

SU Panhandle Phase 2 Project

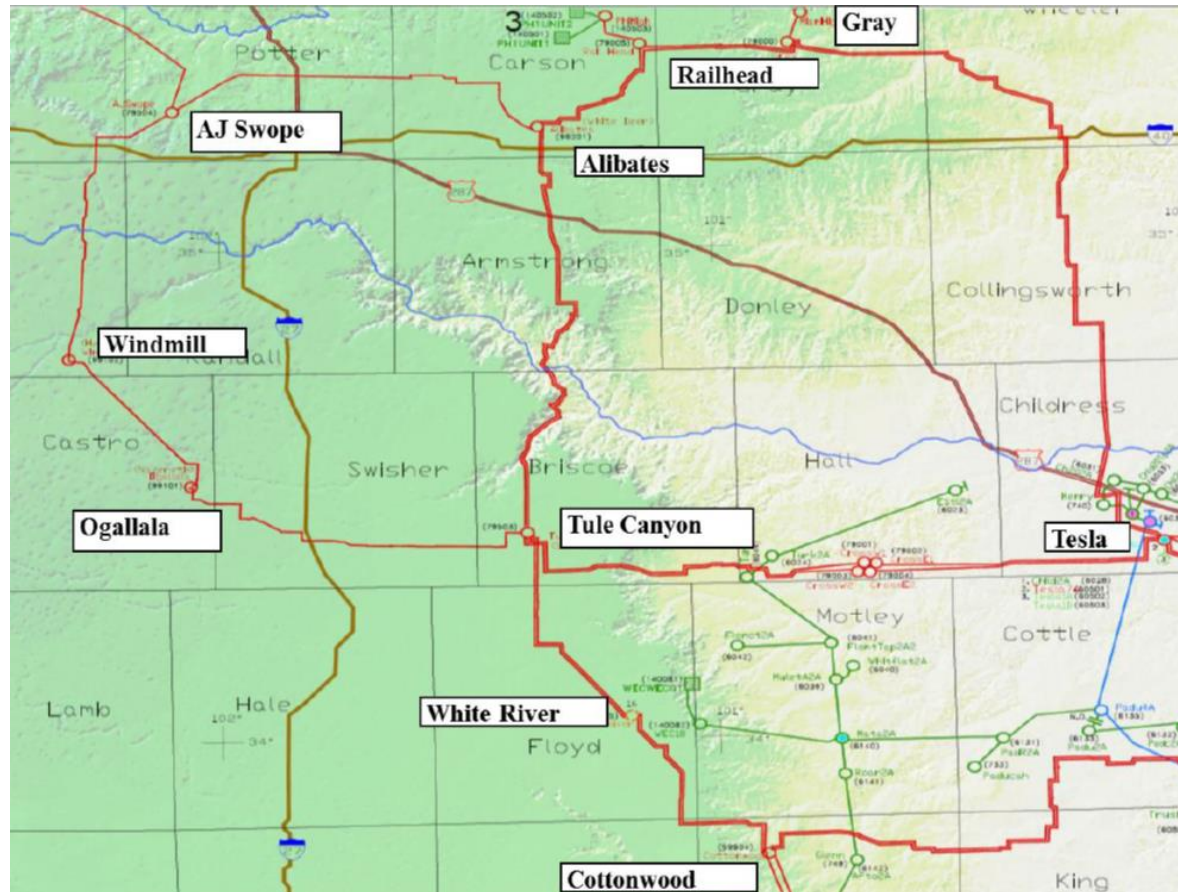


ERCOT Regional Planning Group Meeting
September 20, 2016

Brad Schwarz

Background - Second Circuit Recommendation

- PUCT recommended moving forward with the second 345 kV circuit on the Alibates – AJ Swope – Windmill – Ogallala – Tule Canyon (AAWOT) line under the CREZ Order (PURA §39.904(g)) at the September 24, 2015 Open Meeting.
 - According to the ERCOT presentation given at the Board of Directors meeting, the second circuit would have passed the ERCOT economic planning criteria
 - CCN was approved by the PUCT.
 - On schedule to be completed by June of 2018



Background - Synchronous Condenser Recommendation

- On December 8, 2015, the ERCOT Board of Directors approved the addition of two 150 MVA, 1050 Amp synchronous condensers
 - Alibates and Tule Canyon were deemed the best location for the condensers
 - Approved under the ERCOT economic criteria for transmission additions
 - The tender for the synchronous condenser has been awarded and condensers are on schedule to be completed by June of 2018

Scenario	Transmission Options	Upgrade Cost Assumption (M\$)	Annual Production Cost Savings / Capital Cost	Pass Economic Criteria (3)?
0	N/A	0	N/A	N/A
1	PH Second Circuit	80	21% (1)	Yes
2	PH Second Circuit + SC(4) at Alibates and Tule Canyon	64.25 (SCs only)	34% (2)	Yes

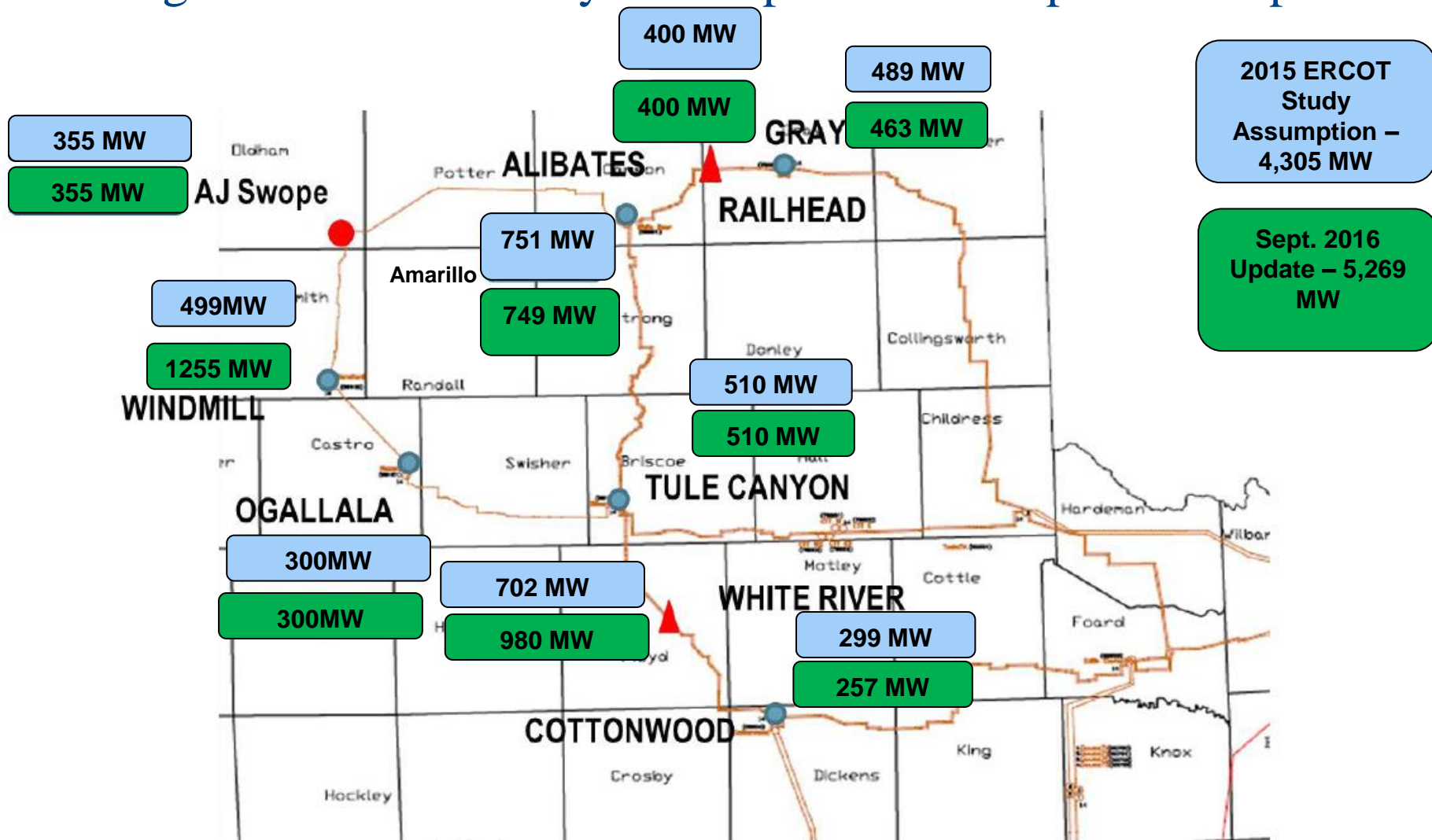
(1) Compared to Scenario 0

(2) Compared to Scenario 1

(3) Per Protocol Section 3.11.2 (5) the projected annual production cost savings of a project must be greater than or equal to the first year annual revenue requirement of a project which is assumed to be 15% of the capital cost of the project

(4) SC = Synchronous Condenser

Background – 2015 Study Assumptions and Sept. 2016 Update



WGRs meeting PG 6.9 requirements (Sept. 2016) – 5,269 MW

Panhandle Phase 2 Study Objectives

- Consistent growth in Wind Generator Resource (WGR) capacity meeting Section 6.9 requirements including 1000 MW since the last ERCOT independent review
 - Sharyland has continued to update and refine the system strength, dynamic and economic assessment models
- Develop detailed transmission options to further increase the Panhandle export limit
 - Additional synchronous condensers
 - Additional dynamic reactive devices
 - Other shunt reactive devices
 - New transmission paths out of the panhandle
- Perform system strength and voltage stability assessment to identify Panhandle export limits associated with each option
- Perform economic evaluations to evaluate economically justifiable options
 - Evaluate sensitivity around LP&L integration for preferred options
 - Evaluate performance of preferred options with additional WGR capacity in the Panhandle (above those meeting Section 6.9 requirements)

Economic Model Benchmarking

- Development and benchmarking of detailed 8,760 hour economic model
 - All generation resources meeting Section 6.9 requirements of ERCOT Planning Guide included
 - Load forecast aligned with ERCOT 2015 RTP economic modeling assumptions
 - Alignment of wind and solar profiles per the RTP economic modeling assumptions
 - Source for commodity price assumptions aligned with ERCOT including sensitivity around gas prices
- Utilized the ERCOT Independent Assessment Results for the Panhandle Stage 1 upgrades for benchmarking
- Panhandle wind curtailment amounts as well as impacts of transmission upgrades align well with the ERCOT model

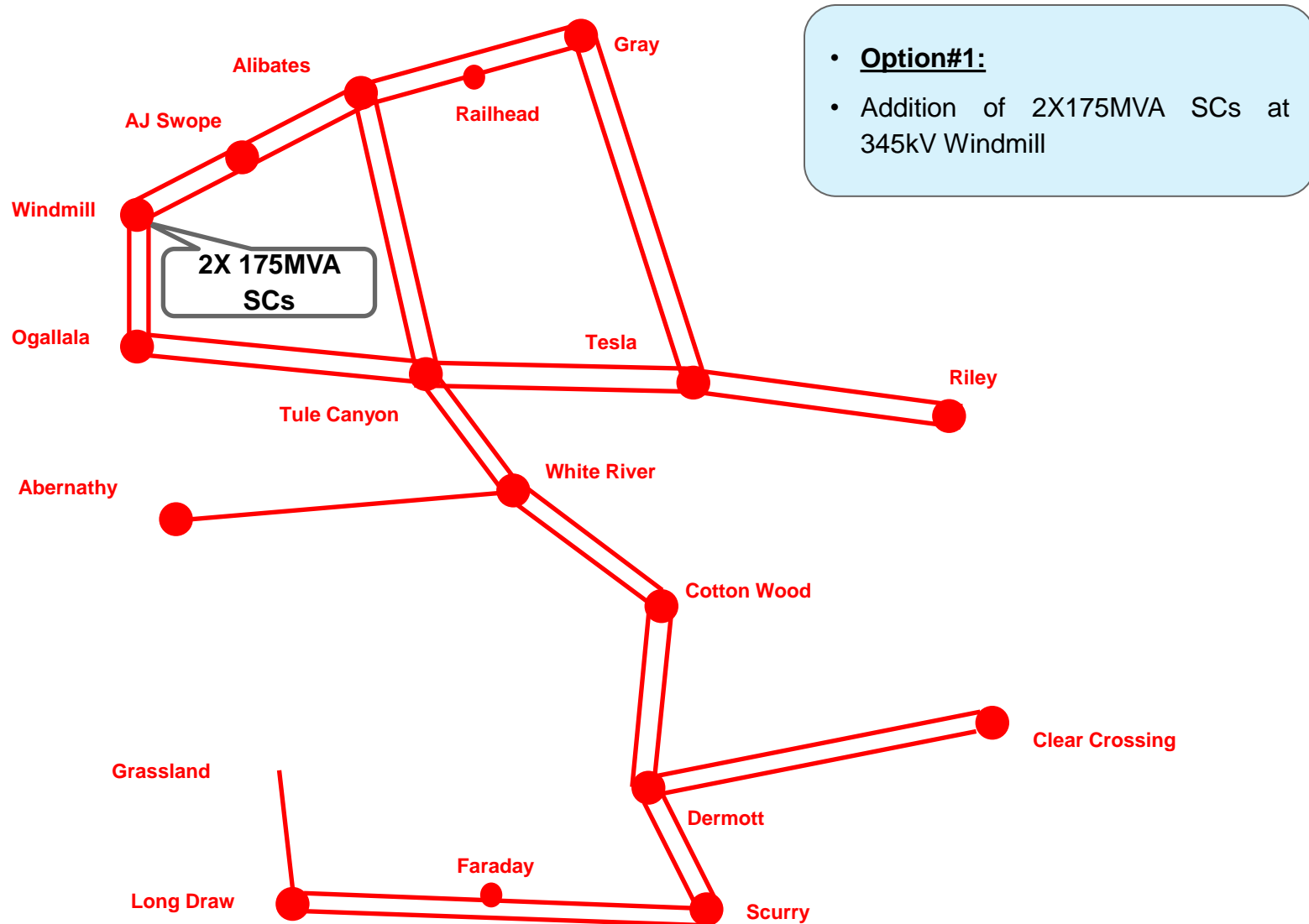
Scenario	Panhandle Wind Capacity (MW)	SCs at Alibates & Tule Canyon	Panhandle Second Circuit	% PH Wind Curtailment-DNV GL	Impact of Transmission Upgrades DNV GL	% PH Wind Curtailment-ERCOT	Impact of Transmission Upgrades ERCOT
Scenario 0	3,604	No	No	3.96%	N/a	3.65%	N/a
Scenario 1	3,604	Yes	No	0.84%	3.12%	0.35%	3.3%
Scenario 2	3,604	No	Yes	2.63%	1.33%	2.27%	1.38%

Synchronous Condenser Location Assessment

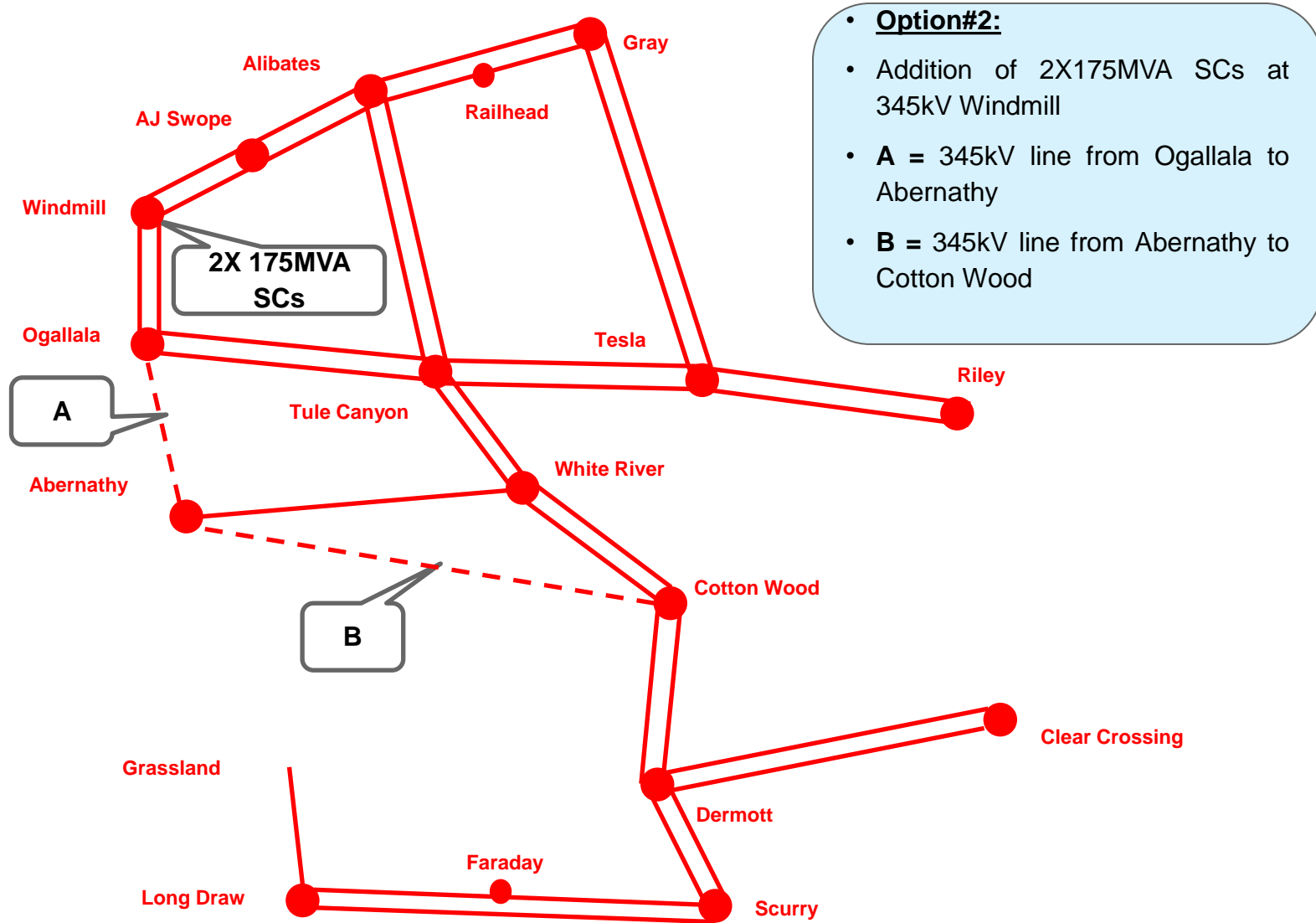
- WSCR analysis performed to identify optimal combination of SC locations across all stations in the Panhandle (as defined by ERCOT)
 - Utilized synchronous condenser specs of 175 MVA with 1606A at 345kV
 - Panhandle WGR capacity aligned with the July ROS report in terms of units meeting Section 6.9 requirements (5269 MW)
 - 2nd circuit along the Panhandle loop and the previously approved SCs included in the model
- Two (2) 175 MVA SCs at Windmill results in the highest Panhandle export limit from a system strength perspective

Panhandle Export Limit for WSCR = 1.5									
New SC Location	WM	AL	TC	WR	GR	CW	AJ	OG	RH
WM	4781	4734	4665	4674	4710	4574	4760	4738	4734
AL	--	4635	4586	4594	4618	4494	4685	4677	4640
TC	--	--	4505	4518	4559	4418	4626	4604	4584
WR	--	--	--	4511	4566	4416	4635	4614	4592
GR	--	--	--	--	4569	4465	4665	4652	4606
CW	--	--	--	--	--	4308	4535	4515	4491
AJ	--	--	--	--	--	--	4694	4709	4688
OG	--	--	--	--	--	--	--	4665	4677
RH	--	--	--	--	--	--	--	--	4614

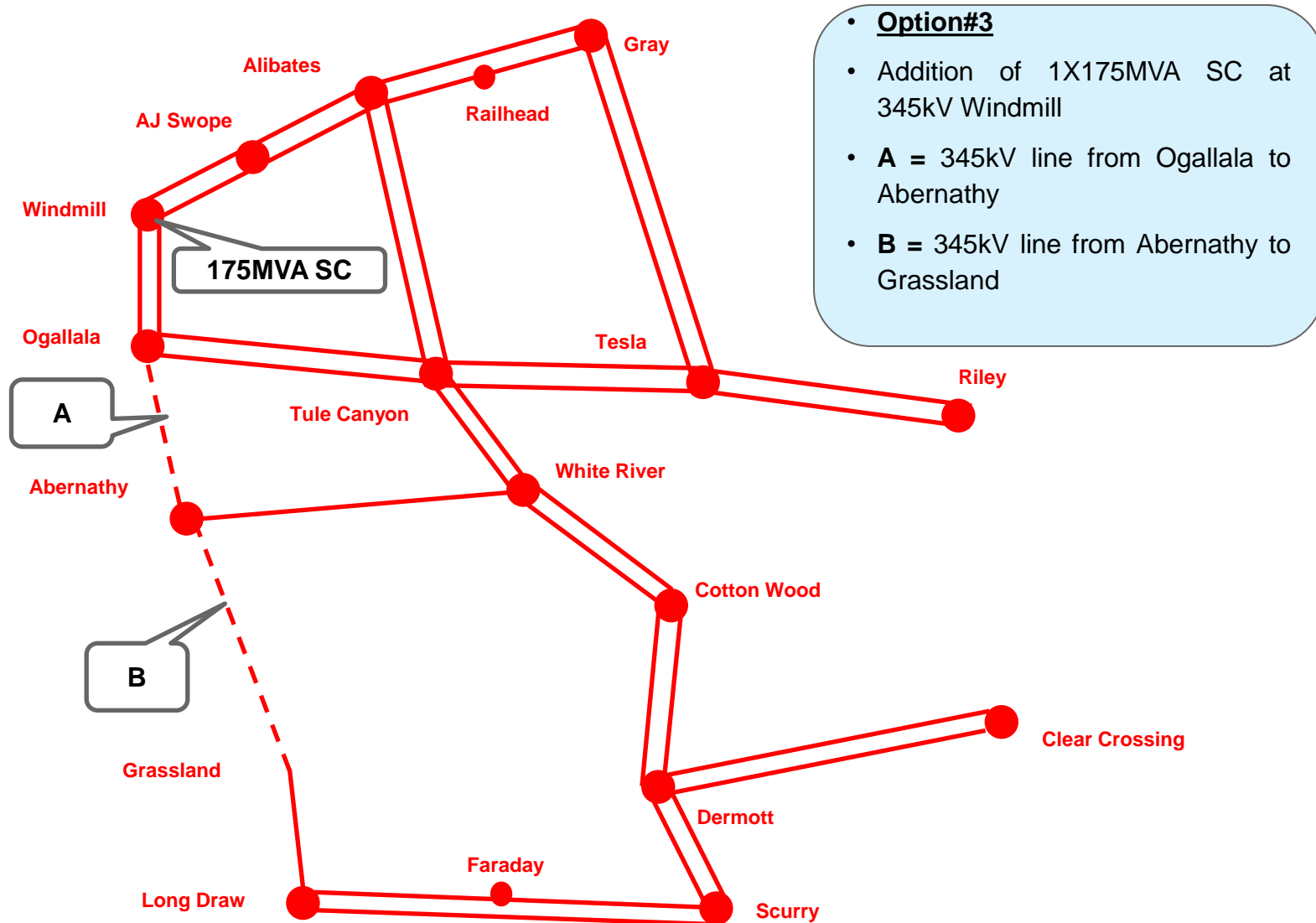
Option 1



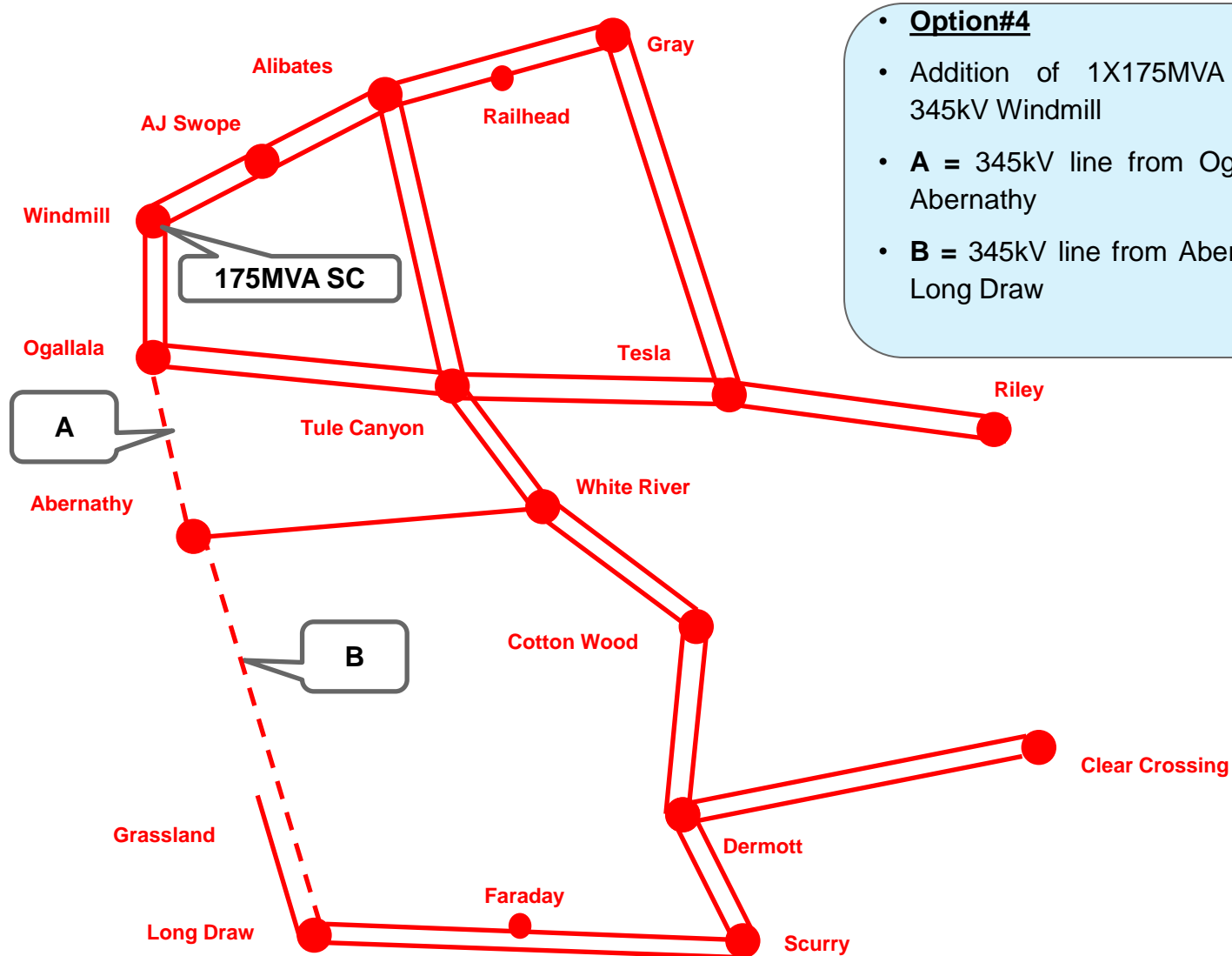
Option 2



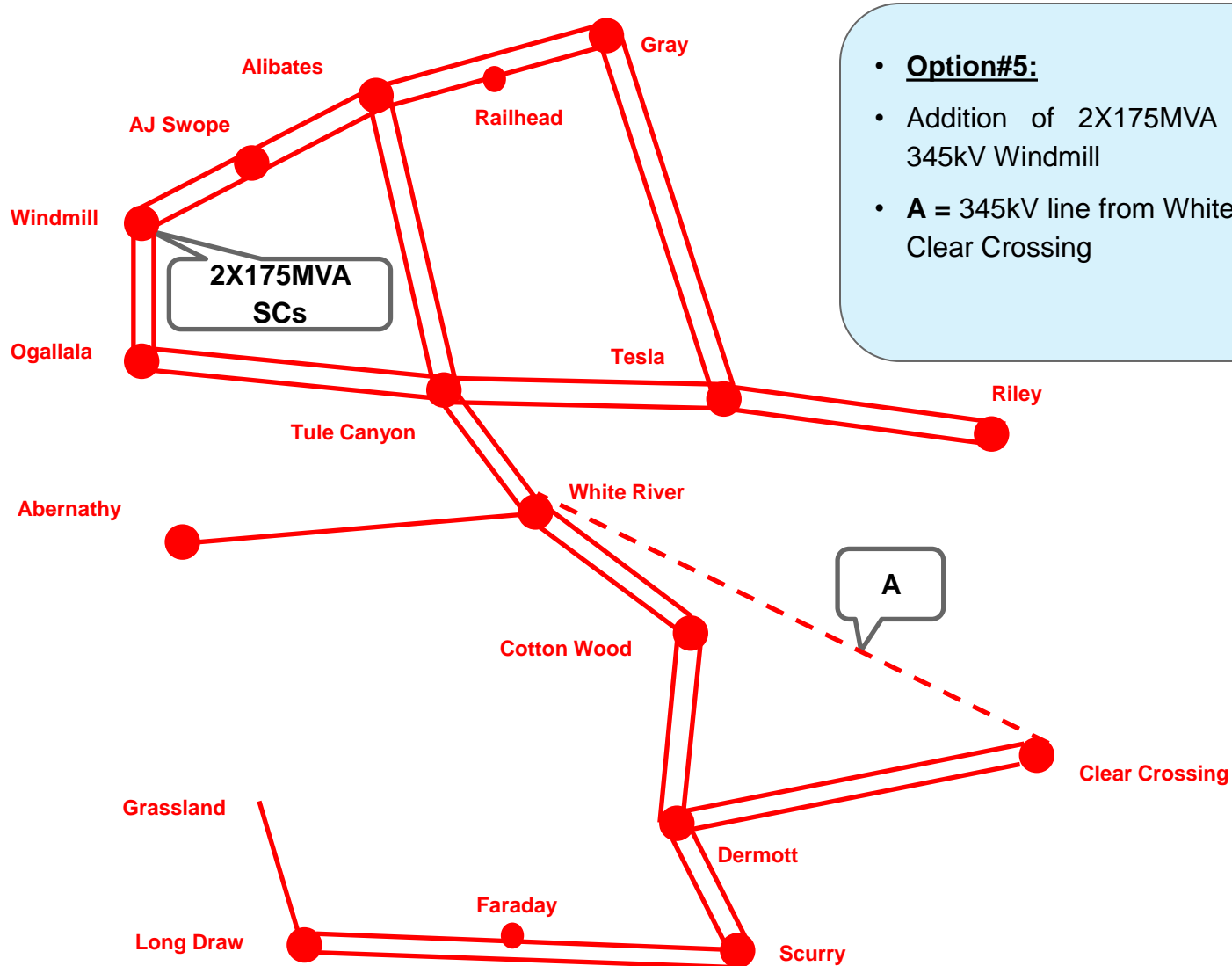
Option 3



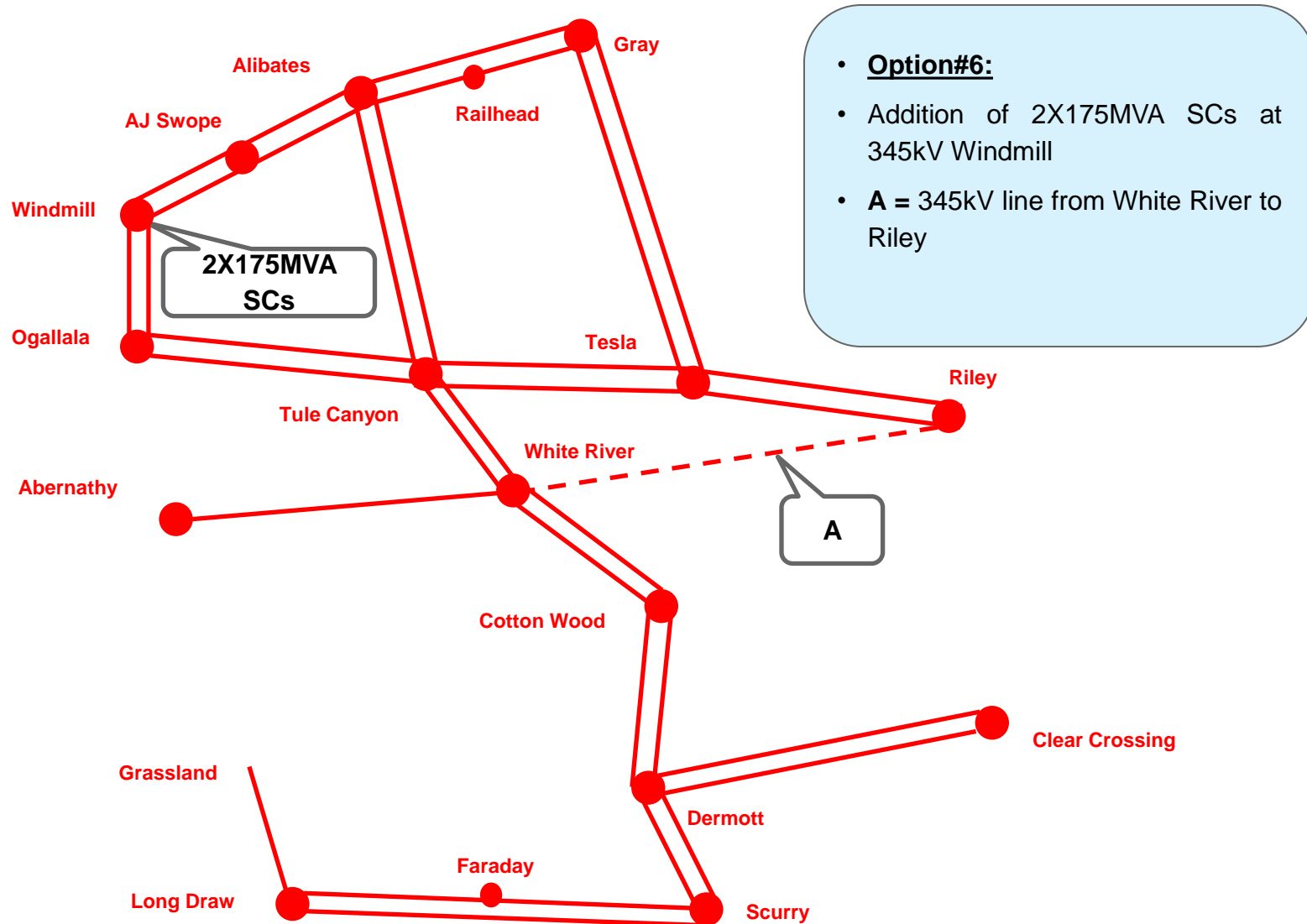
Option 4



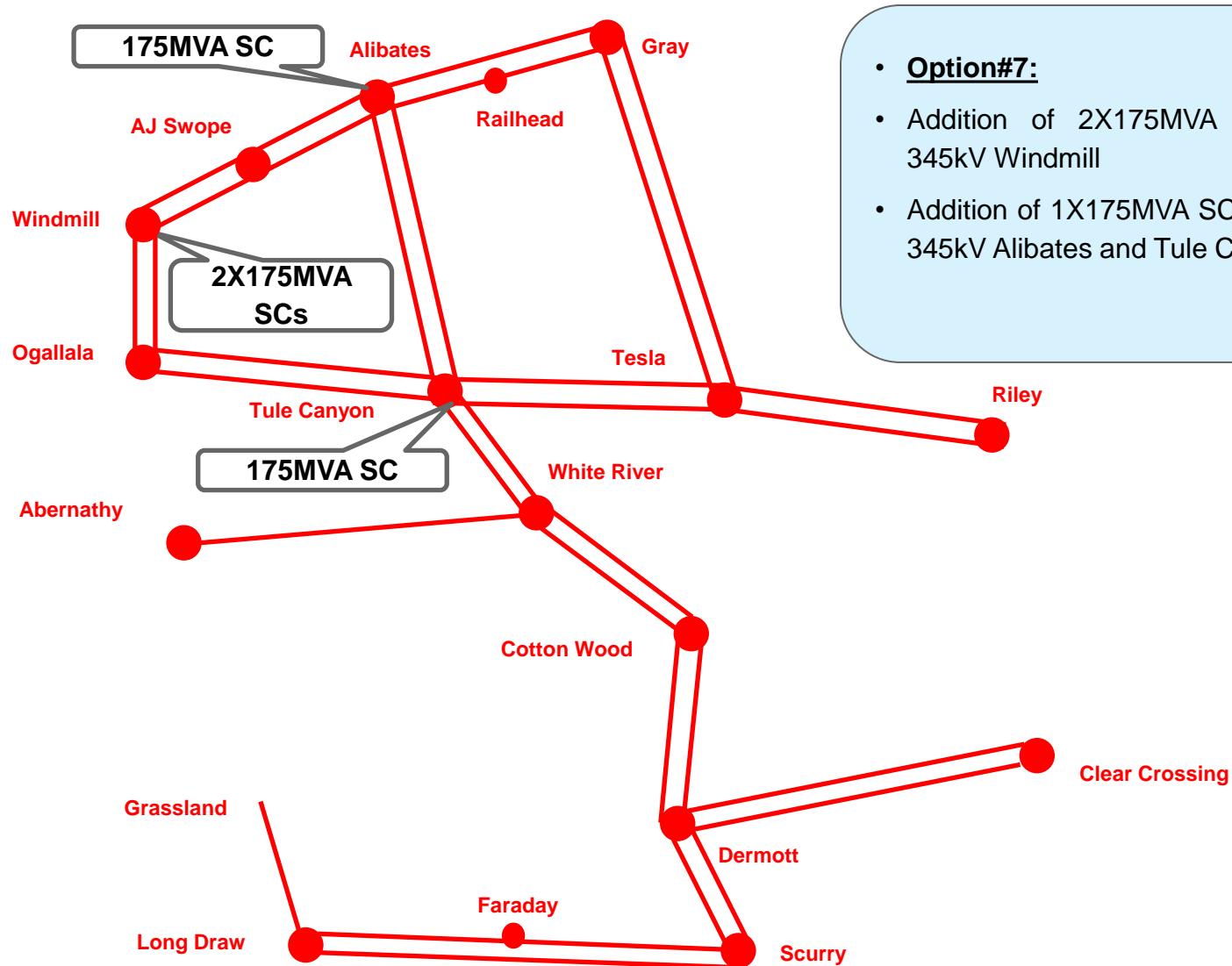
Option 5



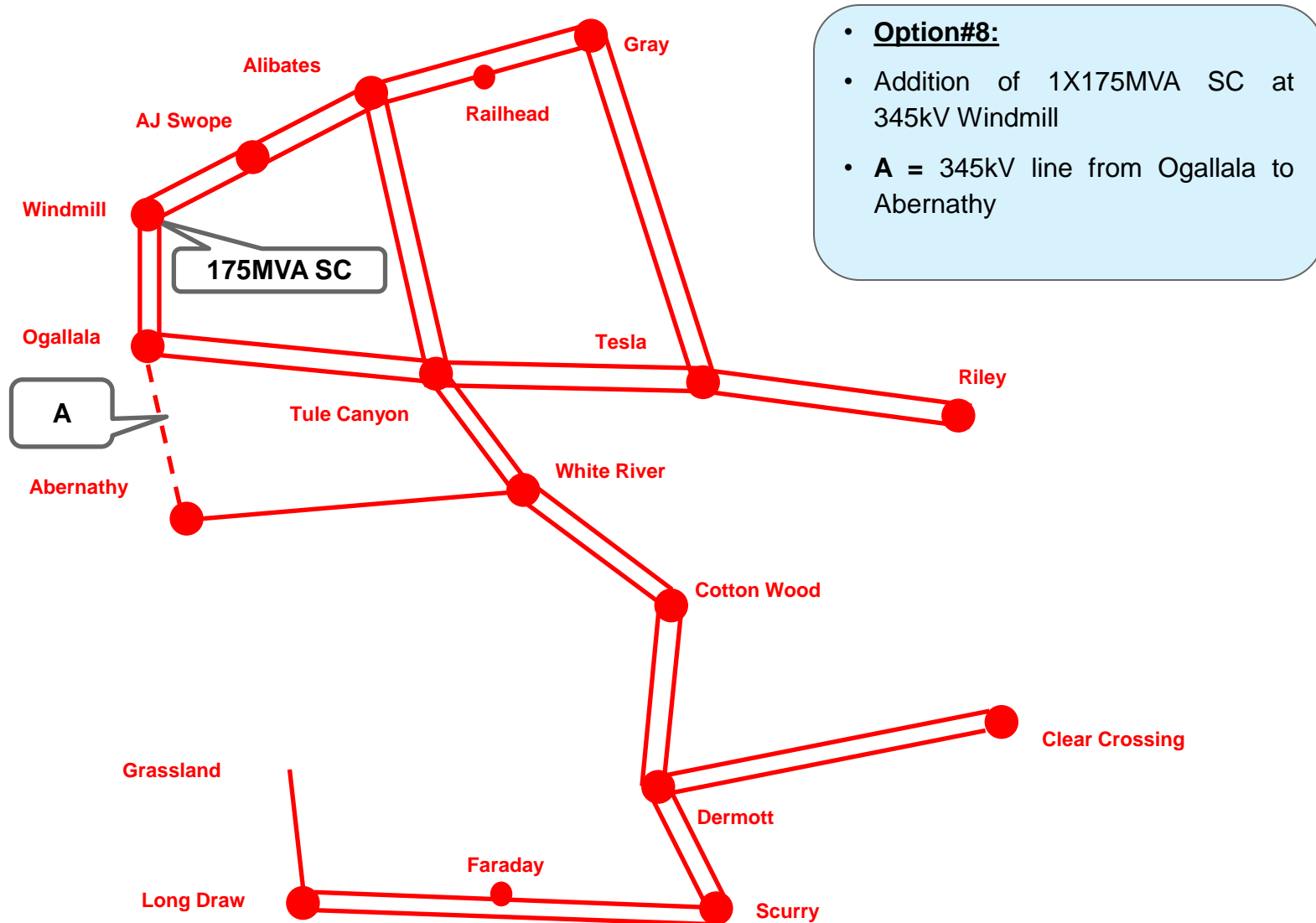
Option 6



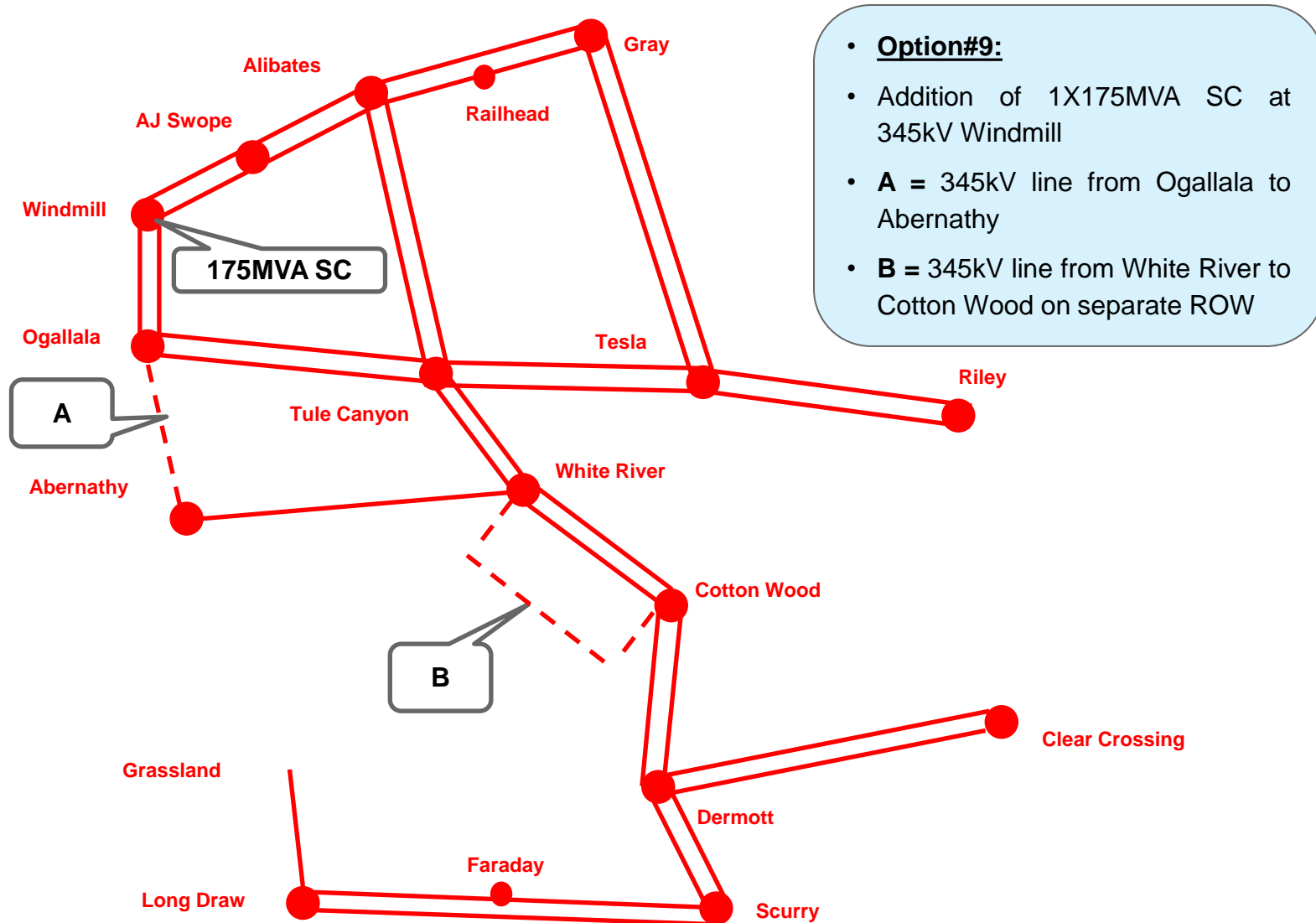
Option 7



Option 8



Option 9



Transmission Option Evaluation

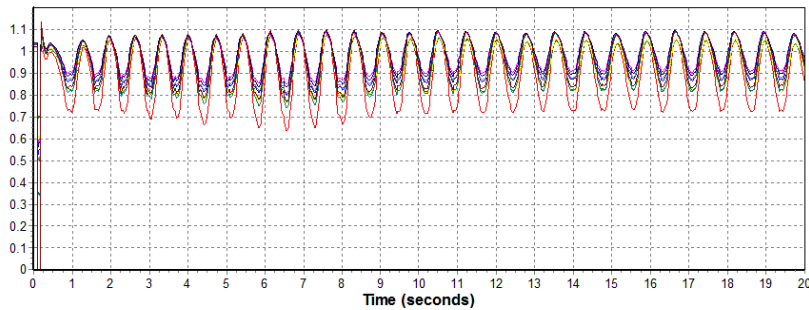
- WSCR analysis performed for all nine (9) options to identify Panhandle export limit for WSCR of 1.5
- Dynamic assessment performed for all the nine (9) options to evaluate transient stability and dynamic performance limits
- Results of the dynamic assessment compared with the WSCR based limits for all 9 options

Option	Additional Synchronous Condensers (@175MVA each)	Transmission Upgrades	Panhandle Transfer Limit for WSCR = 1.5 (MW)	Dynamic Assessment Based Panhandle Export Limit (MW)	
				Export Limit	Local limits
Base Case			4004	4004	None
1	2 SCs @ Windmill	None	4781	4204	None
2	2 SCs @ Windmill	Ogallala – Abernathy – Cottonwood line	4961	4576	None
3	1 SC @ Windmill	Ogallala – Abernathy – Grassland line	4833	4986	Limit generation output at Windmill to 1103 MW
4	1 SC @ Windmill	Ogallala – Abernathy – Longdraw line	4831	4984	Limit generation output at Windmill to 1103 MW
5	2 SCs @ Windmill	White river – Clear Crossing line	4948	4470	None
6	2 SCs @ Windmill	White River – Riley line	4932	4450	None
7	2 SCs @ Windmill + 1 SC @ Tule Canyon and Alibates	None	5321	4204	None
8	1 SC @ Windmill	Ogallala – Abernathy line	4520	4120	None
9	1 SC @ Windmill	Ogallala - Abernathy & White River - Cottonwood (separate ROW)	4627	4627	None

Transmission Option Evaluation

- Option 1
 - WSCR Limit – 4781 MW
 - Dynamic Limit – 4204 MW

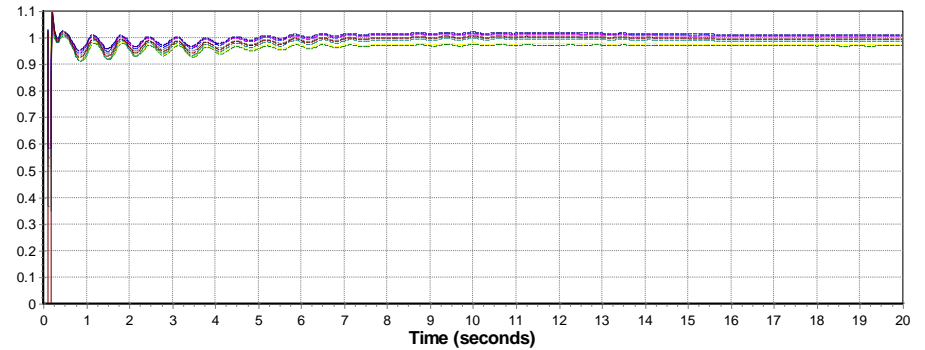
Channel Plot



<input checked="" type="checkbox"/>	24 - VOLT 60501 [TESLA7A 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	7 - VOLT 6101 [RILEY7A 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	23 - VOLT 60500 [EDITHCLA7A 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	45 - VOLT 79500 [ALIBATES 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	46 - VOLT 79501 [OGALLALA 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	47 - VOLT 79502 [WINDMILL 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	48 - VOLT 79503 [TULECNYN 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	49 - VOLT 79504 [AJ_SWOPE 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	50 - VOLT 79505 [WHIT_RVR 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT

WSCR Limit – 4781 MW

Channel Plot



<input checked="" type="checkbox"/>	24 - VOLT 60501 [TESLA7A 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
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<input checked="" type="checkbox"/>	46 - VOLT 79501 [OGALLALA 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	47 - VOLT 79502 [WINDMILL 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	48 - VOLT 79503 [TULECNYN 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	49 - VOLT 79504 [AJ_SWOPE 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT
<input checked="" type="checkbox"/>	50 - VOLT 79505 [WHIT_RVR 345.00] : 3PH-4CY-WTRIVER-CTNWD-DCKT

Stability Limit – 4204 MW

Transmission Option Evaluation – Key Observations

- In general, the dynamic assessment results are more restricting than WSCR-screening based results (especially for SC only options)
 - Higher SC contribution from Synchronous Condensers (1606 A as opposed to 1050 A) – only impacts WSCR assessment (making it more optimistic)
 - Angular stability issues observed in the absence of an additional export path out of Panhandle at export levels greater than 4400 MW
 - Other SC locations not observed to impact results much in the absence of an additional export path
- One (1) SC coupled with an additional export path out of the Panhandle seems to provide the optimal balance in terms of performance across WSCR and dynamic assessment
- Performance evaluation criteria
 - Acceptable dynamic performance **AND** WSCR ≥ 1.5
- More restrictive of the WSCR and the dynamic assessment limit used for the economic assessment for each option

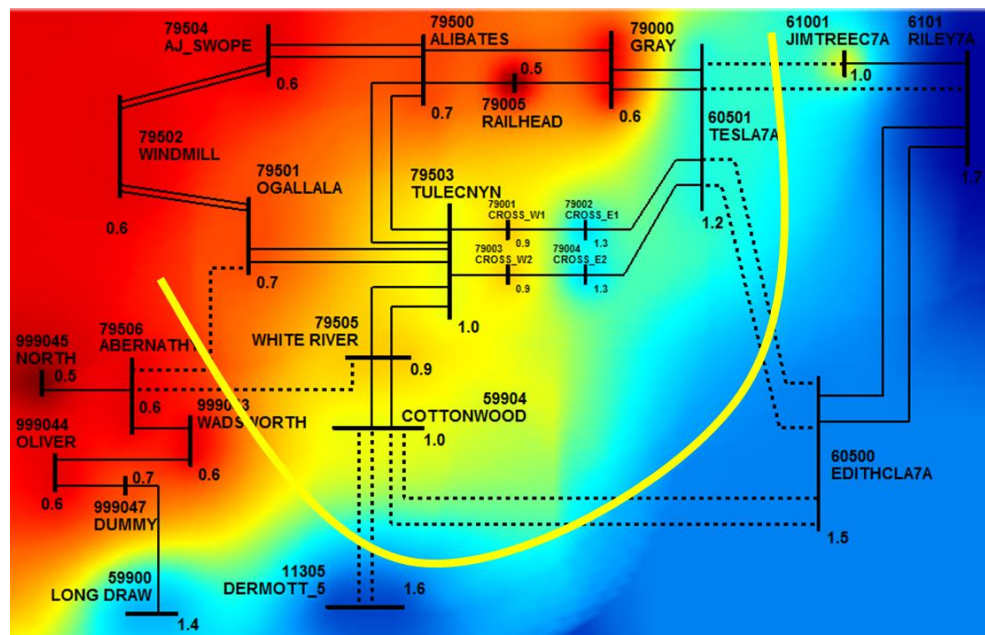
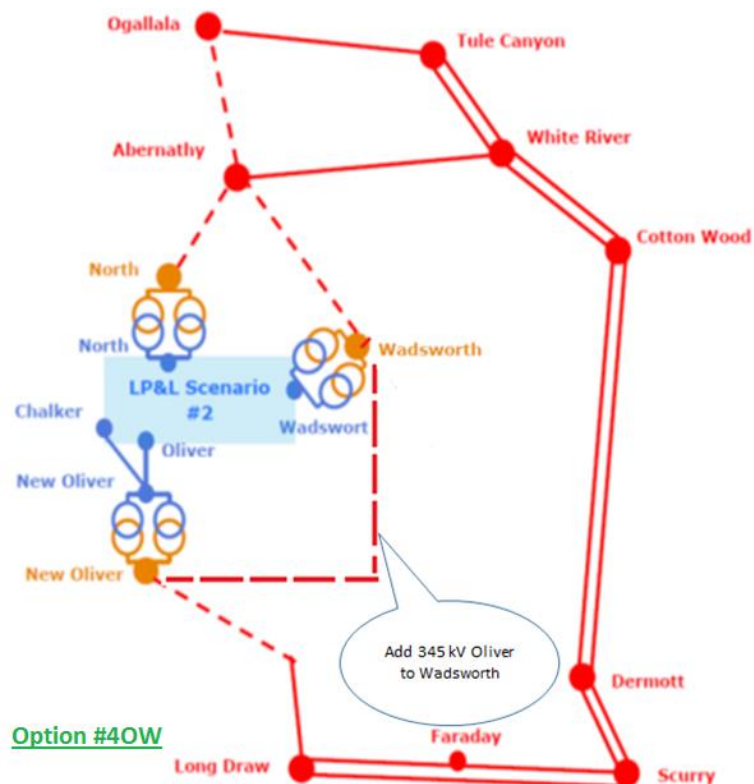
Transmission Option Evaluation

- 10% operational margin applied to Panhandle export limits for the economic assessment
- Options 1, 3 and 9 meet ERCOT economic criteria based on APC savings and the capital cost of the option
 - Option 3 aligns with ERCOT PREZ study Stage 2 and LP&L integration recommendations

Scenario ID	System Strength Limit	Stability Limit	Operational Limit (90% of Min of System Strength and Stability Limit)	APC Savings (\$M)	Capital Cost for Transmission Investment (\$M)	Option Cost Estimate (\$M)
Base Case	4004	4004	3604	NA	NA	NA
Option 1	4781	4204	3784	12.3	82	69
Option 2	4961	4576	4118	31.0	207	273
Option 3	4833	4986	4350	40.5	270	240
Option 4	4831	4984	4348	40.5	270	284
Option 5	4948	4470	4023	25.7	172	296
Option 6	4932	4450	4005	25.1	167	296
Option 7	5321	4204	3784	12.3	82	131
Option 8	4520	4120	3708	7.1	47	133
Option 9	4627	4627	4164	33.2	221	189

Transmission Option Evaluation

- Sensitivity around Lubbock Power & Light (LP&L) integration performed for Options 1, 3 and 9
 - Perform economic simulations to evaluate the APC savings for Options 1, 3 and 9 assuming LP&L integration into ERCOT



LP&L Integration Option 4ow & PH
Interface Definition with LP&L

Transmission Option Evaluation

- Options 1, 3 and 9 deemed economic based on the APC savings and the incremental capital costs vis-a-vis LP&L Option 4ow
- Option 3 performance is similar to Option 1, below in terms of buildout and transfer capability, but with lower capital cost

Scenario ID	System Strength Limit	Stability Limit	Operational Limit (90% of Min of System Strength and Stability Limit)	APC Savings (\$M)	Capital Cost for Transmission Investment (\$M)	Option Cost Estimate (\$M)
With LPL Option 4OW Scenarios						
Base Case	4458	>4458	4012	NA	NA	NA
Option 1 & 3	5191*	4941**	4447	18.1	120.6	69/41
Option 9	4931	>4931	4438	18.0	119.9	101.0

* Limit with 2 SC shown

**LPL lines getting congested

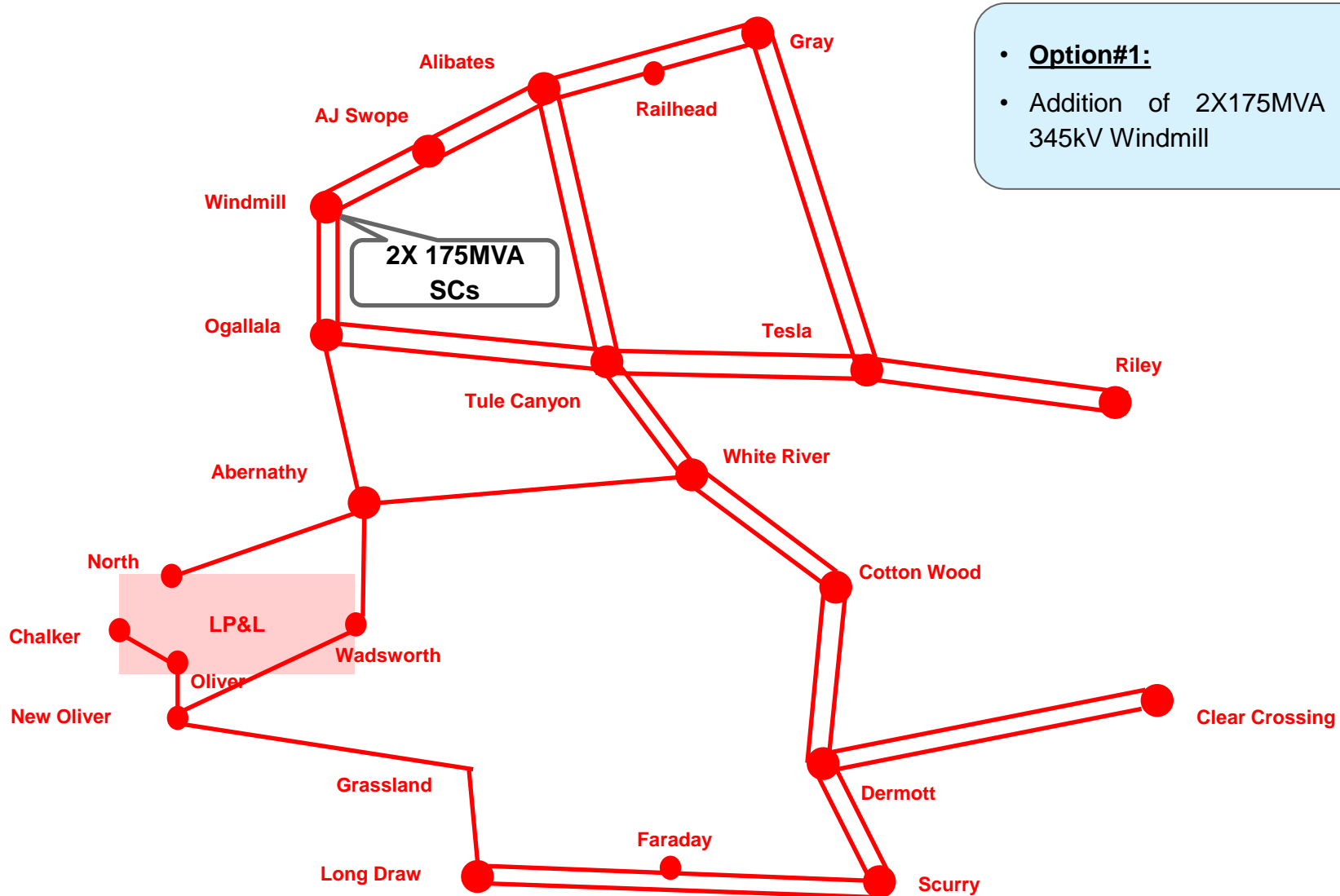
Recommendation

- Sharyland will be recommending to proceed forward with Option 3 as the preferred option based on technical and economic performance
 - Meets ERCOT economic criteria based on the study findings
 - Aligns with ERCOT PREZ stage 2
 - Optimizes both WSCR and dynamic stability limits
 - Aligns with the LP&L integration
- Option 3 would be Sharyland's recommended option irrespective of the LP&L decision

Questions

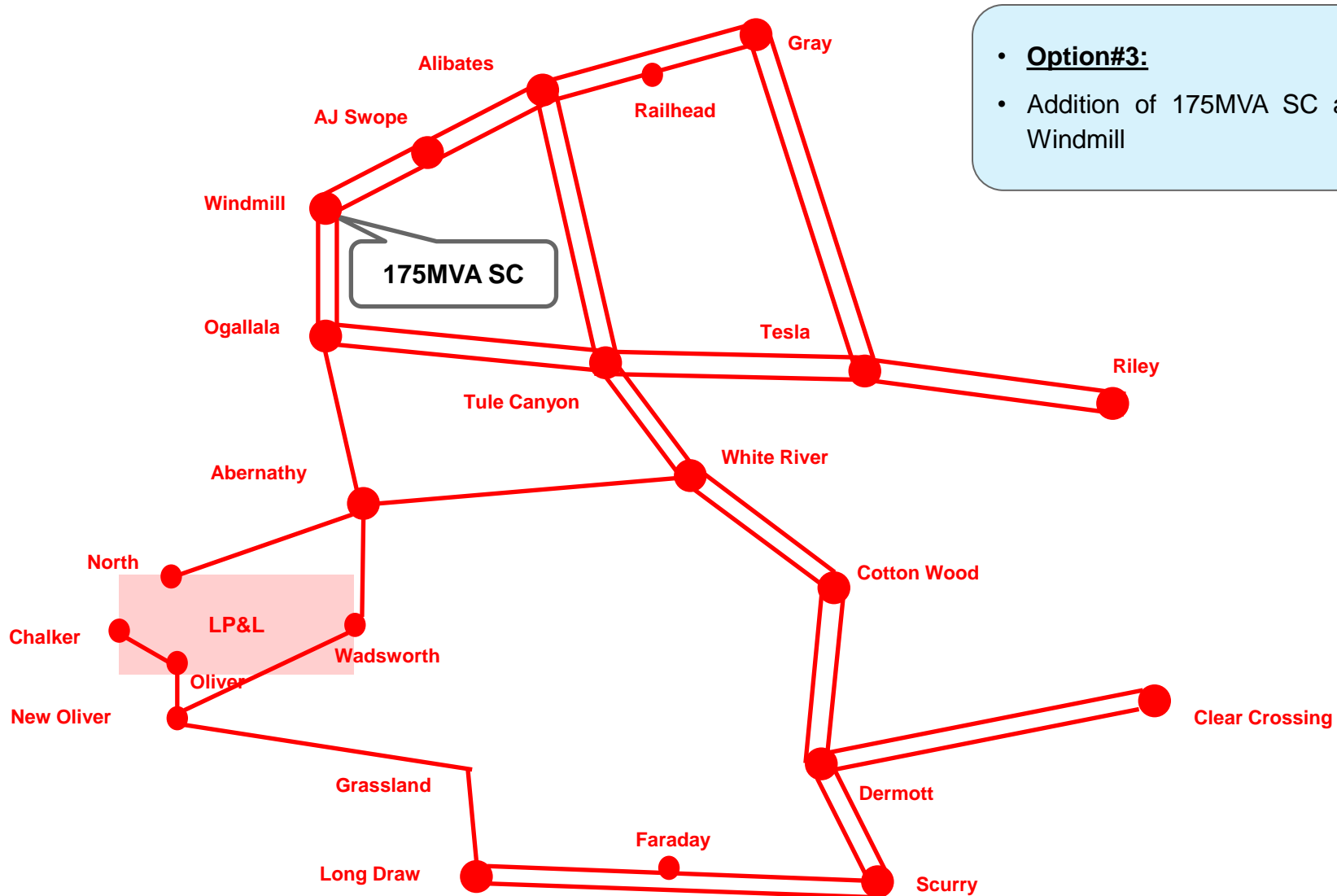


Option 1 with LP&L Option 4ow



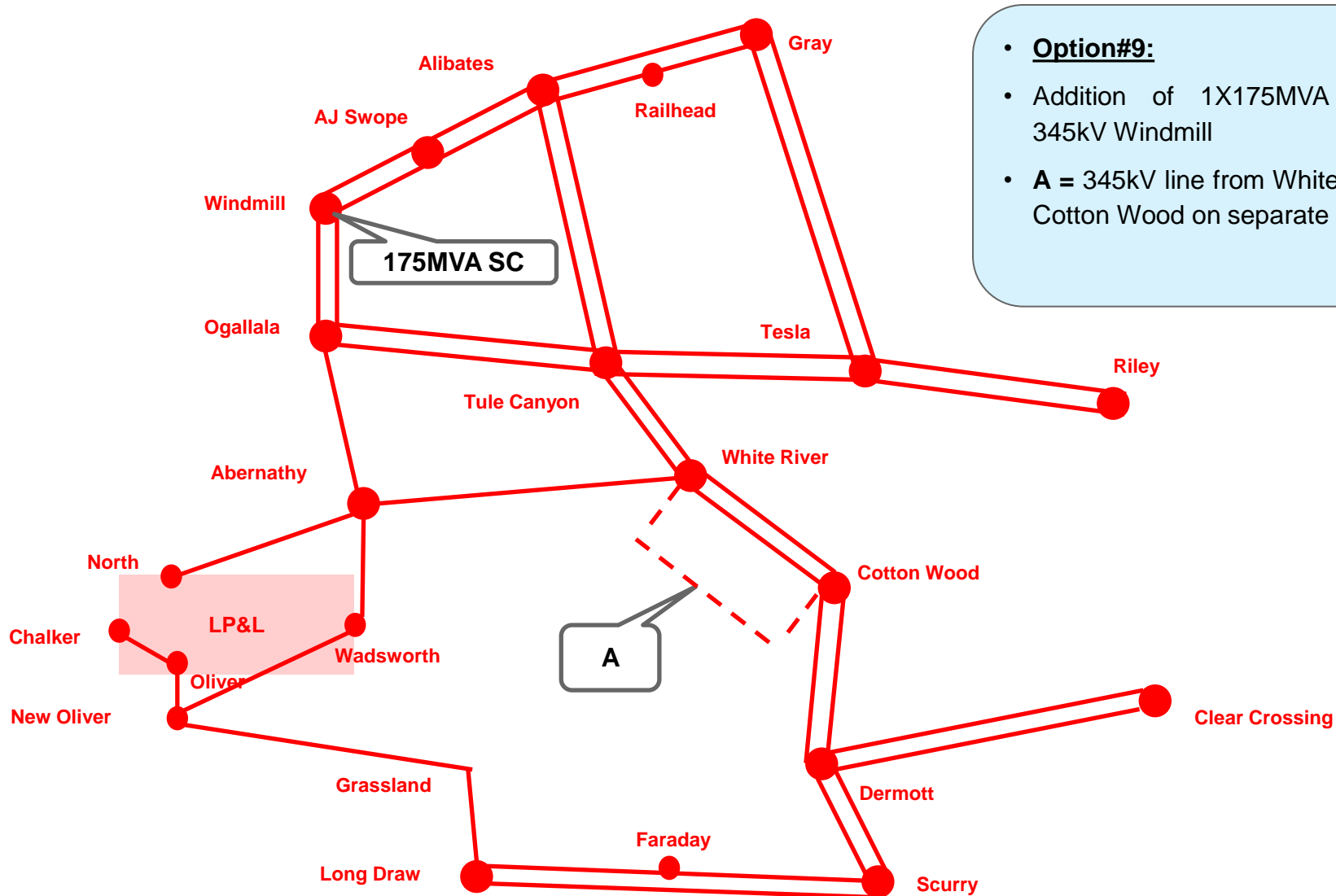
- **Option#1:**
- Addition of 2X175MVA SCs at 345kV Windmill

Option 3 with LP&L Option 4ow



- **Option#3:**
- Addition of 175MVA SC at 345kV Windmill

Option 9 with LP&L Option 4ow



- **Option#9:**
- Addition of 1X175MVA SC at 345kV Windmill
- **A** = 345kV line from White River to Cotton Wood on separate ROW