Reliability Analysis Update

Transmission Expansion Advisory Committee

March 10, 2016

2016 RTEP Assumptions
(Continued from previous TEACs)

2016 RTEP Assumptions Update

- S57, S58 and U3-026 (MTX) Collins “Rock Island Clean Line”
  - 3,500 MW total injection rights (1,192 firm / 2,308 non-firm)
  - Model offline but available to contribute to problems in generator deliverability test
- Y3-092 (MTX) Erie West “Lake Erie Connector”
  - 1,000 MW total firm injection rights
  - 1,000 MW total withdrawal rights (500 firm / 500 non-firm)
  - Model offline but available to contribute to problems in generator deliverability test
- AA1-070 “Hatfield” Project
  - FirstEnergy does not have plans to restart the plant at this time
  - 1590 MW is the ISA value
  - Model offline but available to contribute to problems in generator deliverability test
- Model Duff (MISO) - Rockport (PJM) – Coleman (MISO) 345 kV

2015 RTEP Load Deliverability Study
“As Left” CETL

As Left Study Assumptions

- 2015 RTEP Load Deliverability Study Assumptions
  - Model created from 2020 Summer Peak RTEP base case
  - Updated PJM loads based on January 2016 PJM Load Forecast Report
  - Updated transmission based on upgrades approved by PJM Board through December 2015
  - Update generation model through December 2015
    - Deactivations
    - Interconnection Projects
  - Update transmission service through December 2015

- Limiting facilities identified for LDAs with less than 150% margin

Brattle Recommendation

2015 RTEP Load Deliverability Study					
Area	MW CETO	MW CETL	Margin	Limiting Facility	Violation Type
AE	520	>780	>150%		None
AEP	740	>1110	>150%		None
APS	2680	>4020	>150%		None
ATSI	4490	>6735	>150%		None
BGE	4060	>6090	>150%		None
CLEV	3390	>5085	>150%		None
COMED	610	>915	>150%		None
DAYTON	1290	>1935	>150%		None
DLCO	1630	>2445	>150%		None
DPL	960	>1440	>150%		None
DPL SOUTH	1230	>1845	>150%		None
DEOK	3540	5045	143%	Tanner - Miami Fort 345kV for loss of Terminal - East Bend 345kV	Thermal
EKPC	750	>1125	>150%		None
EMAAC	1580	>2370	>150%		None
JCPL	2670	>4005	>150%		None
MAAC	-6930	>3465	>150%		None
METED	1220	>1830	>150%		None
PECO	2780	>4170	>150%		None
PENELEC	140	>210	>150%		None
PEPCO	2870	>4305	>150%		None
PJM WEST	2050	>3075	>150%		None
PLGRP	-170	>85	>150%		None
PSEG	5590	7856	141%	Roseland - Williams Pipeline 230 kV for loss of Roseland - Cedar Grove 230 kV	Thermal
PSEG NORTH	2280	>3420	>150%		None
SWMAAC	3920	>5880	>150%		None
VAP	-2360	>1180	>150%		None
WMAAC	-8310	>4155	>150%		None

PSE&G Shunt Reactors

Update to PSE&G Shunt Reactors

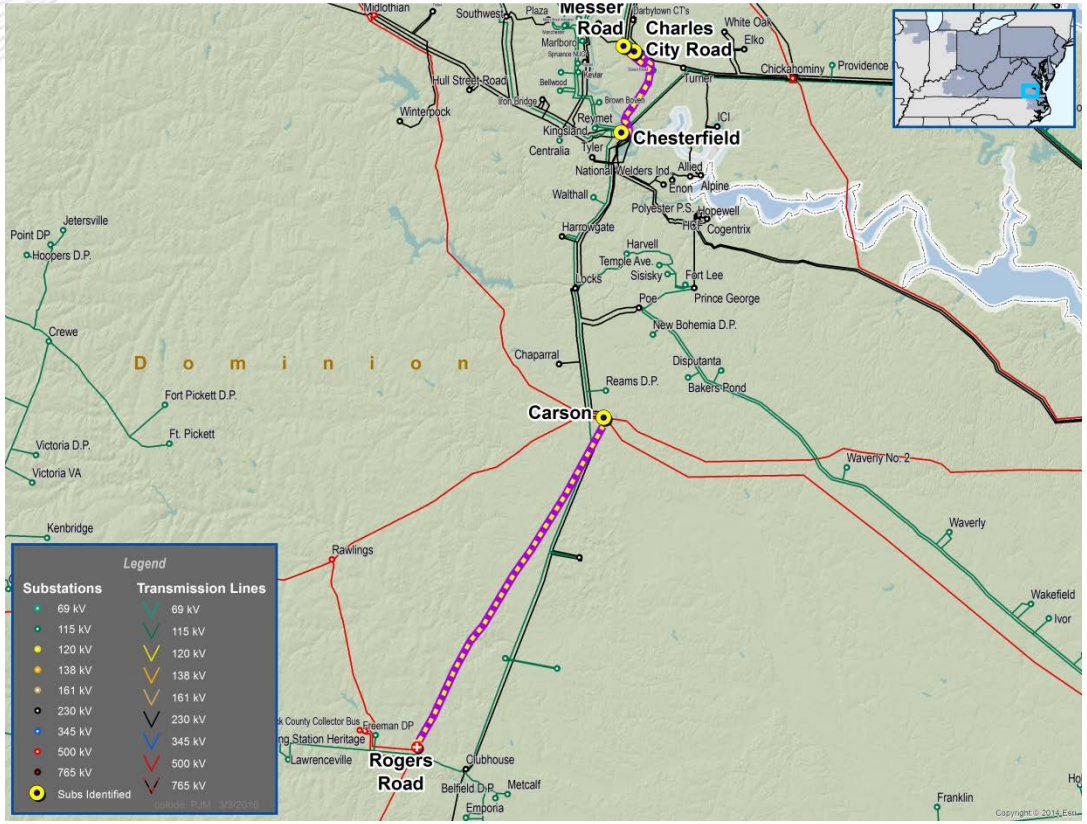
- Modify scope of existing approved RTEP projects
- Substitute two smaller reactors in place of a single larger unit
- Move the Roseland location to Hopatcong

	2015 RTEP					Latest Information				
	Location	Required In-Service Date	Voltage	Size	Estimate	Location	Service Date	Number of Units	Unit Capacity	Estimate
b2707	Bayonne	Staged with 345kV project	345kV	100MVAR	$15,400,000	Bayonne	June 1, 2018	1	100MVAR	$14,300,000
b2706	Bayway		345kV	200MVAR	$26,600,000	Bayway	June 1, 2018	2	100MVAR	$26,600,000
b2705	Bergen		345kV	200MVAR	$38,300,000	Marion	April 1, 2018	2	100MVAR	$23,100,000
b2703	Bergen	Immediately	230kV	100MVAR	$10,600,000	Bergen	April 1, 2018	2	100MVAR	$10,600,000
b2704	Essex	Immediately	230kV	150MVAR	$16,700,000	Essex	April 1, 2018	2	1x50 & 1x100	$16,700,000
b2702	Roseland	Immediately	500kV	350MVAR	$50,100,000	Hopatcong	June 1, 2018	2	175MVAR	$36,700,000

2016 RTEP Proposal Window #1

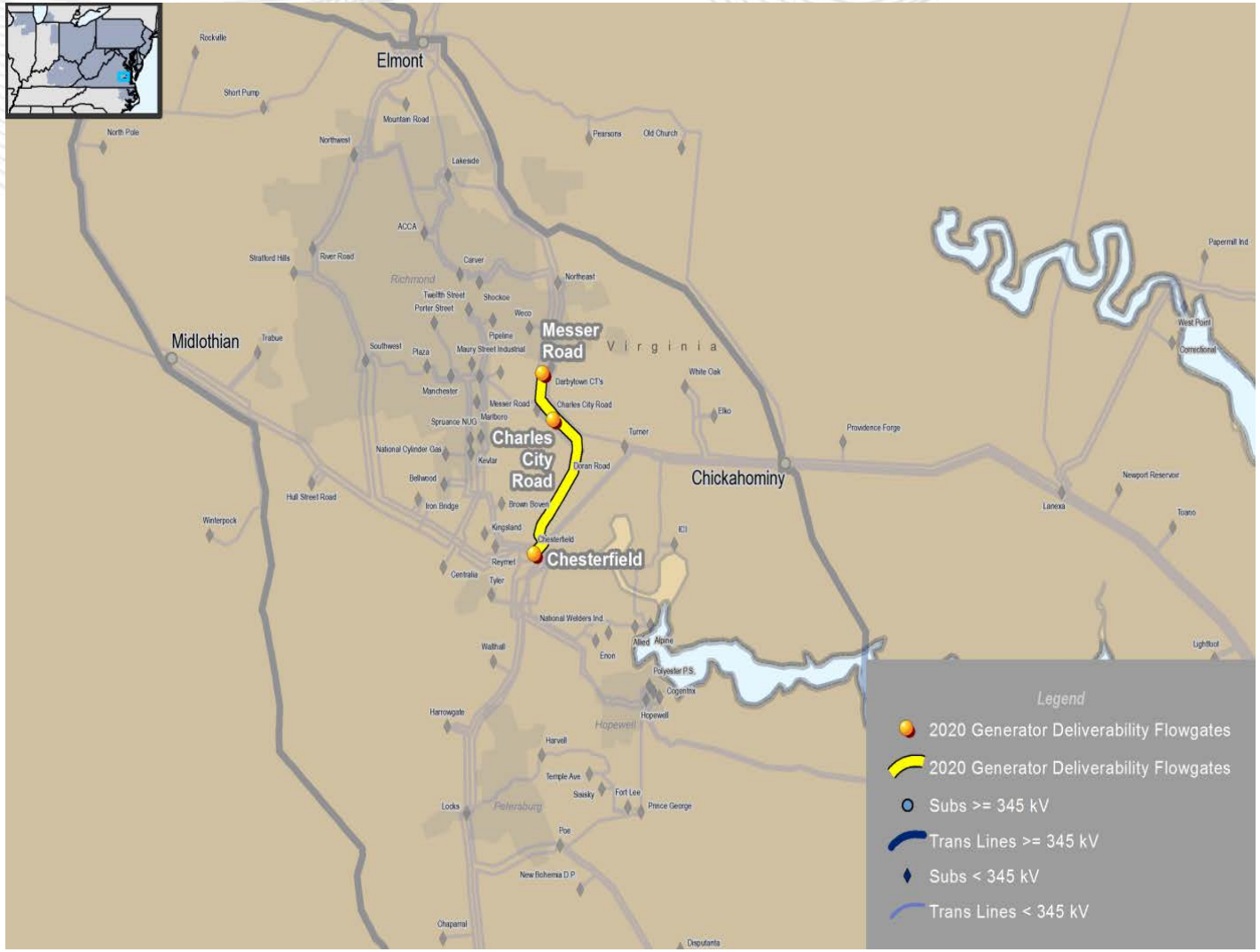
2016 RTEP Proposal Window #1

- Scope
  - Generator Deliverability and Common Mode Outage Violations
  - End of life facilities
- Preliminary Files Released: 2/5/2016
- Window Opened: 2/16/2016
- Window Closes: 3/17/2016 – Proposal definitions, simulation data and planning cost estimate due
- Detailed Cost due: 4/1/2016 – Additional 15 days to develop and provide detailed cost data – See the window documentation for additional information



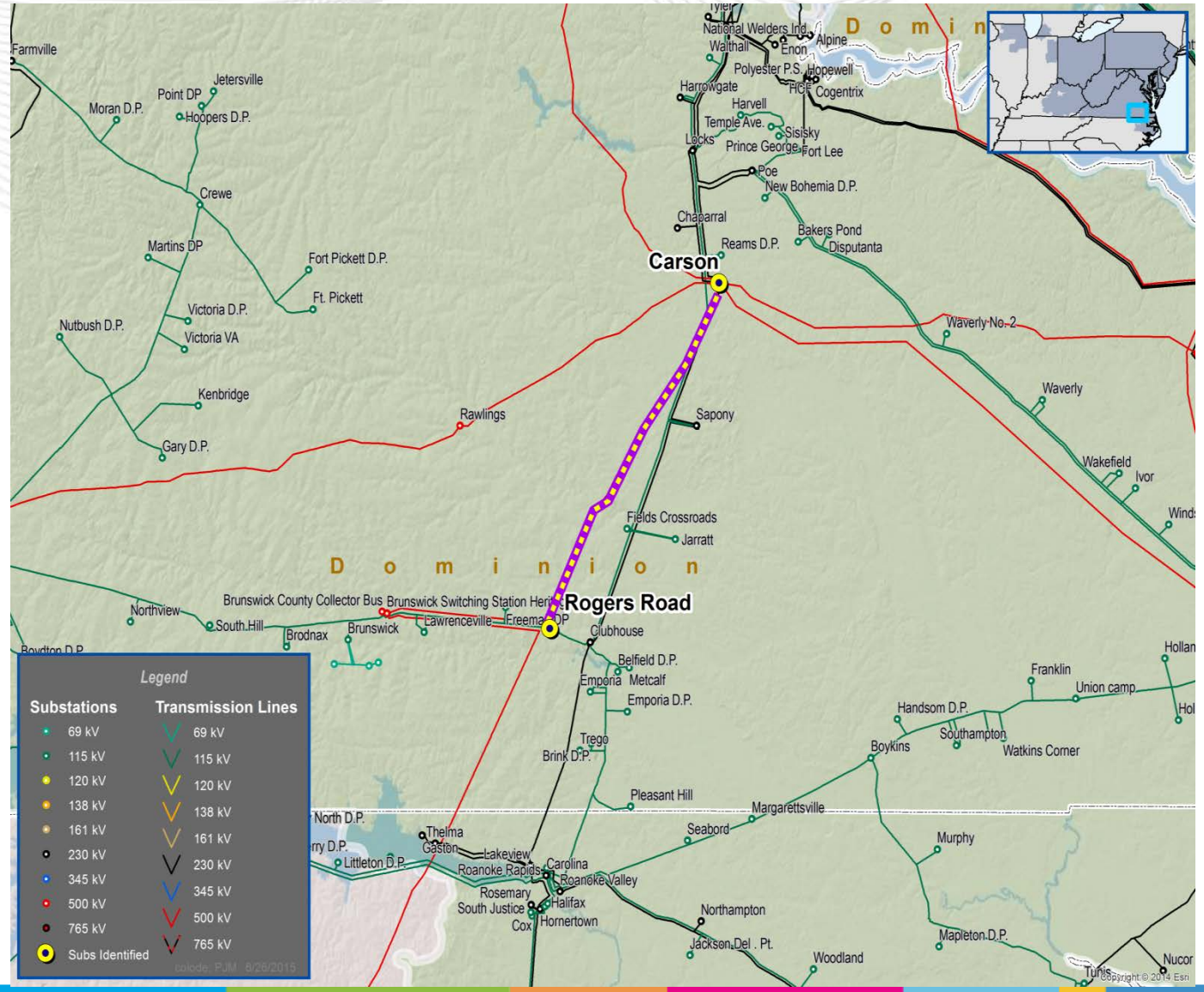
2016 RTEP Proposal Window #1

- **Generation Deliverability and Common Mode Outage (FG# 60, 61, 62, 66, 68, 70, 71, 72, 76, 78, 248, 249)**
- The Chesterfield – Messer Road – Charles City Road 230kV circuit is overloaded for several contingencies



2016 RTEP Proposal Window #1

- **Generation Deliverability and Common Mode Outage (FG# 102)**
- The Carson – Rogers Rd 500 kV circuit is overloaded for single contingency loss of the Carson – Rawlings 500 kV circuit.



2016 RTEP Proposal Window #1

- Next Steps
  - Close window
  - Begin proposal evaluations

- High Level Overview of proposals received to be presented at April TEAC

Dominion Local TO Criteria - End Of Life Criteria Update

Dominion End of Life Criteria

Dominion End of Life Criteria decision point metrics:

1) Facility is nearing, or has already passed, its end of life, and

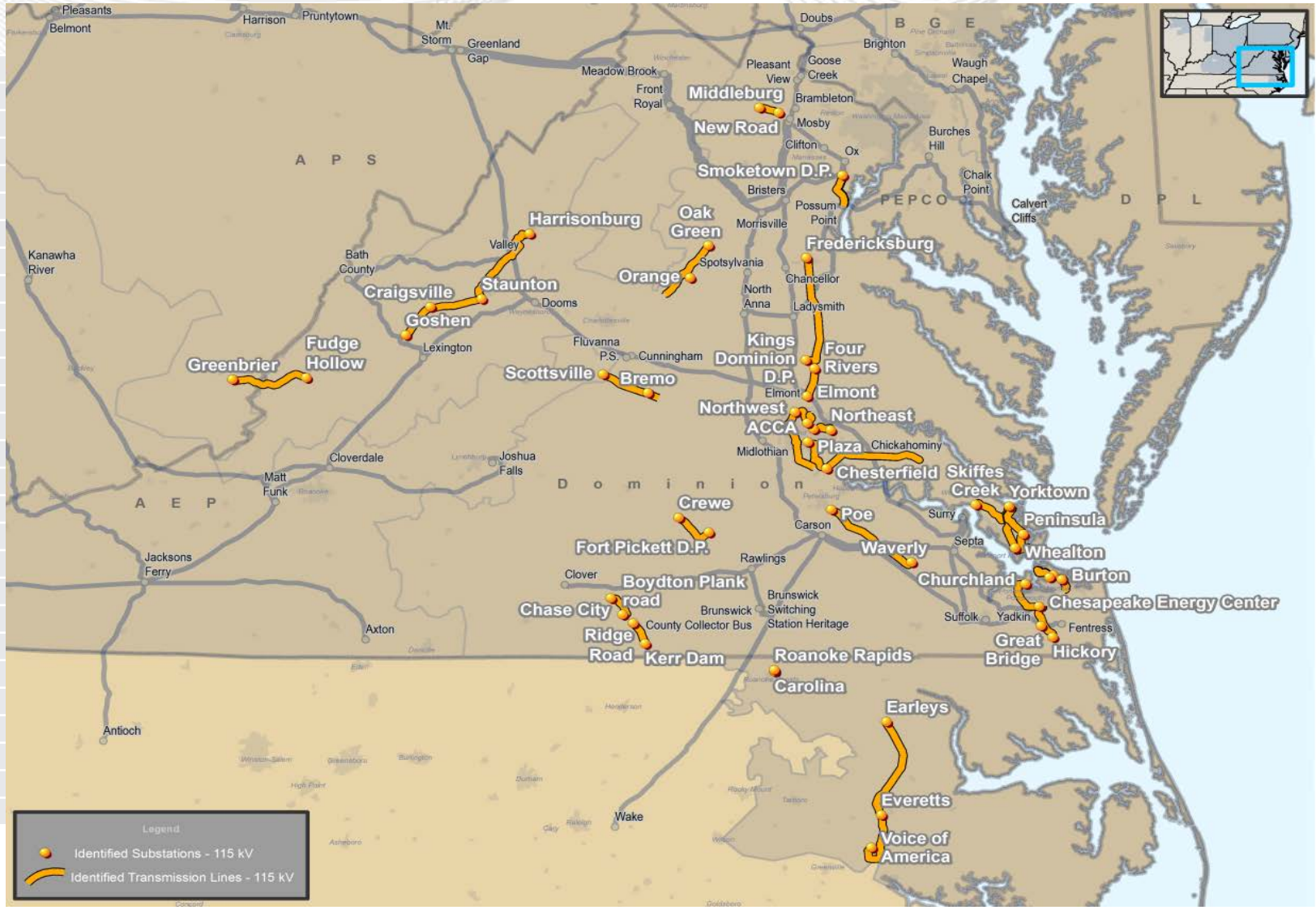
2) Continued operation risks negatively impacting reliability of the transmission system.

- Dominion Local TO Criteria
  - End of Life Criteria
    1. End of Life Assessment
       - Industry guidelines indicate equipment life standards
         - Wood structures - 35-55 years,
         - Conductor and connectors - 40-60 years
         - Porcelain insulators - 50 years.
    2. Reliability and System Impact
       - PJM and DOM are analyzing the impacts of the facilities on the next slides

Dominion End Of Life Facilities

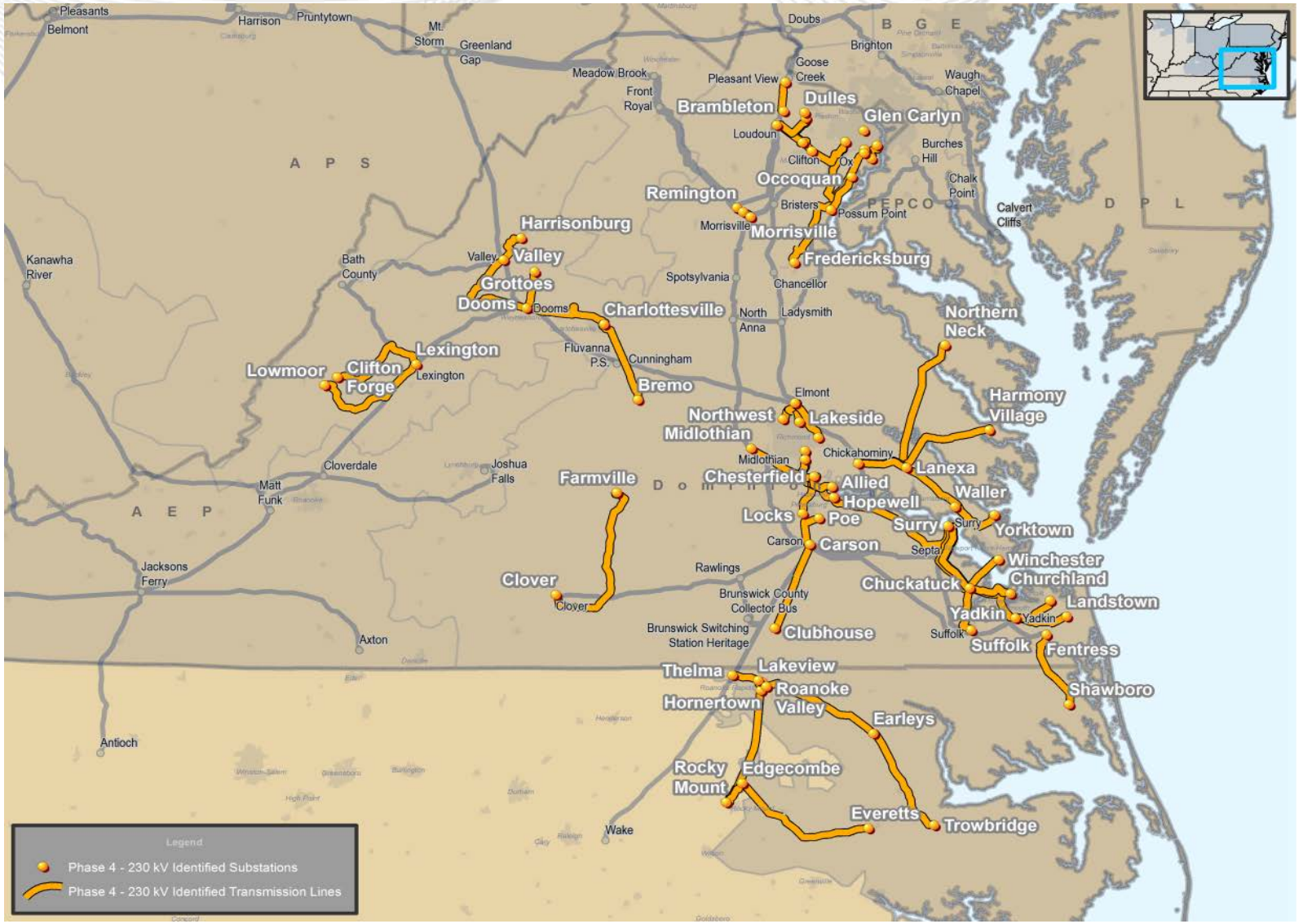
Line	Voltage	Length (mi.)
Carolina-Roanoke Rapids Hydro	115	2.76
Acca-Lakeside	115	3.21
Poe-Waverly	115	5.5
Northeast-Carver	115	6.03
Great Bridge-Hickory	115	6.28
Northwest-Acca	115	6.66
Whealton-Peninsula	115	7.51
Portsmouth-Great Bridge	115	8.36
Elmont-Four Rivers	115	8.97
New Road-Middleburg	115	9.75
Kerr Dam-Ridge Road	115	9.88
Yorktown-Peninsula	115	11.12
Chase City-Boydton Plank	115	11.41
Portsmouth-Greenwich	115	11.51
Chesterfield 115-Plaza	115	14.18
Bremo-Scottsville Inter	115	14.46
Portsmouth-Churchland	115	14.61
Earleys-Everetts	115	16.58
Yorktown-Whealton	115	17.44
Staunton - Craigsville (Radial)	115	19.32
Staunton-Craigsville	115	20.62
Goshen-Craigsville	115	21.24
Staunton-Harrisonburg	115	22.78
Str 551-Str 706	115	25.14
Northwest-Chesterfield 115	115	25.33
Chesterfield 115-Lanexa	115	33.27
Fudge Hollow-Greenbrier Inter	138	14.94

*End of life Facility List has not changed since previously reviewed at January 2015 TEAC



Dominion End Of Life Facilities

Line	Voltage	Length (mi.)
280 Marsh Run Ct 1 Remington 11 Va	230	1.24
210 Hayfield 1A Van Dorn 22 Va	230	2.9
2039 Morrisville 1A Marsh Run Ct 22 Va	230	3.92
239 Lakeview 58 Hornertown 90 Nc	230	4.06
216 Lakeside 1B Elmont 41 Va	230	5.74
221 Northwest 1A Elmont 34E Va	230	5.92
201 Brambleton 26A Pleasant View A Va	230	7.97
231 Yadkin 1A Landstown 103L Va	230	8.54
213 Thelma 1A Carolina 70 Nc	230	8.62
295 Loudoun 1A Bull Run 45A Va	230	8.67
2058 Edgecombe Nug 1A Rocky Mount Inter 34A Nc	230	9.34
2049 Chesterfield 230 1A Allied 75A Va	230	9.95
253 Harrisonburg 1A Valley 66 Va	230	10.58
204 Gum Springs 1A Jefferson St 86 Va	230	10.8
211 Chesterfield 230 1B Hopewell 71A Va	230	11.17
272 Dooms 115 1A Grottoes 80 Va	230	11.53
252 Fredericksburg 5397 Possum Point 5589 Va	230	11.85
205 Chesterfield 230 1B Locks 84 Va	230	12.23
259 Basin 1A Chesterfield 230 106A Va	230	12.4
2001 Possum Point 1A Occoquan 76 Va	230	12.61
2002 Carson 1A Poe 106A Va	230	12.68
283 Northeast 1A Elmont 91A Va	230	13.19
2008 Loudoun 1A Dulles 107A Va	230	13.25
262 Greenwich 1B Yadkin 87 Va	230	13.55
265 Clifton 1 Sully 108 Va	230	14.01
2024 Chickahominy 105A Lanexa 190 Va	230	14.26
Lanexa-Waller	230	14.52



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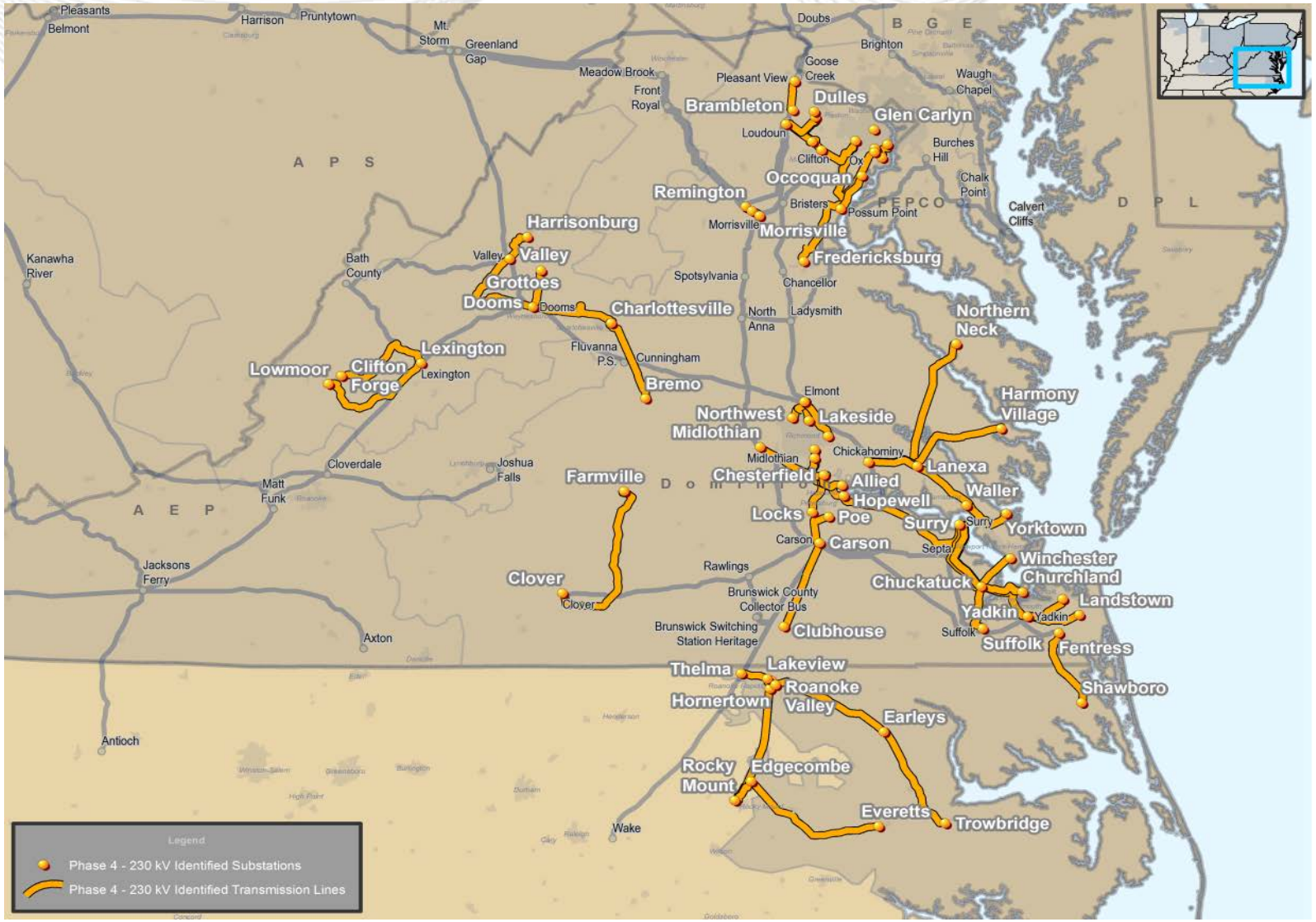
Dominion End Of Life Facilities

Line	Voltage	Length (mi.)
289 Suffolk 1B Chuckatuck 92 Va	230	14.62
229 Everetts 1A Edgecombe Nug 372 Nc	230	16.4
285 Waller 362A Yorktown 490 Va	230	19.96
215 Possum Point 1A Hayfield 127 Va	230	21.02
Chesterfield 230-Lakeside	230	21.32
282 Midlothian Mw 1D Spruance Nug 148A Va	230	21.59
237 Possum Point 1A Braddock 147 Va	230	21.99
233 Charlottesville 1A Dooms 115 149 Va	230	22.66
266 Clifton 59 Glen Carlyn 251 Va	230	24.66
269 Fentress 1A - Shawboro	230	25.33
2028 Charlottesville 1A Bremo 186A Va	230	25.54
238 Carson 1A Clubhouse 264 Va	230	28.55
2102 Chickahominy 139A Waller 362B Va	230	28.68
2016 Lanexa 1B Harmony Village 213 Va	230	31.03
2052 Lexington 1 Clifton Forge 197 Va	230	33.42
293 Dooms 115 1A Valley 261 Va	230	33.97
2034 Earleys 1A Trowbridge 281 Nc	230	35.06
2084 Lexington 1A Lowmoor 224 Va	230	37.37
2056 Hornertown 89 Rocky Mount Inter 351 Nc	230	37.63
214 Winchester 1A Surry 200 Va	230	37.64
2012 Roanoke Valley Nug 1 Earleys 269 Nc	230	37.7
226 Surry 1A Churchland 216 Va	230	37.74
224 Northern Neck 1B Lanexa 306 Va	230	41.27
212 Surry 1A Hopewell 240A Va	230	42.97
223 Yadkin 86A Surry 338 Va	230	44.09
246 Suffolk 1C - Earlys	230	49.77
235 Farmville 1A Clover 436 Va	230	55.46



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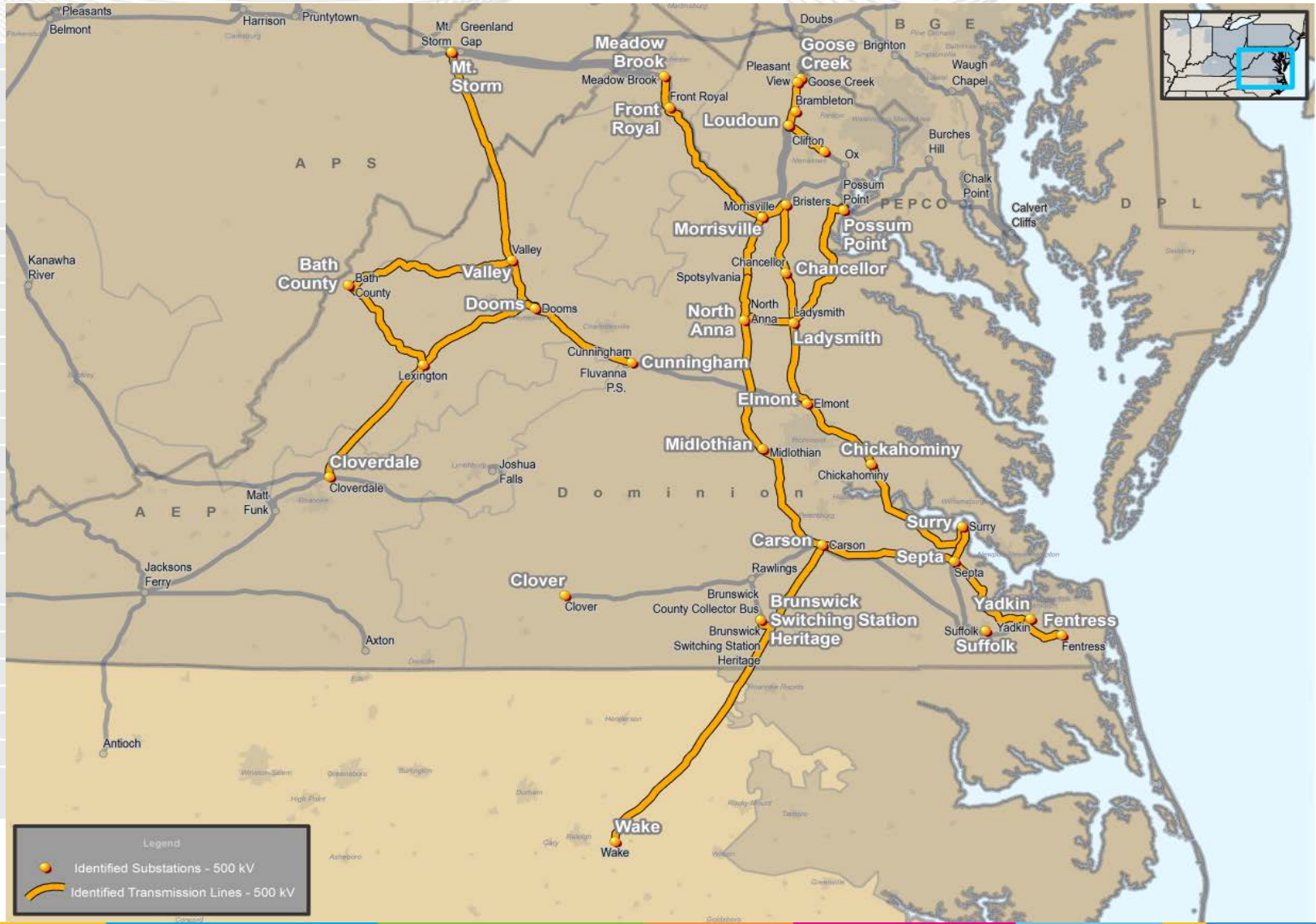
Dominion End Of Life Facilities

Line	Voltage	Length (mi.)
580 Meadowbrook Inter 1 Morrisville 248 Va	500	1.96
561 Clifton 64A Ox 101 Va	500	7.05
545 Bristers 113 Morrisville 159 Va	500	7.9
578 Surry 1A Septa 61 Va	500	11.46
559 Loudoun 1 Clifton 64 Va	500	12.08
573 North Anna 1A Morrisville 182 Va	500	14.02
575 North Anna 1A Ladysmith 79 Va	500	14.53
Valley – Dooms	500	22.56
557 Chickahominy 226A Elmont 359A Va	500	27.73
569 Loudoun 1 - 159 Va	500	31.78
585 Carson 1A - Rodgers Road	500	32.87
579 Septa 1 Fentress 256 Va	500	33.09
Elmont – Ladysmith	500	33.61
547 Bath County 1 Lexington 185 Va	500	34.7
531 Surry 1A Yadkin 255 Va	500	37.27
563 Carson 1A Midlothian 500 209A Va	500	37.41
562 Septa 61 Carson 251A Va	500	38.47
576 North Anna 1A Midlothian 500 209A Va	500	41.13
567 Surry 1A Chickahominy 226A Va	500	44.44
Ladysmith - Bristers	500	46.48
541 Morrisville - Front Royal	500	46.68
568 Possum Point 1A Ladysmith 258 Va	500	47.56
548 Bath County 1 Valley 274 Va	500	51.82
Mt Storm – Valley	500	82.38
570 - Heritage - Wake Intertie (Progress Duke)	500	109

*End of life Facility List has not changed since previously reviewed at January 2015 TEAC



Next Steps

- PJM and DOM are prioritizing End of Life facilities to determine the reliability impacts due to the End of Life Facilities and are evaluating the need for Proposal Windows

End of Life Facilities Summary		
Voltage Level (kV)	# of facilities	Line Length Range (mi.)
115	26	2.76 - 33.27
138	1	14.94
230	54	1.24 - 55.46
500	25	1.96 - 109

Next Steps

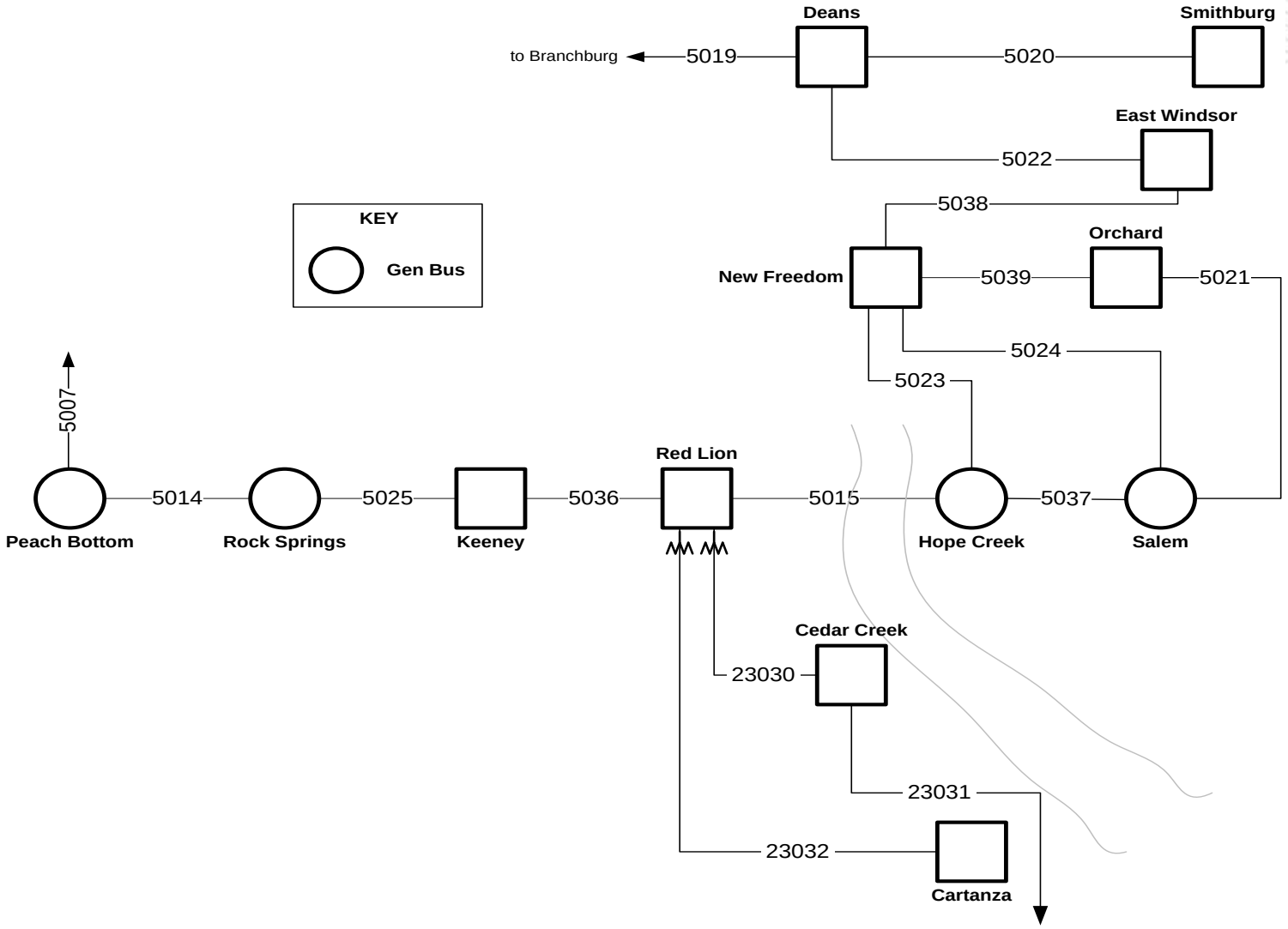
- PJM has reviewed Dominion End of Life evaluation for two near term end of life 500kV facilities
  - Mt. Storm – Valley 500kV
  - Valley – Dooms 500kV

- PJM has independently verified thermal and voltage issues due to the loss of either facility for various contingencies

- PJM will continue to evaluate the next steps to address End of Life violations

Artificial Island Update

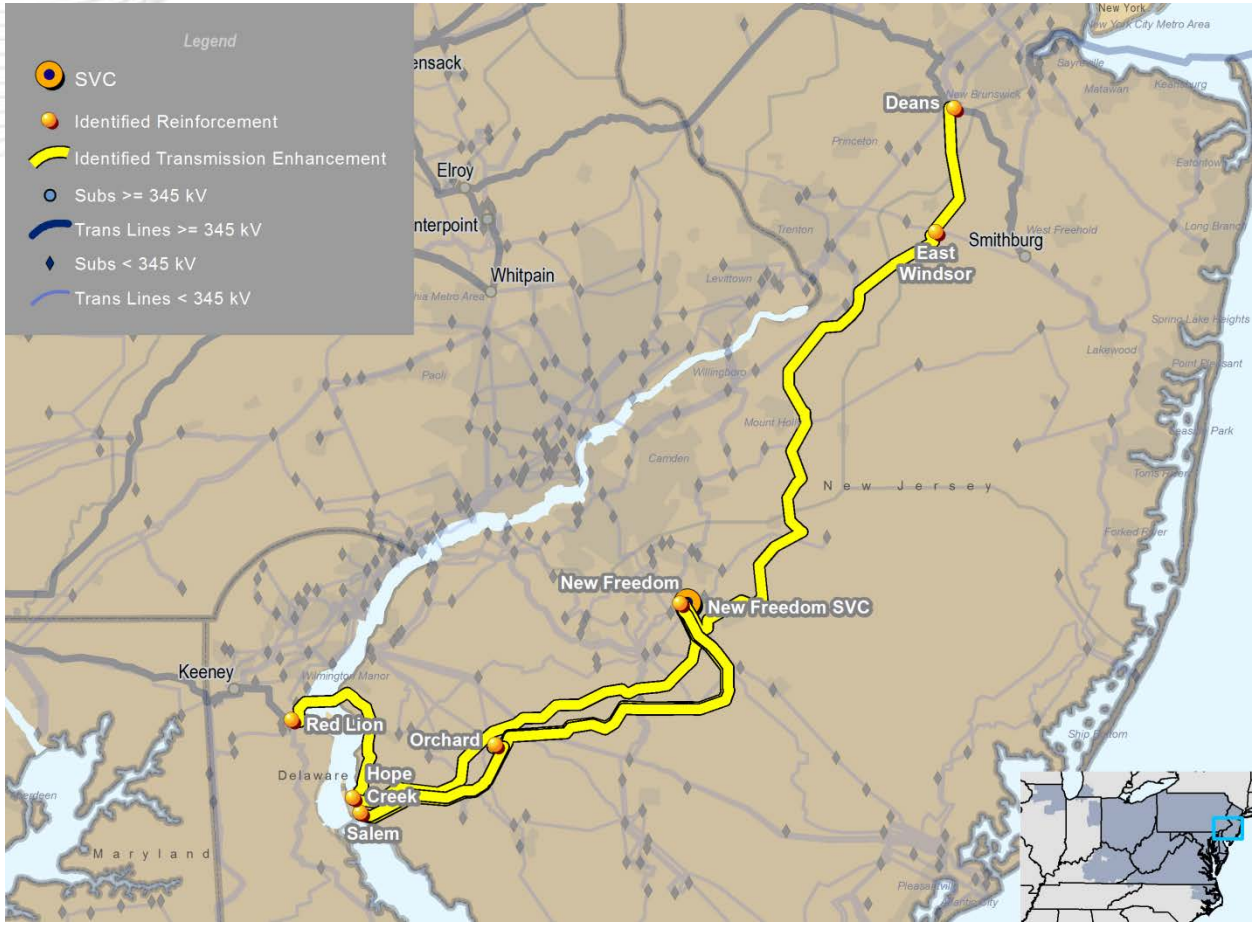
Artificial Island Area Network



Artificial Island Update

PJM Board Approved Artificial Island Upgrades designated to PSE&G

- Three main elements
  - New Freedom SVC - $38 million
  - High Speed Relaying (OPGW) - $25 million
  - Salem Station Expansion - $74 million



Artificial Island Update – New Freedom SVC

- SVC at New Freedom Substation (b2633.4) - $38 million

  Scope of Work

  – New 500kV bay position
  – New +250/-150 MVAr SVC

  Additional site work identified by PSE&G - Cost delta $ 43 million* above PJM Board approved cost

  – Expanded site work to accommodate SVC and New Freedom yard expansion
    - Wetland mitigation, helipad relocation, storm water management, relocation of several buildings on site
  – SVC Installation – Higher vendor cost estimates; incorporates PSE&G design requirements
  – Incorporates PSE&G design standards for substation work
  – Engineering study regarding specifications under way

*Costs excludes PSE&G risk and contingency

Artificial Island Update – High Speed Relaying Upgrades

- OPGW and relaying upgrade (b2633.8, b2633.6.2, b2633.6.3, b2633.6.5, b2633.7.2, b2633.7.3, and b2633.8.2) - $25 million

  Scope of Work

  – Install OPGW on 500 kV Lines - 5015, 5022, 5037, 5038

  – Upgrade relaying on 500 kV Lines - 5015, 5022, 5021, 5023, 5024, 5037, 5038, 5039

  Additional site work identified by PSE&G – Cost delta $ 14 million* above PJM Board approved cost

  – Access to towers, matting and environment requirements

*Costs excludes PSE&G risk and contingency

Artificial Island Update – Salem Substation Expansion

- Salem Expansion (b2633.2) - $74 million

  Scope of Work

  – New 500kV Bay position
  – New 500/230 kV transformer bank and spare single phase unit
  – New 230 kV Switchyard

  Additional site work identified by PSE&G – Cost delta $ 78 million* above PJM Board approved cost

  – New Control House at Salem and relocation of existing relays to new control house
  – Addition of switchable capability of spare 500/230kV transformer
  – Cost differential for work in nuclear switchyard security and access requirements

*Costs excludes PSE&G risk and contingency

Artificial Island Update – Updated Costs

Updated Artificial Island Upgrade Cost for PSE&G designated construction

- Construct an SVC at New Freedom Substation (b2633.4) - $81.1 million
- OPGW and relaying upgrade (b2633.8, b2633.6.2, b2633.6.3, b2633.6.5, b2633.7.2, b2633.7.3, and b2633.8.2) - $39 million
- Salem Expansion (b2633.2) - $152.2 million

*Costs excludes PSE&G risk and contingency

Next Steps

- PJM has reconciled the major components of the deltas from the cost estimate from when approved to the updated PSE&G cost estimate
- PJM will continue discussions with PSE&G to better understand the cost estimates for the components that make up the scope of work
- PJM will coordinate with PSE&G to seek opportunities for reducing SVC project cost by optimizing design
- PJM will coordinate with PSE&G to seek opportunities for reducing project costs at Artificial Island site by optimizing design

RTEP Next Steps

2016 RTEP Proposal Windows

- Evaluate Proposals received from 2016 RTEP Proposal Window #1

- Continue analysis for 2016 RTEP
  - Evaluation of 2021 Models (Summer, Light Load, Winter)
  - Includes studies that will be contained within 2016 RTEP Proposal Windows 2 and 3 (to follow similar format as 2015 Windows 1 and 2)

Questions?

Email: RTEP@pjm.com

Revision History

- Revision History
  - Original version posted to PJM.com – 3/7/2016