



Reliability Analysis Update

Transmission Expansion Advisory
Committee

June 8, 2017

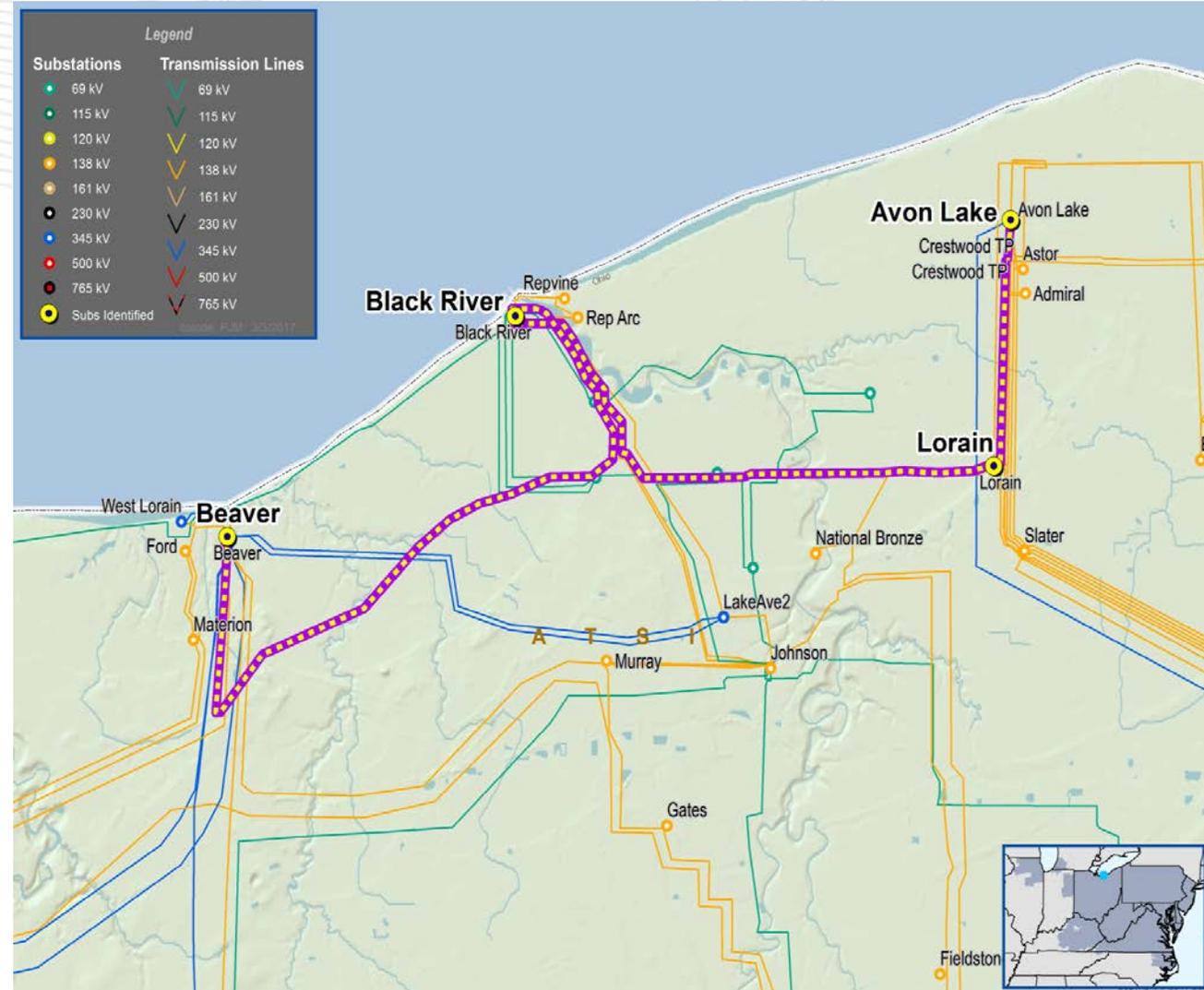




2016 RTEP Proposal Window #3/3A Update

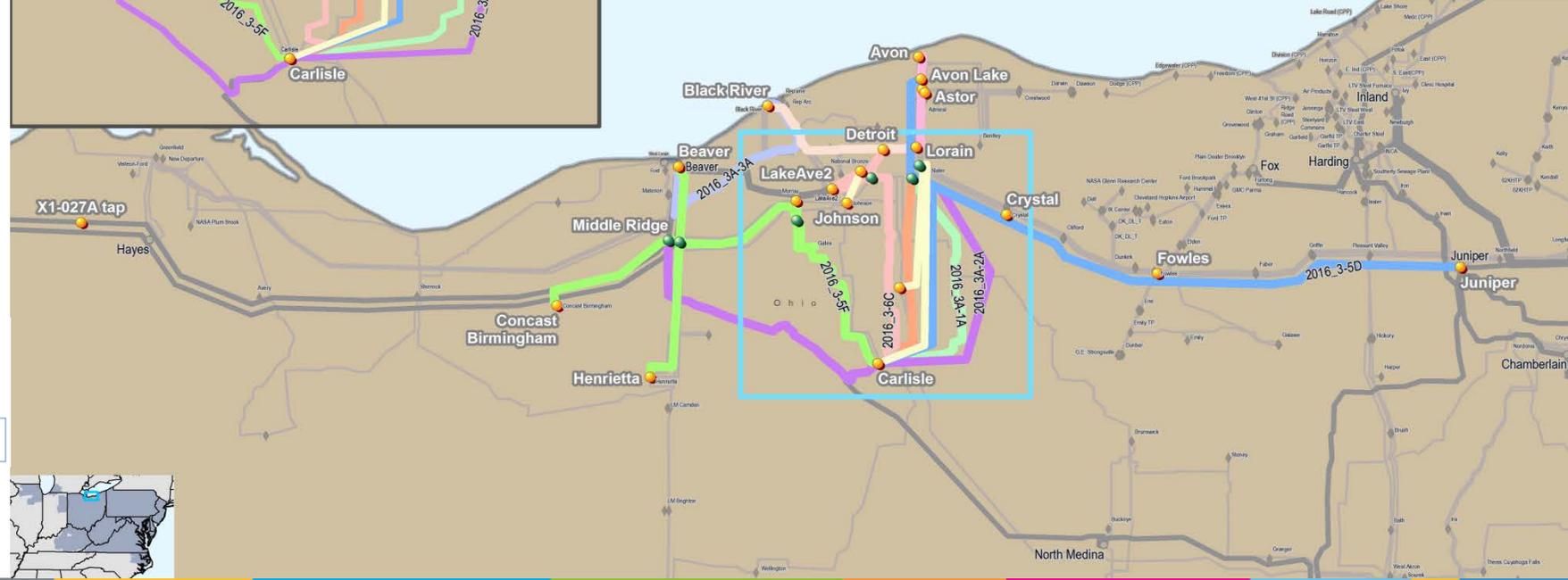
- The Avon Lake – Black River – Beaver area had several flowgates identified as part of 2016 RTEP Window 3
- One of the flowgates found to be invalid due to incorrect modeling and as a result PJM posted an addendum to the 2016 RTEP Window 3
- There were several projects proposed to solve the flowgates listed below during the Window 3 and Window 3 Addendum
 - Window 2 (Summer Analysis) → FG # 915
 - Window 3 (Winter Analysis) → FG # 392, 393, 489, 490, 400, 493, 407 and 504
 - Window 3 Addendum (Winter Analysis) → FG # 386
- PJM evaluated 13 stakeholder proposals

- **Common Mode Outage (FG# 392, 393, 400, 407, 489, 490, 493 and 504) :**
- Black River – Lorain - Avon 138 kV circuit is overloaded for tower outage loss of Avon – Lake Ave 345 kV circuits and line fault stuck breaker contingency loss of the Avon – Lake Ave 345 kV circuits.
- **Common Mode Outage (Summer - FG# 915 and Winter – FG# 386) :**
- The Beaver to Black River 138 kV circuit is overloaded for tower line contingency loss of the Lake Ave – Beaver 345 kV circuits .

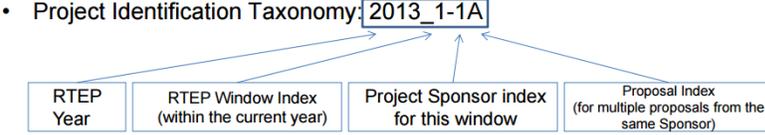


• **Alternatives considered:**

- 2016_3-2C/ 2016_3A-1A
- 2016_3-5B
- 2016_3-5D
- 2016_3-5F
- 2016_3-6B / 2016_3A-3B
- 2016_3-6C
- 2016_3-6D/ 2016_3A-2C
- 2016_3A-3A
- 2016_3A-1B
- 2016_3A-2A



Project Naming Convention





Reliability Analysis Result Summary

	Cost Estimate	FG #	Comment									
Project ID	(\$ Million)	393	490	392	489	400	493	407	504	386	915	
2016_3-2C	44.9	O	O	O	O	O	O	O	O	O	O	Essentially the same as project 2016_3A-1A
2016_3-5B	19	O	O	O	O	O	O	O	O	X	X	
2016_3-5D	35.4	O	O	O	O	O	O	O	O	O	O	New 345 kV circuit overload. Beaver - Carlisle 345 kV (118%) for tower outage
2016_3-5F	12.4	X	X	X	X	X	X	X	X	X	O	
2016_3-6B	13.4	X	X	X	X	O	O	O	O	X	X	Essentially the same as project 2016_3A-3B
2016_3-6C	30.3					O	O	O	O			
2016_3-6D	3.2	O	O	O	O	X	X	X	X	X	X	Essentially the same as project 2016_3A-3C
2016_3A-1A	44.58	O	O	O	O	O	O	O	O	O	O	New 345 kV circuit overload. Beaver - Carlisle 345 kV (118%) for tower outage
2016_3A-1B	50.56											Analysis deferred due to high project cost
2016_3A-2A	62.8											Analysis deferred due to high project cost
2016_3A-3A	19.97	X	X	X	X	X	X	X	X	O	O	
2016_3A-3B	13.46	X	X	X	X	O	O	O	O	X	X	
2016_3A-3C	3.2	O	O	O	O	X	X	X	X	X	X	

- Note:**
- Blue shaded cells indicate the flowgates that were identified by the Proposing Entity as solved by the proposal
 - 'O' means yes, the proposed project solves the flowgate violation
 - 'X' means no, the proposed project doesn't solve the flowgate violation



Proposals Comparison and Cost Summary							
Project ID	Proposing Entity	Cost Estimate (\$ Million)	Advantages	Disadvantages	Additional upgrade	Additional Cost (\$ Million)	Total Cost (\$ Million)
2016_3-2C / 2016_3A-1A	Transource (Greenfield)	44.58	Solves all Flowgates	Causes a new violation. Requires a new ROW	Replace terminal equipments at the Beaver and Carlisle 345 kV stations	1	45.58
2016-3-5B	NTD (Greenfield)	19	Solves 8 Flowgates	2 unsolved flowgates	Upgrade FG # 386 and 915	Cost from 2016-3A-3A (19.97)	38.97
2016_3-5D	NTD (Greenfield)	35.4	Solves all Flowgates	Causes a new violation. Requires a new ROW	Replace terminal equipments at the Beaver and Carlisle 345 kV stations	1	36.4
2016_3-5F	NTD (Greenfield)	12.4	Solves one flowgate	9 unsolved flowgates	Upgrade FG # 386, 392, 393, 489 and 490, 400, 493, 407 and 504	Cost from 2016-3A-3A, 2016_3A-3B and 2016-3A-3C (36.63)	49.03
2016_3-6B / 2016_3A-3B	First Energy (Upgrade)	13.46	Solves 4 flowgates	6 unsolved flowgates	Upgrade FG # 386, 915, 392, 393, 489 and 490	Cost from 2016-3A-3A and 2016-3A-3C (23.17)	36.63
2016_3-6C	First Energy (Greenfield)	30.3	Solves 4 flowgates	6 unsolved flowgates	Upgrade FG # 386, 915, 392, 393, 489 and 490	Cost from 2016-3A-3A and 2016-3A-3C (23.17)	53.47
2016_3-6D / 2016_3A-3C	First Energy (Upgrade)	3.2	Solves 4 flowgates	6 unsolved flowgates	Upgrade FG # 386, 915, 400, 493, 407 and 504	Cost from 2016-3A-3A and 2016_3A-3B (33.43)	36.63
2016_3A-3A	First Energy (Upgrade)	19.97	solves 2 flowgates	8 unsolved flowgates	Upgrade FG # 392, 393, 489 and 490, 400, 493, 407 and 504	Cost from 2016_3A-3B and 2016-3A-3C (16.66)	36.63



2016 RTEP Proposal Window 3/3A ATSI Transmission Zone

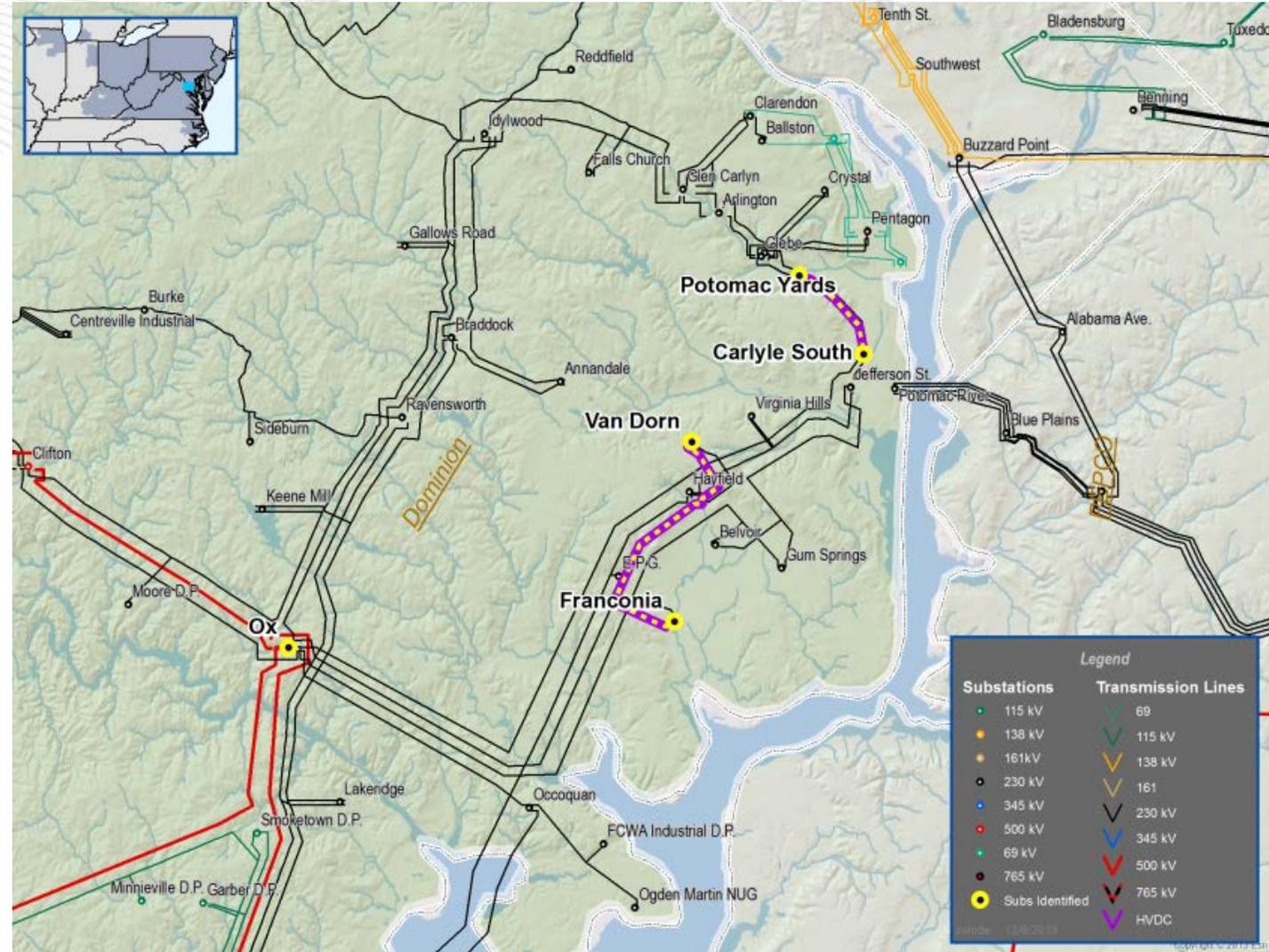
- The First Energy Combined proposals (2016_3A-3A, 2016_3A-3B and 2016_3A-3C) total cost is the lowest of any of the proposed solutions, with the exception of the 2016-3-5D,
- First Energy projects (2016_3A-3A, 2016_3A-3B and 2016_3A-3C) are upgrades to existing facilities and therefore do not have siting or permitting risk associated with the alternative
- Greenfield proposals.
- **Recommended Solution:**
 - Rebuild/Reconductor the Black River – Lorain 138 kV circuit. (2016_3A-3B) → B2896
 - Reconductor the Avon – Lorain 138 kV section and upgrade line drop at Avon (2016_3A-3C) → B2897
 - Reconductor the Beaver - Black River 138kV) with 954Kcmil ACSS conductor and upgrade terminal equipment on both stations. (2016_3A-3A) → B2898
- **Estimated Project Cost:**
 - 2016_3A-3B → \$ 3.2 M
 - 2016_3A-3C → \$ 13.46 M
 - 2016_3A-3A → \$ 19.97 M
- **Required IS Date:** 6/1/2021

Dominion/PEPCO B2443 - Glebe to Station C Project Update

NERC and Dominion Criteria Violations:

- NERC Category B single contingency overloads:
 - Franconia 230kV to Van Dorn 230kV overloads for the outage of Possum Point 230kV to Woodbridge A 230kV
 - Ox 500/230kV Tx #1 overloads for the outage of Tx #2 and vice versa under stressed conditions with Possum Point #6 off

- NERC Category C “N-1-1” overloads:
 - Franconia to Van Dorn 230kV overloads for the N-1-1 outage of N Potomac Yards A 230 kV to S Carlyle 230kV and Possum Point to Woodbridge A 230 kV
 - Ox 500/230kV Tx #1 overloads for the N-1-1 outage of Loudoun 500kV to Ox 500kV and Ox 500/230 kV Tx#2 or Tx#2 for Tx#1.
 - Lines 2023 & 2112 N. Potomac Yards to N. Alexandria to S Carlyle 230 kV overloads for the N-1-1 outage of Line 248 N Potomac Yards to S Carlyle 230 kV and Falls C 230 kV to Idylwood 230 kV.
 - Line 248 N Potomac Yards 230kV to S Carlyle 230 kV overloads for the N-1-1 outage of line 241 Hayfield 230 kV to Jefferson St. 230 kV and Franconia A to Ox 230 kV



Solutions Considered:

- Several alternatives internal to Dominion.
- Evaluated several Dominion to PHI tie-line alternatives.

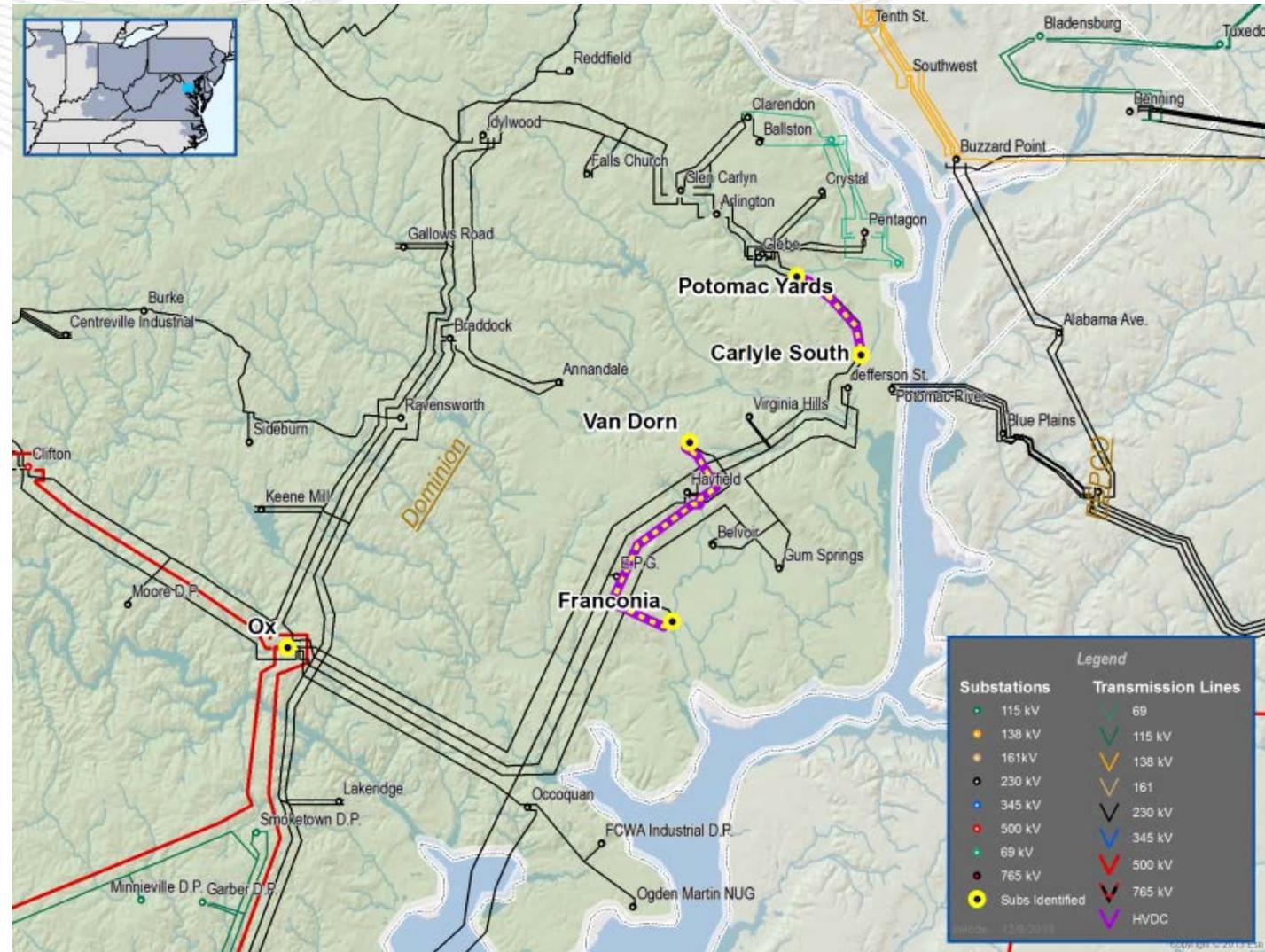
Recommended Solution:

- Baseline upgrade B2443
- Construct new underground 230 kV line from Glebe to Station C, rebuild Glebe Substation, construct 230 kV high-side bus at Station C
- Install a Phase Angle Regulator (PAR) at Station C

Estimated Project Cost: \$165.4 M

Expected In-Service Date: 6/1/2018

TEAC Presentation Dates: 12/11/2013, 01/09/2014, 11/11/2014





Current PJM Board Approved Costs

New Line (Glebe-Potomac River)		
<u>Components</u>	<u>Baseline ID</u>	<u>Estimate</u>
DVP		
Construct new underground 230 kV line from Glebe to Station C	b2443	\$45.8 M
Rebuild Glebe Substation	b2443	\$42.8 M
Replace the Idylwood 230 kV breaker '203512' with 50kA breaker	b2443.1	\$0.255 M
Replace the Ox 230 kV breaker '206342' with 63kA breaker	b2443.2	\$0.27 M
PEPCO		
Station C Substation work associated with new 230 kV line from Glebe	b2443	\$66.8 M
Construct 230 kV high-side bus and install 800 MVA PAR at Potomac River 230 kV (Station C)	b2443.3	\$10 M
Total Cost		\$166 M

New Line (Glebe-Potomac River)		
<u>Components</u>	<u>Baseline ID</u>	<u>Estimate</u>
DVP		
Construct new underground 230 kV line from Glebe to Station C	b2443	\$136.5 M
Rebuild Glebe Substation	b2443	\$65.0 M
Replace the Idylwood 230 kV breaker '203512' with 50kA breaker	b2443.1	\$0.255 M
Replace the Ox 230 kV breaker '206342' with 63kA breaker	b2443.2	\$0.27 M
PEPCO		
New 230kV Potomac River Substation Project (includes PAR)	b2443/b2443.3	\$75.2 M
Blue Plains Substation Breaker Replacements Project	b2443	\$2 M
Potomac River Transmission Line Project	b2443	\$19.6 M
Total Cost		\$299 M

- DVP
 - 230 kV Line Estimate
 - Routing new line complicated due to urban environment & NPS Properties
 - Easement costs exceeded preliminary estimates
 - Underground construction methodology (micro tunneling) resulted in a higher per foot cost versus open trenching
 - Glebe Substation Estimate
 - Expansion of existing substation is not possible and requires conversion to GIS
- PEPCO
 - Refined engineering cost estimates since project was first presented
 - Facilities require relocation to be able to construct project

Dominion Update End of Life Criteria

Baseline Reliability - TO Criteria Violation Line #231 Landstown to Thrasher Rebuild

Problem Statement: Dominion “End of Life Criteria”

- 230kV Line #231 from Landstown to Thrasher is 8.5 miles long and was built mostly on double circuit weathering steel (Corten) towers in 1965. The corten structures are in poor condition. The existing summer emergency rating of this line is 955 MVA.
- This line needs to be rebuilt to current standards based on Dominion’s “End of Life” criteria.
- Permanent MW load loss for removal of this line is 89 MW.

Potential Solution:

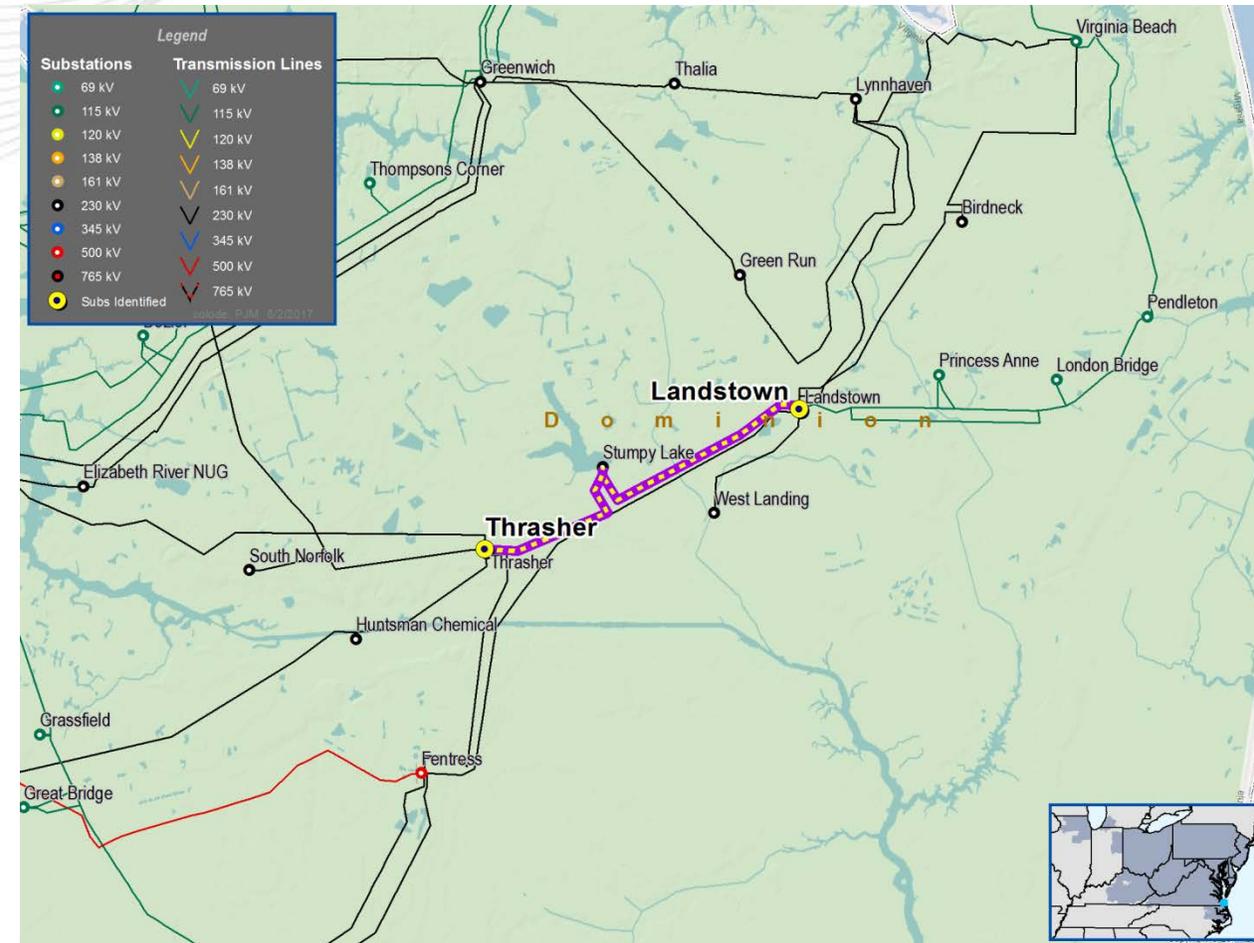
- Line #231 will be rebuilt to current standard with a summer emergency rating of 1046 MVA at 230kV. Proposed conductor is 2-636 ACSR. Structures being considered include double circuit steel pole and double circuit galvanized steel tower.

Alternatives: No feasible alternatives

Estimated Project Cost: \$22 M

Possible IS Date: Dec 2020

Project Status: Conceptual



Supplemental Projects



AEP Transmission Zone Supplemental Project

Supplemental Project: Olive Station Breaker Replacement Previously Presented at 5/4/2017 TEAC

Problem Statement/Driver:

The Circuit Breaker E2 at Olive Station is an SF6, FX-22 type manufactured by GE. There are only 11 of this type in the entire AEP system. Additionally, physical space limitations do not allow ground switches to be installed on the existing breaker. This breaker has had 48 fault operations, exceeding the manufacturer's recommended limit of 3.

Selected Solution:

Replace existing 345kV 50 kA CB E2 at Olive station with a 5000A 63kA circuit breaker along with associated equipment and protection. (S1341)

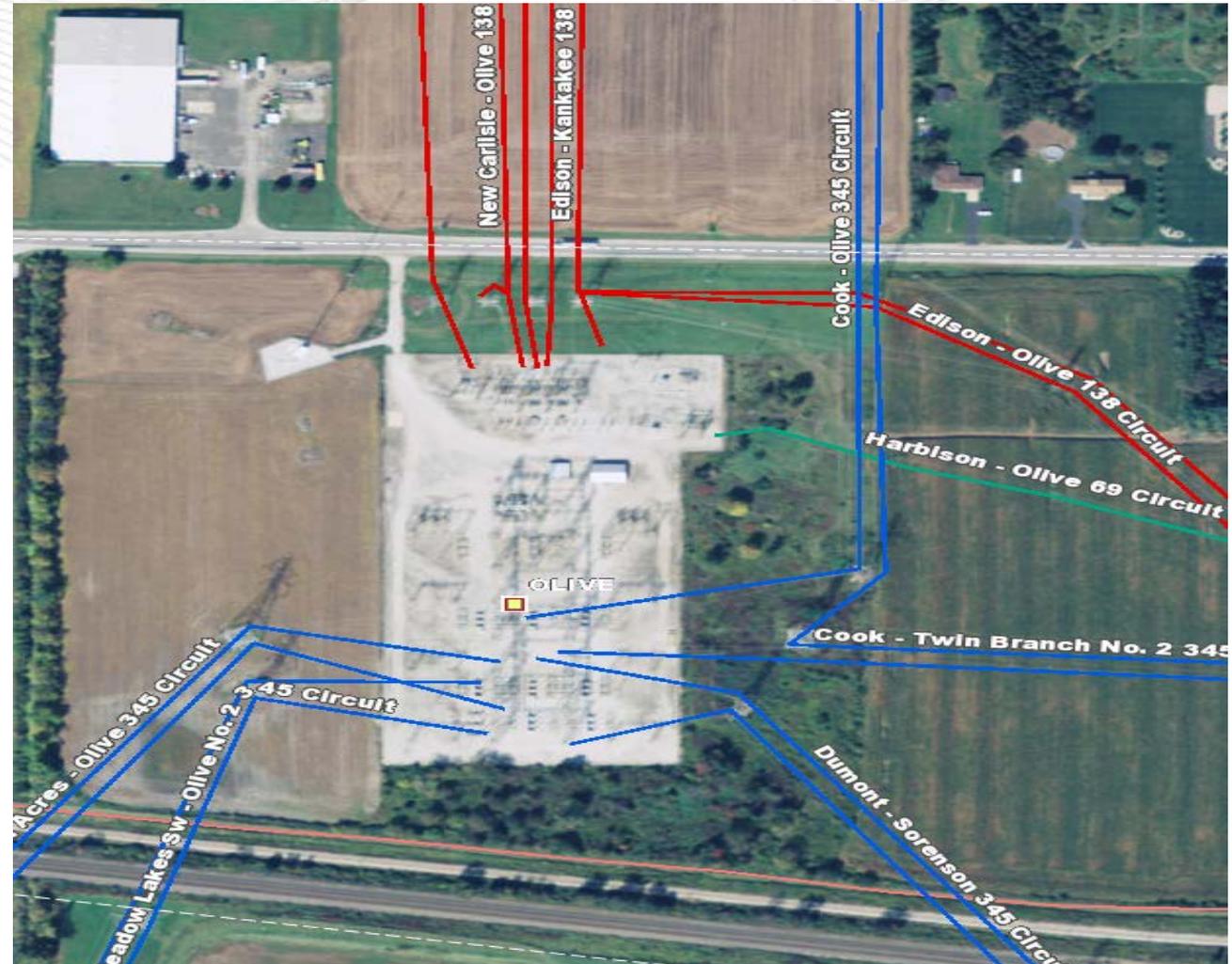
Alternatives:

No additional cost effective alternatives were identified.

Cost Estimate: \$1.077M

Projected IS date: 7/15/2017

Status: Construction





Dominion Transmission Zone Supplemental Project

Supplemental Project: Copeland Park Substation – New 230kV DP

Problem Statement:

- Dominion Distribution has identified the need of a 230kV delivery point at Copeland substation because of load growth and contingency consideration. Load on existing 115/23kV TX#1 will be shifted to this new transformer.

Potential Solution:

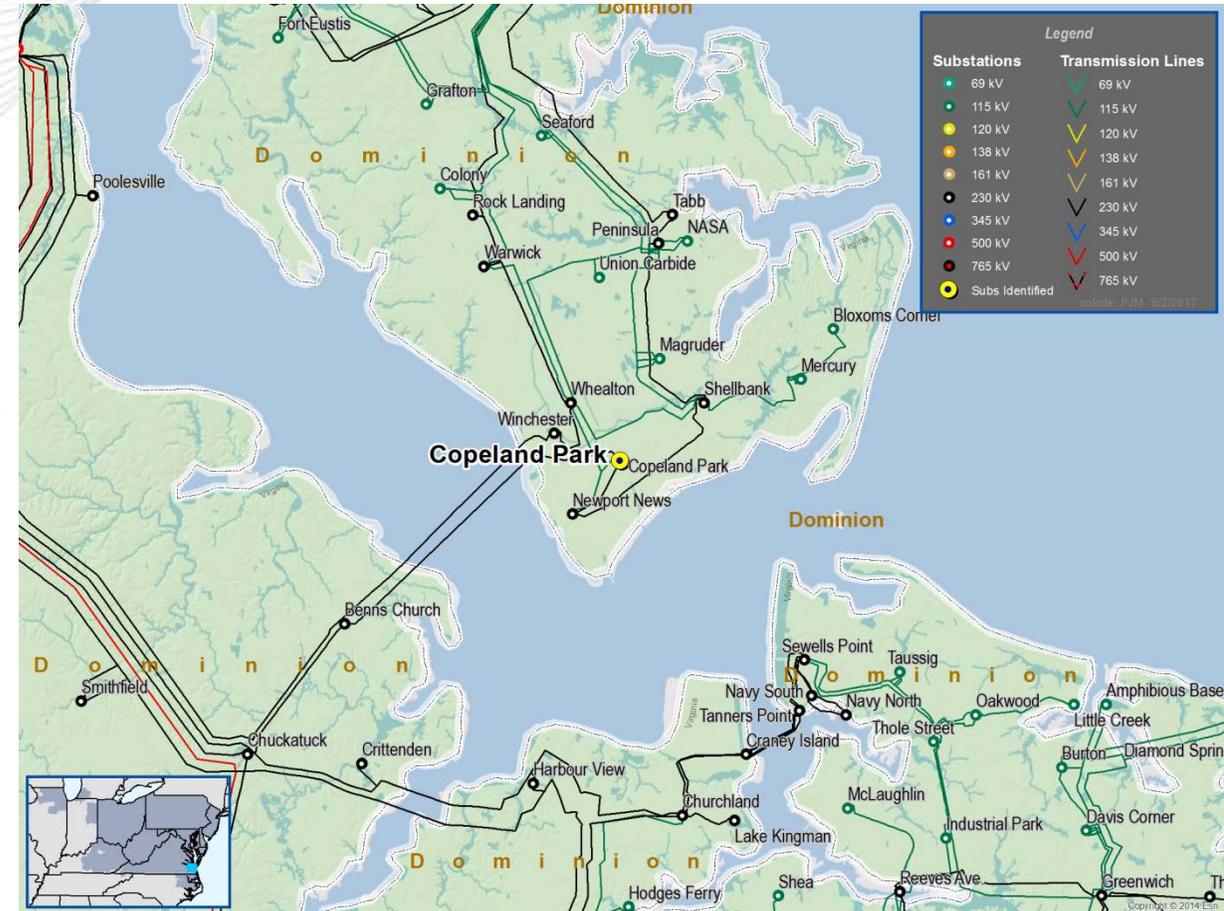
- Transmission will support the delivery point request by installing a 230kV circuit switcher and performing other necessary transmission work on the high side of the new transformer.

Alternatives: No feasible alternatives

Estimated Project Cost: \$600 K

Possible IS Date: 05/15/2019

Project Status: Conceptual





Dominion Transmission Zone Supplemental Project

Supplemental Project: Plaza Substation – New 230kV Circuit Switcher

Problem Statement:

- Dominion Distribution has identified the need to upgrade existing 56MVA 230/34.5kV Transformer #5 to a 84MVA transformer.

Potential Solution:

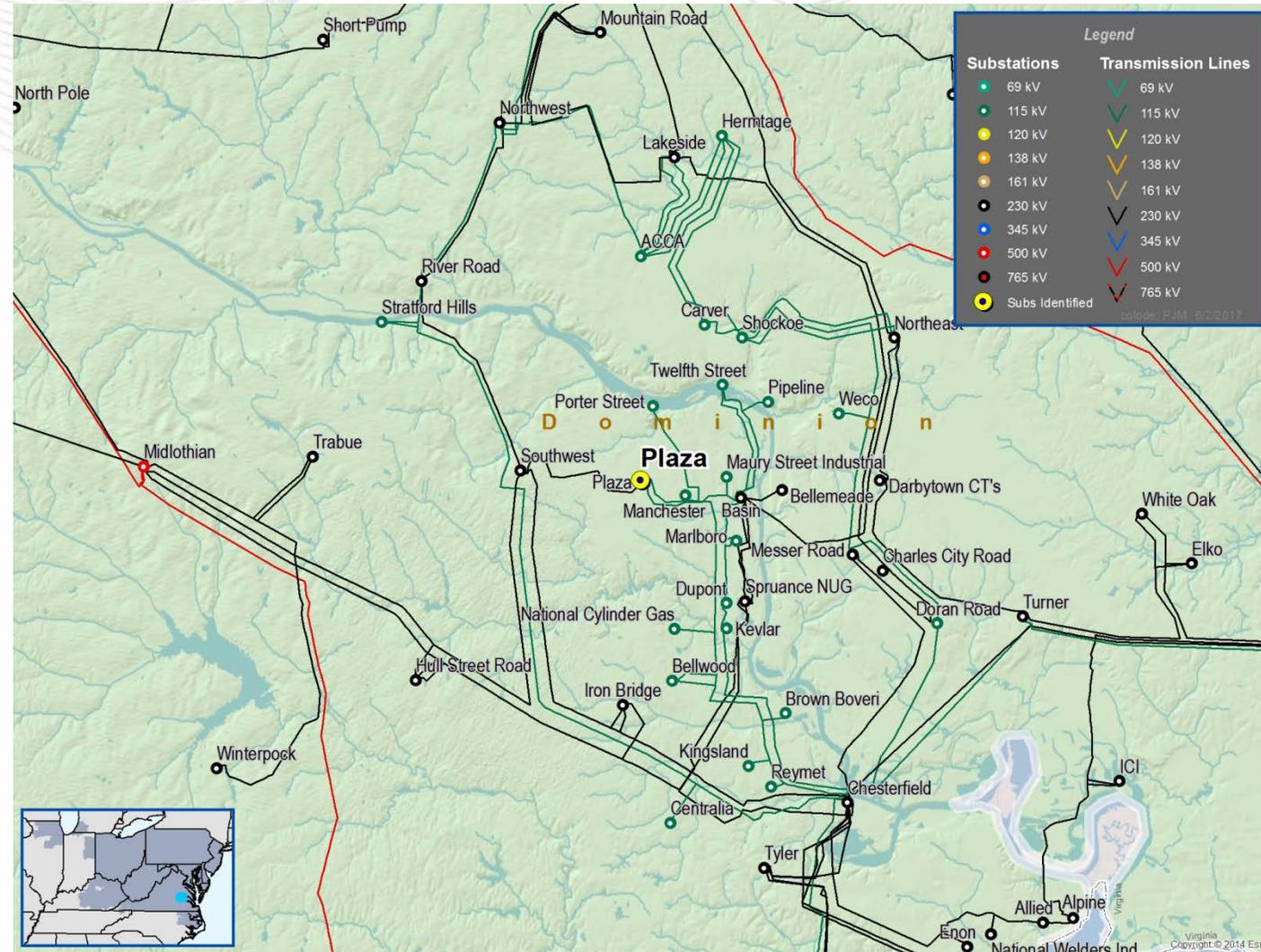
- Remove existing MOAB, install a 230kV circuit switcher and perform other necessary transmission work on the high side of the new transformer.

Alternatives: No feasible alternatives

Estimated Project Cost: \$450 K

Possible IS Date: 10/15/2018

Project Status: Conceptual



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Dominion Project: Line #567 River Crossing Rebuild
to be presented at a future TEAC.

2017 RTEP Next Steps

- Preliminary 2022 Summer results:
 - Baseline N-1: Thermal - Posted
 - Generation Deliverability: Thermal - Posted
 - Load Deliverability – Complete (no problems identified)
 - Baseline N-1: Voltage – In-progress
 - N-1-1: Thermal and Voltage – In-progress

- Finalizing Light Load Results
 - Model complete
 - Initial analysis complete, currently validating
- Winter analysis is in-progress

July 2017 Recommendations to the PJM Board

- All recommended baseline solutions in today's presentation will be presented to the PJM Board in July 2017 and recommended for inclusion in the RTEP.
- Reference the "Appendix" in today's presentation materials for projects that were reviewed at previous TEAC meetings.

Questions?

Email: RTEP@pjm.com

Appendix: Baseline Reliability Projects Previously Reviewed by the TEAC



PJM West



- Previously Presented: 2/9/2017, 5/4/2017
- Ongoing high voltages on the EHV system have been occurring in AEP and surrounding areas under light load conditions
- PJM planners worked closely with AEP planners to determine what operational and planning changes area available
 - Reviewed EMS snapshots of high voltage conditions
 - Suggested modelling and operating changes to PJM & AEP Operations
 - Examined impact of planned, approved reactive upgrades
- Outcome of investigation is the proposed addition of two new 300 MVAR 345 kV reactors on the AEP system with a 9/1/2018 in-service date
- Recommended Solution:
 - B2826.1: Install 300 MVAR reactor at Ohio Central 345 kV substation (\$5M)
 - B2826.2: Install 300 MVAR reactor at West Bellaire 345 kV substation (\$5M)

Previously Presented: 3/9/2017

Problem: Short Circuit

- Eleven Kammer 138kV breakers are overstressed

Significant Driver: George Washington Area Project (b2753)

- Build double circuit 138 kV line from Dilles Bottom - Holloway 138 kV and a George Washington - Holloway 138 kV.

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.

Alternatives Considered:

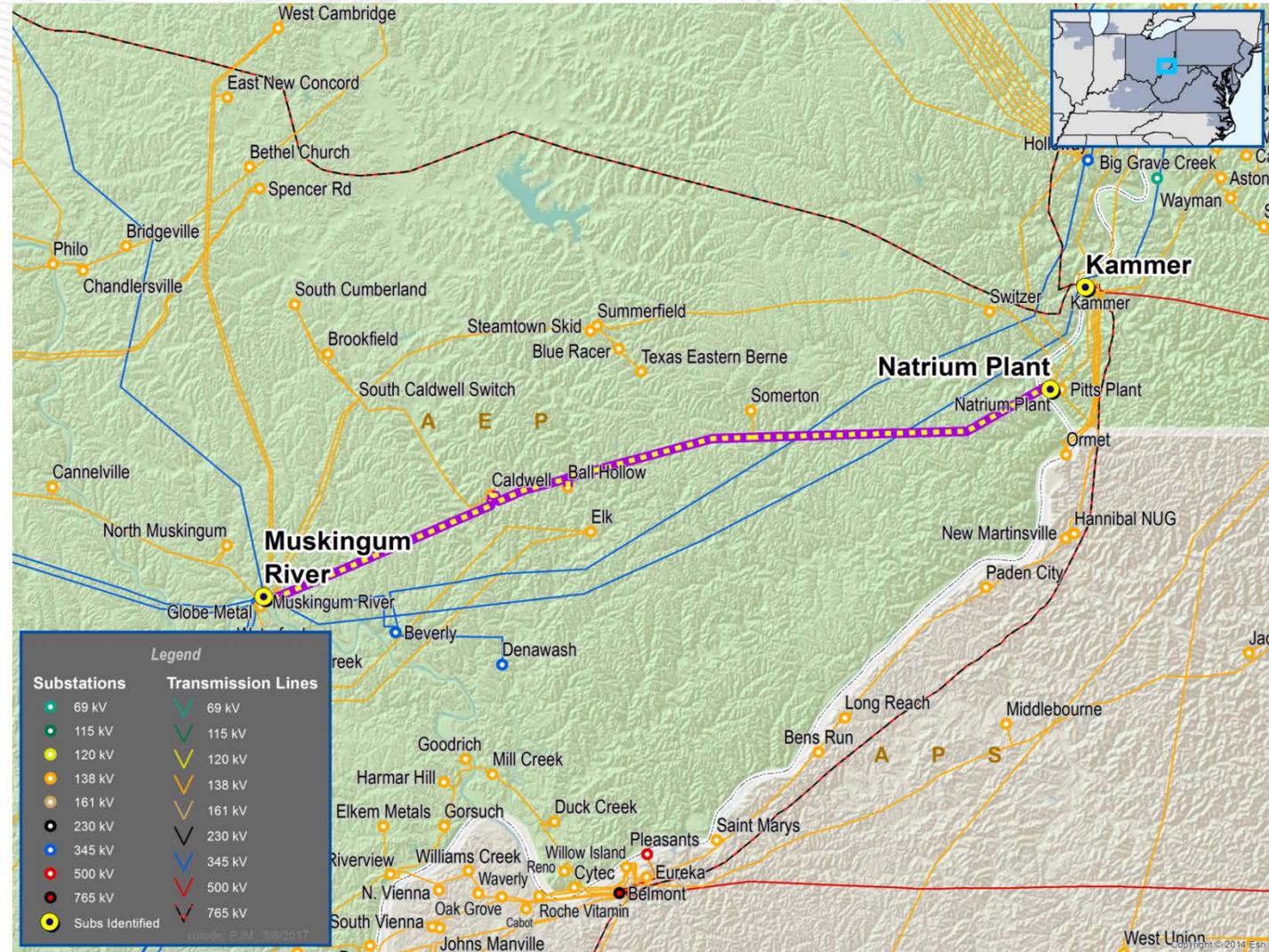
- Due to the immediate need of the project no alternatives were considered

Recommended Solution:

- Remove/Open Kammer 345/138 kV transformer #301 (b2753.9)
- Convert s1197 to a baseline upgrade (b2753.10)
 - S1197: Complete sag study mitigation on the Muskingum – Natrium 138 kV line

Estimated Project Cost: \$2.8 M

Required IS Date: January 1, 2019





AEP Transmission Owner Criteria Violation and Baseline Scope Change

Previously Presented: 11/5/2015, 4/21/2017

Problem Statement:

The Fairdale-Cambridge 69 kV line, the Summerfield-Derwent 69 kV line, and the Cambridge-West Cambridge 34.5kV are Overloaded for several combinations of N-1-1 contingencies in the Cambridge area.

The East Cambridge – Smyrna 34.5 kV circuit was built originally in 1954 and comprised of mostly 1/0 and 4/0 Copper conductor. It presently has 135 open A conditions on the 23.5 mile long line associated with conductor and structure concerns and has caused over 3.1M customer minutes of interruption between 2013 and 2016

The Flushing-Bannock Road and East Cambridge-Smyrna lines and associated stations can't be adequately maintained without shutting power off to customers. After significant outreach and discussions with all stakeholders, including AEP Distribution and the Guernsey-Muskingum Co-op, a commitment to the 69kV loop was agreed to. –Cambridge, OH

Alternative Solutions Considered:

Rebuild the overloaded facilities, approximately 10 miles, and convert West Cambridge-East Cambridge 34.5 kV line to 69 kV operation. While this option would eliminate the planning criteria violations, it does not address customer concerns or the existing condition concerns on the East Cambridge-Smyrna line. The West Cambridge-East Cambridge line does not have nearly the same number of open A conditions or issues that the East Cambridge-Smyrna line has (31 as compared to 135) and has had 0 customer minutes of interruption between 2013 and 2016. Estimated cost: \$20M

Recommended Solution:

Rebuild 23.55 miles of the East Cambridge – Smyrna 34.5 kV circuit with 795 ACSR conductor and convert to 69 kV.

East Cambridge: Install a 2000 A 69 kV 40 kA circuit breaker for the East Cambridge – Smyrna 69 kV circuit.

Old Washington: Install 69 kV 2000 A two way phase over phase switch.

Antrim Switch: Install 69 kV 2000 A two way phase over phase switch.

Modify the scope for PJM project b2715 (\$4M increase over original b2715 cost):

Estimated Cost: \$40.25M

Required IS Date: 6/1/2021

B2715 original Scope : 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. Original Estimated cost: \$14.355M, Old Required IS Date: 6/1/2020

B2715 new Scope: Install a 69 kV ring bus at Flushing instead of a 69/34.5 kV transformer, Convert Smyrna to 69 kV and install two 69 kV breakers, Convert Vail to 69 kV and serve AEP Distribution via a 69/34.5 kV transformer, Build the Flushing – Smyrna line to 69 kV instead of 34.5 kV. New Estimate Cost:18.355M, New Required IS Date: 6/1/2020



Previously Presented: 5/4/2017

Problem

- Stuart and Killen deactivations
- Generation Deliverability Outage: Jefferson – Clifty Creek 345 kV line is overloaded for the stuck breaker contingency tripping the Greentown – Jefferson 765 kV line and the Hanging Rock – Jefferson 765 kV line

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.

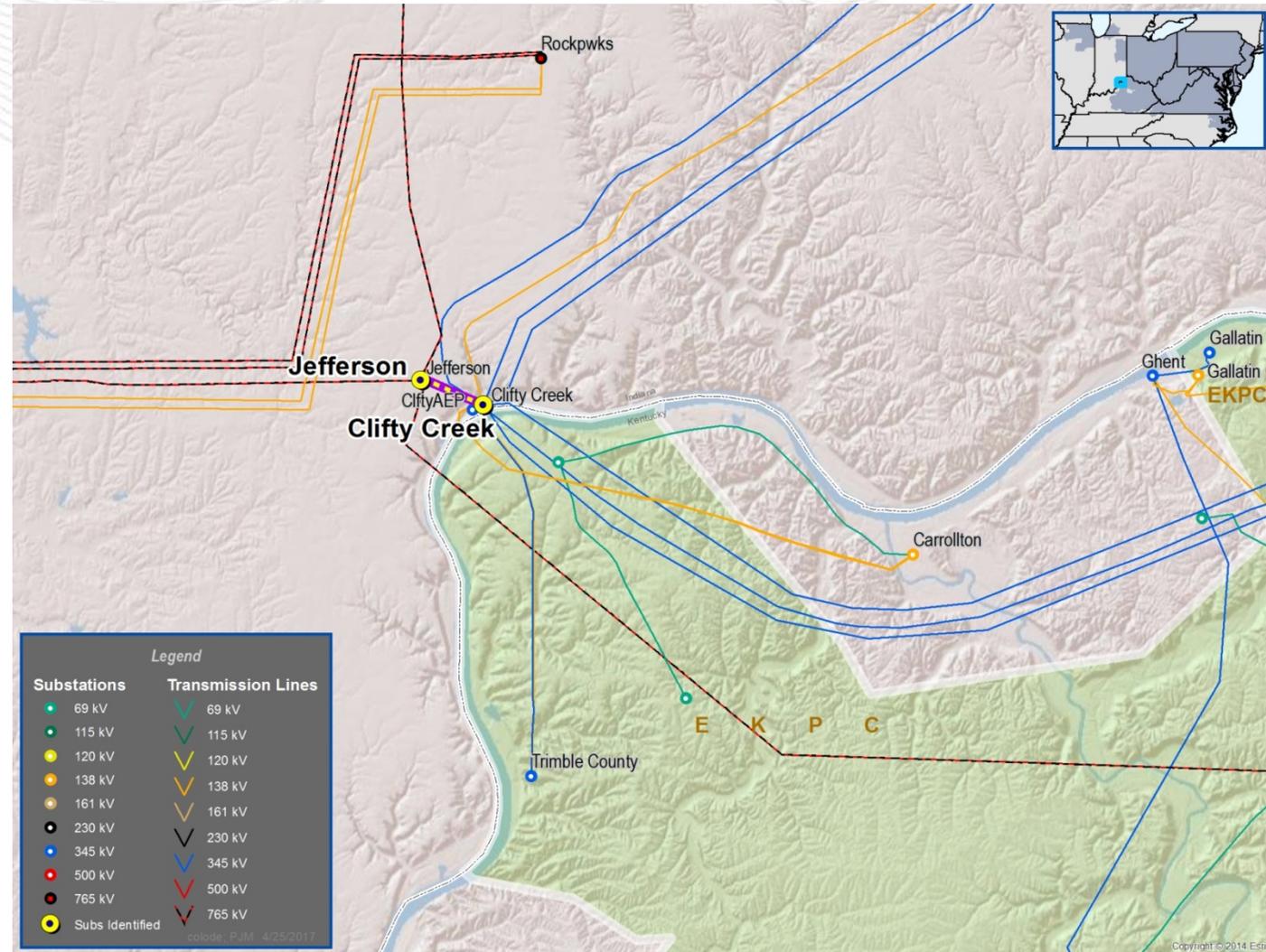
Recommended:

- Increase rating of the Jefferson – Clifty Creek 345 kV line (b2878)

Estimated Project Cost Change: \$0.1 M

Required IS Date: June 1, 2018

Projected IS Date: June 1, 2019



- **Project Scope Change - B2557**
- **Previously Presented: 9/25/2014, 2/9/2017**
- **Targeted Violation:** The Avon 345/138 kV transformer #92 is overloaded for line fault stuck breaker contingency loss of Avon – Juniper 345 kV circuit and Avon 345/138 kV transformer #91
- **Original Scope:** At Avon 345 kV substation, replace the existing 345/138 kV 448 MVA #92 transformer with a 560 MVA unit
- **Original Cost:** \$5.4M (Updated cost: \$6.0M)
- **Required IS date:** 6/1/2019
- **New Scope:** Re-configure the existing Avon 345kV substation into a breaker-and-a-half layout
- **New Cost:** \$5.7M
- **Reasons:**
 - The new configuration eliminates the contingency (stuck breaker) causing the identified thermal overload.
 - Eliminates the 345kV source, bus, and transformer loss at Avon for the stuck breaker contingency.
 - New layout provides increased operational flexibility including transformer and breaker maintenance.
 - Significant decrease in post contingency loading for the Avon transformers as a result of the new configuration when compared to the transformer replacement project.
 - Provides reliability improvement for the broader BES Network by eliminating the thermal violation.
 - After additional engineering design and cost reviews, the cost for the 345kV breaker configuration project is the least cost planning alternative.



Previously Presented: 3/9/2017

Problem: Short Circuit

- The Crossland 138kV breaker “B-16” is overstressed

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.

Alternatives Considered:

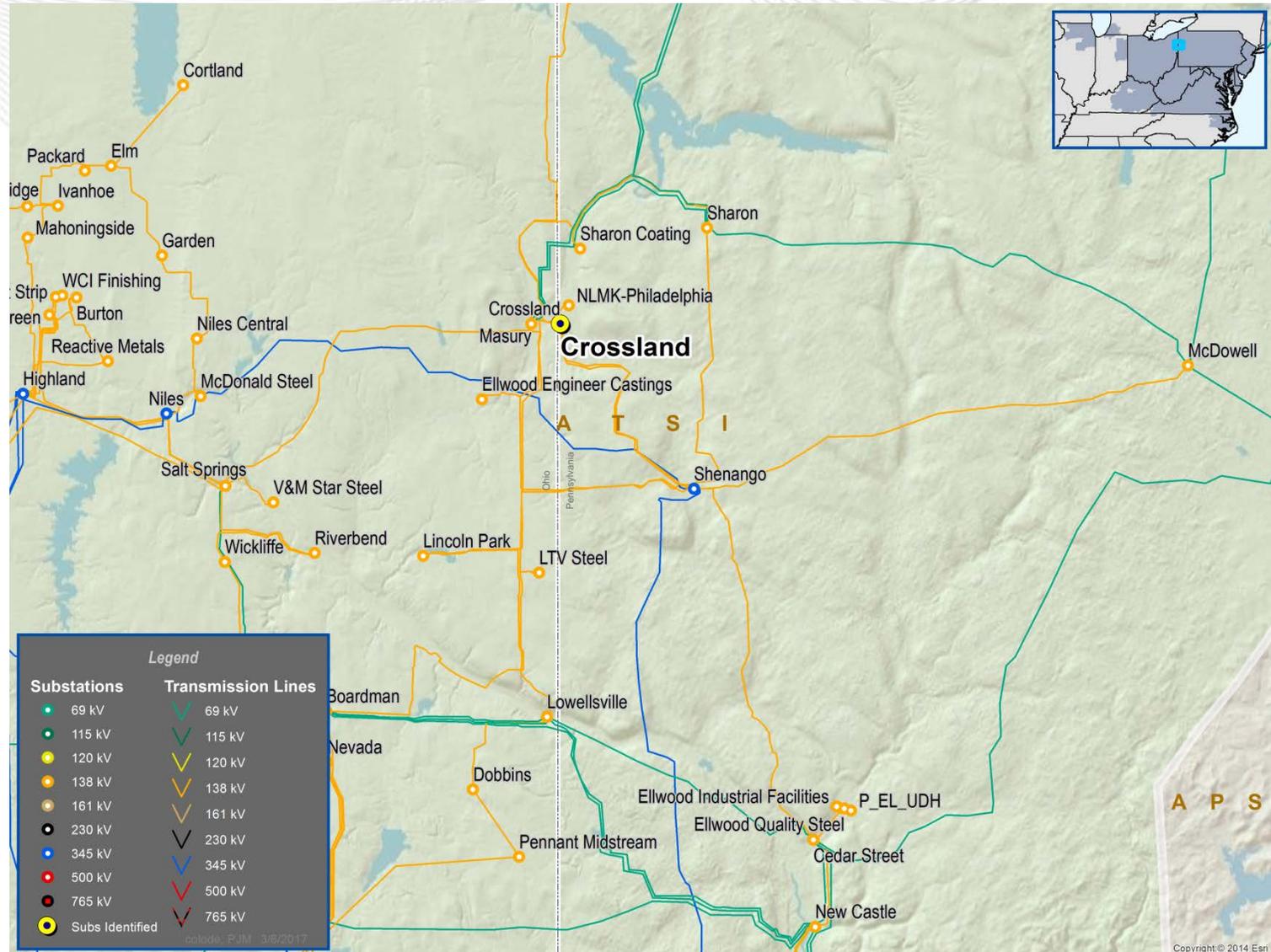
- Due to the immediate need of the project no alternatives were considered

Recommended Solution:

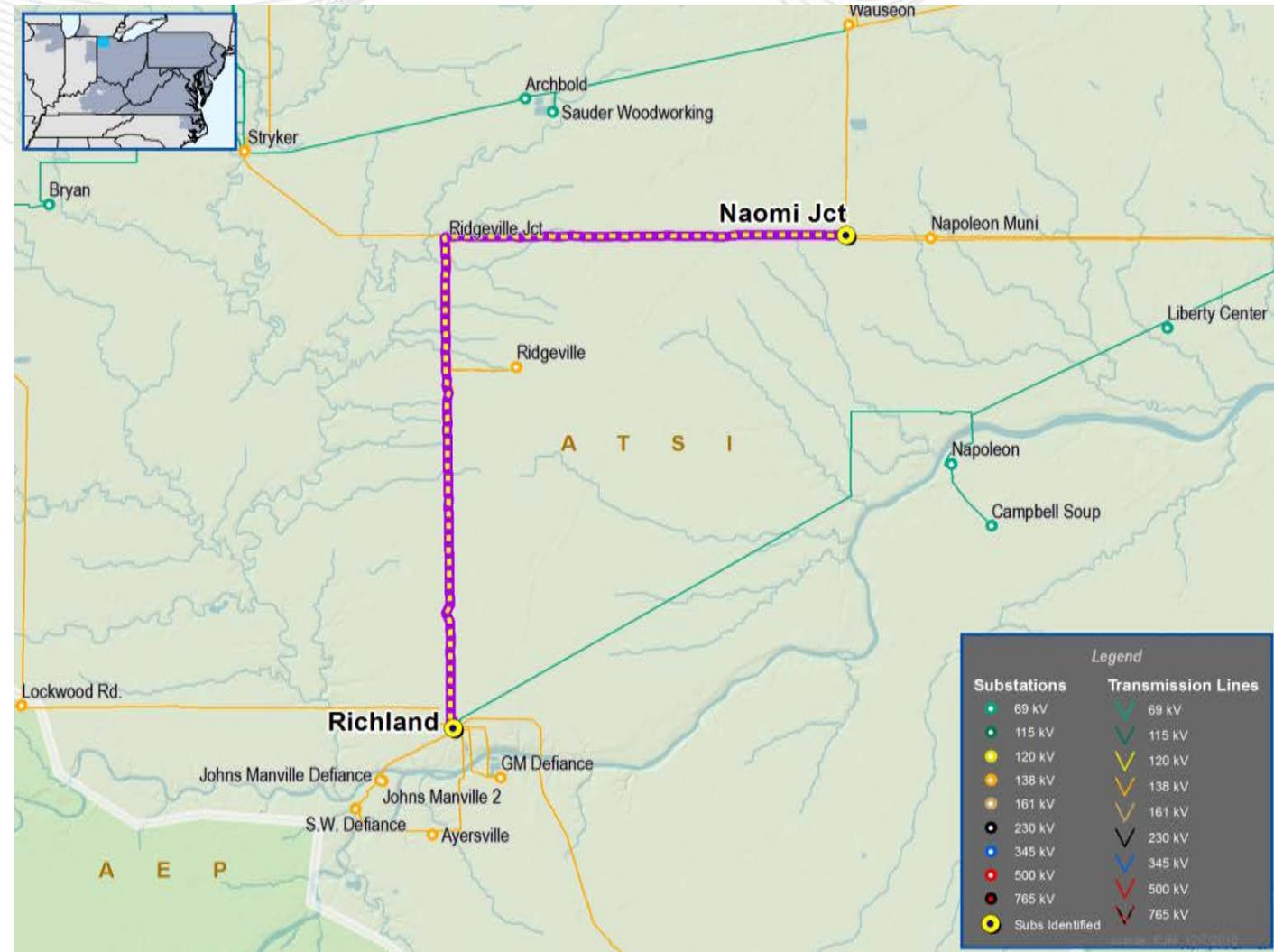
- Replace the Crossland 138kV breaker “B-16” with 40 kA breaker (B2869)

Estimated Project Cost: \$250 K

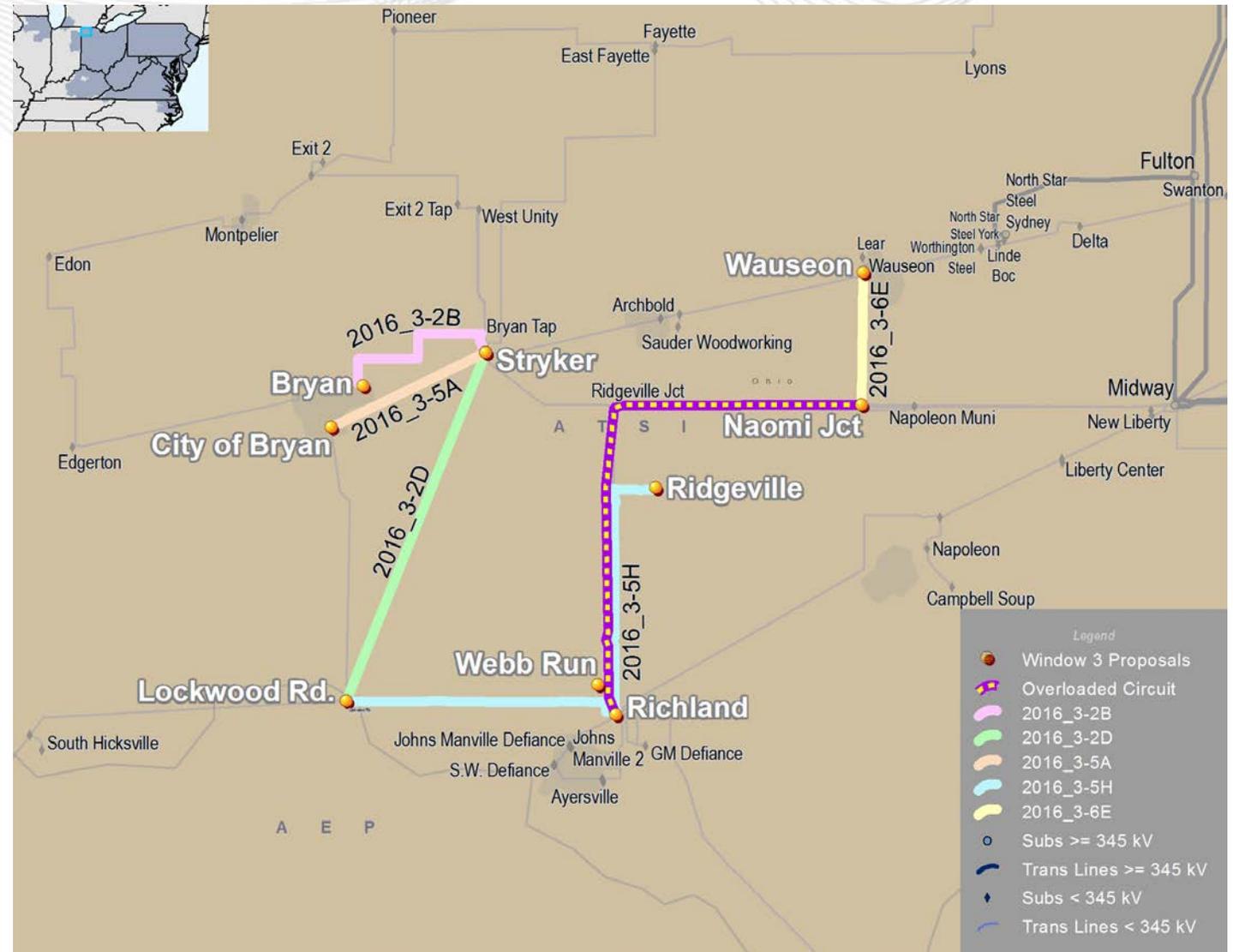
Required IS Date: June 1, 2019



- 2016 RTEP Proposal Window #3
- Common Mode Outage Violations (FG# 1, 2, and 3):
- Richland to Naomi Junction 138 kV circuit is overloaded for multiple bus and line fault stuck breaker contingencies.
- Continued on the next slide...



- Continued from the previous slide...
- Alternatives considered:**
 - 2016_3-2B (\$ 8.3 M)
 - 2016_3-2D (\$ 17.2 M)
 - 2016_3-5A (\$ 8.5 M)
 - 2016_3-5H (\$ 6.1 M)
 - 2016_3-6E (\$ 9.1 M)



Summary of Project Alternatives

Project ID	Project Description	Proposing Entity	Cost Estimate (\$M)	Advantages	Disadvantages
2016_3-2B	Construct a new single circuit 138 kV line between Bryan Station and Stryker Station.	Transource (Greenfield)	8.3	Solves all identified flowgates	Requires a new ROW (~7 miles); relative high cost
2016_3-2D	Construct approximately 14 miles of new 138 kV line establishing a Lockwood Road – Stryker 138 kV Circuit.	Transource (Greenfield)	17.2	Solves all identified flowgates	Requires a new ROW (~14 miles); relative very high cost
2016_3-5A	Build a 138 kV line from the existing 138 kV City of Bryan substation to the existing 138 kV Stryker substation	NTD (Greenfield)	8.5	Solves all identified flowgates	Requires a new ROW (~7 miles); relative high cost
2016_3-5H	Build a 138 kV switching station ("Webb Run") interconnecting the Richland to Lockwood Road 138 kV line and the Richland LJ to Ridgeville 138 kV line	NTD (Greenfield)	6.1	Solves all identified flowgates	Building a new sub next to the existing substation to achieve the "reconfiguration of an existing substation"; Risk of substation site: if the location needs to move farther away from Richland substation it will probably increase the length of the 4 138kV lines ;
2016_3-6E	Eliminate three terminal line at Naomi Junction by constructing a double circuit line towards Wauseon substation. Wauseon substation will need to incorporate a new 138kV line exit by adding a 138kV breaker and relaying.	First Energy (Upgrade)	9.1	Solves all identified flowgates; Creates a third resource into Wauseon 69KV area where a potential reliability concern exists and eliminate the need for the pre-contingency switching of the Wauseon 138/69kV transformer under certain N-1 contingencies; Eliminate the three terminal lines and improve system protection and coordination.	Small margin (95.8% loading); relative high cost
PJM Solution	Relocate the Richland to Ridgeville 138KV line from Richland J bus to K, extend the K bus and install a new breaker.	PJM (Upgrade)	1.7	Solves all identified flowgates; lowest estimated cost	None

* PJM reviewed the proposed cost estimates and found the estimates were reasonable (within \$1~2M difference)

* The 2016_3-2D project cost allocation would be to both AEP and ATSI; the remaining proposals would be 100% allocated to ATSI

Previously Presented: 5/4/2017, 4/13/2017

Recommended Solution:

PJM Proposed Solution: Transmission Owner Upgrade to Relocate the Richland to Ridgeville 138KV line from Richland J bus to K, extend the K bus and install a new breaker. (B2875)

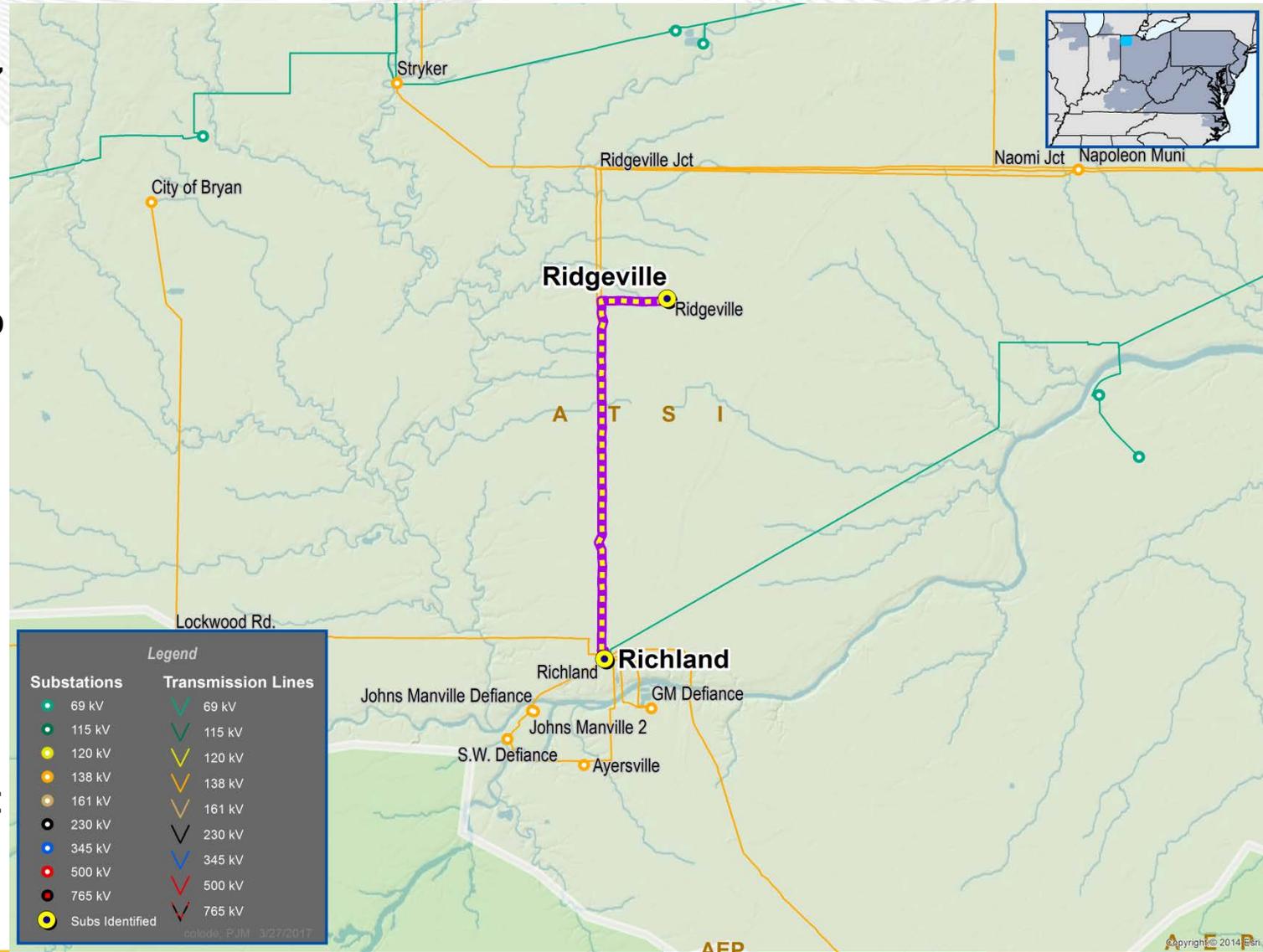
Designated Entity: FirstEnergy (ATSI)

Estimated Project Cost: \$1.7M

Required IS Date: 6/1/2019

Cancel B2558: Close normally open switch A 13404 to create a Richland J Bus - Richland K Bus 138 kV line. Estimated Cost: \$0.02M

Required IS Date: 6/1/2019



Previously Presented: 5/4/2017

Problem

- Stuart and Killen deactivations
- Generation Deliverability Outage: Spurlock – Stuart 345 kV line is overloaded for the loss of the Silver Grover – Zimmer – Red Bank 345 kV line

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.

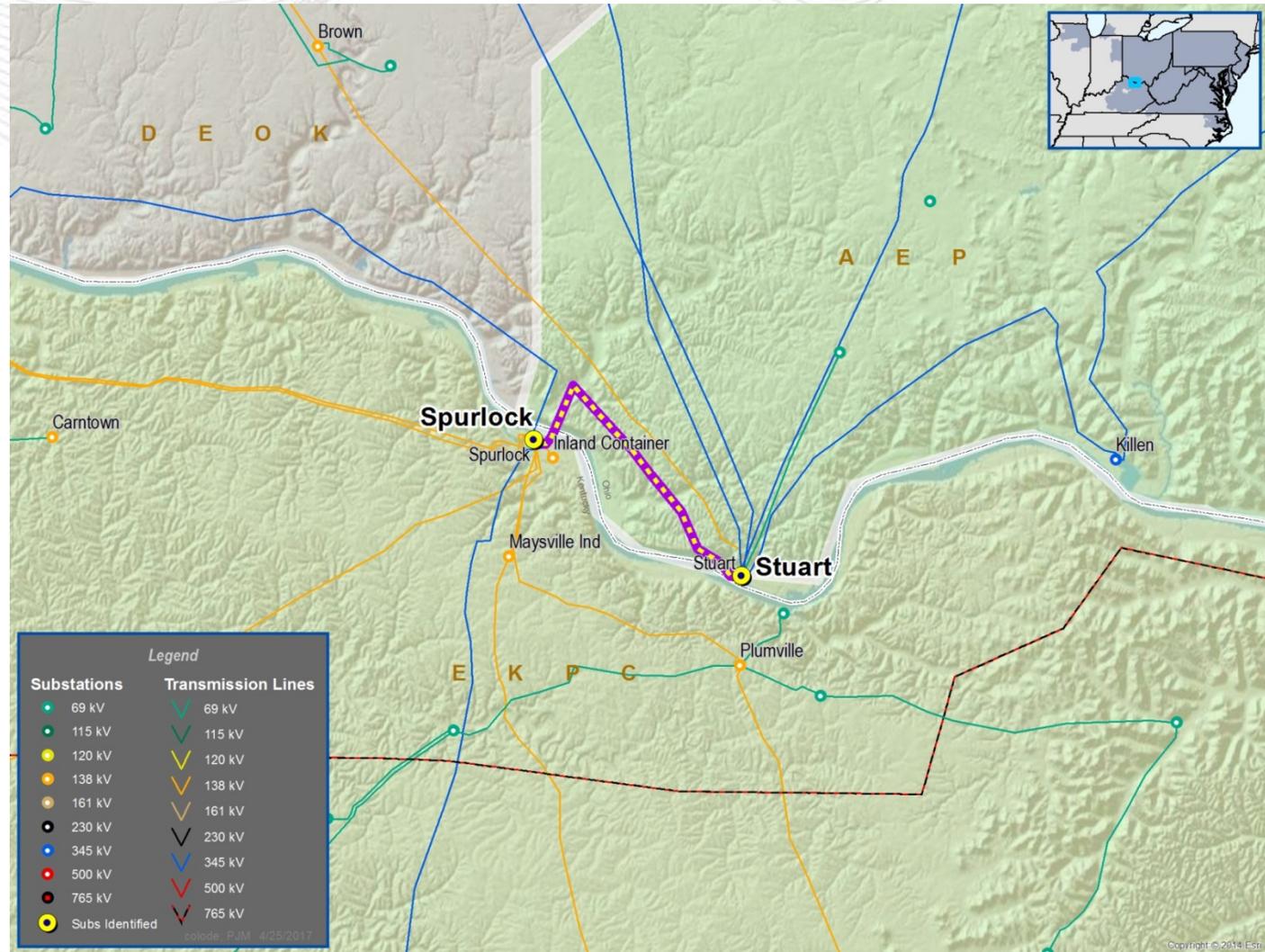
Recommended:

- Upgrade Stuart – Spurlock 345 kV line (b2879)

Estimated Project Cost Change: \$2.51 M

Required IS Date: June 1, 2018

Projected IS Date: December 31, 2018





PJM South



Previously Presented: 5/4/2017, 4/13/2017

Problem Statement: DOM “End of Life Criteria”

- Line #247 Swamp to Suffolk 230kV is constructed primarily on wood H frames in 1968 (~49 years).
- This line needs to be rebuilt to current standards based on Dominion’s “End of Life” criteria.
 - Wood structure life is 35-55 years
 - Conductor & connectors are 40-60 years
 - Porcelain insulators are 50 years
- Permanent MW load loss for removal of this line is 21 MW.

Recommended Solution:

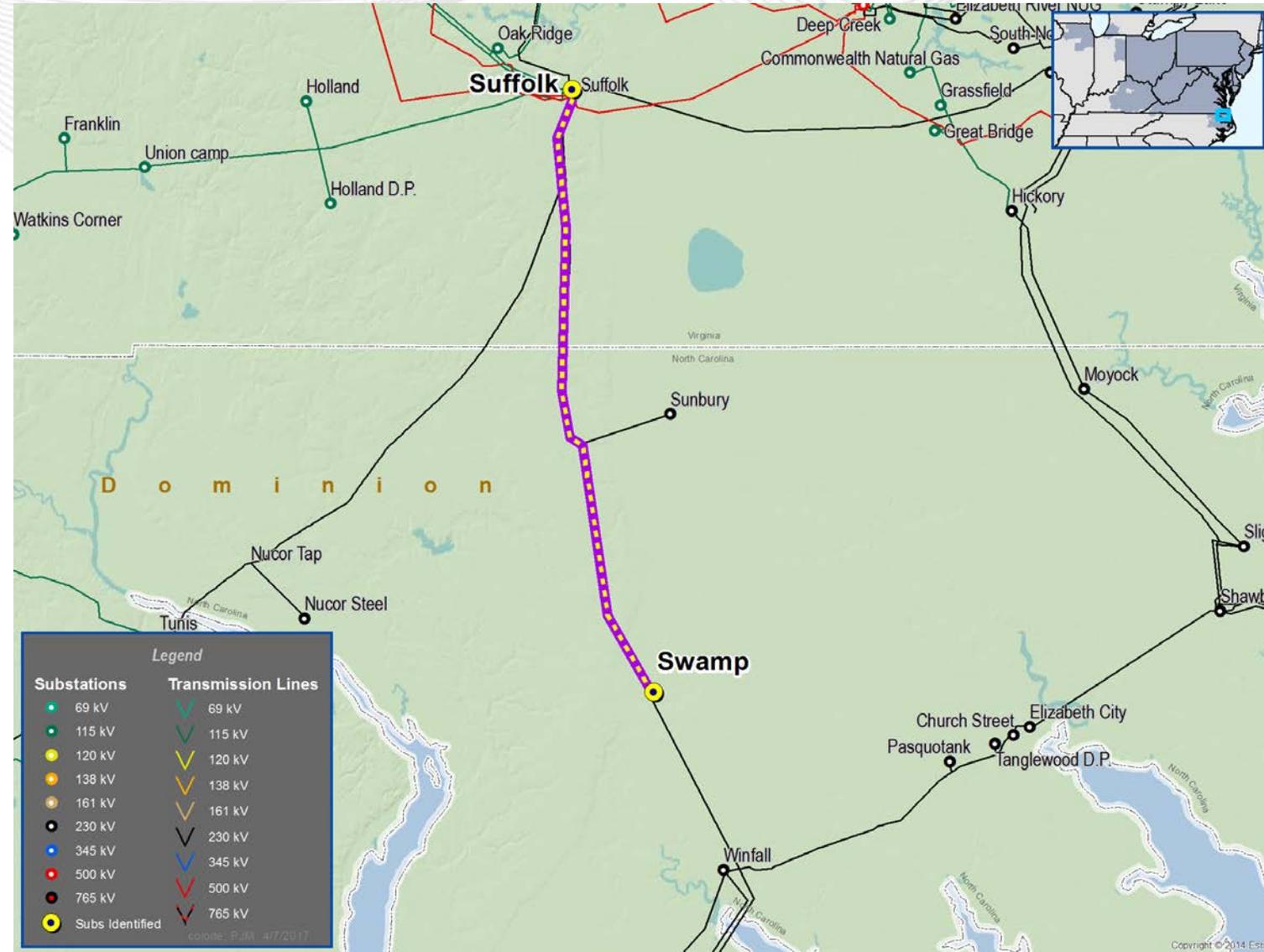
- Rebuild 230kV line #247 from Swamp to Suffolk (31 miles) to current standards with a summer emergency rating of 1047 MVA at 230kV. **(b2871)**

Alternatives: None

Estimated Project Cost: \$31 M

Projected IS Date: 12/30/2022

Project Status: Conceptual



Previously Presented: 3/9/2017

Problem: Short Circuit

- Seven of the Mt. Storm 500kV breakers are overstressed

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.

Alternatives Considered:

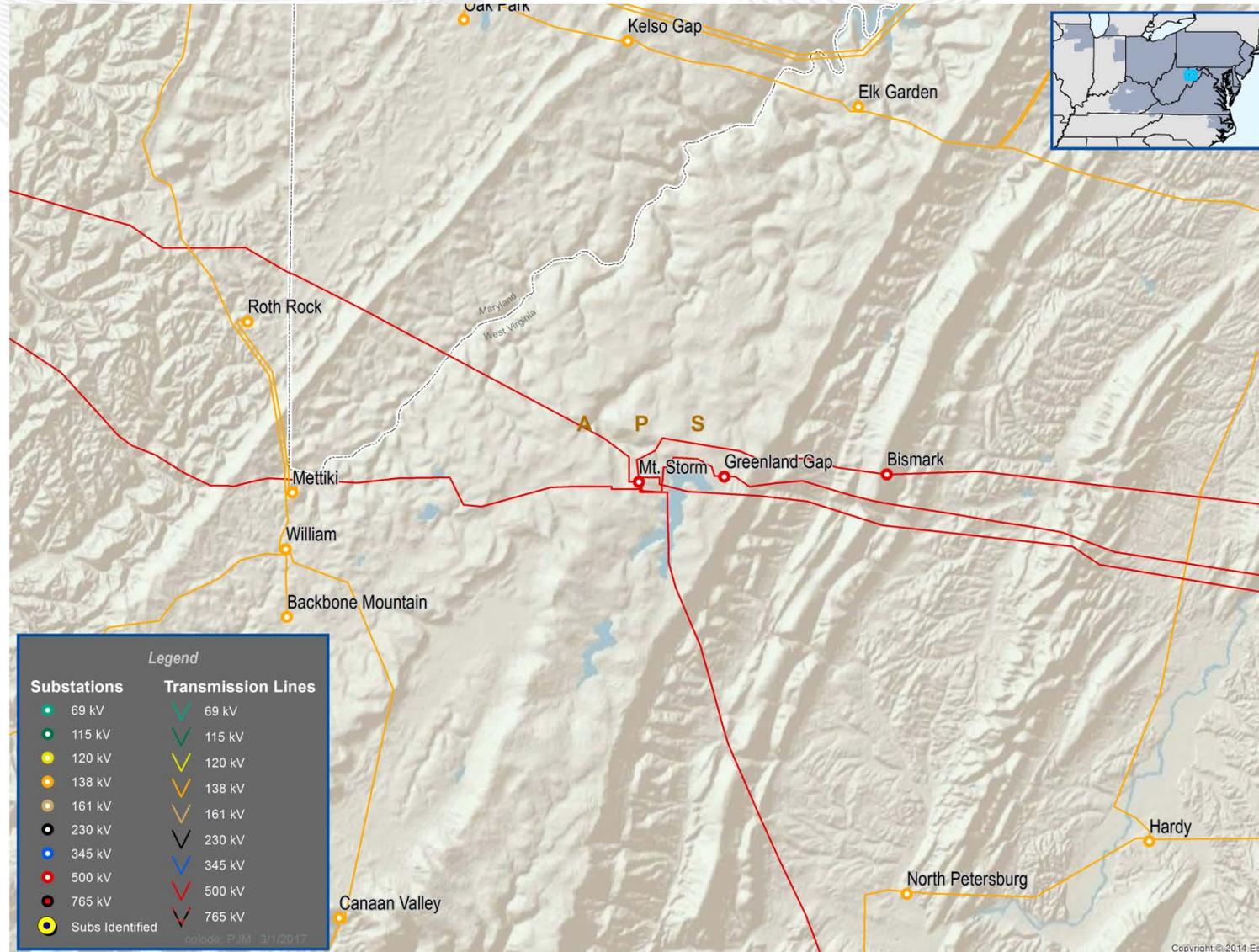
- Due to the immediate need of the project no alternatives were considered

Recommended Solution:

- Upgrade and replace the seven Mt. Storm 500kV with 50kA breakers (b2842-2848)

Estimated Project Cost: \$2.708 M (total)

Required IS Date: June 1, 2019





PJM MAAC



Previously Presented: 3/9/2017

Problem: Short Circuit

- The Sickler 69kV breakers “H,” “M,” and “A” are overstressed

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.

Alternatives Considered:

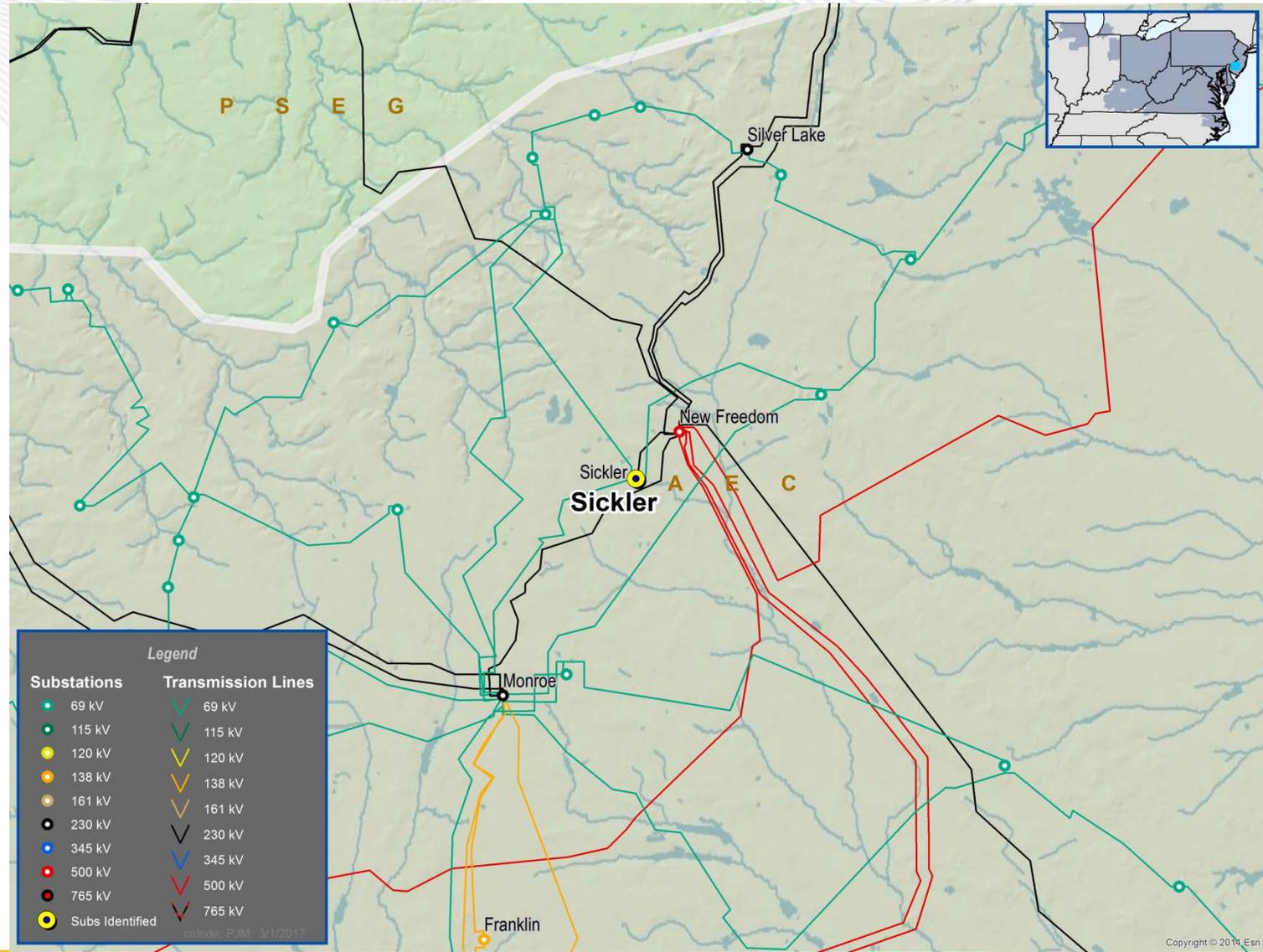
- Due to the immediate need of the project no alternatives were considered

Proposed Solution:

- Replace the Sickler 69kV breakers “H,” “M,” and “A” with 63kA breakers (b2839-2841)

Estimated Project Cost: \$321.67 K (per breaker)

Required IS Date: June 1, 2019





PECO Transmission Zone

Previously Presented: 3/9/2017

Problem: Short Circuit

- Sixteen breakers at Parrish, Plymouth Meeting, Grays Ferry, Eddystone, Waneeta, Chichester, and North Philadelphia 230kV substations are overstressed

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.

Alternatives Considered:

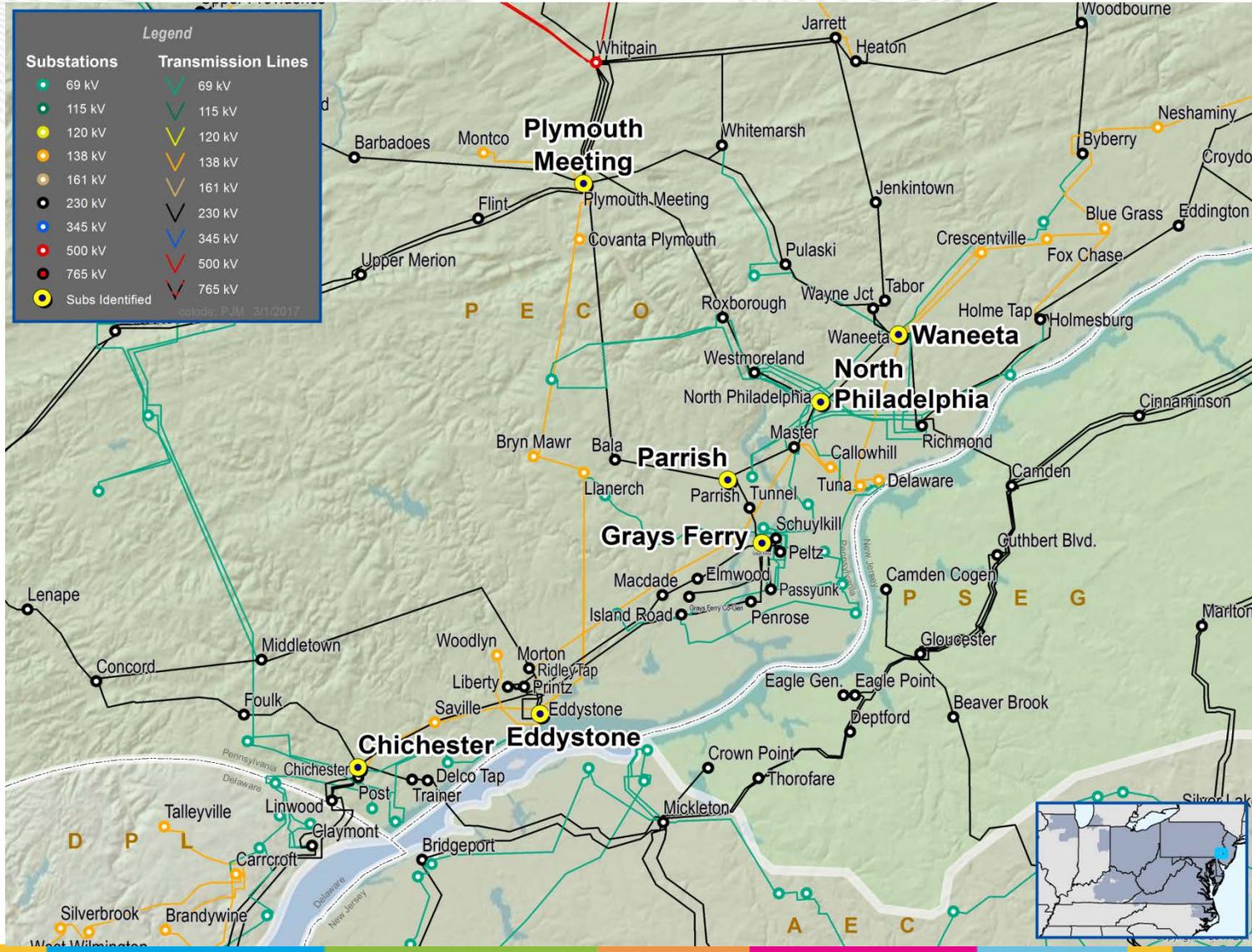
- Due to the immediate need of the project no alternatives were considered

Recommended Solution:

- Replace the Sixteen breakers at Parrish, Plymouth Meeting, Grays Ferry, Eddystone, Waneeta, Chichester, and North Philadelphia 230kV substations with 63kA breakers (b2849-2864)

Estimated Project Cost: \$375 K(per breaker)

Required IS Date: June 1, 2019





Penelec Transmission Zone

Previously Presented: 3/9/2017

Problem: Short Circuit

- The Seward 138kV breakers “Jackson Road,” “Conemaugh N,” “Conemaugh S,” and “No. 8 XFMR” are overstressed

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.

Alternatives Considered:

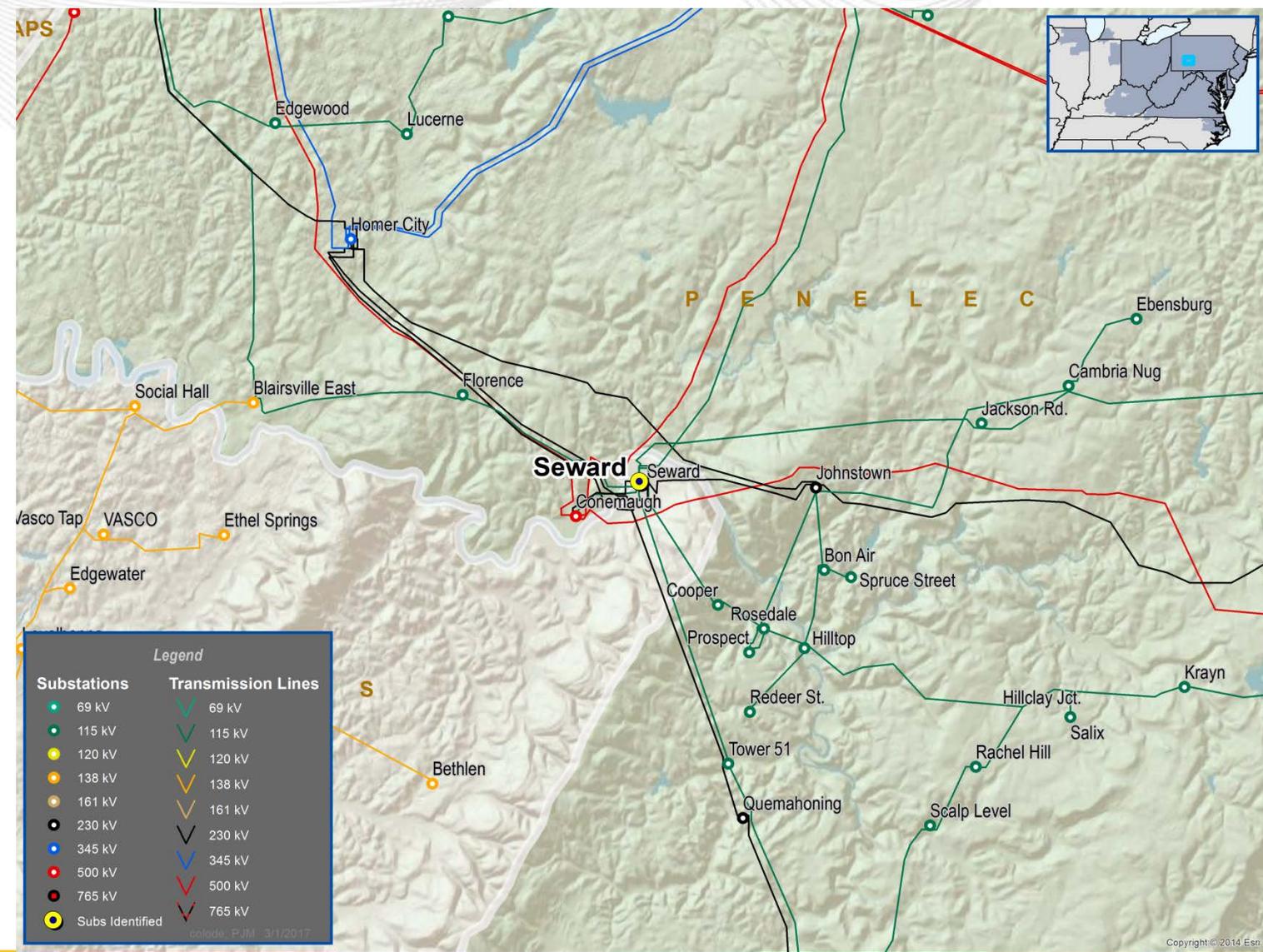
- Due to the immediate need of the project no alternatives were considered

Recommended Solution:

- Replace the Seward 138kV breakers “Jackson Road,” “Conemaugh N,” “Conemaugh S,” and “No. 8 XFMR” with 63kA breakers (b2865-2868)

Estimated Project Cost: \$302.1 K (per breaker)

Required IS Date: June 1, 2019



PSE&G End Of Life Assessment Newark Switch Review

- Refer to PSE&G criteria:

VII. EQUIPMENT ASSESSMENT AND STORM HARDENING

<http://www.pjm.com/~media/planning/planning-criteria/PSE&G-planning-criteria.ashx>

- Risk of a transformer fire that may result in the entire building on fire and thus the loss of $\sim >300$ MVA of load for a long duration. Nearby school/church & healthcare facility.
- Several common mode of failures

- Age: Substation: 1957
- T1: 1972 – T2 & T3: 1958
- Spare: 1992
- Special transformer: Dual ratio (138/26/13)
 - Wye-Wye 13 kV All PSEG 13 kV transformers are delta-wye (30°)
- Maintenance and Maintenance outages
- Rooftop transmission system
- Lower level indoor transformers
- Critical Station (City of Newark - Downtown) ~300 MVA Load
 - Financial buildings
 - City Hall
 - Other Government Buildings
 - NJIT, Rutgers
 - PATH Train, NJ Transit
 - 26kV and 13kV Source station
 - Several Data Centers
 - Downtown Newark
 - Prudential Arena, NJ Performing Arts Center
 - United States Citizenship and Immigration Services (USCIS)

- Basement: Oil rooms, 13 & 26 kV feeders & transmission lines entering the station
- 1st Floor: 26 kV switchgear & Transformers' vaults
- 2nd floor: Distribution reactors
- 3rd floor: Control room/AUX power rooms
- Roof: 138 kV Yard

- Station age and condition
 - Based on unique design, aged equipment and obsolete equipment Newark Switch is considered at end-of-Life.
- Potential risks and consequences
 - Any transformer fire or catastrophic failure would result in the destruction of the whole facility and the loss of 300 MVA of critical load for an extended period of time.
- 26/13 kV bus faults
- Other risks and common modes of failure
- Environmental/structural concerns

- Urban location
- Proximity to existing transmission system



- Distribution feeds below transformer vaults



- Transformers located below the 138 kV rooftop switchyard.
- A transformer fire would be significant and result in catastrophic loss



* PSE&G Pierson transformer fire

* Newark Switch transformer

Potential Project Scope: Build new Newark GIS station in a building located adjacent to the existing Newark Switch and demolish the existing Newark Switch

- New layout is five bay breaker and a half GIS on same property
- 26kV feeders above transformers would move to new GIS building
- 13kV feeders would move to new GIS building
- New (3) story building would require notching out corner of existing building
- Gas Insulated bus (GIB) would run from GIS back through old building
- 13kV and 26kV conductors would run in building to new feeders above GIS back down to underground splices
- Long transformer outages required for cutovers
- Selective demolition of existing building would be done around remaining transformers and new GIB

Anticipated Project Risks

- Construction/demolition in and around live equipment
- Possible extensive structural modifications to support work in building
- Little to no construction laydown
- Long cutover outages on existing circuits
- No stormwater retention to meet city requirements

Cost Estimate

- \$353M

Other Alternatives Considered:

Alternative #2: Find a large property and build a new substation challenges: No large property available in the city of Newark

- Find new property
 - Challenge: No large property available in the city of Newark
- Relocate four (4) 138 kV transmission lines
- Relocate over thirty 26 & 13 kV distribution feeders.
- Requires extended transmission & distribution outages
- Assuming available property, the cost to relocate and rebuild Newark Switch will be ~\$458M (September 2016)

Alternative #3:

- Status quo: Risk of a transformer fire that may result in the loss of entire building and station. The result is the loss of ~>300 MVA of load for a long duration.



Additional Alternative Development Efforts August 2016 to January 2017

PSE&G hired a third party consultant to refine scope

- Evaluate placing new transformers adjacent to new GIS building
- Develop new building design
- Address stormwater retention
- Validate costs and quantify risk

Contacted GIS and switchgear suppliers for alternate equipment configurations

- Validate compact GIS design
- Obtained switchgear/LCC layouts

Conducted constructability reviews

- Developed construction sequencing plan and laydown needs

Public Outreach

- Contacted adjacent property owners regarding expansion
- Continued to evaluate alternates sites for construction laydown
- Met with Mayor and City Council members to identify concerns

Estimate

- Refined costs and modified risk and contingency

Build new Newark GIS station in a building located adjacent to the existing Newark Switch and demolish the existing Newark Switch

Previous Scope from Alternative #1

- New layout is five bay breaker and a half GIS on same property
- 13kV feeders would move to new GIS building

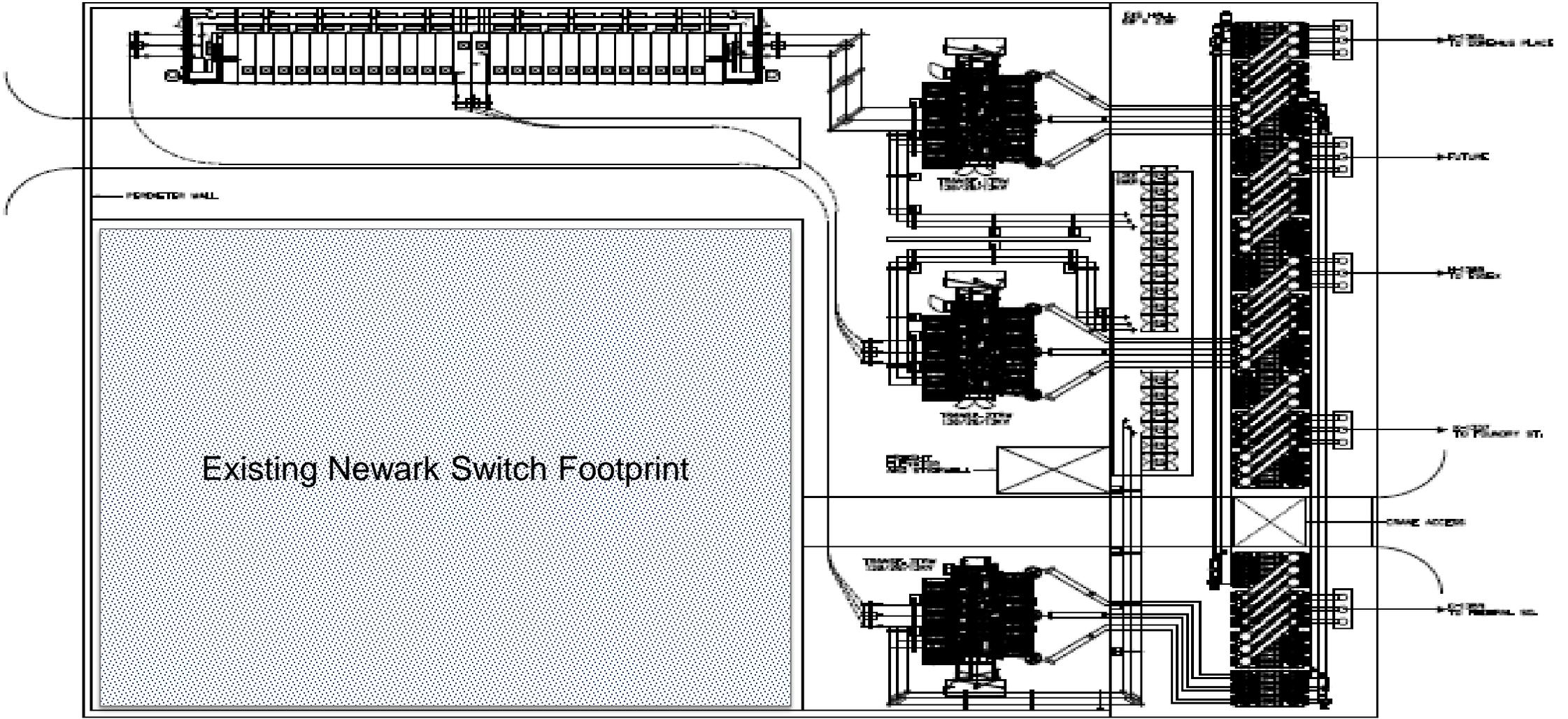
Updated Project Scope for Alternative #1A

- Purchase 3 new dual ratio transformers and place outside of existing building
- 26kV feeders above transformers would move outside on ground level adjacent to new access driveway
- Arrange GIS in compact layout making building narrower, longer and lower
- Build new (3) story building isolated from existing Station building with sub-basement for storm water retention
- GIB is entirely within new building
- 13kV and 26kV feeders are at ground level
- Transformer outages required for cutovers are not as long
- Use conventional demolition methods

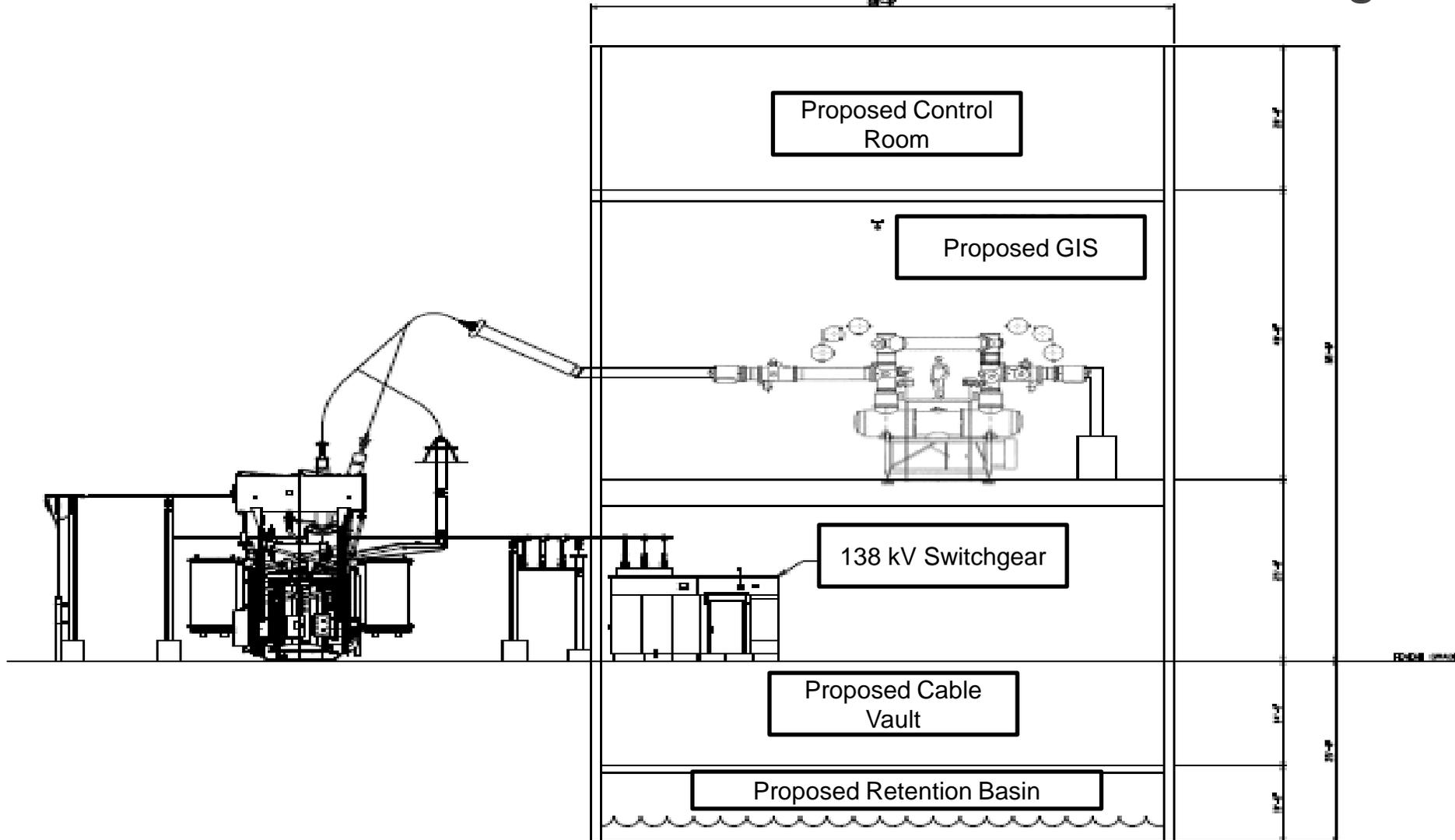
Alternative #1A Cost Estimate

- \$275M

PSE&G Transmission Zone Newark Switch New Design Concept



PSE&G Transmission Zone Newark Switch New Design Concept



- Alternate 1A new scope & layout has less constructability concerns than the previous alternative 1 approach
 - All new construction is completely outside of existing building
 - Work can be done on standard work day schedules, reducing construction productivity risks due to construction during outages (i.e. GIB and transformer bushing work)
 - No longer necessary to build GIB over existing transformers
 - Additional property facilitates staging of equipment deliveries
- Transformer arrangement meets standard fire protection criteria and oil-filled cables are no longer next to transformers
 - GIB is no longer over energized equipment in existing building
- Transformer outage cutovers are reduced
 - GIS and GIB can be fully tested prior to starting cutovers
- Reduction in cost estimate of \$78M
 - \$18M in direct costs
 - \$60M in risk/contingency
- Property negotiations are underway
- All equipment fully energized by June 2021



PSE&G Transmission Zone

Previously Presented: 3/9/2017, 1/12/2017

Problem:
PSE&G FERC 715 Transmission Owner Criteria
Newark Switch Aging Infrastructure

PSE&G FERC 715 Transmission Owner Criteria

- Age
 - Substation: 1953
 - Transformer 1: 1972
 - Transformer 2&3: 1958
 - Spare: 1992
- Housed in an urban building
- Equipment condition assessment
- Equipment has reached its end of life

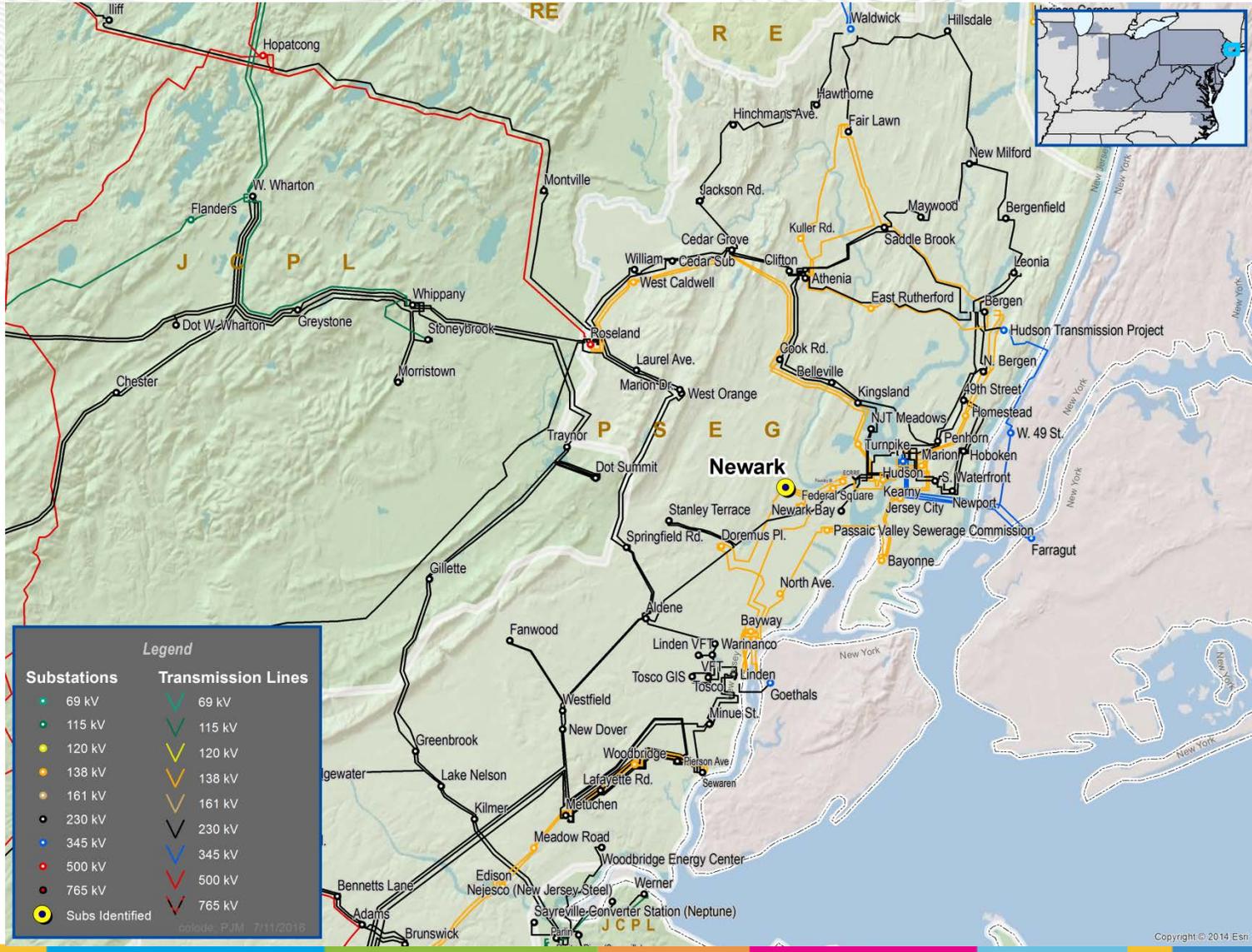
Alternatives Considered:

1. Build new Newark GIS station in a building (layout #1) located adjacent to the existing Newark Switch and demolish the existing Newark Switch
- 1A. Build new Newark GIS station in a building (layout #1A) located adjacent to the existing Newark Switch and demolish the existing Newark Switch
3. Build a new Newark GIS station elsewhere in Newark and relocate all transmission and distribution cables and protection equipment
4. Status quo, do nothing.

Recommended Solution:

Alternative #1A - Build new Newark GIS station in a building (layout #1A) located adjacent to the existing Newark Switch and demolish the existing Newark Switch (b2870)

Current Alternative #1 Estimated Cost: In-progress : \$275 M (January 2017)



- 6/2/2017 – Original Version Posted to PJM.com
- 6/6/2017 – Slide #18, supplemental project # is added. Updated Project IS date and Status
- 6/7/2017 – Slide #21 removed. Dominion Project: Line #567 River Crossing Rebuild to be presented at a future TEAC
- 6/12/2017- Removed several projects from the Appendix that will not be presented to the Board in July 2017. Added first and second read dates to projects going to the July Board.
- 6/13/2017- Added projects b2878 and b2879 associated with the deactivation of Stuart and Killen to Appendix. All projects in Appendix organized into West, South, MAAC.