Reliability Analysis Update

Transmission Expansion Advisory Committee

August 11, 2016

2016 RTEP Window #3 Anticipated Scope and Timeline

Anticipated 2016 RTEP Window #3

- Anticipated 2016 RTEP Window #3
  - Scope
    - 2021 Winter
    - 2021 Light Load Reliability Analysis
    - Short Circuit
  - Timing
    - Post preliminary results
    - Open Window
    - Close Window
    - Window Duration

2016 RTEP Proposal Window #2

2016 RTEP Proposal Window 2

- Scope:
  - Baseline N-1 (thermal and voltage)
  - Generation Deliverability and Common Mode Outage
  - N-1-1 (thermal and voltage)
  - Load Deliverability (thermal and voltage)
- Window Opened: 6/29/2016
- Window Closed: 7/29/2016
  - Proposal definitions, simulation data and planning cost estimate due
- Detailed Cost due: 8/15/2016
  - Additional 15 days to develop and provide detailed cost data
  - See the window documentation for additional information

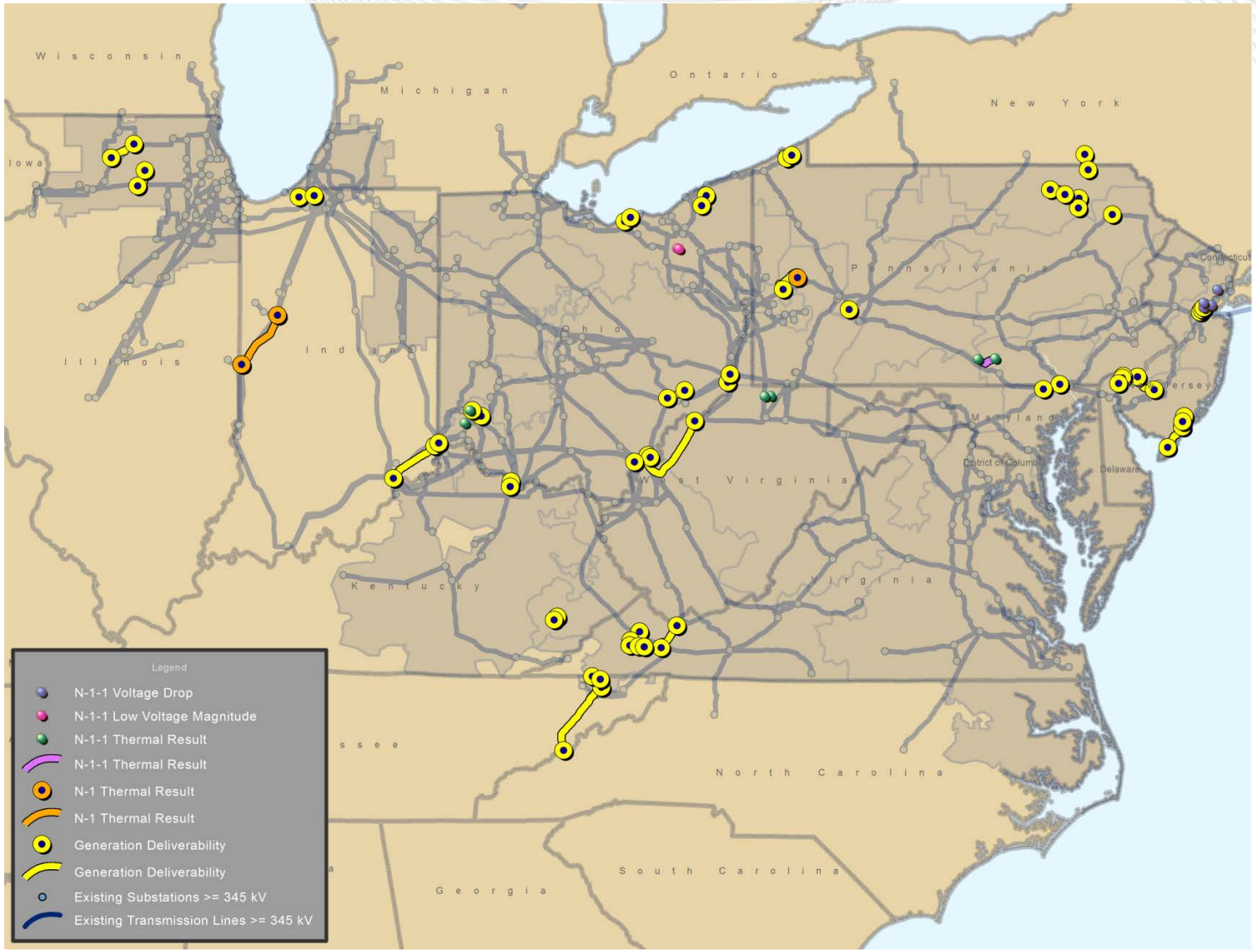
2016 RTEP Proposal Window 2

- 140 total flowgates

Test/kV Level*	100kV - 200kV	230kV	345kV	500kV	765kV	Total
N-1 Thermal	1		2			3
N-1 High Voltage						0
N-1 Low Voltage						0
N-1 Voltage Drop						0
Gen Deliv & CMO	76	9	13	3	1	102
Load Deliv Thermal						0
Load Deliv Voltage						0
N-1-1 Thermal	10					10
N-1-1 Low Voltage	2					2
N-1-1 Voltage Drop	2	18				20
N-1-1 Voltage Collapse						0
Total	91	27	15	3	1	137

*xfmr are categorized based on low side kV

2016 RTEP Proposal Window 2 Violation Locations



2016 RTEP Proposal Window 2

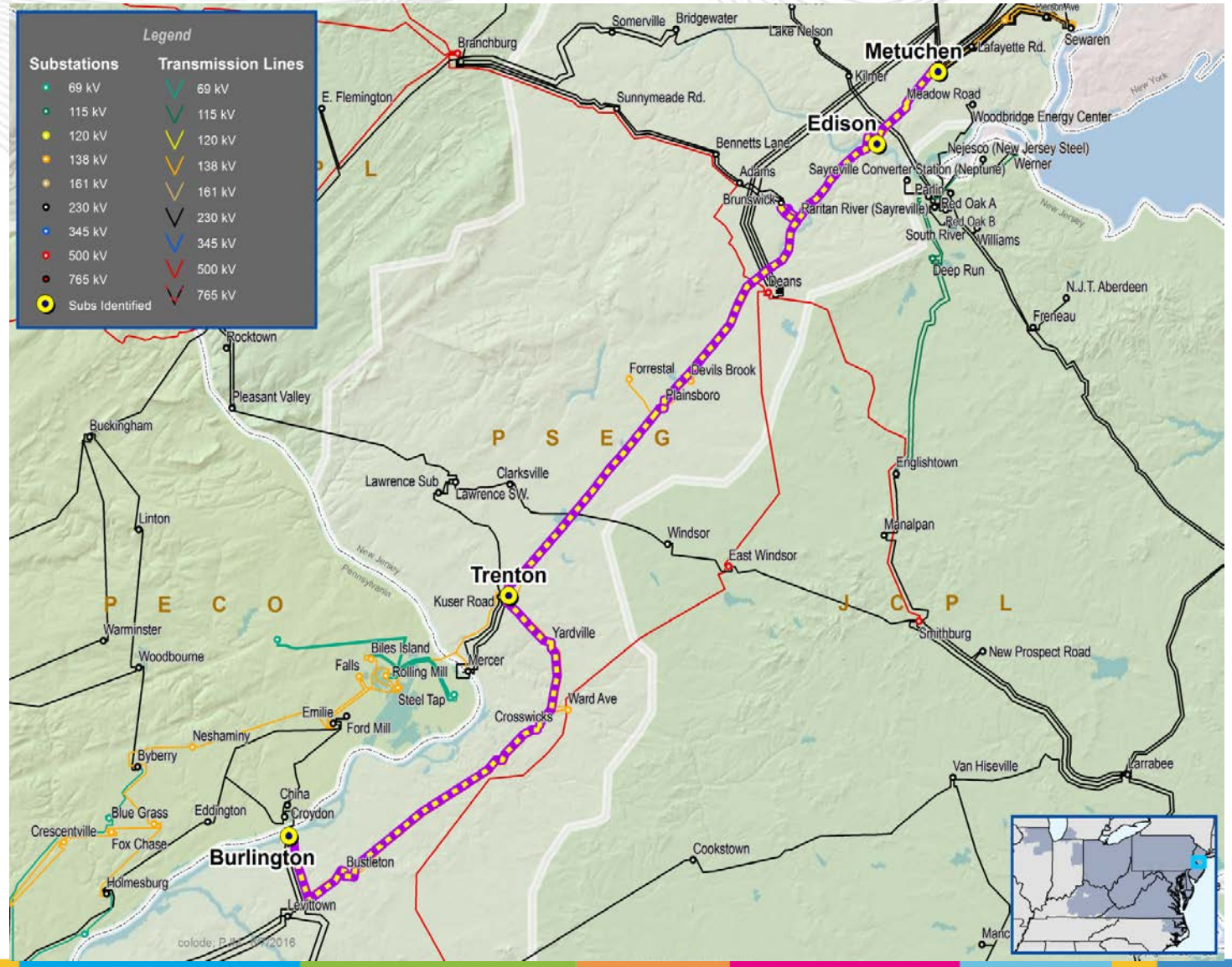
- Window Opened: 6/29/2016
- Window Closed: 7/29/2016
- Additional 15 day window close: 8/15/2016
- 137 Flowgates Identified, 71 Flowgates Recommended for proposals (Remaining flowgates related to Retired Generators)
- 87 Proposals Received from 13 Entities addressing 12 TO Zones
  - 46 Greenfield
    - Cost Range $5M - $224M
  - 41 Transmission Owner Upgrades
    - Cost Range $0.03M - $125M

PSE&G End Of Life Assessment

Metuchen – Edison – Trenton – Burlington Corridor

PSE&G Transmission Zone

- PSE&G's FERC 715 Transmission Owner criterion addresses equipment condition assessments
  - PSE&G assessed the condition of the Metuchen to Trenton (MT-T) and Trenton to Burlington (T-BU)138 kV circuits.



PSE&G Transmission Zone

- Refer to PSE&G criteria:

  VII. EQUIPMENT ASSESSMENT AND STORM HARDENING

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

  - Metuchen to Trenton is approximately 30 miles of 138 kV circuit and the average structure age is 86 years.
  - Trenton to Burlington is approximately 22 miles of 138 kV circuit and the average structure age is 75 years.

- Assessment Result:
  - Consultant - Foundation assessment
    - 23% and 30% of structures for MT-T and T-BU respectively will require extensive foundation rehabilitation or total foundation replacement.
  - Consultant – Tower line assessment
    - 25 % of the tower structures exceed the tower load carrying design capability
    - 35% of the towers are at 99-100% of the tower's load bearing capability, and 81% of the towers at 95-100% of the tower's capability.

PSE&G Transmission Zone

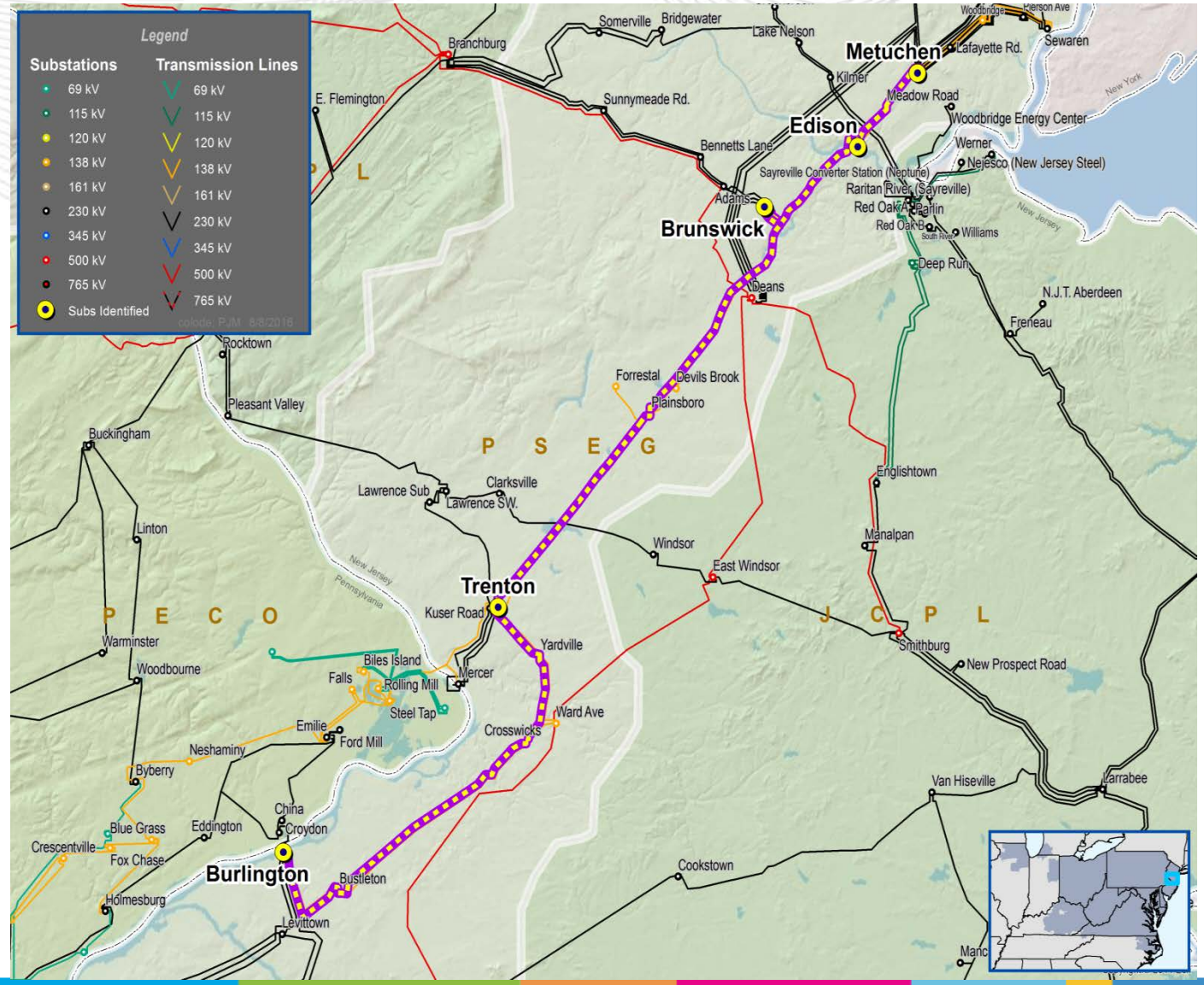
Problem:

PSE&G FERC 715 Transmission Owner Criteria

- Equipment condition assessment for the entire corridor
- Equipment has reached its end of life

NERC Reliability Criteria

- N-1-1 voltage violations in the Metuchen vicinity in the 2016 RTEP Window #2

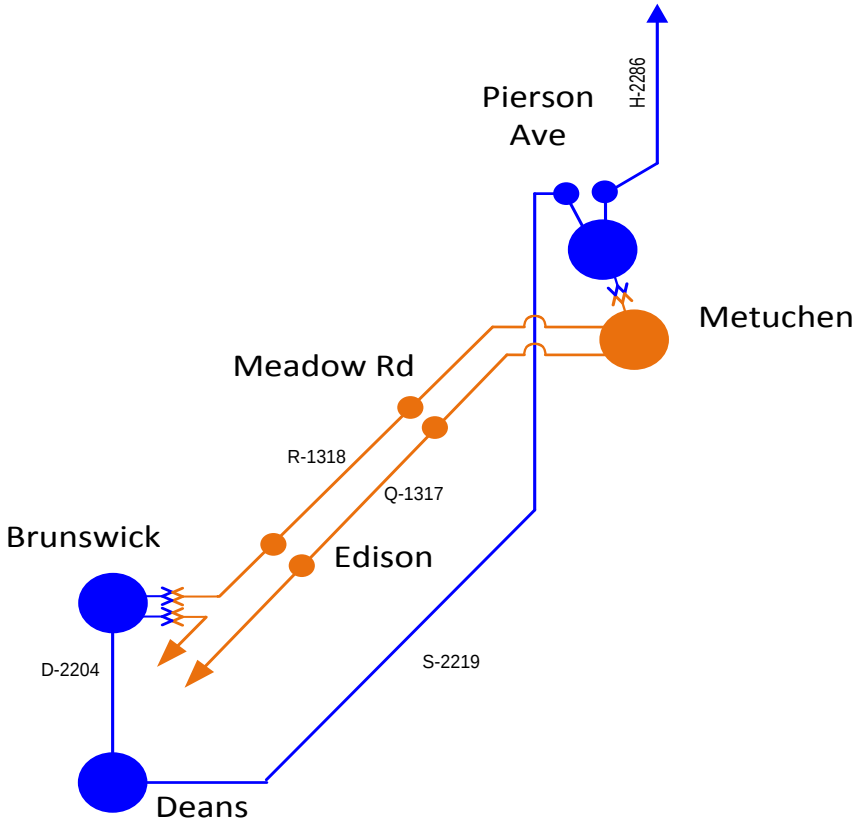


PSE&G Transmission Zone

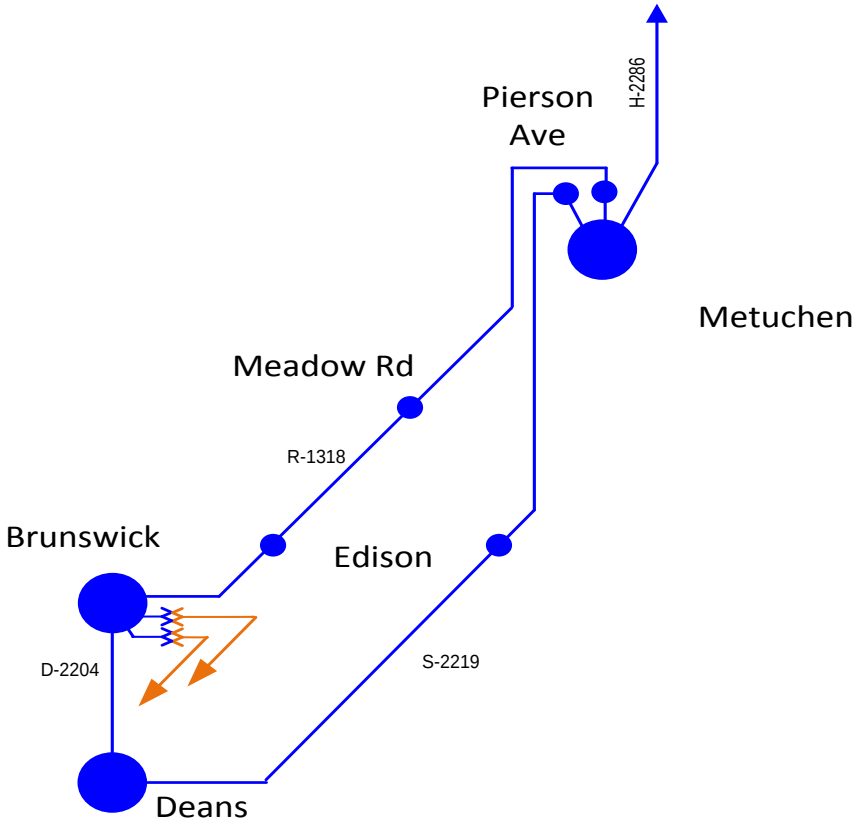
- Potential Solution for Metuchen - Brunswick:
  - Convert the R-1318 and Q1317 (Edison – Metuchen) 138 kV circuits to one 230 kV circuit
    - Metuchen 138 kV will be eliminated
    - The Brunswick 230/138 kV autotransformer will be eliminated
    - The new converted 230 kV circuit will be terminated at the existing Metuchen and Brunswick 230 kV stations.
- Project Benefits:
  - Resolves voltage violation in the Metuchen vicinity identified in the 2016 RTEP 2nd Window
  - Eliminates the need for baseline upgrade (B2590 – Install two 75 MVAR 230 kV capacitors at Sewaren station) identified in the 2014 RTEP window.
  - Strengthens the system by replacing 138 kV circuits with 230 kV circuits, improving capacity and voltage.
  - Creates a strong tie between Southern and Central PSE&G
  - Increases transfers capability to Central PSE&G
  - Addresses future reliability and economic needs
- Estimated Project Cost: $ 125 M
- Alternatives Considered:
  - Rebuild the existing transmission corridor in-kind at 138 kV

Metuchen – Brunswick Existing and Future Diagram

Before



After



PSE&G Transmission Zone

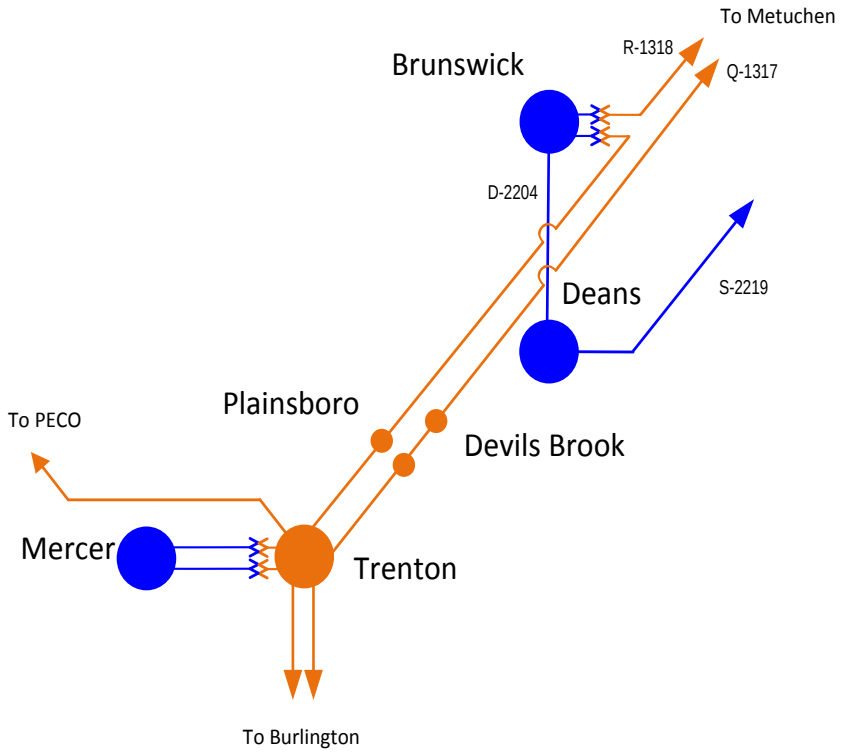
- Potential Solution for Brunswick - Trenton:
  - Convert the N-1340 and T-1372/D-1330 (Brunswick – Trenton) 138 kV circuits to 230 kV circuits
    - The converted circuits will be terminated at the existing Brunswick 230 kV
    - The Deans 230 kV station will be expanded with additional two breaker and half bay
    - The converted two 230 kV circuits will be looped in to Deans 230 kV station
    - The new converted 230 kV circuit will be terminated at the Trenton 138 kV station with two 138 kV transformers
- Project Benefit:
    - Strengthens the system by replacing 138 kV circuits with 230 kV circuits, improving capacity and voltage.
    - Provides better transfers across the network
    - Addresses future reliability and economic needs

Estimated Project Cost: $ 327 M

- Alternatives Considered:
  - Rebuild the existing transmission corridor in-kind at 138 kV

Brunswick – Trenton Existing and Future Diagram

Before



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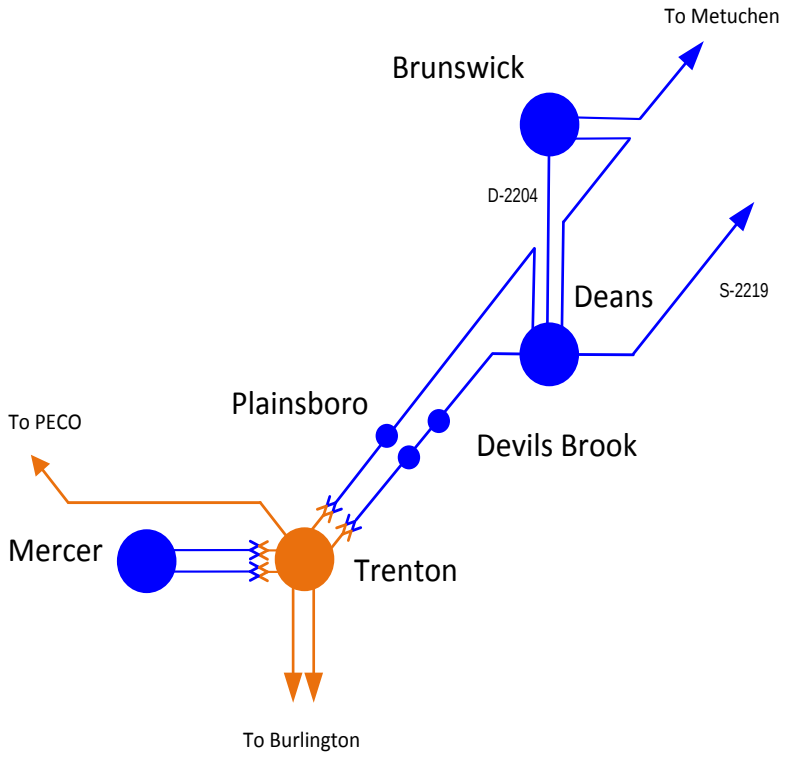


PSE&G Transmission Zone

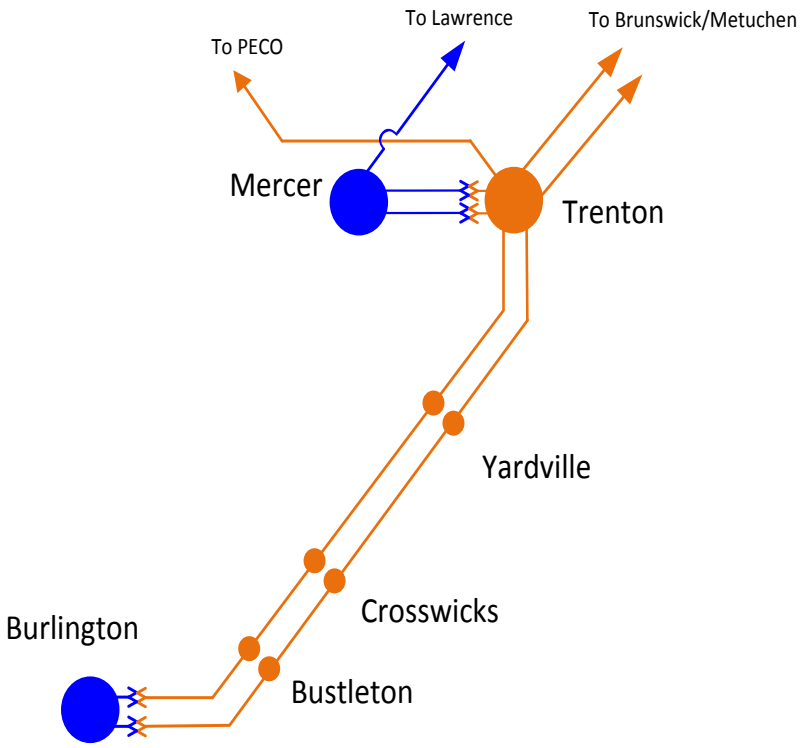
- Potential Solution for Trenton - Burlington:
  - Convert the F-1358/Z1326 and K1363/Y-1325 (Trenton - Burlington) 138 kV circuits to 230 kV circuits
    - Trenton 138 kV substation will be replaced with six bay breaker and half 230 kV substation
    - The A-130-27 138 kV currently from Trenton - US Steel (PECO) will be terminated at Mercer 230 kV with 230/138 kV transformer and the Trenton – Mercer portion of the circuit will be converted to 230 kV
    - Mercer station will be expanded with additional breaker and half bay.
- Project Benefit:
    - Eliminates the need for baseline upgrade (B2589 – Install a 100 MVAR 230 kV shunt reactor at Mercer station) identified in the 2014 RTEP window.
    - Strengthens the system by replacing 138 kV circuits with 230 kV circuits, improving capacity and voltage.
    - Provides better transfers across the network
    - Addresses bottled generation issue at Mercer

Estimated Project Cost: $ 349 M

- Alternatives Considered:
  - Rebuild the existing transmission corridor in-kind at 138 kV

Trenton – Burlington Existing and Future Diagram

Before



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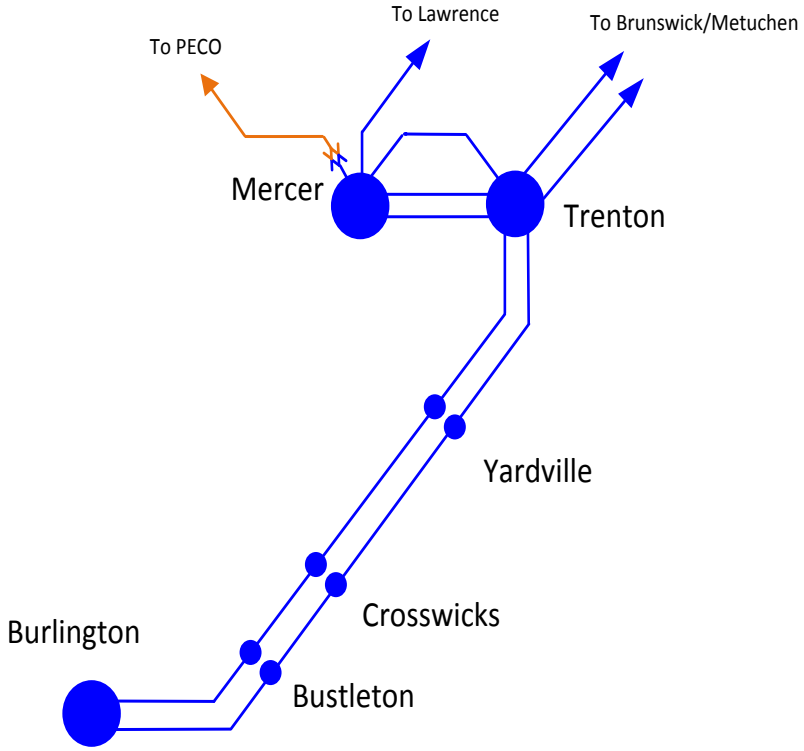


PSE&G End Of Life Assessment
Newark Switch Review

PSE&G Transmission Zone

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

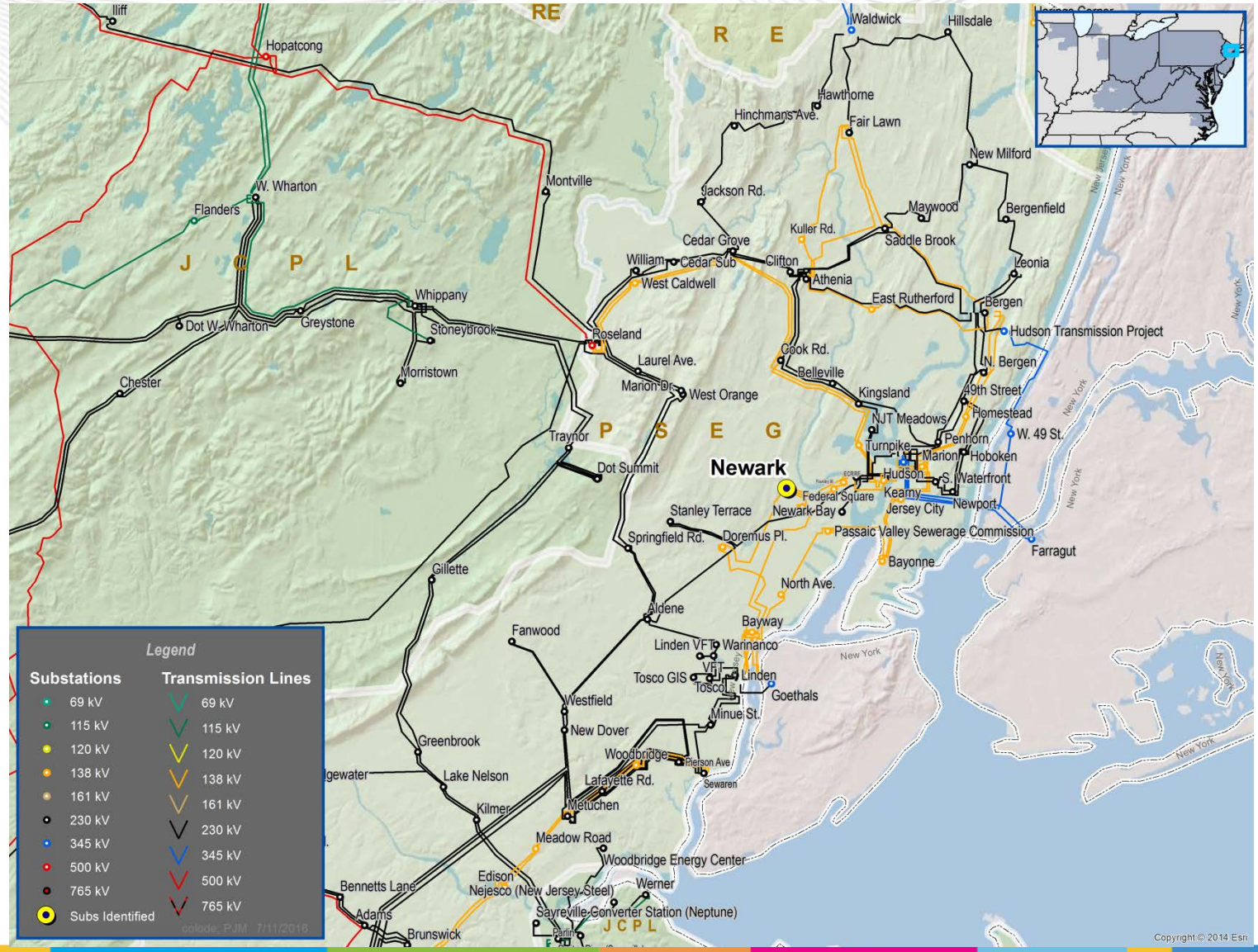
Alternatives Considered:

1. Build new Newark GIS station in a building located adjacent to the existing Newark Switch and demolish the existing Newark Switch
2. Build a new Newark GIS station elsewhere in Newark and relocate all transmission and distribution cables and protection equipment

Potential Solution:

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

Estimated Cost: $353 M



Immediate Need Baseline Upgrades

PPL/JCPLTransmission Area

Problem: Stability

- Martins Creek and Lower Mount Bethel Energy units go unstable for a 3-Phase fault at 80% of Martins Creek – Morris Park 230 kV line with zone 2 clearing

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

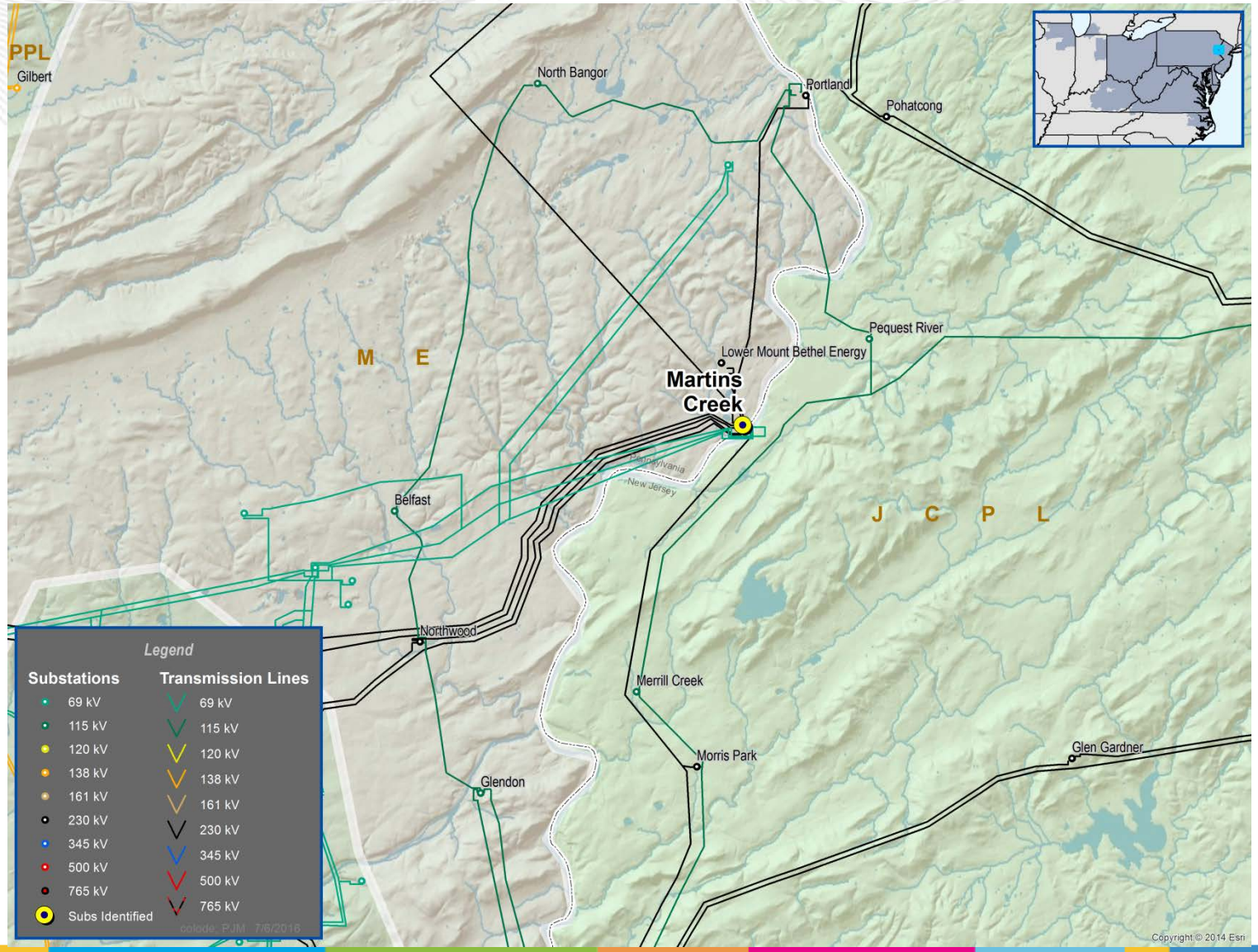
Proposed Solution:

- Install 12 mi of optical pilot ground wiring (OPGW) between Gilbert and Springfield substations
  - 7 mi of construction by PPL on bulk power lines **(b2754.1)**
  - 5 mi of construction by JCPL on bulk power lines **(b2754.2)**
- Install 7 mi of all-dielectric self-supporting (ADSS) fiber optic cable between Morris Park and Northwood substations (JCPL) **(b2754.3)**
- Use ~ 40 route mi. of existing fibers on PPL system to establish direct fiber circuits **(b2754.4)**
- Upgrade relaying at Martins Creek (PPL) **(b2754.5);**, Morris Park (JCPL) **(b2754.6);** and Gilbert (JCPL) **(b2754.7)**

Estimated Cost: $ 1.001 M(PPL)

$1.456 M (JCPL)

Projected IS Date:12/01/2019



Short Circuit Upgrades

PPL Transmission Area

Problem: Short Circuit

- The Martins Creek 230kV breakers are overdutied

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:

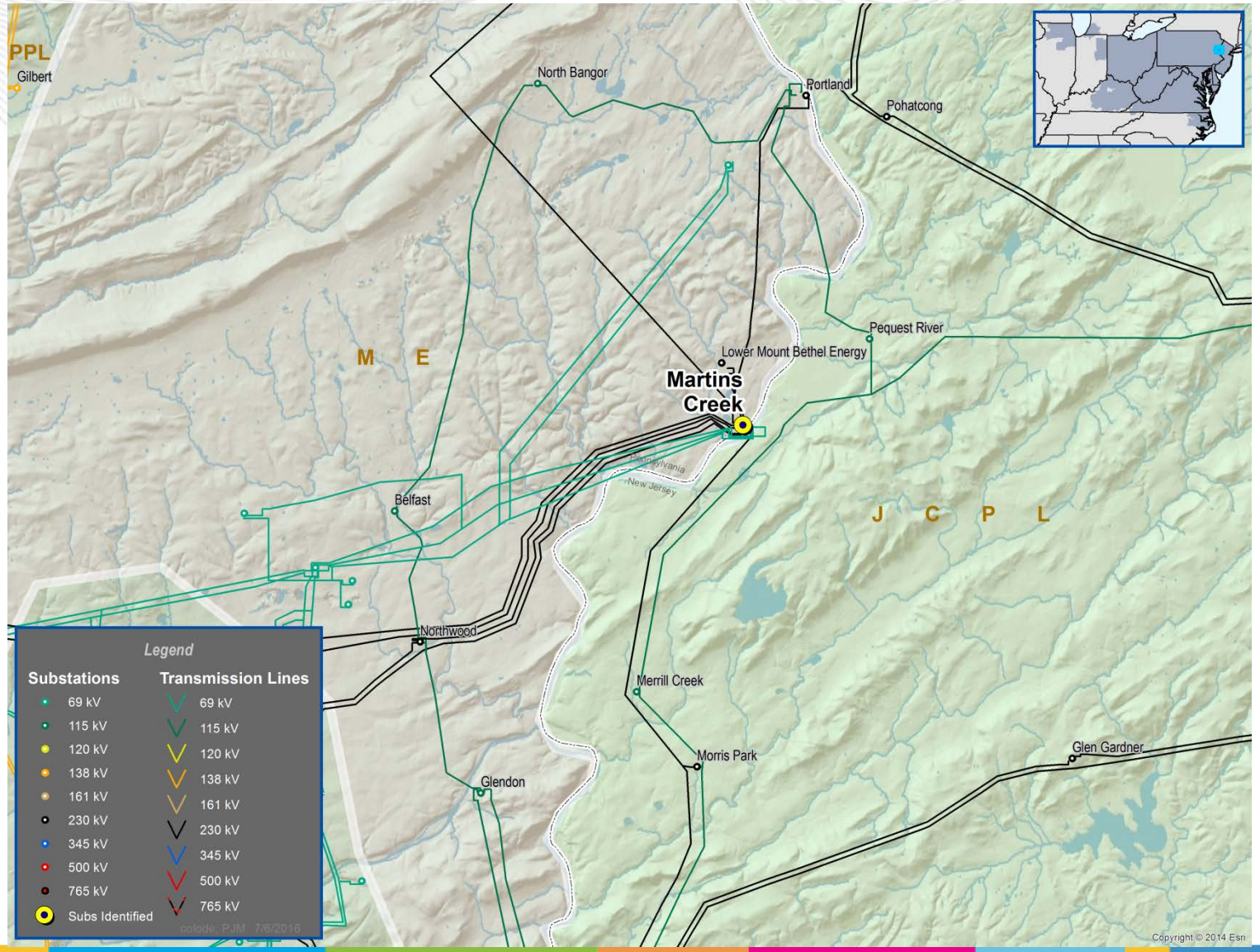
- Due to the immediate need of the project no alternatives were considered

Proposed Solution:

- Install 2% reactors at Martins Creek 230kV (B2756)

Estimated Cost: $ 10 M

Required IS Date: 06/01/2018



Artificial Island Update

Artificial Island Update

- PJM Board Meeting – week of August 1st, 2016
  - The PJM Board decided to suspend all elements of the Artificial Island project and directed PJM staff to perform a comprehensive analysis to support a future course of action.

  - Andy Ott Letter on Behalf of the PJM Board
    - http://www.pjm.com/~/media/documents/reports/20160805-artificial-island-update.ashx
  - Steve Herling Letter to Members and Stakeholders
    - http://www.pjm.com/~/media/documents/reports/20160805-steven-herling-letter-on-artificial-island-suspension.ashx

RTEP Next Steps

Questions?

Email: RTEP@pjm.com

Revision History

- Revision History
  - V1 - Original version posted to PJM.com – 8/8/2016
  - V2 – Added Metuchen – Edison – Trenton – Burlington Corridor diagrams – 8/9/2016
  - V3 – Updated the equipment ages of the Newark Switch (current slide #21) and added a potential solution