Generation Interconnection
Facility Study Report

For

PJM Generation Interconnection Request
Queue Position AB2-100

Clubhouse – Lakeside 230kV
67 MW Capacity / 100 MW Energy

November / 2018

General

This Facilities Study has been prepared in accordance with the PJM Open Access Transmission Tariff §207, as well as the Facilities Study Agreement between Virginia Electric and Power Company, (Interconnection Customer (IC)) and PJM Interconnection, LLC (Transmission Provider (TP)). IC, has proposed a solar generating facility located near Emporia, VA (Greensville County). The installed facilities will have a total capability of 100 MW with 67 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is 12/01/2021. **This study does not imply an ITO commitment to this in-service date.**

Point of Interconnection

AB2-100 will interconnect with the ITO transmission system via a new three breaker ring bus switching station that connects on the Clubhouse – Lakeview 230kV line.

Cost Summary

The AB2-100 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 548,792
Direct Connection Network Upgrades	$6,027,699
Non Direct Connection Network Upgrades	$1,479,415
Allocation for New System Upgrades	$0
Contribution for Previously Identified Upgrades	$0
Total Costs	**$8,055,906**

A. Transmission Owner Facilities Study Summary

1. Description of Project

Queue AB2-100 is a request to interconnect 100 MW (67 MW of Capacity) of energy from a new solar facility located on Dry Bread Road west of the town of Emporia in Greensville County, Virginia. The proposed generation facility will interconnect with the ITO's Clubhouse – Lakeview 230 kV line via a new three breaker ringbus switching station. The requested in-service date is December 1, 2020. Attachment Facility and Direct Connection Network upgrade construction is estimated to be 8 - 12 months.

2. Amendments to the System Impact Study data or System Impact Study Results

Network Impacts

The Queue Project AB2-100 was evaluated as a 100.0 MW (Capacity 67.0 MW) injection tapping the Clubhouse-Lakeview 230kV line in the ITO area. Project AB2-100 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AB2-100 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2020

Generator Deliverability

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
1	N-1	LN 576	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	98.71	100.12	ER	375	5.27
2	N-1	LN 576	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	98.74	100.15	ER	375	5.27
3	N-1	LN 563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	92.88	94.46	ER	449	7.04

Multiple Facility Contingency

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
4	DCTL	LN 208-259	DVP - DVP	6CHARCTY-6LAKESD 230 kV line	314225	314227	1	AC	93.43	95.14	LD	459	9.31	1
5	LFFB	562T563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	93.18	95.17	LD	549	10.9	2

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)

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Cir.	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution	Ref
6	DCTL	LN 208-259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	104.54	106.26	LD	459	9.31	4
7	N-1	LN 259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	101.33	102.93	ER	375	5.99	
8	DCTL	LN 208-259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	104.57	106.29	LD	459	9.31	5
9	N-1	LN 259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	101.36	102.97	ER	375	5.99	

Affected System Analysis & Mitigation

Duke, Progress & TVA Impacts:

Duke Carolina, Progress, & TVA Impacts to be determined during later study phases (as applicable).

None

Delivery of Energy Portion of Interconnection Request

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 developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

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

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution

#	Contingency Type	Contingency Name	Affected Area	Facility Description	Bus From	Bus To	Circuit	Power Flow	Loading % Initial	Loading % Final	Rating Type	Rating MVA	MW Contribution
10	N-1	LN 259	DVP - DVP	6CHARCTY-6LAKESD 230 kV line	314225	314227	1	AC	88.23	90.24	ER	375	8.94
11	N-1	LN 259	DVP - DVP	6MESSER-6CHARCTY 230 kV line	314228	314225	1	AC	101.82	103.84	ER	375	8.94
12	N-1	LN 259	DVP - DVP	6CHSTF B-6MESSER 230 kV line	314287	314228	1	AC	101.86	103.88	ER	375	8.94
13	N-1	LN 563	DVP - DVP	6CHSTF B-6BASIN 230 kV line	314287	314276	1	AC	102.81	105.16	ER	449	10.51
14	N-1	LN 254_A	DVP - DVP	6LAKEVEW-6CAROLNA 230 kV line	314583	314561	1	AC	92.66	109.29	ER	375	62.17
15	N-1	LN 576	DVP - DVP	8ELMONT-8LDYSMTH 500 kV line	314908	314911	1	AC	109.68	110.64	ER	2442	27.7

New System Reinforcements

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

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB2-100 Allocation
# 1	6MESSER-6CHARCTY 230 kV line	Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020	b2745		
# 2	6CHSTF B-6MESSER 230 kV line				
# 3	6CHARCTY-6LAKESD 230 kV line				

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB2-100 Allocation
# 4, 5	6CHSTF B-6BASIN 230 kV line	ITO currently has a reliability project which will reconductor 0.14 miles Chesterfield – Basin 230kV of 1109 ACAR with a conductor which will increase the line rating to approximately 706 MVA (normal), 706 MVA (emergency), and 812 MVA (load dump). Work has been completed.	b2990		
				Total New Network Upgrades	**$0**

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)

Violation #	Overloaded Facility	Upgrade Description	Network Upgrade Number	Upgrade Cost	AB2-100 Allocation
# 6, 7	6MESSER-6CHARCTY 230 kV line	Rebuild 21.32 miles of the Chesterfield - Lakeside 230kV transmission line by 6/1/2020	b2745		
# 8, 9	6CHSTF B-6MESSER 230 kV line				
				Total New Network Upgrades	**$0**

3. Interconnection Customer's Submitted Milestone Schedule

Interconnection Customer has requested the following milestones:

- Plan to break ground February 1, 2021
- Permits – state level CPCN and county level Final Site Plan approval complete by February 1, 2021
- Substantial site work completed July 15, 2021
- Delivery of major electrical equipment August 15, 2021
- Back Feed Power early to October 15, 2021
- Commercial Operation December 1, 2021

4. Scope of Customer's Work

IC will build a solar generating facility in Greensville County, Virginia. The generating facility will be comprised of 100MW's of solar arrays. AB2-100 consists of 42 x 2.5 MW TMEIC PHV-L2500GR inverters and 42 x 34.5/0.6 grounded wye delta 2.5 MVA generator step up (GSU) transformers. The generating facility will connect to the Point of Interconnection (POI) on the through two 230/34.5 kV grounded wye grounded wye main power transformer with a rating of 42/56/70 MVA. The AB2-100 POI will be at a new Interconnection switching station on the ITO's Clubhouse – Lakeview 230 kV line.

5. Description of Facilities Included in the Facilities Study

The ITO will connect the proposed generator lead via Attachment Facilities to a new AB2-100 230 kV switching station. The position of the switching station will be adjacent to the right of way of the existing 230 kV Transmission Line #254, on a property provided by the IC. The station will be positioned in such a way that the new backbone will align with the line near structure 254/13. The cut lines will be attached to the new backbone and risers will be dropped from both sides of the backbone to the bus sections directly underneath the line. The lines will consume two of the three positions in the ring bus. The third position will be for the 230 kV feed from the collector station for the solar farm. The demarcation point between the switching station and the collector station will be the 4-hole pads on the ITO disconnect switch. Metering equipment will be installed in the ITO Switching Station. The ground grid for two stations will be tied together. The IC will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the IC.

Remote relay work will be required at Lakeview and Clubhouse Substations.

6. Total Costs of Transmission Owner Facilities included in Facilities Study

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Substation	$280,592	$195,633	$51,327	$21,240	$548,792
Total Attachment Facilities Cost	$280,592	$195,633	$51,327	$21,240	$548,792
Queue AB2-100 switching station (n5803)	$2,416,432	$2,853,094	$419,811	$338,362	$6,027,699
Transmission line relocation (n5804)	$527,797	$609,691	$84,156	$69,211	$1,290,855

Remote relay (n5805)	$117,232	$41,192	$24,095	$6,041	$188,560
Total Network Upgrades	$3,061,461	$3,503,977	$528,062	$413,614	$7,507,114
Total Project Costs	$3,342,053	$3,699,610	$579,389	$434,854	$8,055,906

7. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:

The total project timeline is 14 - 24 months from ISA execution and assumes that no SCC permit will be required. If a SCC permit is required the timeline for permitting will need to change to 12 - 18 months but in the past the ITO has not been required to get a CPCN if we build adjacent to our existing right of way and do not require new right of way for the build. The project currently meets those criteria but we would still need to get a final buy off from the SCC.

Best case would be:

- Detailed design: 6 - 12 months
- Permitting: 6 - 12 months no SCC permit (Timeline runs concurrent with design)
- Construction 8 - 12 months

B. Transmission Owner Facilities Study Results

1. Attachment Facilities

The ITO will connect the proposed generator lead via Attachment Facilities to a new AB2-100 230 kV switching station. The Attachment Facilities include the portion of the interconnecting switching station which is associated solely with the single feed to the generating facilities collector station. The equipment associated with the Attachment Facilities include the metering accuracy CCVT's, metering accuracy CT's, disconnect switch, conductors and connectors.

Purchase and install at AB2-100 Substation:

1. One (1), 230kV, 3000A, 3-phase Center Break Gang Operated Switches
2. Three (3), 230kV metering accuracy CCVT's
3. Three (3), 230kV metering accuracy CT's
4. Conductors, connectors, conduits, control cables, foundations, steel structures and grounding material

Purchase and install relay material:

1. One (1), 1109 – 28" Dual SEL-587Z Transmission Bus Panel
2. One (1), 4200 – Bus Differential C.T. M.U. Box
3. One (1), 1425 – 28" Dual SEL-735 Metering Panel (Transmission & Generation Interconnect)
4. One (1), 4524 – Revenue Metering C.T. M.U. Box
5. One (1), 4531 – Generator Interconnect CCVT Potential M.U. Box
6. One (1), 1323 – 28" SEL-487E/735 PMU & PQ Monitoring Panel
7. One (1), 4541 - Control Cable M.U. Box

2. Transmission Line – Upgrades

PJM Network Upgrade #n5804 – Re-arrange Clubhouse – Lakeview 230 kV line #254 to loop into and out of the new three (3) breaker AB2-100 Switching station near structure 254/13.

The station will be positioned in such a way that the new backbone will align with the line near structure 254/13. The cut lines will be attached to the new backbone and risers will be dropped from both sides of the backbone to the bus sections directly underneath the line. The line connection will require the installation of (1) backbone structure, two (2) static pole structures, and the addition of seven (7) guy wires on an existing deadend structure, and 1.44 miles of new Fiber. The conceptual design and estimate includes costs for the following:

Estimate – Facilities to be Installed:

1. Install one (1) 230kV SC Light Duty Steel DDE Backbone structure (no switches) with a foundation at Structure 254/13.
2. Install two (2) Galvanized Steel Static Poles with foundations (Strs. 254/13A and 254/13B).
3. Install seven (7) single guy wire assemblies and associated anchors at existing Structure 254/12.
4. Cut and transfer 3-Phase 795 ACSR conductor to the new backbone structure (one span will run from Ex. Str. number 254/12 – 254/13, the other span will run from Str. 254/13 – 254/14).
5. Cut and transfer existing fiber from existing Structure 14 to new Backbone 254/13.
6. Cut and transfer existing 3#6 AW to the new backbone structure.
7. Install 1.44 miles of new OPGW from Existing Structure 254/1A to new Structure 254/13.
    a. Train OPGW down backbone Str. 254/13 and coil at bottom of structure.
8. Install approximately 0.14 miles of 1-7#7 static wire from the new Backbone Structures to the new Static poles.

Estimate – Facilities to be Removed:

1. Remove approximately 1.44 miles of existing OPGW from Str. 254/1A to Str 254/13.
2. Remove existing tangent wood H-Frame Structure at existing structure 254/13.

3. New Substation/Switchyard Facilities

Direct Connection Network Upgrades:

PJM Network Upgrade #n5803 - Build a three (3) breaker AB2-100 230 kV switching station. The site is located adjacent to the ITO's existing right of way for the Clubhouse – Lakeview 230 kV line #254.

A new AB2-100 230kV switching station will be adjacent to the right of way of the existing 230 kV Transmission Line #254, on a property provided by the IC. The station will be positioned between the near existing 254/13 structure. The cut lines will consume two of the three positions in the ring bus. The third position will be for the 230 kV feed from the collector station for the solar farm. The collector substation and ITO switching station will share a common fence. The demarcation point between the switching station and the collector station will be the 4-hole pads

on the ITO disconnect switch. The developer will bring its bus to the demarcation point over the common fence. Metering equipment will be installed in the ITO Switching Station. The grounding systems for both stations will be tied together. The IC will provide the property and access to the switching station. All substation permitting, site preparation and grading activity will be performed by the IC.

Purchase and install substation material (Direct Network Upgrade):

1. Approximately 310' X 285' site preparation and grading as required for installation of the switching station (by the developer)
2. Approximately 1150 linear FT of 5/8" Chain Link, 12 FT tall, perimeter fence around the station along with the security cameras and integrators as per Design 4 fence standards
3. Full substation ground grid as per engineering standards
4. One (1) 230 kV, Heavy Duty Steel Backbone (by Transmission)
5. Two (2) shield wire poles and three span of shield wires (by Transmission)
6. Three (3) 230 kV, 3000A, 50 kA SF6 Circuit Breakers
7. Six (6) 230 kV, 3000A, 3-phase Center Break Gang Operated Switches
8. Nine (9) 180 kV, Station Class Arresters
9. Six (6) 230 kV CCVTs, Relay Accuracy
10. One (1), 230 kV, 3000 Amps Wave Trap and Line Tuner
11. One (1) 24' X 40' Control Enclosure
12. One (1) 125 VDC, 200 Ah Station Battery and 50 Amp Charger (size to be verified during detail engineering)
13. Approximately 240 FT of Cable Trough, with a 20 FT road crossing section
14. Four (4) 100 KVA Power Potential Transformers for station service
15. Oil Containment system for the 230 kV PVTs.
16. Two (2) 230 kV, 3000A, 2-phase Center Break Gang Operated Switches
17. Two (2), 2" conduits from the substation backbone to the cable trough
18. Conduit Tracer Wire, 1/C #10, Green
19. 1-1/4" Orange Polyethylene conduits for fiber in the cable trough
20. Steel structures as required including switch stands, bus supports, station service transformers, CCVT and wave trap supports
21. Foundations as required including control house, equipment and bus support stands
22. Conductors, connectors, conduits, control cables, cable trough, and grounding materials

Purchase and install relay material (Direct Network Upgrade):

1. Three (3), 1510 – 28" Dual SEL-351-7 Transmission Breaker w/ Reclosing Panel
2. Three (3), 4510 - SEL-2411 Breaker Annunciator
3. One (1), 1320 – 28" Dual SEL-421-5 DCB Line Panel
4. One (1), 1809 – 28" Dual SEL-311L Line Diff. w/ Reclosing Panel
5. Two (2), 4506 – 3 Phase CCVT Potential M.U. Box
6. One (1), 1603 – 28" SEL-451 Islanding Control Scheme Panel
7. Two (2), 4000 – Station Service Potential M.U. Box
8. Two (2), 4018 – 500A Station Service AC Distribution Panel
9. Two (2), 4007 – 225A Outdoor Transmission Yard AC NQOD
10. Two (2), 4019 – 225A Three Phase Throwover Switch
11. Two (2), 4016 – 600A PVT Disconnect Switch

12. One (1), 4153 – Wall Mount Station Battery Monitor
13. One (1), 5612 - SEL-3530 Data Concentrator Panel
14. One (1), 1255 – Station Annunciator Panel
15. One (1), 5021 – SEL-2411 RTU Panel
16. One (1), 5609 – Fiber Optic Management Panel
17. Three (3), 4526_A – Circuit Breaker Fiber Optic M.U. Box
18. One (1), 5202 – 26" APP 601 Digital Fault Recorder
19. One (1), 5603 – Station Network Panel 1
20. One (1), 5603 – Station Network Panel 2
21. One (1), 5616 – Station Security Panel

4. Upgrades to Substation / Switchyard Facilities

PJM Network Upgrade #n5803 - Remote protection and communication work. ITO protection requirements to reliably interconnect the proposed generating facility with the transmission system determined that work is required at Clubhouse and Lakeview Substations.

Clubhouse 230kV Substation

Project Summary - provides for the drawing work, relay resets, and field support necessary to change the Line 254 number & destination from Lakeview Substation to the new AB2-100 switching station. Also, replace existing Line 254 Relay Protection with Line Differential Protection utilizing Fiber Optics due to the shortening of the line, install Line 254 Islanding Transfer Trip scheme to now work with the new AB2-100 switching station, remove the Line 254 Wave Trap due to the Powerline Carrier function now being performed over fiber optics, and install Network Panel No. 2 for Fiber Patch Panel. OPGW will need to be routed inside the control enclosure.

Purchase and install substation material at Clubhouse Substation:

1. Two (2), 2" conduits from the substation backbone to the cable trough
2. Conduit Tracer Wire, 1/C #10, Green
3. 1-1/4" Orange Polyethylene conduits for fiber in the cable trough
4. Remove- Wave Trap on the line 254

Purchase and install relay material at Clubhouse Substation:

1. One (1), 1809 – 28" Dual SEL-311L Line Diff. w/ Reclosing Panel
2. One (1), SEL-2411
3. One (1), 5603 – Station Network Panel No. 2
4. One (1), Panel Retirement (Panel 2)

Lakeview 230kV Substation

Project Summary - provides for the drawing work, relay resets, and field support necessary to change the Line 254 destination from Clubhouse Substation to the new AB2-100 switching station. Install Line 254 Islanding Transfer Trip scheme to work with the new AB2-100 switching station.

Purchase and install relay material:

1. One (1), CT-51C Islanding Transfer Trip Set
2. One (1), SEL-2411 Maintenance Switch

Work Description	Direct		Indirect		Total Cost
	Labor	Material	Labor	Material	
Clubhouse	$90,103	$26,896	$17,896	$3,966	$138,861
Lakeview	$27,129	$14,296	$6,199	$2,075	$49,699
Total Remote Relay Upgrades	$117,232	$41,192	$24,095	$6,041	$188,560

5. Metering & Communications

PJM Requirements

The IC 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.

Meteorological Data Reporting Requirement

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

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

ITO Requirements

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

At the IC's expense, the ITO will supply and own at the Point of Interconnection bi-directional revenue metering equipment that will provide the following data:

a. Hourly compensated MWh received from the Customer Facility to the ITO;
b. Hourly compensated MVARh received from the Customer Facility to the ITO;
c. Hourly compensated MWh delivered from the ITO to the Customer Facility; and
d. Hourly compensated MVARh delivered from the ITO to the Customer Facility.

The IC will supply and own metering equipment that will provide Instantaneous net MW and MVar per unit values in accordance with PJM Manuals M-01 and M-14D, and Sections 8.1 through 8.5 of Appendix 2 to the ISA;

The IC will access revenue meter via wireless transceivers or fiber cabling to meter with RS-485 or Ethernet communication port for dial-up reads. IC must provide revenue and real time data to PJM from Interconnection Customer Market Operations Center per "PJM Telemetry Data Exchange Summary" document available at PJM.com.

6. Environmental, Real Estate and Permitting Issues

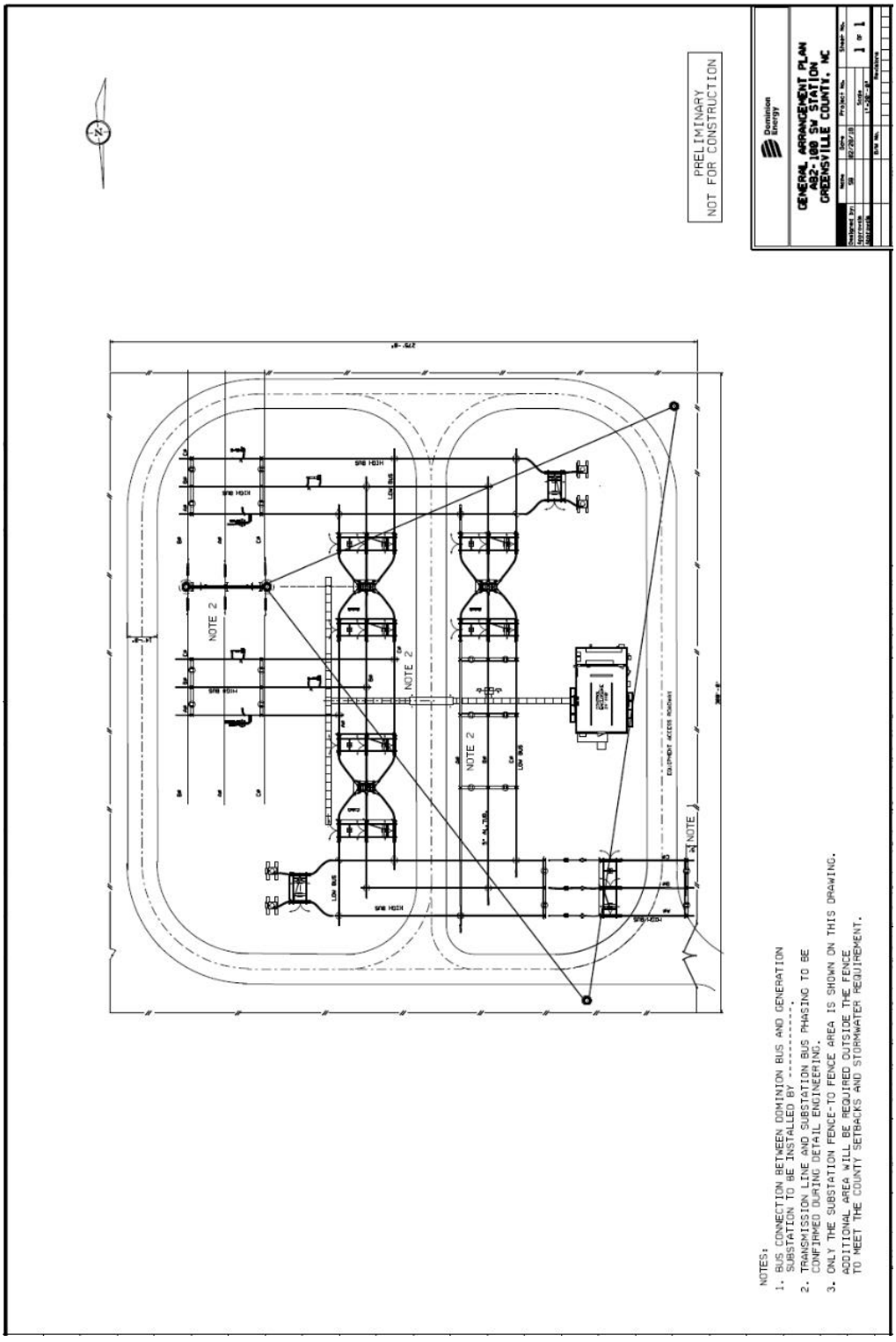
The IC would be responsible for the following expectations in the area of Environmental, Real Estate and Permitting:

- Suitable Access Road from Substation to a North Carolina Maintained Roadway.
- Any additional land needed for Storm Water Management, Landscaping, and Wetlands/Wetlands Mitigation.
- Conditional Use Permit for Substation.
- Any other Land/Permitting requirements required by the Substation.

ITO Real Estate Needs:

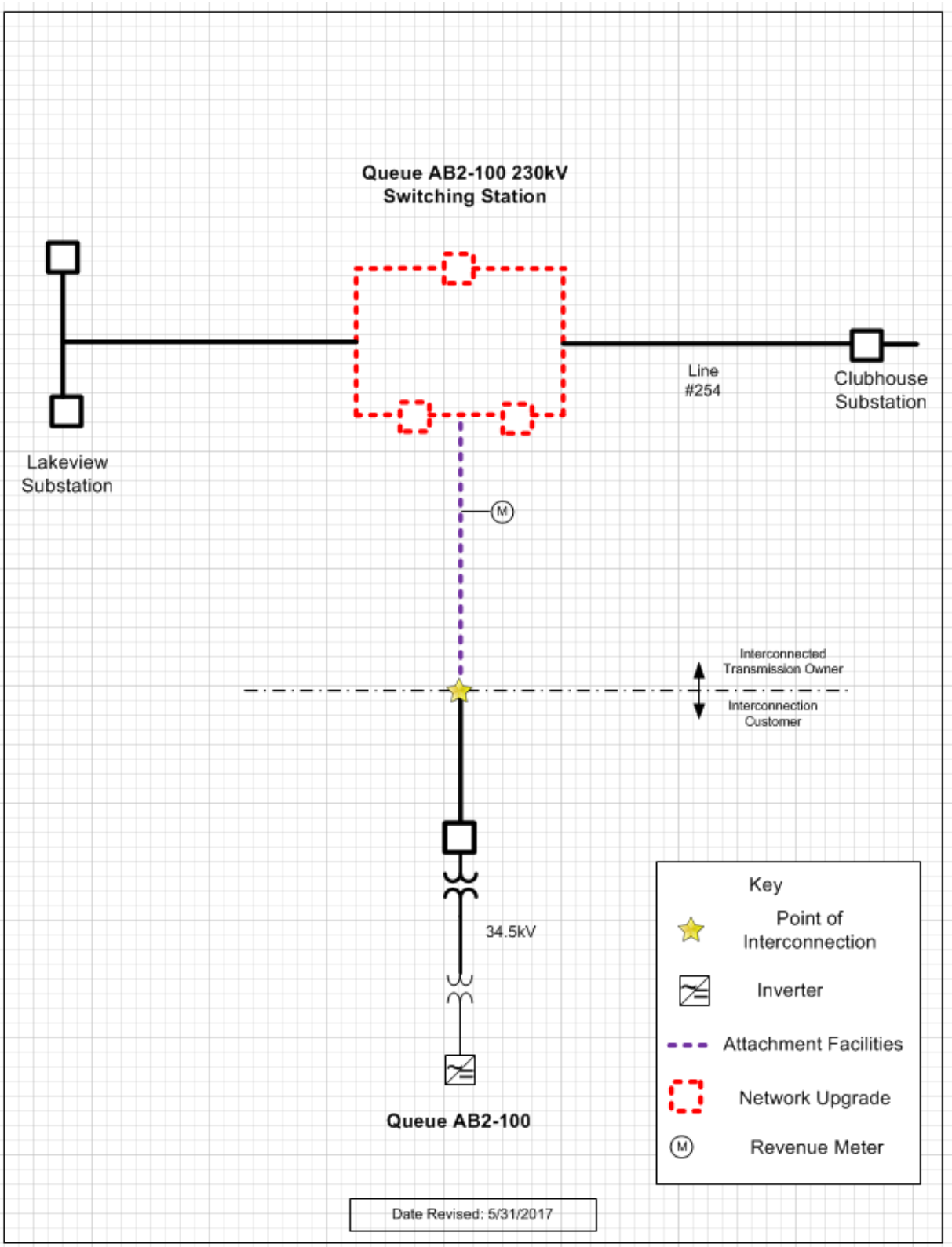
- The substation layout is complete and ITO requires a 300'x 275' piece of property (title in fee) to build the substation. The property includes the piece of property between the substation and collector station for the strain bus.
    - ITO requires ownership transfer of the substation site before they start construction. Target for the deed by October 1, 2020.
    - The size of the station assumes ITO will not need a separate storm water management system for the substation. If the county rules differently than the ITO will need to revisit the land requirements.
- ITO will need a letter similar to the zoning letter from the county stating that if the solar farm is retired and / or decommissioned the substation will remain.

Attachment 1.
AB2-100 Switching Station



Attachment 2.
Switching Station Plan View

Attachment 3.
Single Line



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. Although this information is not used "as is" for cost allocation purposes, it can be used to gage other generators impact.

It should be noted the generator contributions presented in the appendices sections are full contributions, whereas in the body of the report, those contributions take into consideration the commercial probability of each project.

Appendix 1

(DVP - DVP) The 6CHARCTY-6LAKESD 230 kV line (from bus 314225 to bus 314227 ckt 1) loads from 93.43% to 95.14% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 9.31 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
OPEN BUS 314309 /* ISLAND
OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
END

Bus Number	Bus Name	Full Contribution
315065	1CHESTF6	39.25
315077	1HOPHCF1	2.28
315078	1HOPHCF2	2.28
315079	1HOPHCF3	2.28
315080	1HOPHCF4	3.46
315076	1HOPPOLC	1.95
315073	1STONECA	5.71
314784	1WEYRHSB	0.65
314314	3LOCKS	1.06
314539	3UNCAMP	0.81
314541	3WATKINS	0.23
314229	6MT R221	-0.33
315074	CIR_AB2-152	0.59
315075	CIR_AB2-152	-0.26
292791	U1-032 E	2.97
900672	V4-068 E	0.1
901082	W1-029E	13.17
907092	X1-038 E	2.02
914231	Y2-077	0.92
916042	Z1-036 E	13.31
917332	Z2-043 E	0.34
917342	Z2-044 E	0.18
921163	AA1-063AE	1.48
918512	AA1-065 E OP	1.46
918562	AA1-072 E	0.06
921752	AA2-053 C	3.22

921753	AA2-053 E	1.38
921762	AA2-057 C	2.33
921763	AA2-057 E	1.16
921982	AA2-088 C	2.25
921983	AA2-088 E	3.67
922442	AA2-165 C	0.32
922443	AA2-165 E	0.15
922512	AA2-174 C	0.15
922513	AA2-174 E	0.16
922532	AA2-178 C	2.91
922533	AA2-178 E	1.25
923262	AB1-132 C OP	5.95
923263	AB1-132 E OP	2.55
923572	AB1-173 C OP	0.98
923573	AB1-173 E OP	0.46
923582	AB1-173AC OP	0.98
923583	AB1-173AE OP	0.46
923801	AB2-015 C OP	2.9
923802	AB2-015 E OP	2.38
923851	AB2-025 C	1.64
923852	AB2-025 E	0.74
923911	AB2-031 C OP	0.98
923912	AB2-031 E OP	0.48
923991	AB2-040 C OP	3.2
923992	AB2-040 E OP	2.62
924071	AB2-051 C OP	38.5
924501	AB2-099 C	0.2
924502	AB2-099 E	0.09
924511	AB2-100 C	6.24
924512	AB2-100 E	3.07
924811	AB2-134 C OP	8.22
924812	AB2-134 E OP	8.09
925051	AB2-160 C OP	4.25
925052	AB2-160 E OP	6.93
925061	AB2-161 C OP	3.11
925062	AB2-161 E OP	5.07
925122	AB2-169 E	1.77
925171	AB2-174 C OP	3.17
925172	AB2-174 E OP	2.87
925281	AB2-186 C	0.18
925282	AB2-186 E	0.08
925291	AB2-188 C OP	0.72
925292	AB2-188 E OP	0.32
925331	AB2-190 C	12.25
925332	AB2-190 E	5.25

Appendix 2

(DVP - DVP) The 6CHSTF B-6BASIN 230 kV line (from bus 314287 to bus 314276 ckt 1) loads from 93.18% to 95.17% (AC power flow) of its load dump rating (549 MVA) for the line fault with failed breaker contingency outage of '562T563'. This project contributes approximately 10.9 MW to the thermal violation.

```
CONTINGENCY '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
```

Bus Number	Bus Name	Full Contribution
315065	1CHESTF6	39.53
315077	1HOPHCF1	2.1
315078	1HOPHCF2	2.1
315079	1HOPHCF3	2.1
315080	1HOPHCF4	3.19
315076	1HOPPOLC	1.8
315073	1STONECA	5.27
314784	1WEYRHSB	0.8
314314	3LOCKS	0.99
314539	3UNCAMP	0.96
314541	3WATKINS	0.28
315074	CIR_AB2-152	0.55
315075	CIR_AB2-152	-0.24
292791	U1-032 E	2.74
900672	V4-068 E	0.13
901082	W1-029E	15.55
907092	X1-038 E	2.4
913392	Y1-086 E	0.73
914231	Y2-077	0.85
916042	Z1-036 E	15.87
916192	Z1-068 E	0.6
916302	Z1-086 E	3.97
917122	Z2-027 E	0.35
917332	Z2-043 E	0.42
917342	Z2-044 E	0.24
917512	Z2-088 E OP1	3.16
921163	AA1-063AE	1.8
918512	AA1-065 E OP	1.79
921183	AA1-067 E	0.28

918562	AA1-072 E	0.07
921752	AA2-053 C	3.95
921753	AA2-053 E	1.7
921762	AA2-057 C	2.99
921763	AA2-057 E	1.5
921982	AA2-088 C	2.7
921983	AA2-088 E	4.41
922442	AA2-165 C	0.41
922443	AA2-165 E	0.2
922512	AA2-174 C	0.18
922513	AA2-174 E	0.2
922532	AA2-178 C	3.52
922533	AA2-178 E	1.51
922922	AB1-081 C OP	3.62
922923	AB1-081 E OP	1.55
923262	AB1-132 C OP	7.21
923263	AB1-132 E OP	3.09
923572	AB1-173 C OP	1.18
923573	AB1-173 E OP	0.55
923582	AB1-173AC OP	1.18
923583	AB1-173AE OP	0.55
923801	AB2-015 C OP	3.45
923802	AB2-015 E OP	2.83
923831	AB2-022 C	0.76
923832	AB2-022 E	0.41
923851	AB2-025 C	1.87
923852	AB2-025 E	0.84
923911	AB2-031 C OP	1.17
923912	AB2-031 E OP	0.58
923941	AB2-035 C	0.14
923942	AB2-035 E	0.06
923991	AB2-040 C OP	3.85
923992	AB2-040 E OP	3.15
924071	AB2-051 C OP	43.82
924151	AB2-059 C	4.27
924152	AB2-059 E	2.2
924391	AB2-088 C	0.17
924392	AB2-088 E	0.08
924401	AB2-089 C	0.8
924402	AB2-089 E	0.41
924491	AB2-098 C	0.22
924492	AB2-098 E	0.09
924501	AB2-099 C	0.24
924502	AB2-099 E	0.1
924511	AB2-100 C	7.3

924512	AB2-100 E	3.6
924811	AB2-134 C OP	7.78
924812	AB2-134 E OP	7.65
925051	AB2-160 C OP	3.95
925052	AB2-160 E OP	6.45
925061	AB2-161 C OP	3.17
925062	AB2-161 E OP	5.17
925122	AB2-169 E	2.23
925171	AB2-174 C OP	3.8
925172	AB2-174 E OP	3.44
925281	AB2-186 C	0.21
925282	AB2-186 E	0.09
925291	AB2-188 C OP	0.87
925292	AB2-188 E OP	0.39
925331	AB2-190 C	11.64
925332	AB2-190 E	4.99

Appendix 4

(DVP - DVP) The 6MESSER-6CHARCTY 230 kV line (from bus 314228 to bus 314225 ckt 1) loads from 104.54% to 106.26% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 9.31 MW to the thermal violation.

CONTINGENCY 'LN 208-259'
OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1 /* 6CHSTF A 230.00 - 6IRON208 230.00
OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1 /* 6IRON208 230.00 - 6SOUWEST 230.00
OPEN BUS 314309 /* ISLAND
OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1 /* 6BASIN 230.00 - 6CHSTF B 230.00
END

Bus Number	Bus Name	Full Contribution
315065	1CHESTF6	39.25
315077	1HOPHCF1	2.28
315078	1HOPHCF2	2.28
315079	1HOPHCF3	2.28
315080	1HOPHCF4	3.46
315076	1HOPPOLC	1.95
315073	1STONECA	5.71
314784	1WEYRHSB	0.65
314314	3LOCKS	1.06
314539	3UNCAMP	0.81
314541	3WATKINS	0.23
314229	6MT R221	-0.33
315074	CIR_AB2-152	0.59
315075	CIR_AB2-152	-0.26
292791	U1-032 E	2.97
900672	V4-068 E	0.1
901082	W1-029E	13.17
907092	X1-038 E	2.02
914231	Y2-077	0.92
916042	Z1-036 E	13.31
917332	Z2-043 E	0.34
917342	Z2-044 E	0.18
921163	AA1-063AE	1.48
918512	AA1-065 E OP	1.46
918562	AA1-072 E	0.06
921752	AA2-053 C	3.22

921753	AA2-053 E	1.38
921762	AA2-057 C	2.33
921763	AA2-057 E	1.16
921982	AA2-088 C	2.25
921983	AA2-088 E	3.67
922442	AA2-165 C	0.32
922443	AA2-165 E	0.15
922512	AA2-174 C	0.15
922513	AA2-174 E	0.16
922532	AA2-178 C	2.91
922533	AA2-178 E	1.25
923262	AB1-132 C OP	5.95
923263	AB1-132 E OP	2.55
923572	AB1-173 C OP	0.98
923573	AB1-173 E OP	0.46
923582	AB1-173AC OP	0.98
923583	AB1-173AE OP	0.46
923801	AB2-015 C OP	2.9
923802	AB2-015 E OP	2.38
923851	AB2-025 C	1.64
923852	AB2-025 E	0.74
923911	AB2-031 C OP	0.98
923912	AB2-031 E OP	0.48
923991	AB2-040 C OP	3.2
923992	AB2-040 E OP	2.62
924071	AB2-051 C OP	38.5
924501	AB2-099 C	0.2
924502	AB2-099 E	0.09
924511	AB2-100 C	6.24
924512	AB2-100 E	3.07
924811	AB2-134 C OP	8.22
924812	AB2-134 E OP	8.09
925051	AB2-160 C OP	4.25
925052	AB2-160 E OP	6.93
925061	AB2-161 C OP	3.11
925062	AB2-161 E OP	5.07
925122	AB2-169 E	1.77
925171	AB2-174 C OP	3.17
925172	AB2-174 E OP	2.87
925281	AB2-186 C	0.18
925282	AB2-186 E	0.08
925291	AB2-188 C OP	0.72
925292	AB2-188 E OP	0.32
925331	AB2-190 C	12.25
925332	AB2-190 E	5.25

Appendix 5

(DVP - DVP) The 6CHSTF B-6MESSER 230 kV line (from bus 314287 to bus 314228 ckt 1) loads from 104.57% to 106.29% (AC power flow) of its load dump rating (459 MVA) for the tower line contingency outage of 'LN 208-259'. This project contributes approximately 9.31 MW to the thermal violation.

```
CONTINGENCY 'LN 208-259'
  OPEN BRANCH FROM BUS 314286 TO BUS 314309 CKT 1              /* 6CHSTF A
230.00 - 6IRON208 230.00
  OPEN BRANCH FROM BUS 314309 TO BUS 314338 CKT 1              /* 6IRON208
230.00 - 6SOUWEST 230.00
  OPEN BUS 314309                                  /* ISLAND
  OPEN BRANCH FROM BUS 314276 TO BUS 314287 CKT 1              /* 6BASIN 230.00 -
6CHSTF B 230.00
  END
```

Bus Number	Bus Name	Full Contribution
315065	1CHESTF6	39.25
315077	1HOPHCF1	2.28
315078	1HOPHCF2	2.28
315079	1HOPHCF3	2.28
315080	1HOPHCF4	3.46
315076	1HOPPOLC	1.95
315073	1STONECA	5.71
314784	1WEYRHSB	0.65
314314	3LOCKS	1.06
314539	3UNCAMP	0.81
314541	3WATKINS	0.23
314229	6MT R221	-0.33
315074	CIR_AB2-152	0.59
315075	CIR_AB2-152	-0.26
292791	U1-032 E	2.97
900672	V4-068 E	0.1
901082	W1-029E	13.17
907092	X1-038 E	2.02
914231	Y2-077	0.92
916042	Z1-036 E	13.31
917332	Z2-043 E	0.34
917342	Z2-044 E	0.18
921163	AA1-063AE	1.48
918512	AA1-065 E OP	1.46
918562	AA1-072 E	0.06
921752	AA2-053 C	3.22

921753	AA2-053 E	1.38
921762	AA2-057 C	2.33
921763	AA2-057 E	1.16
921982	AA2-088 C	2.25
921983	AA2-088 E	3.67
922442	AA2-165 C	0.32
922443	AA2-165 E	0.15
922512	AA2-174 C	0.15
922513	AA2-174 E	0.16
922532	AA2-178 C	2.91
922533	AA2-178 E	1.25
923262	AB1-132 C OP	5.95
923263	AB1-132 E OP	2.55
923572	AB1-173 C OP	0.98
923573	AB1-173 E OP	0.46
923582	AB1-173AC OP	0.98
923583	AB1-173AE OP	0.46
923801	AB2-015 C OP	2.9
923802	AB2-015 E OP	2.38
923851	AB2-025 C	1.64
923852	AB2-025 E	0.74
923911	AB2-031 C OP	0.98
923912	AB2-031 E OP	0.48
923991	AB2-040 C OP	3.2
923992	AB2-040 E OP	2.62
924071	AB2-051 C OP	38.5
924501	AB2-099 C	0.2
924502	AB2-099 E	0.09
924511	AB2-100 C	6.24
924512	AB2-100 E	3.07
924811	AB2-134 C OP	8.22
924812	AB2-134 E OP	8.09
925051	AB2-160 C OP	4.25
925052	AB2-160 E OP	6.93
925061	AB2-161 C OP	3.11
925062	AB2-161 E OP	5.07
925122	AB2-169 E	1.77
925171	AB2-174 C OP	3.17
925172	AB2-174 E OP	2.87
925281	AB2-186 C	0.18
925282	AB2-186 E	0.08
925291	AB2-188 C OP	0.72
925292	AB2-188 E OP	0.32
925331	AB2-190 C	12.25
925332	AB2-190 E	5.25