



Transmission Expansion Advisory Committee

Reliability Analysis Update

November 5, 2015

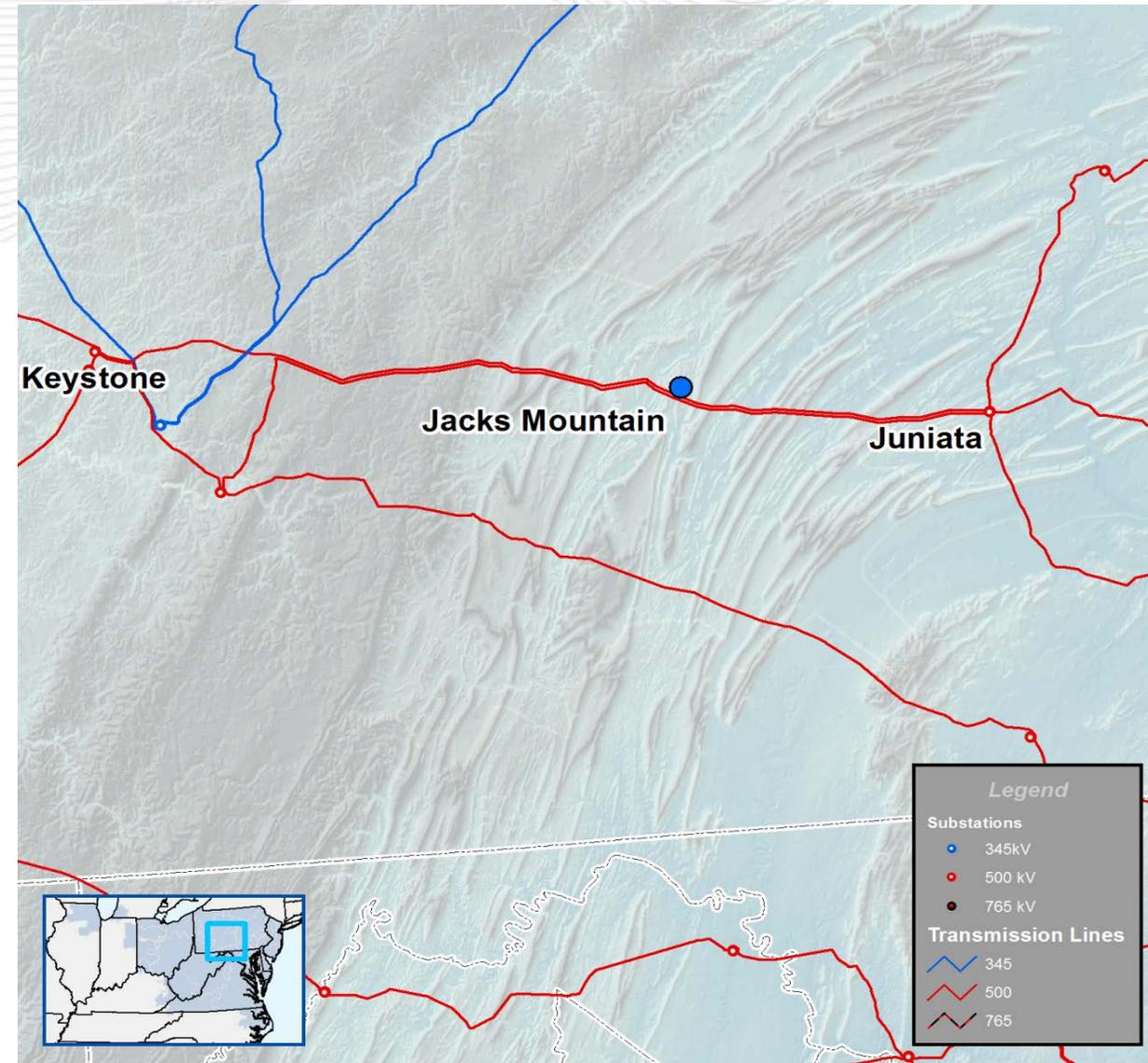
Reliability Analysis Update



PenElec Transmission Zone

- Update:
 - The Jacks Mountain facility was not included in the 2015 RTEP as a sensitivity to determine the continued need for this facility.
- Result:
 - The latest analysis shows, there are no RTEP violations or drivers that would require the Jacks Mt. upgrade.
- Recommendation:
 - Cancel the Jacks Mt. and related upgrades. The upgrades are no longer required.

Upgrade ID	Description	Transmission Owner
b0284.1	Build Jack's Mountain 500kV substation - Tap the Keystone - Juniata and Conemaugh - Juniata 500kV, connect the circuits with a breaker and half scheme, and install new 400 MVAR capacitor	PENELEC
b0284.3	Replace wave trap and upgrade a bus section at Keystone 500kV - on the Keystone - New Jack's Mountain 500kV sub	PENELEC
b0284.4	Changes at Juniata 500 kV substation	PPL
b0285.1	Replace wave trap at Keystone 500kV - on the Keystone - Conemaugh 500kV	PENELEC
b0285.2	Replace wave trap and relay at Conemaugh 500kV - on the Conemaugh - Keystone 500kV	PENELEC
b0369	Install 100 MVAR Fast Switched Capacitor Banks at Jack's Mountain 500kV substation	PENELEC
b0370	Install 500 MVAR Fast Switched CApacitor Banks at Jack's Mountain 500kV substation	PENELEC

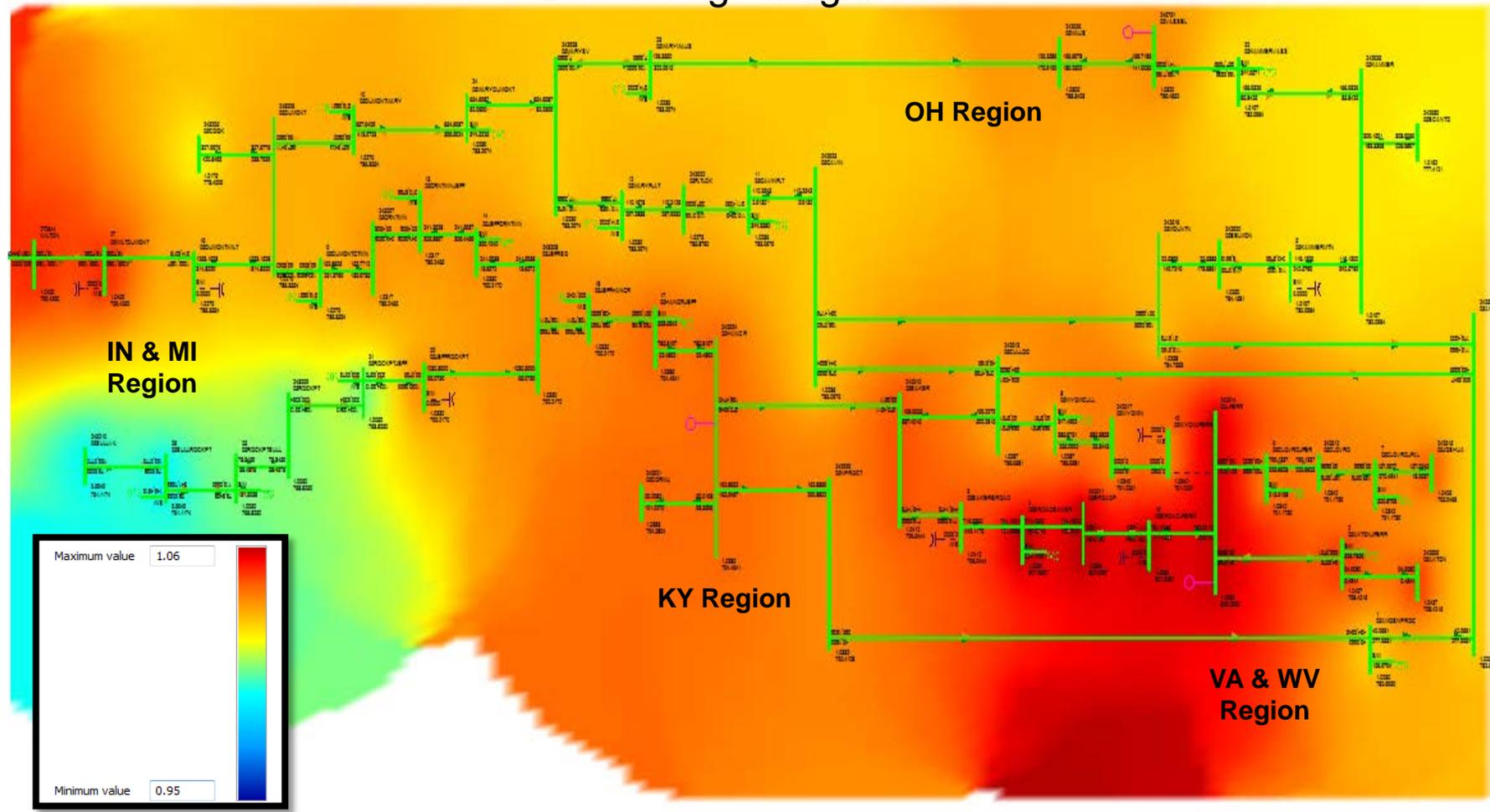


High Voltage in PJM Operations

- In PJM Operations, the AEP transmission zone and northeastern Mid-Atlantic regions have experienced a large increase in high voltage warnings over the past year; Additionally, AEP has also experienced a large increase in reactor switching for both low and high voltage conditions
- There are several drivers that include changes in dispatch due to new and deactivated generation, reactive support deficiencies and increased line charging from new transmission facilities
- Conditions generally occur during light load periods
- Approved RTEP reactive devices planned to come online over the next several years will help lower the voltages to some extent, but anticipated generation deactivations and additional line charging from planned transmission facilities will further aggravate the problem

- Large increase in number high voltage alarms over the past year
- Operating conditions have required 765 kV circuits to be taken out of service to manage high voltages
- Over 5,000 MW of deactivations in 2015
 - Large reduction in dynamic reactive support
- Large increase in amount of switching of existing reactors for both high and low voltage conditions resulting in multiple failed reactors and reduced life expectancy.
- Simulations demonstrate a potential solution of new SVCs and replenishment of the existing reactors and inclusion of circuit breakers for enhanced switching capability. The first component of this solution has been identified and will be proposed as an immediate need solution.

Bus Voltage Magnitude

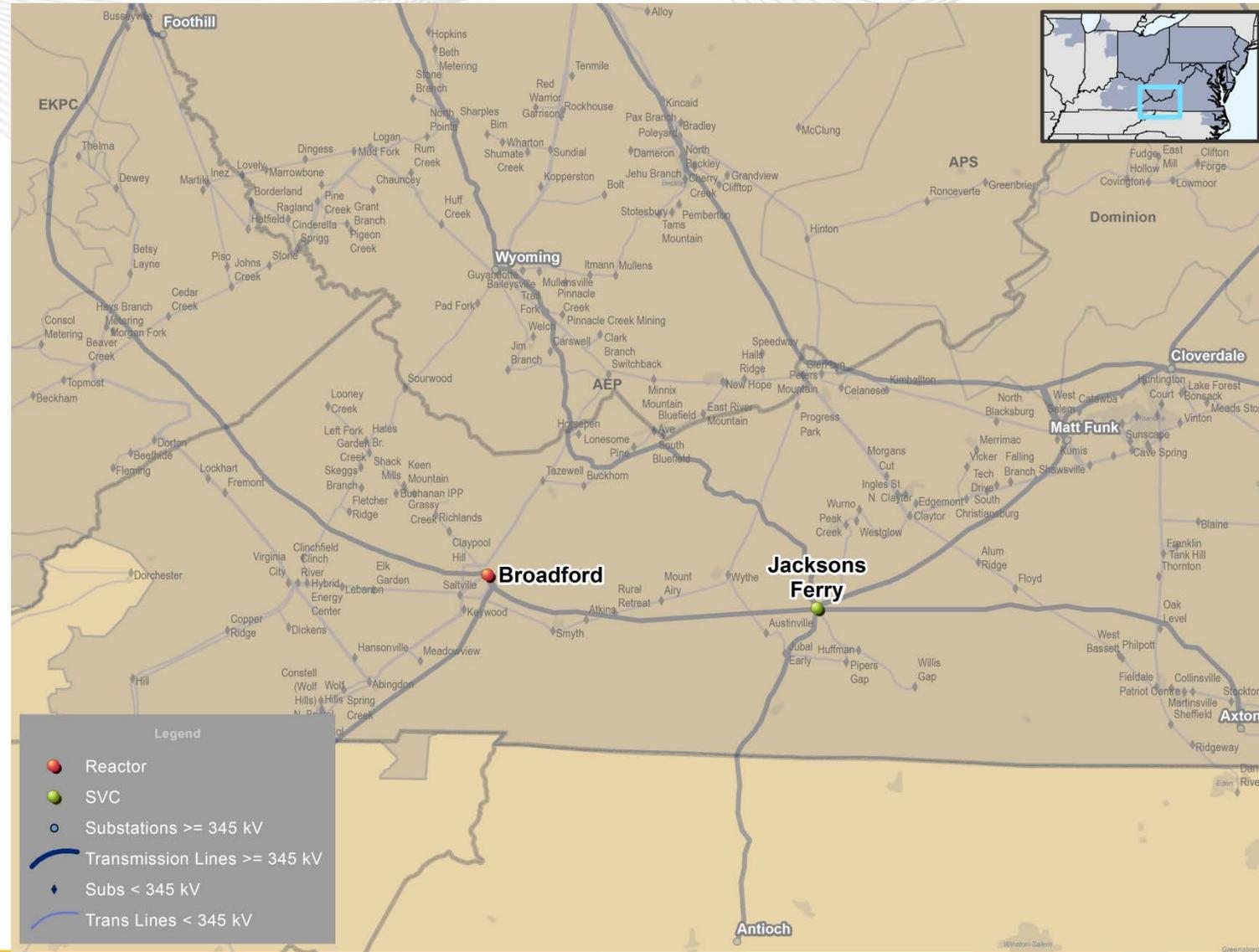


Recommendation for Immediate Need Reliability Solutions: Alternatives Considered

- Several locations were considered for the SVC/shunt reactors, however, the recommended locations were found to be the optimal location.

Immediate Need

- AEP system has been experiencing high voltage issue recently that requires an immediate mitigation. Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.





Southern AEP Transmission Zone High Voltages

- Recommended new static shunt reactor installations:
 - Install a +/- 450 MVAR SVC at Jacksons Ferry 765 kV substation (B2687.1)
 - Install a 300 MVAR shunt line reactor on the Broadford end of the Broadford – Jacksons Ferry 765 kV line (B2687.2)

Estimated Project Cost:

\$ 51M Total Project Cost

- \$36.5M for SVC (B2687.1)
- \$14.5M for 300 MVAR Reactor (B2687.2)

Projected IS Date:

6/1/2018

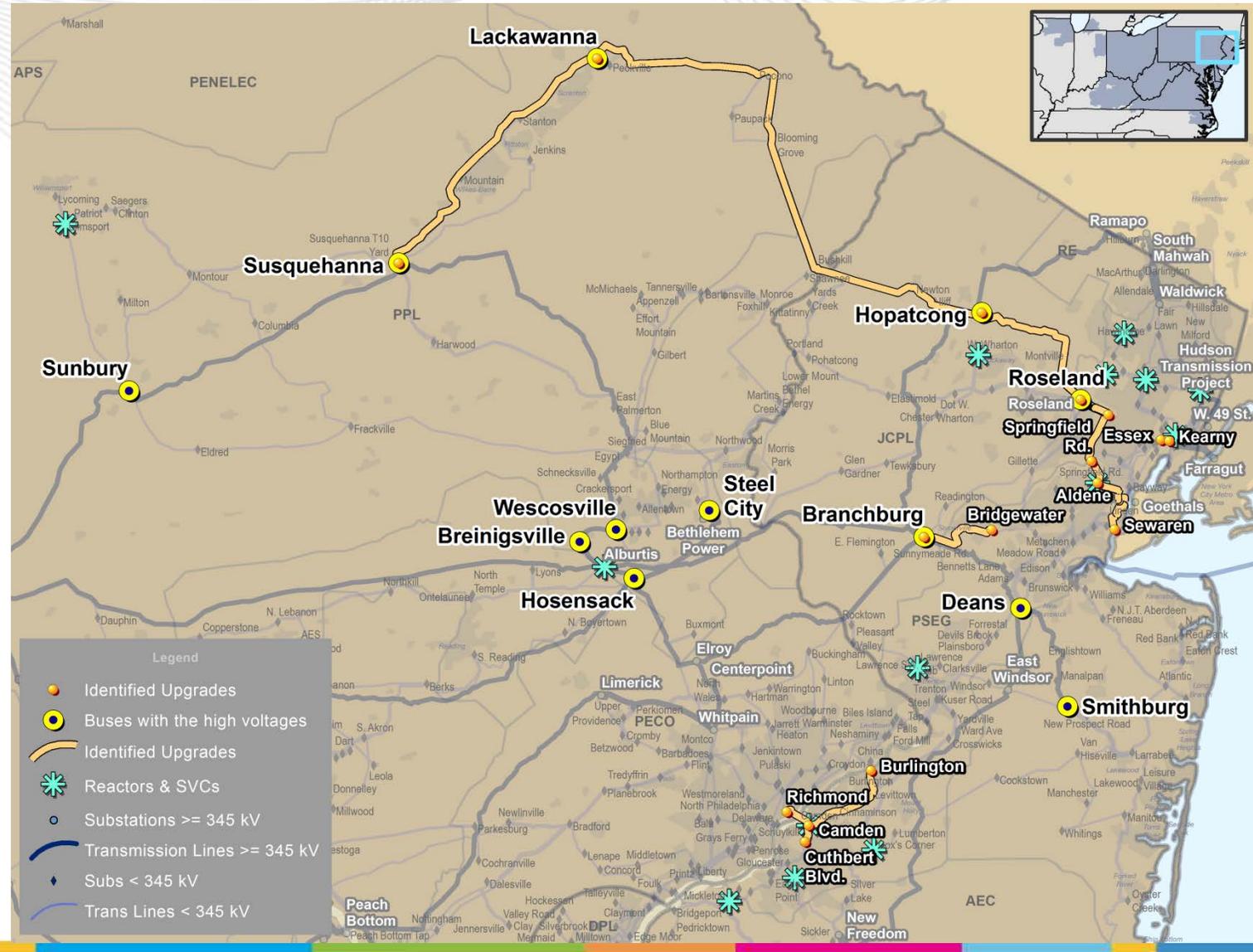
Construction Designation:

- The local Transmission Owner (AEP)



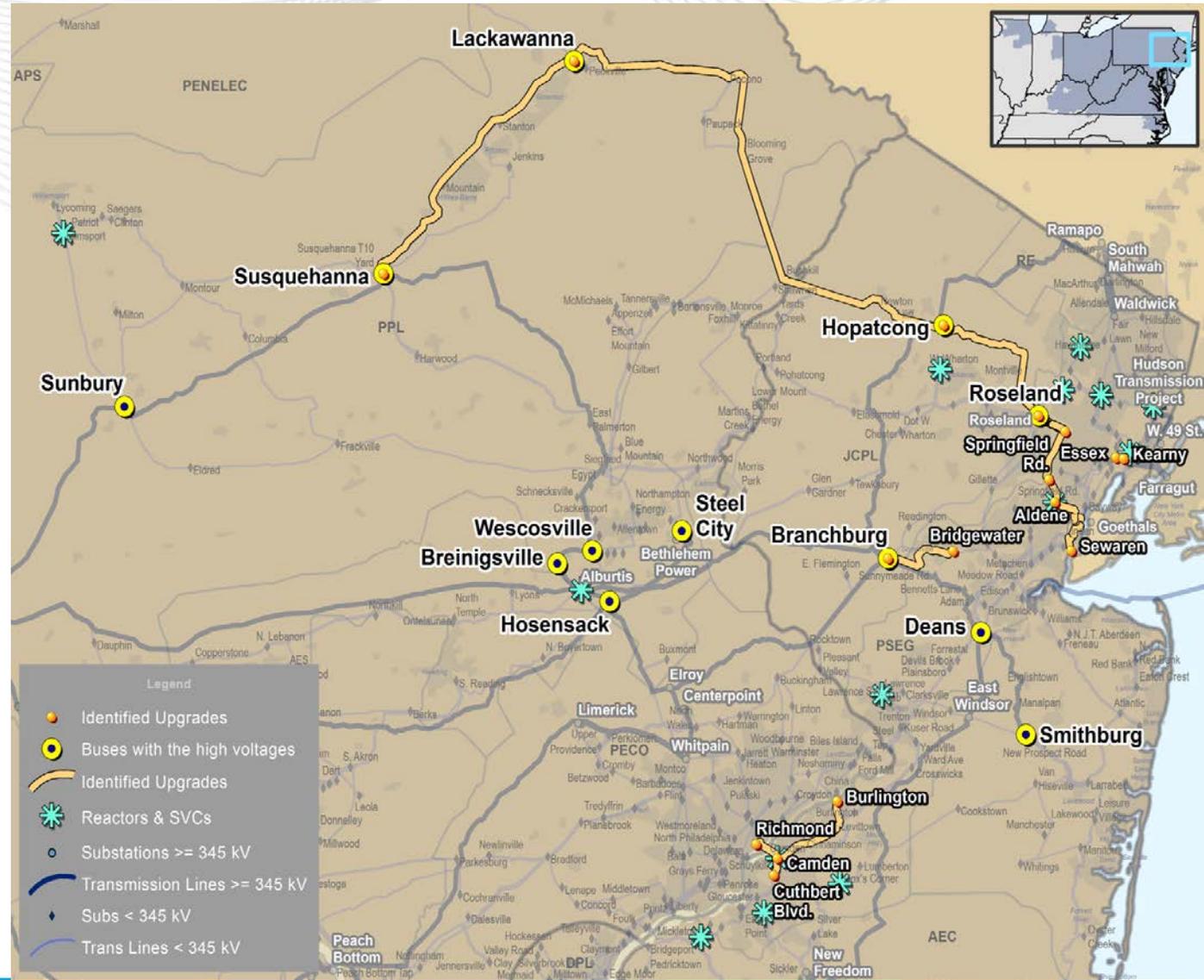
Northeastern Mid-Atlantic High Voltages

- PJM Operations observes high voltages mainly on the 500 kV system
 - Map shows the locations of recent high voltage locations
- Largest driver is increased line charging due to new required RTEP upgrades located mostly in the PSEG area coupled with loss of dynamic MVAR due to generation deactivations
- On the order of 1,500 MVARs of approved reactors and SVCs planned to go in service in 2015 and 2016 in this region – greatly reduces (improves) the voltage profile
- Planning studies, however, show that future planned transmission will require additional reactive devices to control voltages in the area



Northeastern Mid-Atlantic High Voltages

- The need for additional shunt reactors has been identified on the PSEG system.
- Recommended new static shunt reactor installations:
 - B2702: 350 MVARs at Roseland 500 kV (\$50.1M)
 - B2703: 100 MVAR at Bergen 230 kV (\$10.6M)
 - B2704: 150 MVAR at Essex 230 kV (\$16.7M)
 - B2705: 200 MVAR at Bergen 345 kV (\$38.3M)
 - B2706: 200 MVAR at Bayway 345 kV (\$26.6M)
 - B2707: 100 MVAR at Bayonne 345 kV (\$15.4M)
- The first three devices (B2702, B2703, B2704) are required as soon as possible to address the ongoing operational performance issues
- The remaining three devices (B2705, B2706, B2707) will be staged to accommodate the addition of the Bergen to Linden Corridor 345 kV project



Alternatives Considered

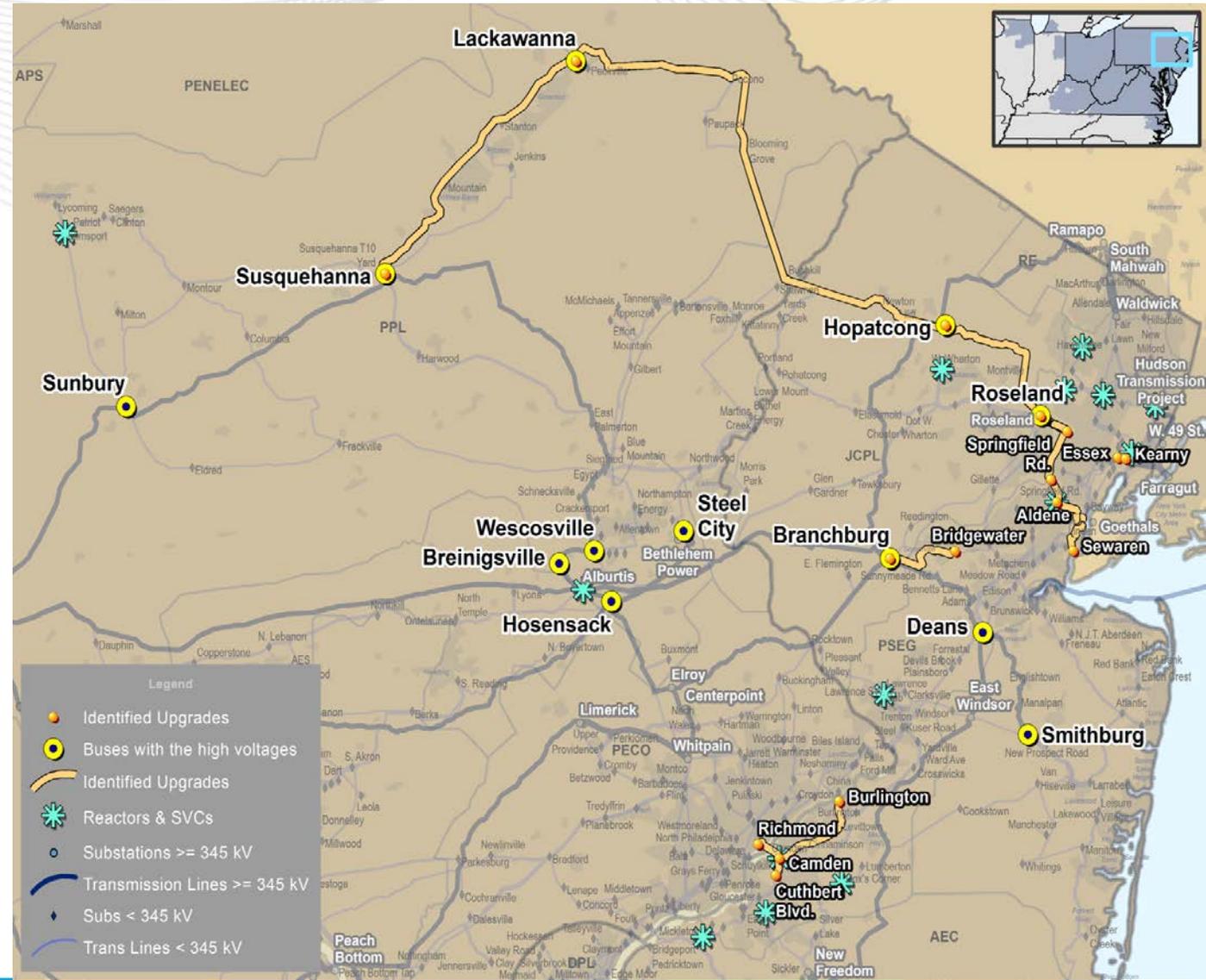
- Several locations were considered for the SVC/shunt reactors, however, the recommended locations were found to be the optimal locations.

Immediate Need

- PSEG system has been experiencing high voltage issue recently that requires an immediate mitigation. Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Construction Designation:

- The local Transmission Owner (PSEG)



- Next steps
- December PJM Board Meeting
 - Recommend the Southern AEP Transmission Zone and Northeastern Mid-Atlantic Transmission Zone reactive reinforcement recommendations to the PJM Board

Scenario Studies

- Recap of 2014 and 2015
 - OPSI recommended scenarios supplemented by PJM
 - 16 scenarios evaluated for economics and reliability
 - Three levels of at-risk generation evaluated: 6GW, 16GW and 32GW
 - Transmission system reliability studies were designed to identify broad regional impacts that may require long lead time projects
 - Snapshot case approach was used, in reality there will be many moving parts: Timing of “at-risk,” in-service date of new generation, location and type of new resources

- Anticipated 2016 Approach
 - Revisit and refine the 2014 and 2015 assumptions
 - Additional stakeholder feedback and suggestions
 - PJM will seek input at the 2016 RTEP assumptions meetings next month

Interregional Coordination

- Coordination with MISO MEP process to relieve Newtonville – Coleman 161 kV congestion
 - Duff – Rockport – Coleman area status
 - MISO status
 - PJM status

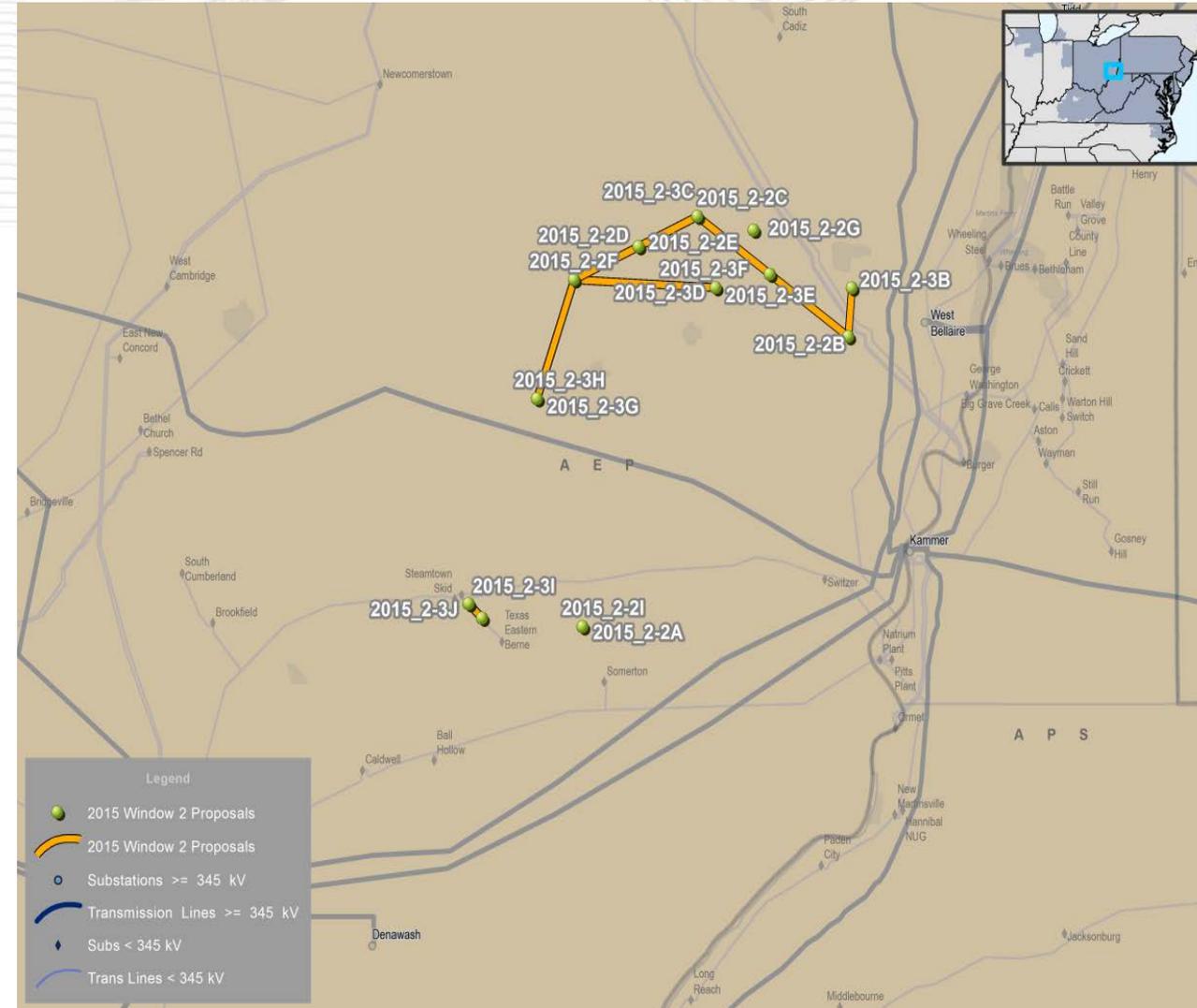
Current Year + 7 (2022) Analysis

- Updated 2020 RTEP base case to reflect 2022 load forecast
- 2015 RTEP approved upgrades not included
- Performed generator deliverability and common mode outage examining single and tower contingencies
- Performed load deliverability for LDAs where CETL < 150% CETO in 2019
 - CLEV, DEOK, PSEG, DPL South, BGE
- Analysis did not identify any additional reliability violations

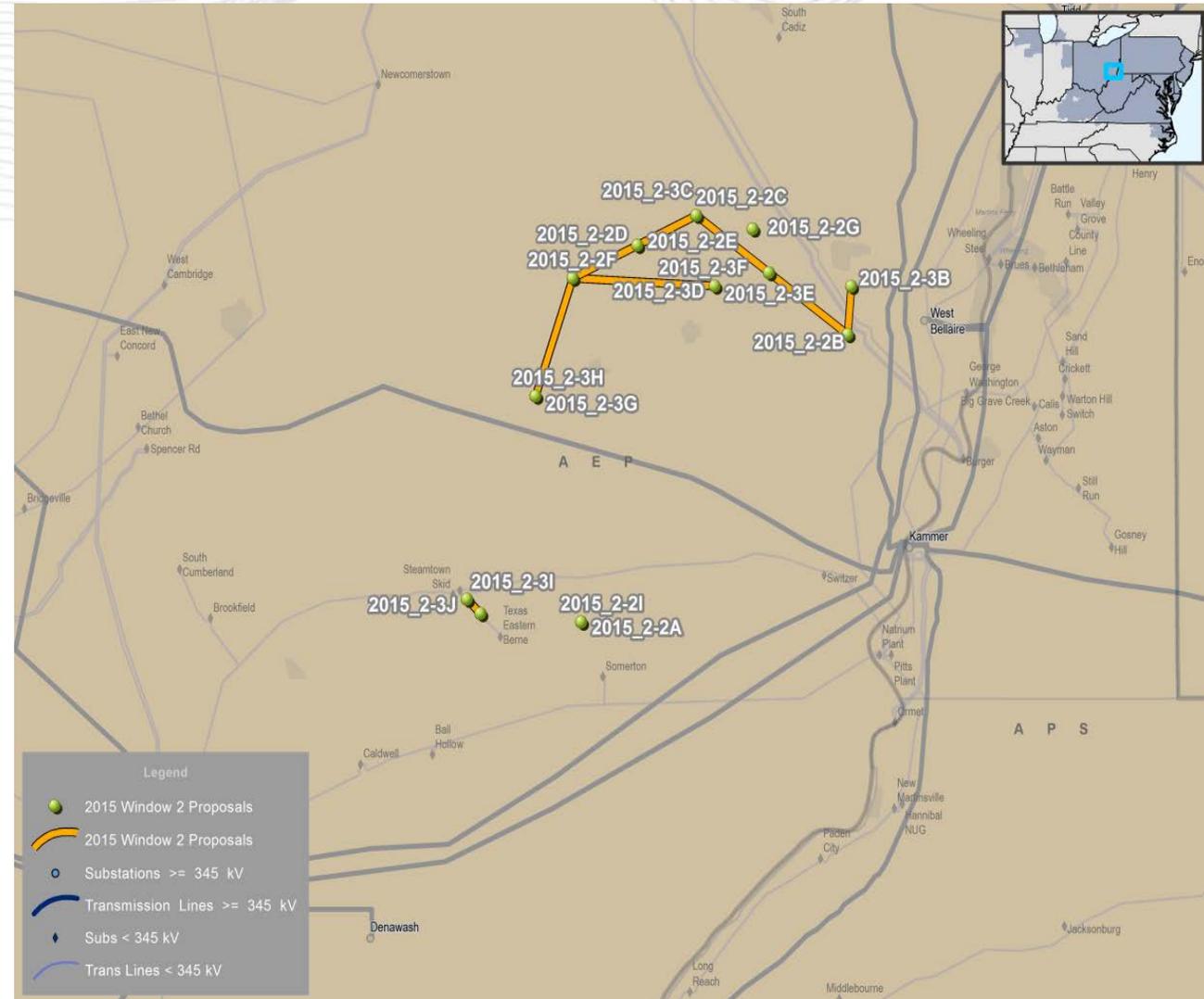


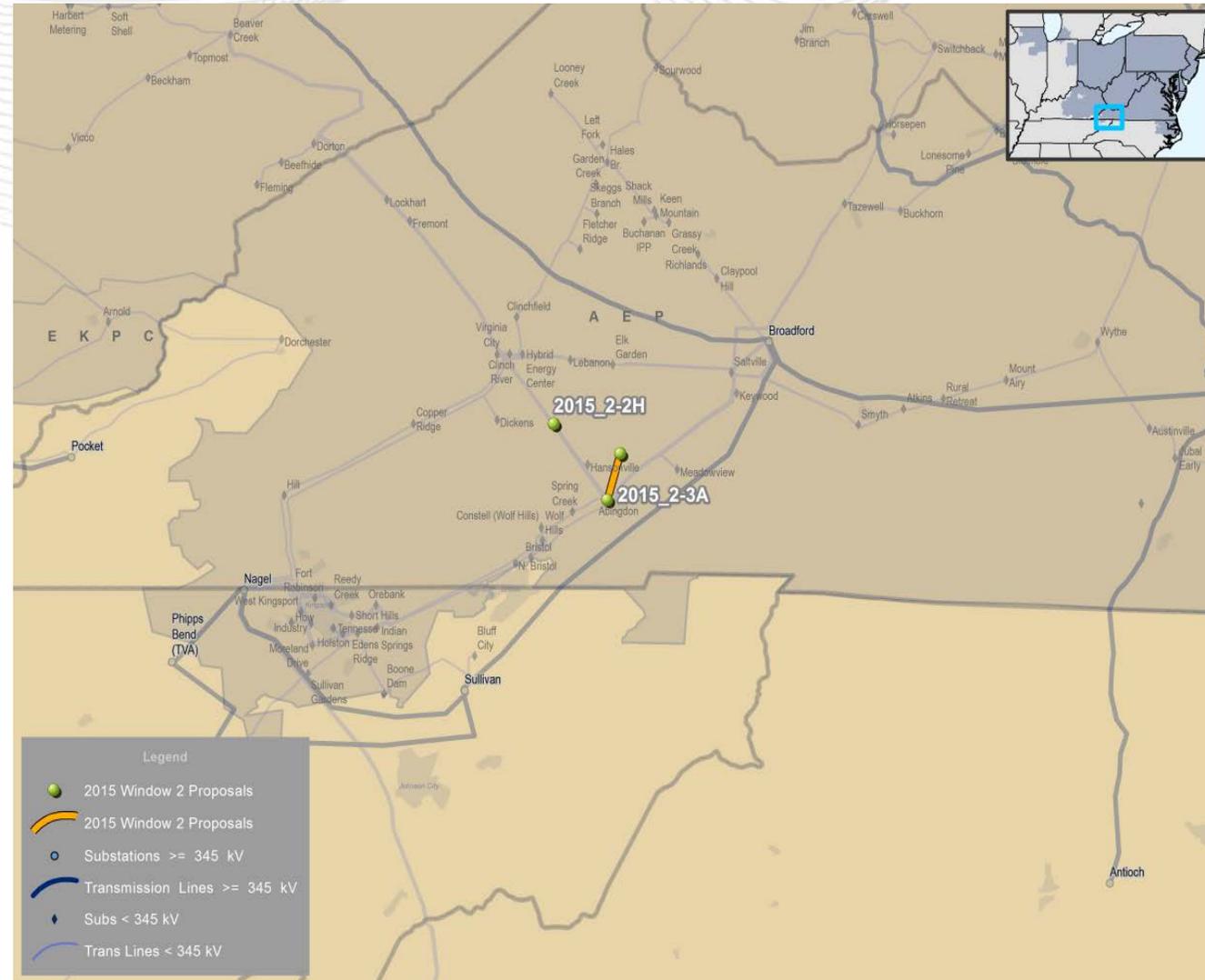
2015 RTEP Proposal Window #2 – Analytical Update

- **AEP Transmission Owner Criteria Violation (FG# AEP-T5 and AEP-T6)**
- **Violation description:** The Glencoe – Willow Grove 69 kV line is overloaded for multiple contingencies.
- **PJM Cost Estimation:** PJM performed a high level cost estimation applying similar estimation assumptions across all proposals.
- **Alternatives considered:**
 - Northeast Transmission Development Proposals
 - 2015_2_2B (\$6.2 M, PJM cost estimate \$7.7M)
 - 2015_2_2C (\$4.0 M, PJM cost estimate \$5.78M)
 - 2015_2_2G (\$6.0 M, PJM cost estimate \$9.3M)
 - 2015_2_2I (\$29.7 M, PJM cost estimate \$44.7M)
 - AEP Proposal
 - 2015_2_3B (\$6.014 M, PJM cost estimate \$5.21M)
- **Other factor considered:** The Glencoe – Willow Grove 69 kV line is 1946 vintage copper conductor and it is aging infrastructure.
- **Recommended Solution :**
 - Rebuild/upgrade line between Glencoe and Willow Grove Switch 69 kV. (2015_2_3B)
- **Construction Designation:**
 - The local Transmission Owner, AEP
- **Estimated Project Cost:** \$6.014M
- **Required IS Date:** 6/1/2020



- **AEP Transmission Owner Criteria Violation (FG# AEP-T10, AEP-T11, AEP-V6, AEP-V7, AEP-V8 and AEP-V9)**
- **Violation description:**
- The East Cambridge – Old Washington - Antrim 34.5 kV circuit is overloaded for basecase pre-contingency condition.
- Low Voltage violations at Antrim Sw., Antrim (G.M. Co-op), Vail Sw. and Smyrna 69 kV stations for basecase pre-contingency condition.
- **PJM Cost Estimation:** PJM performed a high level cost estimation applying similar estimation assumptions across all proposals.
- **Alternatives considered:**
- Northeast Transmission Development Proposals
 - 2015_2_2D (\$18.4M, PJM estimate cost \$25.6M)
 - 2015_2_2E (\$12.6M, PJM estimate cost \$20M)
 - 2015_2_2F (\$19.8M, PJM estimate cost \$29.3M)
 - 2015_2_2I (\$29.7M, PJM estimate cost \$44.7M)
- AEP Proposals
 - 2015_2_3C (\$24.32M, PJM estimate cost \$28.2M)
 - 2015_2_3D (\$21.9M, PJM estimate cost \$26.2M)
 - 2015_2_3E (\$22.57M, PJM estimate cost \$26.2M)
 - 2015_2_3F (\$14.355M, PJM estimate cost \$16.24M)
 - 2015_2_3G (\$21.9M, PJM estimate cost \$28.8M)
 - 2015_2_3H (\$14.355M, PJM estimate cost \$17.71M)
- **Recommended Solution:**
 - Build approximately 11.5 miles of 34.5 kV line with 556.5 ACSR 26/7 Dove conductor on wood poles from Flushing station to Smyrna station. (2015_2_3F) and designate to AEP
- **Estimated Project Cost:** \$14.355M
- **Required IS Date:** 6/1/2020





AEP Transmission Owner Criteria Violation (FG# AEP-T9)

Violation description:

The Abingdon – Hillman 69 kV line is overloaded for single contingency loss of the Broadford 765/500 kV transformer and Broadford – Sullivan 500 kV circuit.

PJM Cost Estimation: PJM performed a high level cost estimation applying similar estimation assumptions across all proposals.

Alternatives considered:

- 2015_2_2H (\$6.0 M, PJM cost estimate \$9.3 M)
- 2015_2_3A (\$25.19 M, PJM cost estimate \$40.6M)

Recommended Solution Status:

Technical Evaluation in progress

Dominion End of Life Criteria Violations

Dominion End of Life Criteria decision point metrics:

1. Facility is nearing, or has already passed, its end of life, and
2. Continued operation risks negatively impacting reliability of the transmission system.

Dominion Local TO Criteria

- End of Life Criteria
 1. End of Life Assessment
 2. Reliability and System Impact

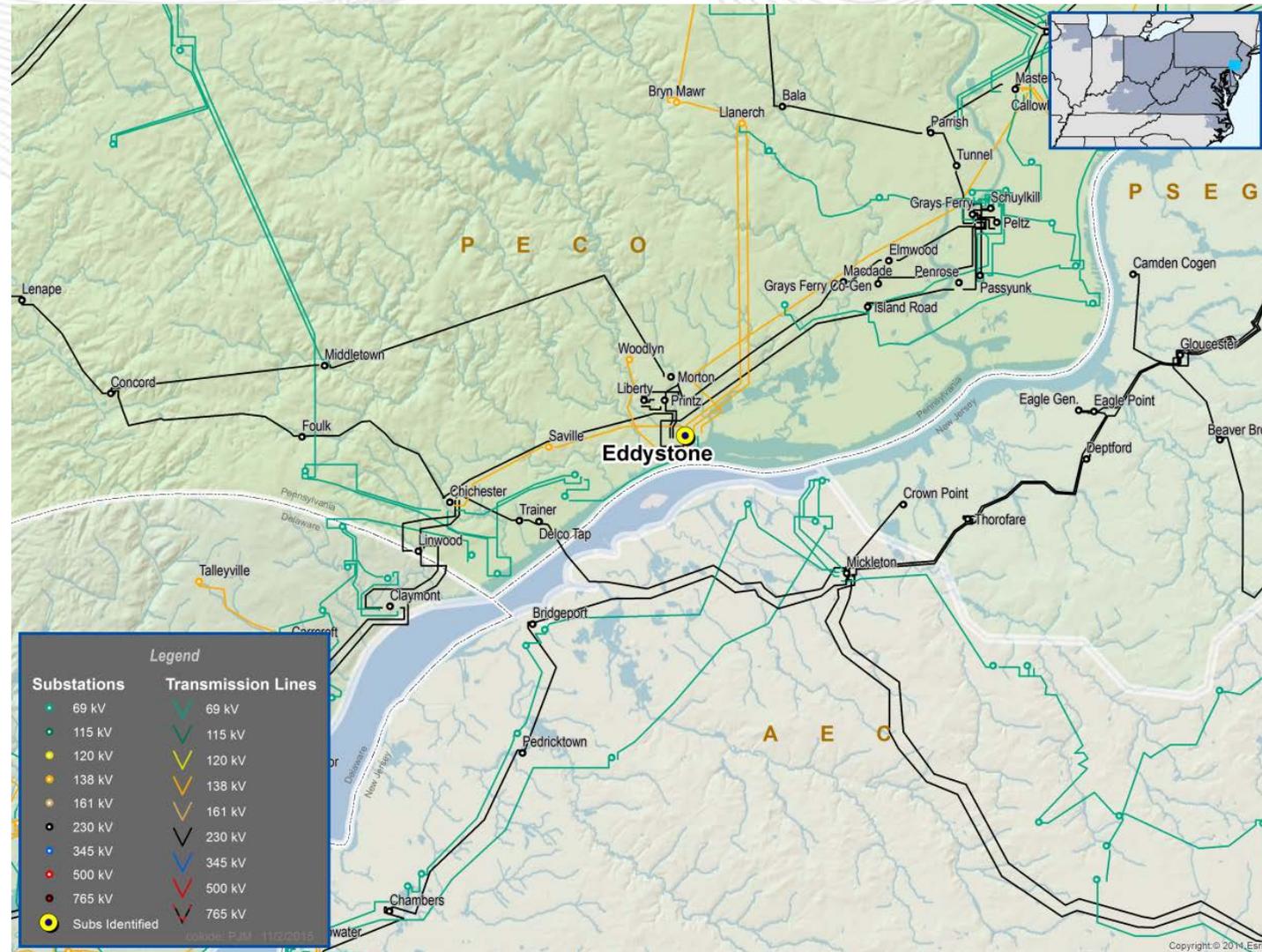
Next Steps

- DOM has provided PJM with a comprehensive list of facilities for End of Life status consideration
 - Evaluation reliability and system impact
 - Communication with TEAC

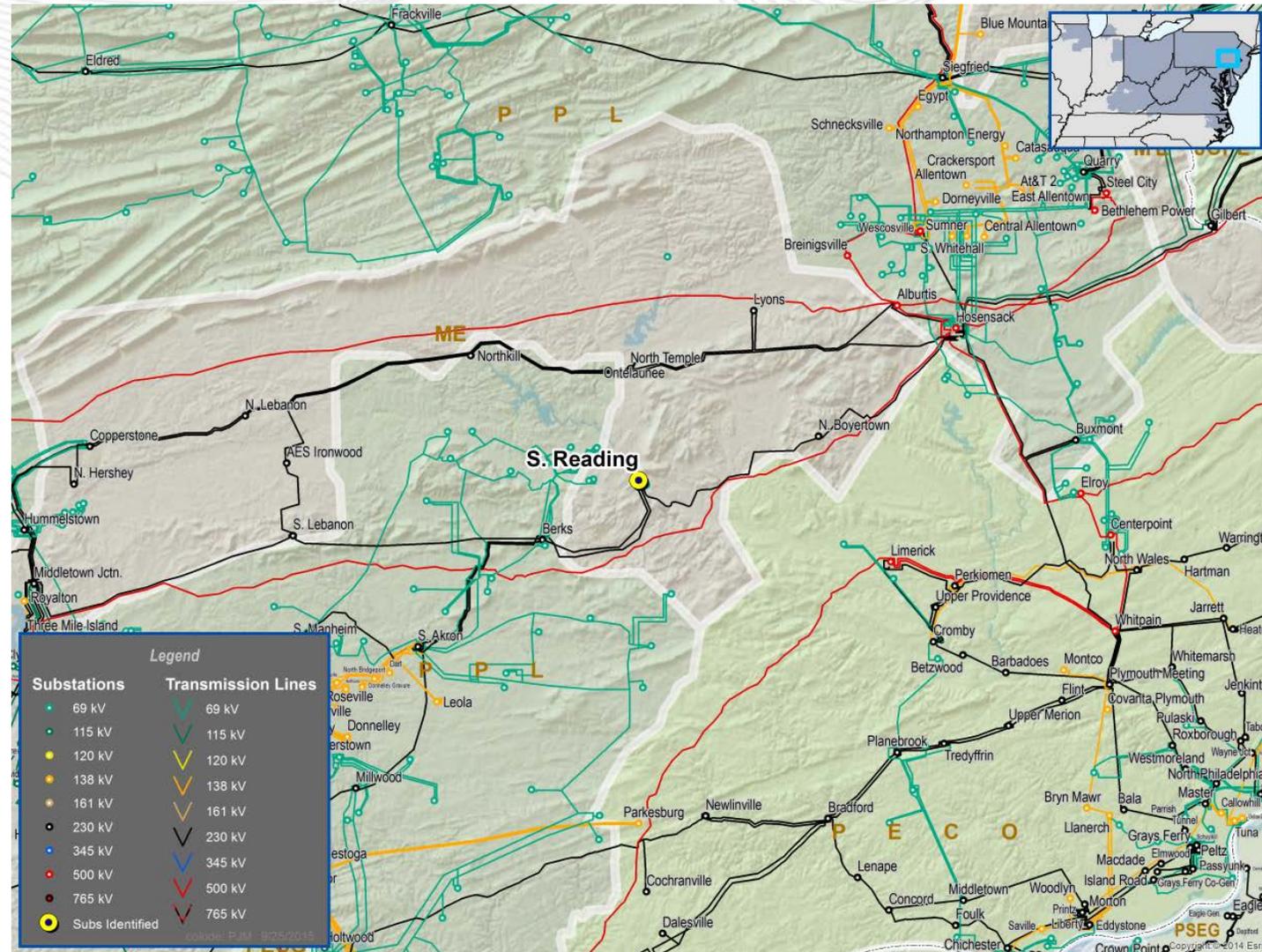


Short Circuit Upgrades

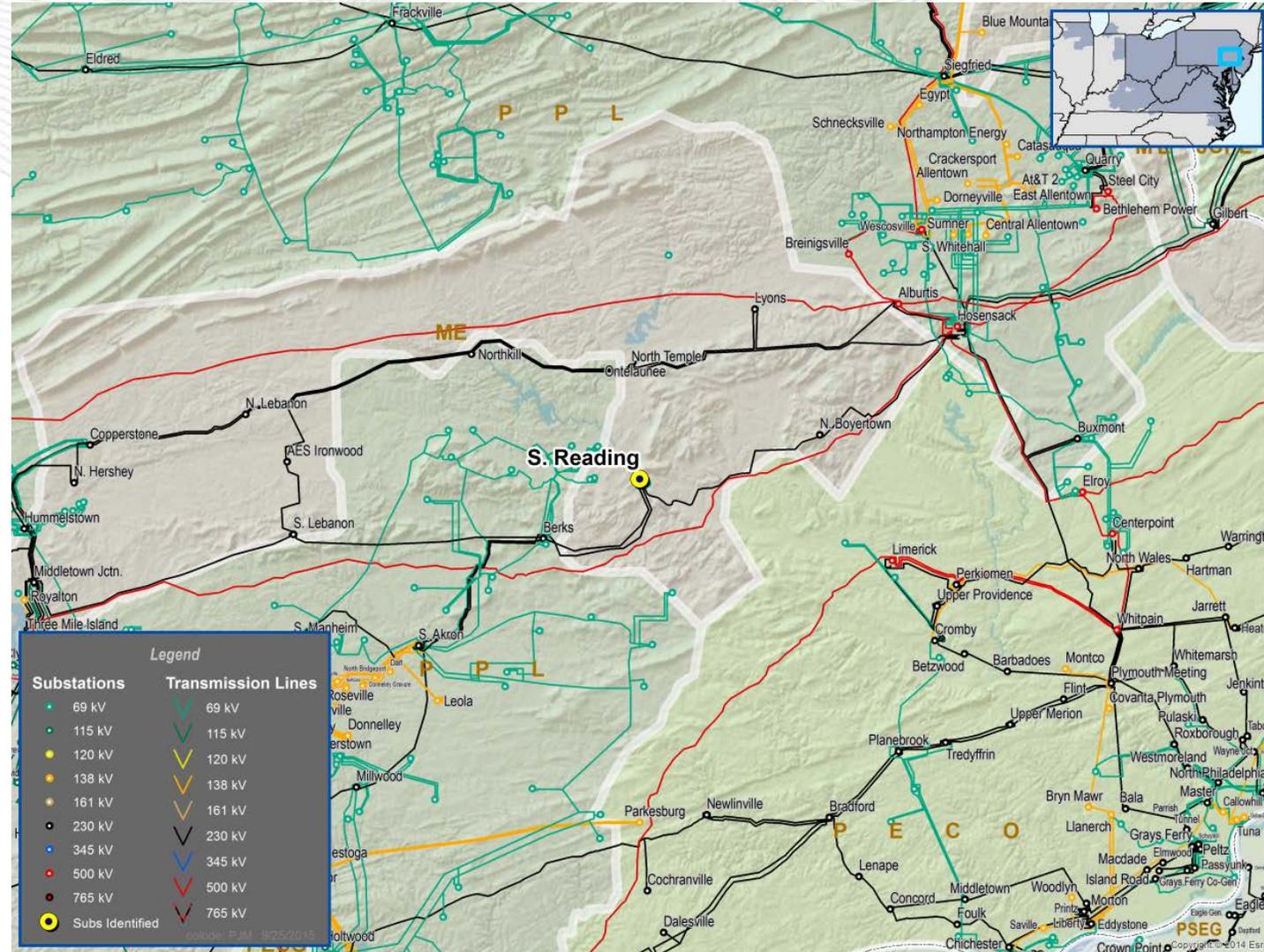
- **Short Circuit Violation:** The Eddystone 138kV '205' breaker is overstressed
- **Significant Driver:** Install a second Eddystone 230/138 kV transformer (b2222)
- **Proposed Solution:** Replace the Eddystone 138kV '205' breaker with 63kA breakers (b2222.1)
- **Estimated Project Cost:** \$319.5 K
- **Required In Service Date:** 6/1/2017



- **Short Circuit Violation:** The South Reading 69kV '81342' and '82842' breakers are overstressed
- **Significant Driver:** Construct a new 230/69 kV Lauschtown substation. The South Akron - Berks 230 kV line and South Akron - South Reading 230 kV line will terminate into the new 230 kV yard at Lauschtown (b2006.2)
- **Proposed Solution:** Replace the South Reading 69kV '81342' and '82842' breakers with 40kA breakers (b2006.4 –b2006.5)
- **Estimated Project Cost:** \$200 K per breaker
- **Required In Service Date:** 6/1/2016

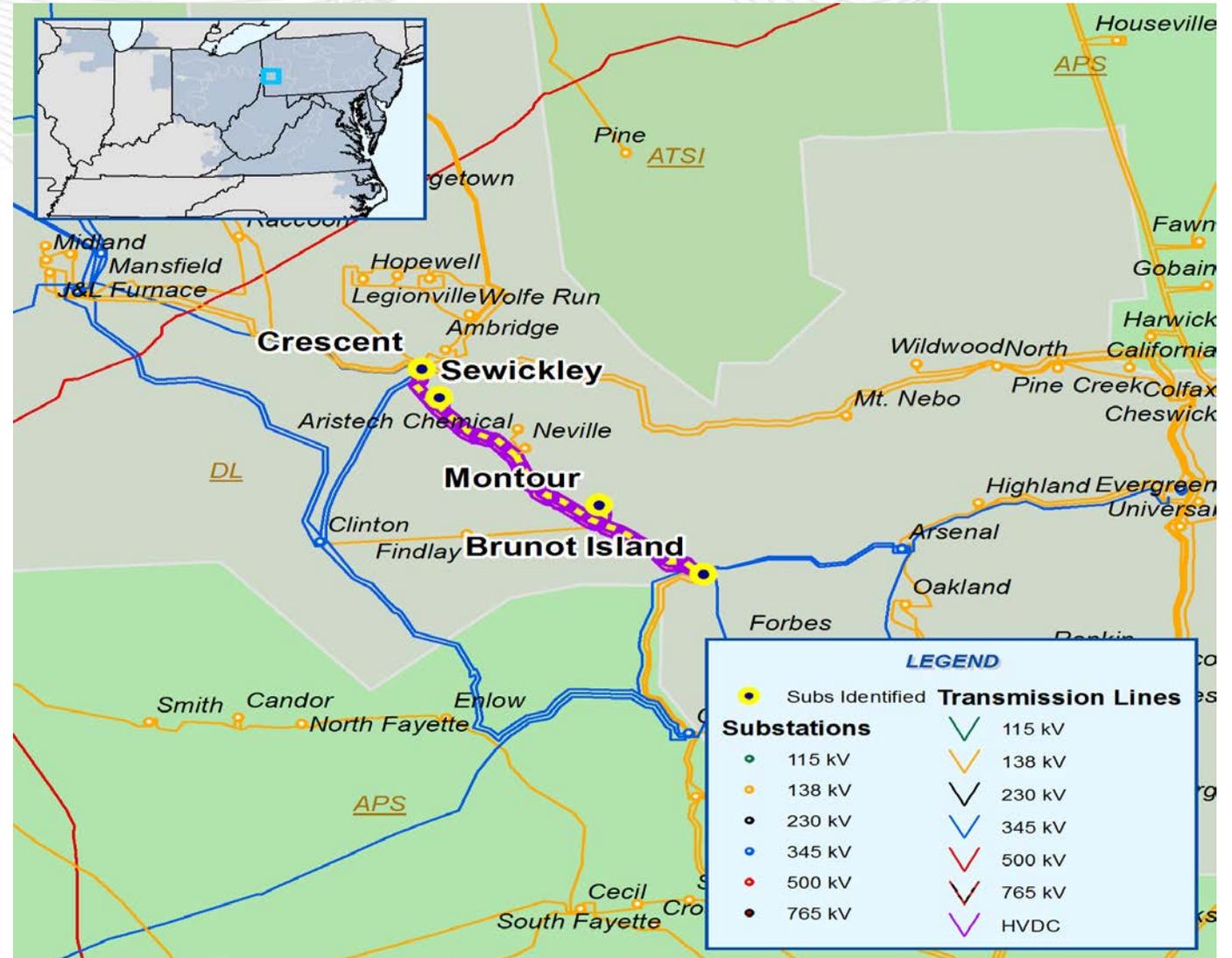


- **Proposed Solution:**
Replace the South Reading 69kV '80642' breaker with 40kA breaker (s1011)
- **Estimated Project Cost:** \$200 K
- **Projected In-Service Date:** 6/1/2016

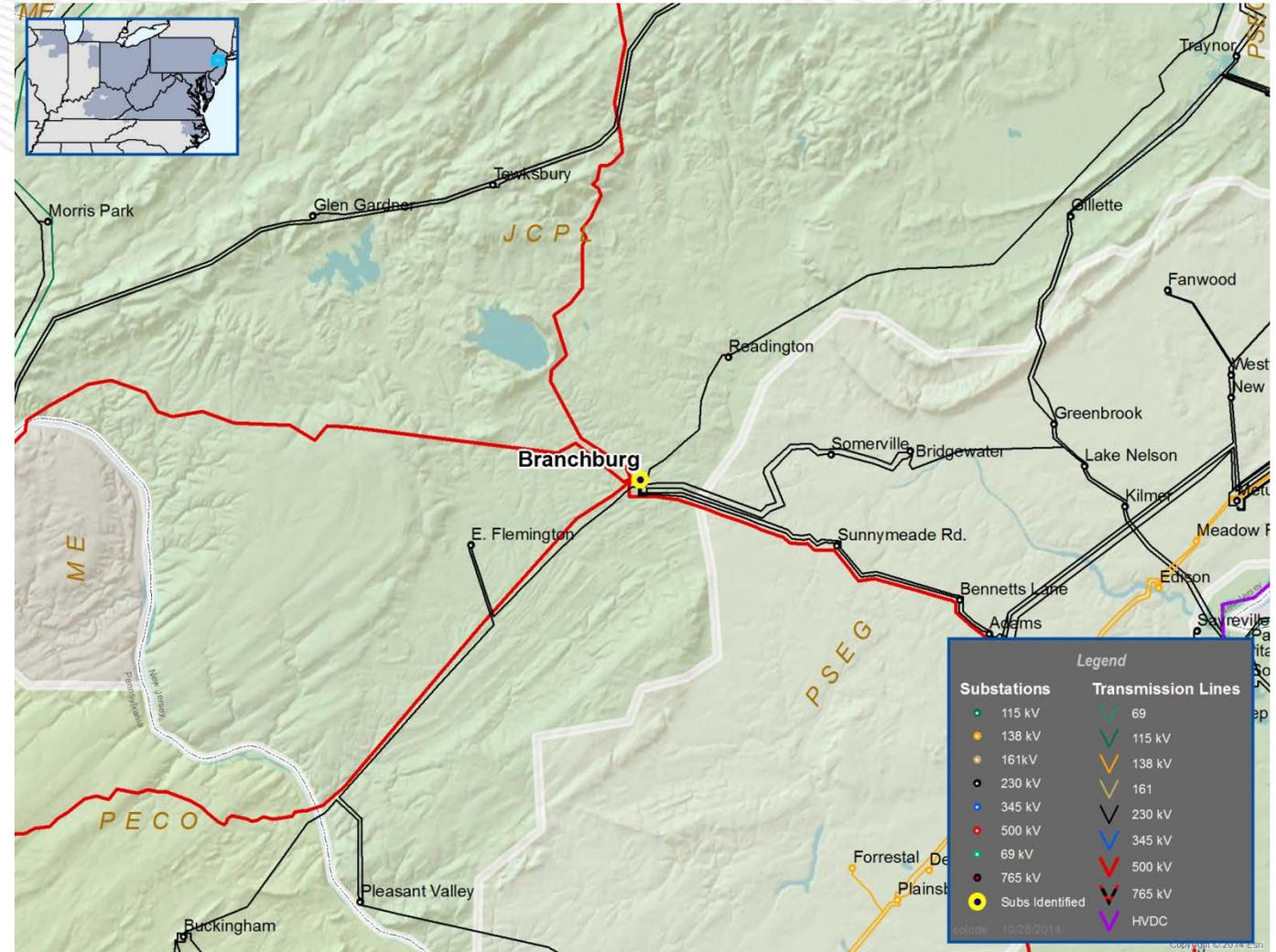


Supplemental Projects

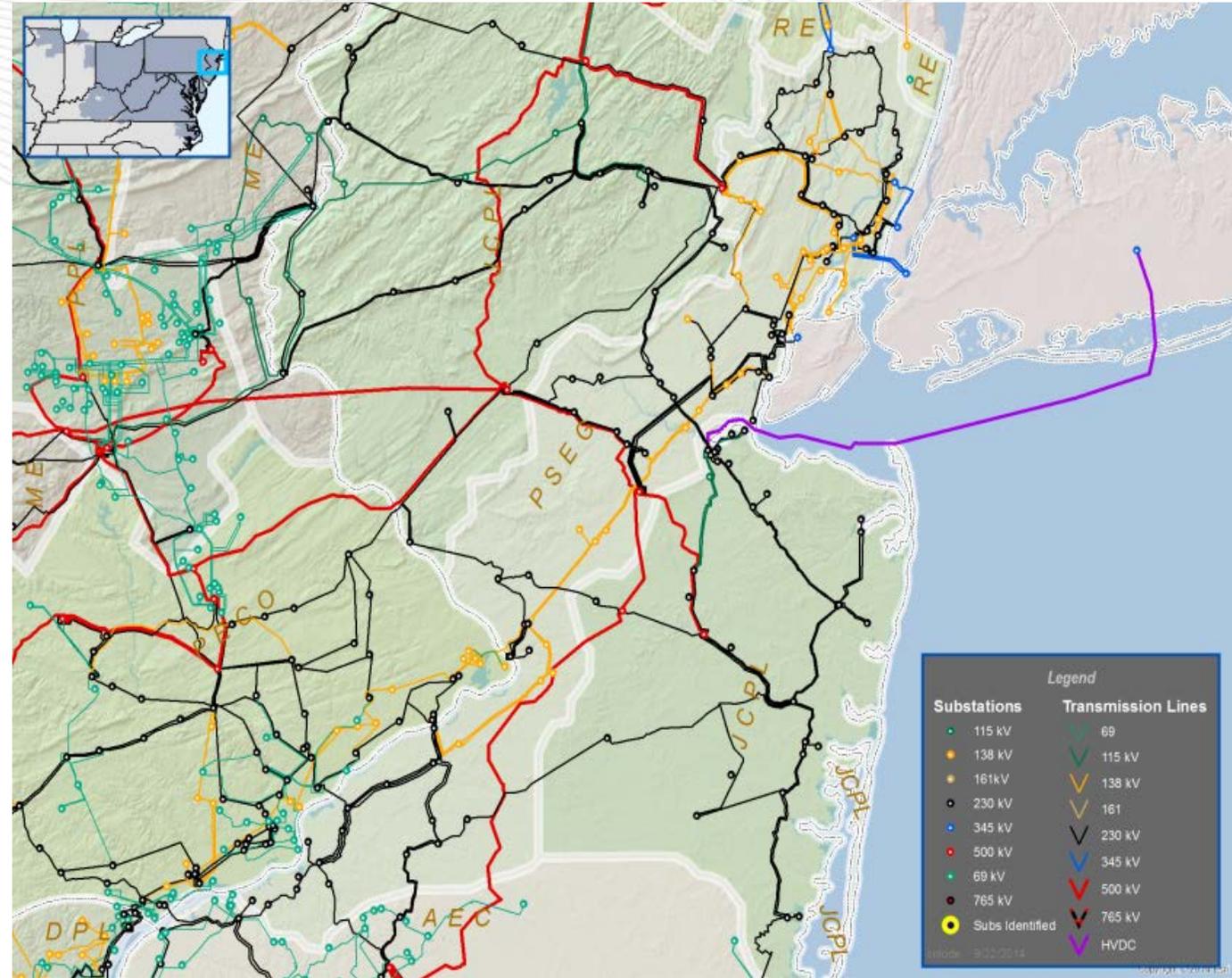
- Supplemental Project
- Project scope change (S0320)
- Old Scope: Reconductor the Crescent - Montour, Brunot Island - Sewickley, Brunot Island - Montour, and Crescent - Sewickley 138 kV circuits
- New Scope:
 - Rebuild the aging double circuit 138kV tower line between Brunot Island and Crescent substations with a 345/138kV tower line.
 - Reconfigure the 138kV circuits to create Brunot Island-Montour, Montour-Sewickley, and Crescent-Sewickley 138kV circuits and establish a new Brunot Island-Crescent 345kV circuit.
- New Estimated Project Cost: \$40M
- Projected IS Date: 6/1/2021



- Supplemental Upgrade:
- To improve reliability by remotely monitoring major assets
- Proposed Solution:
Install microprocessor relays, transformer equipment, SCADA systems and alarm panels at Branchburg to monitor the 500/230 kV transformers 500-1 and 500-2.
- Estimated Project Cost:
\$ 9.0 M
- Projected IS Date:
12/1/2016



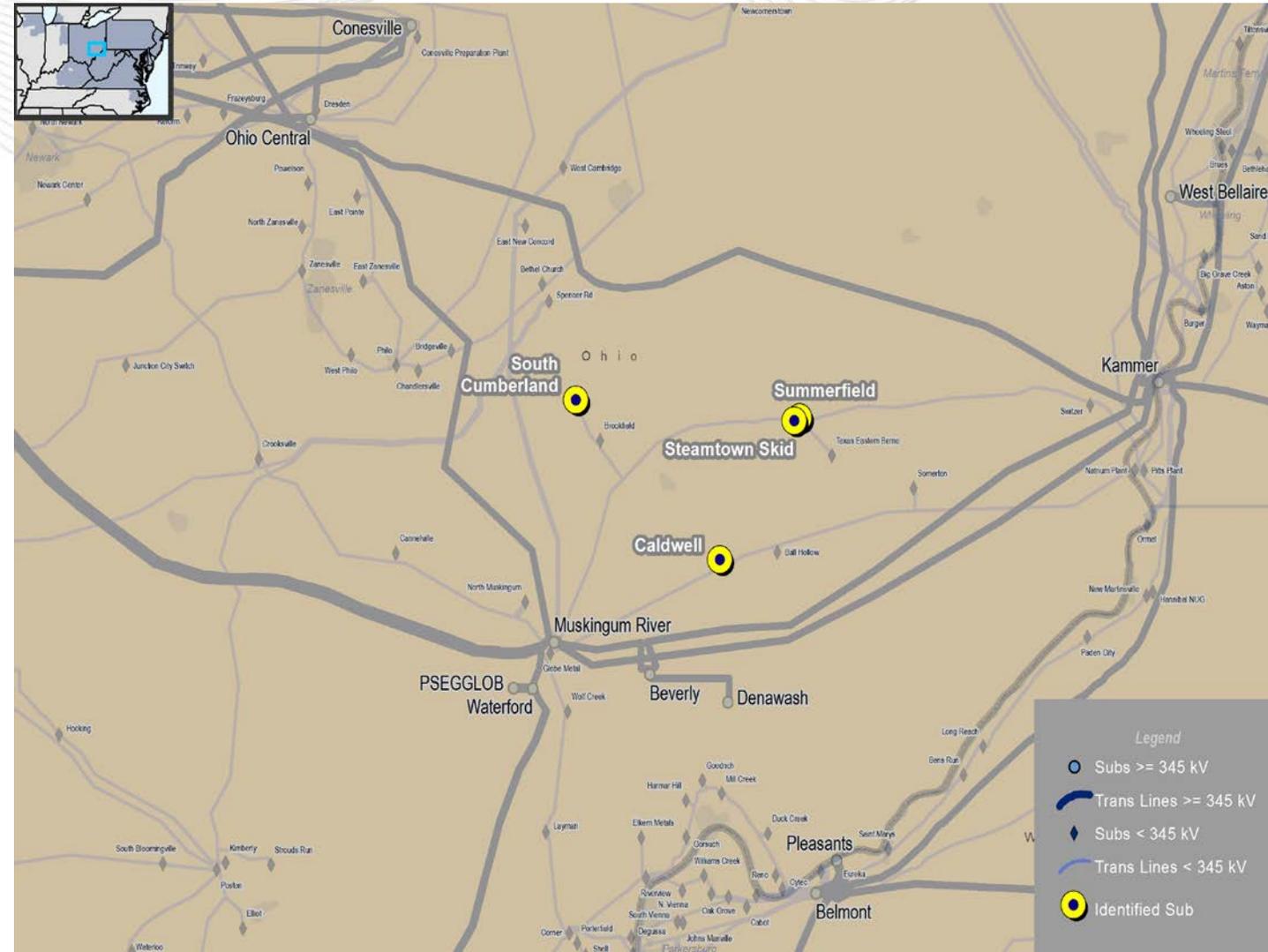
- Supplemental Project:
- To improve reliability and transformer availability during contingency events or other failures
- Proposed Solution:
 - Purchase 750 MVA 345/230 kV autotransformer (Special Divided or Dissociated Phases) . (S1010.1)
 - Purchase 750 MVA, 345/230 kV autotransformer (Conventional 3-Phase). (S1010.2)
- Estimated Project Cost:
\$ 23 M
- Projected IS Date:
6/1/2016 - 6/1/2018



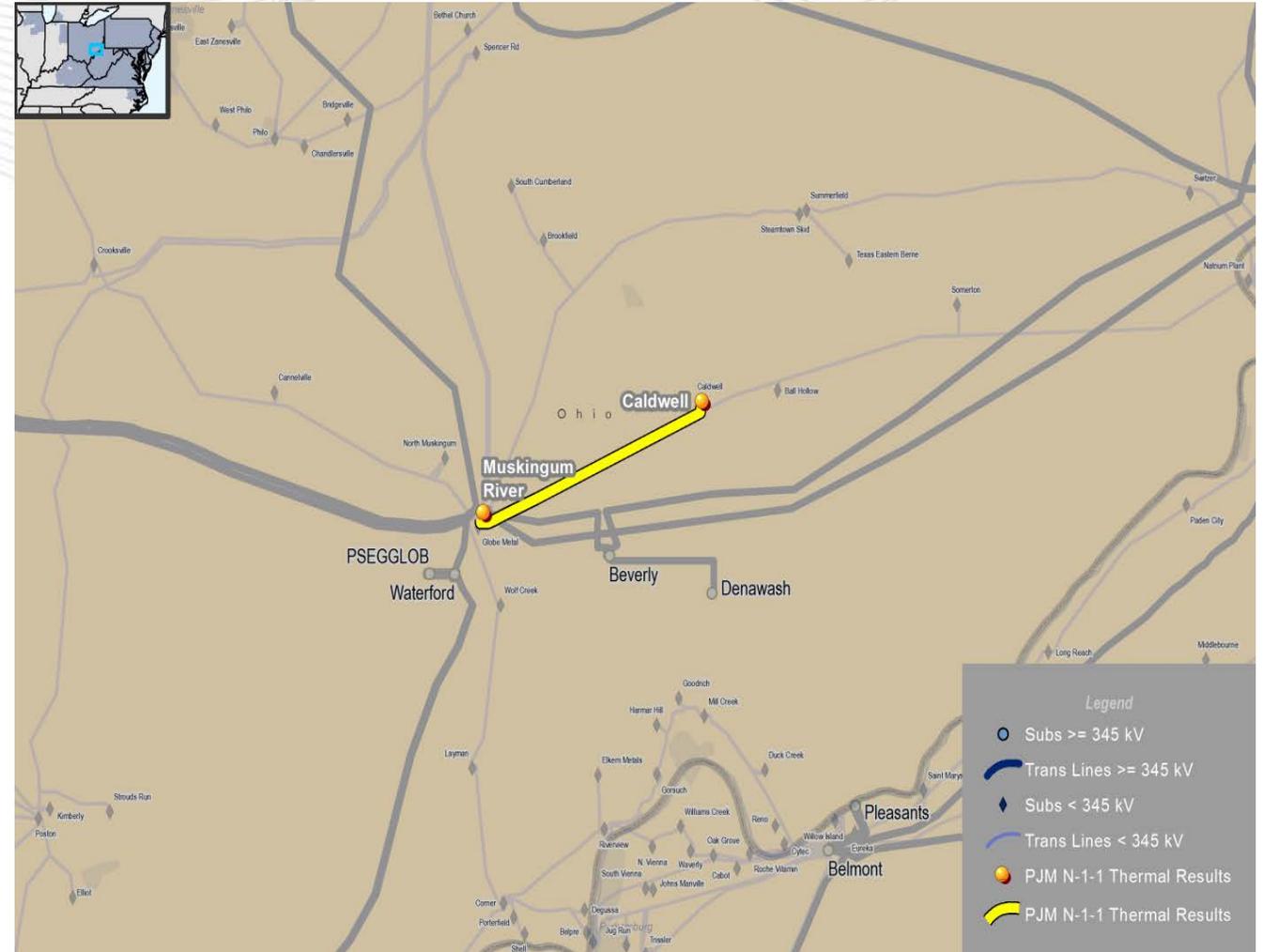


Previously Reviewed Baseline Upgrades for the December 2015 PJM Board Recommendation

- **N-1-1 Voltage (FG#: N2-VM70 – 76, N2-VD73 – 74):**
- Low voltage at South Cumberland, Summerfield 138kV buses for several contingency pairs
- Low voltage at South Caldwell and Steamtown 138kV buses and voltage drop at South Caldwell and South Cumberland 138kV buses for the loss of the Muskingum – South Caldwell 138kV line and the loss of the Muskingum –East New Concord-West Cambridge 138kV line
- **Alternatives considered:**
 - 2015_1-2L (\$25.82 M)
 - 2015_1-8R (\$7.4 M)



- **N-1-1 Thermal Violation (FG# N2-T16 and N2-T17):**
- South Caldwell – Muskingum 138 kV circuit is overloaded for several contingencies.
- **Alternatives considered:**
 - 2015_1-2L (\$25.82 M)
 - 2015_1-8R (\$7.4 M)



Project ID	Proposing Entity	General Description/Scope	Component 1	Component 2	Component 3	Component 4	Component 5
2015_1-2L	AEP	Construct Herlan Station and Herlan-Blue Racer 138kV circuit.	Construct Herlan station as breaker and a half configuration with 9-138kV CB's on 4 strings and with 2-28.8 MVar capacitor banks.	Construct new 138kV line from Herlan station to Blue Racer station. Estimated at approx. 3.2 miles of 1234 ACSS/TW Yukon and OPGW.	Install 1-138kV CB at Blue Racer to terminate new Herlan circuit.	Rebuild Summerfield-Berne 138kV line with 3.47 miles of 1234 ACSS/TW Yukon and OPGW.	Upgrade Summerfield MOAB and terminal equipment.
		AEP cost estimate	\$15.64 M	\$5.78 M	\$0.32 M	\$4.03 M	\$0.05 M
2015_1-8R	Northeast Transmission Development (NTD)	Build a 138 kV switching station ("Grassy Creek") interconnecting the Summerfield-Switzer 138 kV line, the Steamtown Skid-Natrium 138 kV line and the Tap to Somerton 138 kV line	Build a 138 kV switching station ("Grassy Creek") interconnecting the Summerfield-Switzer 138 kV line, the Steamtown Skid-Natrium 138 kV line and the Tap to Somerton 138 kV line	Construct 5 new towers to connect the existing transmission lines into the new Grassy Creek switching station. NTD anticipates completing this work.			
		NTD cost estimate	\$6.1M	\$ 1.3M			

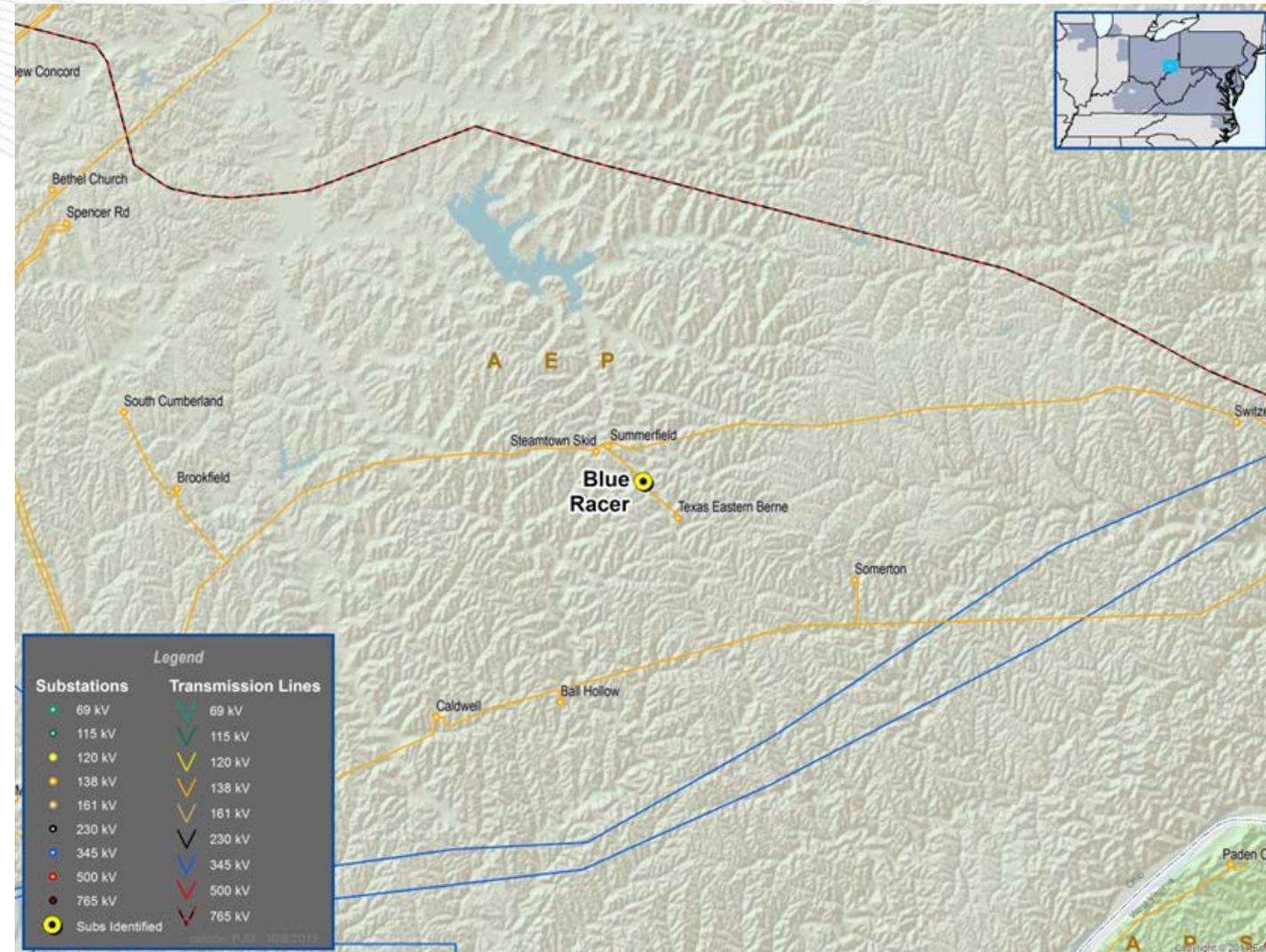


AEP Transmission Zone

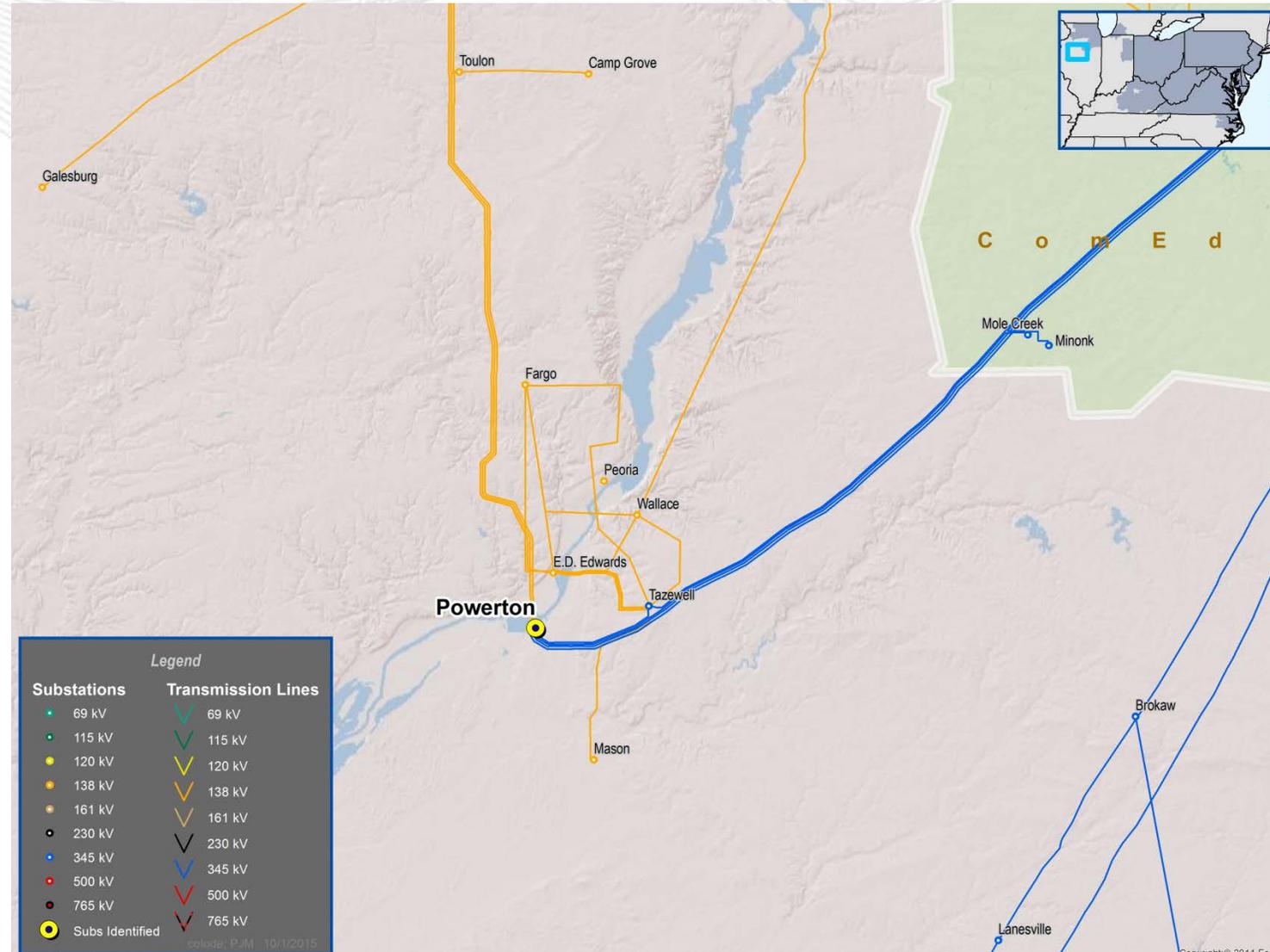
Project ID	Resolves Posted Violation	Final Project Cost (\$M)	PJM Cost Estimate (\$M)	Potential Future Violation	Pros	Cons	Recommended Solution
2015_1-2L (Components 1, 2, 3)	Yes (Components 4&5 are not needed)	21.42	29.1	Not anticipated in the 15 year horizon	Limited outage required	Higher cost	Yes
					Handles anticipated load growth (High possibility since it's the shale gas area)		
					Improves reliability for the local 69KV network (voltage support and thermal loading)		
					Solves Several Window #2 Reliability Criteria Violations		
					Solves the local radial voltage collapse (beyond criteria) for an N-1-1 condition		
2015_1-8R (Components 1, 2)	Yes	7.4	14.3	Yes (Grassy Creek – Summerfield 138KV line is loaded above 98% for the N-1-1 condition.)	Lower cost	High cost of Potential future overload (Grassy Creek – Summerfield 138KV line), >\$10M	No
					Limited outage		
					Solves Several Window #2 Reliability Criteria Violations		

- **Recommended Solution: (2015_1-2L)**
 - Construct Herlan station as breaker and a half configuration with 9-138kV CB's on 4 strings and with 2-28.8 MVar capacitor banks. (B2701.1)
 - Construct new 138kV line from Herlan station to Blue Racer station. Estimated at approx. 3.2 miles of 1234 ACSS/TW Yukon and OPGW. (B2701.2)
 - Install 1-138kV CB at Blue Racer to terminate new Herlan circuit. (B2701.3)
- **Estimated Project Cost:** \$15.64 M for B2701.1, \$5.78M for B2701.2, \$0.32M for B2701.3
- **Required IS Date:** 6/1/2020

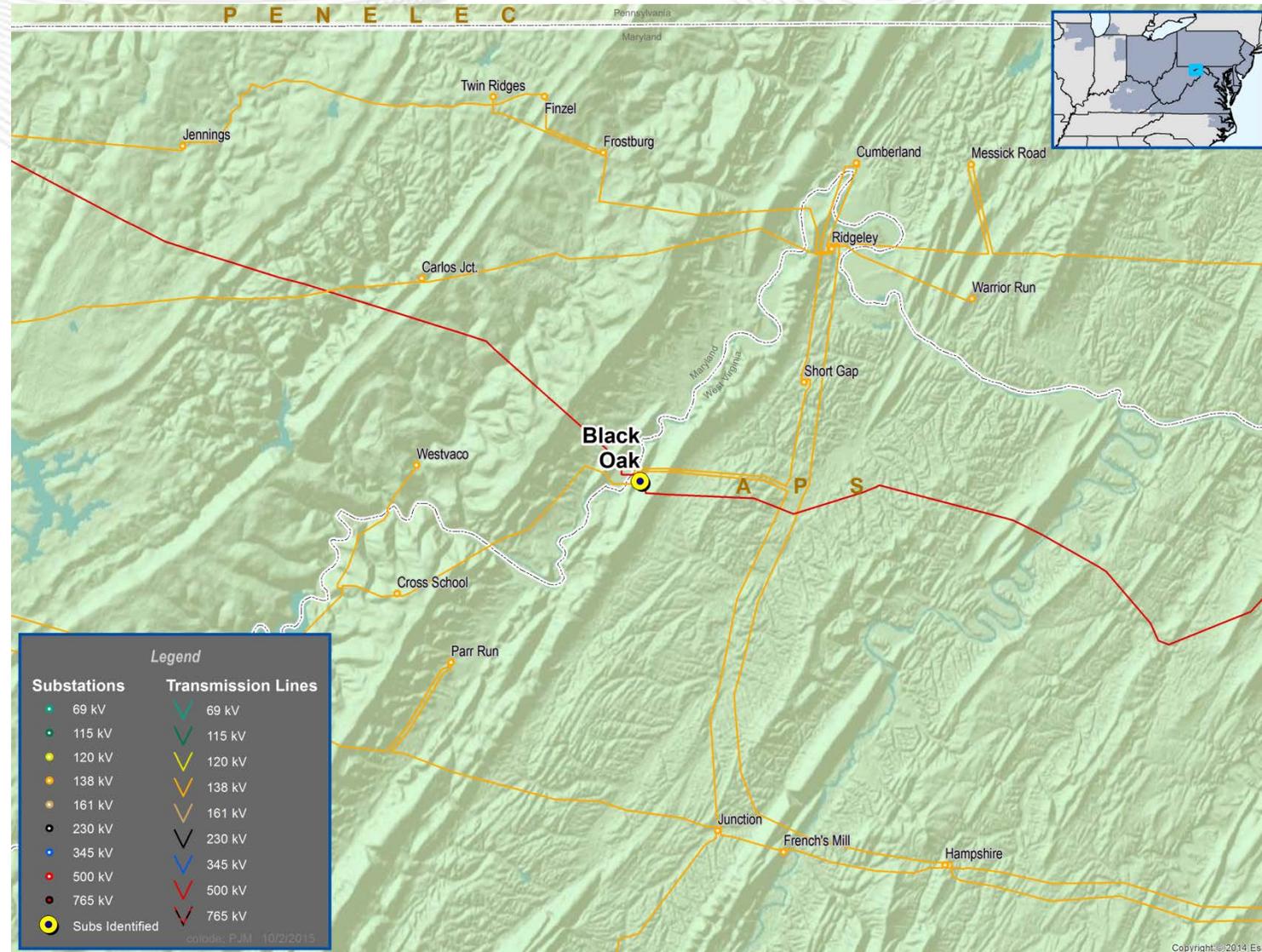
- Recommended Solution: (2015_1-2L)
 - Construct Herlan station as breaker and a half configuration with 9-138kV CB's on 4 strings and with 2-28.8 MVar capacitor banks. (B2701.1)
 - Construct new 138kV line from Herlan station to Blue Racer station. Estimated at approx. 3.2 miles of 1234 ACSS/TW Yukon and OPGW. (B2701.2)
 - Install 1-138kV CB at Blue Racer to terminate new Herlan circuit. (B2701.3)
- Designate construction to the project sponsor and local Transmission Owner (AEP)
- Estimated Project Cost:
 - \$15.64 M for B2701.1
 - \$5.78M for B2701.2
 - \$0.32M for B2701.3
- Required IS Date: 6/1/2020



- Operational Performance
- Reduce the complexity of the existing Powerton SPS
 - The system has continued to change around Powerton, including the addition of new generation, including several wind farms
 - Recent studies show that some events require out-of-step relays to trip units to meet NERC criteria.
- This condition exists today in the immediate need time frame
- Alternatives Considered:** Add additional SPS schemes at Powerton, which will make the current SPS more complex
- Proposed Immediate Need Solution:**
 - Replace five Powerton 345 kV circuit breakers with 2 cycle IPO breakers and install one new 345 kV circuit breaker; Swap the line 0302 and line 0303 bus positions; Reconfigure the Powerton 345KV bus as a single ring configuration. (B2699.1)
 - Remove SPS logic that trips generators or sectionalizes the bus under normal conditions; minimal SPS logic will remain. (B2699.2)
- Estimated Cost:** \$15M
- Projected IS Date:** 6/1/2018



- Black Oak SPS Removal
- Recent studies demonstrate that the Black Oak SPS is no longer needed for reliability
- **Alternatives Considered:** No alternatives available
- **Proposed immediate Need Solution:**
 - Remove the existing Black Oak SPS
 - The current Black Oak SPS trips the Black Oak 500/138kV transformer #3 for the loss of Black Oak – Hatfield 500KV line. (B2700)
- **Estimated Cost:** \$0.1M
- **Projected IS Date:** 12/1/2015



Problem:

- End of Life Criteria -The 34 mile section of the Line #47 between Kings Dominion 115kV and Fredericksburg 115kV was constructed on wood H-frames in 1957 and has 795 ACSR conductor with a 3/8" steel static wire.
- System Impact Assessment - Failure of Line #47 would permanently drop 96 MW of load
- This is an immediate need project based on "End of Life" criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on "End of Life" criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

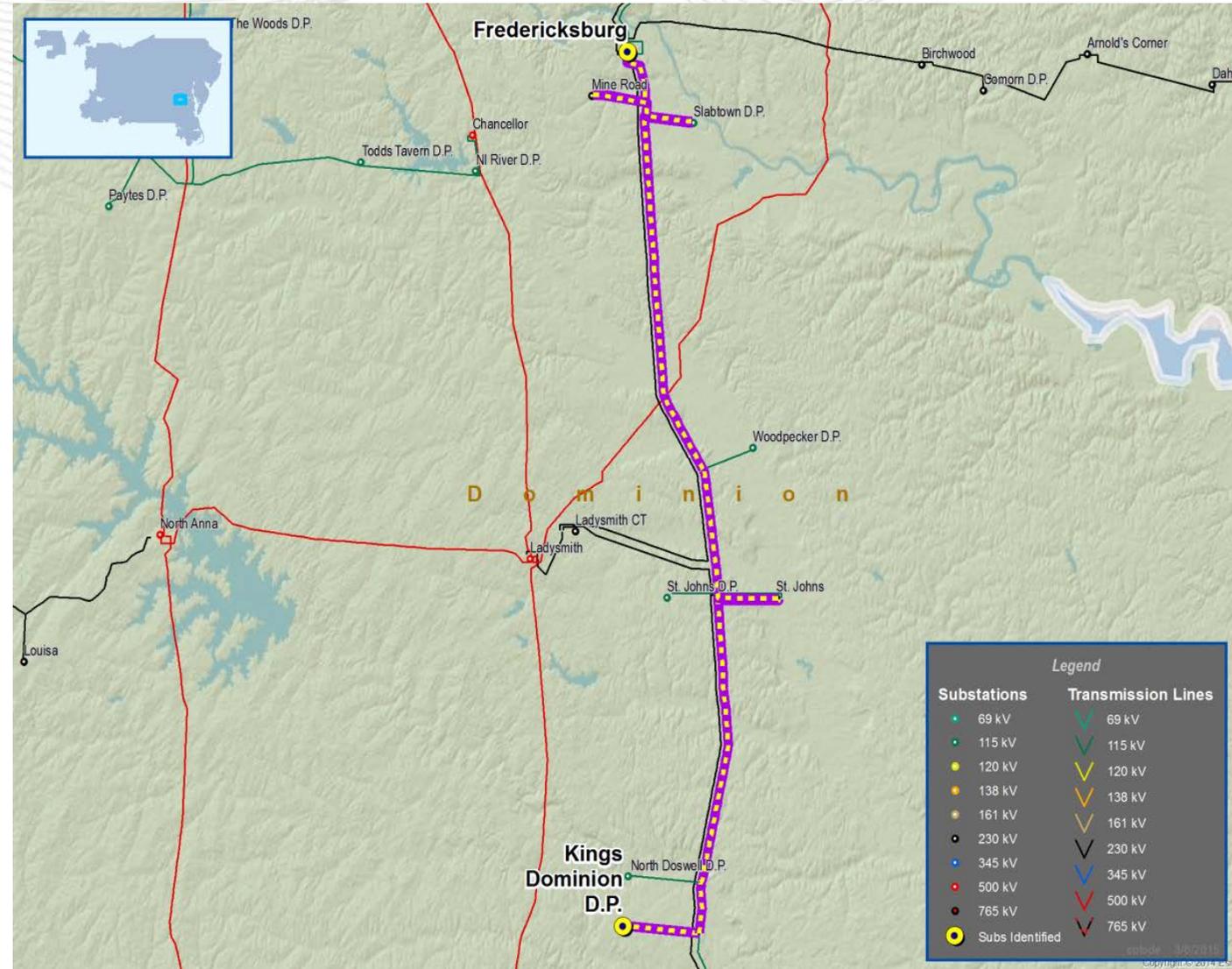
- Rebuild Line #47 between Kings Dominion 115kV and Fredericksburg 115kV to current standards with a summer emergency rating of 353 MVA at 115kV. (B2622)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$51.0 M

Projected IS Date: 12/31/2017



Problem:

- End of Life Criteria - Line #4 between Brema 115kV and Structure 8474 115kV was constructed on wood H-frame structures in 1947. This line has copper conductor and 3/8" steel static.
- System Impact Assessment - Failure of Line #4 would permanently drop 86.7 MW of load
- This is an immediate need project based on "End of Life" criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on "End of Life" criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

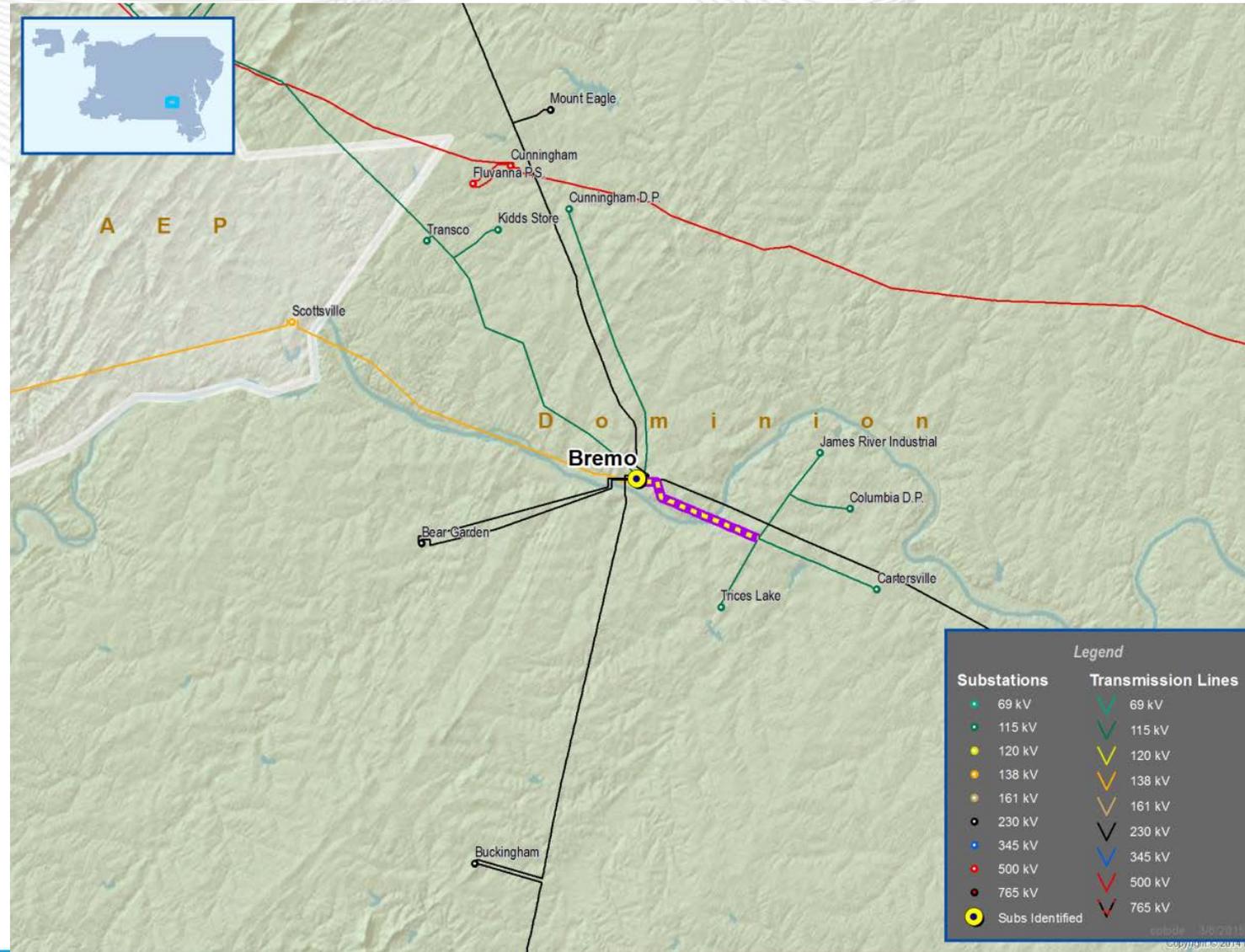
- Rebuild Line #4 between Brema 115 kV and Structure 8474 (4.5 miles) to current standards with a summer emergency rating of 261 MVA at 115kV. (B2623)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$6.8 M

Projected IS Date: 12/31/2016



Problem:

- End of Life Criteria - 115kV Lines #18 and #145 are approximately 8.35 miles long and were constructed on double-circuit, 3-pole wood H-frame structures in the timeframe between 1948 and 1954..
- System Impact Assessment - Failure of Lines #18 & #145 would permanently drop 68.5 MW of load
- This is an immediate need project based on “End of Life” criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on “End of Life” criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

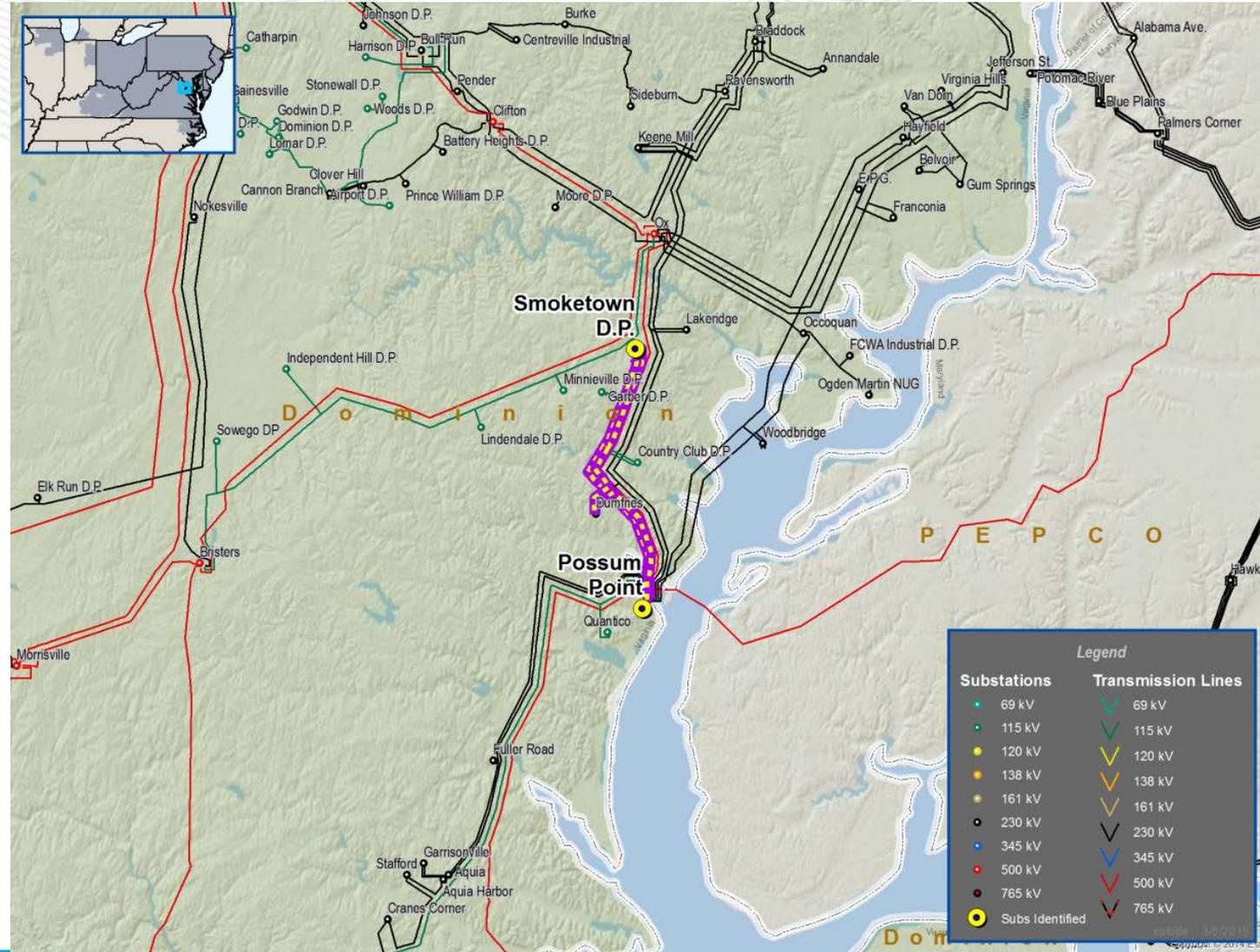
- Rebuild 115kV Lines #18 and #145 between Possum Point Generating Station and NOVEC’s Smoketown DP (approx. 8.35 miles) to current 230kV standards with a normal continuous summer rating of 524 MVA at 115kV (1047 MVA at 230kV) (B2624)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$24.7 M

Projected IS Date: 12/31/2016



Problem:

- End of Life Criteria - The 115kV Lines #48 (Sewells Point to Thole Street) and #107 (Sewells Point to Oakwood) were built on double circuit weathering steel (corten) towers in 1965. Field reports and condition assessment indicate the corten structures are in poor condition and additional structure loading will be required due to a need for fiber to be installed on these structures
- System Impact Assessment - Failure of Lines #48 & #107 would permanently drop 27 MW of load
- This is an immediate need project based on “End of Life” criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on “End of Life” criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

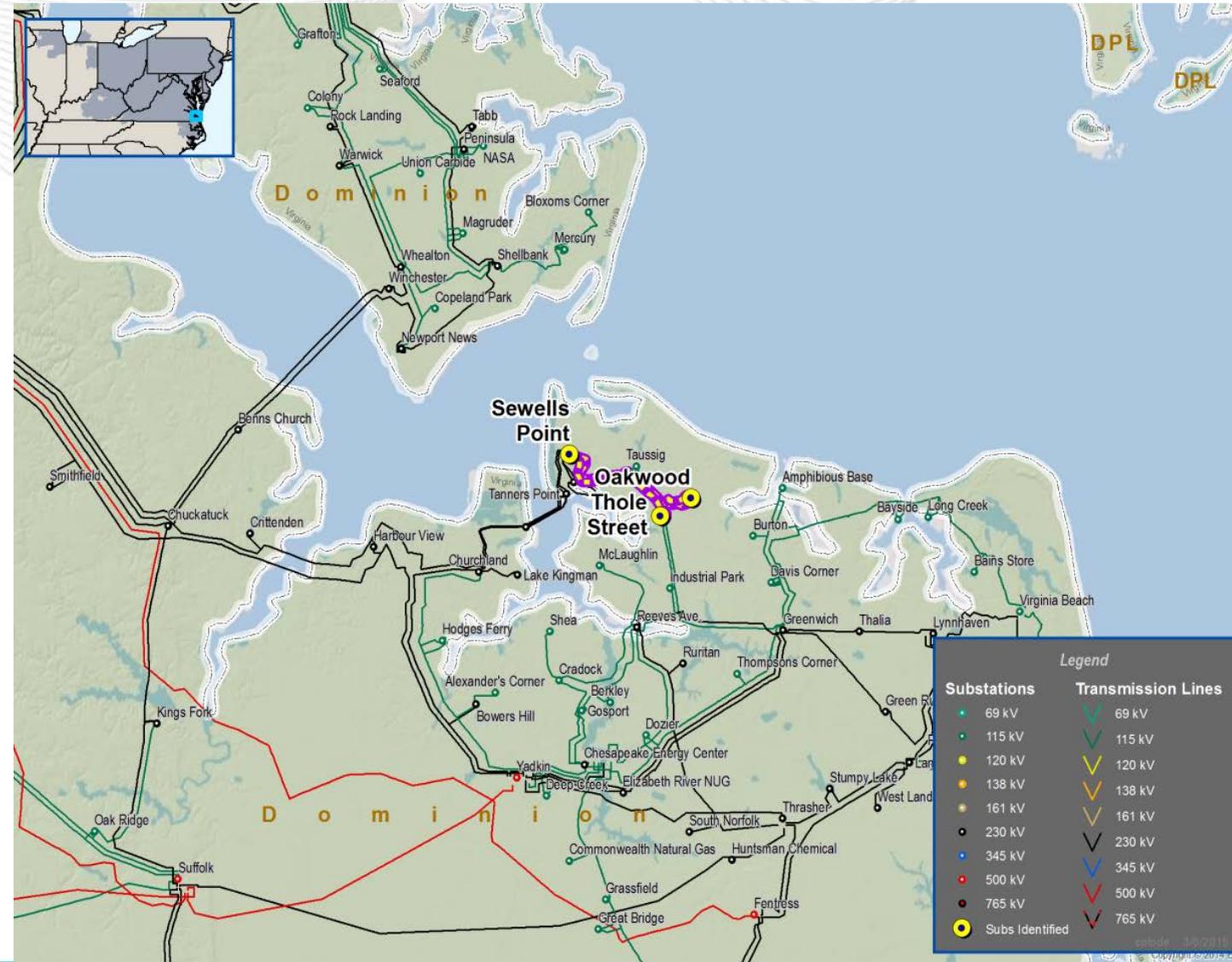
- Rebuild 115kV Line #48 between Thole Street and structure 48/71 to current standard. The remaining line to Sewells Point is 2007 vintage.
- Rebuild 115kV Line #107 line between structure 107/17 and 107/56 to current standard (B2625)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$15.3 M

Projected IS Date: 12/31/2018



Problem:

- End of Life Criteria - The 13 mile 115kV Line #34 from Skiffes Creek – Yorktown was built on wood H-frames in the 1940’s and 1950’s. This line has sections of 4/0 copper conductor and 3/8” steel static. The first 4.5 miles out of Yorktown is on 3 pole double circuit wood H-frames with the Line #61 line.
- System Impact Assessment - Failure of Lines #34 & #61 would permanently drop 198 MW of load
- This is an immediate need project based on “End of Life” criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on “End of Life” criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

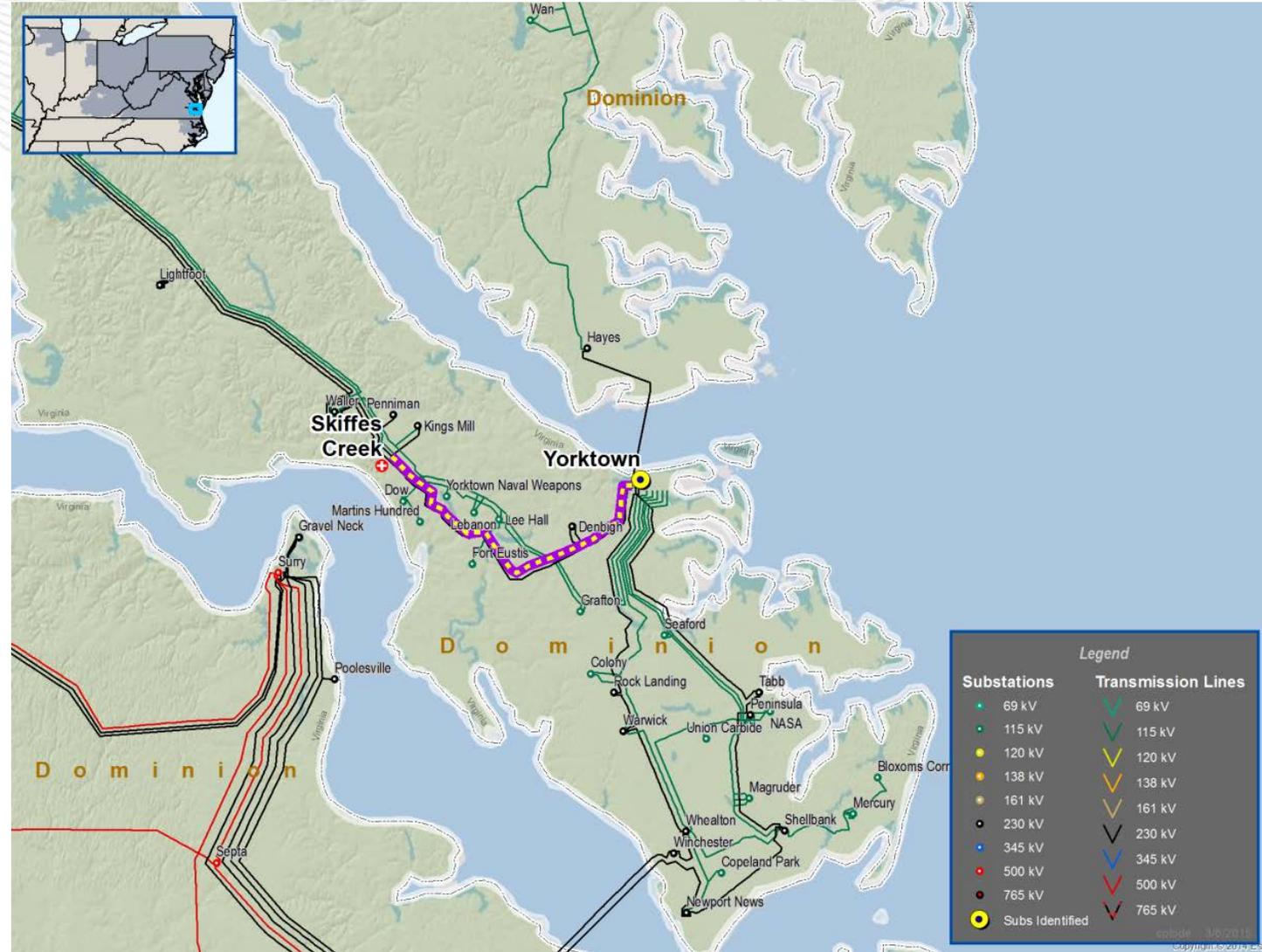
Proposed Solution:

- Rebuild the 115kV Line #34 and the double circuit portion of 115kV Line # 61 to current standards with a summer emergency rating of 353 MVA at 115kV. (B2626)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

- **Estimated Project Cost:** \$24 M
- **Projected IS Date:** 12/31/2018



Problem:

- End of Life Criteria - The 115kV Line # 1 was constructed on wood H-frame structures in 1942. This line has 2/0 copper conductor and 3/8 inch steel static.
- System Impact Assessment - Failure of Line #1 would permanently drop 31 MW of load
- This is an immediate need project based on “End of Life” criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on “End of Life” criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

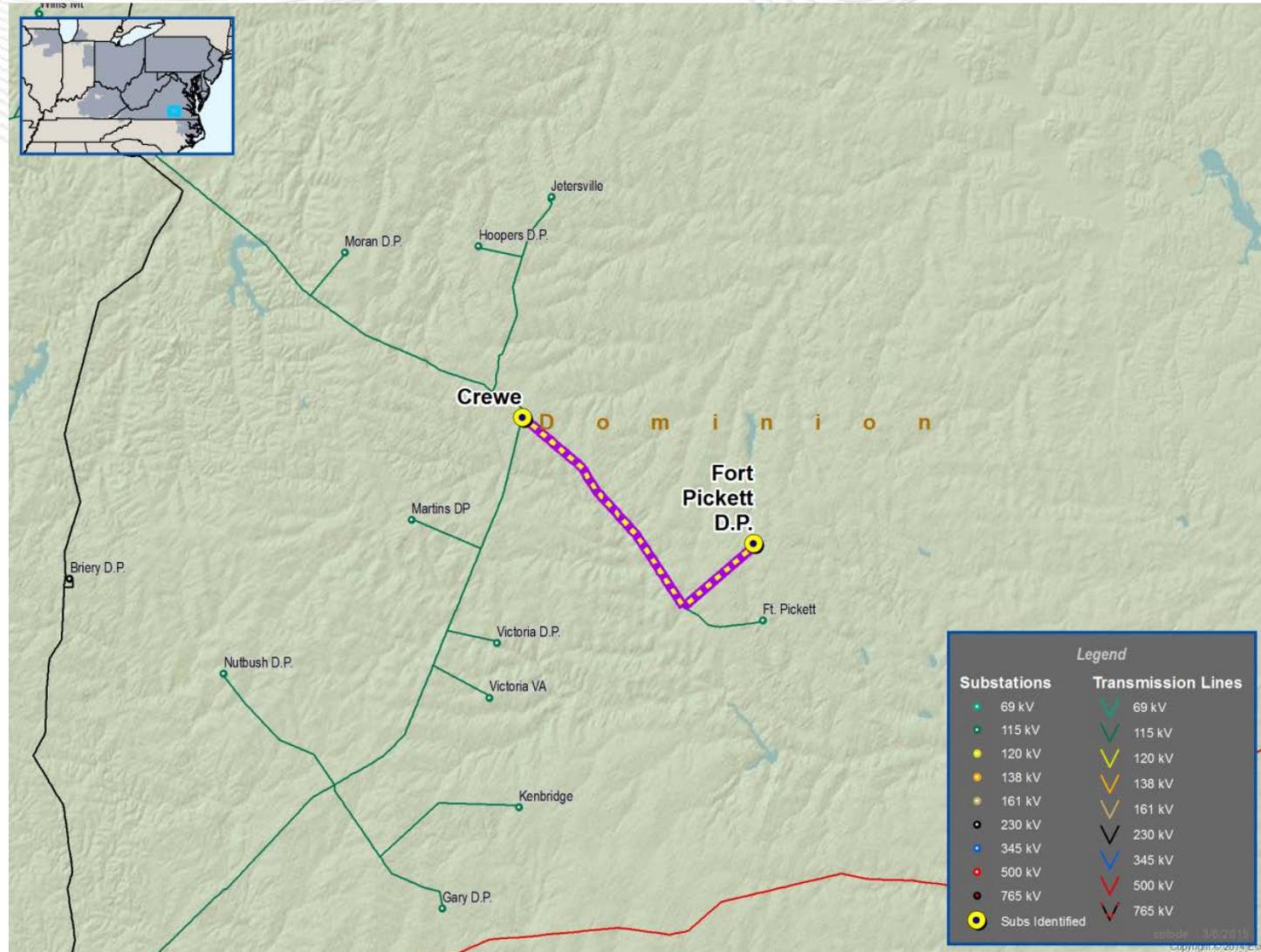
- Rebuild 115kV Line #1 between Crewe 115kV and Fort Pickett DP 115kV (12.2 miles) to current standards with a summer emergency rating of 261 MVA at 115kV. (B2627)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$18.3 M

Projected IS Date: 12/31/2016



Problem:

- End of Life Criteria - The Line #82 line was constructed on wood H-frame structures in 1953. This line has ACSR conductor and 3/8 inch steel static.
- System Impact Assessment - Failure of Line #82 would permanently drop 49 MW of load
- This is an immediate need project based on “End of Life” criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on “End of Life” criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

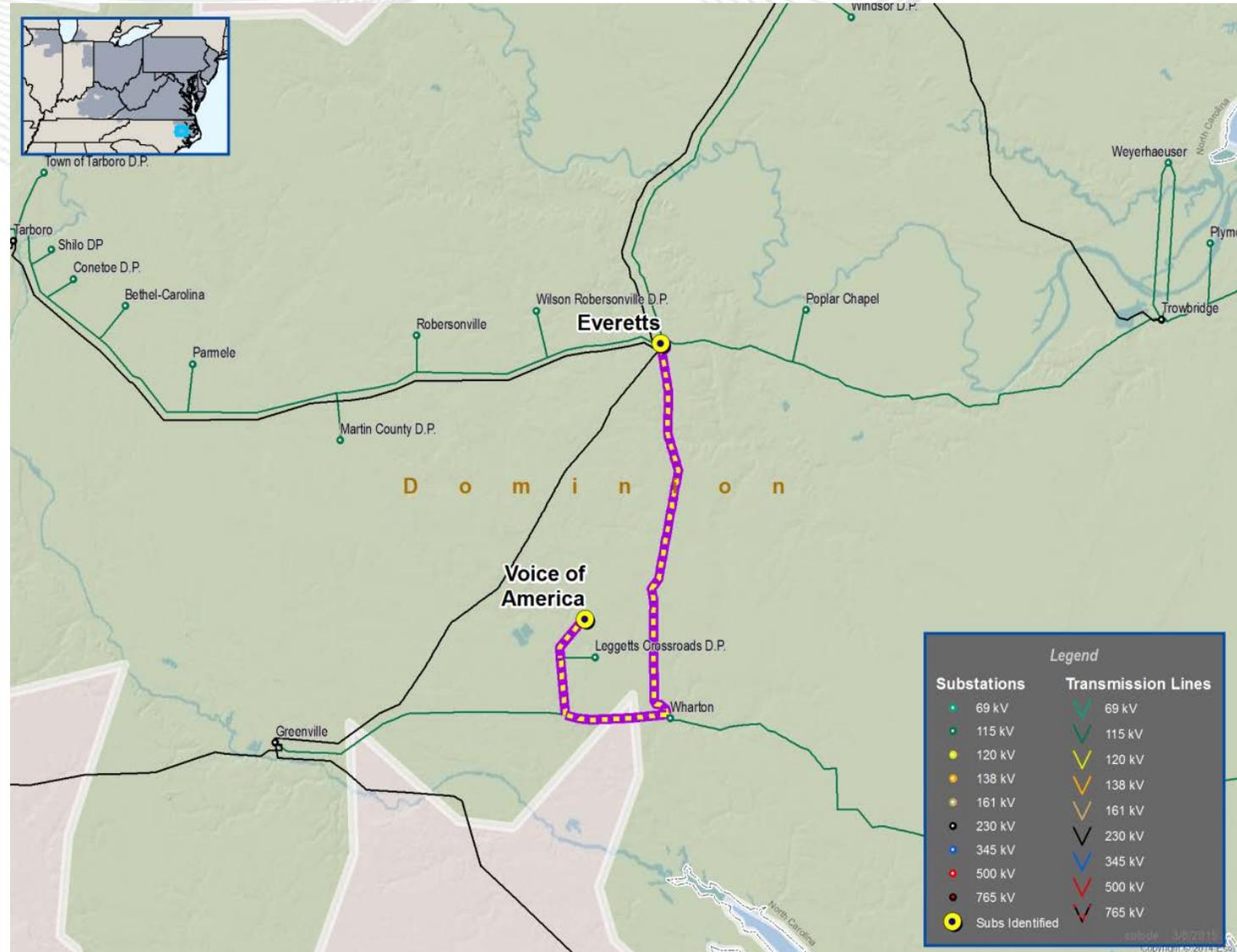
- Rebuild 115kV Line #82 Everetts – Voice of America (20.8 miles) to current standards with a summer emergency rating of 261 MVA at 115kV (B2628)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$24 M

Projected IS Date: 12/31/2017



Problem:

- End of Life Criteria - The 115kV Lines #27 (new line 166) and # 67 lines from Greenwich to Burton were built on double circuit weathering steel (Corten) towers in 1964. The corten structures are in poor condition and additional structure loading will be required due to a need for fiber to be installed on these structures.
- System Impact Assessment - Failure of Lines #27 & #67 would permanently drop 90 MW of load
- This is an immediate need project based on “End of Life” criteria.
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on “End of Life” criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

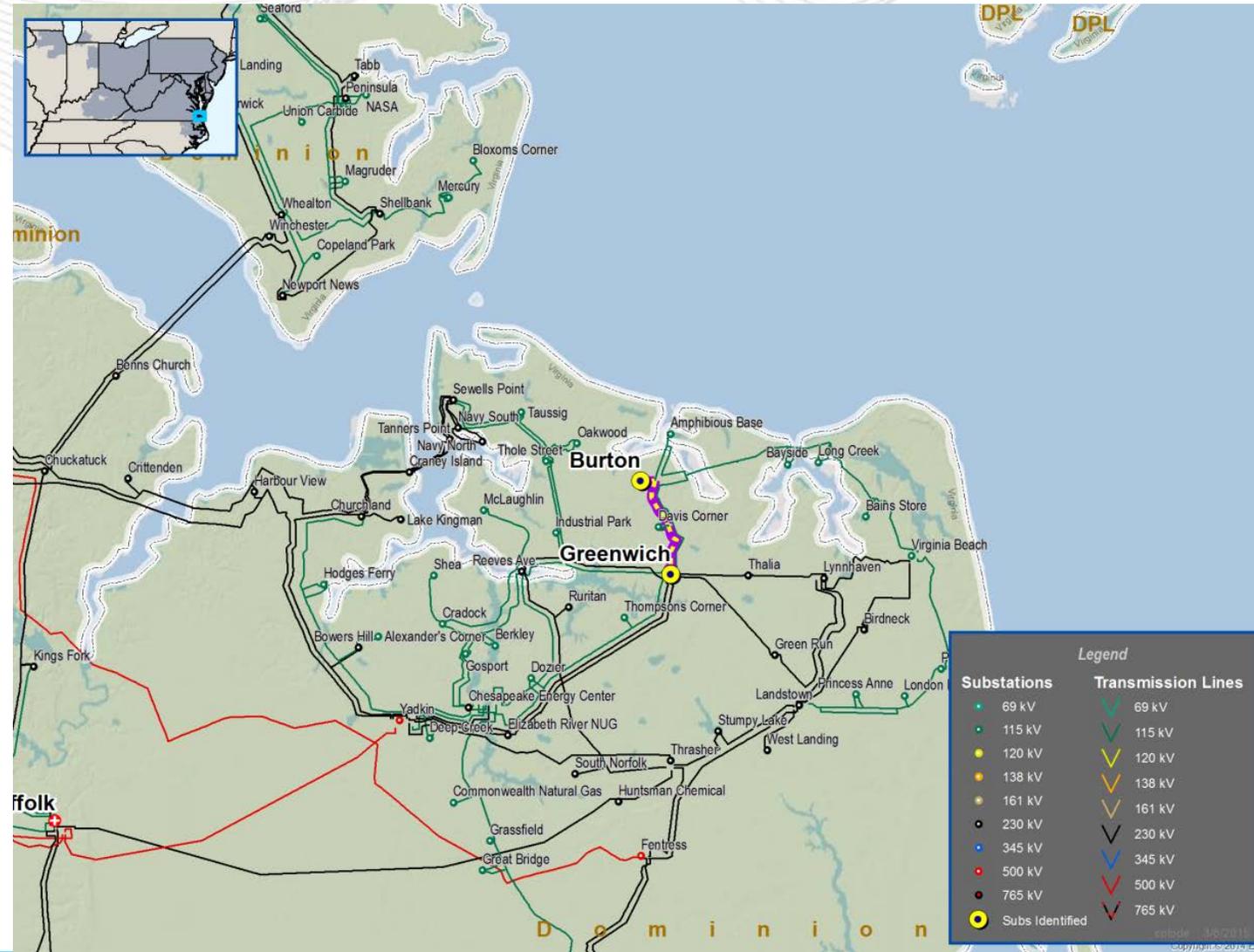
- Rebuild the 115kV Lines #27 & #67 lines from Greenwich 115kV to Burton 115kV Structure 27/280 to current standard with a summer emergency rating of 262 MVA at 115kV (B2629)

Construction Designation:

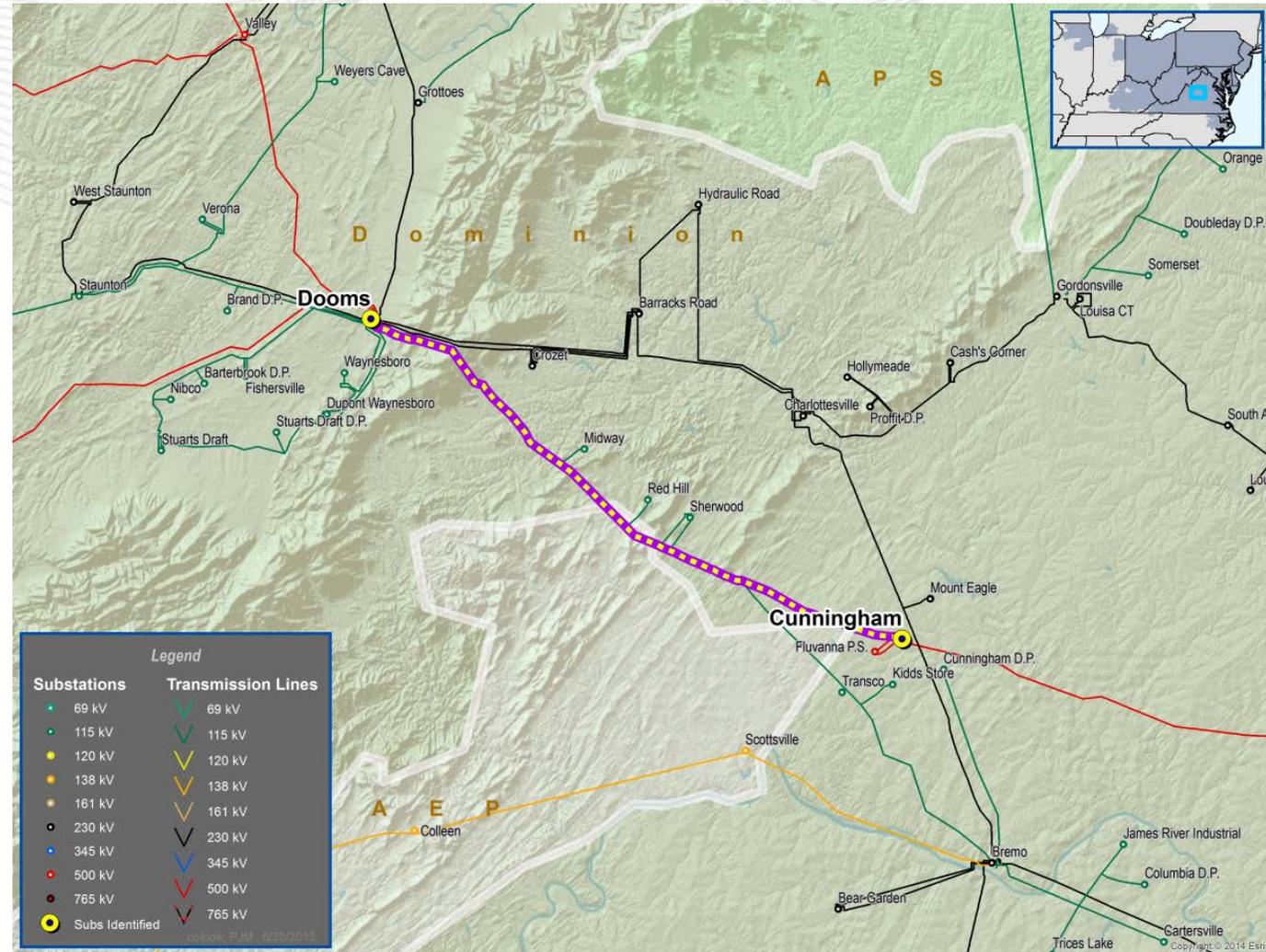
The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$8.85 M

Projected IS Date: 12/31/2019



- Dominion End of Life Criteria Violation on the Cunningham to Dooms 500 kV Line
 - Third party evaluation:
 - Confirmed the Cunningham to Dooms 500 kV is nearing or has reached its End of Life
 - Performed a Risk Assessment
 - Reliability Assessments without the line result in Criteria violations:
 - PJM validated the following violations
 - NERC B “N-1” (New NERC TPL-001-4 P3) Violations:
 - Initial Loss of Front Royal generation followed by loss of Mt Storm- Valley 500kV line
 - Overload of Edinburg - Strasburg 138 Kv
- Continued on the next slide



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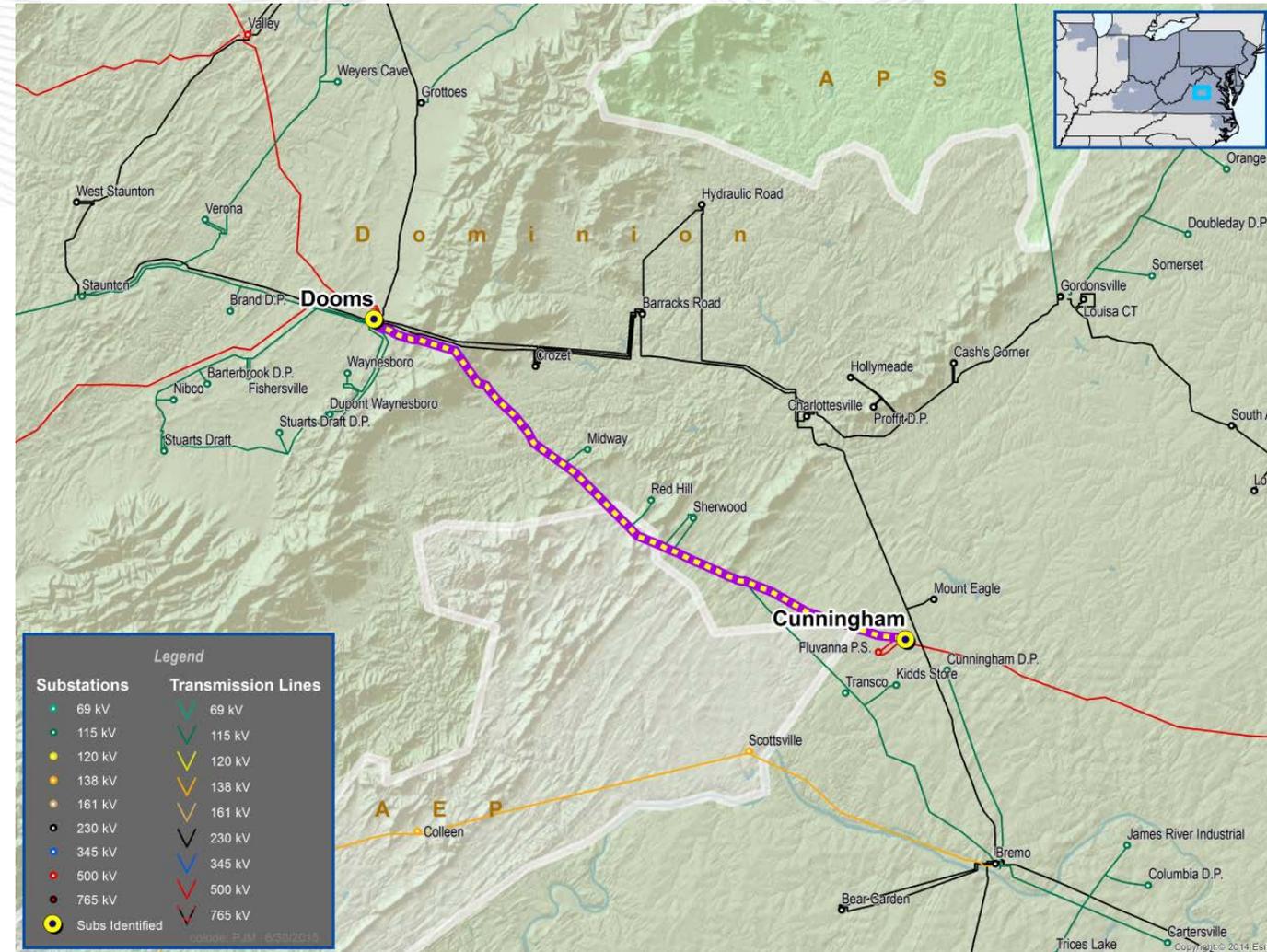
- NERC C3 “N-1-1” (New NERC TPL-001-4 P6)
 - Loss of Lexington – Cloverdale 500kV and Bath County to Valley 500kV lines causes the following issues
 - Low voltage and voltage drop in the 500kV area of Bath County, Doods, Lexington, and Valley
 - Voltage drop in the 230kV area of Lexington Low Moor, and Clifton
- When this criteria violation was identified, the need date was already in the immediate need timeframe This is an immediate need project based on “End of Life” criteria.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner (Dominion) is the Designated Entity.
- Recommended Solution: Rebuild the Cunningham – Doods 500 kV line as a PJM baseline upgrade
- Estimated Cost: \$110M
- Projected In Service Date: June 2020



Driver:

- The Chesapeake - Deepcreek - Bowers Hill - Hodges Ferry 115 kV line is overloaded for various GenDeliv and N-1-1 contingencies.
- PJM was notified of this generation deactivation in the immediate need timeframe. When this criteria violation was identified, the need date was already in the immediate need timeframe.

Alternatives Considered

- Given the immediate need timing of the violation, alternatives that would require new lines to be built were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

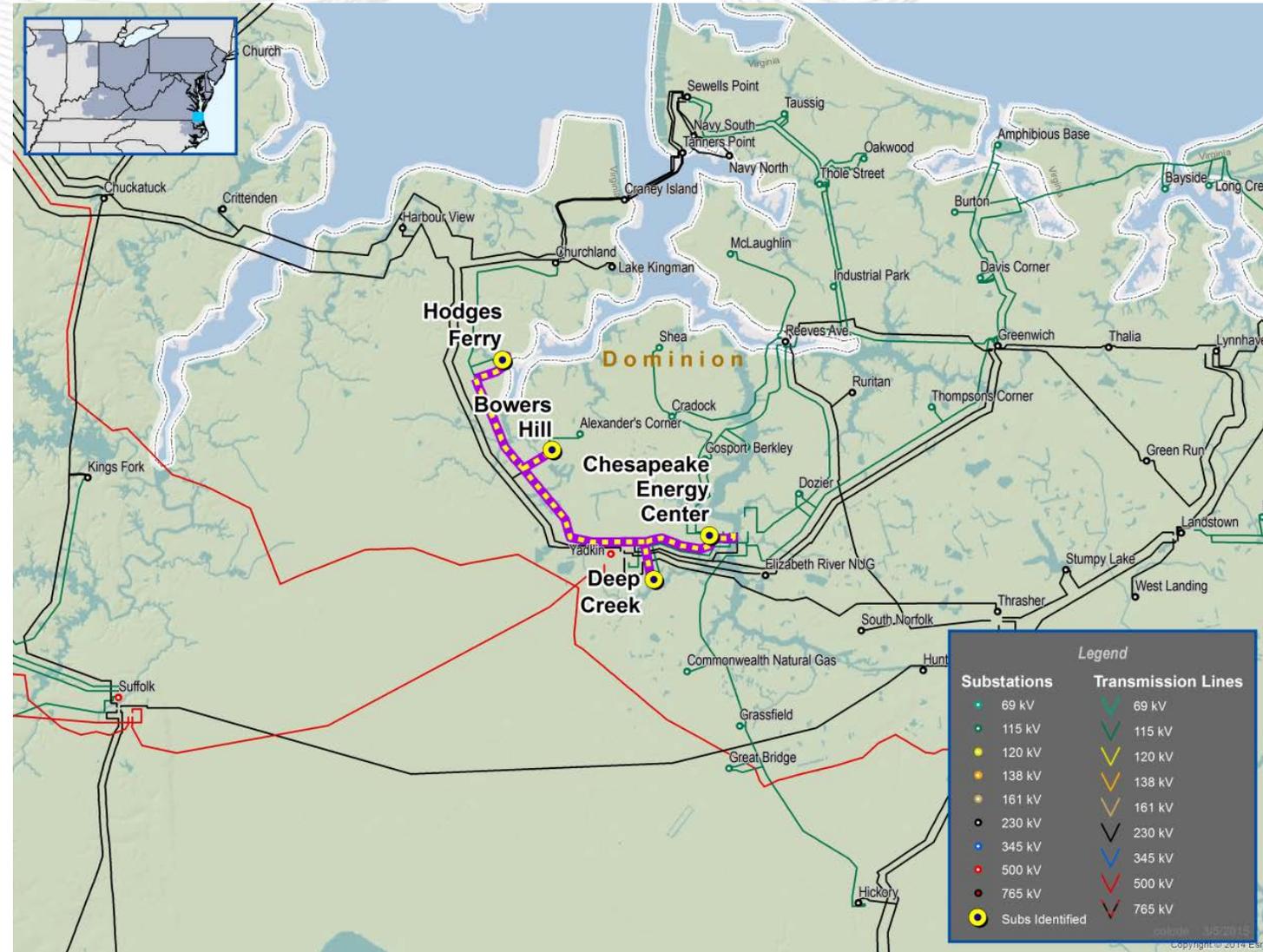
- Wreck and rebuild the Chesapeake - Deepcreek - Bowers Hill - Hodges Ferry 115 kV line; minimum rating 239 MVA normal/emergency, 275 MVA load dump rating (b2620)

Construction Designation:

- The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$10 M

Required IS Date: 6/1/2016



Problem:

- Transmission upgrades are needed on GSU units #4 and #5 at Gravel Neck to improve Operational Performance.

Alternatives Considered

- Given the immediate need timing of the violation and estimated cost of the solution additional alternatives were not considered.

Immediate Need

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

Proposed Solution:

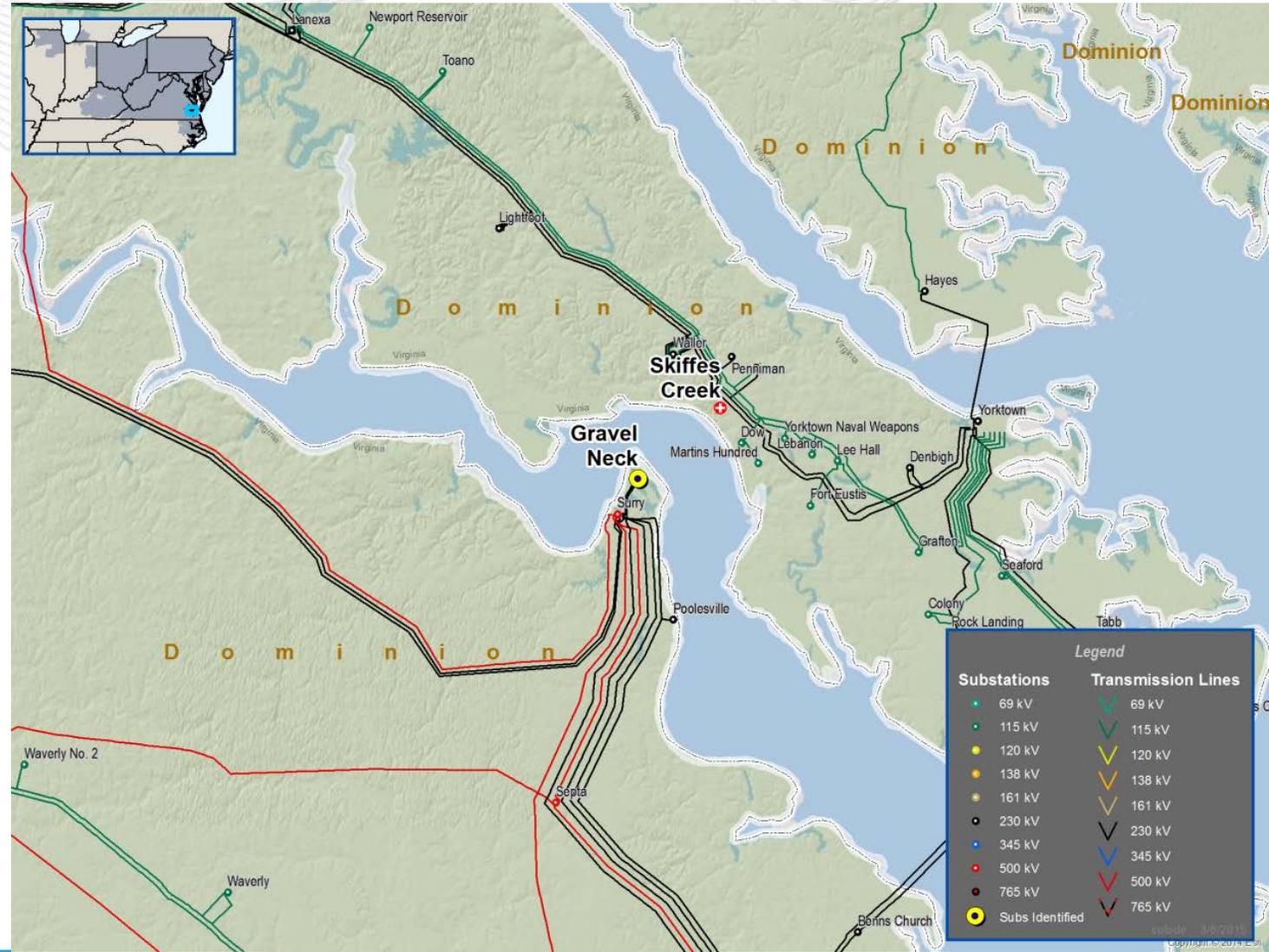
- Install circuit switchers on GSU units #4 and #5. Install two 230kV CCVT's on Lines #2407 and #2408 for loss of source sensing (B2630)

Construction Designation:

The local Transmission Owner (Dominion Virginia Power)

Estimated Project Cost: \$662 K

Projected IS Date: 5/31/2015





Project Scope Change: B2637

Previous Scope: Convert Middletown Junction 230 kV substation to nine bay double breaker configuration

New Scope:

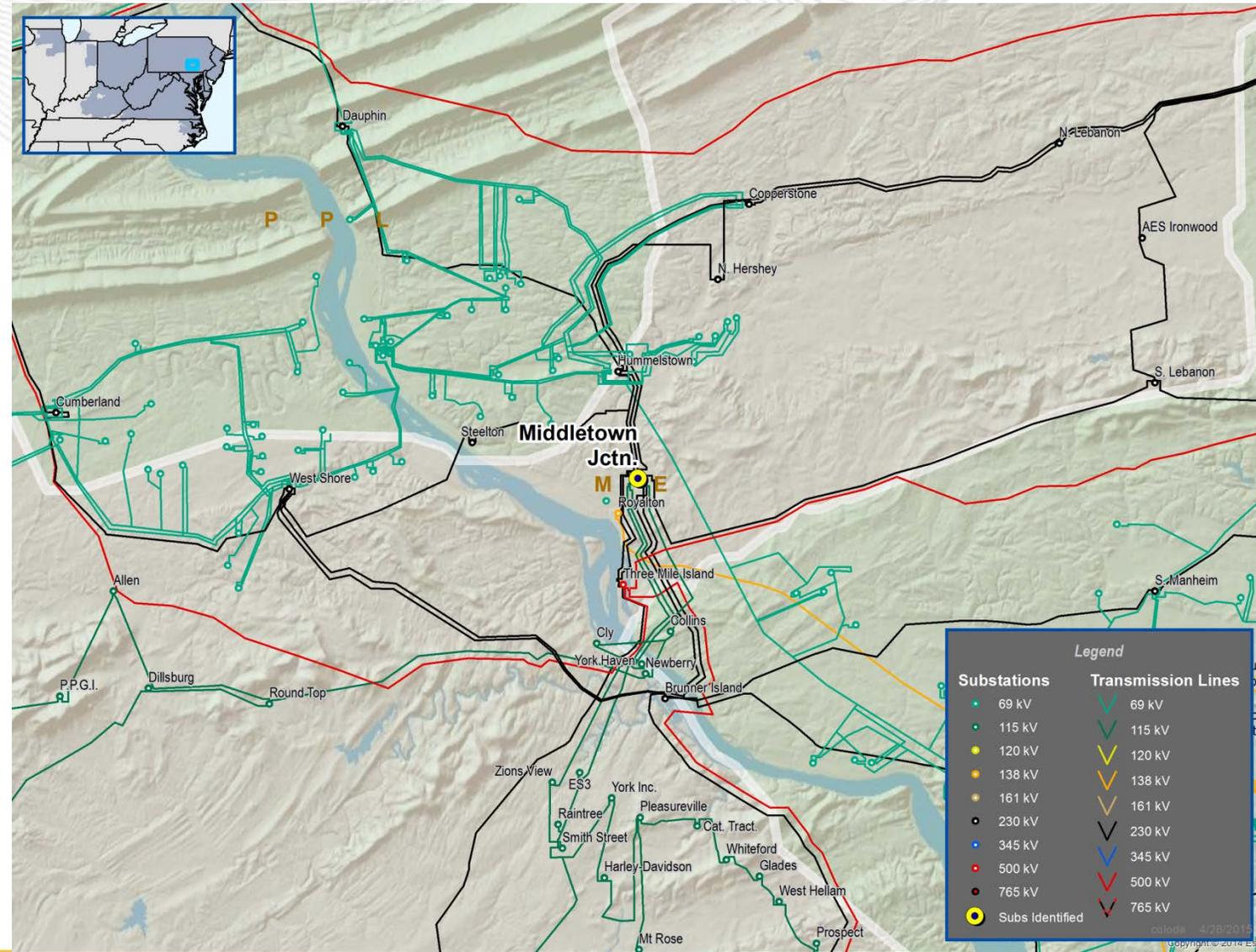
- Relocate the line terminals for four 230 kV lines at Middletown Junction (B2637.1)
- Install 230 kV circuit breakers on high sides of #1 and #2 230/115 kV and #3 230/69 kV transformers at Middletown Junction (3 new 230 kV circuit breakers total) (B2637.2)

Due to the time sensitive nature that this current issue presents, MetEd/FirstEnergy (Local TO) will be the Designated Entity

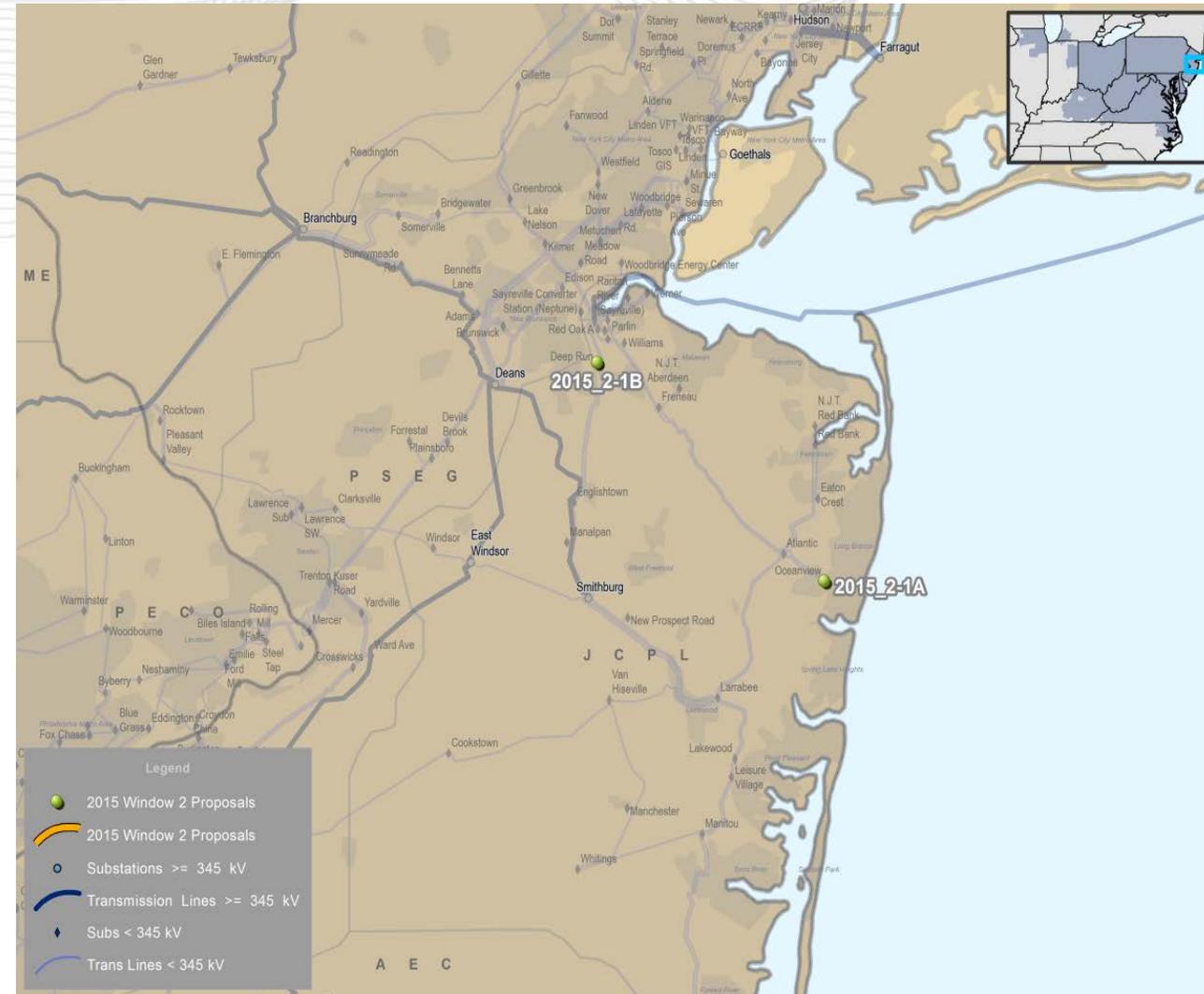
Old Estimated Cost: \$15.5 M

New Estimated Cost: \$7.8 M

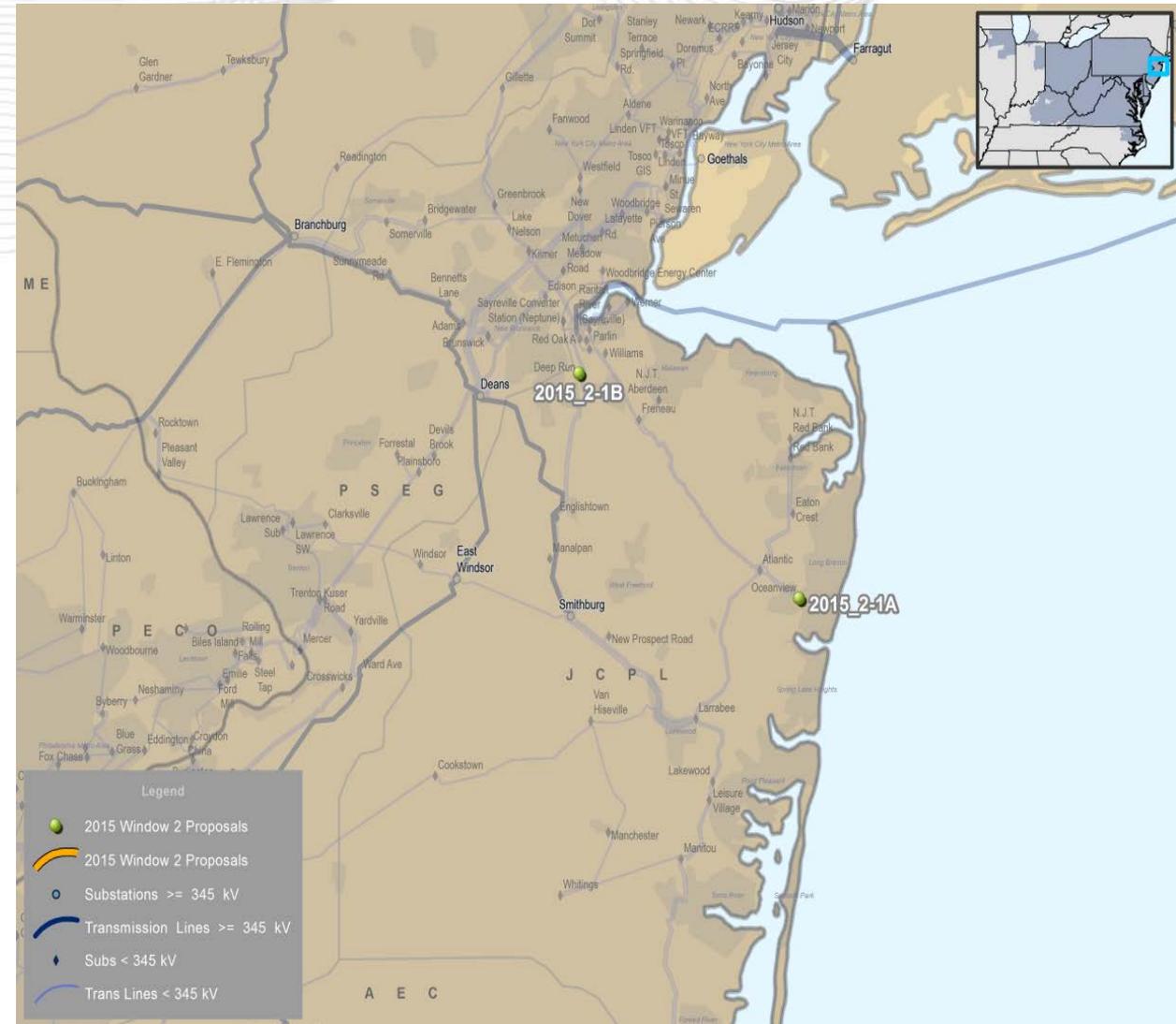
Required IS Date: 6/1/2015



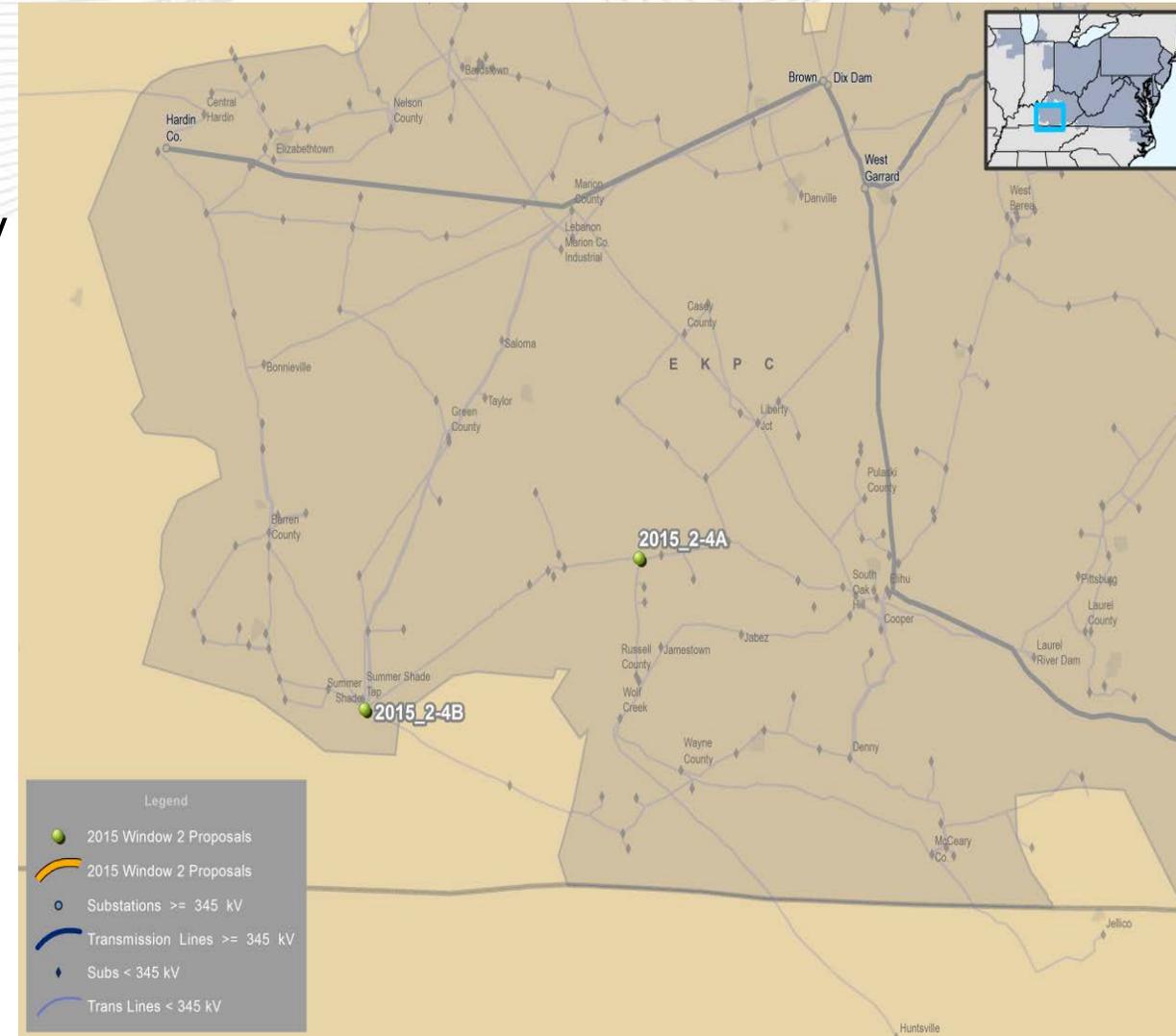
- **FE Transmission Owner Criteria Violation (FG# JC-1 and JC-2)**
- The Oceanview 230/34.5 kV transformer #1 is overloaded for loss of the Oceanview 230/34.5 kV transformer #2.
- **Alternatives considered:**
 - 2015_2_1A (\$4.065 M)
- **Recommended Solution:**
 - Replace the Oceanview 230/34.5 kV transformer #1 . (2015_2_1A) (B2708)
- **Construction Designation:**
 - The local Transmission Owner, FirstEnergy
- **Estimated Project Cost: \$4.065 M**
- **Required IS Date: 6/1/2020**



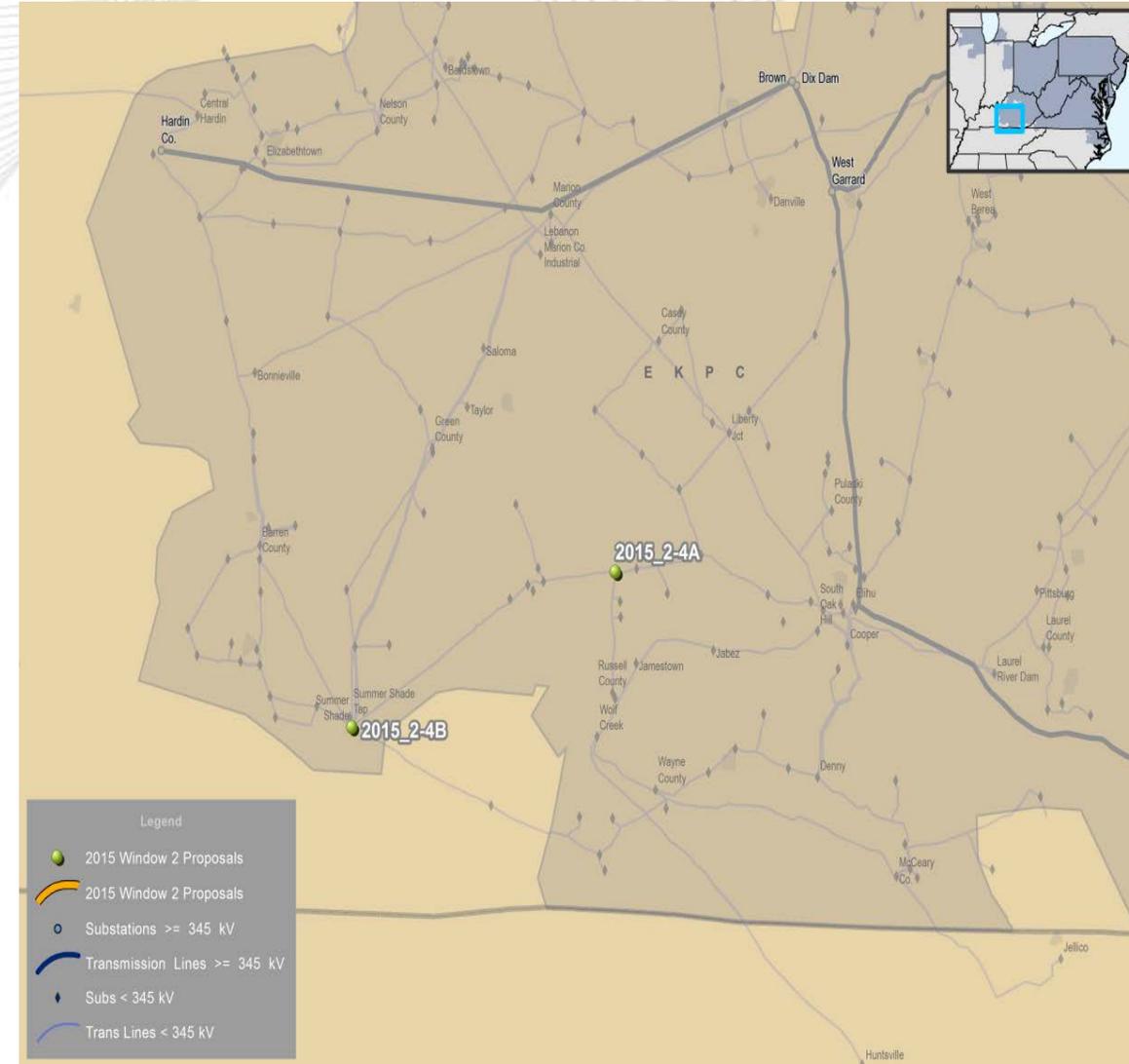
- **FE Transmission Owner Criteria Violation (FG# JC-3 and JC-4)**
- The Deep Run 230/34.5 kV transformer #1 is overloaded for several contingencies.
- **Alternatives considered:**
 - 2015_2_1B (\$2.432 M)
- **Recommended Solution:**
 - Replace the Deep Run 230/34.5 kV transformer #1 . (2015_2_1B) (B2709)
- **Construction Designation:**
 - The local Transmission Owner, FirstEnergy
- **Estimated Project Cost: \$2.432 M**
- **Required IS Date: 6/1/2020**



- **EKPC Transmission Owner Criteria Violation (FG# EKPC-T1)**
- The Summer Shade 161/69 kV transformer #1 is overloaded for the loss of the Barren County 161/69 kV.
- **Alternatives considered:**
 - 2015_2_4B (\$0.075 M)
- **Recommended Solution:**
 - Upgrade the Summer Shade bus and CT associated with the 161/69 kV transformer #1. (2015_2_4B) (B2710)
- **Construction Designation:**
 - The local Transmission Owner, EKPC
- **Estimated Project Cost: \$0.075 M**
- **Required IS Date: 6/1/2020**



- **EKPC Transmission Owner Criteria Violation (FG# EKPC-V1)**
- Low Voltage violation at Sewellton Junction 69 kV substation for single contingency loss of the Cooper – Wolf Creek 161 kV path.
- **Alternatives considered:**
 - 2015_2_4A (\$0.4M)
- **Recommended Solution:**
 - Install 25.5 MVAR 69 kV capacitor at Sewellton Junction 69 kV substation. (2015_2_4A) (B2711)
- **Construction Designation:**
 - The local Transmission Owner, EKPC
- **Estimated Project Cost: \$0.4 M**
- **Required IS Date: 6/1/2020**





December 2015 Recommendations to the PJM Board

- All recommended baseline solutions in today's presentation will be presented to the PJM Board in December and recommended for inclusion in the RTEP.



RTEP Next Steps

- 2015 RTEP Windows
- Status of market Efficiency analysis
- Cases and models build update
- Assumptions review in December 2015
- 2016 Scenario analysis

Questions?

Email: RTEP@pjm.com

- Revision History
 - Original version posted to PJM.com – 11/4/2015
 - Version 2 – posted to PJM.com – 11/5/2015
 - Slide 23 updates to PJM estimate cost and recommended solution wording