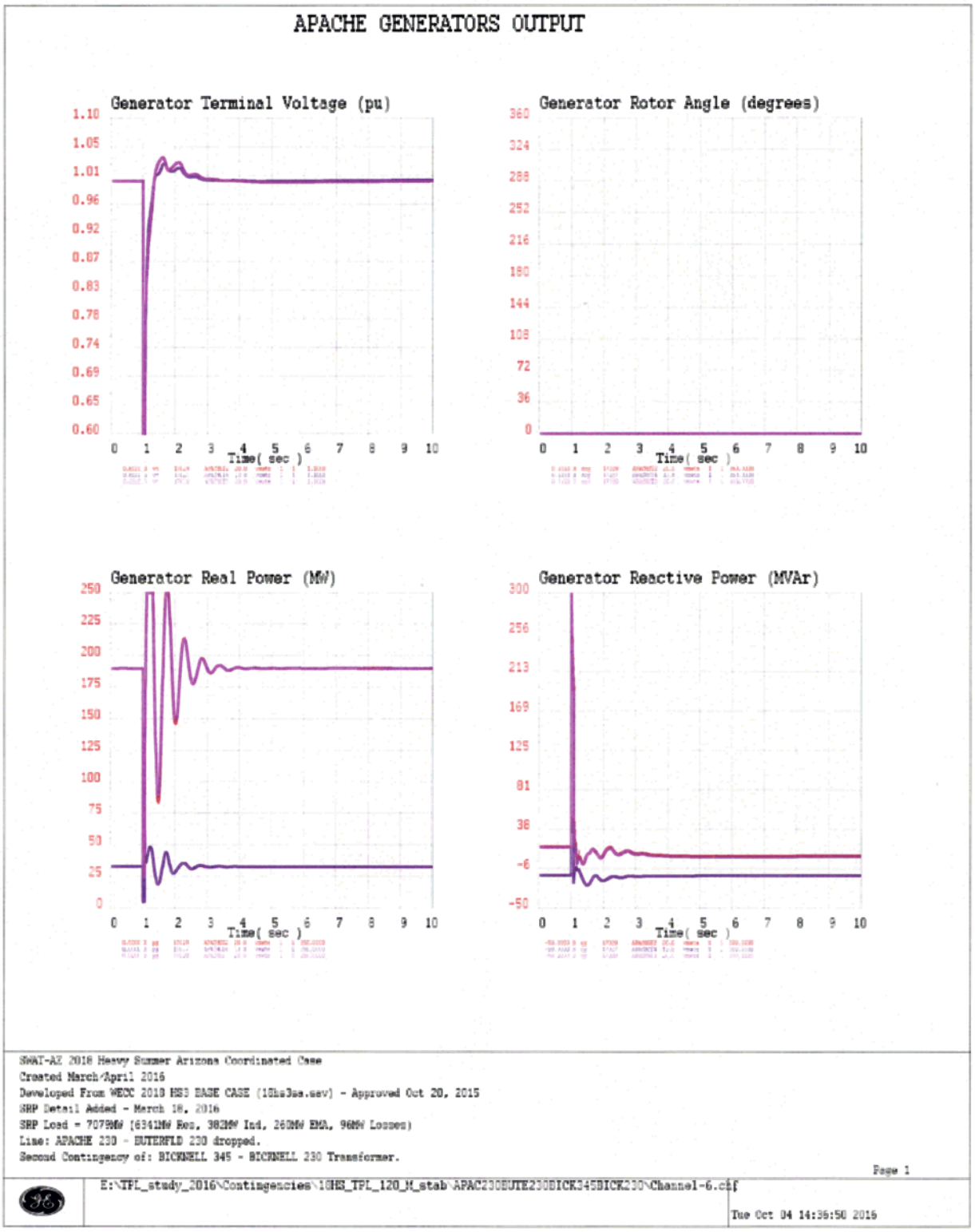
2018 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
345 kV & 230 kV System Voltages



2018 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
230 kV & 115 kV System Voltages

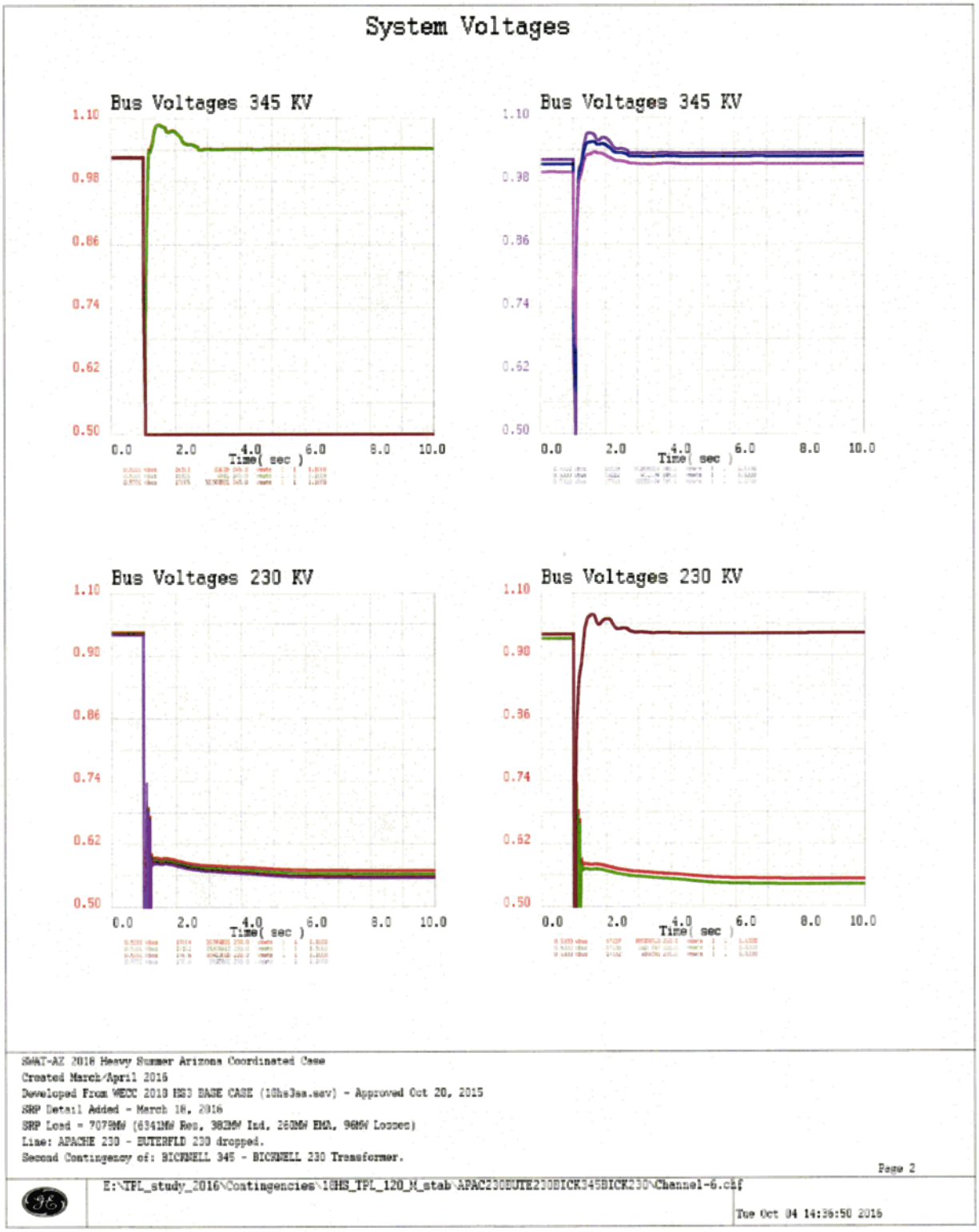


2018 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages Apache Generators Output

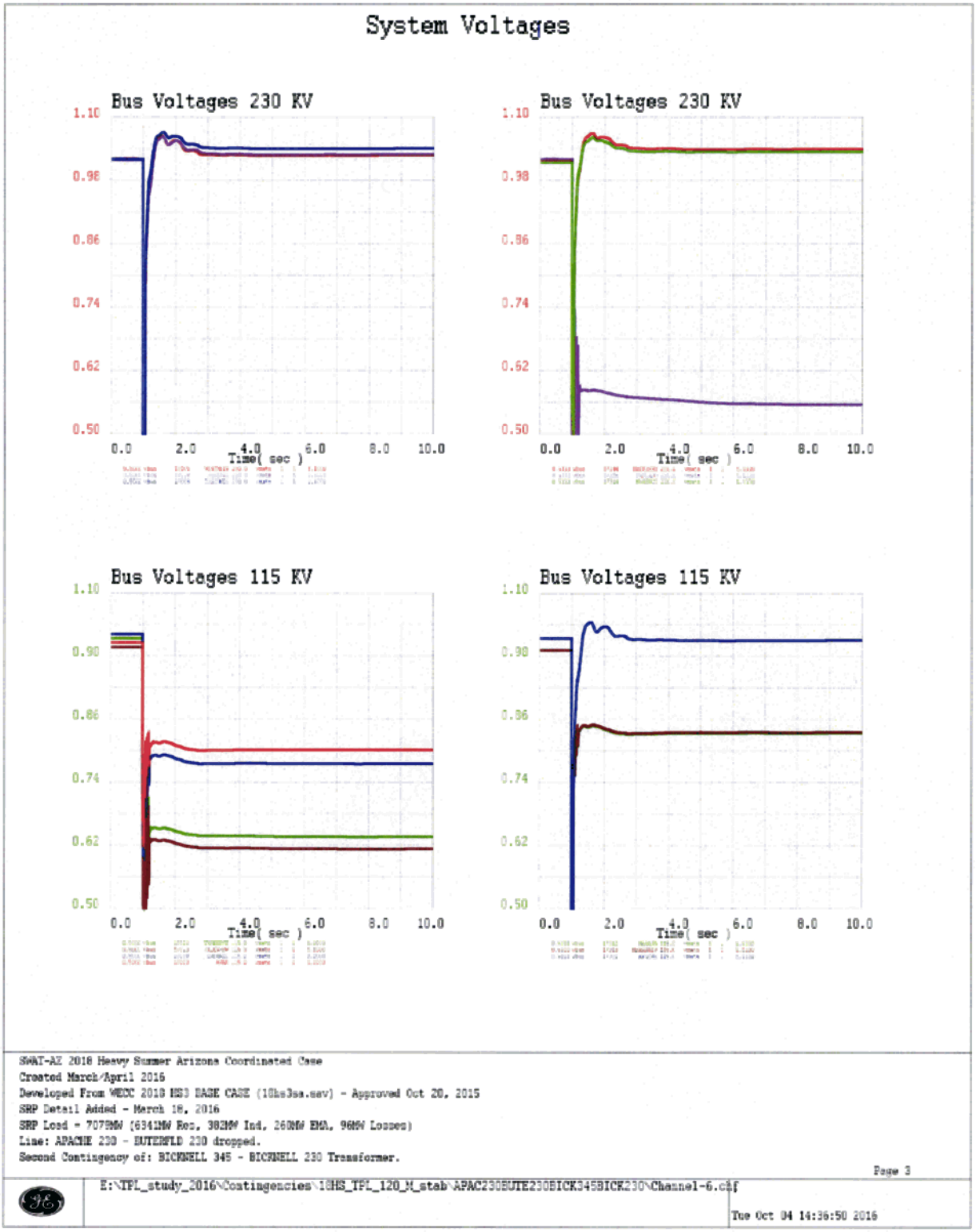


2018 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages

345 kV & 230 kV System Voltages

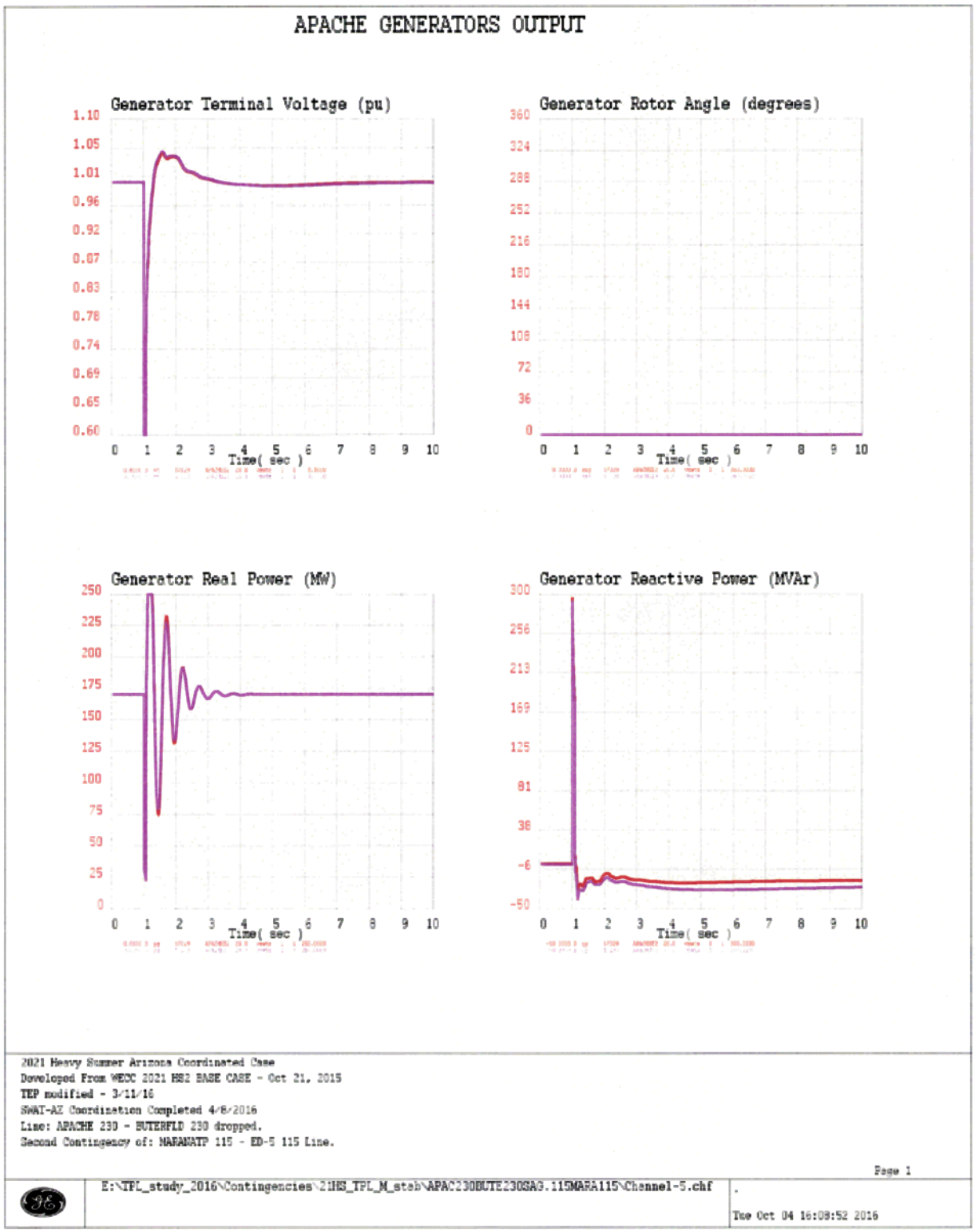


2018 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages
230 kV & 115 kV System Voltages

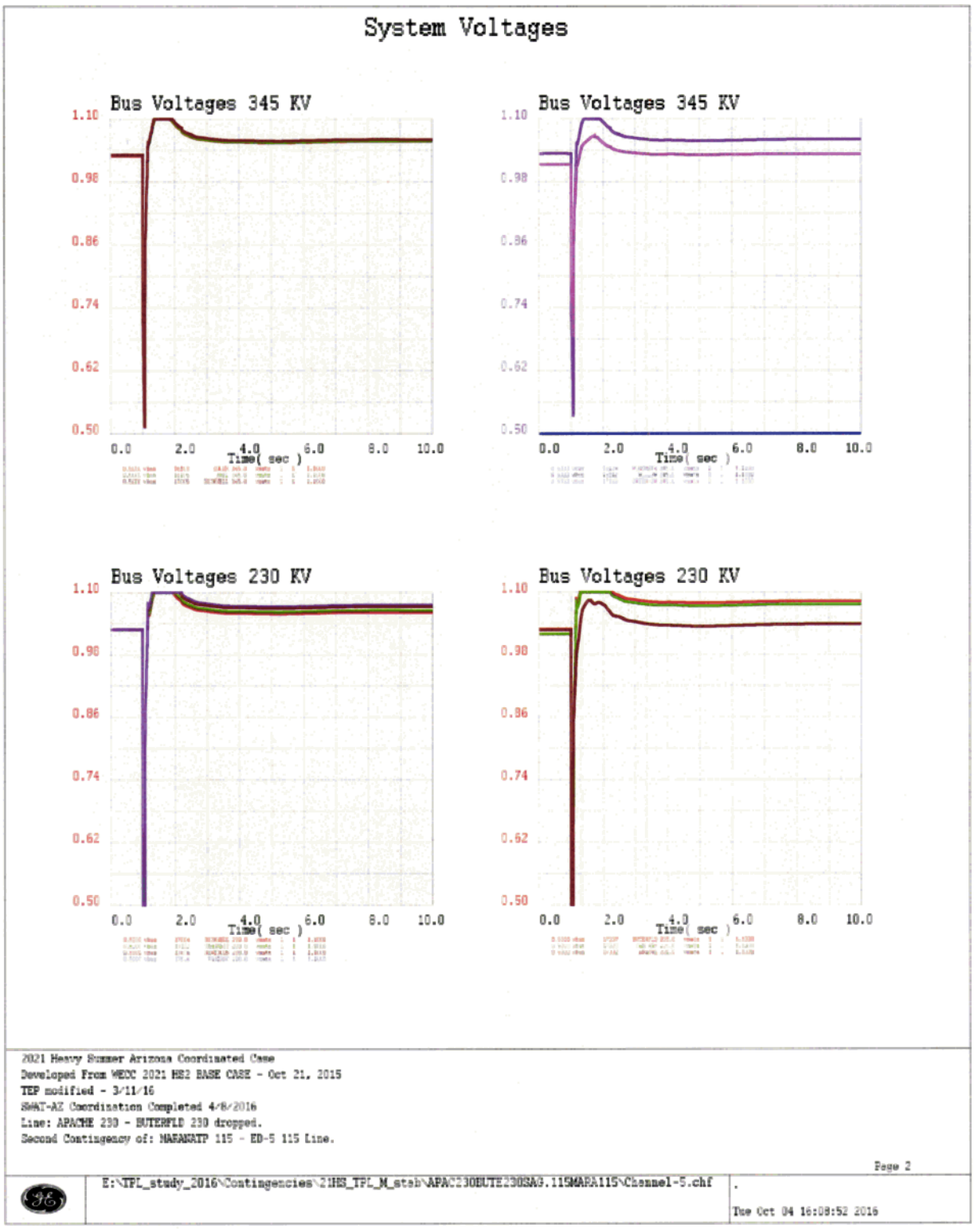


2021 HEAVY SUMMER P6 Contingencies

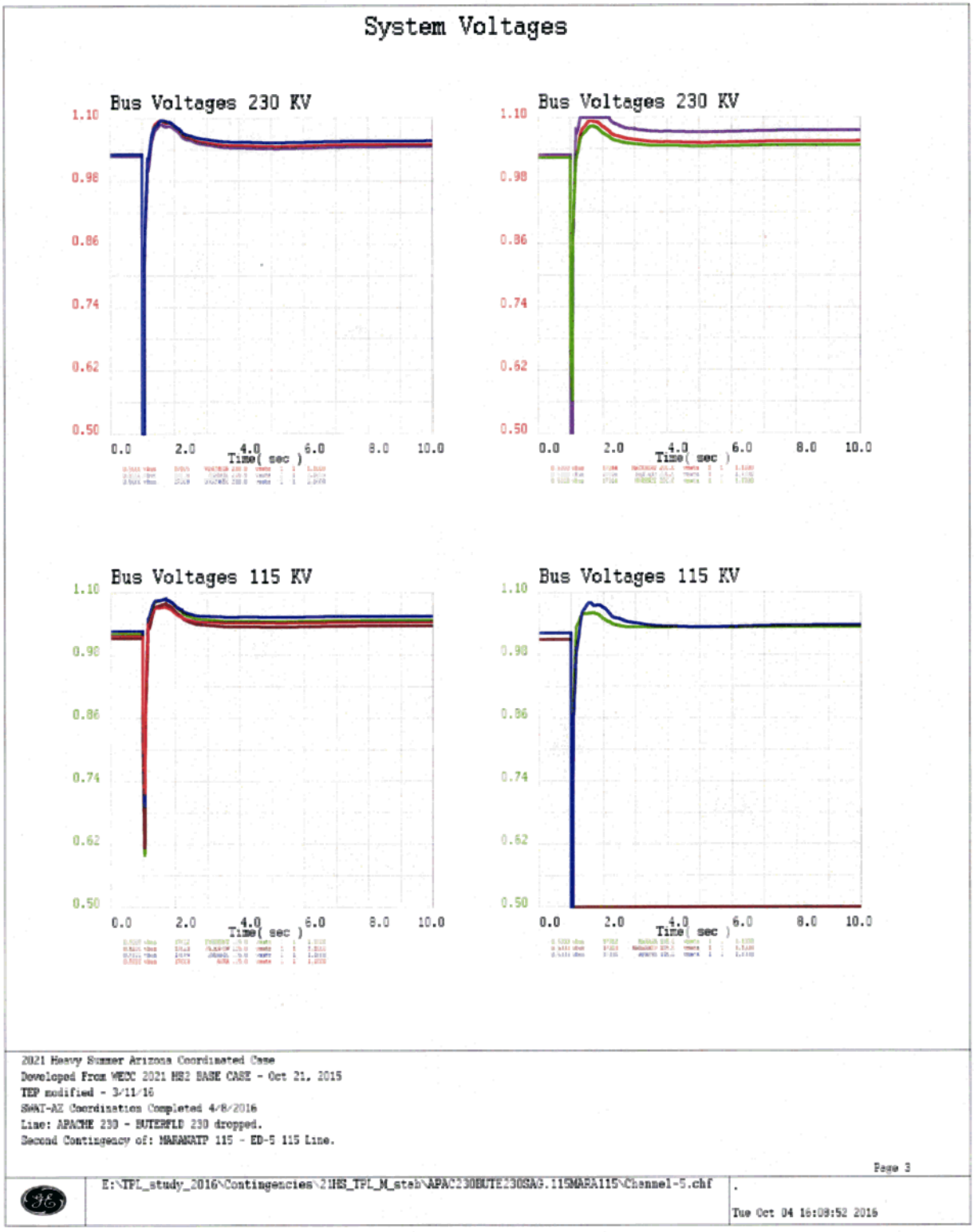
2021 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
Apache Generators Output



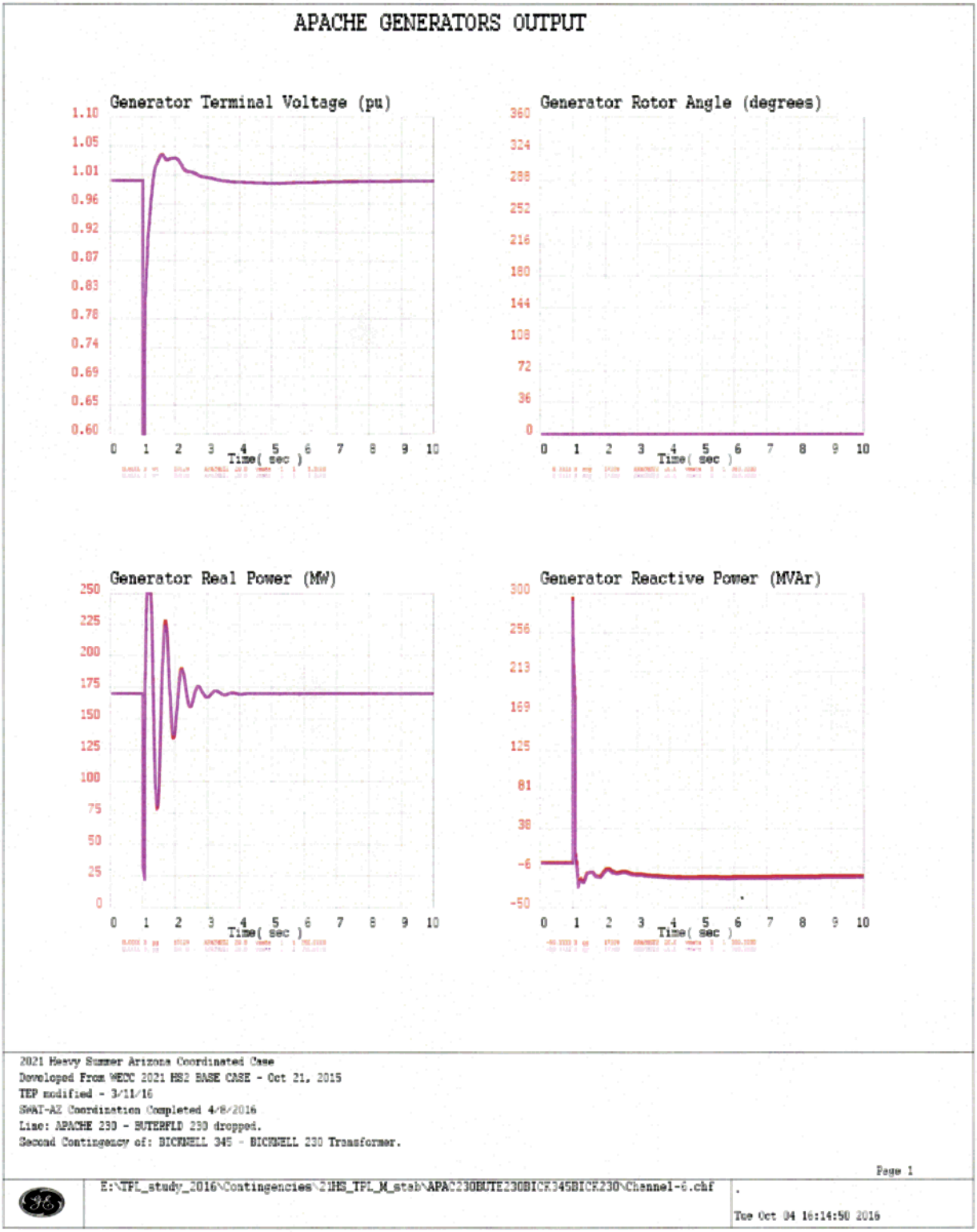
2021 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
345 kV & 230 kV System Voltages



2021 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
230 kV & 115 kV System Voltages

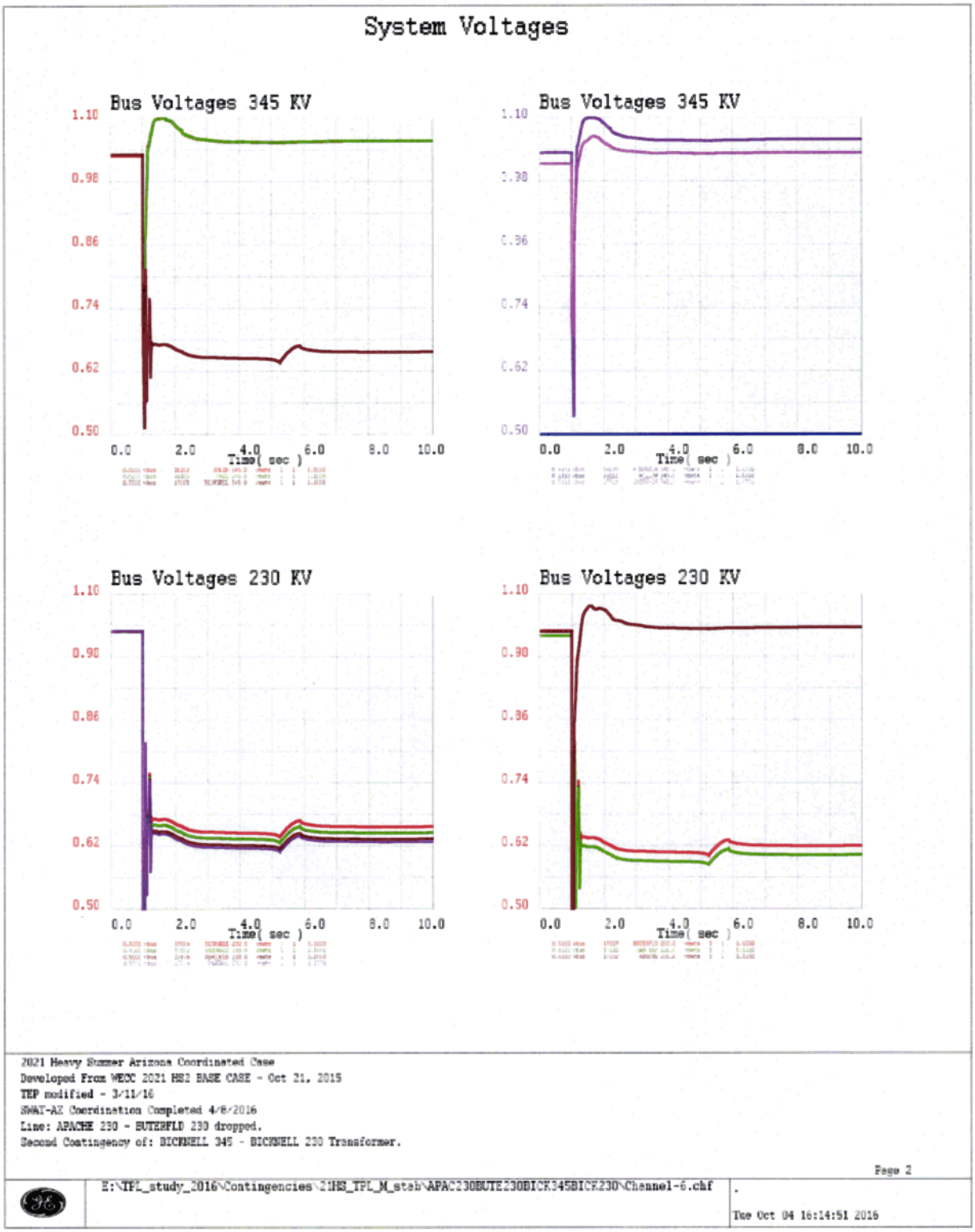


2021 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages Apache Generators Output

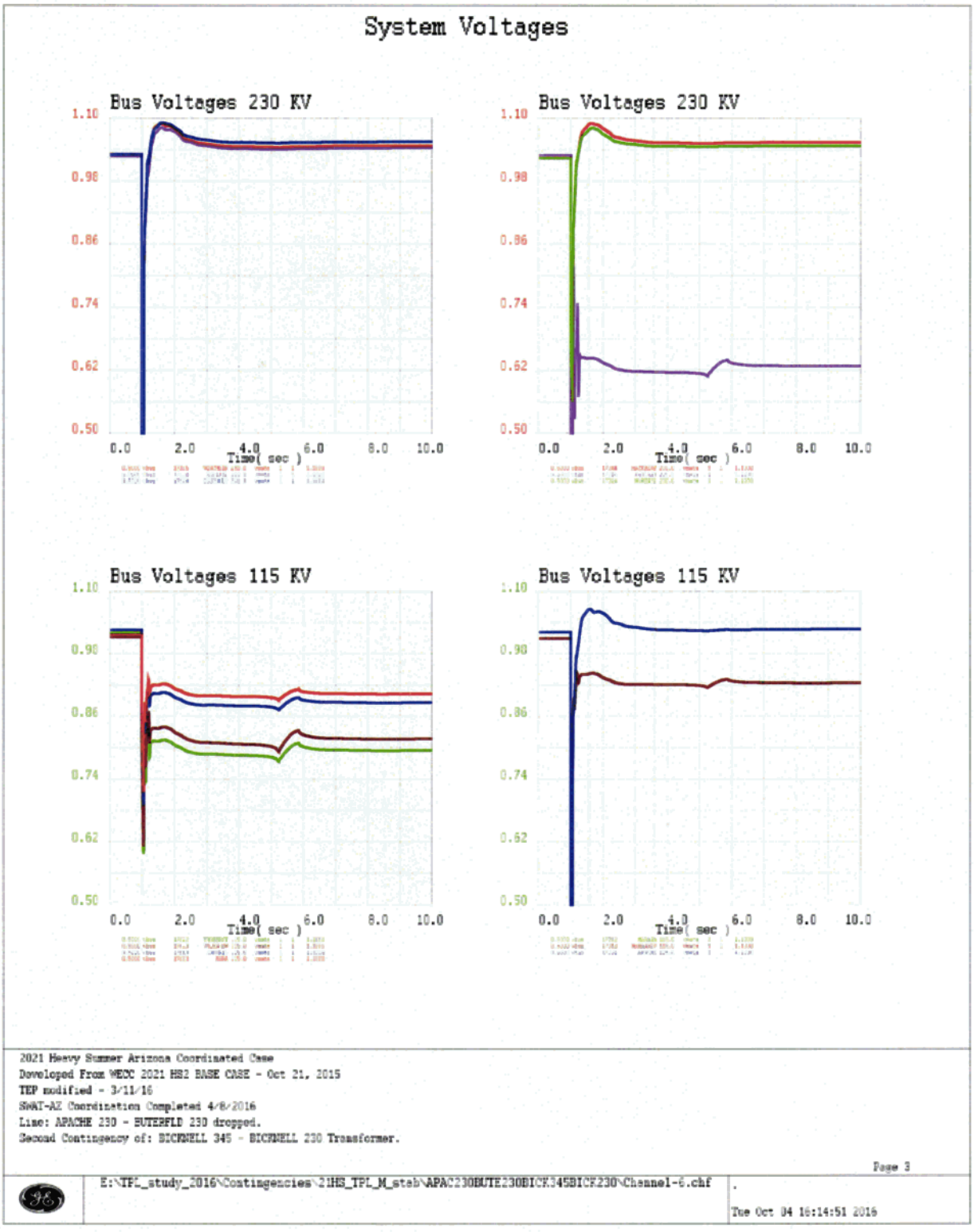


2021 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages

345 kV & 230 kV System Voltages

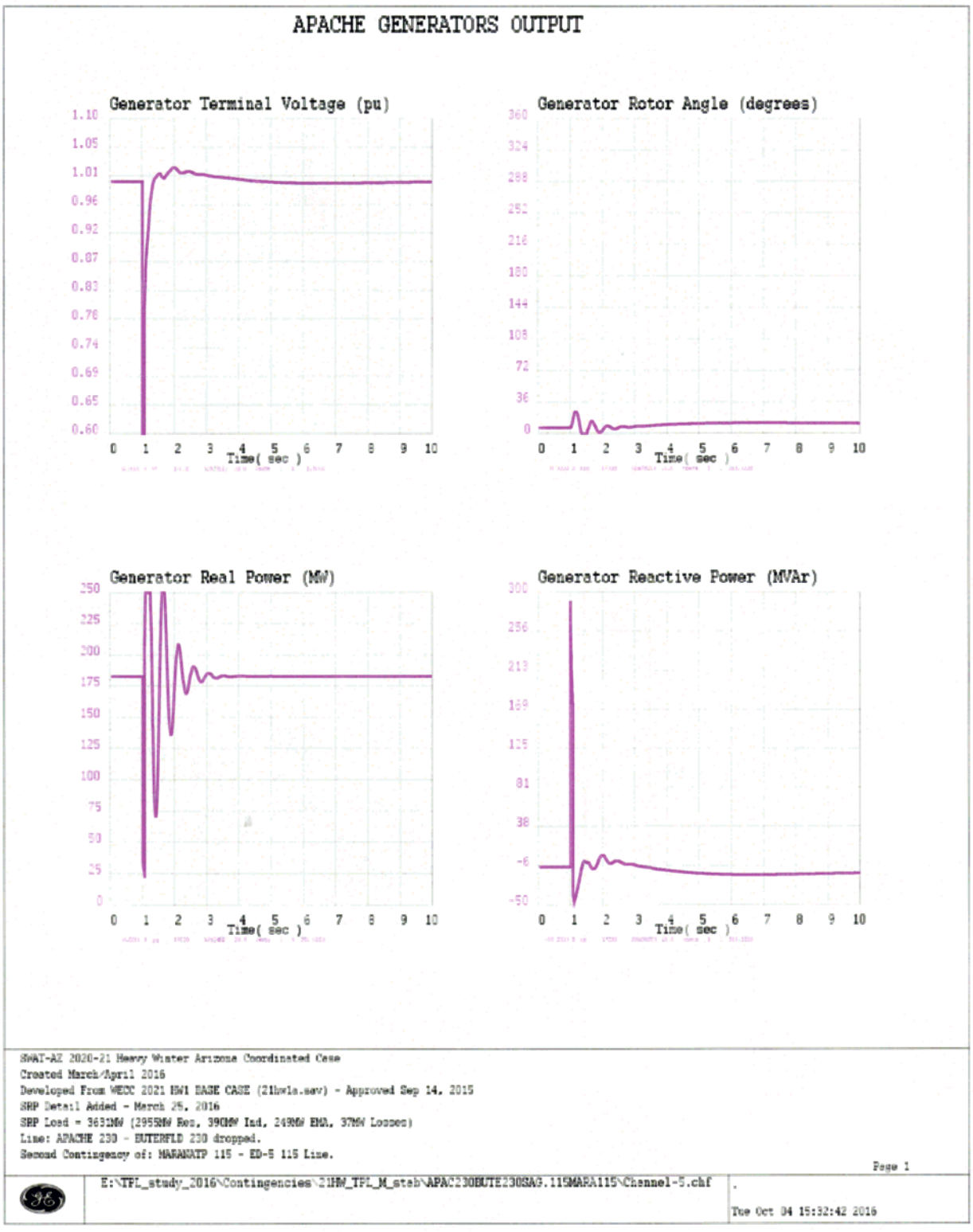


2021 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages
230 kV & 115 kV System Voltages

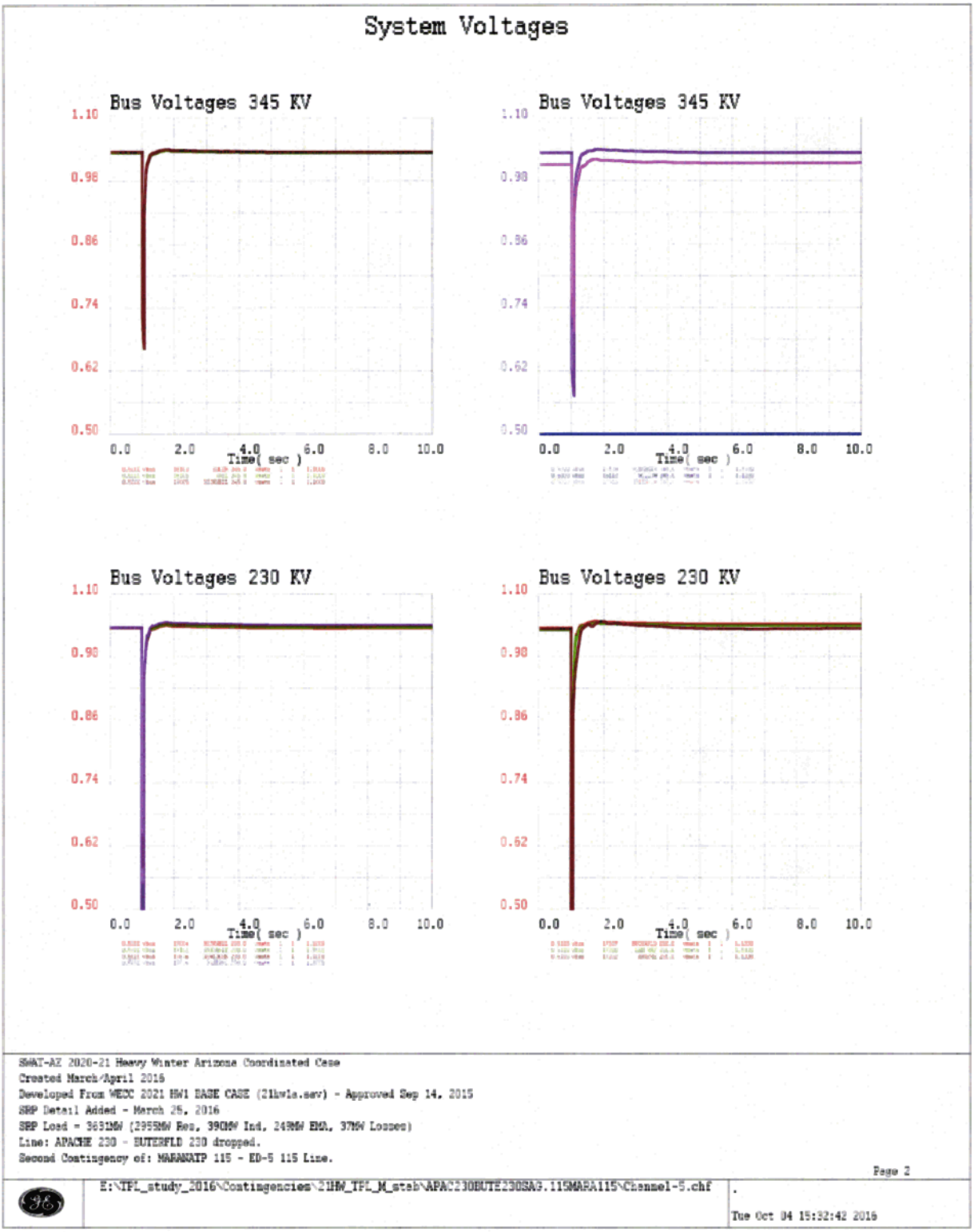


2021 HEAVY WINTER P6 Contingencies

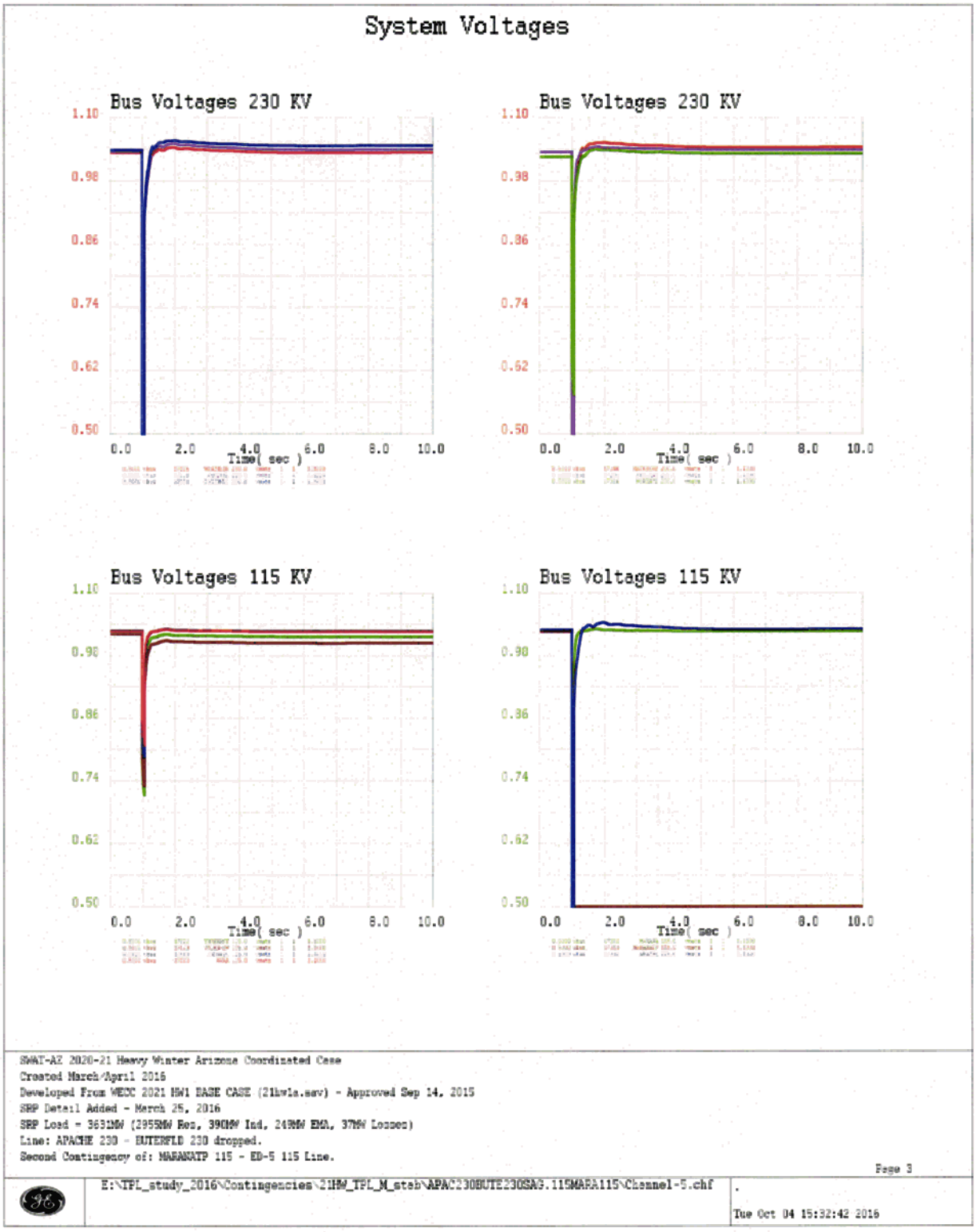
2021 HW – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
Apache Generators Output



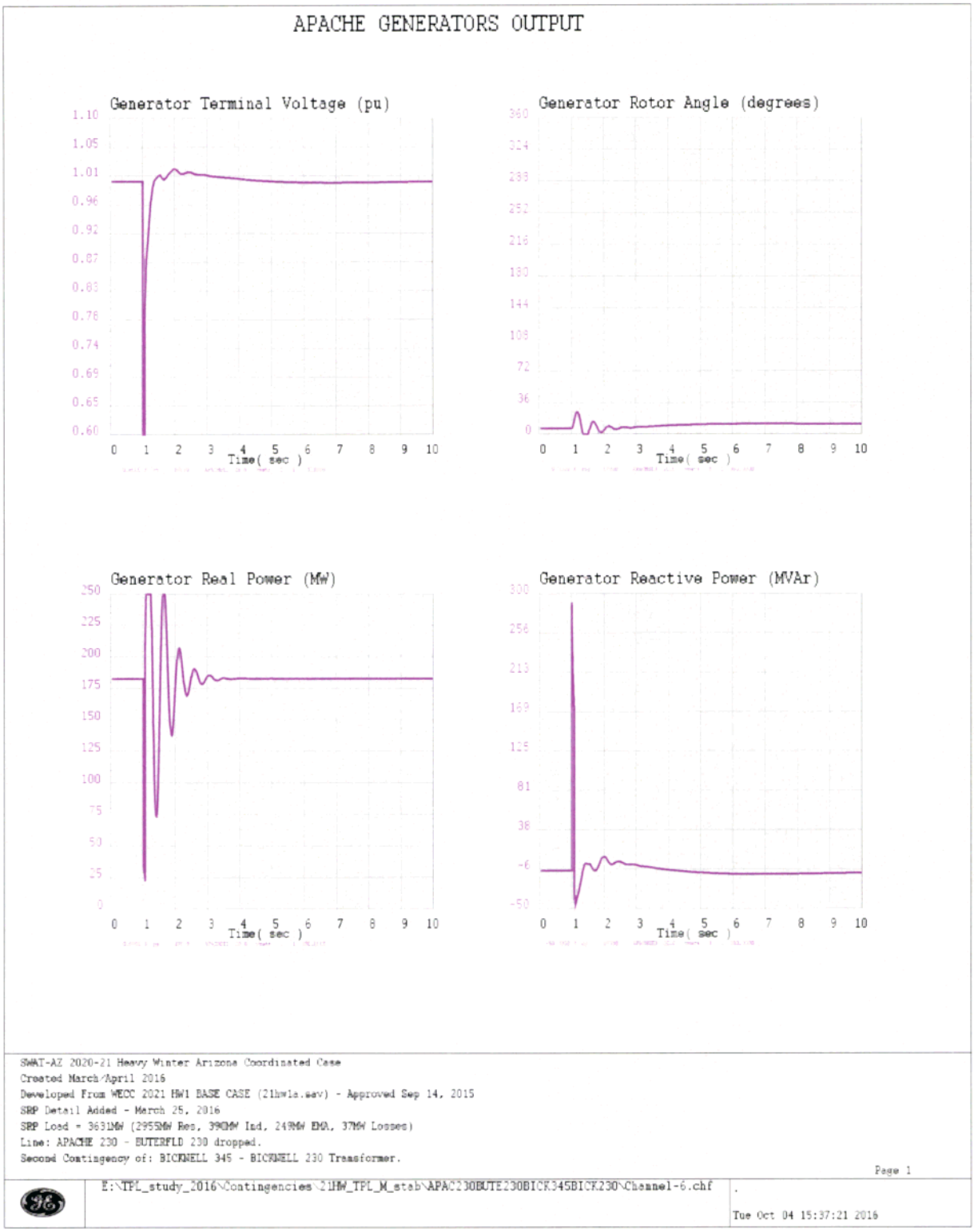
2021 HW – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
345 kV & 230 kV System Voltages



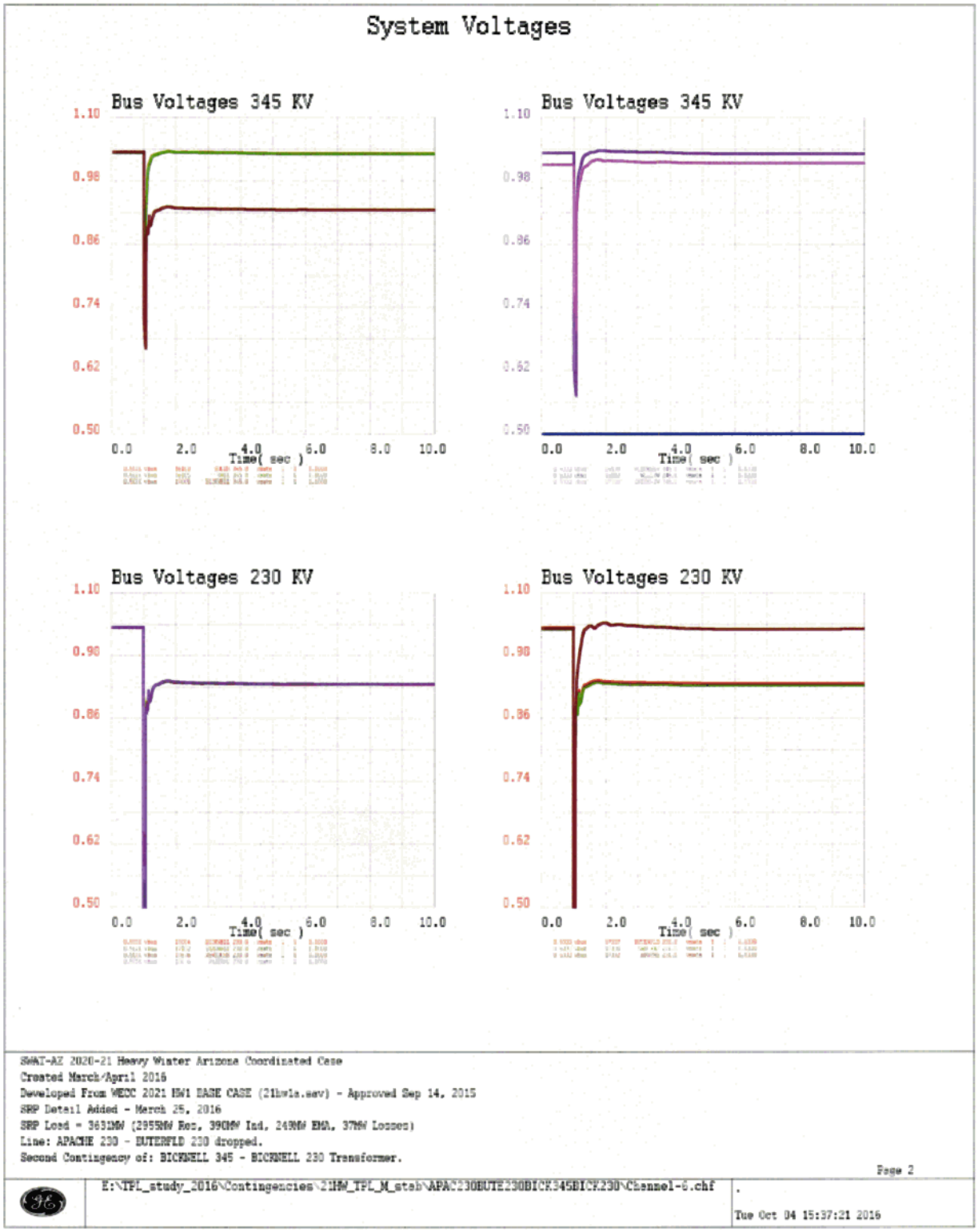
2021 HW – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
230 kV & 115 kV System Voltages



2021 HW – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages Apache Generators Output

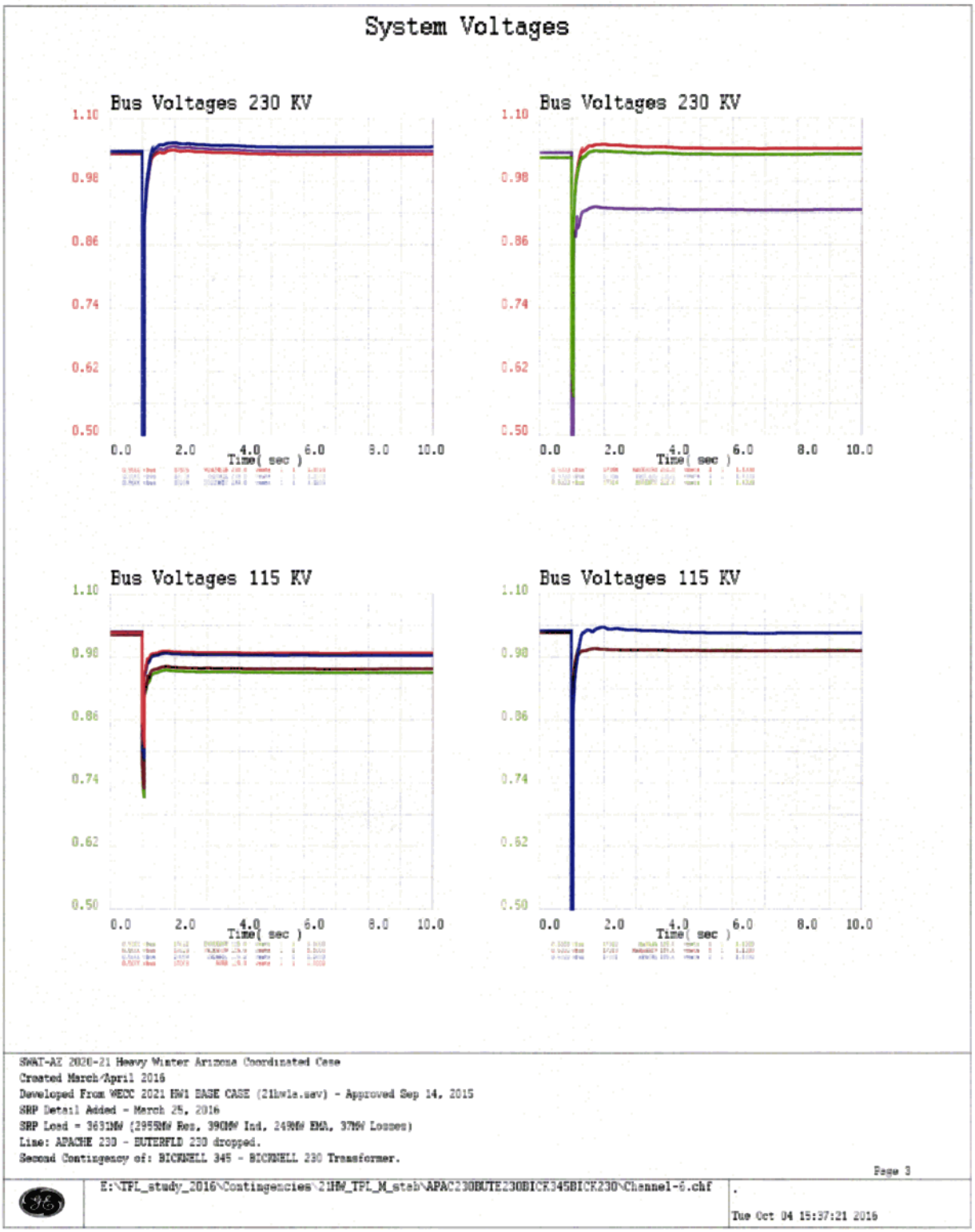


2021 HW – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages
345 kV & 230 kV System Voltages



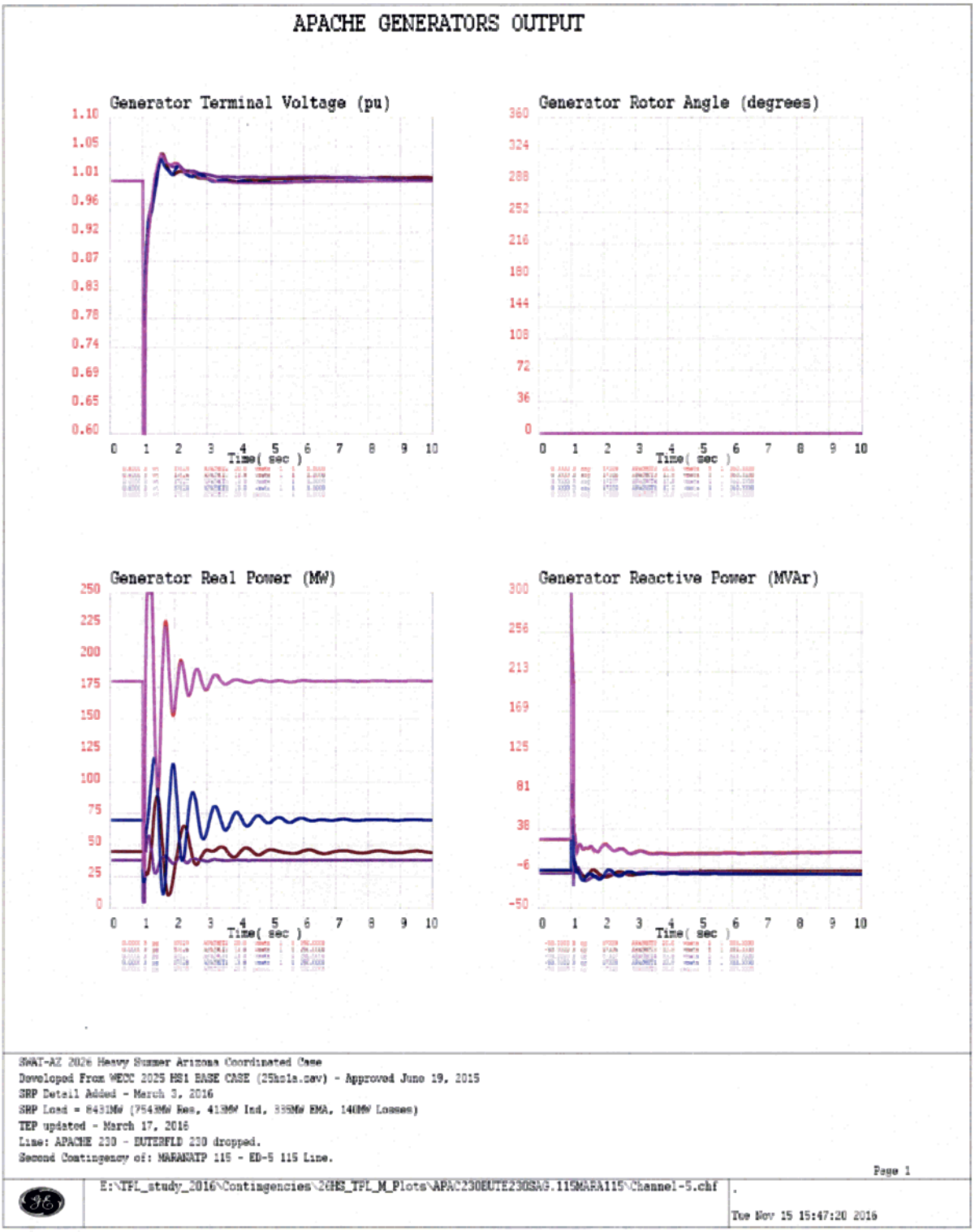
2021 HW – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages

230 kV & 115 kV System Voltages

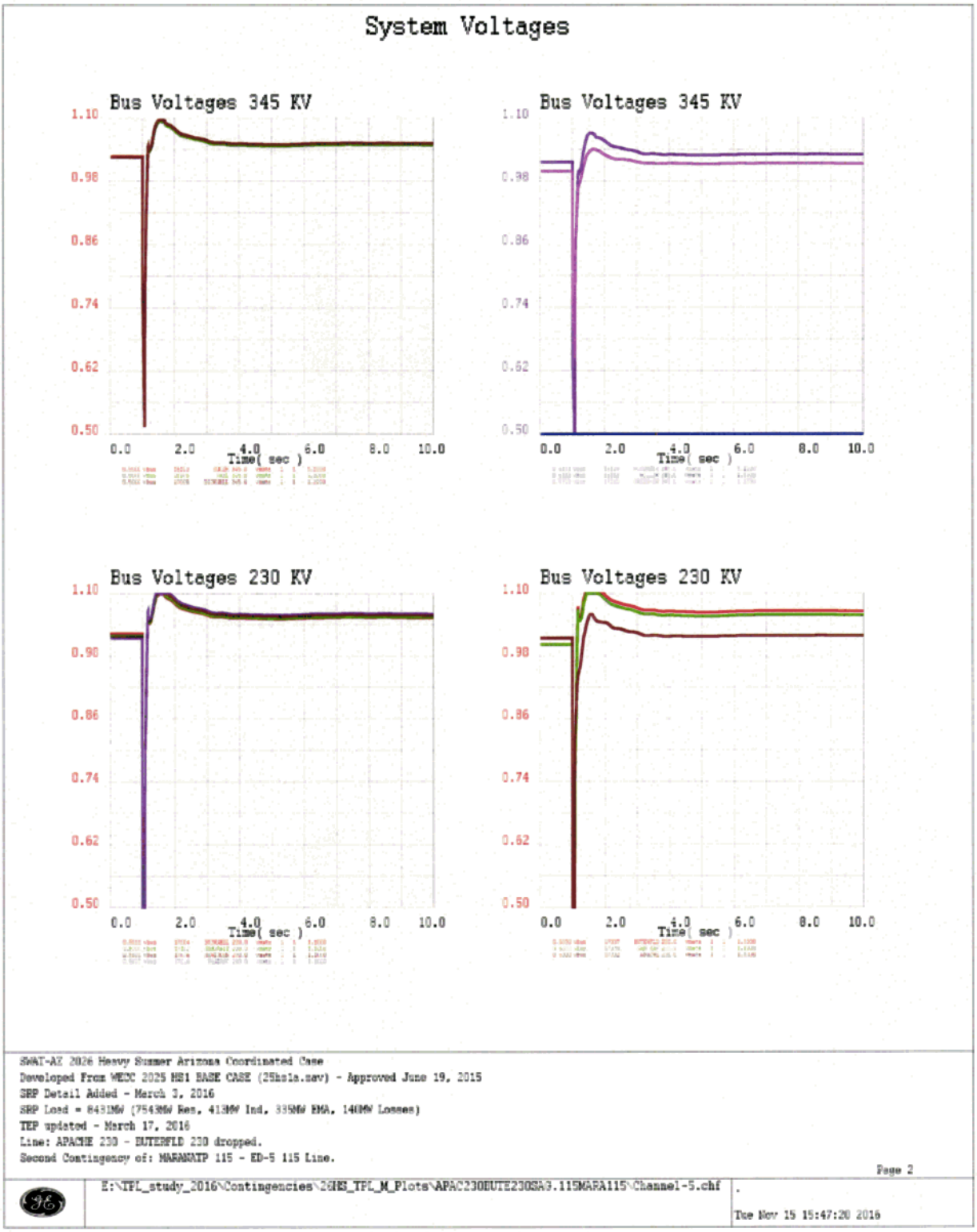


2026 HEAVY SUMMER P6 Contingencies

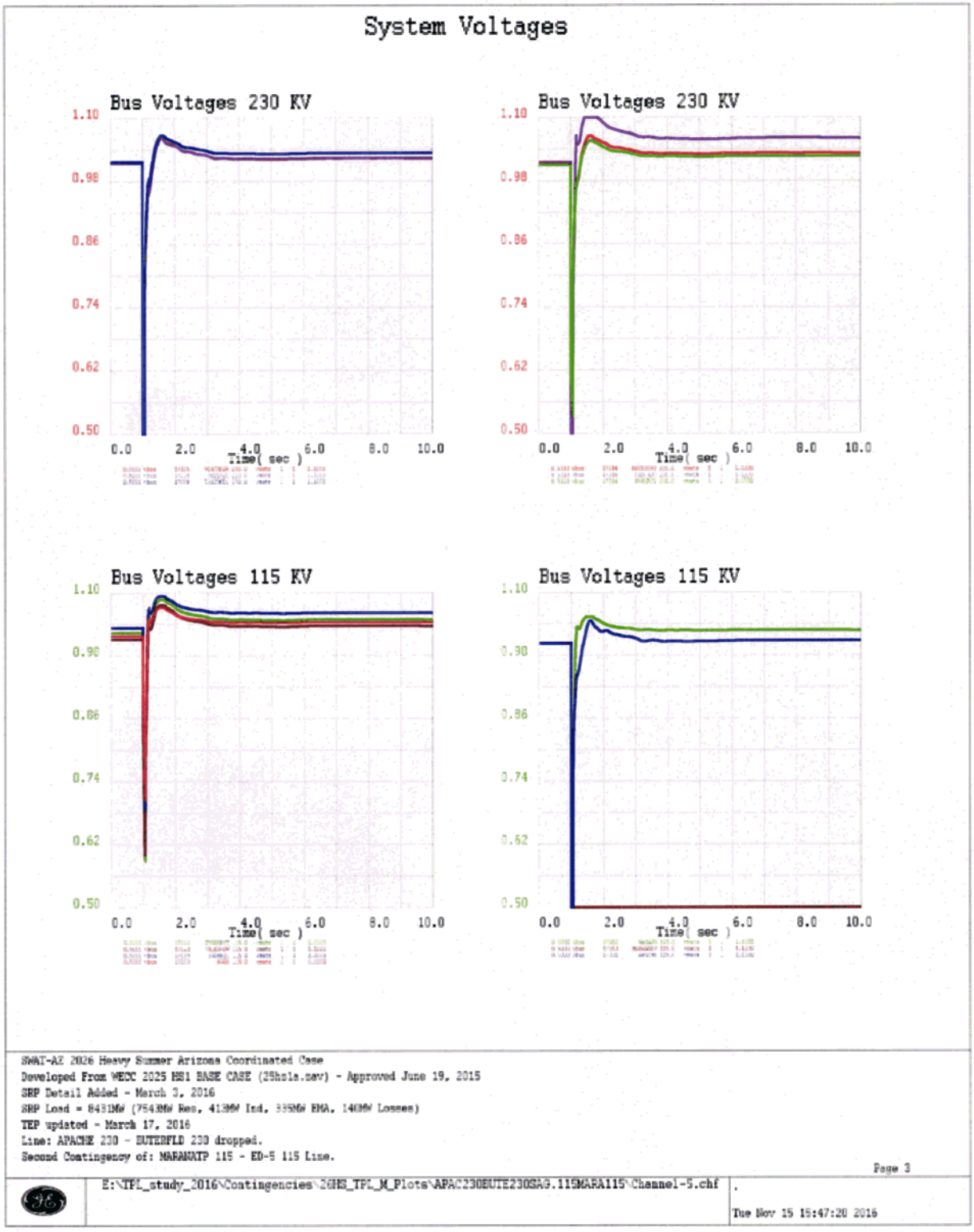
2026 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
Apache Generators Output



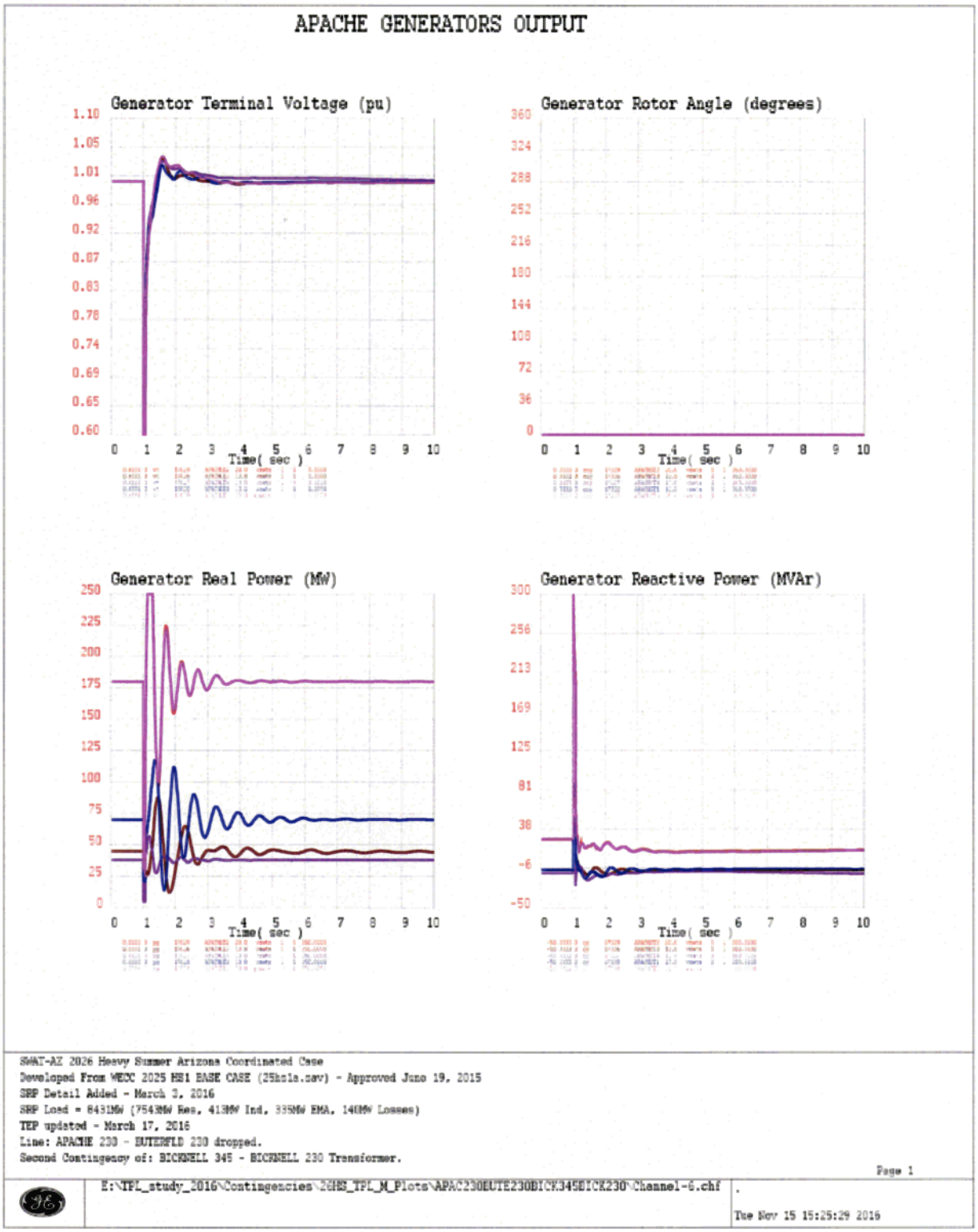
2026 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
345 kV & 230 kV System Voltages



2026 HS – Apache to Butterfield 230 kV & Marana Group 115 kV Line Outages
230 kV & 115 kV System Voltages

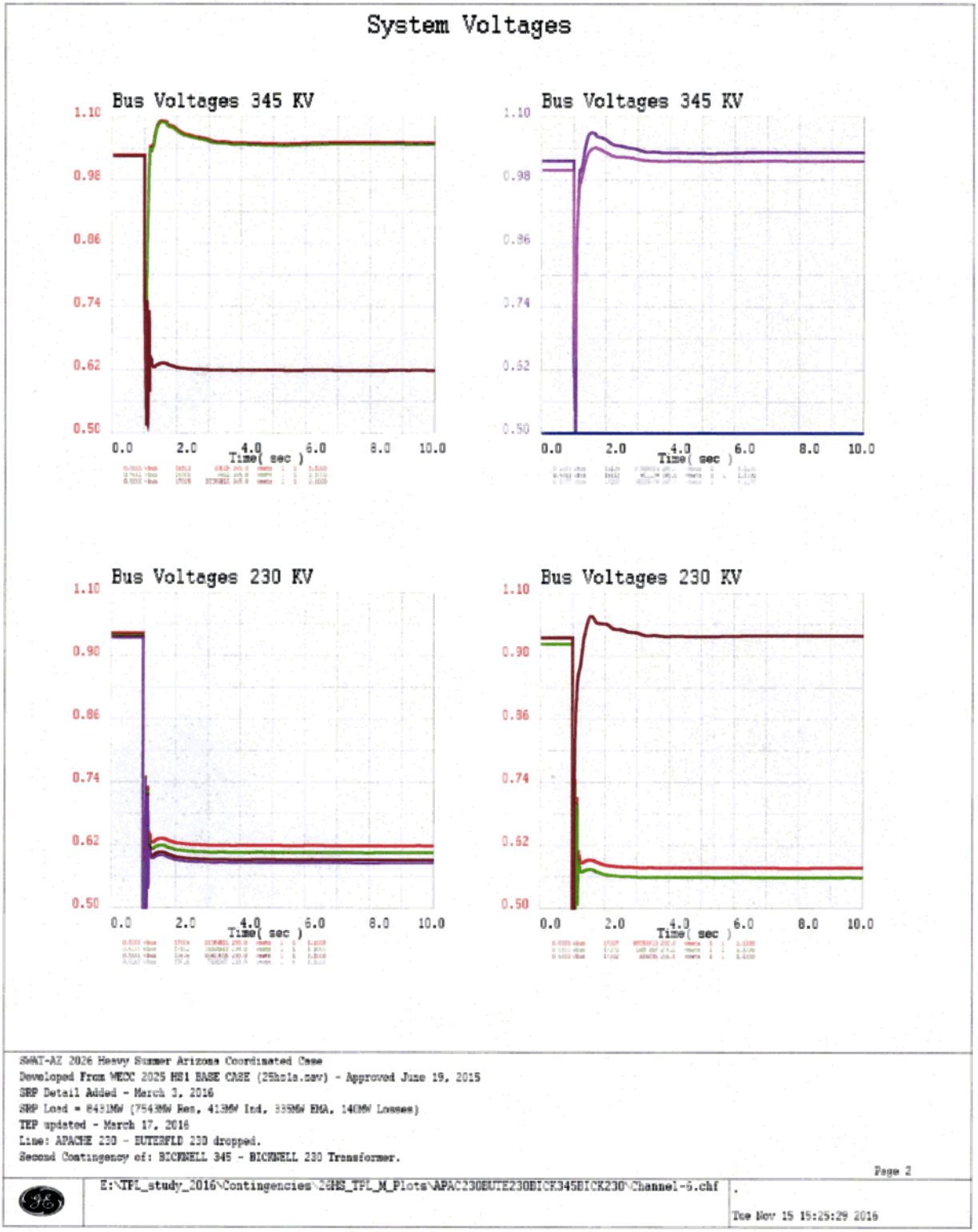


2026 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages Apache Generators Output



2026 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages

345 kV & 230 kV System Voltages



2026 HS – Bicknell 345/230 kV Transformer & Apache to Butterfield 230 kV Line Outages
230 kV & 115 kV System Voltages