

***Generation Interconnection  
System Impact Study Report***

***For***

***PJM Generation Interconnection Request  
Queue Position AD1-074/075/076***

***Trowbridge 230kV  
320.7 MW Capacity / 484.0 MW Energy***

**Revision 6: January 2023  
Revision 5: November 2022  
Revision 4: June 2022  
Revision 2/3: May 2022  
Revision 1: February 2022  
Revision 0: December 2019**

## **Introduction**

This System Impact Study (SIS) has been prepared in accordance with the PJM Open Access Transmission Tariff, Section 205, as well as the System Impact Study Agreement between Macadamia Solar LLC, the Interconnection Customer (IC) and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Virginia Electric and Power Company (VEPCO).

## **Preface**

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the IC. As a requirement for interconnection, the IC may be responsible for the cost of constructing Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner. In some instances an IC may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The IC is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

## **Revision 1 Summary – January 2022**

This revision is being issued to incorporate the results of a re-tool and completed stability analysis.

## **Revision 2/3 Summary – May 2022**

The revision is being issued due to a re-tool necessitated by the withdrawal of AD1-023 and to update costs based on the completed facilities study.

## **Revision 4 Summary – June 2022**

This revision is being issued because a lower cost upgrade was found to fix overloads driven by the “DVP\_P7-1: LN 25-2034-A” contingency.

## **Revision 5 Summary – November 2022**

This revision is being issued after a retool necessitated by the reduction of Z1-036.

## Revision 6 Summary – January 2023

This revision is being issued after a retool necessitated by the reduction of AD1-056/057 and to update revised upgrade cost.

### General

The IC has proposed a solar generating facility located in Washington County, North Carolina. The installed AD1-074/075/076 facilities will have a total capability of 484 MW with 320.7 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is June 1, 2020. This study does not imply an ITO commitment to this in-service date.

### Point of Interconnection

AD1-074/075/076 will interconnect with the ITO transmission system via a direct connection into the Trowbridge 230kV substation.

### Cost Summary

The AD1-074/075/076 project will be responsible for the following costs:

<b>Description</b>	<b>Total Cost</b>
Attachment Facilities	<b>\$3,956,516</b>
Direct Connection Network Upgrades	<b>\$0</b>
Non Direct Connection Network Upgrades	<b>\$4,000,000</b>
Allocation for New System Upgrades	<b>\$61,792,297</b>
Contribution for Previously Identified Upgrades	<b>\$0</b>
<b>Total Costs</b>	<b>\$69,748,813</b>

## **Attachment Facilities**

Generation Substation: Install metering and associated protection equipment. The estimated cost is \$788,752.

Transmission: Construct approximately one span of 230kV Attachment line between the generation substation and the Trowbridge 230kV Substation. The estimated cost for this work is \$3,167,764.

The estimated total cost of the Attachment Facilities is \$3,817,005. It is estimated to take 30-34 months to complete this work upon execution of an Interconnection Construction Service Agreement (ICSA). These preliminary cost estimates are based on typical engineering costs. A more detailed engineering cost estimates are normally done when the IC provides an exact site plan location for the generation substation during the Facility Study phase.

## **Direct Connection Cost Estimate**

None.

## **Non-Direct Network Upgrades:**

Substation: Add two breakers in the Trowbridge 230 kV Substation and rearrange the 230 kV bus. See Attachment 1 for One-Line Diagram. The estimated cost of this work scope is \$4,000,000. It is estimated to take 24-36 months to complete this work upon execution of an Interconnection Construction Service Agreement. Note attachment 1 shows a third 230 kV breaker due to n6287. See stability analysis portion of this report for details.

Remote Terminal Work: During the Facilities Study, ITO's System Protection Engineering Department will review transmission line protection as well as anti-islanding required to accommodate the new generation and interconnection substation. System Protection Engineering will determine the minimal acceptable protection requirements to reliably interconnect the proposed generating facility with the transmission system. The review is based on maintaining system reliability by reviewing ITO's protection requirements with the known transmission system configuration which includes generating facilities in the area. This review may determine that transmission line protection and communication upgrades are required at remote substations.

## **Interconnection Customer Requirements**

ITO's Facility Interconnection Requirements as posted on PJM's website

<http://www.pjm.com/~media/planning/plan-standards/private-dominion/facility-connection-requirements1.ashx>

**Voltage Ride Through Requirements** - The Customer Facility shall be designed to remain in service (not trip) for voltages and times as specified for the Eastern Interconnection in Attachment 1 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for both high and low voltage conditions, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

**Frequency Ride Through Requirements** - The Customer Facility shall be designed to remain in service (not trip) for frequencies and times as specified in Attachment 2 of NERC Reliability Standard PRC-024-1, and successor Reliability Standards, for both high and low frequency condition, irrespective of generator size, subject to the permissive trip exceptions established in PRC-024-1 (and successor Reliability Standards).

**Reactive Power** - The Generation Interconnection Customer shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the generator's terminals.

**Meteorological Data Reporting Requirement** - The solar generation facility shall, at a minimum, be required to provide the Transmission Provider with site-specific meteorological data including:

- Temperature (degrees Fahrenheit)
- Atmospheric pressure (hectopascals)
- Irradiance
- Forced outage data

## **Revenue Metering and SCADA Requirements**

### **PJM Requirements**

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

### **Interconnected Transmission Owner Requirements**

Metering and SCADA/Communication equipment must meet the requirements outlined in section 3.1.6 Metering and Telecommunications of ITO's Facility Connection Requirement NERC Standard FAC-001 which is publically available at [www.dom.com](http://www.dom.com).

## **Network Impacts**

The Queue Project AD1-074/075/076 was evaluated as a 484.0 MW (Capacity 320.7 MW) injection at Trowbridge 230 kV substation in the Dominion area. Project AD1-074/075/076 was

evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AD1-074/075/076 was studied with a commercial probability of 100%. Potential network impacts were as follows:

### Contingency Descriptions

The following contingencies resulted in overloads:

Contingency Name	Description
DVP_P1-2: LN 2020	CONTINGENCY 'DVP_P1-2: LN 2020'  OPEN BRANCH FROM BUS 313851 TO BUS 314638 CKT 1      /* 6ECITYDP2 230.00 - 6ELIZ CT 230.00  OPEN BRANCH FROM BUS 313851 TO BUS 314639 CKT 1      /* 6ECITYDP2 230.00 - 6TANGLEW 230.00  OPEN BRANCH FROM BUS 314639 TO BUS 314651 CKT 1      /* 6TANGLEW 230.00 - 6WINFALL 230.00  OPEN BUS 313851      /* ISLAND  OPEN BUS 314639      /* ISLAND  OPEN BUS 913391      /* ISLAND  OPEN BUS 913392      /* ISLAND  END
DVP_P1-2: LN 2034-A	CONTINGENCY 'DVP_P1-2: LN 2034-A'  OPEN BRANCH FROM BUS 314614 TO BUS 314616 CKT 1      /* 3TROWBR2 115.00 - 6TRWBRDG 230.00  OPEN BRANCH FROM BUS 314616 TO BUS 933990 CKT 1      /* 6TRWBRDG 230.00 - AD1-023 TAP 230.00  END
DVP_P1-2: LN 2034-B	CONTINGENCY 'DVP_P1-2: LN 2034-B'  OPEN BRANCH FROM BUS 314569 TO BUS 314620 CKT 1      /* 6EARLEYS 230.00 - 6CASHIE 230.00  OPEN BRANCH FROM BUS 933990 TO BUS 314620 CKT 1      /* AD1-023 TAP 230.00 - 6CASHIE 230.00  OPEN BUS 314620      /* ISLAND  END

DVP_P1-2: LN 2058	<p>CONTINGENCY 'DVP_P1-2: LN 2058'</p> <p>OPEN BRANCH FROM BUS 304222 TO BUS 313845 CKT 1 /* 6ROCKYMT230T230.00 - 6MORNSTR 230.00</p> <p>END</p>
DVP_P1-2: LN 2131A	<p>CONTINGENCY 'DVP_P1-2: LN 2131A'</p> <p>OPEN BRANCH FROM BUS 314662 TO BUS 916040 CKT 1 /* 6S HERTFORD 230.00 - Z1-036 TAP 230.00</p> <p>OPEN BRANCH FROM BUS 314651 TO BUS 314662 CKT 1 /* 6WINFALL 230.00 - 6S HERTFORD 230.00</p> <p>OPEN BUS 314662 /* ISLAND</p> <p>END</p>
DVP_P1-2: LN 2181	<p>CONTINGENCY 'DVP_P1-2: LN 2181'</p> <p>OPEN BUS 304226 /* ISLAND: 6PA-RMOUNT#4115.00</p> <p>OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1 /* 6PA- RMOUNT#4230.00 - 6NASH 230.00</p> <p>OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1 /* 6HATHAWAY 230.00 - 6NASH 230.00</p> <p>OPEN BUS 314591 /* ISLAND: 6NASH 230.00</p> <p>END</p>
DVP_P1-2: LN 246	<p>CONTINGENCY 'DVP_P1-2: LN 246'</p> <p>OPEN BRANCH FROM BUS 314537 TO BUS 314575 CKT 1 /* 6SUFFOLK 230.00 - 6NUCO TP 230.00</p> <p>OPEN BRANCH FROM BUS 314569 TO BUS 314575 CKT 1 /* 6EARLEYS 230.00 - 6NUCO TP 230.00</p> <p>OPEN BRANCH FROM BUS 314575 TO BUS 314590 CKT 1 /* 6NUCO TP 230.00 - 6NUCOR 230.00</p> <p>OPEN BUS 314575 /* ISLAND</p> <p>OPEN BUS 314590 /* ISLAND</p> <p>END</p>
DVP_P1-2: LN 247	<p>CONTINGENCY 'DVP_P1-2: LN 247'</p> <p>OPEN BRANCH FROM BUS 314537 TO BUS 314648 CKT 1 /* 6SUFFOLK 230.00 - 6SUNBURY 230.00</p> <p>OPEN BRANCH FROM BUS 314648 TO BUS 901080 CKT 1 /* 6SUNBURY 230.00 - W1-029 230.00</p> <p>OPEN BUS 314648 /* ISLAND</p>

	END
DVP_P1-2: LN 563	CONTINGENCY 'DVP_P1-2: LN 563'  OPEN BRANCH FROM BUS 314902 TO BUS 314914 CKT 1 /* 8CARSON 500.00 - 8MDLTHAN 500.00  END
DVP_P1-2: LN 574	CONTINGENCY 'DVP_P1-2: LN 574'  OPEN BRANCH FROM BUS 314908 TO BUS 314911 CKT 1 /* 8ELMONT 500.00 - 8LDYSMTH 500.00  END
DVP_P1-2: LN 575	CONTINGENCY 'DVP_P1-2: LN 575'  OPEN BRANCH FROM BUS 314911 TO BUS 314918 CKT 1 /* 8LDYSMTH 500.00 - 8NO ANNA 500.00  END
DVP_P1-2: LN 576	CONTINGENCY 'DVP_P1-2: LN 576'  OPEN BRANCH FROM BUS 314914 TO BUS 314918 CKT 1 /* 8MDLTHAN 500.00 - 8NO ANNA 500.00  END
DVP_P1-2: LN 594	CONTINGENCY 'DVP_P1-2: LN 594'  OPEN BRANCH FROM BUS 314916 TO BUS 314934 CKT 1 /* 8MORRSVL 500.00 - 8SPOTSYL 500.00  END
DVP_P4-2: 246T247	CONTINGENCY 'DVP_P4-2: 246T247' /* SUFFOLK 230 KV  OPEN BRANCH FROM BUS 314537 TO BUS 314575 CKT 1 /* 6SUFFOLK 230.00 - 6NUCO TP 230.00  OPEN BRANCH FROM BUS 314569 TO BUS 314575 CKT 1 /* 6EARLEYS 230.00 - 6NUCO TP 230.00  OPEN BRANCH FROM BUS 314575 TO BUS 314590 CKT 1 /* 6NUCO TP 230.00 - 6NUCOR 230.00  OPEN BUS 314575 /* ISLAND: 6NUCO TP 230.00  OPEN BUS 314590 /* ISLAND: 6NUCOR 230.00  OPEN BRANCH FROM BUS 314537 TO BUS 314648 CKT 1 /* 6SUFFOLK 230.00 - 6SUNBURY 230.00



	<p>OPEN BRANCH FROM BUS 314648 TO BUS 901080 CKT 1 /* 6SUNBURY 230.00 - W1-029 230.00</p> <p>OPEN BUS 314648 /* ISLAND: 6SUNBURY 230.00</p> <p>END</p>
DVP_P4-2: 562T563	<p>CONTINGENCY 'DVP_P4-2: 562T563' /*CARSON</p> <p>OPEN BRANCH FROM BUS 314902 TO BUS 314923 CKT 1 /*CARSON TO MIDLOTHIAN</p> <p>OPEN BRANCH FROM BUS 314914 TO BUS 314902 CKT 1 /*CARSON 500.00 - 8SEPTA 500.00</p> <p>END</p>
DVP_P4-3: 203422	<p>CONTINGENCY 'DVP_P4-3: 203422' /* TROWBRIDGE</p> <p>OPEN BRANCH FROM BUS 314616 TO BUS 933990 CKT 1 /* LINE 2034</p> <p>OPEN BRANCH FROM BUS 314616 TO BUS 314613 CKT 1 /* TROWBRIDGE TX.*1</p> <p>END</p>
DVP_P7-1: LN 2058-2181	<p>CONTINGENCY 'DVP_P7-1: LN 2058-2181'</p> <p>OPEN BRANCH FROM BUS 304222 TO BUS 313845 CKT 1 /* 6ROCKYMT230T230.00 - 6HATHAWAY 230.00</p> <p>OPEN BUS 304226 /* ISLAND: 6PA-RMOUNT#4115.00</p> <p>OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1 /* 6PA- RMOUNT#4230.00 - 6NASH 230.00</p> <p>OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1 /* 6HATHAWAY 230.00 - 6NASH 230.00</p> <p>OPEN BUS 314591 /* ISLAND: 6NASH 230.00</p> <p>END</p>
DVP_P7-1: LN 25- 2034_A	<p>CONTINGENCY 'DVP_P7-1: LN 25-2034_A' /*REPLACED ON 4/19/2016</p> <p>OPEN BRANCH FROM BUS 314573 TO BUS 314596 CKT 1 /* 3EVERETS 115.00 - 3POPLR C 115.00</p> <p>OPEN BRANCH FROM BUS 314596 TO BUS 314614 CKT 1 /* 3POPLR C 115.00 - 3TROWBR2 115.00</p> <p>OPEN BUS 314596 /* ISLAND</p> <p>OPEN BRANCH FROM BUS 314614 TO BUS 314616 CKT 1 /* 3TROWBR2 115.00 - 6TRWBRDG 230.00</p> <p>OPEN BRANCH FROM BUS 314616 TO BUS 933990 CKT 1 /* 6TRWBRDG</p>

	230.00 - AD1-023 TAP 230.00
	END
DVP_P7-1: LN 81-2056	CONTINGENCY 'DVP_P7-1: LN 81-2056'  OPEN BRANCH FROM BUS 314559 TO BUS 314578 CKT 1           /* 3CAROLNA 115.00 - 3HORNRTN 115.00  OPEN BRANCH FROM BUS 314578 TO BUS 314598 CKT 1           /* 3HORNRTN 115.00 - 3ROAN DP 115.00  OPEN BRANCH FROM BUS 314598 TO BUS 314628 CKT 1           /* 3ROAN DP 115.00 - 3DARLINGT DP115.00  OPEN BUS 314578   /* ISLAND: 3HORNRTN 115.00  OPEN BUS 314598   /* ISLAND: 3ROAN DP 115.00  OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1           /* 6PA- RMOUNT#4230.00 - 6NASH 230.00  OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1           /* 6MORNSTR 230.00 - 6NASH 230.00  OPEN BRANCH FROM BUS 304226 TO BUS 304222 CKT 1           /* 6PA- RMOUNT#4230.00 - 6ROCKYMT230T  OPEN BUS 304226   /* ISLAND  OPEN BUS 314591   /* ISLAND: 6NASH 230.00  END

## Summer Peak Analysis – 2021

### Generator Deliverability

*(Single or N-1 contingencies for the Capacity portion only of the interconnection)*

Overload Number	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating		MW Contribution	Flowgate Appendix
					From	To			Initial	Final	Type	MVA		
1	N-1	DVP_P1-2: LN 2181	DVP - CPLE	6MORNSTR-6ROCKYMT230T 230 kV line	313845	304222	1	AC	92.81	100.26	ER	374	28.43	
2	N-1	DVP_P1-2: LN 563	DVP - DVP	6CHESTF B-6BASIN 230 kV line	314287	314276	1	AC	99.22	103.01	ER	449	19.71	

### Multiple Facility Contingency

*(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output).*

Overload Number	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating		MW Contribution	Flowgate Appendix
					From	To			Initial	Final	Type	MVA		
3	DCT L	DVP_P7-1: LN 2058-2181	DVP - CPLE	6EVERETS-6GREENVILE T 230 kV line	314574	304451	1	AC	99.98	116.52	ER	478	82.65	3
4	DCT L	DVP_P7-1: LN 25-2034_A	DVP - DVP	3FIVE PT-3WHARTON 115 kV line	314576	314622	1	DC	46.96	108.65		91	56.13	4
5	DCT L	DVP_P7-1: LN 25-2034_A	DVP - DVP	AB2-169 TAP-3FIVE PT 115 kV line	925120	314576	1	DC	58.28	119.97		91	56.13	5

### Short Circuit

*(Summary of impacted circuit breakers)*

New circuit breakers found to be over-duty:

None

Contributions to previously identified circuit breakers found to be over-duty:

None

### Contribution to Previously Identified Overloads

*(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)*

Overload	Contingency	Affected Area	Facility Description	Bus	Circuit	Power Flow	Loading %	Rating	MW Contribution	Flowgate
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Number	Type	Name		From	To			Initial	Final	Type	MVA	n	Appendix	
6	DCTL	DVP_P7-1: LN 81-2056	DVP - CPLE	6MORNSTR-6ROCKYMT230T 230 kV line	313845	304222	1	AC	125.64	135.42	ER	374	43.04	6
7	LFFB	DVP_P4-2: 562T563	DVP - DVP	6CHESTF B-6BASIN 230 kV line	314287	314276	1	AC	104.47	109.01		549	29.23	7
8	LFFB	DVP_P4-2: 246T247	DVP - DVP	AB2-100 TAP-6CLUBHSE 230 kV line	924510	314563	1	AC	101.76	114.26		459	68.22	8

## New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this interconnection request)

Appendix #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AD1-074/ AD1-075/ AD1-076 Allocation
#1	6MORNSTR-6ROCKYMT230 T 230 kV line	AD1-074/075/076 is the driver of this overload for contingency 'DVP_P1-2: LN 2181' but also a contributor for a more heavily loaded contingency. See item 6 in the Contributions to Previously Identified System Reinforcements section.	-	-	-
#2	6CHESTF B-6BASIN 230 kV line	AD1-074/075/076 is the driver of this overload for contingency 'DVP_P1-2: LN 563' but also a contributor for a more heavily loaded contingency. See item 7 in the Contributions to Previously Identified System Reinforcements section.	-	-	-
#3	6EVERETS-6GREENVILE T 230 kV line	<b>Dominion Portion:</b> Rebuild 20.32 miles of 230 kV Line 218 from Everetts to Greenville with 2-636 ACSR Rating: 1047/1047/1204 MVA Schedule: 30-36 months  AD1-074/075/076 is the driver for this upgrade.	n6144	\$39,923,299	<b>\$39,923,299</b>

		<p><b>Duke Energy/Progress Portion:</b> Rebuild 1.87 miles of aging double circuit 230kV towers, ISD 6/1/2027</p> <p>Rating: 1195/1195/1195 MVA Schedule: 30-36 months</p> <p>Note: The Duke/Progress Energy portion of this line is studied under Duke’s FERC tariff process. Reference the applicable affected system study for the AD1 cluster.</p>	dep0003	\$19,000,000	<b>\$0</b>
		<p><b>Duke Energy/Progress Portion:</b> Reconductor 1.87 miles of one side of double circuit 230kV line plus terminal equipment</p> <p>Rating: 1195/1195/1195 MVA Schedule: 30-36 months</p> <p>Note: The Duke/Progress Energy portion of this line is studied under Duke’s FERC tariff process. Reference the applicable affected system study for the AD1 cluster.</p>	dep0003	\$350,000	<b>\$0</b>
#4 #5	3FIVE PT- 3WHARTON 115 kV	<p><b><u>DVP:</u></b> <b>Project Id:</b> n8113 <b>Project Description:</b> The Contingency driving this upgrade Overload is DVP_P7-1: LN 25-2034-A which is the tower failure of the Dominion 115 kV Line#25</p>	n8113	\$4,737,743	<b>\$4,737,743</b>

	AB2-169 TAP-3FIVE PT 115 kV line	<p>Trowbridge-Everett and 230 kV Line#2034 who share a common tower. Dominion new proposal is to resolve the overload by splitting line #25 off of line#2034, which eliminate the tower contingency.</p> <p><b>Project Type:</b> CON  <b>Cost:</b> \$1,875,000  <b>Time Estimate:</b></p> <p><b>Note: AD1-074/075/076 is the driver for this overload/upgrade.</b></p>			
<b>Total Cost(\$)</b>				<b>\$64,011,042</b>	<b>\$44,661,042</b>

**Contribution to Previously Identified System Reinforcements**

*(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which is calculated and reported for in the Impact Study)*

Appendix #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AD1-074/075/076 Allocation
#6	6MORNSTR-6ROCKYMT230 T 230 kV line	<p><b>Dominion Portion:</b></p> <p>Description: Rebuild 4.3 miles of Dominion 230 kV Line #2058 Rocky Mt. – Hathaway</p> <p>Rating: 1047/1047/1204</p> <p>Schedule: 12/31/2024 in-service date</p> <p>Note: Although Queue Project AD1-074/AD1-075/AD1-076 may not have cost responsibility for this</p>	b3122	\$13,000,000	<b>\$0</b>

		upgrade, it may need this upgrade in-service to be deliverable to the PJM system. If Queue Project AD1-074/AD1-075/AD1-076 comes into service prior to completion of the upgrade, it will need an interim study.			
#6	6CHESTF B-6BASIN 230 kV	Chesterfield to Basin 230 kV line - Replace 0.14 miles of 1109 ACAR with a conductor which will increase the line rating to approximately 706 MVA.  Note: Project is in-service as of 4/27/2018	b2990	\$350,000	\$0
#8	AB2-100 TAP-6CLUBHSE 230 kV line	Rebuild Clubhouse-Lakeview 230 kV Line #254 with single-circuit wood pole equivalent structures at the current 230 kV standard with a minimum rating of 1047 MVA.  Schedule: 10/15/23  Note: Although Queue Project AD1-074/075/076 may not have cost responsibility for this upgrade, Queue Project AD1-074/075/076 may need this upgrade in-service to be deliverable to the PJM system. If Queue Project AD1-074/075/076 comes into service prior to completion of the upgrade, Queue Project AD1-074/075/076 will need an interim study	b3121	\$23,670,000	\$0
				<b>Total Cost (\$)</b>	<b>\$0</b>

## Potential Congestion due to Local Energy Deliverability

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The IC can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this interconnection request by addressing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

Overload		Contingency	Affected Area	Facility Description	Bus		Circuit	Power Flow	Loading %		Rating	MW Contribution	Flowgate Appendix
Number	Type	Name			From	To			Initial	Final	Type	MVA	
9	N-1	DVP_P1-2: LN 2181	DVP - CPLE	6MORNSTR-6ROCKYMT230T 230 kV line	313845	304222	1	AC	125.04	134.84	ER	374	42.91
10	N-1	DVP_P1-2: LN 2058	DVP - DVP	6MORNSTR-6NASH 230 kV line	313845	314591	1	AC	110.99	119.27	ER	449	43.77
11	N-1	DVP_P1-2: LN 563	DVP - DVP	6CHESTF B-6BASIN 230 kV line	314287	314276	1	AC	118.97	124.6	ER	449	29.74
12	N-1	DVP_P1-2: LN 2131A	DVP - DVP	6CLUBHSE-6SAPONY 230 kV line	314563	314435	1	AC	94.15	106.65	ER	599	75.14
13	N-1	DVP_P1-2: LN 2131A	DVP - DVP	6EARLEYS-6NUCO TP 230 kV line	314569	314575	1	AC	95.75	125.12	ER	572	170.35
14	N-1	DVP_P1-2: LN 2131A	DVP - DVP	6NUCO TP-6SUFFOLK 230 kV line	314575	314537	1	AC	89.58	118.91	ER	572	170.35
15	N-1	DVP_P1-2: LN 2131A	DVP - DVP	6LAKEVEW-AB2-100 TAP 230 kV line	314583	924510	1	AC	97.68	116.52	ER	375	71.82
16	N-1	DVP_P1-2: LN 2058	DVP - CPLE	6NASH-6PA-RMOUNT#4 230 kV line	314591	304226	1	AC	101.17	109.08	ER	470	43.77
17	N-1	DVP_P1-2: LN 2131A	DVP - DVP	6CASHIE-6EARLEYS 230 kV line	314620	314569	1	AC	47.47	107.48	ER	572	362.61
18	N-1	DVP_P1-2: LN 2020	DVP - DVP	6SUNBURY-6SUFFOLK 230 kV line	314648	314537	1	AC	72.87	106.92	ER	449	153.13
19	N-1	DVP_P1-2: LN 576	DVP - DVP	8ELMONT-8LADYSMITH 500 kV line	314908	314911	1	AC	104.35	109.6	ER	2442	137.51
20	N-1	DVP_P1-2: LN 574	DVP - DVP	8MDLTHAN-8NO ANNA 500 kV line	314914	314918	1	AC	96.49	100.99	ER	2442	126.53
21	N-1	DVP_P1-2: LN 2020	DVP - DVP	W1-029-6SUNBURY 230 kV line	901080	314648	1	AC	74.25	108.3	ER	449	153.13
22	N-1	DVP_P1-2: LN 246	DVP - DVP	Z1-036 TAP-6S HERTFORD 230 kV line	916040	314662	1	AC	71.23	101.26	ER	733	219.81
23	N-1	DVP_P1-2: LN 246	DVP - DVP	AB2-100 TAP-6CLUBHSE 230 kV line	924510	314563	1	AC	120.29	133.83	ER	375	60.27
24	Non	Non	DVP - DVP	AB2-100 TAP-6CLUBHSE 230 kV line	924510	314563	1	AC	100.45	110.24	NR	375	43.26
25	N-1	DVP_P1-2: LN 2131A	DVP - DVP	AD1-023 TAP-6CASHIE 230 kV line	933990	314620	1	AC	49.3	109.21	ER	572	362.61



## **Stability Study Executive Summary**

This system impact study will be performed for generation interconnection request AD1-074, AD1-075, and AD1-076.

Generator Interconnection Request AD1-074 is for a 300 MW Maximum Facility Output (MFO) solar generating facility. AD1-074 consists of 141 x 2.167 MW SMA Sunny Central MVB 2500-US solar inverters. Generator Interconnection Request AD1-075 is for a 75 MW Maximum Facility Output (MFO) solar generating facility. AD1-075 consists of 36 x 2.119 MW SMA Sunny Central MVB 2500-US solar inverters. Generator Interconnection Request AD1-076 is for a 109 MW Maximum Facility Output (MFO) solar generating facility. AD1-076 consists of 52 x 2.133 MW SMA Sunny Central MVB 2500-US solar inverters. Generation interconnection requests AD1-074, AD1-075, and AD1-076 have a Point of Interconnection (POI) directly at the Trowbridge 230 kV substation in Washington County, North Carolina, in the Dominion Energy transmission system.

The power flow scenario for the analysis was based on the RTEP 2021 summer peak load case, modified to include applicable queue projects. AD1-074, AD1-075, and AD1-076, has been dispatched online at maximum facility output, with approximately unity power factor at the high side of the station transformer.

AD1-074, AD1-075, and AD1-076 was tested for compliance with NERC, PJM, Transmission Owner and other applicable criteria. For this study, 92 contingencies were simulated, each with a 20 second simulation time period. Studied faults included:

- Steady-state operation (20 second simulation)
- Three-phase faults with normal clearing time
- Single-phase faults with a stuck breaker
- Single-phase faults placed at 80% of the line with delayed (Zone 2) clearing at remote line end because of primary communications/relaying failure
- Single-phase fault with loss of multiple circuits caused by a common tower contingency

The 92 fault contingencies with the proposed mitigation simulated on the 2021 summer peak load case met the recovery criteria:

- The AD1-074, AD1-075, and AD1-076 generators were able to ride through the faults except for faults where protective actions trip one or more generator(s).
- All generators maintained synchronism and any post-contingency oscillations are positively damped with a damping margin of at least 3%.
- All bus voltages recover to 0.7 p.u. within 2.5 seconds and the final voltages are within the steady-state voltage ranges below per DVP's transmission planning criteria.
  - P1 Category Contingencies:
    - 0.93 to 1.05 p.u. for 230, 115, 69 kV facilities
    - 0.93 to 1.03 p.u. for 138 kV facilities due to legacy switches
    - 1.01 to 1.096 p.u. for 500 kV facilities

- P2, P4, P5, and P7 Category Contingencies:
  - 0.90 to 1.05 p.u. for 230, 115, 69 kV facilities
  - 0.90 to 1.03 p.u. for 138 kV facilities due to legacy switches
  - 1.00 to 1.096 p.u. for 500 kV facilities
- No transmission element trips, other than those either directly connected or designated to trip as a consequence of the fault.

The following mitigation was identified for the interconnection of the AD1-074, AD1-075, and AD1-076 queue projects:

- An additional 58.87 Mvar of reactive support was identified as mitigation to interconnect the AD1-074, AD1-075, and AD1-076 generators because the plant did not meet the 0.95 lagging power factor requirement. This needs to be addressed by the Interconnection Customer.
- The Trowbridge 230 kV substation was reconfigured to prevent instability of the AD1-074, AD1-075, and AD1-076 queue projects. If the AD1-074, AD1-075, and AD1-076 generator tie line connection is moved between new circuit breakers 2 and 3 and the Trowbridge to Mackeys 230 kV transmission line is moved between new circuit breakers 1 and 2 the AD1-074, AD1-075, and AD1-076 queue projects can remain connected to a 230 kV line at Trowbridge for all P4 contingencies at Trowbridge 230 kV. To accommodate the 230 kV reconfiguration DVP is updating the Trowbridge 115 kV substation to a ring bus therefore the case was updated to have one 115 kV Trowbridge bus.
- Network upgrade number n6287 has been created for the reconfiguration of Trowbridge substation with the following preliminary scope of work and preliminary cost estimate:

Preliminary Scope:

230kV Yard

- Expand 230kV yard to accommodate additional rung of 230kV breakers. This will require relocation of existing 115kV equipment.
- Relocate Transformer #1 to accommodate new rung of 230kV breakers
- Install 3 new 230kV breakers<sup>1</sup>, and 2 new 230kV backbones
- Reterminate Line 2126 on new rung, will require T Line reconfiguration outside of station
- Terminate new AD1-074/75/76 line on new rung. Will require T Line reconfiguration outside of the station to utilize existing 115kV Line 25 station entrance infrastructure

115kV Yard

- Expand station to the north and rebuild entire 115kV yard (8 breakers, 4 backbones)
- Reterminate all (4) existing 115kV lines

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<sup>1</sup> Two of these breakers are included in the scope of the non-direct physical interconnection at a cost of \$4,000,000.

- Line 1020 and line 25 will require significant T-Line reconfigurations outside of the station

Preliminary Cost Estimate: \$ 21,131,255 - \$4,000,000 = \$17,131,255<sup>2</sup>

### New System Reinforcements

Violation #	Upgrade Description	Network Upgrade Number	Upgrade Cost	AD1-074/ AD1-075/ AD1-076 Allocation
P4.08, P4.09	<b>Dominion Portion:</b> Description: Reconfiguration of Trowbridge 230 kV and 115 kV substation	n6287	\$17,131,255	<b>\$17,131,255</b>

### Steady-State Voltage Requirements

*(Summary of the VAR requirements based upon the results of the steady-state voltage studies)*

The AD1-074, AD1-075, and AD1-076 projects did not meet the 0.95 lagging power factor requirement. An additional 58.87 Mvar would be required for the plant to meet the 0.95 lagging power factor requirement. The plant did meet the 0.95 leading power factor requirement.

Generator	MFO (MW)	Required Power Factor Range		Maximum Lagging (Mvar)	Minimum Leading (Mvar)
		Lagging	Leading		
AD1-074, AD1-075, and AD1-076	484.00	0.95	0.95		
<b>Total Reactive Power Required</b>				159.08	-159.08
<b>Reactive Power from Generator</b>				<b>Qmax</b>	<b>Qmin</b>
				178.75	-178.75
<b>Customer Planned Compensation</b>				0	0

<sup>2</sup> This preliminary estimate includes \$4,000,000 in non-direct physical interconnection costs. The additional cost of the work driven by the stability analysis is \$17,131,255. The total cost of Trowbridge substation work driven by stability analysis and physical interconnection is \$21,131,255.

<b>Reactive Power Losses</b>	-78.54	-78.54
<b>Total Available Reactive Power at High Side of Main Transformer</b>	100.21	-257.29
<b>Deficiency in Reactive Power</b>	-58.87	Meet

### **Stability and Reactive Power Requirement for Low Voltage Ride Through**

*(Summary of the VAR requirements based upon the results of the dynamic studies)*

The AD1-074, AD1-075, and AD1-076 generators were observed to be unstable for the contingencies listed in the table below. These P4 contingencies were caused by breaker 2034T2126 failing to open resulting in both 230 kV lines connected to Trowbridge 230 kV tripping. The AD1-074, AD1-075, and AD1-076 queue projects lost synchronism once the two 230 kV line tripped and the generators were connected to the system through the two Trowbridge 230/115 kV transformers.

<b>Fault ID</b>	<b>Fault Description</b>	<b>Clearing Time Normal/Delayed (Cycles)</b>	<b>AD1-074, AD1-075, and AD1-076</b>
P4.08	Fault at Trowbridge 230 kV on AD1-022 TAP circuit 2034. Breaker 2034T2126 is stuck. Fault is cleared with loss of Trowbridge 230/115 kV Transformer 1 and Trowbridge to Mackeys 230 kV circuit 2126.	5.5/26	Unstable
P4.09	Fault at Trowbridge 230 kV on Mackeys circuit 2126. Breaker 2034T2126 is stuck. Fault is cleared with loss of Trowbridge 230/115 kV Transformer 1 and Trowbridge to AD1-022 Tap 230 kV circuit 2034.	5.5/26	Unstable

The Trowbridge 230 kV substation was reconfigured to prevent instability of the AD1-074, AD1-075, and AD1-076 queue projects. If the AD1-074, AD1-075, and AD1-076 generator tie line connection is moved between new circuit breakers 2 and 3 and the Trowbridge to Mackeys 230 kV transmission line is moved between new circuit breakers 1 and 2 the AD1-074, AD1-075, and AD1-076 queue projects can remain connected to a 230 kV line at Trowbridge for all P4 contingencies at Trowbridge 230 kV. To accommodate the 230 kV reconfiguration DVP proposed updating the Trowbridge 115 kV substation to a ring bus therefore the case was updated to have one 115 kV Trowbridge bus. AD1-074, AD1-075, and AD1-076 remained stable for all P4 contingencies with the Trowbridge 230 and 115 kV substation reconfigured. The reconfiguration moving the Mackeys – Trowbridge 230kV line is captured under Network Upgrade n6287 with an estimated cost of \$21,131,255. This upgrade replicates \$4,000,000 of non-direct physical interconnection work and therefore has a cost of \$17,131,255.

## **Light Load Analysis in 2021**

Not required

### **Affected System Analysis & Mitigation**

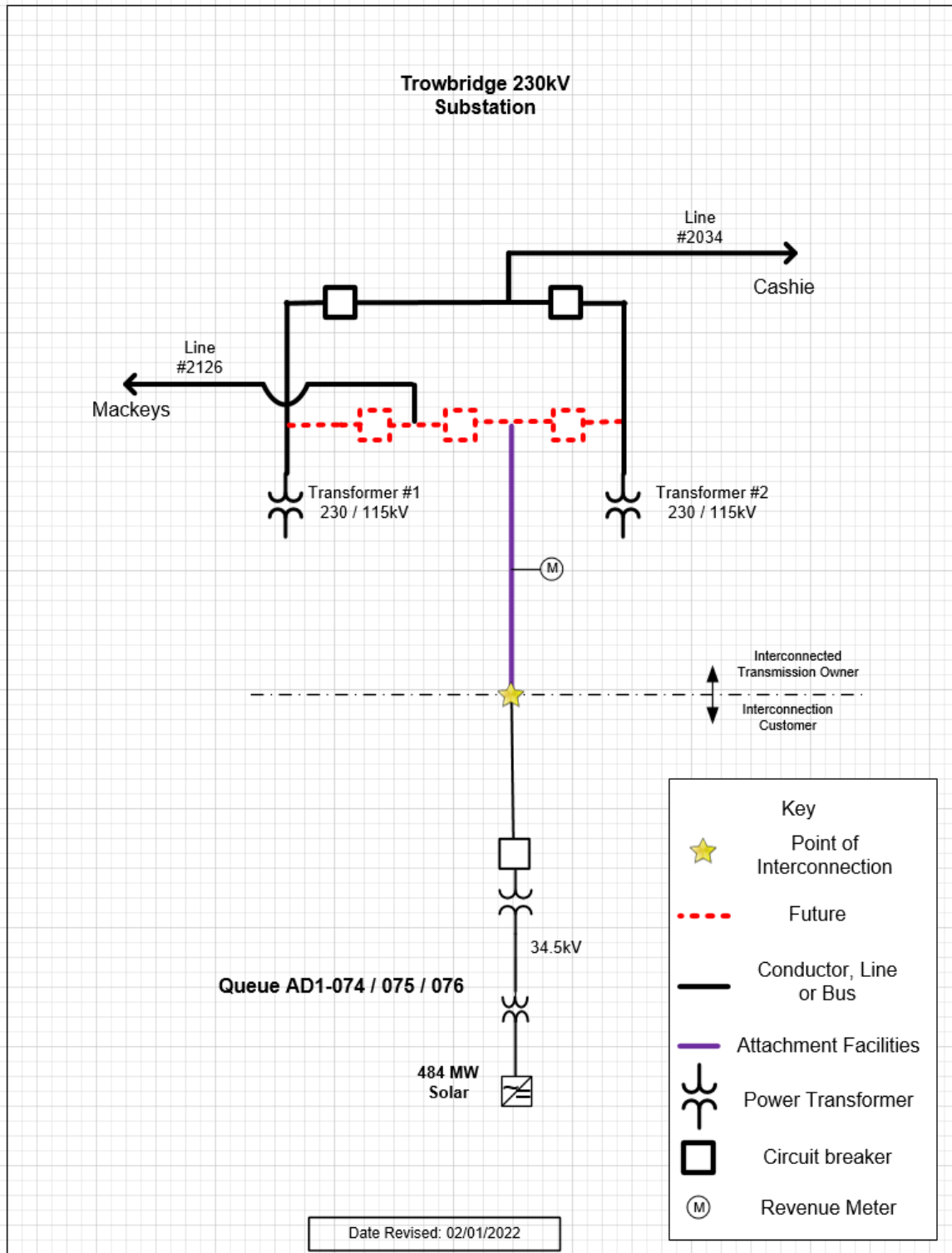
#### **Duke Energy/Progress:**

Potential constraints were identified by PJM on the following Dominion – Duke Energy/Progress (DEP) tie lines. Duke/Progress Energy portion of this line will need to be studied under Duke’s FERC tariff process. The following facilities were identified in this report:

- Everetts - Greenville 230 kV line

# Attachment 1.

## System Configuration



## **Appendices**

The following appendices contain additional information about each flowgate presented in the body of the report. For each appendix, a description of the flowgate and its contingency was included for convenience. However, the intent of the appendix section is to provide more information on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the Appendices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the Appendices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators.

It should be noted the project/generator MW contributions presented in the body of the report and appendices sections are full contributions, whereas the loading percentages reported in the body of the report, take into consideration the commercial probability of each project as well as the ramping impact of "Adder" contributions.

### Appendix 3

(DVP - CPLE) The 6EVERETS-6GREENVILE T 230 kV line (from bus 314574 to bus 304451 ckt 1) loads from 99.98% to 116.52% (AC power flow) of its emergency rating (478 MVA) for the tower line contingency outage of 'DVP\_P7-1: LN 2058-2181'. This project contributes approximately 82.65 MW to the thermal violation.

CONTINGENCY 'DVP\_P7-1: LN 2058-2181'

OPEN BRANCH FROM BUS 304222 TO BUS 313845 CKT 1 /\*

6ROCKYMT230T230.00 - 6HATHAWAY 230.00

OPEN BUS 304226 /\* ISLAND: 6PA-RMOUNT#4115.00

OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1 /\* 6PA-

RMOUNT#4230.00 - 6NASH 230.00

OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1 /\* 6HATHAWAY  
230.00 - 6NASH 230.00

OPEN BUS 314591 /\* ISLAND: 6NASH 230.00

END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
315294	1DOMTR10	2.92
315292	1DOMTR78	1.97
315293	1DOMTR9	1.61
315131	1EDGECEMA	8.
315132	1EDGECEMB	8.
315136	1ROSEMG1	1.85
315138	1ROSEMG2	0.87
315137	1ROSEMS1	1.15
314557	3BETHEL C	1.15
314554	3BTLEBRO	0.43
314566	3CRESWEL	2.04
314572	3EMPORIA	0.21
314578	3HORNRTN	2.04
314603	3SCOT NK	2.51
314541	3WATKINS	0.36
314620	6CASHIE	0.88
314574	6EVERETS	5.39
314594	6PLYMOTH	0.83
314648	6SUNBURY	0.4
314651	6WINFALL	0.97
932631	AC2-084 C	4.63
932632	AC2-084 E	2.28
933991	AD1-022 C	8.98
933992	AD1-022 E	4.89
934331	AD1-057 C O1	8.71
934332	AD1-057 E O1	4.65



934521	AD1-076 C O1	54.77
934522	AD1-076 E O1	27.89
LTF	AMIL	0.48
LTF	BLUEG	2.5
LTF	CALDERWOOD	1.54
LTF	CANNELTON	0.48
LTF	CATAWBA	1.5
LTF	CBM-N	< 0.01
LTF	CELEVELAND /* 35% REVERSE 4479079 4642907	< 0.01
LTF	CHEOAH	1.44
LTF	CLIFTY	9.03
LTF	COTTONWOOD	5.2
LTF	EDWARDS	0.78
LTF	ELMERSMITH	1.41
LTF	FARMERCITY	0.62
LTF	G-007A	1.04
LTF	GIBSON	0.88
LTF	HAMLET	3.22
LTF	MORGAN	4.56
LTF	NEWTON	2.15
LTF	NYISO	0.09
LTF	O-066A	0.48
LTF	PRAIRIE	4.68
LTF	SMITHLAND	0.42
LTF	TATANKA	1.05
LTF	TILTON	0.92
LTF	TRIMBLE	0.47
LTF	TVA	1.91
LTF	UNIONPOWER	2.56
900672	V4-068 E	0.21
LTF	VFT	2.76
901082	W1-029E	16.22
907092	X1-038 E	2.96
913392	Y1-086 E	1.05
LTF	Y3-032	< 0.01
916041	Z1-036 C	2.73
916042	Z1-036 E	18.34
917122	Z2-027 E	0.51
917331	Z2-043 C	0.37
917332	Z2-043 E	0.86
917342	Z2-044 E	0.33
917511	Z2-088 C OPI	1.42
917512	Z2-088 E OPI	6.13
918411	AA1-050	1.2

918492	AA1-063AE OP	2.44
918511	AA1-065 C OP	1.8
918512	AA1-065 E OP	4.84
918531	AA1-067 C	0.69
918532	AA1-067 E	1.62
918561	AA1-072 C	0.06
918562	AA1-072 E	0.14
919692	AA2-053 E	2.58
919701	AA2-057 C	4.25
919702	AA2-057 E	2.12
920042	AA2-088 E	6.25
920592	AA2-165 E	0.28
920672	AA2-174 E	0.3
920691	AA2-178 C	1.5
920692	AA2-178 E	3.5
930402	AB1-081 E	2.42
930861	AB1-132 C	10.36
930862	AB1-132 E	4.44
931231	AB1-173 C	1.21
931232	AB1-173 E	0.56
931241	AB1-173AC	1.21
931242	AB1-173AE	0.56
923831	AB2-022 C	1.02
923832	AB2-022 E	0.55
923911	AB2-031 C OI	1.2
923912	AB2-031 E OI	0.59
923991	AB2-040 C OI	3.93
923992	AB2-040 E OI	3.22
924151	AB2-059 C OI	6.65
924152	AB2-059 E OI	3.42
924501	AB2-099 C	0.53
924502	AB2-099 E	0.23
924511	AB2-100 C	5.86
924512	AB2-100 E	2.88
925121	AB2-169 C	10.02
925122	AB2-169 E	8.99
925171	AB2-174 C OI	3.64
925172	AB2-174 E OI	3.3
925591	AC1-034 C	4.3
925592	AC1-034 E	3.25
926071	AC1-086 C	15.26
926072	AC1-086 E	6.95
926201	AC1-098 C	4.33
926202	AC1-098 E	2.58
926211	AC1-099 C	1.45

926212	<i>ACI-099 E</i>	0.85
<i>LTF</i>	<i>ACI-131</i>	5.64
927021	<i>ACI-189 C</i>	15.46
927022	<i>ACI-189 E</i>	7.7
927141	<i>ACI-208 C</i>	5.75
927142	<i>ACI-208 E</i>	2.55

## Appendix 4

(DVP - DVP) The 3FIVE PT-3WHARTON 115 kV line (from bus 314576 to bus 314622 ckt 1) loads from 46.96% to 108.65% (**DC power flow**) of its load dump rating (91 MVA) for the tower line contingency outage of 'DVP\_P7-1: LN 25-2034\_A'. This project contributes approximately 56.13 MW to the thermal violation.

CONTINGENCY 'DVP\_P7-1: LN 25-2034\_A' /\*REPLACED ON  
 4/19/2016  
 OPEN BRANCH FROM BUS 314573 TO BUS 314596 CKT 1 /\* 3EVERETS  
 115.00 - 3POPLR C 115.00  
 OPEN BRANCH FROM BUS 314596 TO BUS 314614 CKT 1 /\* 3POPLR C  
 115.00 - 3TROWBR2 115.00  
 OPEN BUS 314596 /\* ISLAND  
 OPEN BRANCH FROM BUS 314569 TO BUS 314620 CKT 1 /\* 6EARLEYS  
 230.00 - 6CASHIE 230.00  
 OPEN BRANCH FROM BUS 314614 TO BUS 314616 CKT 1 /\* 3TROWBR2  
 115.00 - 6TRWBRDG 230.00  
 OPEN BRANCH FROM BUS 314616 TO BUS 933990 CKT 1 /\* 6TRWBRDG  
 230.00 - AD1-023 TAP 230.00  
 END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
315294	1DOMTR10	2.96
315292	1DOMTR78	2.
315293	1DOMTR9	1.63
314566	3CRESWEL	1.3
314594	6PLYMOTH	0.56
934521	AD1-076 C O1	37.19
934522	AD1-076 E O1	18.94
LTF	AMIL	0.06
LTF	BLUEG	0.31
LTF	CALDERWOOD	0.18
LTF	CANNELTON	0.06
LTF	CARR	< 0.01
LTF	CATAWBA	0.17
LTF	CHEOAH	0.17
LTF	CLIFTY	1.12
LTF	COTTONWOOD	0.61
LTF	EDWARDS	0.09
LTF	ELMERSMITH	0.17
LTF	FARMERCITY	0.07
LTF	G-007A	0.11
LTF	GIBSON	0.11
LTF	HAMLET	0.36

<i>LTF</i>	<i>MORGAN</i>	<i>0.53</i>
<i>LTF</i>	<i>NEWTON</i>	<i>0.26</i>
<i>LTF</i>	<i>O-066A</i>	<i>0.05</i>
<i>LTF</i>	<i>PRAIRIE</i>	<i>0.56</i>
<i>LTF</i>	<i>RENSSELAER</i>	<i>&lt; 0.01</i>
<i>LTF</i>	<i>SMITHLAND</i>	<i>0.05</i>
<i>LTF</i>	<i>TATANKA</i>	<i>0.13</i>
<i>LTF</i>	<i>TILTON</i>	<i>0.11</i>
<i>LTF</i>	<i>TRIMBLE</i>	<i>0.06</i>
<i>LTF</i>	<i>TVA</i>	<i>0.22</i>
<i>LTF</i>	<i>UNIONPOWER</i>	<i>0.3</i>
<i>LTF</i>	<i>VFT</i>	<i>0.29</i>
<i>916041</i>	<i>Z1-036 C</i>	<i>1.51</i>
<i>916042</i>	<i>Z1-036 E</i>	<i>10.16</i>
<i>920692</i>	<i>AA2-178 E</i>	<i>2.23</i>
<i>925121</i>	<i>AB2-169 C</i>	<i>19.</i>
<i>925122</i>	<i>AB2-169 E</i>	<i>17.05</i>

## Appendix 5

(DVP - DVP) The AB2-169 TAP-3FIVE PT 115 kV line (from bus 925120 to bus 314576 ckt 1) loads from 58.28% to 119.97% (**DC power flow**) of its load dump rating (91 MVA) for the tower line contingency outage of 'DVP\_P7-1: LN 25-2034\_A'. This project contributes approximately 56.13 MW to the thermal violation.

CONTINGENCY 'DVP\_P7-1: LN 25-2034\_A' /\*REPLACED ON  
 4/19/2016  
 OPEN BRANCH FROM BUS 314573 TO BUS 314596 CKT 1 /\* 3EVERETS  
 115.00 - 3POPLR C 115.00  
 OPEN BRANCH FROM BUS 314596 TO BUS 314614 CKT 1 /\* 3POPLR C  
 115.00 - 3TROWBR2 115.00  
 OPEN BUS 314596 /\* ISLAND  
 OPEN BRANCH FROM BUS 314569 TO BUS 314620 CKT 1 /\* 6EARLEYS  
 230.00 - 6CASHIE 230.00  
 OPEN BRANCH FROM BUS 314614 TO BUS 314616 CKT 1 /\* 3TROWBR2  
 115.00 - 6TRWBRDG 230.00  
 OPEN BRANCH FROM BUS 314616 TO BUS 933990 CKT 1 /\* 6TRWBRDG  
 230.00 - AD1-023 TAP 230.00  
 END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
315294	1DOMTR10	2.96
315292	1DOMTR78	2.
315293	1DOMTR9	1.63
314566	3CRESWEL	1.3
314594	6PLYMOTH	0.56
934521	AD1-076 C O1	37.19
934522	AD1-076 E O1	18.94
LTF	AMIL	0.06
LTF	BLUEG	0.31
LTF	CALDERWOOD	0.18
LTF	CANNELTON	0.06
LTF	CARR	< 0.01
LTF	CATAWBA	0.17
LTF	CHEOAH	0.17
LTF	CLIFTY	1.12
LTF	COTTONWOOD	0.61
LTF	EDWARDS	0.09
LTF	ELMERSMITH	0.17
LTF	FARMERCITY	0.07
LTF	G-007A	0.11
LTF	GIBSON	0.11
LTF	HAMLET	0.36

<i>LTF</i>	<i>MORGAN</i>	<i>0.53</i>
<i>LTF</i>	<i>NEWTON</i>	<i>0.26</i>
<i>LTF</i>	<i>O-066A</i>	<i>0.05</i>
<i>LTF</i>	<i>PRAIRIE</i>	<i>0.56</i>
<i>LTF</i>	<i>RENSSELAER</i>	<i>&lt; 0.01</i>
<i>LTF</i>	<i>SMITHLAND</i>	<i>0.05</i>
<i>LTF</i>	<i>TATANKA</i>	<i>0.13</i>
<i>LTF</i>	<i>TILTON</i>	<i>0.11</i>
<i>LTF</i>	<i>TRIMBLE</i>	<i>0.06</i>
<i>LTF</i>	<i>TVA</i>	<i>0.22</i>
<i>LTF</i>	<i>UNIONPOWER</i>	<i>0.3</i>
<i>LTF</i>	<i>VFT</i>	<i>0.29</i>
<i>916041</i>	<i>Z1-036 C</i>	<i>1.51</i>
<i>916042</i>	<i>Z1-036 E</i>	<i>10.16</i>
<i>920692</i>	<i>AA2-178 E</i>	<i>2.23</i>
<i>925121</i>	<i>AB2-169 C</i>	<i>19.</i>
<i>925122</i>	<i>AB2-169 E</i>	<i>17.05</i>

## Appendix 6

(DVP - CPLE) The 6MORNSTR-6ROCKYMT230T 230 kV line (from bus 313845 to bus 304222 ckt 1) loads from 125.64% to 135.42% (AC power flow) of its emergency rating (374 MVA) for the tower line contingency outage of 'DVP\_P7-1: LN 81-2056'. This project contributes approximately 43.04 MW to the thermal violation.

CONTINGENCY 'DVP\_P7-1: LN 81-2056'

OPEN BRANCH FROM BUS 314559 TO BUS 314578 CKT 1 /\* 3CAROLNA  
115.00 - 3HORNRTN 115.00  
OPEN BRANCH FROM BUS 314578 TO BUS 314598 CKT 1 /\* 3HORNRTN  
115.00 - 3ROAN DP 115.00  
OPEN BRANCH FROM BUS 314598 TO BUS 314628 CKT 1 /\* 3ROAN DP  
115.00 - 3DARLINGT DP115.00  
OPEN BUS 314578 /\* ISLAND: 3HORNRTN 115.00  
OPEN BUS 314598 /\* ISLAND: 3ROAN DP 115.00  
OPEN BRANCH FROM BUS 304226 TO BUS 314591 CKT 1 /\* 6PA-  
RMOUNT#4230.00 - 6NASH 230.00  
OPEN BRANCH FROM BUS 313845 TO BUS 314591 CKT 1 /\* 6MORNSTR  
230.00 - 6NASH 230.00  
OPEN BRANCH FROM BUS 304226 TO BUS 304222 CKT 1 /\* 6PA-  
RMOUNT#4230.00 - 6ROCKYMT230T  
OPEN BUS 304226 /\* ISLAND  
OPEN BUS 314591 /\* ISLAND: 6NASH 230.00  
END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
315131	1EDGECEMA	21.38
315132	1EDGECEMB	21.38
315139	1GASTONA	3.75
315141	1GASTONB	3.75
315126	1ROARAP2	1.14
315128	1ROARAP4	1.1
315136	1ROSEMG1	3.14
315138	1ROSEMG2	1.47
315137	1ROSEMS1	1.95
314557	3BETHEL C	1.61
314554	3BTLEBRO	1.08
314566	3CRESWEL	1.09
314572	3EMPORIA	0.27
314603	3SCOT NK	3.23
314541	3WATKINS	0.33
314620	6CASHIE	0.49
314574	6EVERETS	1.81



314594	6PLYMOTH	0.44
932631	AC2-084 C	7.04
932632	AC2-084 E	3.47
933991	AD1-022 C	4.84
933992	AD1-022 E	2.63
934331	AD1-057 C O1	19.56
934332	AD1-057 E O1	10.46
934521	AD1-076 C O1	28.52
934522	AD1-076 E O1	14.52
LTF	AMIL	0.38
LTF	BLUEG	1.99
LTF	CALDERWOOD	1.17
LTF	CANNELTON	0.38
LTF	CARR	< 0.01
LTF	CATAWBA	1.14
LTF	CELEVELAND /* 35% REVERSE 4479079 4642907	< 0.01
LTF	CHEOAH	1.09
LTF	CLIFTY	7.31
LTF	COTTONWOOD	3.91
LTF	EDWARDS	0.61
LTF	ELMERSMITH	1.11
LTF	FARMERCITY	0.48
LTF	G-007A	0.76
LTF	GIBSON	0.69
LTF	HAMLET	2.25
LTF	MORGAN	3.43
LTF	NEWTON	1.68
LTF	O-066A	0.35
LTF	PRAIRIE	3.62
LTF	SMITHLAND	0.32
LTF	TATANKA	0.82
LTF	TILTON	0.72
LTF	TRIMBLE	0.38
LTF	TVA	1.45
LTF	UNIONPOWER	1.94
900671	V4-068 C	0.06
900672	V4-068 E	0.18
LTF	VFT	2.03
907092	X1-038 E	2.6
LTF	Y3-032	< 0.01
917331	Z2-043 C	0.36
917332	Z2-043 E	0.84
917341	Z2-044 C	0.32
917342	Z2-044 E	0.75

917511	Z2-088 C OPI	1.56
917512	Z2-088 E OPI	6.74
918411	AA1-050	1.32
918491	AA1-063AC OP	1.07
918492	AA1-063AE OP	2.74
918511	AA1-065 C OP	1.09
918512	AA1-065 E OP	2.92
918531	AA1-067 C	0.23
918532	AA1-067 E	0.54
918561	AA1-072 C	0.05
918562	AA1-072 E	0.14
919691	AA2-053 C	1.19
919692	AA2-053 E	2.79
919701	AA2-057 C	8.78
919702	AA2-057 E	4.39
920042	AA2-088 E	5.93
920591	AA2-165 C	0.22
920592	AA2-165 E	0.58
920671	AA2-174 C	0.05
920672	AA2-174 E	0.32
920692	AA2-178 E	1.86
930401	AB1-081 C	2.67
930402	AB1-081 E	6.24
930861	AB1-132 C	15.62
930862	AB1-132 E	6.7
931231	AB1-173 C	1.56
931232	AB1-173 E	0.73
931241	AB1-173AC	1.56
931242	AB1-173AE	0.73
923852	AB2-025 E	0.45
923911	AB2-031 C OI	1.55
923912	AB2-031 E OI	0.76
923991	AB2-040 C OI	5.07
923992	AB2-040 E OI	4.15
924151	AB2-059 C OI	17.15
924152	AB2-059 E OI	8.84
924501	AB2-099 C	0.4
924502	AB2-099 E	0.17
924511	AB2-100 C	8.3
924512	AB2-100 E	4.09
925121	AB2-169 C	4.03
925122	AB2-169 E	3.62
925171	AB2-174 C OI	4.75
925172	AB2-174 E OI	4.3
925591	AC1-034 C	11.11

925592	<i>ACI-034 E</i>	8.38
926071	<i>ACI-086 C</i>	23.01
926072	<i>ACI-086 E</i>	10.47
926201	<i>ACI-098 C</i>	6.58
926202	<i>ACI-098 E</i>	3.92
926211	<i>ACI-099 C</i>	2.21
926212	<i>ACI-099 E</i>	1.3
927021	<i>ACI-189 C</i>	12.21
927022	<i>ACI-189 E</i>	6.08
927141	<i>ACI-208 C</i>	10.44
927142	<i>ACI-208 E</i>	4.64

## Appendix 7

(DVP - DVP) The 6CHESTF B-6BASIN 230 kV line (from bus 314287 to bus 314276 ckt 1) loads from 104.47% to 109.01% (AC power flow) of its load dump rating (549 MVA) for the line fault with failed breaker contingency outage of 'DVP\_P4-2: 562T563'. This project contributes approximately 29.23 MW to the thermal violation.

CONTINGENCY 'DVP\_P4-2: 562T563' /\*CARSON  
 OPEN BRANCH FROM BUS 314902 TO BUS 314923 CKT 1 /\*CARSON TO  
 MIDLOTHIAN  
 OPEN BRANCH FROM BUS 314914 TO BUS 314902 CKT 1 /\*CARSON 500.00  
 - 8SEPTA 500.00  
 END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
315065	1CHESTF6	32.84
315131	1EDGECEMA	3.05
315132	1EDGECEMB	3.05
315074	1HOPCGN1	5.66
315075	1HOPCGN2	5.66
315077	1HOPHCF1	1.74
315078	1HOPHCF2	1.74
315079	1HOPHCF3	1.74
315080	1HOPHCF4	2.64
315076	1HOPPOLC	1.24
315073	1STONECA	4.88
314557	3BETHEL C	0.3
314554	3BTLEBRO	0.3
314572	3EMPORIA	0.22
314578	3HORNRTN	1.43
314314	3LOCKS	0.06
314315	3LOCKS E	0.83
314603	3SCOT NK	1.31
314541	3WATKINS	0.27
314620	6CASHIE	0.31
314594	6PLYMOTH	0.3
932591	AC2-079 C	2.7
932592	AC2-079 E	4.41
932631	AC2-084 C	2.64
932632	AC2-084 E	1.3
933991	AD1-022 C	3.17
933992	AD1-022 E	1.72
934011	AD1-025 C O1	9.49
934012	AD1-025 E O1	5.62
934331	AD1-057 C O1	4.21

934332	AD1-057 E O1	2.25
934521	AD1-076 C O1	19.37
934522	AD1-076 E O1	9.86
934571	AD1-082 C O1	5.2
934572	AD1-082 E O1	2.97
935161	AD1-151 C O1	9.07
935162	AD1-151 E O1	6.05
LTF	CARR	0.23
LTF	CBM-S1	3.99
LTF	CBM-S2	8.63
LTF	CBM-W1	7.45
LTF	CBM-W2	20.89
LTF	CIN	1.7
LTF	CPLE	2.76
LTF	G-007	1.04
LTF	IPL	1.08
LTF	LGEE	0.37
LTF	MEC	4.07
LTF	MECS	1.38
LTF	O-066	6.63
LTF	RENSSELAER	0.18
900672	V4-068 E	0.12
LTF	WEC	0.47
907092	X1-038 E	2.34
914231	Y2-077	0.7
916302	Z1-086 E	3.71
917332	Z2-043 E	0.39
917342	Z2-044 E	0.22
917512	Z2-088 E OP1	1.45
918492	AA1-063AE OP	1.7
918512	AA1-065 E OP	1.69
918562	AA1-072 E	0.07
919692	AA2-053 E	1.6
919701	AA2-057 C	2.8
919702	AA2-057 E	1.4
LTF	AA2-074	1.88
920042	AA2-088 E	4.24
920592	AA2-165 E	0.18
920672	AA2-174 E	0.18
930402	AB1-081 E	1.46
930861	AB1-132 C	6.74
930862	AB1-132 E	2.89
931231	AB1-173 C	1.1
931232	AB1-173 E	0.52
931241	AB1-173AC	1.1

931242	AB1-173AE	0.52
923851	AB2-025 C	0.32
923852	AB2-025 E	0.78
923911	AB2-031 C OI	1.1
923912	AB2-031 E OI	0.54
923991	AB2-040 C OI	3.6
923992	AB2-040 E OI	2.94
924151	AB2-059 C OI	4.01
924152	AB2-059 E OI	2.06
924501	AB2-099 C	0.23
924502	AB2-099 E	0.1
924511	AB2-100 C	6.79
924512	AB2-100 E	3.35
924811	AB2-134 C OI	7.23
924812	AB2-134 E OI	7.11
925051	AB2-160 C OI	3.59
925052	AB2-160 E OI	5.86
925061	AB2-161 C OI	2.28
925062	AB2-161 E OI	3.72
925121	AB2-169 C	2.34
925122	AB2-169 E	2.1
925171	AB2-174 C OI	3.52
925172	AB2-174 E OI	3.18
925331	AB2-190 C	11.28
925332	AB2-190 E	4.84
925591	AC1-034 C	2.6
925592	AC1-034 E	1.96
925821	AC1-061	< 0.01
926071	AC1-086 C	9.93
926072	AC1-086 E	4.52
926201	AC1-098 C	2.46
926202	AC1-098 E	1.47
926211	AC1-099 C	0.83
926212	AC1-099 E	0.49
927021	AC1-189 C	3.2
927022	AC1-189 E	1.59
927141	AC1-208 C	3.74
927142	AC1-208 E	1.66
927221	AC1-216 C OI	5.52
927222	AC1-216 E OI	4.34

## Appendix 8

(DVP - DVP) The AB2-100 TAP-6CLUBHSE 230 kV line (from bus 924510 to bus 314563 ckt 1) loads from 101.76% to 114.26% (AC power flow) of its load dump rating (459 MVA) for the line fault with failed breaker contingency outage of 'DVP\_P4-2: 246T247'. This project contributes approximately 68.22 MW to the thermal violation.

CONTINGENCY 'DVP\_P4-2: 246T247' /\* SUFFOLK 230 KV  
 OPEN BRANCH FROM BUS 314537 TO BUS 314575 CKT 1 /\* 6SUFFOLK  
 230.00 - 6NUCO TP 230.00  
 OPEN BRANCH FROM BUS 314569 TO BUS 314575 CKT 1 /\* 6EARLEYS  
 230.00 - 6NUCO TP 230.00  
 OPEN BRANCH FROM BUS 314575 TO BUS 314590 CKT 1 /\* 6NUCO TP  
 230.00 - 6NUCOR 230.00  
 OPEN BUS 314575 /\* ISLAND: 6NUCO TP 230.00  
 OPEN BUS 314590 /\* ISLAND: 6NUCOR 230.00  
 OPEN BRANCH FROM BUS 314537 TO BUS 314648 CKT 1 /\* 6SUFFOLK  
 230.00 - 6SUNBURY 230.00  
 OPEN BRANCH FROM BUS 314648 TO BUS 901080 CKT 1 /\* 6SUNBURY  
 230.00 - W1-029 230.00  
 OPEN BUS 314648 /\* ISLAND: 6SUNBURY 230.00  
 END

<i>Bus Number</i>	<i>Bus Name</i>	<i>Full Contribution</i>
315294	1DOMTR10	1.98
315131	1EDGECEMA	9.02
315132	1EDGECEMB	9.02
315139	1GASTONA	7.4
315141	1GASTONB	7.4
315126	1ROARAP2	1.52
315128	1ROARAP4	1.46
315136	1ROSEMG1	4.97
315138	1ROSEMG2	2.33
315137	1ROSEMS1	3.08
314557	3BETHEL C	0.87
314554	3BTLEBRO	0.84
314566	3CRESWEL	1.63
314578	3HORNRTN	3.35
314603	3SCOT NK	3.54
314541	3WATKINS	0.32
314620	6CASHIE	0.83
314574	6EVERETS	2.43
314594	6PLYMOTH	0.69
932631	AC2-084 C	6.99
932632	AC2-084 E	3.44

933991	ADI-022 C	7.95
933992	ADI-022 E	4.33
934331	ADI-057 C O1	15.88
934332	ADI-057 E O1	8.49
934521	ADI-076 C O1	45.21
934522	ADI-076 E O1	23.02
LTF	CARR	0.09
LTF	CBM-S1	4.49
LTF	CBM-S2	9.26
LTF	CBM-W1	9.8
LTF	CBM-W2	24.09
LTF	CIN	2.19
LTF	CPLE	3.18
LTF	G-007	0.61
LTF	IPL	1.4
LTF	LGEE	0.47
LTF	MEC	4.97
LTF	MECS	2.19
LTF	O-066	3.86
LTF	RENSSELAER	0.08
900672	V4-068 E	0.24
LTF	WEC	0.6
916041	Z1-036 C	2.04
916042	Z1-036 E	13.69
917331	Z2-043 C	0.47
917332	Z2-043 E	1.09
917341	Z2-044 C	0.26
917342	Z2-044 E	0.61
917511	Z2-088 C OP1	0.95
917512	Z2-088 E OP1	4.11
918411	AA1-050	0.8
918491	AA1-063AC OP	1.36
918492	AA1-063AE OP	3.51
918511	AA1-065 C OP	1.98
918512	AA1-065 E OP	5.33
918531	AA1-067 C	0.31
918532	AA1-067 E	0.73
918561	AA1-072 C	0.07
918562	AA1-072 E	0.18
919691	AA2-053 C	1.64
919692	AA2-053 E	3.86
919701	AA2-057 C	7.45
919702	AA2-057 E	3.72
LTF	AA2-074	2.16
920042	AA2-088 E	6.93



920591	AA2-165 C	0.19
920592	AA2-165 E	0.49
920671	AA2-174 C	0.08
920672	AA2-174 E	0.45
920692	AA2-178 E	2.8
930401	AB1-081 C	1.74
930402	AB1-081 E	4.08
930861	AB1-132 C	30.87
930862	AB1-132 E	13.23
924151	AB2-059 C OI	11.21
924152	AB2-059 E OI	5.78
924501	AB2-099 C	0.61
924502	AB2-099 E	0.26
924511	AB2-100 C	42.66
924512	AB2-100 E	21.01
925121	AB2-169 C	5.87
925122	AB2-169 E	5.26
925591	AC1-034 C	7.26
925592	AC1-034 E	5.48
925781	AC1-054 C	3.7
925782	AC1-054 E	1.7
926071	AC1-086 C	45.46
926072	AC1-086 E	20.69
926201	AC1-098 C	6.54
926202	AC1-098 E	3.89
926211	AC1-099 C	2.19
926212	AC1-099 E	1.29
927021	AC1-189 C	8.99
927022	AC1-189 E	4.48
927141	AC1-208 C	9.4
927142	AC1-208 E	4.17