Artificial Island Proposal Window

PJM Special TEAC

Artificial Island Review

05/19/2014

Version 2

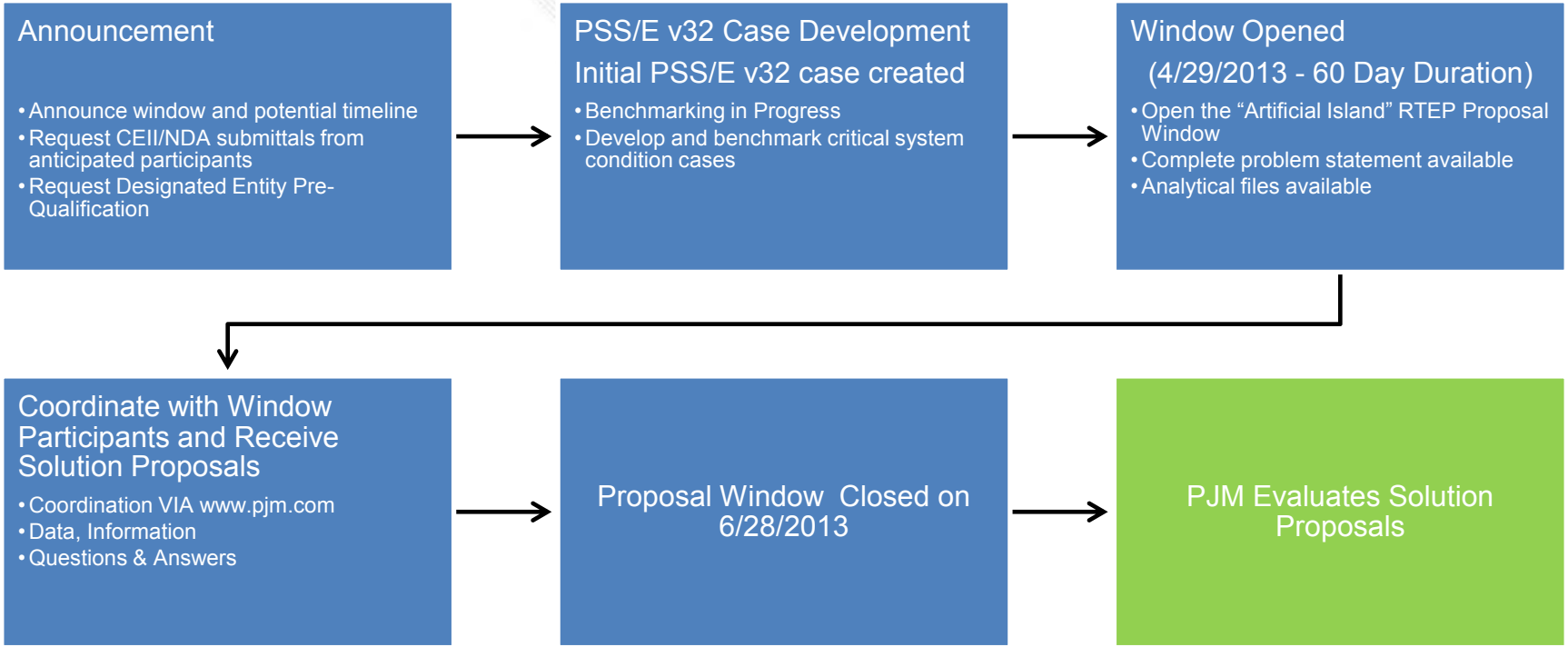
Artificial Island Problem Statement Summary

- Generate maximum power from the AI under both the baseline (N-0) and maintenance (N-1) assumptions

- Satisfy applicable planning criteria

  – http://pjm.com/~/media/planning/rtep-dev/expan-plan-process/ferc-order-1000/rtep-proposal-windows/redacted-artificial-island-problem-statement.ashx

Artificial Island Proposal Window Timeline



Past Timeline

- 9/13/2012 – PJM discusses the Artificial Island with PJM Stakeholders
- March 2013 - TEAC Previewed conceptual timeline and next steps for an Artificial Island Proposal Window
- 4/29/2013 – Artificial Island Proposal Window Opened
- 6/28/2013 – Artificial Island Proposal Window Closed
- July 2013 through April 2014 – PJM discusses the details of project performance, cost and constructability

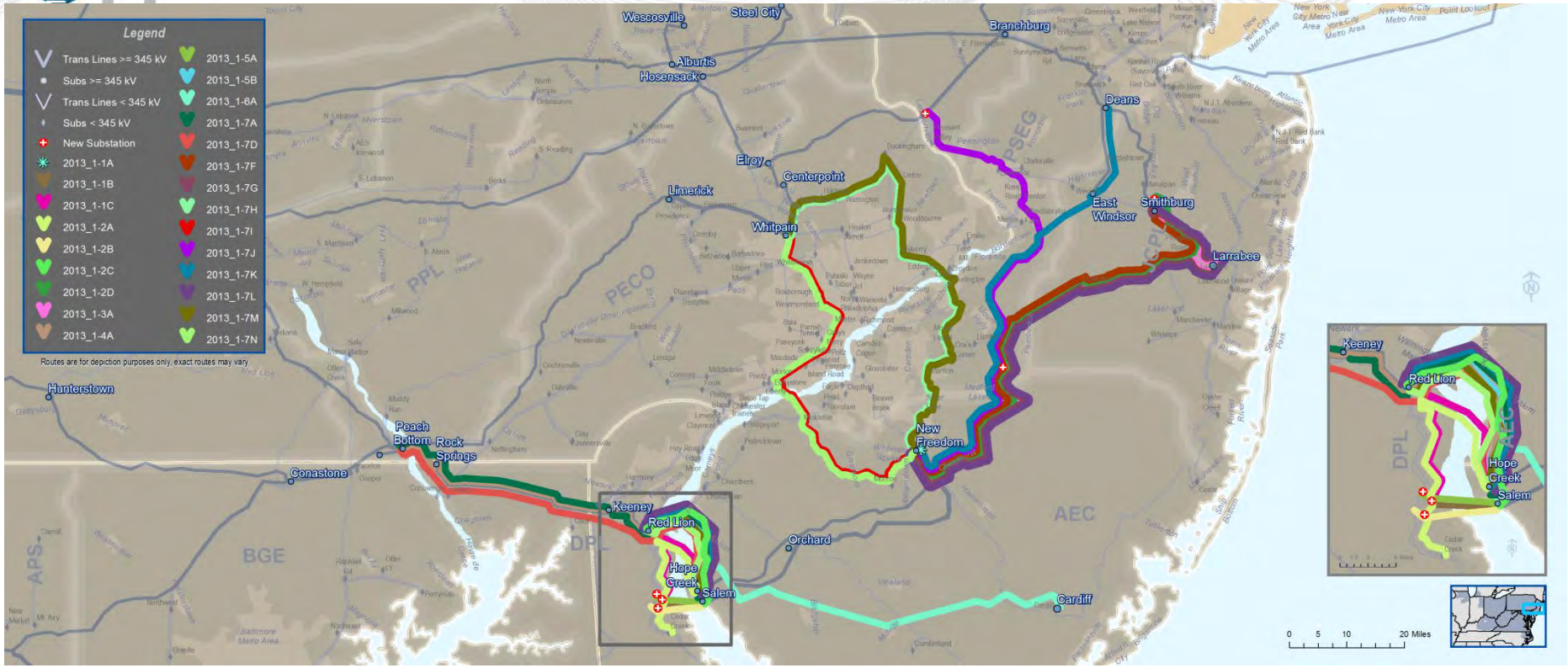
Proposals Overview

- 26 Proposals received from 7 individual entities
- **Cost Estimates:** Approximate range of $100 M to $1.5 B
- **Technology:** Static Var Compensator (SVC), Thyristor Controlled Series Compensation (TCSC), High Voltage Direct Current (HVDC) transmission line, (AC) transformers, (AC) overhead transmission line, underground/underwater cable transmission line, circuit breakers and associated protection equipment
- **Voltages:** 230 and 500kV
- **Station Connections:** Broad diversity of proposed methods to connect to existing stations or construct new stations as needed
- **Routing:** Wide variety of proposed methods to route new transmission over/under existing rights of way (ROW) or through new ROW

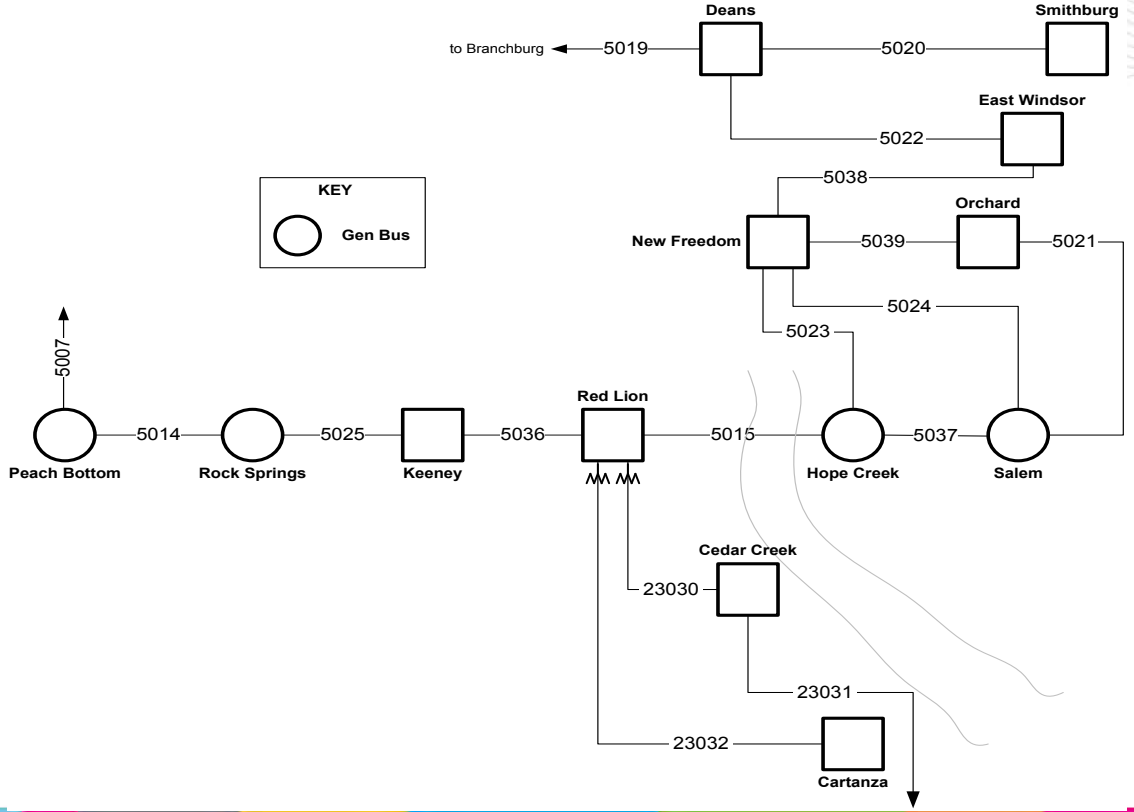
Artificial Island Project Proposal Overviews

Project ID	TO	Cost ($)	Major Components	Supporting info
P2013_1-1A	Virginia Electric and Power Com	$ 133	500 MVAR SVC near New Freedom	Two (2) Thyristor Controlled Series Compensation (TCSC) Devices near New Freedom
P2013_1-1B	Virginia Electric and Power Com	$ 126	New 500 kV from Salem - a new station in Delaware	New 500/230 kV station in Delaware that taps existing Cedar Creek - Red Lion 230kV and Catanza - Red Lion 230kV
P2013_1-1C	Virginia Electric and Power Com	$ 202	New 500 kV from Hope Creek - a new Station in Delaware	Install a new 500kV line from Hope Creek - Red Lion; New Salem - Hope Creek 500 kV line
P2013_1-2A	Transource	$213 - $269	Salem - Cedar Creek 230 kV	Two (2) 500/230 Transformers near Salem; Loop in Red Lion - Cartanza 230 to Cedar Creek
P2013_1-2B	Transource	$165 - $208	Salem - North Cedar Creek (new) 230 kV	Two (2) 500/230 transformers near Salem and loop in Red Lion - Cartanza 230 and Red Lion - Cedar Creek 230 kV
P2013_1-2C	Transource	$123 - $156	Salem - Red Lion 500 kV	
P2013_1-2D	Transource	$788 - $994	New Freedom - Lumberton - North Smithburg (New) 500 kV line	New Salem - Hope Creek 500 kV line and new 500/230 station east of Lumberton
P2013_1-3A	First Energy	$410.7 (Only FirstEnergy portion)	New Freedom-Smithburg 500 kV line with a loop into Larrabee	Hope Creek - Red Lion 500 kV line
P2013_1-4A	PHI Exelon	$ 475	Peach Bottom - Keeney - Red Lion - Salem 500 kV	Remove Keeney - Red Lion 230 kV; Reconfigure 230 around Hay Road; Reconductor Harmony-Chapel St 138 kV
P2013_1-5A	LS Power	$116.3M - $148.3M	Salem - Silver Run (new) 230 kV; Salem 500/230 kV Transformer	New 230 kV station that taps existing Cedar Creek - Red Lion 230kV and Catanza - Red Lion 230kV
P2013_1-5B	LS Power	$ 170	Salem - Red Lion 500 kV	
P2013_1-6A	Atlantic Wind	$ 1,012	320 kV HVDC Salem/Hope Creek - Cardiff	SVC at Salem/Hope Creek; New HVDC Stations at Cardiff and Salem
P2013_1-7A	PSE&G	$ 1,371	Salem-Hope Creek to Peach Bottom 500 kV	Existing ROW
P2013_1-7B	PSE&G	$ 1,372	Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with Loop into Keeney
P2013_1-7C	PSE&G	$ 1,372	Salem-Hope Creek to Peach Bottom 500 kV	Same at 7A with Loop into Red Lion
P2013_1-7D	PSE&G	$ 831	Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with New ROW
P2013_1-7E	PSE&G	$ 692	New Freedom - Deans 500 & Salem - Hope Creek 500 kV lines	
P2013_1-7F	PSE&G	$ 879	New Freedom - Smithburg and Salem-Hope Creek 500 kV lines	Existing ROW
P2013_1-7G	PSE&G	$ 1,034	New Freedom - Smithburg and Salem-Hope Creek 500 kV lines	Same as 7F with a Loop into a new Larrabee 500 kV station
P2013_1-7H	PSE&G	$ 1,177	New Freedom - Whitpain and Salem - Hope Creek 500 kV lines	Northern Route
P2013_1-7I	PSE&G	$ 1,353	New Freedom - Whitpain and Salem - Hope Creek 500 kV lines	Same as 7H with the Southern Route
P2013_1-7J	PSE&G	$ 915	New Freedom - New Station on Branchburg-Elroy 500 kV line ("5017 Junction") and Salem - Hope Creek 500 kV line	Existing ROW
P2013_1-7K	PSE&G	$ 1,066	New Freedom - Deans & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7E with Hope Creek - Red Lion
P2013_1-7L	PSE&G	$ 1,250	New Freedom - Smithburg & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7F with Hope Creek - Red Lion
P2013_1-7M	PSE&G	$ 1,548	New Freedom - Whitpain (North) & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7H with Hope Creek - Red Lion
P2013_1-7N	PSE&G	$ 1,289	New Freedom - a new Station on the Branchburg-Elroy 500 kV line ("5017 Junction") & Salem-Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	

Artificial Island Proposals



Artificial Island Area Network



Dominion Virginia Power (DVP) 1A

- New switching station cutting the 5023 and 5024 lines near New Freedom substation that includes
  - a 500kV SVC (+500 to -300 MVAr)
  - Two Thyristor Controlled Series Compensation (TCSC) devices
- Proposed Cost Estimate: $130MM

Dominion Virginia Power (DVP) 1B

- Install a new 500kV line from Salem 500kV to a new station in Delaware
- Aerial crossing of the Delaware river
- New substation in Delaware that taps the existing Red Lion to Cartanza 230kV and Red Lion to Cedar Creek 230kV lines
- Proposed Cost Estimate: $133MM

Dominion Virginia Power (DVP) 1C

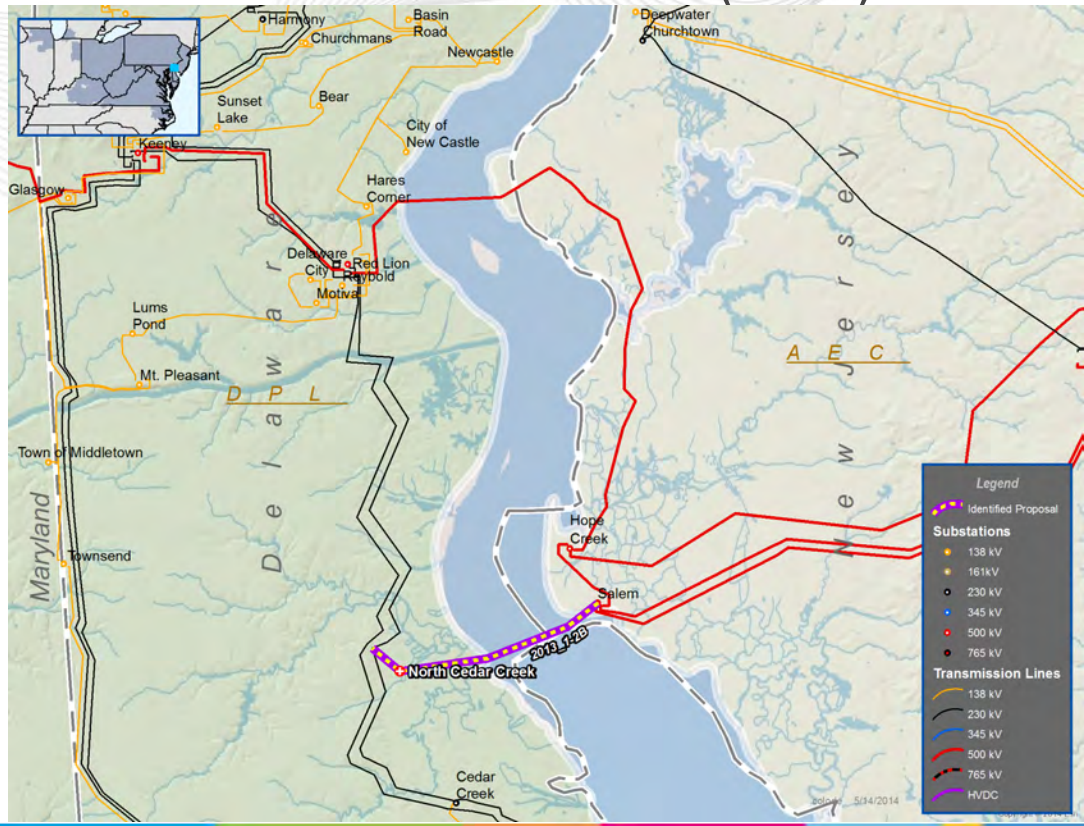
- Expansion of Hope Creek substation
- 17 mile 500kV line from Hope Creek to Red Lion
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Second Hope Creek to Salem tie line
- Reconfiguration of Red Lion substation into a breaker and a half scheme
- Proposed Cost Estimate: $199MM

Transource (AEP) 2A

- Expansion of the Salem substation
- New substation near Artificial Island with two 500/230 kV autotransformers
- Submarine line under the Delaware river
- Expand existing Cedar Creek substation to accept the new line and to loop in the Red Lion – Cartanza 230kV line
- Proposed Cost Estimate: $213-$269MM

Transource (AEP) 2B

- Expansion of the Salem substation
- New substation near Artificial Island with two 500/230 kV autotransformers
- Submarine line under the Delaware river
- New substation in Delaware that taps the existing Red Lion to Cartanza 230 kV and Red Lion to Cedar Creek 230 kV lines
- Proposed Cost Estimate: $165-$208MM



Transource (AEP) 2C

- Expansion of Salem substation
- Move 5024 and 5021 line bays within Salem substation
- 17 mile 500kV line from Red Lion to Salem
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Reconfiguration of Red Lion substation into a breaker and a half scheme
- Proposed Cost Estimate: $123-$156MM

Transource (AEP) 2D

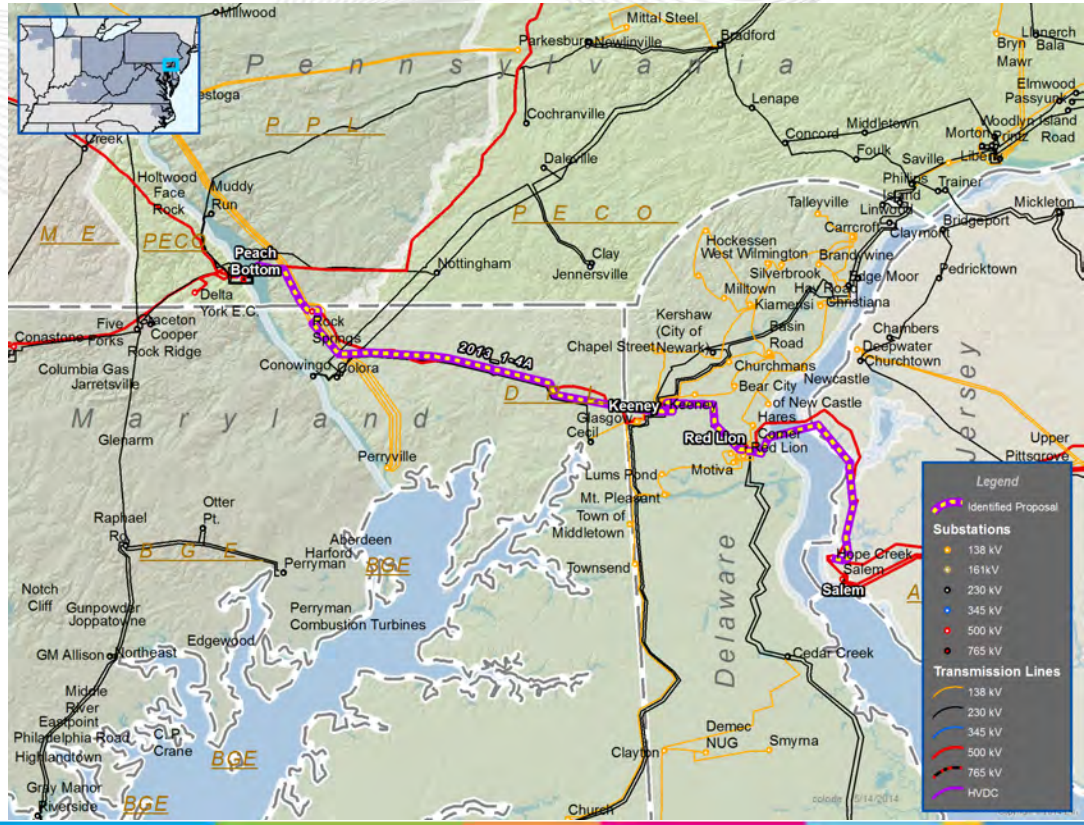
- Install a new 500kV line from New Freedom to Lumberton to North Smithburg
- New 500/230 substation east of Lumberton
- Second Hope Creek to Salem 500kV tie line
- Proposed Cost Estimate: $788-$994MM

FirstEnergy 3A

- Install a new, New Freedom to Smithburg 500kV line with a loop into Larrabee substation
- Install two new 500/230 auto-transformers at Larrabee
- 17 mile 500kV line from Hope Creek to Red Lion
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Proposed Cost Estimate: $452MM

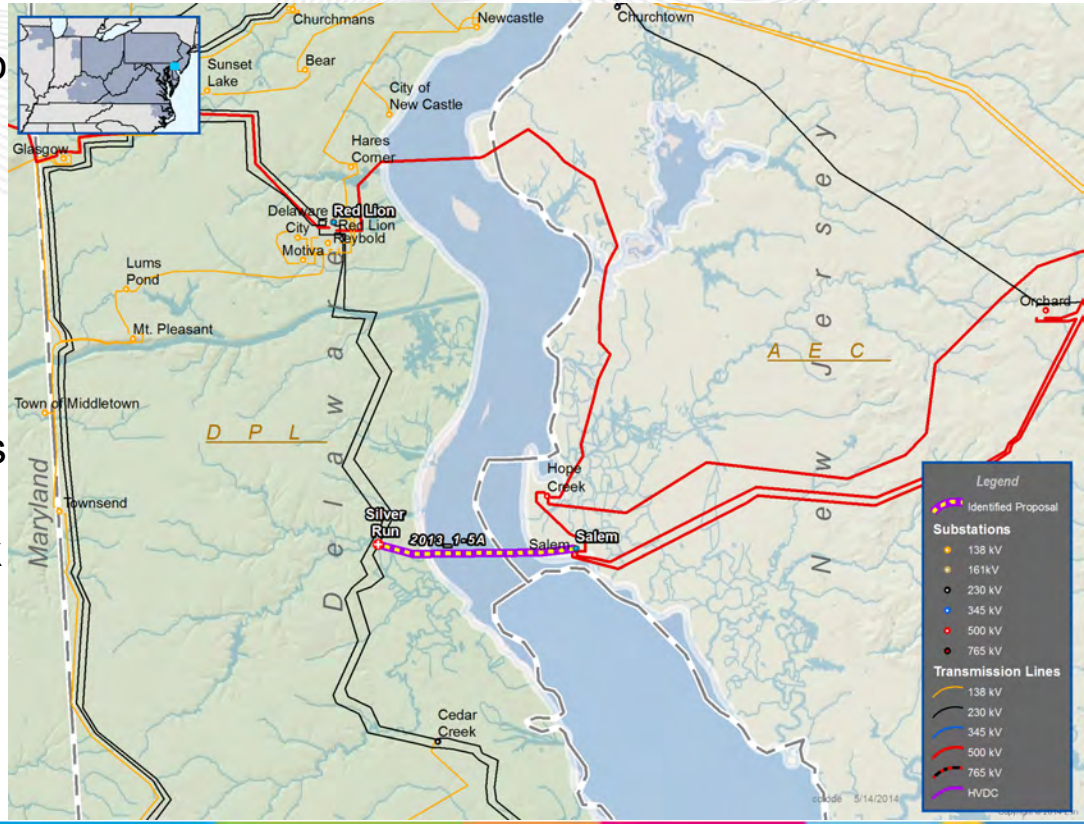
PHI / Exelon 4A

- Install a new Peach Bottom to Keeney to Red Lion to Salem 500kV line
- Remove existing Keeney to Red Lion 230 kV circuit
- Reconfigure the existing 230 kV line from Hay Road to Red Lion to terminate at Keeney instead of Red Lion
- Re-conductor the Harmony to Chapel Street 138 kV line
- Proposed Cost Estimate: $475MM



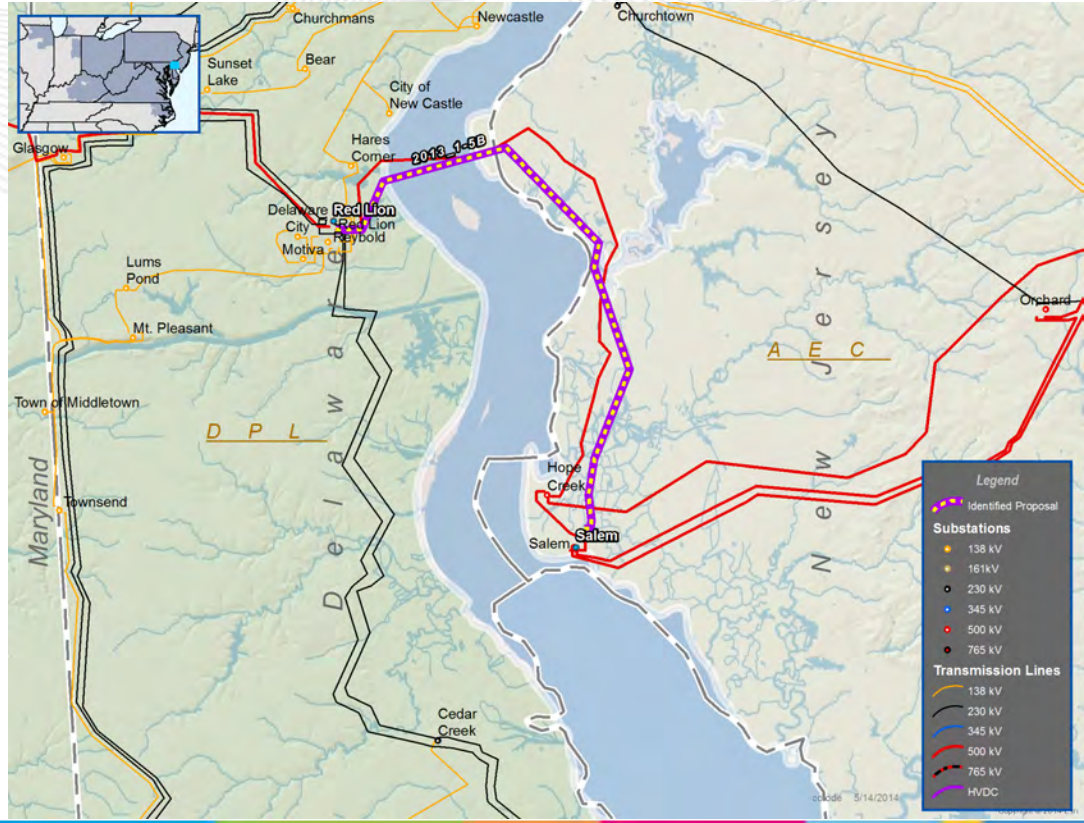
LS Power 5A

- Expansion of the Salem substation to the south to include a new 500/230kV auto-transformer
- Submarine or aerial line over the Delaware
- New substation in Delaware that taps the existing Red Lion to Cartanza 230 kV and Red Lion to Cedar Creek 230 kV lines
- Proposed Cost Estimate: $116 - $148MM



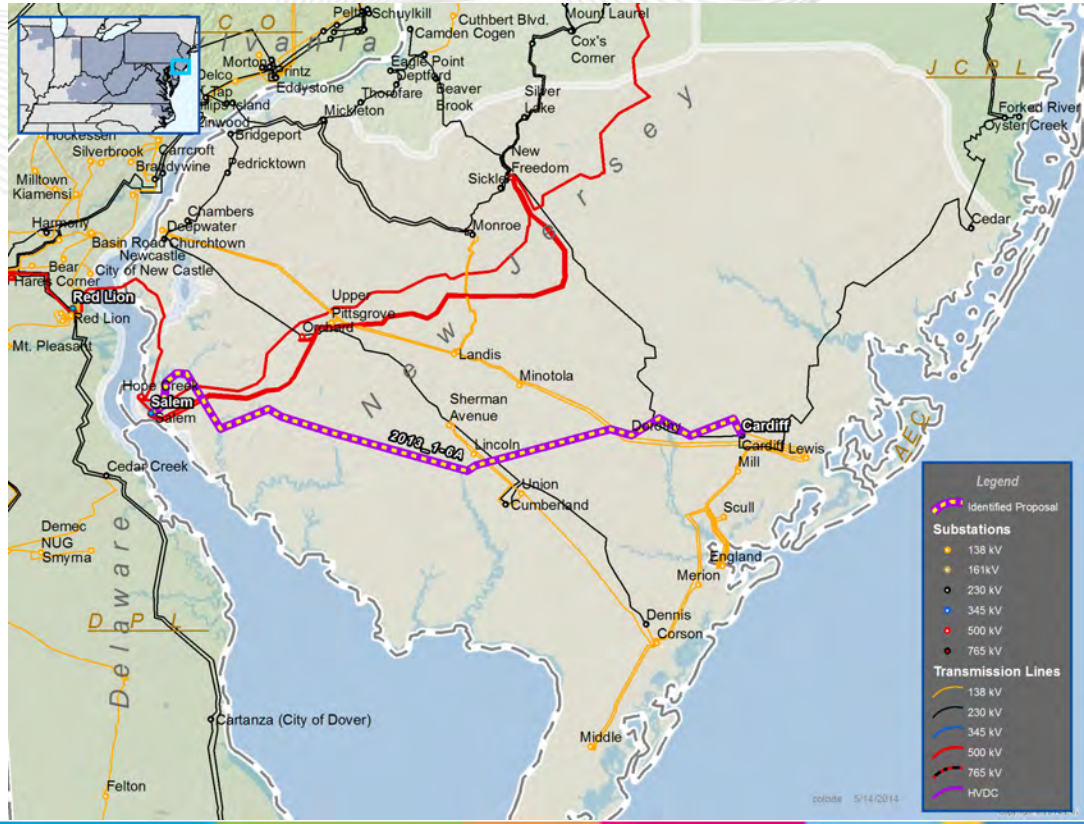
LS Power 5B

- Expansion of Salem substation
- 17 mile 500kV line from Red Lion to Salem
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Expansion of Red Lion substation ring-bus
- Proposed Cost Estimate: $170MM



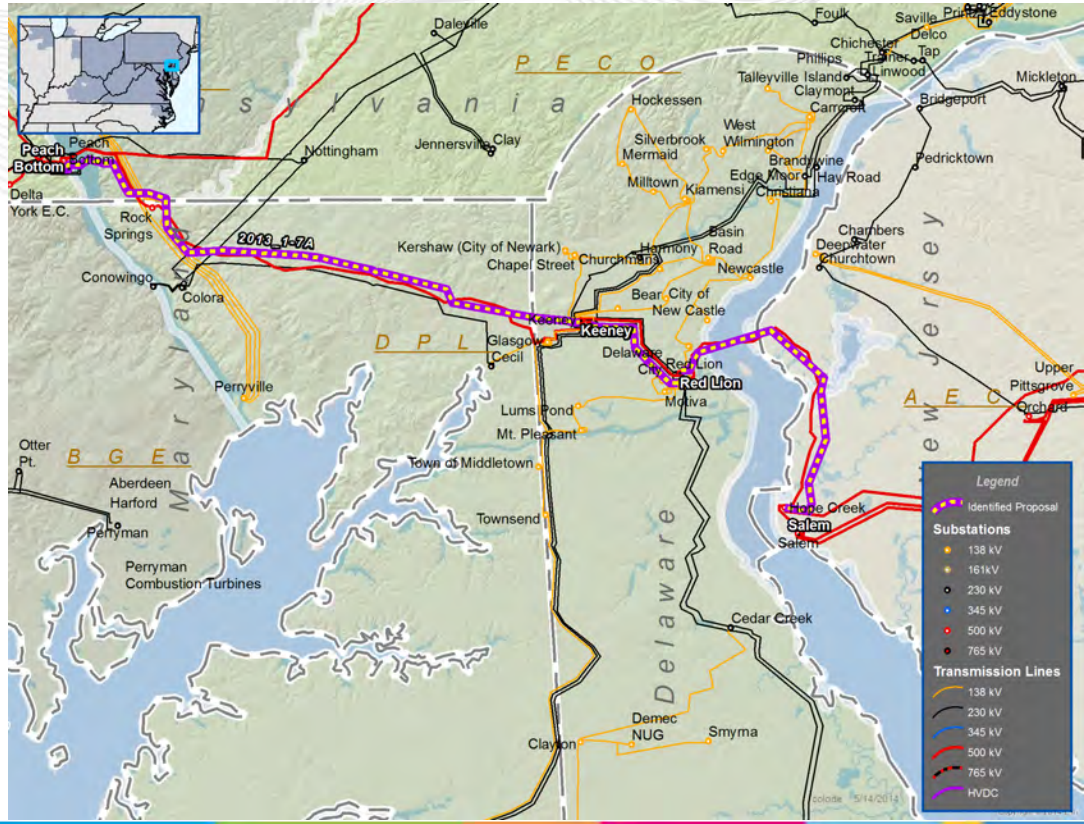
Atlantic Wind 6A

- Install a HVDC converter station near the Artificial Island
  - Install a SVC at the new Artificial Island HVDC station
- Install a HVDC converter station near the existing Cardiff 230 kV
- Install a 320kV HVDC line from the new Artificial Island HVDC station and the new HVDC station near Cardiff 230kV
- Proposed Cost Estimate : $1,012MM



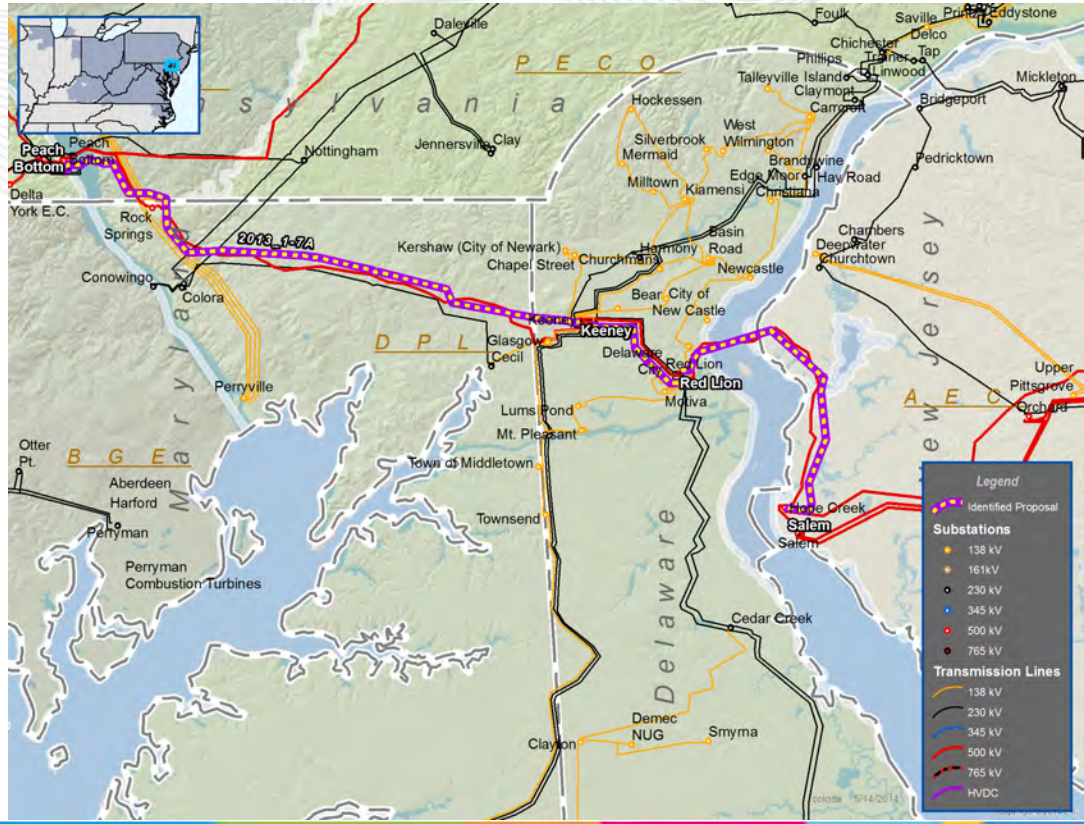
PSE&G 7A

- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Peach Bottom 500 kV line on existing right of way
- Proposed Cost Estimate: $1,371MM



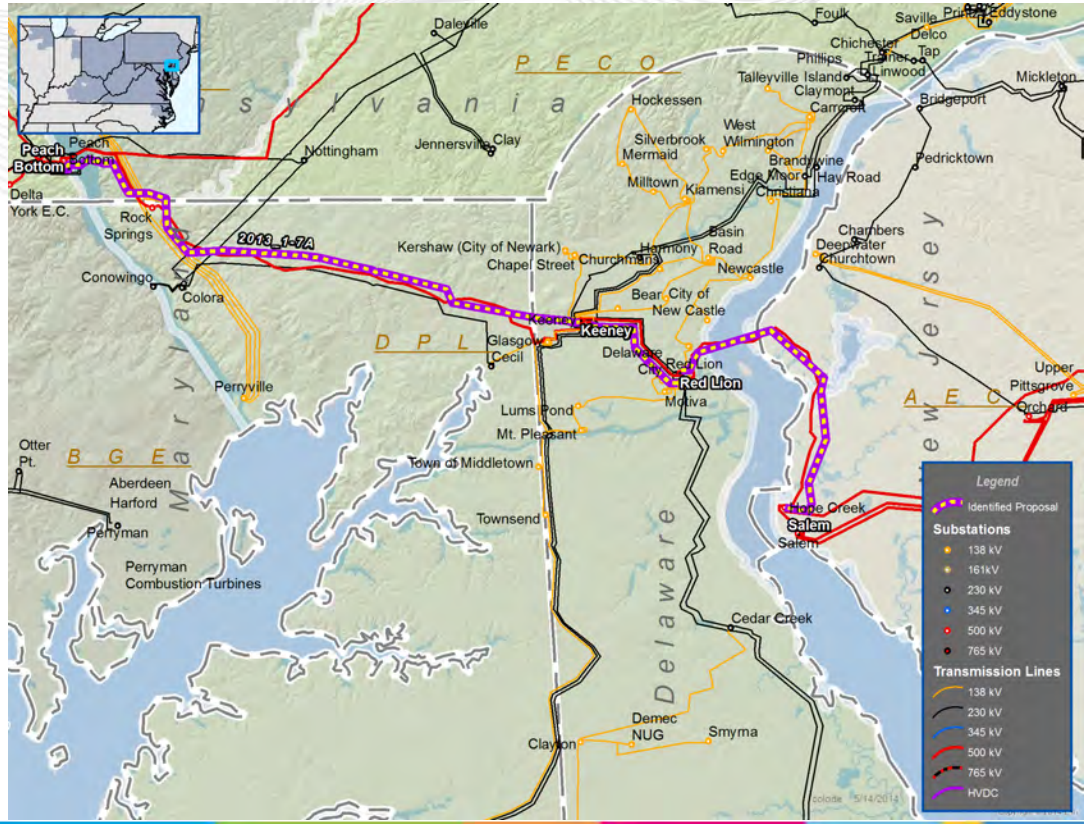
PSE&G 7B

- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Keeney to Peach Bottom 500 kV line on existing right of way
- Tie 5036 and 5025 lines together to open a bay position at Keeney substation
- Proposed Cost Estimate: $1,372MM



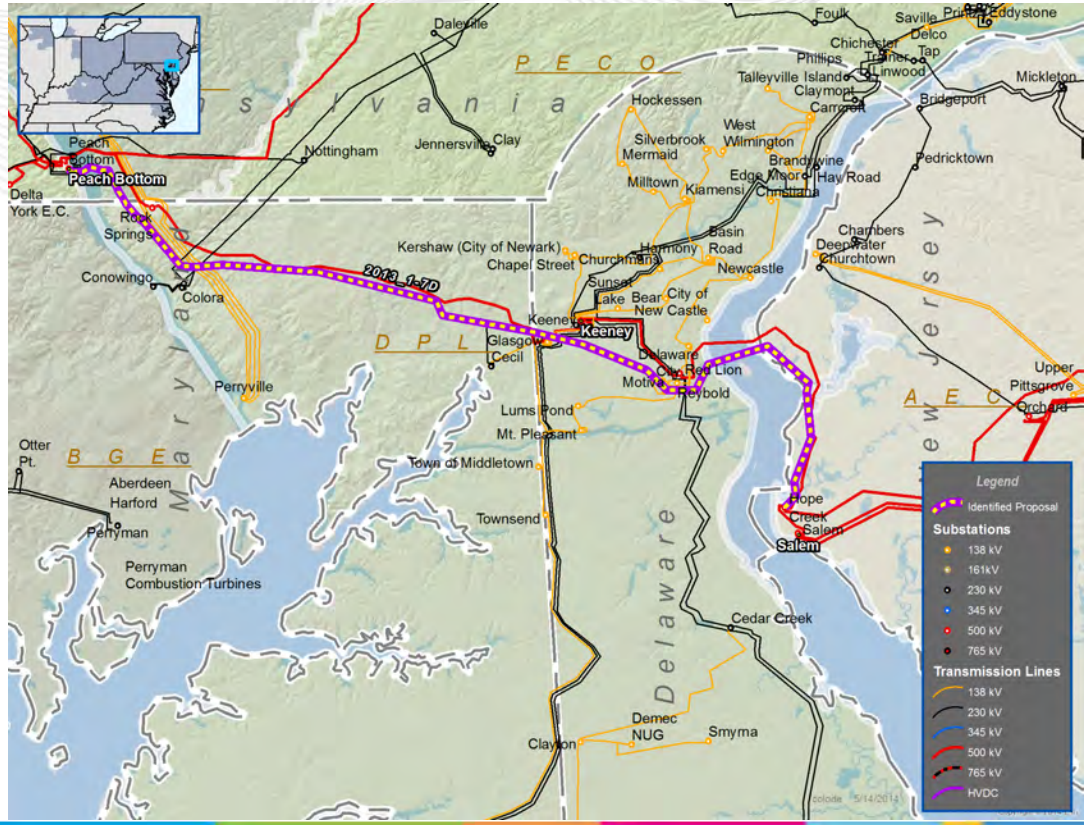
PSE&G 7C

- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Red Lion to Peach Bottom 500 kV line on existing right of way
- Tie 5036 and 5015 lines together to open a bay position at Red Lion substation
- Proposed Cost Estimate: $1,372MM



PSE&G 7D

- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Peach Bottom 500 kV line on new right of way
- Proposed Cost Estimate: $831MM



PSE&G 7E

- Second Salem to Hope Creek tie line
- Install a new 500kV line Deans to New Freedom
- Proposed Cost Estimate: $692MM

PSE&G 7F

- Second Salem to Hope Creek tie line
- Install a new Smithburg to New Freedom 500kV line
- Proposed Cost Estimate: $879MM

PSE&G 7G

- Second Salem to Hope Creek tie line
- Install a new Smithburg to Larrabee to New Freedom 500kV line
- Expand Larrabee substation to accept the new 500kV connection
- Proposed Cost Estimate: $1,034MM

PSE&G 7H

- Second Salem to Hope Creek tie line
- Install a new Whitpain to New Freedom 500kV line using a northern route
- Proposed Cost Estimate: $1,177MM

PSE&G 7I

- Second Salem to Hope Creek tie line
- Install a new Whitpain to New Freedom 500kV line using a southern route
- Proposed Cost Estimate: $1,353MM

PSE&G 7J

- Second Salem to Hope Creek tie line
- New substation at the 5017 junction site cutting the 5017 Elroy to Branchburg line
- Install a new 5017 Junction to New Freedom 500kV line
- Proposed Cost Estimate: $915MM

PSE&G 7K

- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Install a new Deans to New Freedom 500kV line
- Proposed Cost Estimate: $1,066MM

PSE&G 7L

- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Install a new Smithburg to New Freedom 500kV line
- Proposed Cost Estimate: $1,250MM

PSE&G 7M

- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Install a new Whitpain to New Freedom 500kV line using a northern route
- Proposed Cost Estimate: $1,548MM

PSE&G 7N

- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
  - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- New substation at the 5017 junction site cutting the 5017 Elroy to Branchburg line
- Install a new 5017 Junction to New Freedom 500kV line
- Proposed Cost Estimate: $1,289MM

Artificial Island Project Evaluation

Evaluation of Proposals

Objectives

- ✓ Achieve desired system performance
- ✓ Minimize initial project cost
- ✓ Assess risk factors to minimize impact to cost and schedule
- ✓ Minimize impact to transmission operations
- ✓ No adverse impact to nuclear licensing

Evaluation of Proposals – PJM Approach

- Performed extensive technical analysis
  - Stability, thermal, voltage, short circuit, market efficiency
  - Studied all solutions as is and with modifications

    Initial analysis showed only two of the highest cost solutions worked as submitted
- Engage outside engineers to perform constructability review
  - *focus on physical, cost, schedule, RoW, siting, permitting*
- Met with all proposers for clarification as needed
- Met with AI nuclear plant representatives
- PJM Operations review
- PJM independent cost evaluation
- Met with equipment manufacturers

Artificial Island Evaluation Considerations

- Primary Considerations
  - Technical Analysis
    - Thermal
    - Stability
    - Short-circuit
    - Voltage
    - NERC Cat-D Contingencies
  - Cost Factors
    - Cost effectiveness
    - Market efficiency
    - PJM estimated costs
- Secondary Considerations
  - Schedule
    - Permitting
    - Construction
    - Long lead time equipment
  - Project Complexity
    - Line crossings
    - Outage requirements
    - Modifications to other transmission facilities
    - Modification to Artificial Island substations
    - Modifications to Red Lion substation
  - Right of Way and Land Acquisition
    - No eminent domain in Delaware
    - New right of way required
    - Substation land required
  - Siting and Permitting
    - Wetlands impact
    - Public opposition risk
    - Delaware river crossing
    - Land permitting
    - Historic and scenic highway
  - Operational Impact
    - Artificial island facility requirements
    - Ongoing maintenance
    - Blackstart
    - Route diversity

Project Modifications

Project Modifications

- Identified and implemented by PJM

- Modification Examples to Improve Performance
  - Move connection point to eliminate a critical fault
  - Add SVC to improve stability performance

- Modification Examples to reduce cost and improve constructability
  - Remove proposed new breakers that aren't needed to pass applicable criteria testing
  - Remove proposed transmission that isn't needed to pass applicable criteria testing

Modification Summary

		Southern Crossing Lines (Submarine)			Southern Crossing Lines (Overhead)		Red Lion to Artificial Island Lines						
							From Salem			From Hope Creek			
		LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - Overhead	Dominion 1B - 500kV Overhead	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion 1C - Red Lion to Hope Creek (Remove RL - HK)	PSE&G 7K- Red Lion to Hope Creek (Remove RL - HK)
Modifications	**SVC Additions at Orchard, NF, AI**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓*	✓*
	Moved Connection At Salem or Hope Creek						✓						✓
	Removed proposed breakers					✓				✓		✓	✓
	Removed proposed Transmission										✓	✓	✓

* SVC option at AI is excluded.

PJM Evaluation of Potential Solutions

Dominion (VEPCO) 1A

- New switching station cutting New Freedom to Hope Creek and New Freedom to Salem (5023 and 5024) lines. Two Thyristor Controlled Series Compensation (TCSC) devices at the new station.

- PJM modifications
  - Changed SVC size

DVP 1A – Technical Analysis

- Stability Performance
  - Failed required performance
    - Failed as proposed by project sponsor. Did not satisfy stability criteria for a three phase fault with normal clearing with AI units at unity power factor under 5038 maintenance outage condition
  - Passed required performance when SVC size increased to 750MVAr to achieve acceptable performance.
  - Stability performance is not as good as 230kV options + SVC or as good as 500kV options + SVC.
  - Anticipate nuclear regulatory concerns in approving this configuration.

Transource (AEP) 2D

- Lines between:
  - New Freedom to Lumberton
  - Lumberton to North Smithburg
  - Hope Creek to Salem tie
- Estimated costs higher than other proposals

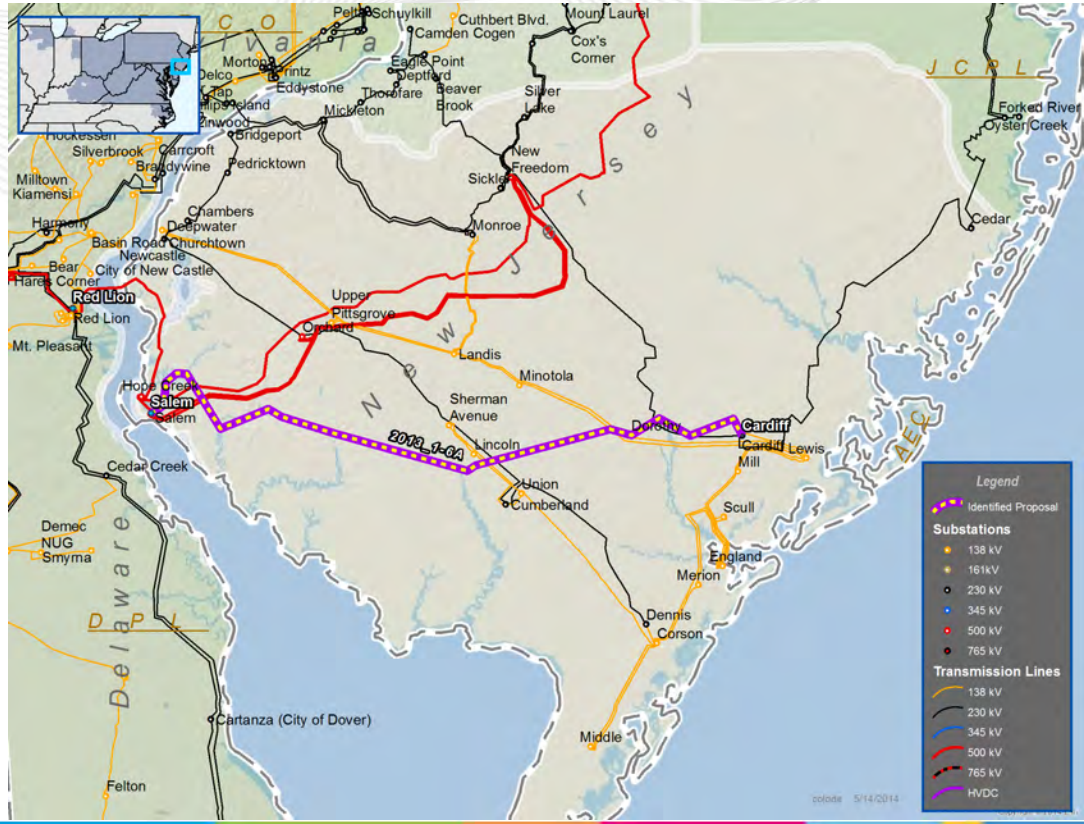
FirstEnergy 3A

- Lines between:
  - Smithburg to Larrabee
  - Larrabee to New Freedom
  - Hope Creek to Red Lion

- Estimated costs higher than other proposals

Atlantic Wind 6A

- HVDC line between Artificial Island and Cardiff
- SVC at Artificial Island converter station
- Estimated costs higher than other proposals



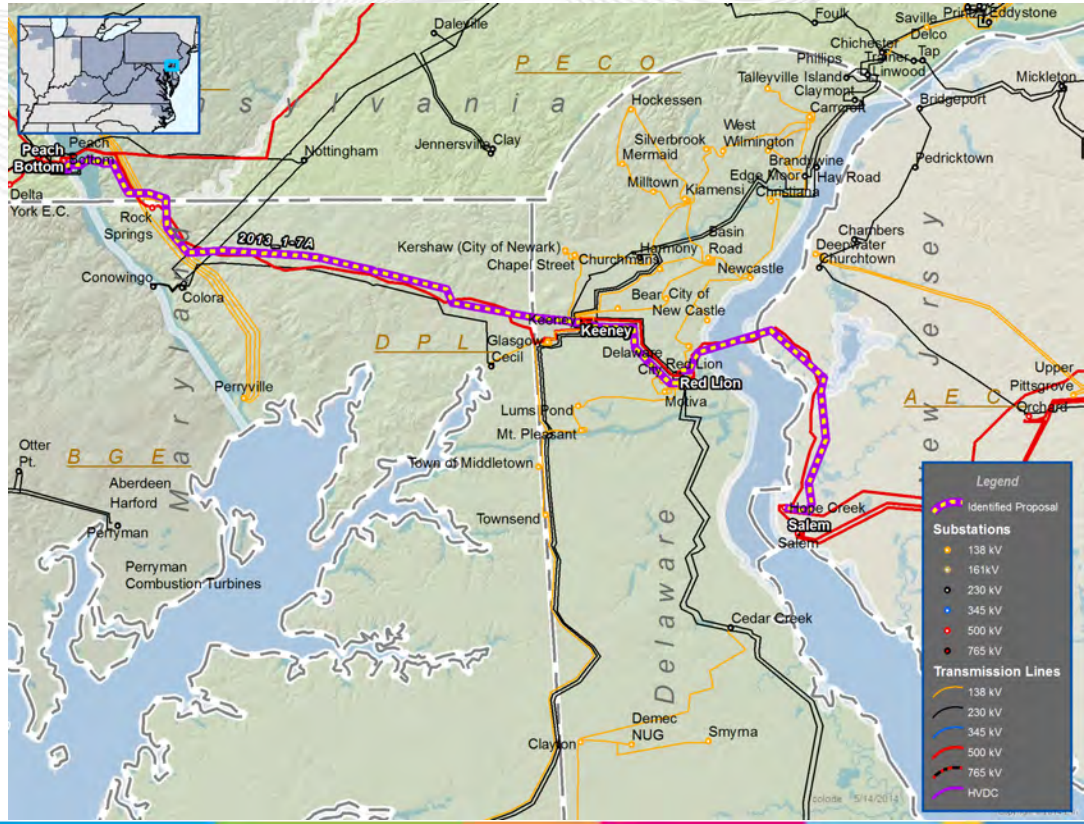
- Stability Performance

  - Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition without significant MW flow on the proposed HVDC facility from the AI to Cardiff.

PSE&G 7A

- Lines between:
  - Salem to Hope Creek tie
  - Hope Creek to Peach Bottom (existing right of way)

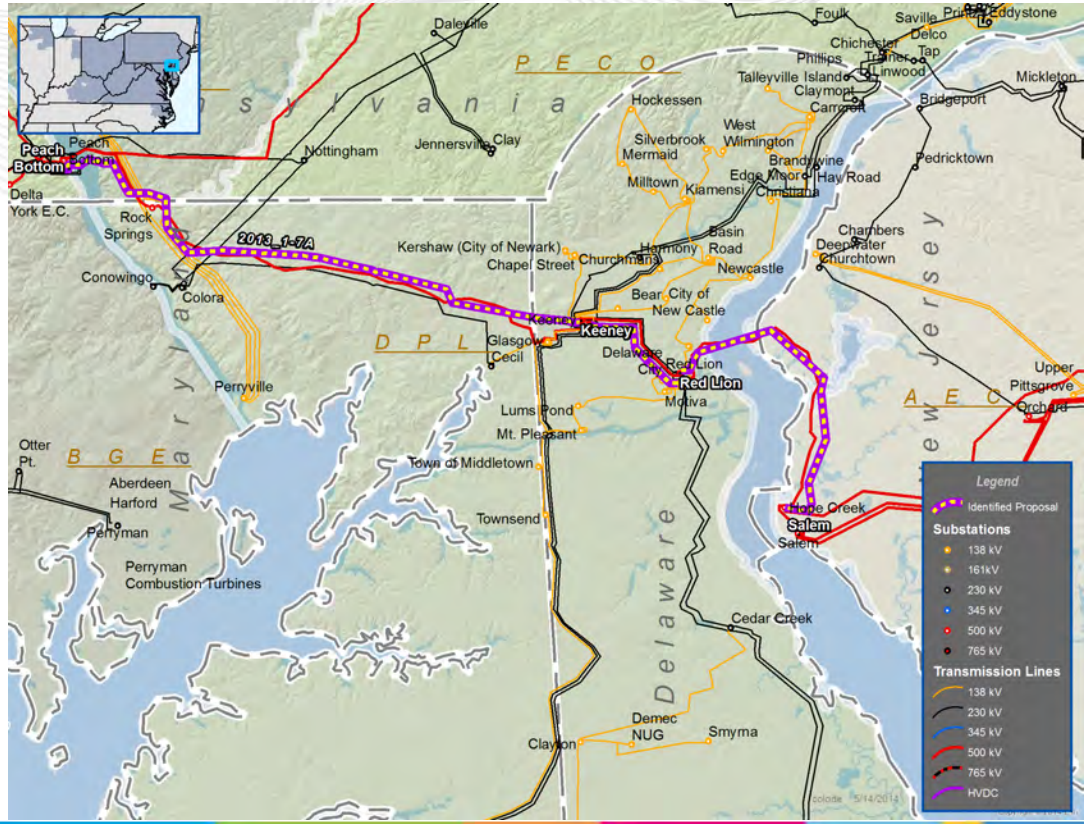
- Estimated costs higher than other proposals



PSE&G 7B

- Lines between:
  - Salem to Hope Creek tie
  - Hope Creek to Keeney
  - Keeney to Peach Bottom
  - Remove Keeney from existing Rock Springs to Keeney to Red Lion lines (5025 and 5036)

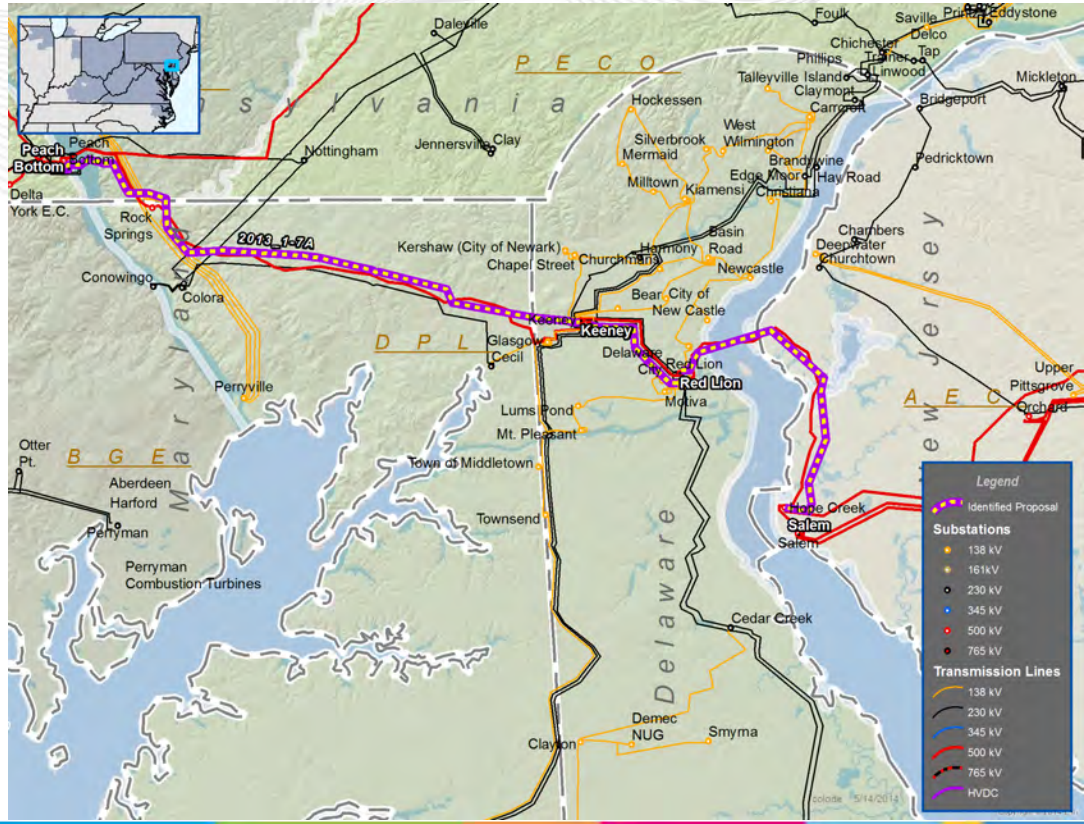
- Estimated costs higher than other proposals



PSE&G 7C

- Lines between:
  - Salem to Hope Creek tie
  - Hope Creek to Red Lion
  - Red Lion to Peach Bottom
  - Remove Red Lion from existing Keeney to Red Lion to Hope Creek lines (5036 and 5015)

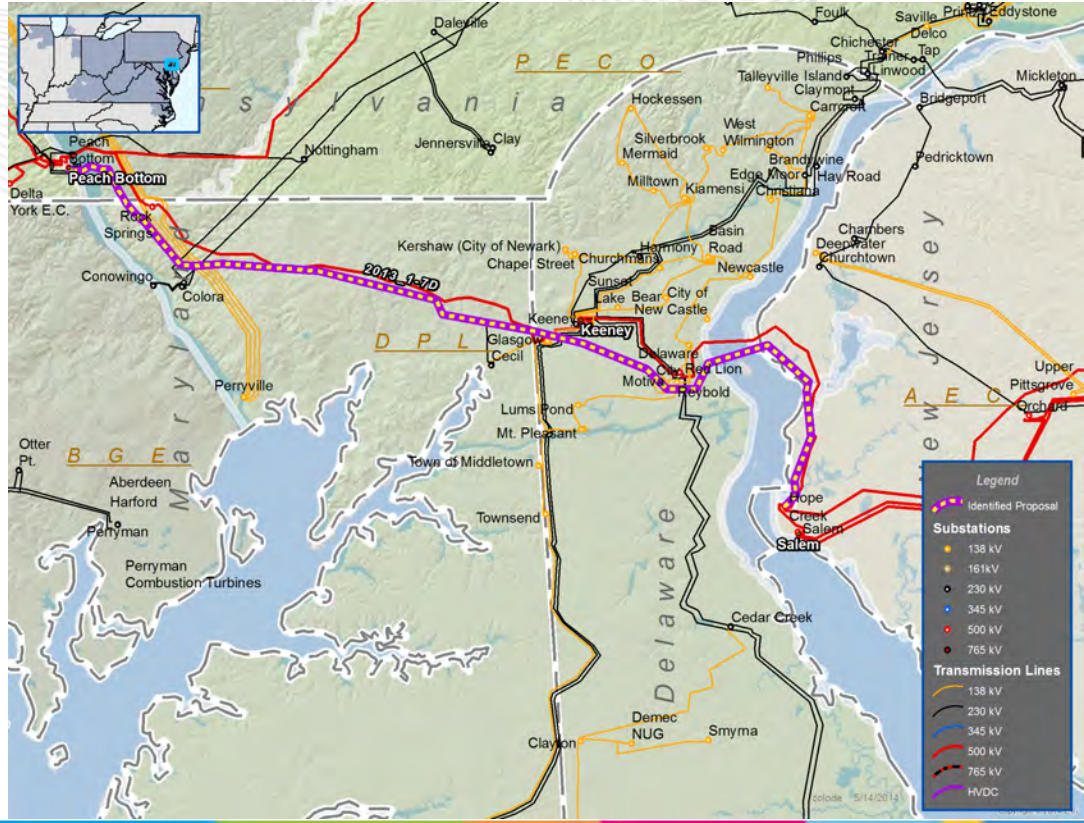
- Estimated costs higher than other proposals



PSE&G 7D

- Lines between:
  - Salem to Hope Creek tie
  - Hope Creek to Peach Bottom (new right of way)

- Estimated costs higher than other proposals



PSE&G 7E

- Lines between:
  - Salem to Hope Creek tie
  - Deans to New Freedom

- Estimated costs higher than other proposals

PSE&G 7F

- Lines between:
  - Salem to Hope Creek tie
  - Smithburg to New Freedom
- Estimated costs higher than other proposals

PSE&G 7G

- Lines between:
  - Salem to Hope Creek tie
  - Smithburg to Larrabee
  - Larrabee to New Freedom

- Estimated costs higher than other proposals

PSE&G 7H

- Lines between:
  - Salem to Hope Creek tie
  - Whitpain to New Freedom (northern route)
- Estimated costs higher than other proposals

PSE&G 7H

- Lines between:
  - Salem to Hope Creek tie
  - Whitpain to New Freedom (northern route)
- Estimated costs higher than other proposals

PSE&G 7I

- Lines between:
  - Salem to Hope Creek tie
  - Whitpain to New Freedom (southern route)
- Estimated costs higher than other proposals

PSE&G 7J

- Lines between:
  - Salem to Hope Creek tie
  - 5017 Junction (cutting the 5017 Elroy to Branchburg line) to New Freedom

- Estimated costs higher than other proposals

PSE&G 7L

- Lines between:
  - Salem to Hope Creek tie
  - Hope Creek to Red Lion
  - New Smithburg to New Freedom

- Estimated costs higher than other proposals

PSE&G 7M

- Lines between:
  - Salem to Hope Creek tie
  - Hope Creek to Red Lion
  - Whitpain to New Freedom (northern route)

- Estimated costs higher than other proposals

PSE&G 7N

- Lines between:
  - Salem to Hope Creek tie
  - Hope Creek to Red Lion
  - 5017 Junction (cutting the 5017 Elroy to Branchburg line) to New Freedom

- Estimated costs higher than other proposals

Submarine Southern Delaware Crossing Lines

- Expansion of the Salem substation to the south
- Submarine line under the Delaware river
- New or expansion of existing substation in Delaware
- Proposing Entities:

Transource

LS Power

Transource (AEP) 2A

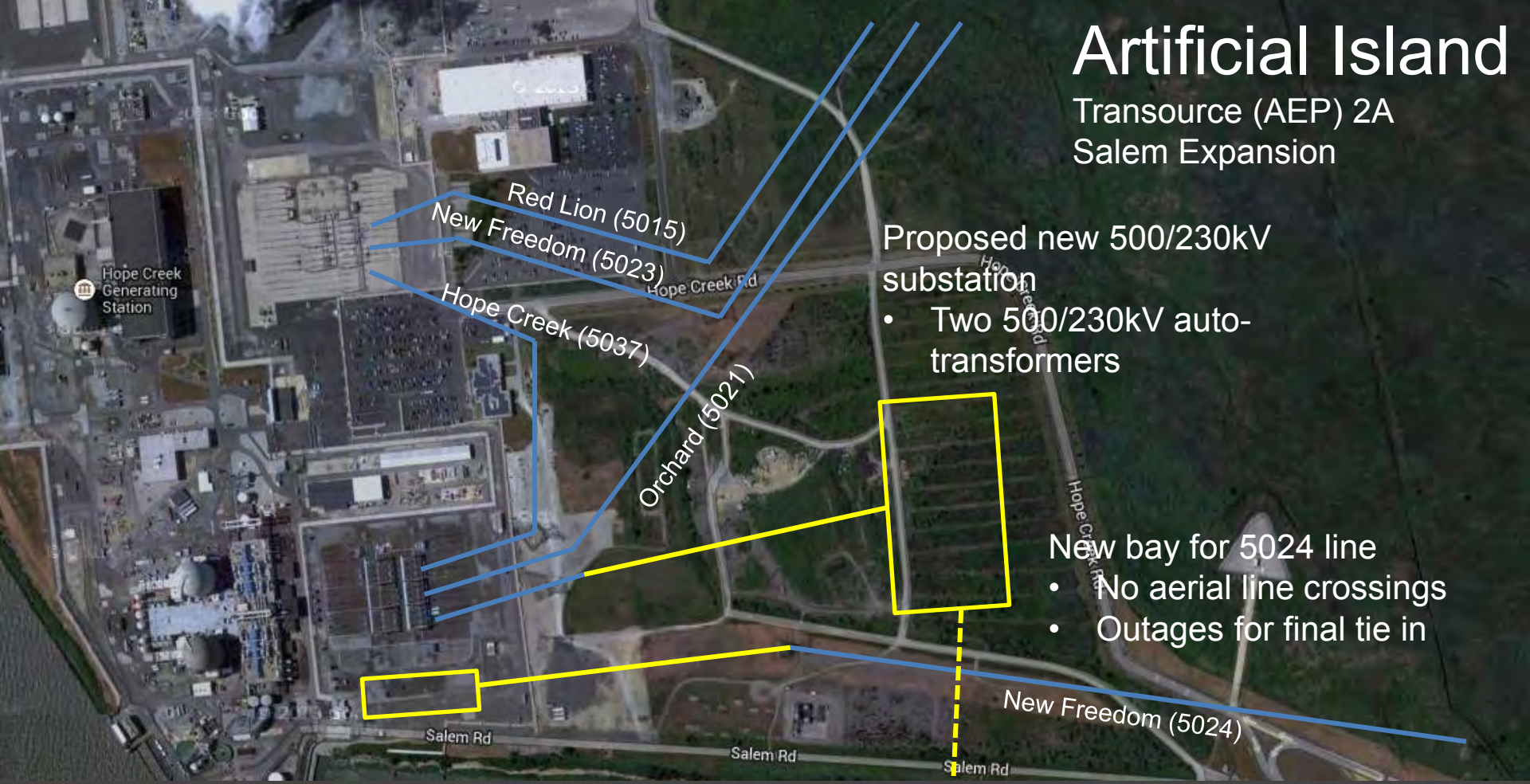
- Line between new substation near Artificial Island and Cedar Creek substation
- Submarine under the Delaware river
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:
    - Spare submarine cable added
    - New Salem connection as a full bay

Transource (AEP) 2A – Technical Analysis

- Stability Performance
  - Failed required performance
    - Failed as proposed by project sponsor
    - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.
  - Passed required performance
    - Passed when modified with the addition of an SVC at Orchard, New Freedom or Artificial Island

Artificial Island

Transource (AEP) 2A
Salem Expansion

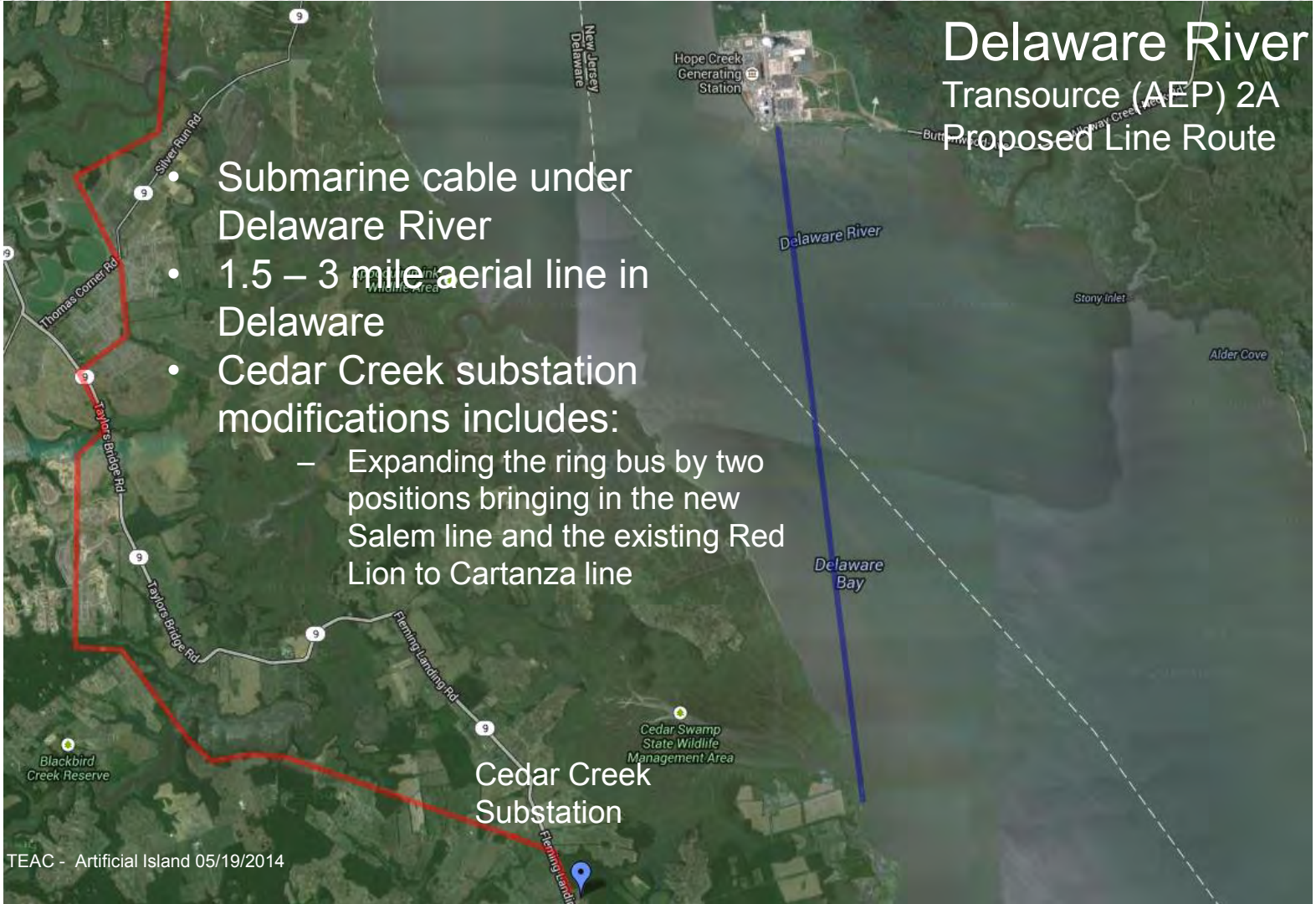


Proposed new 500/230kV substation

- Two 500/230kV auto-transformers

New bay for 5024 line

- No aerial line crossings
- Outages for final tie in


Delaware River
Transource (AEP) 2A
Proposed Line Route
Submarine cable under Delaware River
1.5 – 3 mile aerial line in Delaware
Cedar Creek substation modifications includes:
Expanding the ring bus by two positions bringing in the new Salem line and the existing Red Lion to Cartanza line
Cedar Creek Substation
Hope Creek Generating Station
New Jersey
Delaware
Delaware River
Delaware Bay
Stony Inlet
Alder Cove
Silver Run Rd
Thomas Corner Rd
Taylors Bridge Rd
Taylors Bridge Rd
Fleming Landing Rd
Fleming Landing Rd
Cedar Swamp State Wildlife Management Area
Blackbird Creek Reserve
TEAC - Artificial Island 05/19/2014

Transource (AEP) 2A - Cost Factors

PJM Estimated Cost: $366-$446 (million)

- 5.7 circuit miles of submarine cable (two cables per phase plus one spare cable)
- Six 500/230kV auto-transformers

Proposed Cost Estimate: $213-269 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
  - Approximate benefit to cost ratio of 0.25
  - Approximately $92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in

Transource (AEP) 2A - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 24 months
- RoW acquisition: 12 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - Auto-transformers and submarine cable
- Construction
  - Specialized equipment needed for submarine cable installation
  - Could be impacted by restrictions due to endangered species and shipping traffic

Transource (AEP) 2A - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - Approximately 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
  - Approximately 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
  - Land in New Jersey will need to be acquired for the new substations

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 10 acres of forested wetlands
- Public Opposition Risk
  - Submarine crossing of the Delaware river does not incur any new view-shed impact
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - Not applicable
- Delaware River Crossing
  - Numerous approvals and permits required:
    (a few major permits are listed below)
    - Delaware River Basin Commission approval required
    - Delaware and New Jersey CPCNs required
    - US Army Corps of Engineers Section 404 and 10 authorizations
    - Multiple US Fish and Wildlife permits required
    - National Marine Fisheries Service

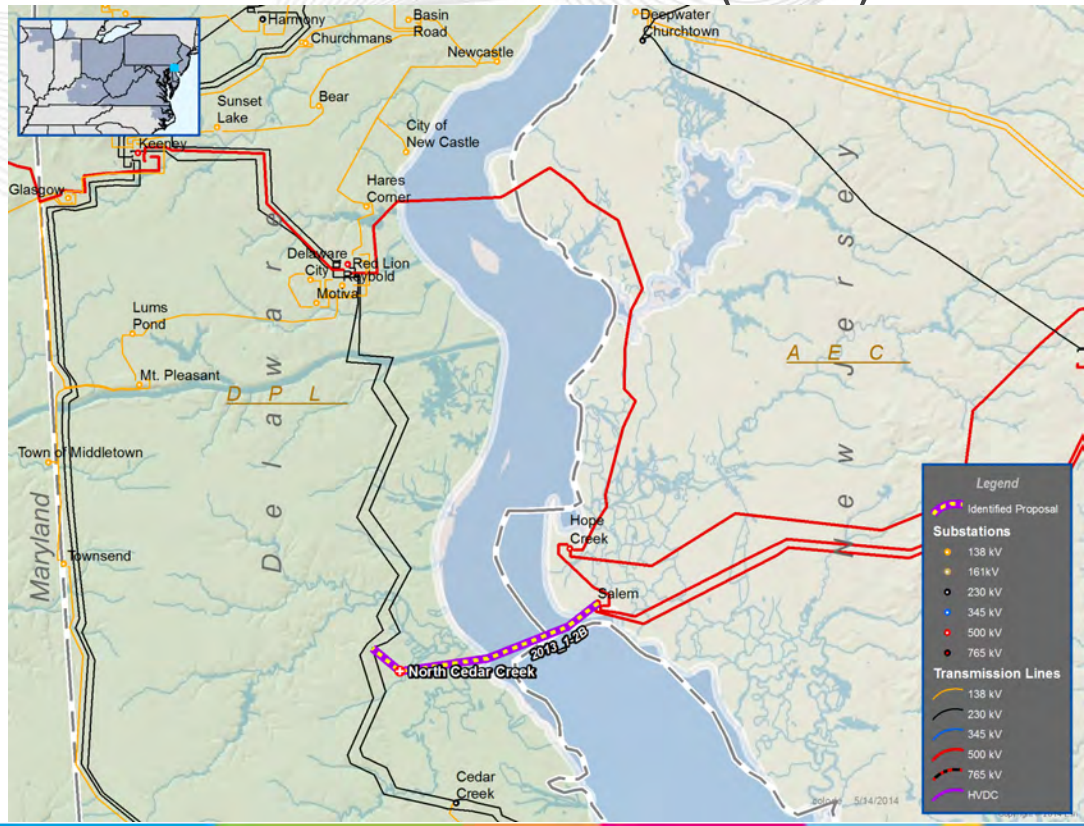
Transource (AEP) 2A - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - 230kV connection may provide additional benefit
- Route Diversity
  - Project route is new and does not parallel an existing line
- Ongoing Maintenance
  - Auto-transformers as line component may increase outage frequency
  - Salt spray concern with proximity to Delaware river

Transource (AEP) 2B

- Line between new substation near Artificial Island and new substation in Delaware
- Submarine under the Delaware river
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:
    - Spare submarine cable added
    - New Salem connection as a full bay

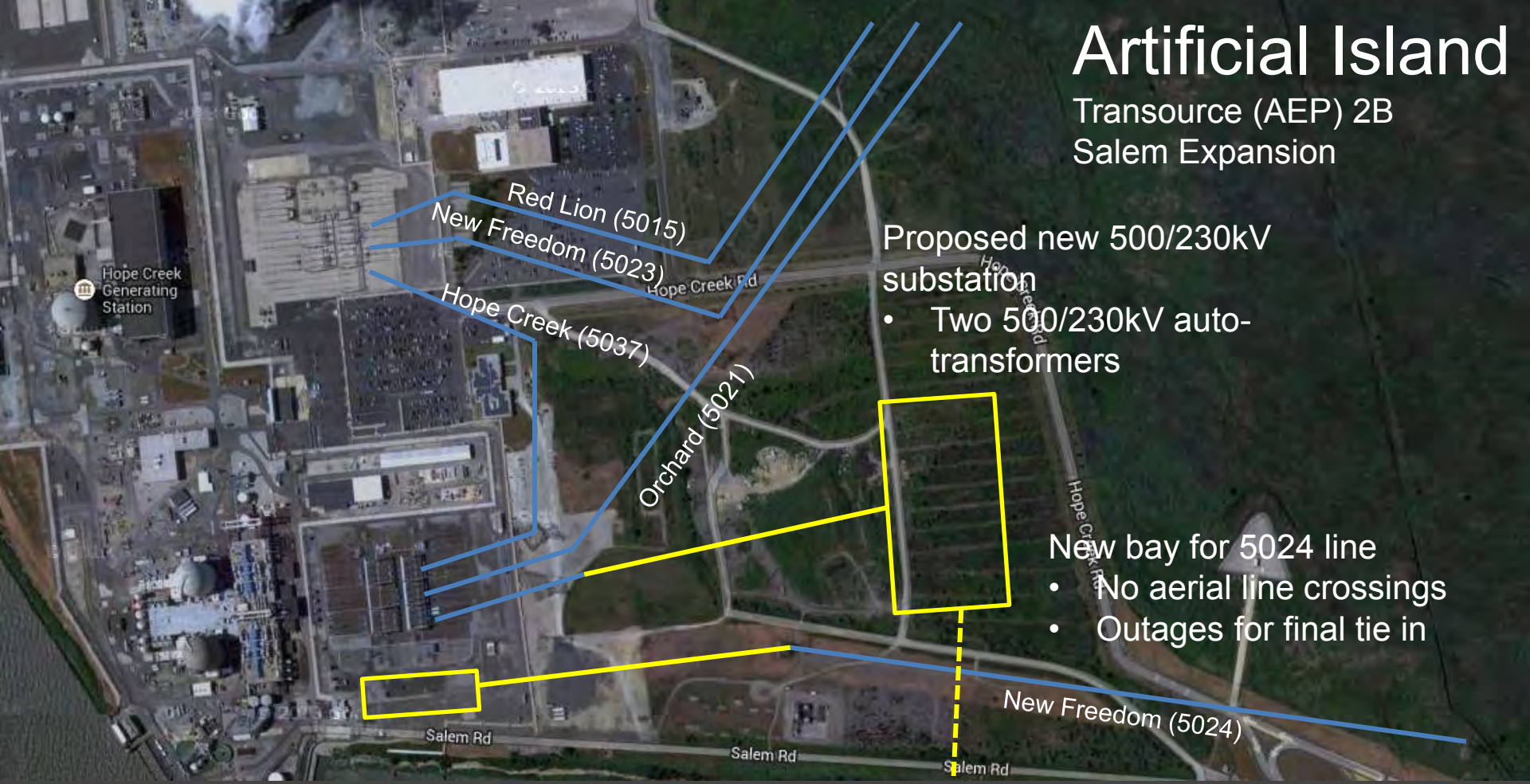


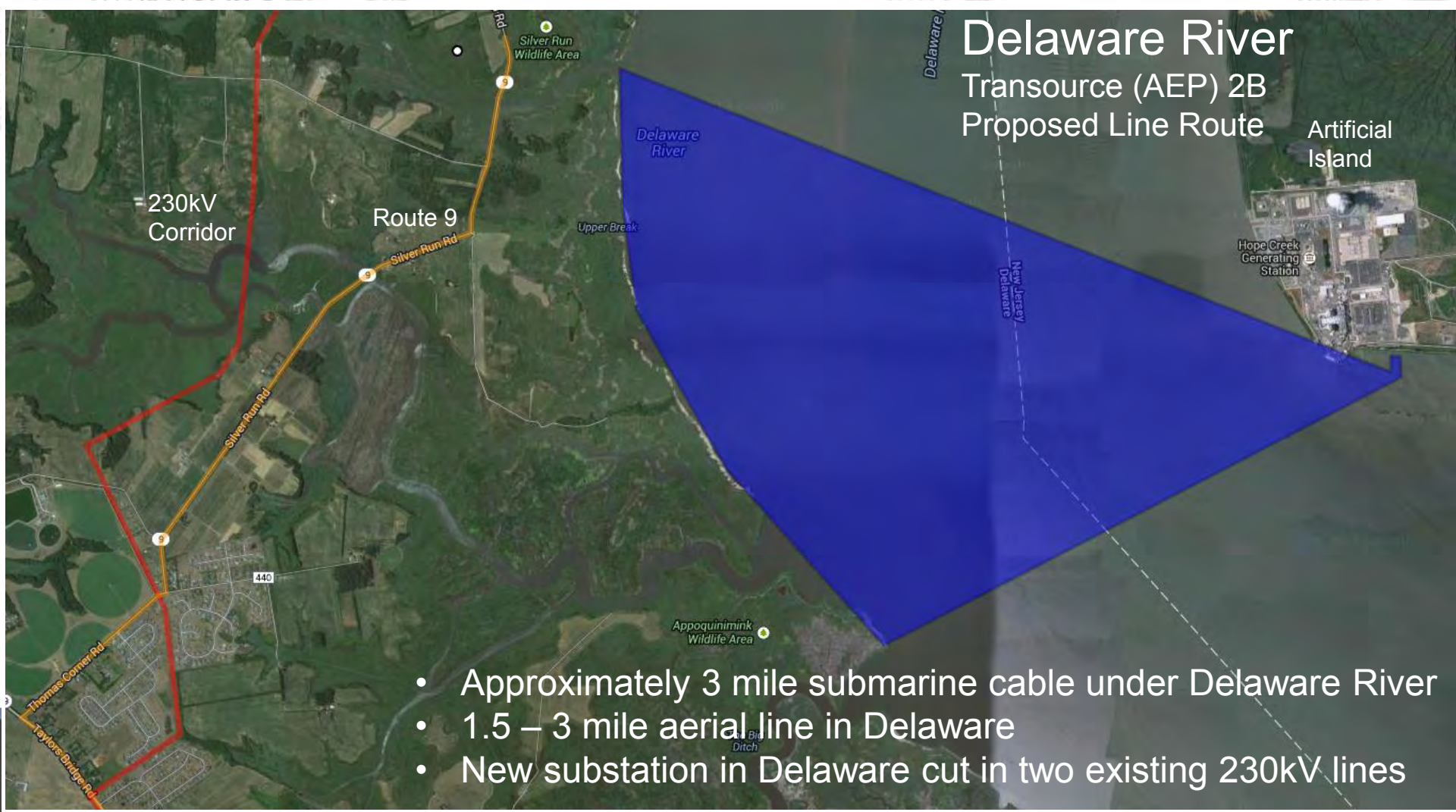
Transource (AEP) 2B – Technical Analysis

- Stability Performance

  - Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.

  - Passed required performance
    - Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island


Artificial Island
Transource (AEP) 2B
Salem Expansion
Proposed new 500/230kV substation
• Two 500/230kV auto-transformers
New bay for 5024 line
• No aerial line crossings
• Outages for final tie in
Red Lion (5015)
New Freedom (5023)
Hope Creek (5037)
Orchard (5021)
New Freedom (5024)
Hope Creek Generating Station
Hope Creek Rd
Salem Rd
Salem Rd
Salem Rd


Delaware River
Transource (AEP) 2B
Proposed Line Route
Artificial Island
230kV Corridor
Route 9
Silver Run Wildlife Area
Silver Run Rd
Delaware River
Upper Break
Hope Creek Generating Station
New Jersey
Delaware
Appoquinimink Wildlife Area
Thomas Corner Rd
Taylors Bridge Rd
440
• Approximately 3 mile submarine cable under Delaware River
• 1.5 – 3 mile aerial line in Delaware
• New substation in Delaware cut in two existing 230kV lines

Transource (AEP) 2B - Cost Factors

PJM Estimated Cost: $257-$313 (million)

- Approximately 3 miles of submarine cable (two cables per phase plus one spare cable)
- Six 500/230kV auto-transformers

Proposed Cost Estimate: $165-$208 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
  - Approximate benefit to cost ratio of 0.25
  - Approximately $92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in

Transource (AEP) 2B - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 30 months
- RoW acquisition: 9 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - Auto-transformers and submarine cable
- Construction
  - Specialized equipment needed for submarine cable installation
  - Could be impacted by restrictions due to endangered species and shipping traffic

Transource (AEP) 2B - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
  - Land in Delaware and New Jersey will need to be acquired for the new substations

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - New route will allow flexibility
- Public Opposition Risk
  - Submarine crossing of the Delaware river does not incur any new view-shed impact
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - Proposed line route crosses Delaware state route 9, which is classified as a ‘Scenic and Historic” highway which may impact permitting
- Delaware River Crossing
  - Numerous approvals and permits required:
    (a few major permits are listed below)
    - Delaware River Basin Commission approval required
    - Delaware and New Jersey CPCNs required
    - US Army Corps of Engineers Section 404 and 10 authorizations
    - Multiple US Fish and Wildlife permits required
    - National Marine Fisheries Service

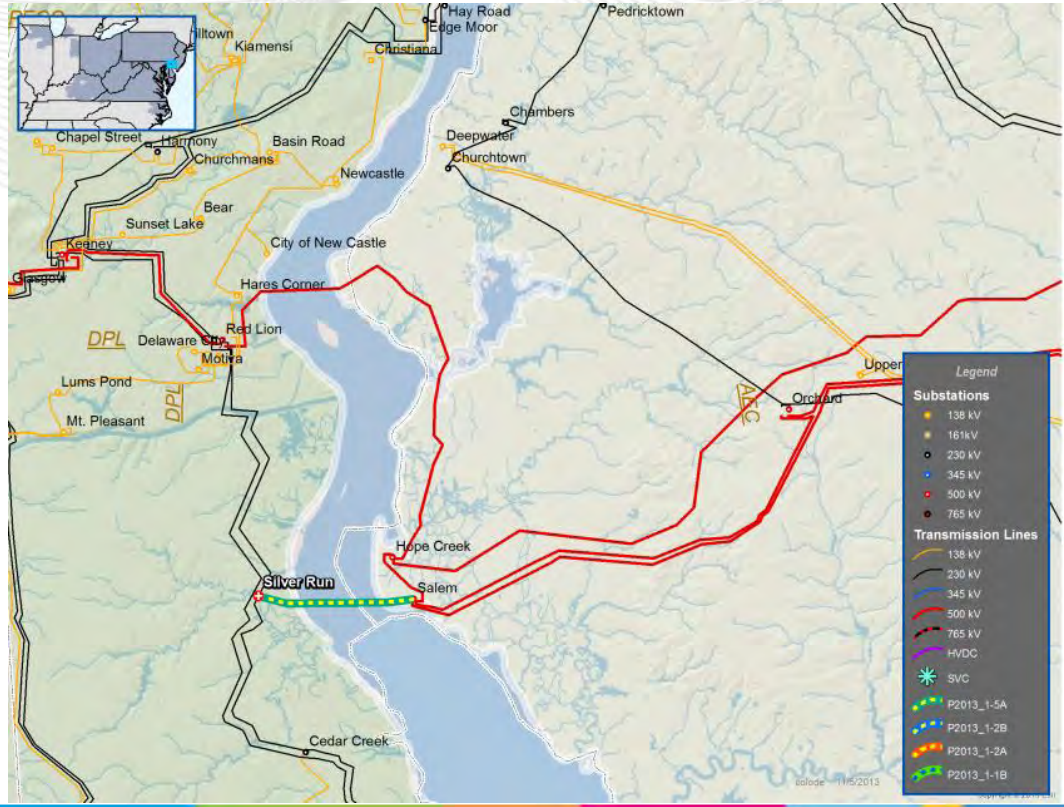
Transource (AEP) 2B - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - 230kV connection may provide additional benefit
- Route Diversity
  - Project route is new and does not parallel an existing line
- Ongoing Maintenance
  - Auto-transformers as line component may increase outage frequency
  - Salt spray concern with proximity to Delaware river

LS Power 5A (Submarine)

- Line between Salem and new substation in Delaware
- Submarine under the Delaware river
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:
    - Spare transformer phase added
    - Spare submarine cable added



LS Power 5A (Submarine) – Technical Analysis

- Stability Performance

  – Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.

  – Passed required performance
    - Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island

Artificial Island

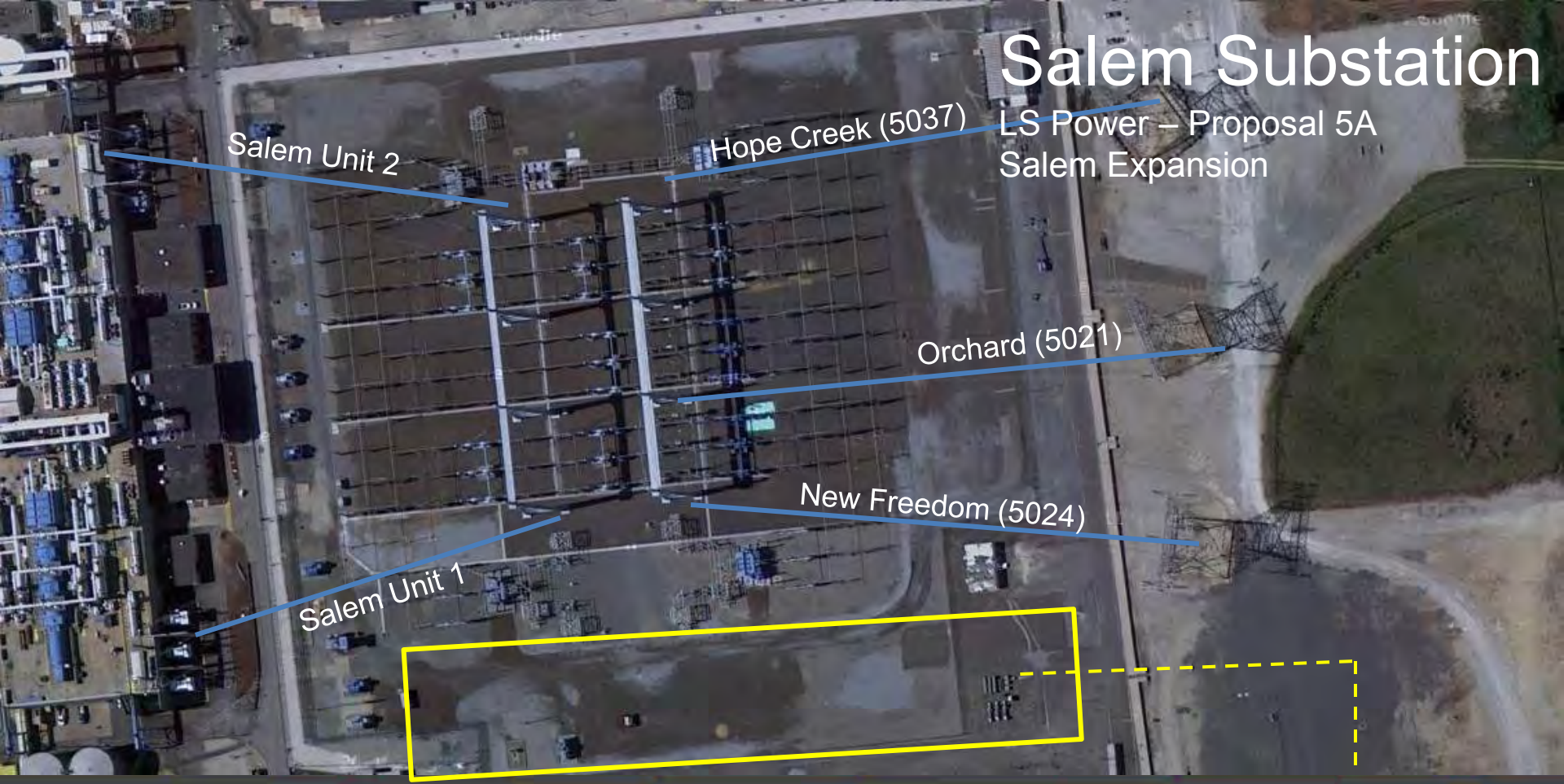
LS Power – Proposal 5A
Salem Expansion

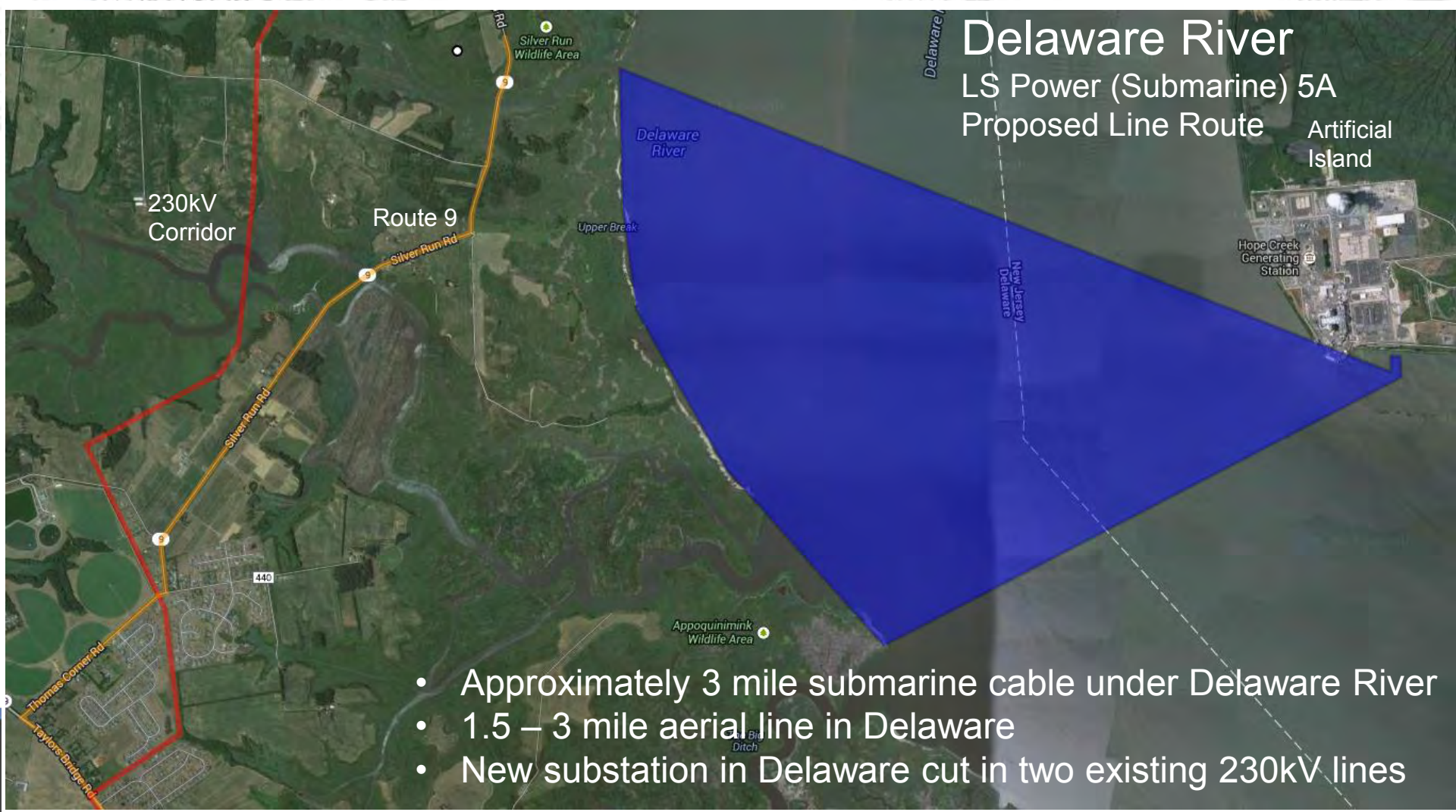
New 500kV bay and 500/230kV autotransformer in Salem substation

- No aerial line crossings
- Outages for final tie in

Salem Substation

LS Power – Proposal 5A
Salem Expansion




Delaware River
LS Power (Submarine) 5A
Proposed Line Route
Artificial Island
230kV Corridor
Route 9
Silver Run Wildlife Area
Delaware River
Upper Break
Hope Creek Generating Station
New Jersey
Silver Run Rd
Appoquinimink Wildlife Area
Thomas Corner Rd
Taylors Bridge Rd
440
• Approximately 3 mile submarine cable under Delaware River
• 1.5 – 3 mile aerial line in Delaware
• New substation in Delaware cut in two existing 230kV lines

LS Power 5A (Submarine) - Cost Factors

PJM Estimated Cost: $248 - $311 (million)

- 3.3 circuit miles of submarine cable (two cables per phase plus one spare cable)
- Four 500/230kV auto-transformers

Proposed Cost Estimate: $148 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
  - Approximate benefit to cost ratio of 0.25
  - Approximately $92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in

LS Power 5A (Submarine) - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 30 months
- RoW acquisition: 9 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - Auto-transformers and submarine cable
- Construction
  - Specialized equipment needed for submarine cable installation
  - Could be impacted by restrictions due to endangered species and shipping traffic

LS Power 5A (Submarine) - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
  - Has acquired an option on a site for the proposed new switching station in Delaware

LS Power 5A (Submarine) - Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - New route will allow flexibility
- Public Opposition Risk
  - Submarine crossing of the Delaware river does not incur any new view-shed impact
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - Proposed line route parallels Delaware state route 9, which is classified as a ‘Scenic and Historic” highway which may impact permitting
- Delaware River Crossing
  - Numerous approvals and permits required:
    (a few major permits are listed below)
    - Delaware River Basin Commission approval required
    - Delaware and New Jersey CPCNs required
    - US Army Corps of Engineers Section 404 and 10 authorizations
    - Multiple US Fish and Wildlife permits required
    - National Marine Fisheries Service

LS Power 5A (Submarine) - Operational Impact

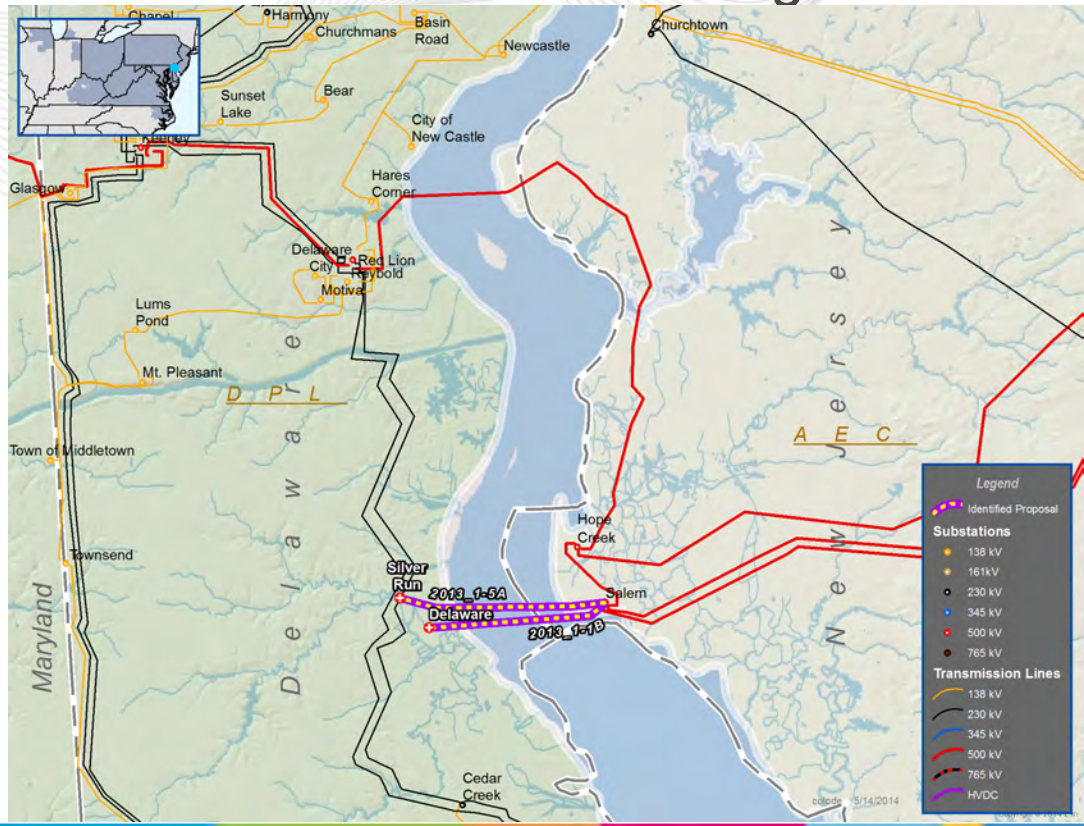
Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - 230kV connection may provide additional benefit
- Route Diversity
  - Project route is new and does not parallel an existing line
- Ongoing Maintenance
  - Auto-transformers as line component may increase outage frequency
  - Salt spray concern with proximity to Delaware river

Overhead Southern Delaware Crossing Lines

- Expansion of the Salem substation to the south
- Aerial line over the Delaware river
- New substation in Delaware
- Proposing Entities:

Dominion
LS Power



Dominion Virginia Power (DVP) 1B

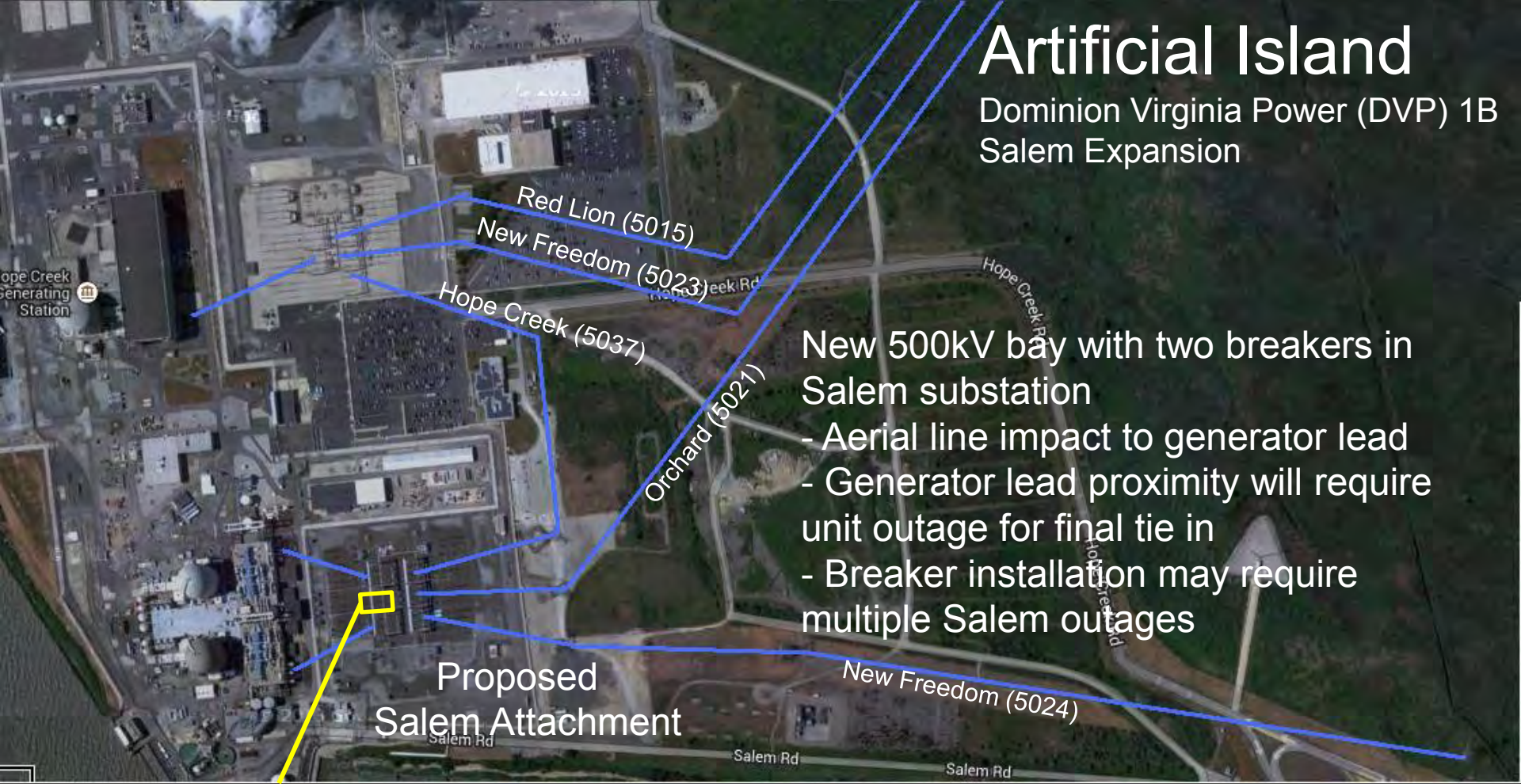
- Line between Salem and new substation in Delaware
- Aerial crossing of the Delaware river
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:

Dominion Virginia Power (DVP) 1B – Technical Analysis

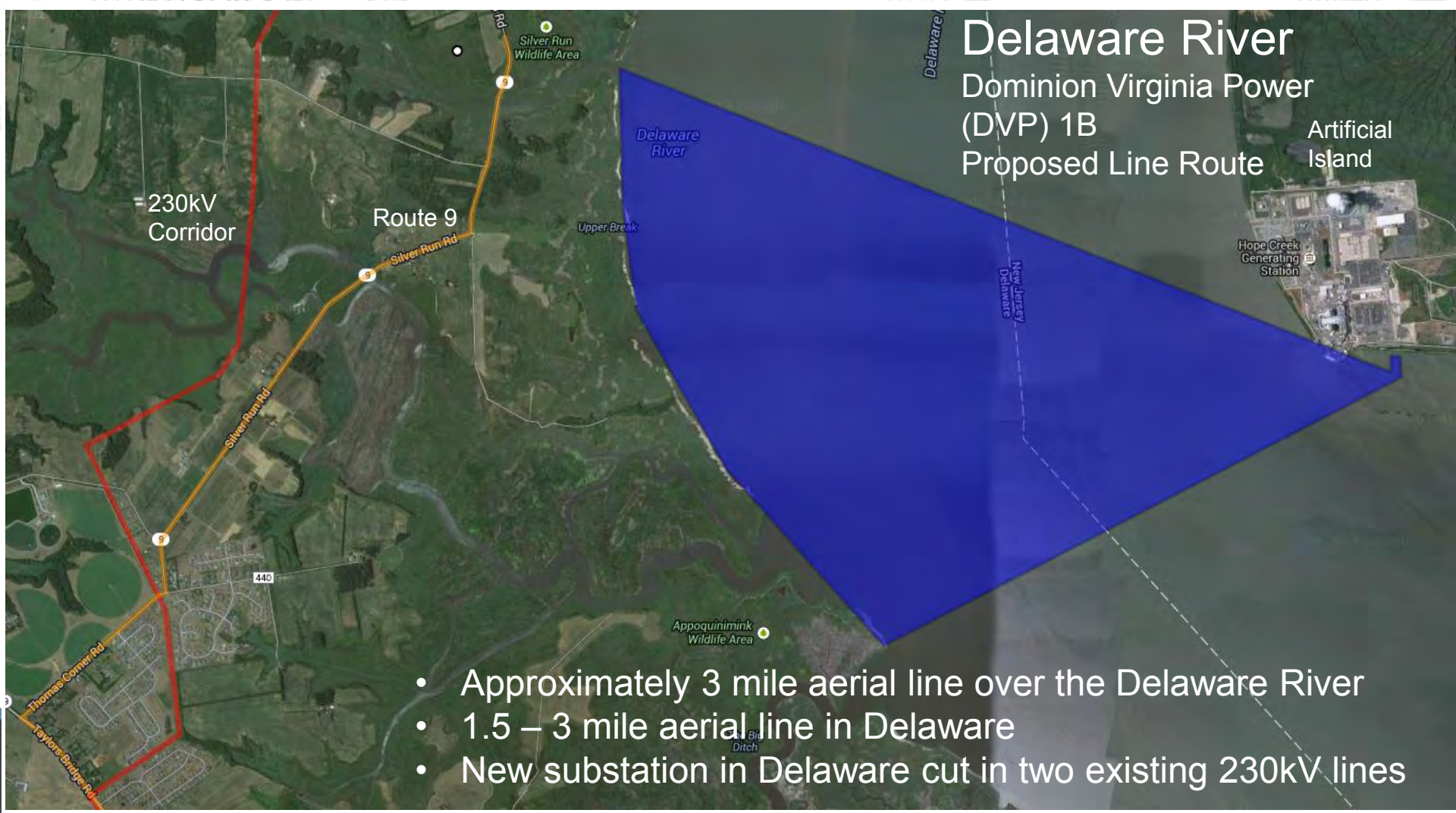
- Stability Performance
  - Failed required performance
    - Failed as proposed by project sponsor.
    - Failed with modification to remove proposed breakers.
    - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.
    - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition with modification to remove proposed breakers.
  - Passed required performance
    - Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Artificial Island

Dominion Virginia Power (DVP) 1B
Salem Expansion



New 500kV bay with two breakers in Salem substation
- Aerial line impact to generator lead
- Generator lead proximity will require unit outage for final tie in
- Breaker installation may require multiple Salem outages


Delaware River
Dominion Virginia Power
(DVP) 1B
Proposed Line Route
Artificial
Island
230kV
Corridor
Route 9
Silver Run Rd
Silver Run
Wildlife Area
Delaware
River
Upper Break
Hope Creek
Generating
Station
New Jersey
Delaware
Appoquinimink
Wildlife Area
Thomas Corner Rd
Taylors Bridge Rd
440
• Approximately 3 mile aerial line over the Delaware River
• 1.5 – 3 mile aerial line in Delaware
• New substation in Delaware cut in two existing 230kV lines

Dominion Virginia Power (DVP) 1B- Cost Factors

PJM Estimated Cost: $233 - $283 (million)

- Six 500/230kV auto-transformers
- Aerial crossing of the Delaware River

Proposed Cost Estimate: $133 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
  - Approximate benefit to cost ratio of 0.25
  - Approximately $92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in

Dominion Virginia Power (DVP) 1B - Project Schedule

Proposed Schedule 93 months (items run concurrent)

- Permitting: 50 months
- RoW acquisition: 56 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - Auto-transformers
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

Dominion Virginia Power (DVP) 1B RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
  - Land in Delaware will need to be acquired for the new substation

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - New route will allow flexibility
- Public Opposition Risk
  - Aerial crossing of the Delaware river would create a new view-shed impact
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - Proposed line route parallels Delaware state route 9, which is classified as a ‘Scenic and Historic” highway which may impact permitting
- Delaware River Crossing
  - Numerous approvals and permits required:
    (a few major permits are listed below)
    - Delaware River Basin Commission approval required
    - Delaware and New Jersey CPCNs required
    - US Army Corps of Engineers Section 404 and 10 authorizations
    - Multiple US Fish and Wildlife permits required
    - National Marine Fisheries Service

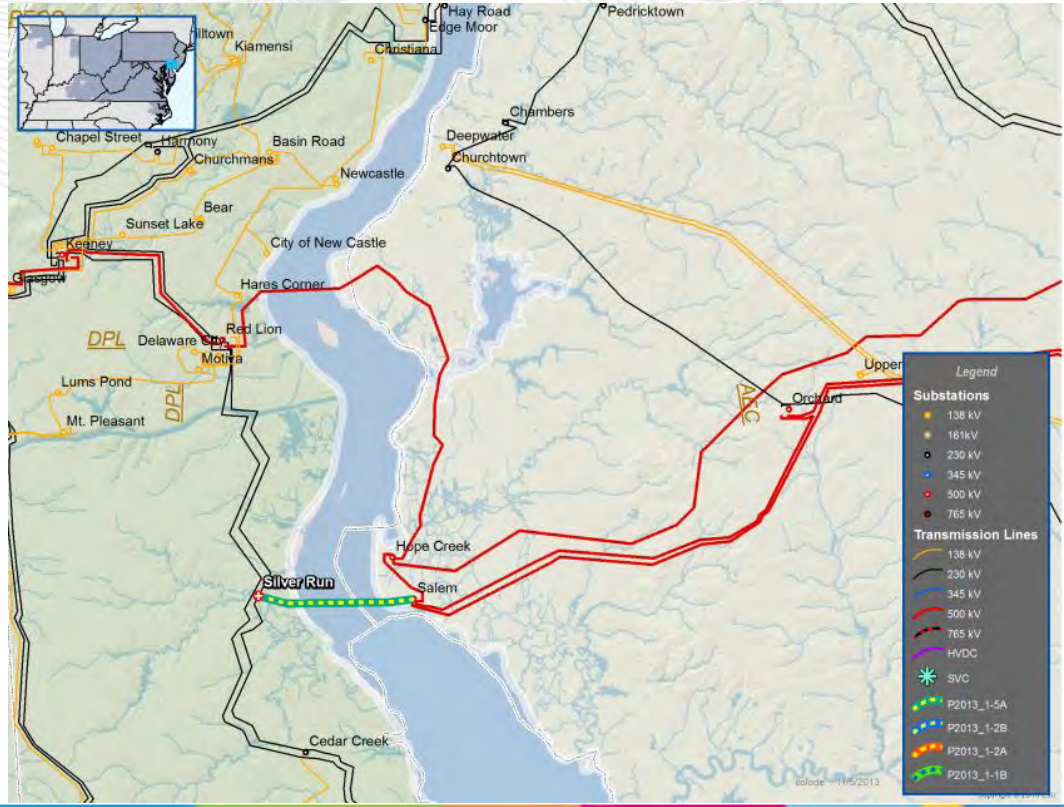
Dominion Virginia Power (DVP) 1B - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - 500kV connection may provide additional benefit
- Route Diversity
  - Project route is new and does not parallel an existing line
- Ongoing Maintenance
  - Auto-transformers as line component may increase outage frequency

LS Power 5A (Aerial)

- Line between Salem and new substation in Delaware
- Aerial crossing of the Delaware river
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:
    - Spare transformer phase added

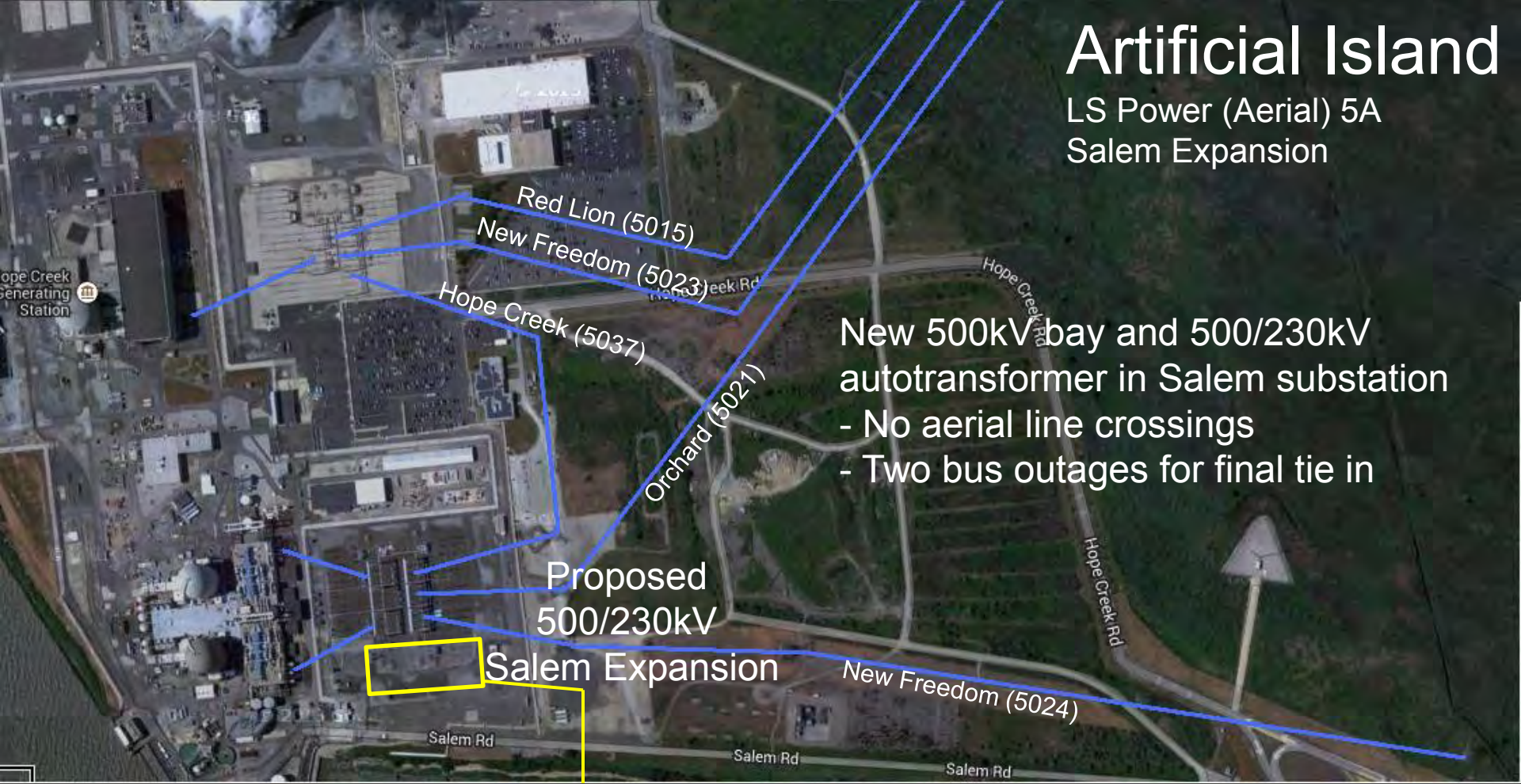


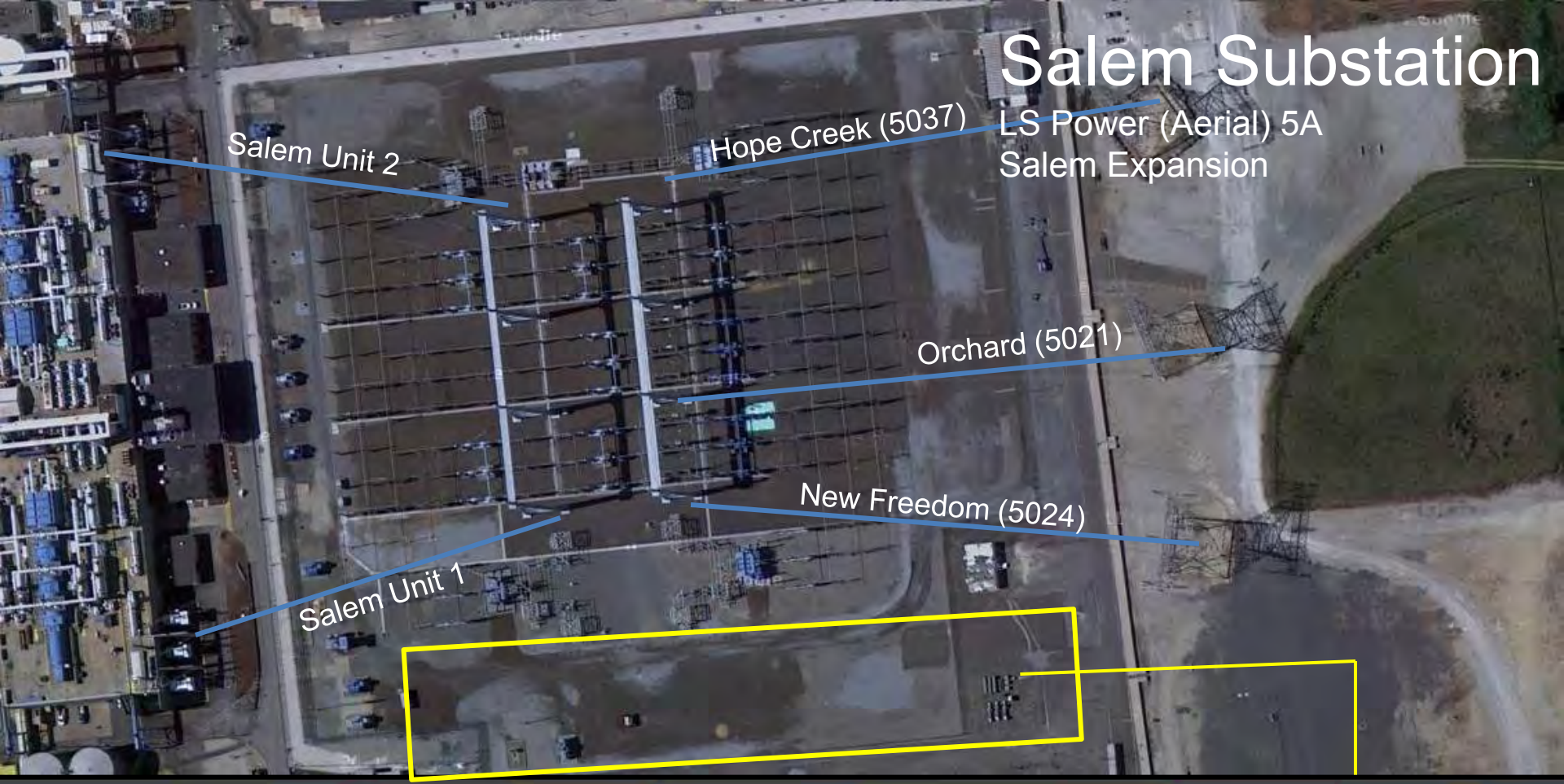
LS Power 5A (Overhead) – Technical Analysis

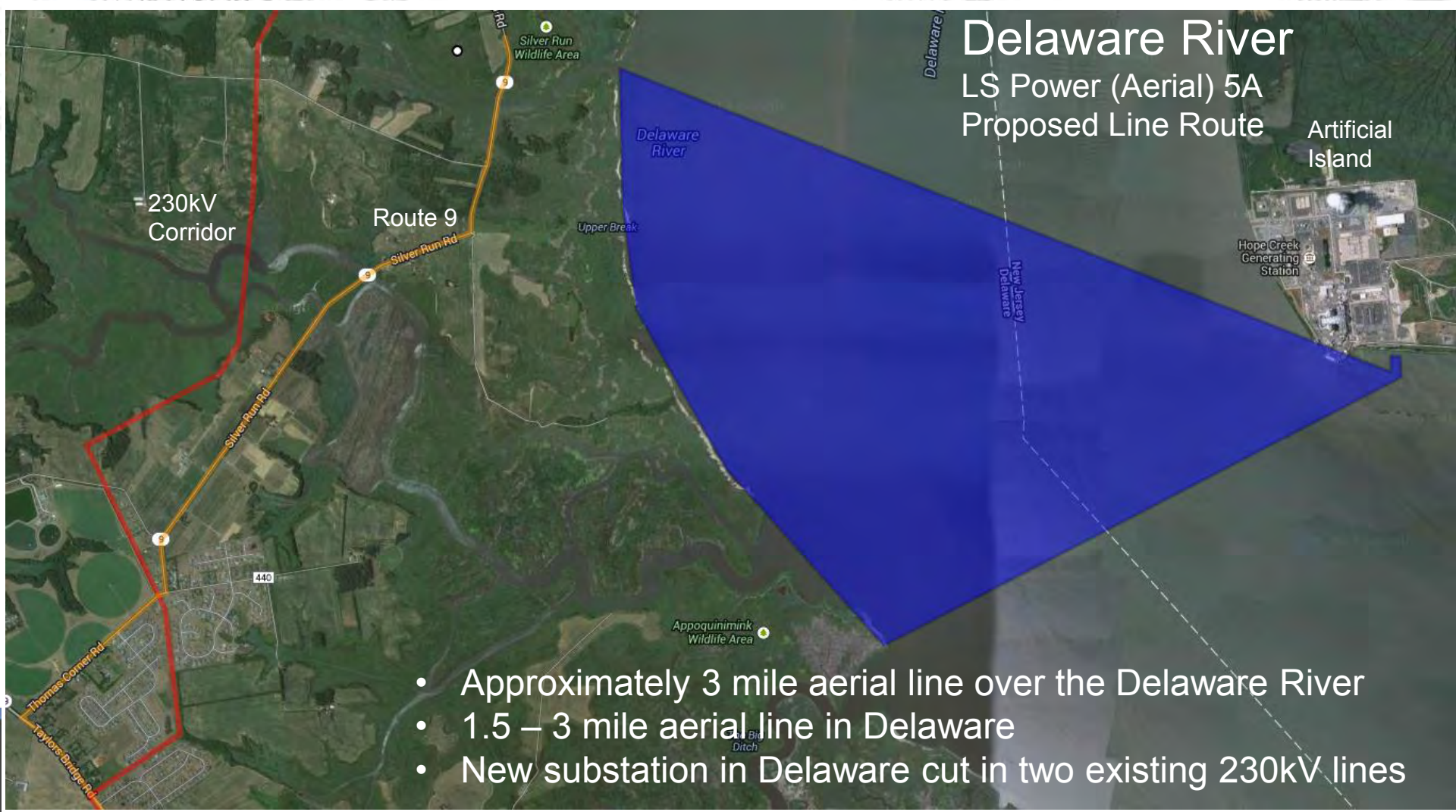
- Stability Performance

  – Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.

  – Passed required performance
    - Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island.


Artificial Island
LS Power (Aerial) 5A
Salem Expansion
Red Lion (5015)
New Freedom (5023)
Hope Creek (5037)
Orchard (5021)
New 500kV bay and 500/230kV autotransformer in Salem substation
- No aerial line crossings
- Two bus outages for final tie in
Proposed 500/230kV Salem Expansion
New Freedom (5024)
Hope Creek Rd
Salem Rd
Salem Rd
Salem Rd


Salem Substation
LS Power (Aerial) 5A
Salem Expansion
Salem Unit 2
Hope Creek (5037)
Orchard (5021)
New Freedom (5024)
Salem Unit 1



- Approximately 3 mile aerial line over the Delaware River
- 1.5 – 3 mile aerial line in Delaware
- New substation in Delaware cut in two existing 230kV lines

LS Power 5A (Aerial) - Cost Factors

PJM Estimated Cost: $211 - $257 (million)

- Four 500/230kV auto-transformers
- Aerial Delaware river crossing

Proposed Cost Estimate: $116 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
  - Approximate benefit to cost ratio of 0.25
  - Approximately $92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in

LS Power 5A (Aerial) - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 30 months
- RoW acquisition: 9 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - Auto-transformers
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

LS Power 5A (Aerial) - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - Has acquired an option on a site for the proposed new switching station in Delaware
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
  - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
  - Has acquired an option on a site for the proposed new switching station in Delaware

LS Power 5A (Aerial) - Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - New route will allow flexibility
- Public Opposition Risk
  - Aerial crossing of the Delaware river would create a new view-shed impact
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - Proposed line route parallels Delaware state route 9, which is classified as a ‘Scenic and Historic” highway which may impact permitting
- Delaware River Crossing
  - Numerous approvals and permits required:
    (a few major permits are listed below)
    - Delaware River Basin Commission approval required
    - Delaware and New Jersey CPCNs required
    - US Army Corps of Engineers Section 404 and 10 authorizations
    - Multiple US Fish and Wildlife permits required
    - National Marine Fisheries Service

LS Power 5A (Aerial) - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - 230kV connection may provide additional benefit
- Route Diversity
  - Project route is new and does not parallel an existing line
- Ongoing Maintenance
  - Auto-transformers as line component may increase outage frequency
  - Salt spray concern with proximity to Delaware river

Salem to Red Lion Lines

- Expansion of Salem substation
- 17 mile 500kV line
- Parallels 5015 (Existing Red Lion – Hope Creek 500 kV)
- Proposing Entities:

PHI/Exelon
LS Power
Transource

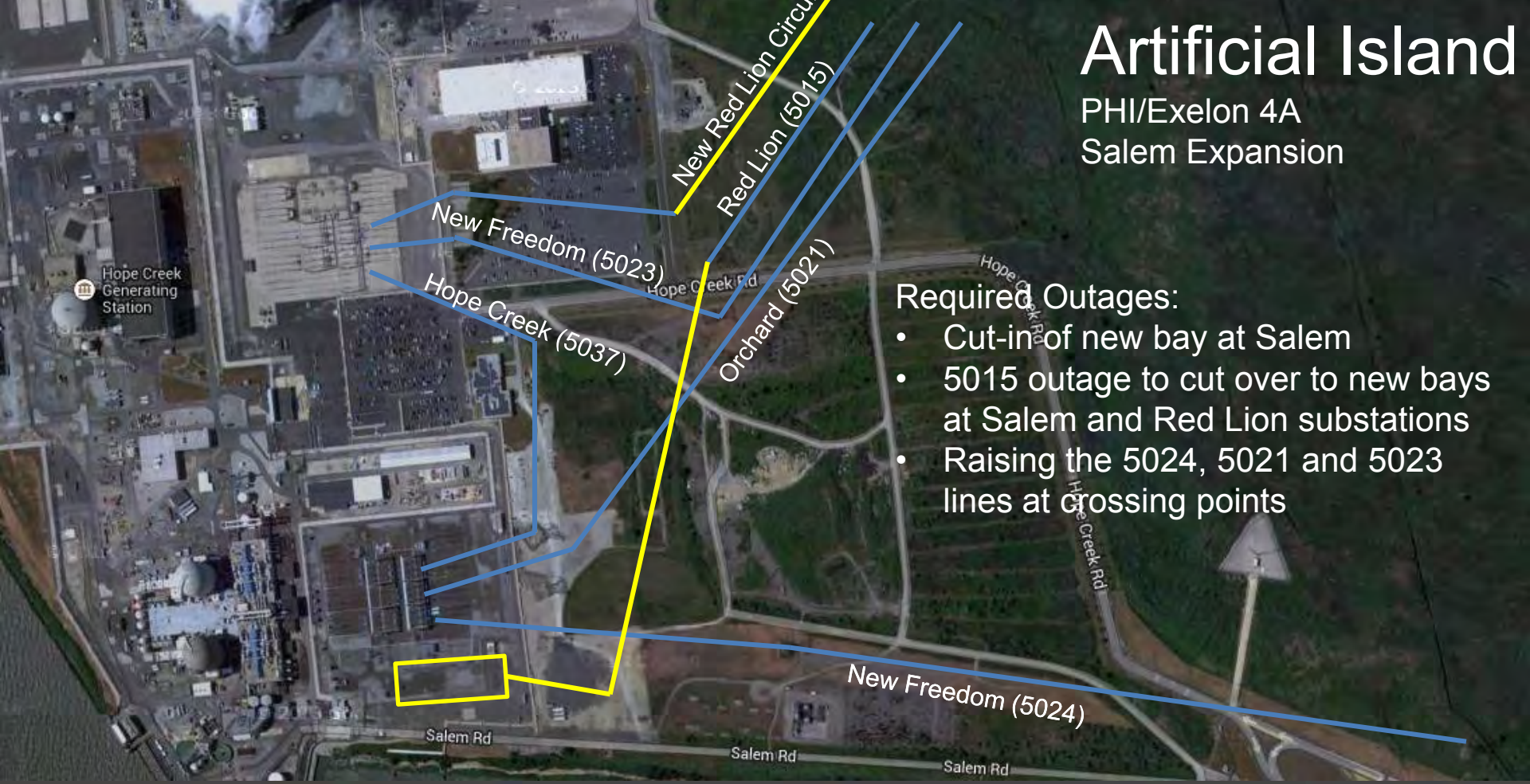
PHI / Exelon 4A

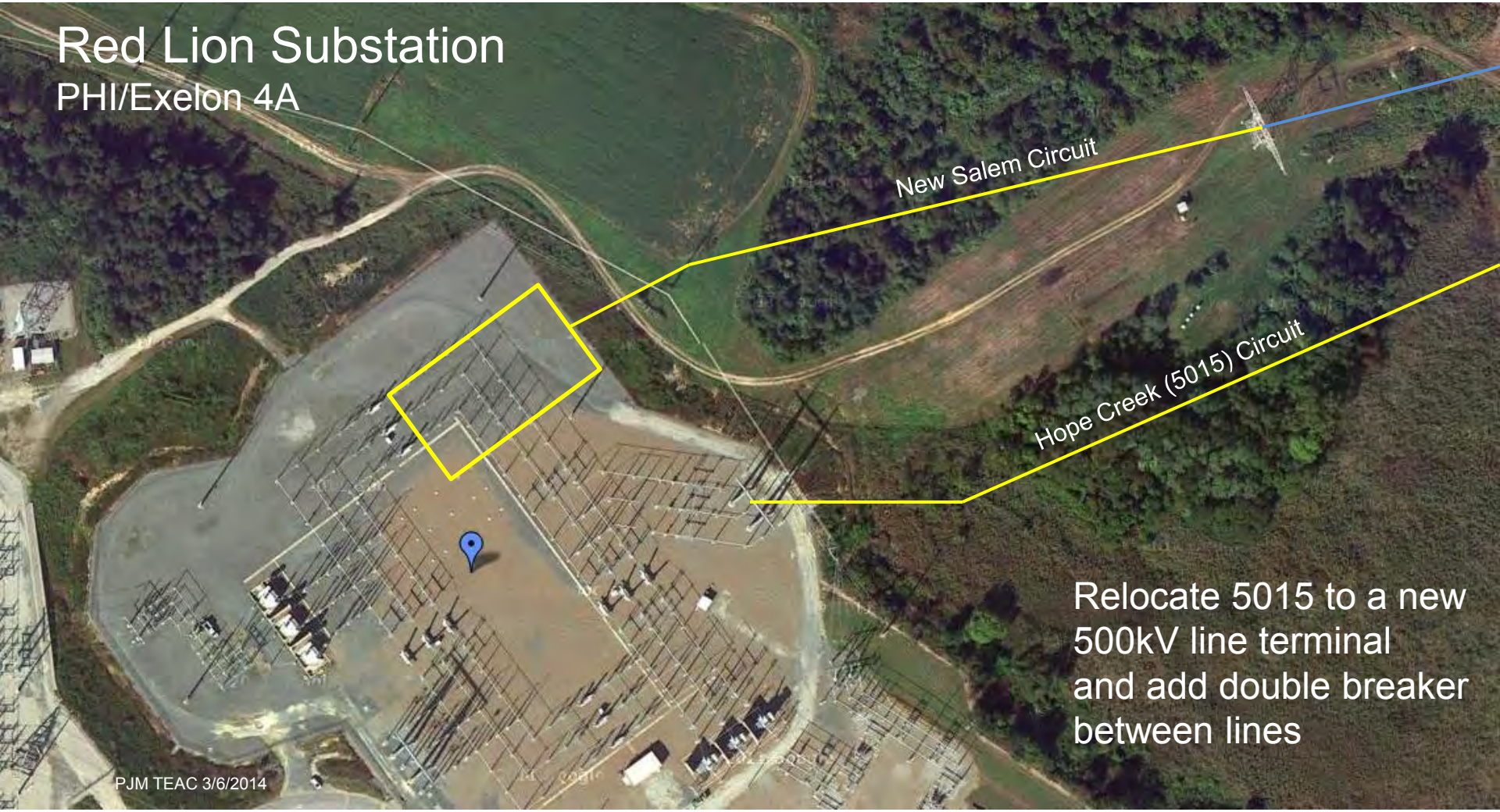
- New 500kV Line between Salem and Red Lion substations

- PJM modifications
  - Technical:
    - Analysis based on building only the Salem to Red Lion segment of proposed Salem to Peach Bottom proposal
    - Added SVC
  - Constructability:
    - Dead-end towers added around line crossing
    - New Salem connection as a full bay

PHI/Exelon 4A – Technical Analysis

- Stability Performance
  - Failed required performance
    - Failed as proposed by project sponsor.
    - Failed with modification to change connection point at Salem to bus bar #1 from #2.
    - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.
    - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition with modification to change connection point at Salem to bus bar #1 from #2.
  - Passed required performance
    - Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.


Artificial Island
PHI/Exelon 4A
Salem Expansion
New Red Lion Circu
Red Lion (5015)
New Freedom (5023)
Hope Creek (5037)
Orchard (5021)
Hope Creek Generating Station
Hope Creek Rd
Hope Creek Rd
New Freedom (5024)
Salem Rd
Salem Rd
Salem Rd
Required Outages:
• Cut-in of new bay at Salem
• 5015 outage to cut over to new bays at Salem and Red Lion substations
• Raising the 5024, 5021 and 5023 lines at crossing points


Red Lion Substation
PHI/Exelon 4A
New Salem Circuit
Hope Creek (5015) Circuit
Relocate 5015 to a new 500kV line terminal and add double breaker between lines
PJM TEAC 3/6/2014

PHI / Exelon 4A - Cost Factors

PJM Estimated Cost: $216-$263 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: $181 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New 500 kV path from the AI to Red Lion
- Results:
  - Approximate benefit to cost ratio of 0.15
  - Approximately $57 million over 15 years

Outage Cost

- 5015 outage estimated at 30 days

PHI / Exelon 4A - Project Schedule

Proposed Schedule 60 months (items run concurrent)

- Permitting: 34 months
- Design and Construction: 50 months
- Property Acquisition: 0 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - No significant long lead time equipment required
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

PHI / Exelon 4A - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
    - Land is coastal and under state jurisdiction
  - Red Lion substation expansion is on land currently owned by PHI

- New Right of Way Required
  - As participants in the LDV agreement, party has a right of way agreement for the new line

- Substation Land Required
  - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
  - View-shed impacts minimal as this is adjacent to the existing 5015
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - No impact
- Land Permitting
  - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
  - Numerous approvals and permits required:

  (a few major permits are listed below)
  - Delaware River Basin Commission approval required
  - Delaware and New Jersey CPCNs required
  - US Army Corps of Engineers Section 404 and 10 authorizations
  - Multiple US Fish and Wildlife permits required
  - National Marine Fisheries Service

PHI / Exelon 4A - Operational Impact

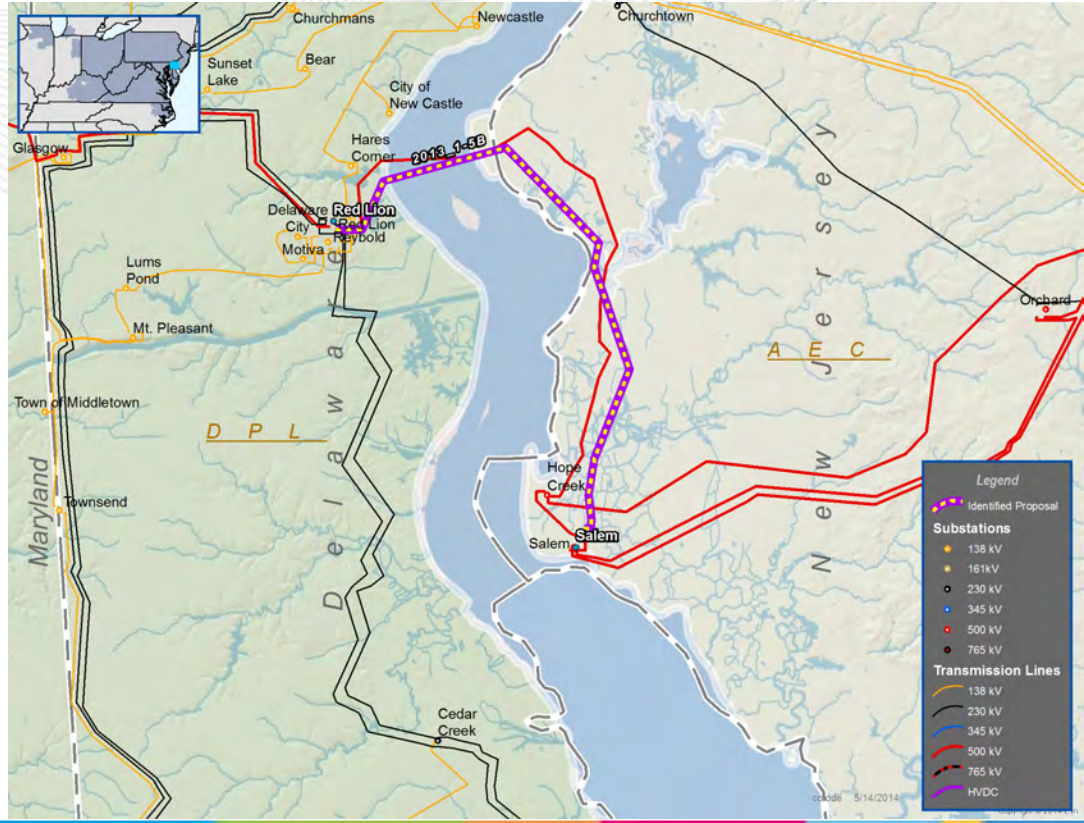
Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - No blackstart advantage
- Route Diversity
  - Project route is parallels the existing 5015 line
- Ongoing Maintenance
  - Salt spray concern with proximity to Delaware river

LS Power 5B

- New 500kV Line between Salem and Red Lion substations

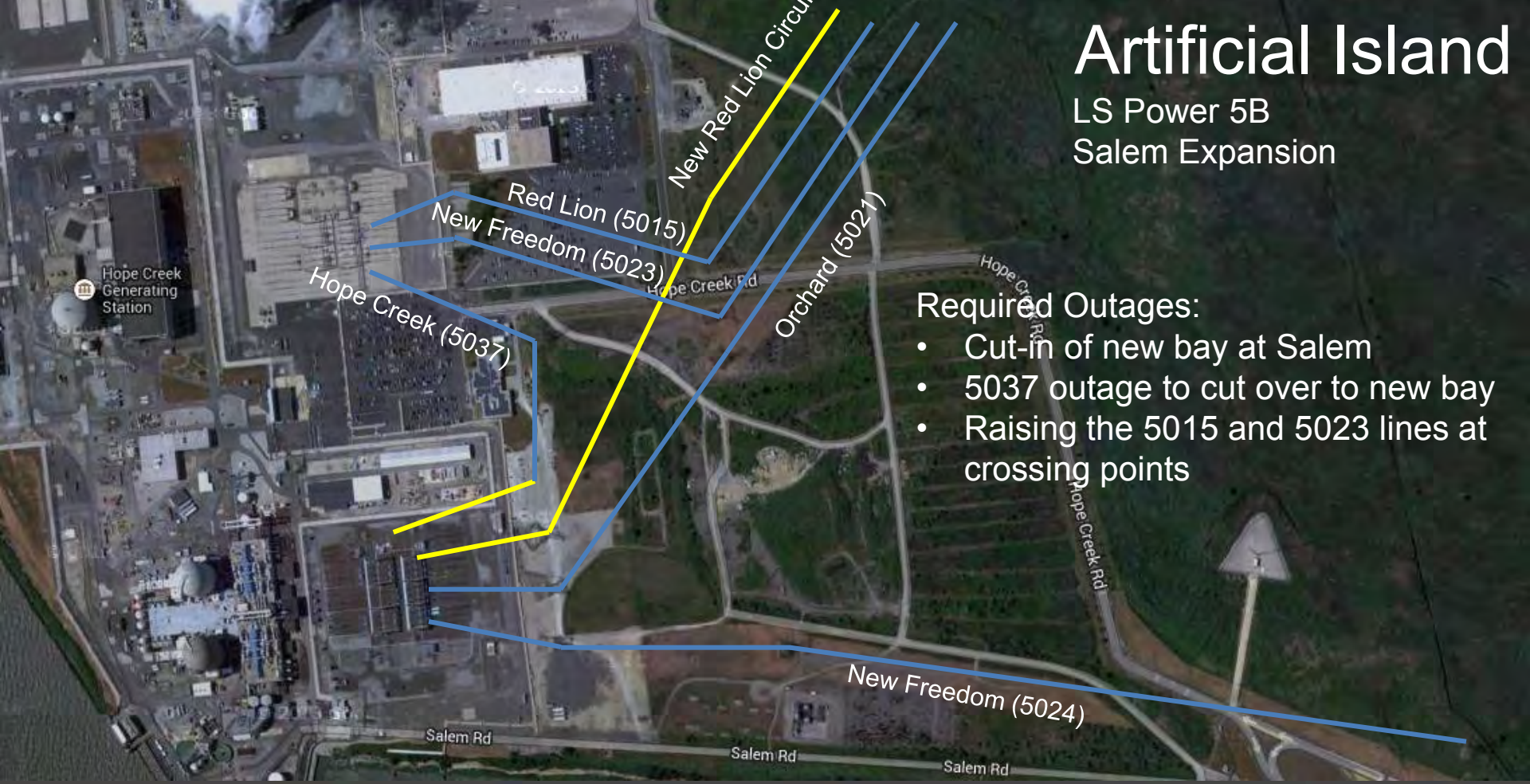
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:
    - Dead-end towers added around line crossing
    - New Salem connection as a full bay



- Stability Performance

  - Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.

  - Passed required performance
    - Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island.



Artificial Island

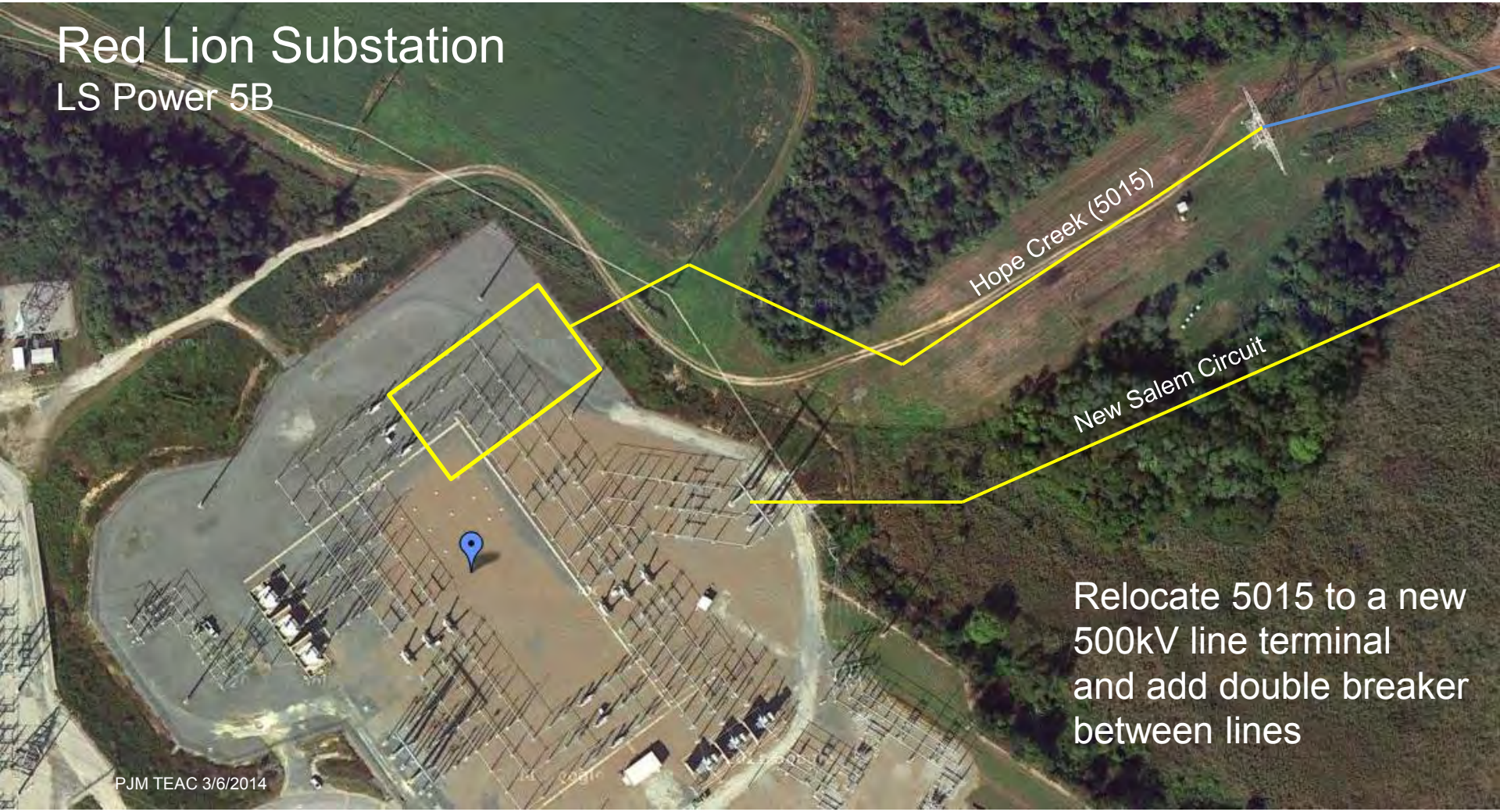
LS Power 5B
Salem Expansion

Required Outages:

- Cut-in of new bay at Salem
- 5037 outage to cut over to new bay
- Raising the 5015 and 5023 lines at crossing points

Red Lion Substation

LS Power 5B



Relocate 5015 to a new 500kV line terminal and add double breaker between lines

LS Power 5B - Cost Factors

PJM Estimated Cost: $221-$269 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: $171 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New 500 kV path from the AI to Red Lion
- Results:
  - Approximate benefit to cost ratio of 0.15
  - Approximately $57 million over 15 years

Outage Cost

- 5015 outage estimated at 30 days

LS Power 5B - Project Schedule

Proposed Schedule 60 months (items run concurrent)

- Permitting: 27 months
- Design and Construction: 60 months
- Property Acquisition: 18 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - No significant long lead time equipment required
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

LS Power 5B - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
    - Land is coastal and under state jurisdiction
  - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
  - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities
- Substation Land Required
  - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
  - View-shed impacts minimal as this is adjacent to the existing 5015
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - No impact
- Land Permitting
  - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
  - Numerous approvals and permits required:

  (a few major permits are listed below)
  - Delaware River Basin Commission approval required
  - Delaware and New Jersey CPCNs required
  - US Army Corps of Engineers Section 404 and 10 authorizations
  - Multiple US Fish and Wildlife permits required
  - National Marine Fisheries Service

LS Power 5B - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - No blackstart advantage
- Route Diversity
  - Project route is parallels the existing 5015 line
- Ongoing Maintenance
  - No impact

Transource (AEP) 2C

- New 500kV Line between Salem and Red Lion substations

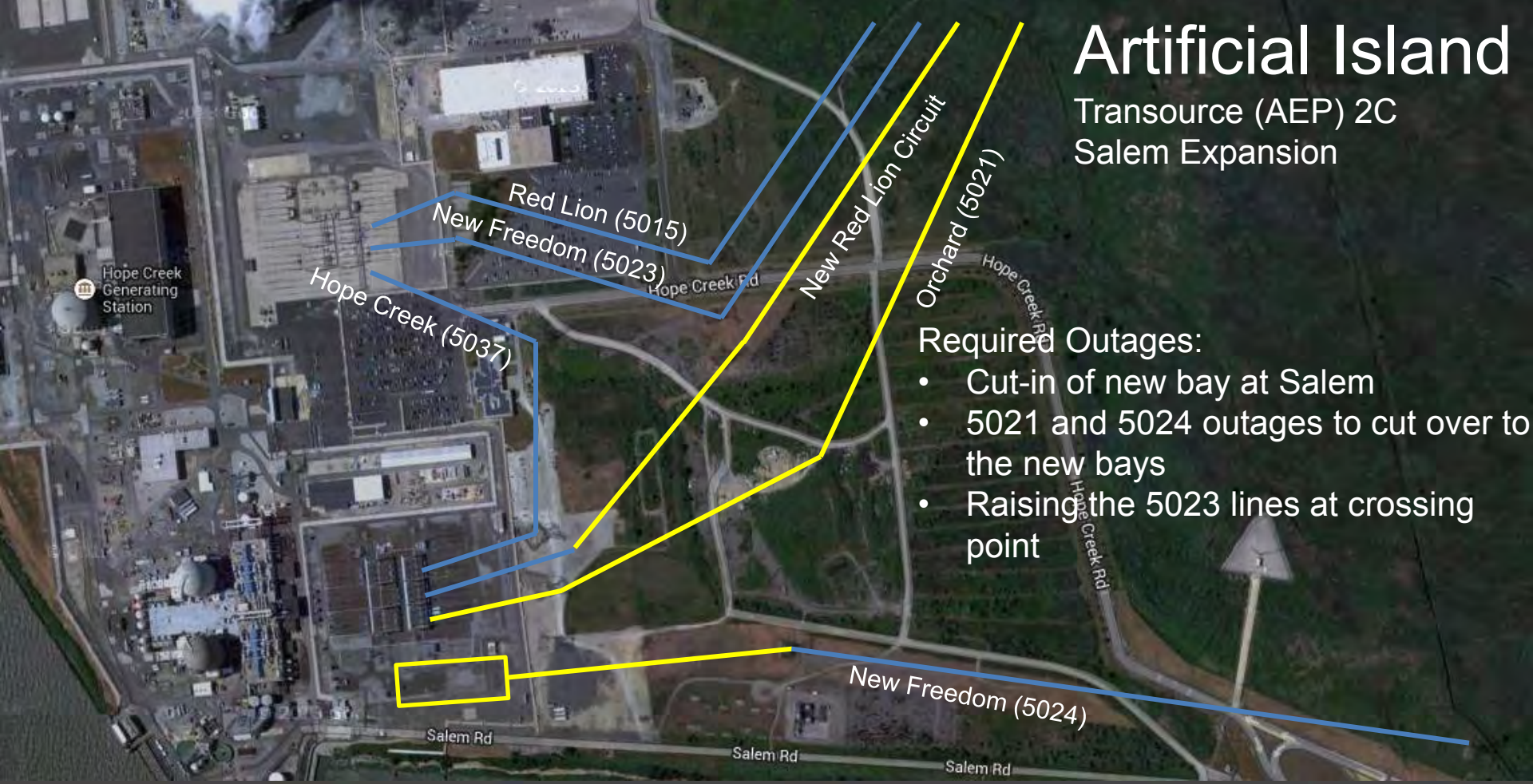
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:
    - Dead-end towers added around line crossing
    - New Salem connection as a full bay

Transource (AEP) 2C – Technical Analysis

- Stability Performance

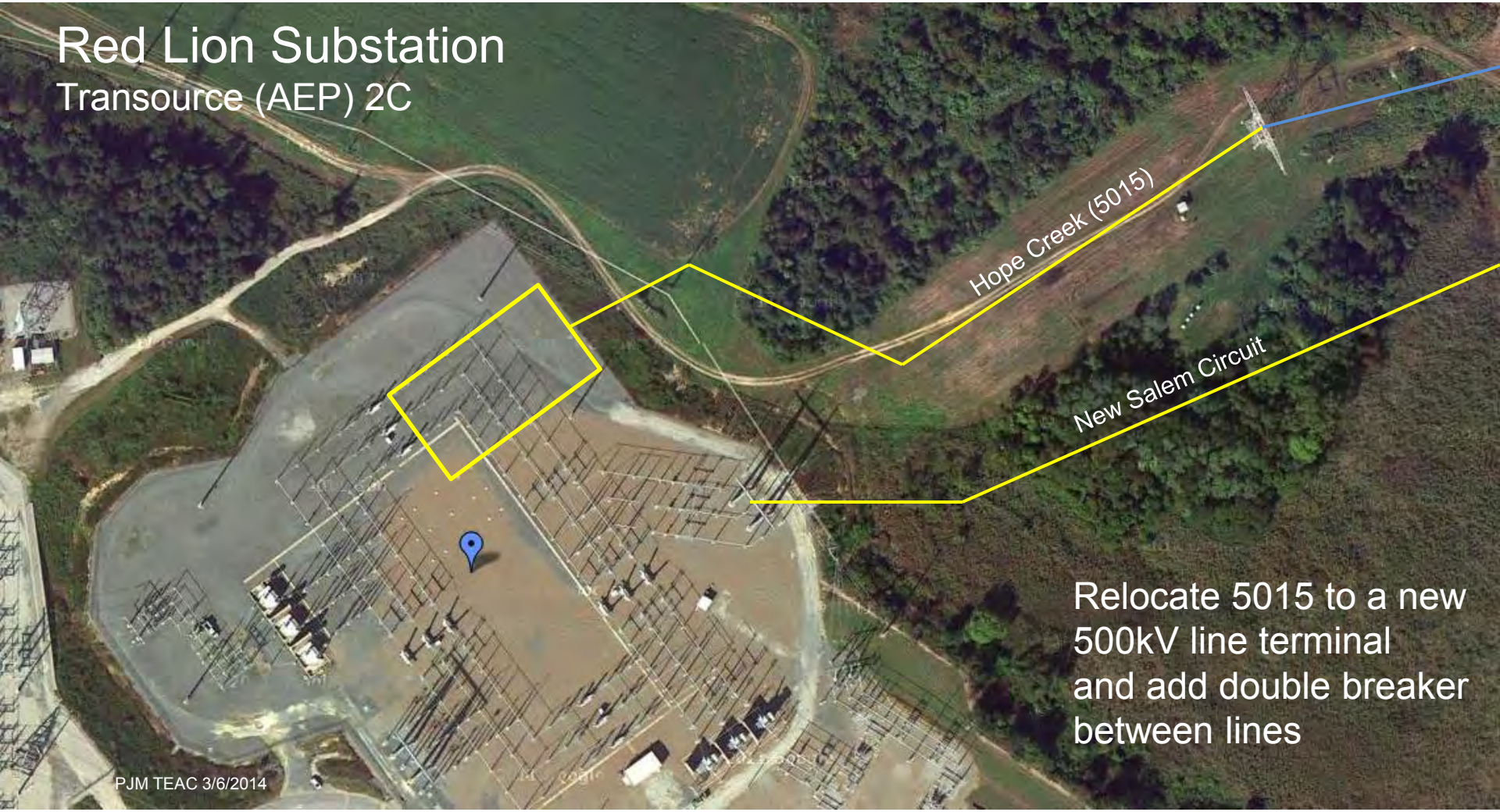
  – Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.

  – Passed required performance
    - Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island.


Artificial Island
Transource (AEP) 2C
Salem Expansion
Red Lion (5015)
New Freedom (5023)
Hope Creek (5037)
New Red Lion Circuit
Orchard (5021)
Hope Creek Generating Station
Hope Creek Rd
Hope Creek Rd
Hope Creek Rd
Required Outages:
• Cut-in of new bay at Salem
• 5021 and 5024 outages to cut over to the new bays
• Raising the 5023 lines at crossing point
New Freedom (5024)
Salem Rd
Salem Rd
Salem Rd

Red Lion Substation

Transource (AEP) 2C



Relocate 5015 to a new 500kV line terminal and add double breaker between lines

Transource (AEP) 2C - Cost Factors

PJM Estimated Cost: $232-$282 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: $123-156 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New 500 kV path from the AI to Red Lion
- Results:
  - Approximate benefit to cost ratio of 0.15
  - Approximately $57 million over 15 years

Outage Cost

- 5015 outage estimated at 30 days

Transource (AEP) 2C - Project Schedule

Proposed Schedule 48 months (items run concurrent)

- Permitting: 27 months
- Design and Construction: 30 months
- Property Acquisition: 15 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - No significant long lead time equipment required
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

Transource (AEP) 2C - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
    - Land is coastal and under state jurisdiction
  - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
  - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities
- Substation Land Required
  - Red Lion substation expansion will be done on land currently owned by PHI.

Transource (AEP) 2C - Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
  - View-shed impacts minimal as this is adjacent to the existing 5015
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - No impact
- Land Permitting
  - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
  - Numerous approvals and permits required:

  (a few major permits are listed below)
  - Delaware River Basin Commission approval required
  - Delaware and New Jersey CPCNs required
  - US Army Corps of Engineers Section 404 and 10 authorizations
  - Multiple US Fish and Wildlife permits required
  - National Marine Fisheries Service

Transource (AEP) 2C - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - No blackstart advantage
- Route Diversity
  - Project route is parallels the existing 5015 line
- Ongoing Maintenance
  - Salt spray concern with proximity to Delaware river

Hope Creek to Red Lion Lines

- Expansion of Hope Creek substation
- 17 mile 500kV line
- Parallels 5015 (Existing Red Lion – Hope Creek 500 kV)
- Proposing Entities:

Dominion
PSE&G

Dominion Virginia Power (DVP) 1C

- New 500kV Line between Hope Creek and Red Lion substations
- New bus tie between Hope Creek and Salem substations
- PJM modifications
  - Technical:
    - Added SVC
  - Constructability:
    - Dead-end towers added around line crossing

Dominion Virginia Power (DVP) 1C – Technical Analysis

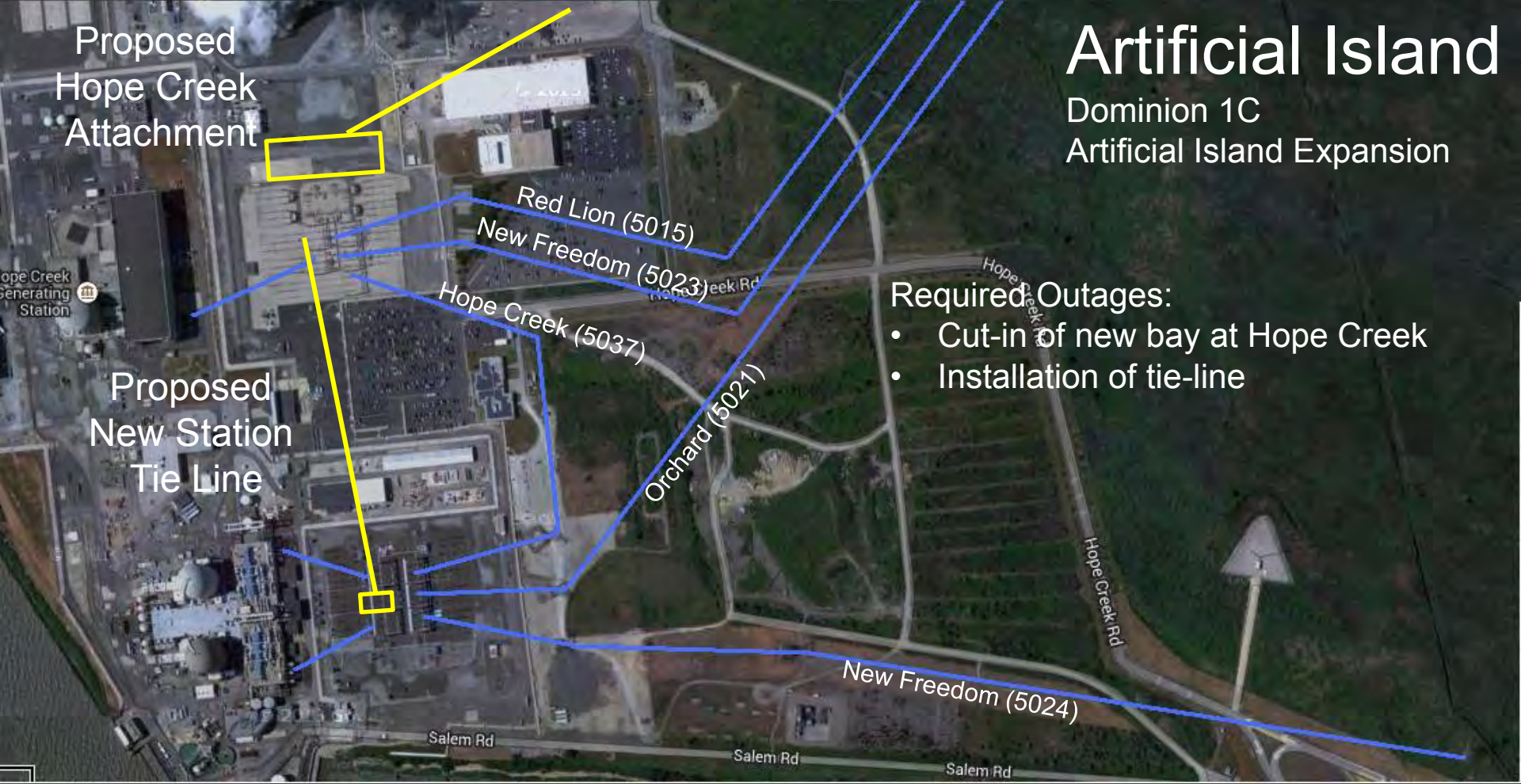
- Stability Performance

  - Failed required performance
    - Failed as proposed by project sponsor.
    - Failed with modification to remove proposed breakers.
    - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under new Hope Creek – Red Lion line maintenance outage condition.
    - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under new Hope Creek – Red Lion line maintenance outage condition with modification to remove proposed breakers.

  - Passed required performance
    - Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Artificial Island

Dominion 1C
Artificial Island Expansion



Required Outages:

- Cut-in of new bay at Hope Creek
- Installation of tie-line

Red Lion Substation

Dominion 1C

- Substation proposed to be rebuilt as a double bus – double breaker scheme
- New line crosses the 5015 line

Dominion Virginia Power (DVP) 1C - Cost Factors

PJM Estimated Cost: $242-$294 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: $199 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New 500 kV path from the AI to Red Lion
- Results:
  - Approximate benefit to cost ratio of 0.15
  - Approximately $57 million over 15 years

Outage Cost

- 5015 outage estimated at 40 days

Dominion Virginia Power (DVP) 1C - Project Schedule

Proposed Schedule 111 months (items run concurrent)

- Permitting: 24 months
- Design and Construction: 38 months
- Property Acquisition: 78 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - No significant long lead time equipment required
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

Dominion Virginia Power (DVP) 1C - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
    - Land is coastal and under state jurisdiction
  - Red Lion substation expansion is on land currently owned by PHI

- New Right of Way Required
  - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities

- Substation Land Required
  - Red Lion substation expansion will be done on land currently owned by PHI.

Dominion Virginia Power (DVP) 1C - Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
  - View-shed impacts minimal as this is adjacent to the existing 5015
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - No impact
- Land Permitting
  - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
  - Numerous approvals and permits required:

  (a few major permits are listed below)
  - Delaware River Basin Commission approval required
  - Delaware and New Jersey CPCNs required
  - US Army Corps of Engineers Section 404 and 10 authorizations
  - Multiple US Fish and Wildlife permits required
  - National Marine Fisheries Service

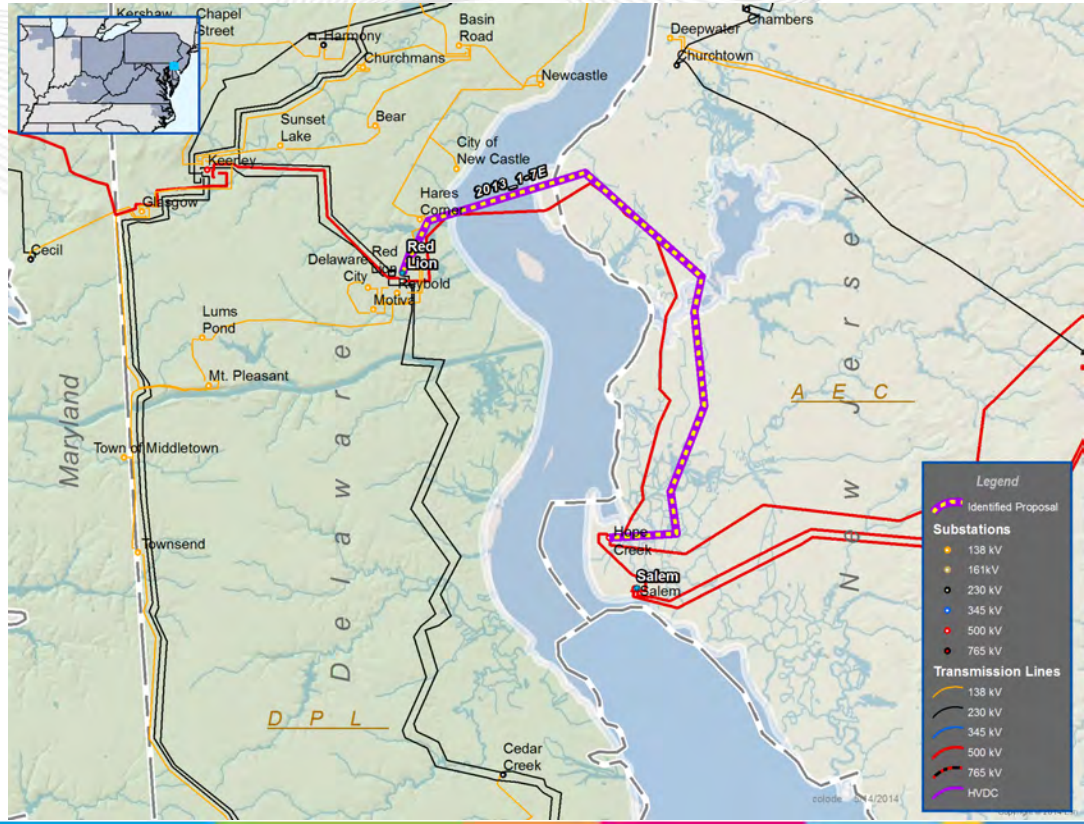
Dominion Virginia Power (DVP) 1C - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - No blackstart advantage
- Route Diversity
  - Project route parallels the existing 5015 line
- Ongoing Maintenance
  - Limited physical access could lead to maintenance issues on the new tie line between Salem and Hope Creek

PSE&G 7K

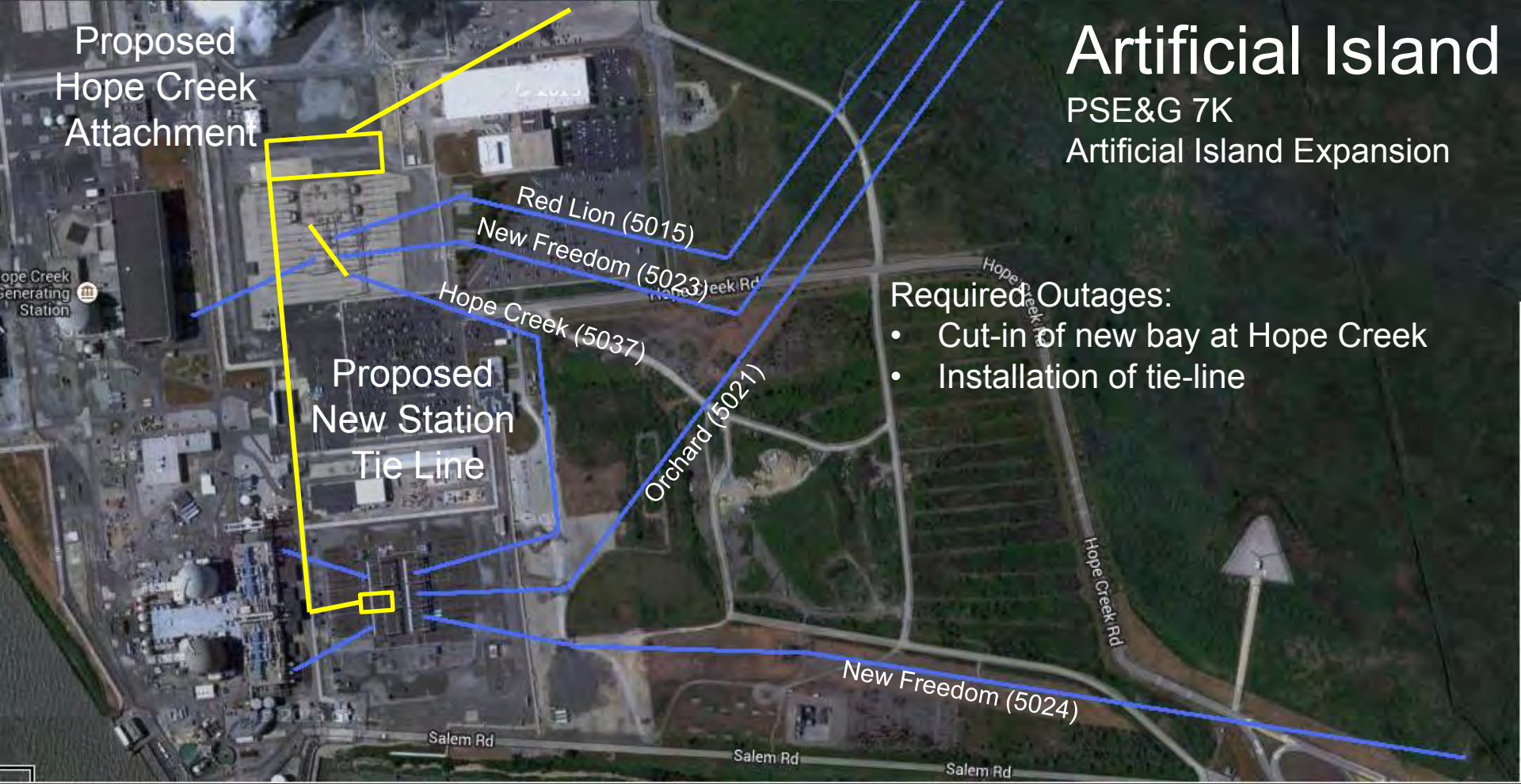
- New 500kV Line between Hope Creek and Red Lion substations
- New bus tie between Hope Creek and Salem substations
- PJM modifications
  - Technical:
    - Removed the New Freedom to Deans portion of the project
    - Added SVC
  - Constructability:
    - Dead-end towers added around line crossing



- Stability Performance

  – Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5037 maintenance outage condition.

  – Passed required performance
    - Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.



Artificial Island

PSE&G 7K
Artificial Island Expansion

Required Outages:

- Cut-in of new bay at Hope Creek
- Installation of tie-line

- Substation proposed to be rebuilt as a breaker and a half scheme
- New line crosses the 5015 line

Red Lion Substation

PSE&G 7K

PSE&G 7K - Cost Factors

PJM Estimated Cost: $249-$304 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: $297 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New 500 kV path from the AI to Red Lion
- Results:
  - Approximate benefit to cost ratio of 0.15
  - Approximately $57 million over 15 years

Outage Cost

- 5015 outage estimated at 40 days

PSE&G 7K - Project Schedule

Proposed Schedule 51 months (items run concurrent)

- Permitting: 51 months
- Design and Construction: 48 months
- Property Acquisition: 0 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - No significant long lead time equipment required
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

PSE&G 7K - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
    - Land is coastal and under state jurisdiction
  - Red Lion substation expansion is on land currently owned by PHI

- New Right of Way Required
  - As participants in the LDV agreement, party has a right of way agreement for the new line

- Substation Land Required
  - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
  - View-shed impacts minimal as this is adjacent to the existing 5015
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - No impact
- Land Permitting
  - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
  - Numerous approvals and permits required:

  (a few major permits are listed below)
  - Delaware River Basin Commission approval required
  - Delaware and New Jersey CPCNs required
  - US Army Corps of Engineers Section 404 and 10 authorizations
  - Multiple US Fish and Wildlife permits required
  - National Marine Fisheries Service

PSE&G 7K - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
    - Salem control house is a part of plant facilities and access is constrained
- Blackstart
  - No blackstart advantage
- Route Diversity
  - Project route is parallels the existing 5015 line
- Ongoing Maintenance
  - The new gas-insulated bus tie line between Salem and Hope Creek may require more frequent maintenance

Dominion Virginia Power (DVP) 1C (No New Bus Tie)

- New 500kV Line between Hope Creek and Red Lion substations
- PJM modifications
  - Technical:
    - Removed the new tie between Salem and Hope Creek substations
    - Added SVC
  - Constructability:
    - Red Lion expansion changed from a breaker and a half to an expansion of the existing ring-bus

Dominion Virginia Power (DVP) 1C (No New Bus Tie) Technical Analysis

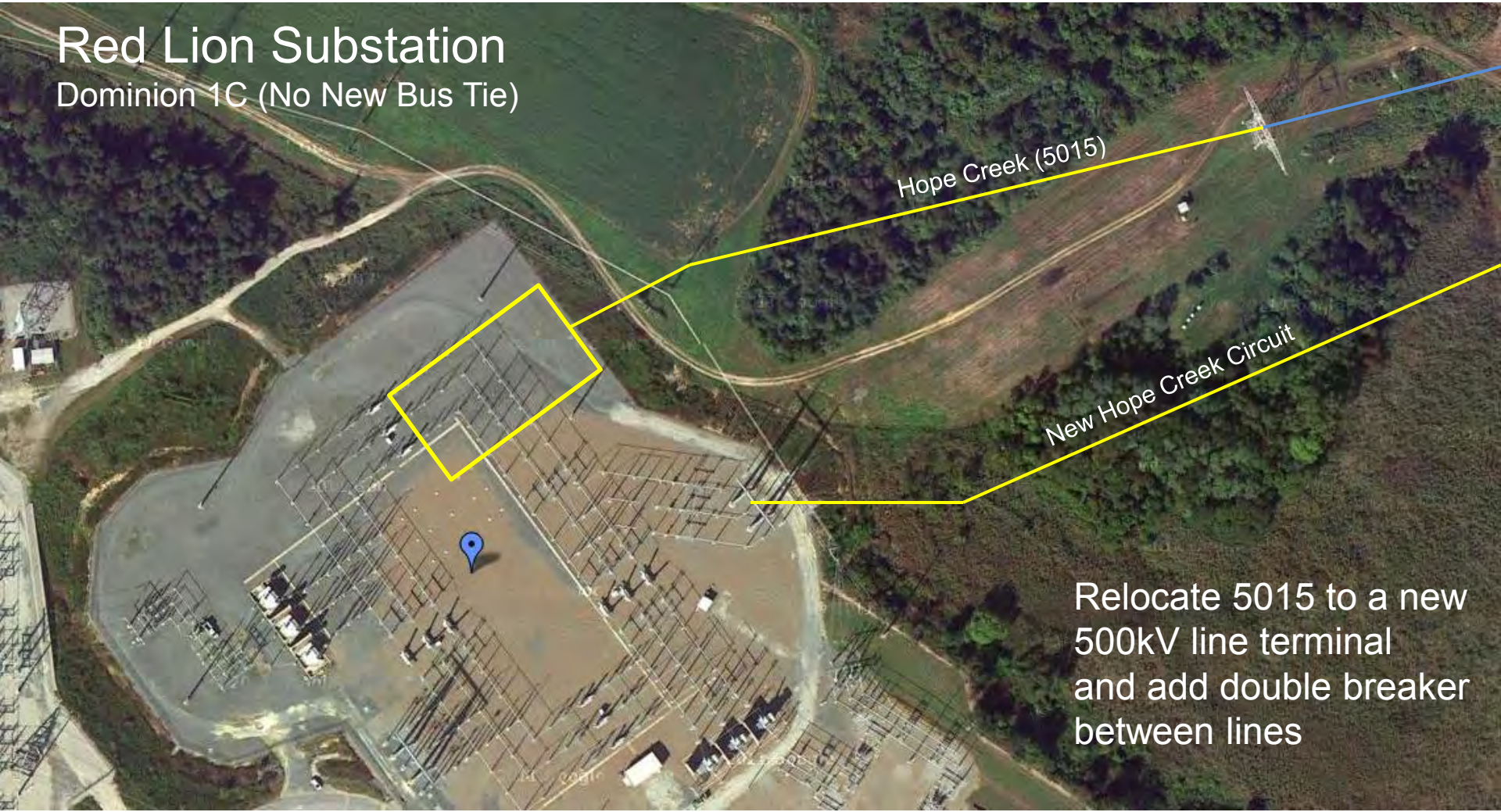
- Stability Performance
  - Failed required performance
    - Failed as proposed by project sponsor.
    - Failed with modification to remove proposed breakers and transmission line.
    - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under Hope Creek – Red Lion line maintenance outage condition.
    - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under Hope Creek – Red Lion line maintenance outage condition with modification to remove proposed breakers and transmission line.
  - Passed required performance
    - Passed as modified with the addition of an SVC at Orchard or New Freedom.

Artificial Island

Dominion 1C (No New Bus Tie)
Hope Creek Expansion

Required Outages:

- Cut-in of new bay at Hope Creek


Red Lion Substation
Dominion 1C (No New Bus Tie)
Hope Creek (5015)
New Hope Creek Circuit
Relocate 5015 to a new 500kV line terminal and add double breaker between lines

Dominion Virginia Power (DVP) 1C (No New Bus Tie) Cost Factors

PJM Estimated Cost: $211-$257 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New 500 kV path from the AI to Red Lion
- Results:
  - Approximate benefit to cost ratio of 0.15
  - Approximately $57 million over 15 years

Outage Cost

- 5015 outage estimated at 14 days

Dominion Virginia Power (DVP) 1C (No New Bus Tie) Project Schedule

Proposed Schedule 111 months (items run concurrent)

- Permitting: 24 months
- Design and Construction: 38 months
- Property Acquisition: 78 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - No significant long lead time equipment required
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

Dominion Virginia Power (DVP) 1C (No New Bus Tie) RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
    - Land is coastal and under state jurisdiction
  - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
  - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities
- Substation Land Required
  - Red Lion substation expansion will be done on land currently owned by PHI.

Dominion Virginia Power (DVP) 1C (No New Bus Tie) Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
  - View-shed impacts minimal as this is adjacent to the existing 5015
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - No impact
- Land Permitting
  - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
  - Numerous approvals and permits required:

  (a few major permits are listed below)
  - Delaware River Basin Commission approval required
  - Delaware and New Jersey CPCNs required
  - US Army Corps of Engineers Section 404 and 10 authorizations
  - Multiple US Fish and Wildlife permits required
  - National Marine Fisheries Service

Dominion Virginia Power (DVP) 1C (No New Bus Tie) Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Hope Creek north has available land for expansion
    - Hope Creek control house has adequate space and access for expansion

- Blackstart
  - No blackstart advantage
- Route Diversity
  - Project route is parallels the existing 5015 line
- Ongoing Maintenance
  - No impact

PSE&G 7K (No New Bus Tie)

- New 500kV Line between Hope Creek and Red Lion substations
- PJM modifications
  - Technical:
    - Removed the New Freedom to Deans portion of the project
    - Removed the new tie between Salem and Hope Creek substations
    - Added SVC
  - Constructability:
    - Red Lion expansion changed from a breaker and a half to an expansion of the existing ring-bus

- Stability Performance

  – Failed required performance
    - Failed as proposed by project sponsor.
    - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under new Hope Creek – Red Lion 500kV line maintenance outage condition with modification to remove Salem – Hope Creek 2nd tie and proposed breakers.

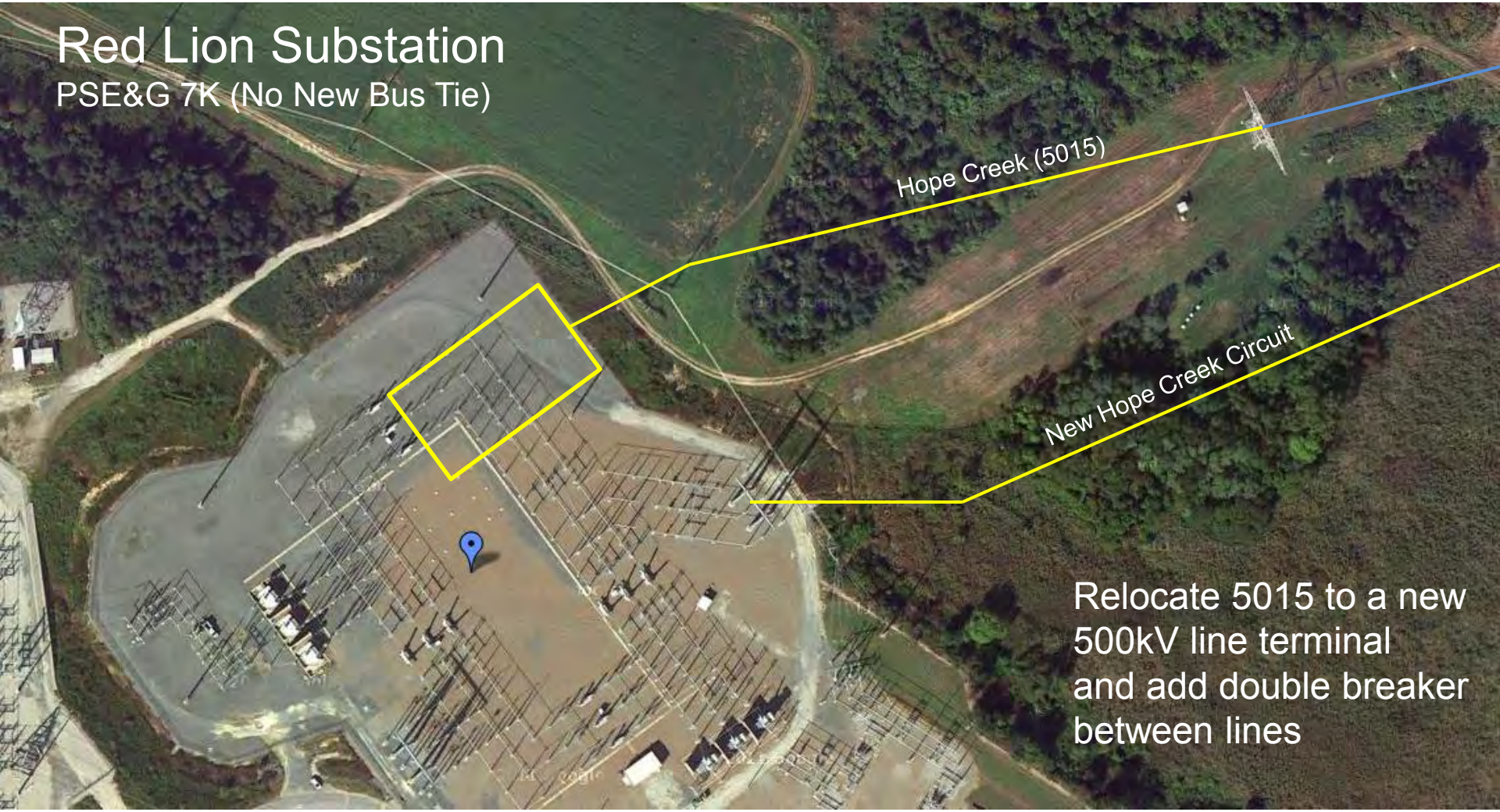
  – Passed required performance
    - Passed as modified with the addition of an SVC at Orchard or New Freedom.

Artificial Island

PSE&G 7K (No New Bus Tie)
Hope Creek Expansion

Required Outages:

- Cut-in of new bay at Hope Creek


Red Lion Substation
PSE&G 7K (No New Bus Tie)
Hope Creek (5015)
New Hope Creek Circuit
Relocate 5015 to a new 500kV line terminal and add double breaker between lines

PSE&G 7K (No New Bus Tie) - Cost Factors

PJM Estimated Cost: $211-$257 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Market Efficiency Analysis Sensitivity Study

- Scenario:
  - New 500 kV path from the AI to Red Lion
- Results:
  - Approximate benefit to cost ratio of 0.15
  - Approximately $57 million over 15 years

Outage Cost

- 5015 outage estimated at 14 days

PSE&G 7K (No New Bus Tie) - Project Schedule

Proposed Schedule: 51 months (items run concurrent)

- Permitting: 51 months
- Design and Construction: 48 months
- Property Acquisition: 0 months

Schedule Criteria

- Permitting
  - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
  - No significant long lead time equipment required
- Construction
  - Could be impacted by restrictions due to endangered species and shipping traffic

PSE&G 7K (No New Bus Tie) - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
  - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
    - Land is coastal and under state jurisdiction
  - Red Lion substation expansion is on land currently owned by PHI

- New Right of Way Required
  - As participants in the LDV agreement, party has a right of way agreement for the new line

- Substation Land Required
  - Red Lion substation expansion will be done on land currently owned by PHI.

PSE&G 7K (No New Bus Tie) - Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
  - Permits required to cross the Delaware state lands on the river coast
  - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
  - View-shed impacts minimal as this is adjacent to the existing 5015
  - Some opposition to any river crossing is expected
- Historic and Scenic Highway
  - No impact
- Land Permitting
  - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
  - Numerous approvals and permits required:

  (a few major permits are listed below)
  - Delaware River Basin Commission approval required
  - Delaware and New Jersey CPCNs required
  - US Army Corps of Engineers Section 404 and 10 authorizations
  - Multiple US Fish and Wildlife permits required
  - National Marine Fisheries Service

PSE&G 7K (No New Bus Tie) - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
  - PJM Operations Review
    - Request to minimize impact to existing transmission facilities
  - Salem/Hope Creek Facility Owner Feedback
    - Request to minimize outage and physical impacts to existing transmission facilities
    - Hope Creek north has available land for expansion
    - Hope Creek control house has adequate space and access for expansion
- Blackstart
  - No blackstart advantage
- Route Diversity
  - Project route is parallels the existing 5015 line
- Ongoing Maintenance
  - No impact

SVCs

- SVC Locations Considered:
  - New Freedom
  - Orchard
  - Artificial Island
- Schedule Estimate 36 months
  - SVC lead time of 24 months
  - Permitting and land acquisition 6 months
- Cost Estimate $80 million
  - SVC $60 million

SVC Constructability Analysis

- No determining factor difference between the Orchard or New Freedom SVC
  - Project complexity
    - Expansion of existing substations at either Orchard or New Freedom
  - Land acquisition
    - New land purchase at Orchard
    - PSE&G owns adjacent land at New Freedom
  - Siting and permitting will be similar between the two projects
  - Cost and schedule estimates are the same

- Artificial Island
  - Anticipated nuclear regulatory concerns in approving this device at Artificial Island

Consolidated Summary

Artificial Island Technical Summary

		Southern Crossing Lines (Submarine)			Southern Crossing Lines (Overhead)		Red Lion to Artificial Island Lines						
							From Salem			From Hope Creek			
		LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - Overhead	Dominion 1B - 500kV Overhead	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion 1C - Red Lion to Hope Creek (Remove HC-S 2nd Tie)	PSE&G 7K- Red Lion to Hope Creek (Remove HC-S 2nd Tie)
Technical Analysis Criteria	**Stability**	Maximum angle swing range of 80 - 112 degrees, dependent on solution and SVC location			Maximum angle swing range of 80 - 110 degrees, dependent on solution and SVC location		Maximum angle swing range of 77 - 102 degrees, dependent on solution and SVC location						
	Thermal	Preliminary analysis indicates no thermal overloads			Preliminary analysis indicates no thermal overloads		Preliminary analysis indicates no thermal overloads						
	Market Efficiency Results	Approximate $92 M cost savings over 15 Years			Approximate $92 M cost savings over 15 Years		Approximate $57 M cost savings over 15 Years						
	Short Circuit	Three overdutied 230 kV breakers		No overdutied breakers	Three overdutied 230 kV breakers		No overdutied breakers						

Criteria Evaluation

- The following slides provide a summary review of PJM's assessment of the modified proposals in terms of technical performance, cost, constructability and other factors, which are covered in greater detail in the preceding slides.

- Legend:

Positive or limited impact	
Some impact	
Negative impact	
Does not apply	

Southern Crossing Lines – Project Complexity

Criteria	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Project Complexity	Line Crossings	None	None	None	None	Generator lead line
	Outage Requirements	New bay tie-in at Salem	Relocation of 5024 line at Salem	Relocation of 5024 line at Salem; Cedar Creek ring-bus expansion	New bay tie-in at Salem	New tie-in at Salem will necessitate a unit outage; Breaker installation may require multiple Salem outages.
	Modification to other Transmission Facilities	Cutting the two 230kV lines into the new Delaware substation	Cutting the two 230kV lines into the new Delaware substation; installing one new span on the 5024 line.	Expanding the Cedar Creek ring bus by two positions to bring in the new Salem line and the existing Red Lion to Cartanza line; installing one new span on the 5024 line.	Cutting the two 230kV lines into the new Delaware substation	Cutting the two 230kV lines into the new Delaware substation

Southern Crossing Lines – Project Complexity

	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Project Complexity	Modification of Artificial Island Substations	New bay and auto-transformer to the south in Salem	New bay for 5024 line to the south in Salem	New bay for 5024 line to the south in Salem	New bay and auto-transformer to the south in Salem	Installing two breakers into the open middle bay in Salem
	Modification of Red Lion Substation	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

AI to Red Lion Lines – Project Complexity

Criteria	Project Class	Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Project Complexity	Line Crossings	5023, 5021, 5024 lines	5015 and 5023 lines	5023 line	5015 line; aerial tie has multiple crossings	5015 line	None	None
	Outage Requirements	5015 line position changing at both ends; Raising the three 500kV lines	Raising 5015 line and moving it to the new position at Red Lion. Relocation of 5037 line at Salem; Raising the 5023 line	Relocating the 5024 and 5021 lines at Salem; New line crosses the 5023 line.	Multple 500kV outages to convert the Red Lion ring bus to a breaker and a half scheme; New line crosses the 5015 line; Outages to suppor the new Hope Creek to Salem tie	Multple 500kV outages to convert the Red Lion ring bus to a breaker and a half scheme; New line crosses the 5015 line; Outages to suppor the new Hope Creek to Salem tie; 5037 into new position at Hope Creek	5015 line position changing at Red Lion. New bay tie-in at Hope Creek	5015 line position changing at Red Lion. New bay tie-in at Hope Creek
	Modification to other Facilities	Impacts detailed in other sub-criteria	Installing one new span on the 5037 line.	Use of the existing 5021 for a number of spans and build a new portion of 5021 along that length; installing one new span for the 5024 line	Impacts detailed in other sub-criteria	Impacts detailed in other sub-criteria	Impacts detailed in other sub-criteria	Impacts detailed in other sub-criteria

AI to Red Lion Lines – Project Complexity

Criteria	Project Class	Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
Project Complexity	Modification of AI Subs	New bay to the south in Salem	New bay for 5037 line to the north in Salem	New bay for 5024 line to the south and relocate 5021 line in Salem	New bay in Hope Creek and a new tie between Hope Creek and Salem	New bay in Hope Creek and a new tie between Hope Creek and Salem; moving the 5037 into the existing open bay at Hope Creek	New bay in Hope Creek	New bay in Hope Creek
	Modification of Red Lion Sub	Moving 5015 line into new ring-bus position	Moving 5015 line into new ring-bus position	Moving 5015 line into new ring-bus position	Rebuilding the substation as a double bus - double breaker scheme	Rebuilding the substation as a breaker and a half scheme	Moving 5015 line into new ring-bus position	Moving 5015 line into new ring-bus position

Southern Crossing Lines – Cost Factors

	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Cost Factors	PJM Estimated Project	$248-$302	$257-$313	$366-$446	$211-$257	$233-$283
	Proposed Project Costs	$148	$165-$208	$213-269	$116	$133
	Market Efficiency	Approximately $92 over 15 years			Approximately $92 over 15 years	
	Outage Cost	230kV outage during substation cut-in	230kV outage during substation cut-in	230kV outage during substation cut-in	230kV outage during substation cut-in	230kV outage during substation cut-in

Note: Costs are for the line project only; SVC costs are not included.

AI to Red Lion Lines – Cost Factors

Criteria	Project Class	Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Cost Factors	PJM Estimated Project	$216-$263	$221-$269	$232-$282	$242-$294	$249-$304	$211-$257	$211-$257
	Proposed Project Costs	$181	$171	$123-156	$199	$297		
	Market Efficiency	Approximately $57 over 15 years			Approximately $57 over 15 years			
	Outage Cost	5015 outage estimated at 30 days	5015 outage estimated at 30 days	5015 outage estimated at 14 days	5015 outage estimated at 40 days	5015 outage estimated at 40 days	5015 outage estimated at 14 days	5015 outage estimated at 14 days

Note: Costs are for the line project only; SVC costs are not included.

Southern Crossing Lines – Operational Impact

Criteria	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Operational Impact	Artificial Island Facility Requirements	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained
	Blackstart	Additional access to blackstart resources	Additional access to blackstart resources	Additional access to blackstart resources	Additional access to blackstart resources	Additional access to blackstart resources
	Route Diversity	New route	New route	New route	New route	New route
	Ongoing Maintenance	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Auto-transformer maintenance may increase line outage frequency

AI to Red Lion Lines – Operational Impact

Criteria	Project Class	Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
Operational Impact	Artificial Island Facility Requirements	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Land available to the north of Hope Creek for expansion and control house has adequate space and access for expansion	Land available to the north of Hope Creek for expansion and control house has adequate space and access for expansion
	Blackstart	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage
	Route Diversity	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line
	Ongoing Maintenance	Salt spray concern with proximity to Delaware river	No impact	Salt spray concern with proximity to Delaware river	The new gas-insulated bus tie line between Salem and Hope Creek may require more frequent maintenance	Limited physical access could lead to maintenance issues on the new tie line between Salem and Hope Creek	No impact	No impact

Southern Crossing Lines
Right of Way and Land Acquisition

	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Right of Way and Land Acquisition	No Eminent Domain in Delaware	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware
	New Right of Way Required	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware
	Substation Land Required	Acquired an option on a substation location in Delaware	New substation land required in Delaware and New Jersey	New substation land required in Delaware and New Jersey	Acquired an option on a substation location in Delaware	New substation land required in Delaware

AI to Red Lion Lines
Right of Way and Land Acquisition

Criteria	Project Class	Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
Right of Way and Land Acquisition	No Eminent Domain in Delaware	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction
	New Right of Way Required	Participant in the LDV agreement which governs 5015 RoW	Negotiate with LDV parties or individual land owners	Negotiate with LDV parties or individual land owners	Negotiate with LDV parties or individual land owners	Participant in the LDV agreement which governs 5015 RoW	Negotiate with LDV parties or individual land owners	Participant in the LDV agreement which governs 5015 RoW
	Substation Land Required	None	None	None	None	None	None	None

Southern Crossing Lines - Siting and Permitting

Criteria	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Siting and Permitting	Wetlands Impact	New route will allow flexibility	New route will allow flexibility	Impacts approximately 10 acres of forested wetland	New route will allow flexibility	New route will allow flexibility
	Land Permitting	No major permit identified	No major permit identified	No major permit identified	No major permit identified	No major permit identified
	Public Opposition Risk	No view-shed impact; some opposition to any river crossing is expected	No view-shed impact; some opposition to any river crossing is expected	No view-shed impact; some opposition to any river crossing is expected	Creates a new view-shed impact and would become the southern-most aerial infrastructure on the Delaware Rive	Creates a new view-shed impact and would become the southern-most aerial infrastructure on the Delaware Rive
	Historic and Scenic Highway	New line parallels Delaware state route 9	New line crosses Delaware state route 9	Not applicable	New line parallels Delaware state route 9	New line crosses Delaware state route 9
	Delaware River Crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing

AI to Red Lion Lines - Siting and Permitting

Criteria	Project Class	Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
Siting and Permitting	Sub-Criteria							
	Wetlands Impact	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland
	Land Permitting	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required
	Public Opposition Risk	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected
	Historic and Scenic Highway	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Delaware River Crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing

Southern Crossing Lines – Project Schedule

Criteria	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Project Schedule	Permitting	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits
	Construction	Submarine cable installation requires specialized equipment; Spawning/nesting seasons of endagered species may impact construction timeframes	Submarine cable installation requires specialized equipment; Spawning/nesting seasons of endagered species may impact construction timeframes	Submarine cable installation requires specialized equipment; Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes
	Long Lead Time Materials	Submarine cable and auto-transformers	Submarine cable and auto-transformers	Submarine cable and auto-transformers	Auto-transformers	Auto-transformers

AI to Red Lion Lines – Project Schedule

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Project Schedule	Permitting	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits
	Construction	Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes	Spawning/nesting seasons of endagered species may impact construction timeframes
	Long Lead Time Materials	None	None	None	None	None	None	None

Criteria	Project Class	Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
Technical Analysis	Stability												
	Thermal												
	Market Efficiency Results	Approximate 0.15 Benefit to Cost Ratio			Approximate 0.15 Benefit to Cost Ratio		Approximate 0.2 Benefit to Cost Ratio			Approximate 0.2 Benefit to Cost Ratio			
	Short Circuit												
	NERC Cat-D Contingencies												
Cost Factors	PJM Estimated Project Cost	$248-$302	$257-$313	$366-$446	$211-$257	$233-$283	$216-$263	$221-$269	$232-$282	$242-$294	$249-$304	$211-$257	$211-$257
	Project Costs as Proposed	$148	$165-$208	$213-269	$116	$133	$181	$171	$123-156	$199	$297		
	Market Efficiency	Approximately $92 over 15 years			Approximately $92 over 15 years		Approximately $57 over 15 years			Approximately $57 over 15 years			
	Outage Cost												
Project Schedule	Permitting												
	Construction												
	Long Lead Time Materials												
Risks to Cost and Schedule													
Project Complexity	Line Crossings												
	Outage Requirements												
	Modification to other Facilities												
	Modification of AI Subs												
	Modification of Red Lion Sub												
RoW and Land Acquisition	No Eminent Domain in Delaware												
	New Right of Way Required												
	Substation Land Required												
Siting and Permitting	Wetlands Impact												
	Land Permitting												
	Public Opposition Risk												
	Historic and Scenic Highway												
	Delaware River Crossing												
Operational Impact	Artificial Island Facility Requirements												
	Blackstart												
	Route Diversity												
	Ongoing Maintenance												

Artificial Island Timeline

- **Today - Monday, May 19th Special TEAC**
  - **3 hour stakeholder technical meeting**
  - **In-person at PJM CTC**
- Monday, June 2nd – Due date for stakeholder comment/feedback (14 day comment period)
- June 5th TEAC
- **Monday, June 16th – PJM review of stakeholder comment/feedback and final decision meeting**
  - **Special TEAC Webex / Teleconference**
- Comment Period to the PJM Board (36 days for comment period)
- July 10th TEAC
- **Tuesday, July 22nd – PJM Board meeting**
  - **Artificial Island solution recommendation to the PJM Board**

Appendix

Technical Overview

Minimum AI voltage for 230kV proposals

Comparison Method:
Assume 1.065 p.u. at the AI (unstable below 1.065), solve the power flow for the corresponding Salem and Hope Creek MVAr output. Simulate the combination of the most critical fault and outage. Do not assume the addition of an SVC.
Result:
Measure the maximum machine angle swing.
All 230 kV proposals pass the stability criteria.

Group	Project ID	230 kV Transmission Solution	AI 500kV bus voltage	AI MVAr output	Critical Outage	Critical Contingency	Maximum Angle Swing (deg.)
1.1	**P2013_1-5A**	LS Power	**1.065 pu**	1044	5015*	14b**	**102**
1.1	**P2013_1-2B**	Transource (AEP)	**1.065 pu**	965	5015	14b	**105**
1.1	**P2013_1-2A**	Transource (AEP)	**1.065 pu**	940	5015	14b	**110**
1.2	**P2013_1-1B**	DVP	**1.065 pu**	926	5015	14b	**115**

5015*: Hope Creek – Red Lion 500kV line
14b**: single-line-to-ground fault on the new line from Salem w/ delayed clearing due to stuck breaker

230kV proposal comparison - 5015 outage

Comparison Method:
For each proposal, assume a fixed MVAr output at the Artificial Island, solve the power flow for the corresponding Artificial Island bus voltages. Simulate the combination of the most critical fault and outage. Do not assume the addition of an SVC.
Result:
Measure the maximum machine angle swing.
All 230 kV proposal pass the stability criteria.

Group	Project ID	230 kV Transmission Solution	AI 500kV bus voltage	AI MVAr output	Critical Outage	Critical Contingency	Maximum Angle Swing (deg)
1.1	**P2013_1-5A**	LS Power	1.065	1044	5015	14b	**102**
1.1	**P2013_1-2B**	Transource (AEP)	1.071	1044	5015	14b	**95**
1.1	**P2013_1-2A**	Transource (AEP)	1.074	1044	5015	14b	**95**
1.2	**P2013_1-1B**	DVP	1.074	1044	5015	14b	**97**

5015*: Hope Creek – Red Lion 500kV line
14b**: single-line-to-ground fault on the new line from Salem w/ delayed clearing due to stuck breaker

230kV proposal comparison – 5038 outage

Comparison Method:
For each proposal, assume a fixed MVAr output at the Artificial Island, solve the power flow for the corresponding Artificial Island bus voltages. Simulate the combination of the most critical fault and outage. Do not assume the addition of an SVC.
Result:
Measure the maximum machine angle swing.
All 230 kV proposal pass the stability criteria.

Group	Project ID	230 kV Transmission Solution	AI 500kV bus voltage	AI MVAr output	Critical Outage	Critical Contingency	Maximum Angle Swing (deg)
1.1	**P2013_1-5A**	LS Power	1.044	832	5038*	2b**	**121**
1.1	**P2013_1-2B**	Transource (AEP)	1.052	832	5038	2b	**89**
1.1	**P2013_1-2A**	Transource (AEP)	1.053	832	5038	2b	**93**
1.2	**P2013_1-1B**	DVP	1.049	832	5038	2b	**87**

5038*: New Freedom – East Windsor 500kV line
2b**: single-line-to-ground fault on Hope Creek-Red Lion 500kV line w/ delayed clearing due to stuck breaker

230kV+ SVC proposal comparison

Comparison Method:
For each proposal, assume the addition of an SVC at each of three locations. Simulate the combination of the most critical fault and outage.
Result:
Measure the maximum machine angle swing.
All 230 kV proposals with SVC additions pass the stability criteria with greater margin than without SVCs.

Project ID	230 kV Transmission Solution	SVC option	AI 500kV Bus Voltage	AI MVAr Output	Critical Outage	Critical Contingency	Maximum Angle Swing
P2013_1-5A-SVC	LS Power	Artificial Island	1.042	728	5015	14b	80
		Orchard	1.041	724	5015	14b	108
		New Freedom	1.041	721	5015	14b	112
P2013_1-2B-SVC	Transource (AEP)	Artificial Island	1.042	664	5015	14b	81
		Orchard	1.042	662	5015	14b	105
		New Freedom	1.042	662	5015	14b	109
P2013_1-2A-SVC	Transource (AEP)	Artificial Island	1.043	655	5015	14b	82
		Orchard	1.042	658	5015	14b	107
		New Freedom	1.042	658	5015	14b	112
P2013_1-1B-SVC	DVP	Artificial Island	1.042	672	5015	14b	85
		Orchard	1.041	670	5015	14b	106
		New Freedom	1.041	674	5015	14b	110

Note: The study results are obtained under the assumption of unity power factor at the high side of GSU.

Compare TCSC + SVC (assumes +750 MVAR) alternative to 230 kV + SVC alternatives

Project	Project ID	TO	SVC location	AI 500kV bus voltage	AI MVAr output	Outage	Contingency	Maximum Angle Swing
230kV+SVC	P2013_1-5A-SVC	LS Power	New Freedom	1.032	645	5038	2a	**54**
	P2013_1-2B-SVC	Transource	New Freedom	1.040	645	5038	2a	**47**
	P2013_1-2A-SVC	Transource	New Freedom	1.042	645	5038	2a	**48**
	P2013_1-1B-SVC	DVP	New Freedom	1.037	645	5038	2a	**46**
TCSC+SVC	P2013_1-1A	DVP	New Freedom	1.029	645	5038	2a	**88**

Artificial Island Analytical Evaluation
Load Flow Analysis Update

- Load Flow Analysis
  - 230 kV Transmission Solutions
    - No thermal or voltage violations identified for summer peak case
  - New 500 kV transmission from the Artificial Island to Red Lion 500 kV
    - No thermal or voltage violations identified for summer peak case

Artificial Island Analytical Evaluation
Short Circuit Analysis Update

- Short Circuit Analysis
  - 230 kV Transmission Solutions
    - Several 50 kA circuit breakers overdutied at Red Lion 230 kV
  - New 500 kV transmission from the Artificial Island to Red Lion 500 kV
    - No new overdutied breakers identified

Cost Factors

Constructability Review – PJM Cost Estimates

- PJM performed a per-unit cost estimate analysis

- Major components account for 70% - 90% of estimated material and construction costs
  - Submarine cable at $5.3 million per mile
  - 500kV aerial at $3.6 million per mile
  - Aerial Delaware river crossing at $100 million
  - 500/230kV auto transformer at $7.8 to $10.5 million per phase

Constructability Review – PJM Cost Estimates

- Costs independently estimated in collaboration with PJM outside consultants
  - Engineering at 2.5%
  - Project management at 5%
  - Contingency range from 15% to 40%

- Estimate Sources
  - RTEP project cost estimates and actuals
  - Inputs from multiple outside consultants
  - Industry sources

PJM Cost Estimates

Class	Proposals	PJM Estimate	
Southern Crossing Lines (Submarine)	LS Power 5A - Submarine Option	$ 248	$ 302
	Transource 2B - North Cedar Creek	$ 257	$ 313
	Transource 2A - Cedar Creek Expansion	$ 366	$ 446
Southern Crossing Lines (Overhead)	LS Power 5A - Overhead	$ 211	$ 257
	Dominion 1B - 500kV Overhead	$ 233	$ 283
Red Lion to Salem Lines	PHI/Exelon 4A - Red Lion to Salem	$ 216	$ 263
	LS Power 5B - Red Lion to Salem	$ 221	$ 269
	Transource 2C - Red Lion to Salem	$ 232	$ 282
Red Lion to Hope Creek Lines	Dominion 1C - Red Lion to Hope Creek	$ 242	$ 294
	PSE&G 7K- Red Lion to Hope Creek	$ 249	$ 304
	Dominion – Red Lion to Hope Creek (No New Bus Tie)	$ 211	$ 257
	PSE&G – Red Lion to Hope Creek (No New Bus Tie)	$ 211	$ 257

Revision History

Revision History

- Original Version Distributed to PJM TEAC
  - V1 - 5/16/2014
  - V2 – 5/20/2014
    - Updated slides 15, 20, 161 and 170 to remove errors
    - Added a clarifying note to slides 187 and 188
    - Updated slide 45 with corrected failure mode