Garland Power & Light **NORTH GARLAND RELIABILITY INFRASTRUCTURE PROJECT (N-GRIP)**	**Document Number:** **JSS09SEPT2016**

North Garland Reliability Infrastructure Project (N-GRIP)

Garland Power & Light,

Oncor Electric Delivery

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EXECUTIVE SUMMARY

This project is in response to meet system reliability and anticipated high load growth in the northern Garland area. The overall solution proposed in this study benefits both Garland and Oncor by removing overloads in the system that effect both utilities and provides additional support in the fast growing area.

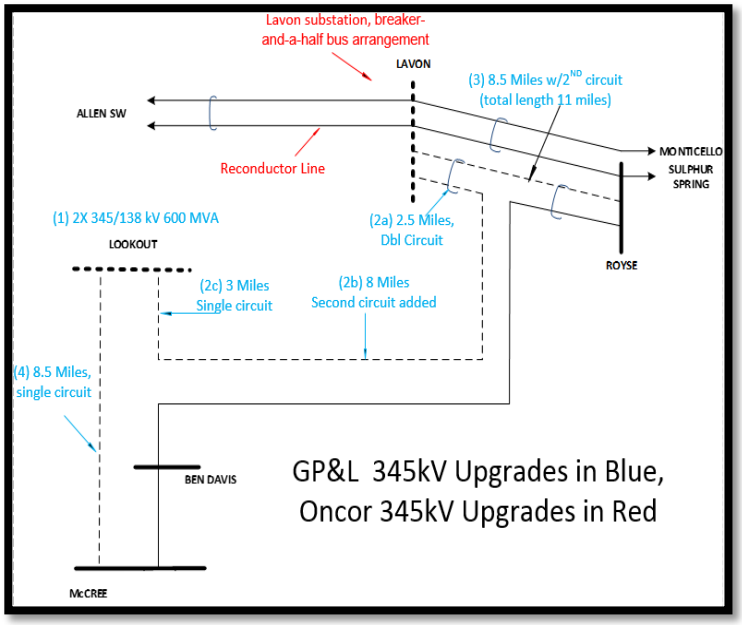
This report reviewed a series of 138 kV and 345 kV options to serve the new load in this area. Due to the high load growth, the 138 kV options alone did not meet ERCOT's reliability criteria and the NERC Planning Standard. Based on a holistic approach of the area requirements and to provide a solution that technically meets reliability issues, a joint planning approach was established with local transmission owners in the area. This group developed the final solution proposed in this report.

Currently, there are two large data centers with signed interconnection agreements in the Northern Garland area and a possible third one in the early stages of negotiation with the City of Garland. Of the three data centers, one has already started construction of its facility. The second data center has purchased 47 acres of land and is negotiating an interconnection agreement. Estimated load growth for each data center is between 100 to 125 MW. All three of the new data centers are planned for the same area in North Garland. This area is undeveloped and near a large information technology (IT) technical hub. Additionally, there has been some discussion of an additional fourth data center proposed to the Northwest of Lookout in Oncor's service territory that will influence load growth in this vicinity.

One of the growing concerns for this area is Ben Davis substation. This is a major substation in the northern Garland footprint and is one of two interconnect points that connect the Garland system to the 345kV network. Ben Davis is a major interconnection point for north Garland transmission system. In recent years (2016) this substation has been flooded. During the flood, the Ben Davis Substation sustained damage to fencing and gravel surfacing. Ben Davis substation is currently built in a Federal Emergency Management Agency (FEMA) designated floodway. As this surrounding area develops near and around this substation there has been an increase in rain water run-off and associated increase in flooding. Because of the flood way, there is a concern that this substation is at higher risk than other facilities. Moreover, expanding the substation would affect the flow of water in the flood way and require additional permits and is not considered prudent utility practice. (FEMA Flood map for the Ben Davis substation is attached in appendix). Currently, GP&L is in the process of repairing this substation's and elevating the control house with stilts.

The proposed upgrades of the Lookout Substation, new Holford Substation and 345 kV lines are designed to meet and accommodate this new forecasted load growth and provide an additional 345kV tie line to this area. Together this group of projects represents the **N**orthern **G**arland **R**eliability **I**nfrastructure **P**roject, **N-GRIP**. This report describes the background, purpose and necessity for substations and associated facilities and is provided for ERCOT Regional Planning Group (RPG) endorsement.

The overall solution proposed in this report provides support to both GP&L and Oncor, and was reached by a joint planning process. GP&L's portion of the project include adding two 345/138 kV 600 MVA transformers and a four breaker 345 kV ring bus at the Lookout Substation, and constructing 33 miles of new 345 kV circuits. GP&L's estimated cost of upgrades is $56M. Oncor's portion of the project include constructing a 9-breaker 345 kV switching station in breaker-and-a-half arrangement (Lavon Switching Station), upgrading the 12-mile Lavon Sw. Sta. – Allen Sw. Sta. 345 kV circuit and adding a 345 kV line terminal at Royse Switching Station. Oncor's estimated cost of upgrades is $22M. Total project cost for both GP&L and Oncor is estimated around $78M (planning estimate). This is a Tier 1 project and requires both ERCOT review and ERCOT Board of Directors endorsement.



Graph 1: One line of 345 kV transmission upgrades

SUMMARY OF N-GRIP PROJECT UPGRADES

To serve the requested customer load additions in this area, GP&L and Oncor are planning the following system upgrades. This proposed upgrades are required for the ultimate build-out with supporting auxiliary loads.

Transmission Upgrades:

1) Upgrade the existing Lookout substation to accommodate a 345 kV breaker-and-a-half bus arrangement and two 345/138 kV 600 MVA autotransformers. This substation serves both Garland and Oncor loads.

2) Construct the Lavon Switching Station with 9-breaker 345 kV breaker-and-a-half bus arrangement. Construct a 13.5-mile 345 kV circuit from Lavon Switching Station to the Lookout Substation.

3) Construct an 11-mile 345 kV circuit from the Lavon Switching Station to the Royse Switching Station This new circuit will share double-circuit structures for the first 2.5 miles as shown in Graph 1. The remaining 8.5 miles of circuit will be added on to the existing Royse Sw. Sta. – Ben Davis 345 kV towers which are capable of supporting a double-circuit line.

4) Upgrade the Lavon Switch Station – Allen Switching Station 345 kV circuit.

5) Construct an 8.5-mile 345 kV line from Lookout to McCree substation. This line will be designed for a future second circuit.

BACKGROUND

This proposal is in response to exponential load growth in the North Garland area. Currently, there are two large data centers with signed interconnection agreements in the Northern Garland area and a possible third one in the early stages of negotiation with the City of Garland. Each of the data centers have a forecasted ultimate load of 120 MW. Total new load growth in this area is expected to be in the range of 500 MW by FY 2030. In addition, to this load there is another data center that has been considering interconnecting in the same area. This load growth is beyond any previous forecasts for this area and will require, new transmission infrastructure and substations to insure system reliability.

Data centers are used by a variety of customers from enterprises to home computers, server and networking systems and components for the company's information technology (IT) needs, which typically involve storing, processing and serving large amounts of mission-critical data to clients in a client/server architecture. A data center often requires extensive redundant or backup power supply systems, cooling systems, redundant networking connections and policy-based security systems for running the enterprise's core applications. Large data centers are industrial scale operations that use as much electricity as a small town but require exceptional reliability.

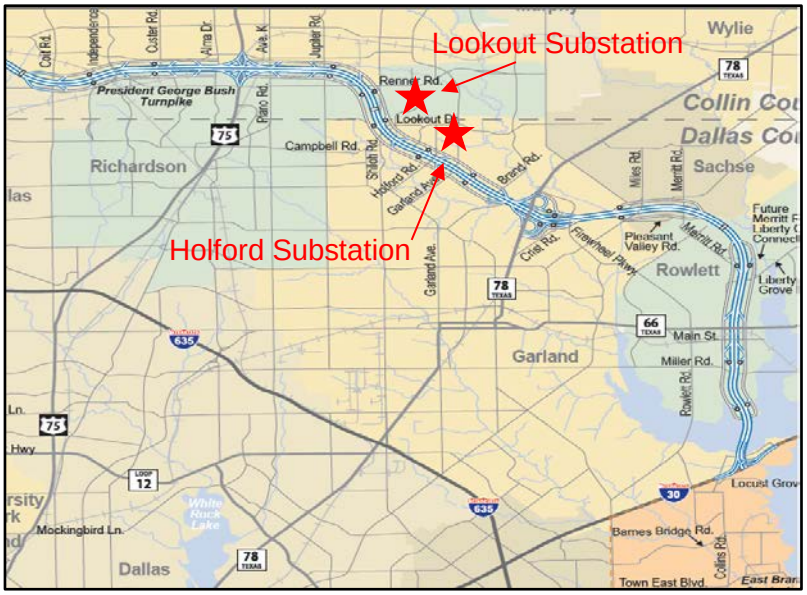
The energy use for data centers are on the rise and now has the capability to impact the electric grid reliability during peak. Moreover, with the adoption of scalable “pay as you grow” architectures, it is becoming easier to install these systems. It allows the data center manager to simply add modules as the needs of the data center grow.

Fundamentally, for this area two new substations, Lookout and Holford substations, are required to meet load grow in the North Garland and surrounding areas.

The Lookout substation is located on Northern edge of the Garland service territory between Apollo and Freewheel substations on the 138 kV transmission system. The physical location is near the intersection of Lookout and Telecom roads, North of the new President George Bush Turnpike. The Lookout substation is in a prime location to serve new load growth developed along the President George Bush Turnpike. This substation serves both Garland and Oncor loads and under construction was recently completed on both the Garland and Oncor portions of the substation.

The proposed site for the Holford Substation is approximately one mile southeast of Lookout on Holford road. This substation will tap the Firewheel to Lookout 138kV and require a new 138kV line from Holford substation to the Ben Davis Substation.

To the south of the proposed growth corridor is the relatively recently constructed President George Bush Turnpike. The President George Bush Turnpike offers a significant east-west route within a major developing economic area in the Northern half of the Dallas-Fort Worth Metroplex. The 52-mile, six-lane, toll road links commuters to high-tech corridors, corporate headquarters and other important destinations, and gives motorists additional access to U.S. 75, the Dallas North Tollway, Interstate 35E, and I-635. The toll road also offers an alternative route to the Dallas/Fort Worth International Airport. The region North of Garland is prime location for high tech growth.



Location of Lookout and Holford Substation

One of the proposed data centers in Garland has been in the works for several years, and is currently under construction. Presently the Raging Wire company has two data centers open in California and Virginia. Its west coast data center is the largest data center in the State of California with over 52 megawatts of high density critical IT capacity spread across three fully integrated buildings totaling 680,000 square feet of data center space. The proposed facility will be one of the biggest in the nation and has an expected in-service date of late 2016. The Lookout Substation has been constructed to meet the initial demand. Initial load is expected between 25 to 50 MW,

and will grow to the ultimate size of 120 to 150 MW by 2020. This initial growth is based on estimated load growth of the Raging Wire data center.

The current plan is to serve the proposed facility from Lookout Substation. Lookout Substation's ultimate design is planned for twelve transformers, four for Oncor, two for Garland and six transformers for the proposed facility. In addition to the transformers the substation footprint is designed to accommodate two 345 kV transmission lines, a 345 kV ring bus and two 345/138 kV, 600 MVA auto-transformers. (One-line diagram is attached in the appendix.)

Furthermore, recent development in the area has increased the load expected in this area. Namely, two additional data center developers have approached GP&L about developing near the Lookout Substation. Both of the new developers have indicated that similarly, they plan to increase load in the 125 to 150 MW range for each of the new data centers. Load forecast for the data centers were provided by the developers of the data centers. Because of feeder space requirements this new growth will require an additional substation near the Lookout Substation. The tentative name of the new substation is Holford.

The ultimate design of the Holford Substation is a 138 kV four breaker ring-bus configuration that would accommodate load serving transformers and three 138 kV transmission lines. This station will be served via the Lookout – Firewheel 138kV transmission line. In the future GP&L plans to build a 138kV circuit from Holford to Ben Davis as load matures.

The new Holford Substation will be built adjacent to the newly proposed data center. As load matures in this area an additional transformer will be added, the approximate distance from this new station to Ben Davis is 2.5 miles.

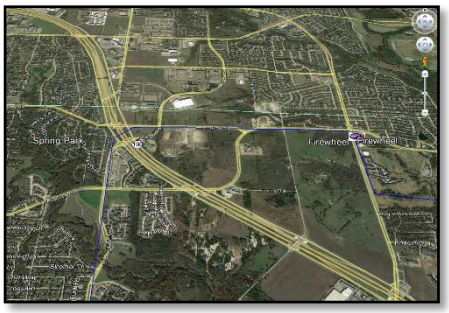
1. LOAD GROWTH

Under normal circumstances load growth in the Garland area is based on historical data and the internal future system load expectations, under normal conditions GP&L has established a linear forecast for base load modeling. However, for the North Garland area there are three developers planning on building data centers in this area. The total load in this area is expected to grow to approximately 290 MW by 2020. Load growth forecast is a joint effort developed by Oncor, GP&L and developers. For Garland, this would be considered exponential growth, and the current transmission and distribution system is not designed to meet the anticipated load growth. The following table outlines the ultimate load growth for this area for the two new substations proposed and the ultimate projected load growth of approximately 500 MW.

Estimated North Garland Load Growth								
Lookout		2016	2017	2018	2019	2020	2025	2030
	Raging Wire	20	40	60	80	100	100	120
	Oncor	28.4	28.8	29.3	29.7	30.1	50.3	53.3
	GPL			10	15	20	45	50
	Total	48.4	68.8	99.3	124.7	150.1	195.3	223.3
Holford								
	Phase I		20	40	60	100	100	120
	Phase II			20	40	100	100	120
	Total	0	20	60	100	200	200	240
	Grand Total	48.4	88.8	159.3	224.7	350.1	395.3	463.3

This North Garland area is undeveloped and near a large IT technical hub. To the west of this area is the fast growing town of Richardson. The City of Richardson is located northwest of Garland, and is an affluent inner suburb of Dallas and home of The University of Texas at Dallas and the Telecom Corridor with a high concentration of telecommunications companies. More than 5,000 businesses have operations within Richardson's 28 square miles, including many of the world's largest telecommunications/networking companies: AT&T, Ericsson, Verizon, Cisco Systems, Samsung, Metro PCS, Texas Instruments, TriQuint Semiconductor, and Fujitsu. As load develops in the Richardson area it is moving east towards Garland.

The diagram below on the right shows one of the data centers under construction.

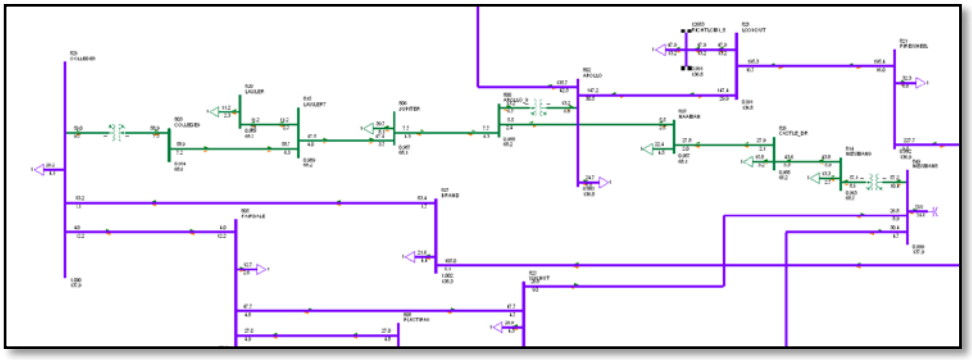


North Garland Area

Construction of new Data Center

1.1 Base Case

This part of the study was developed to test if there were existing system concerns before adding new load or new projects. Study used the most recently ERCOT load flow cases developed in the 2015 case development cycle. This data represents the most recent data set available at the time of the study. For the Garland area, for the base case and under N-1 conditions there are no overloads or system concerns before the new load was added.

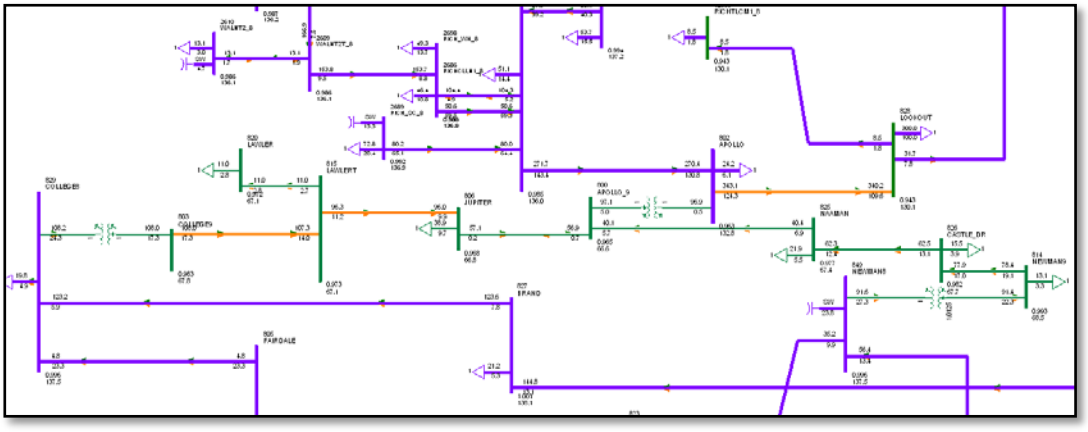


North Garland without Load Growth

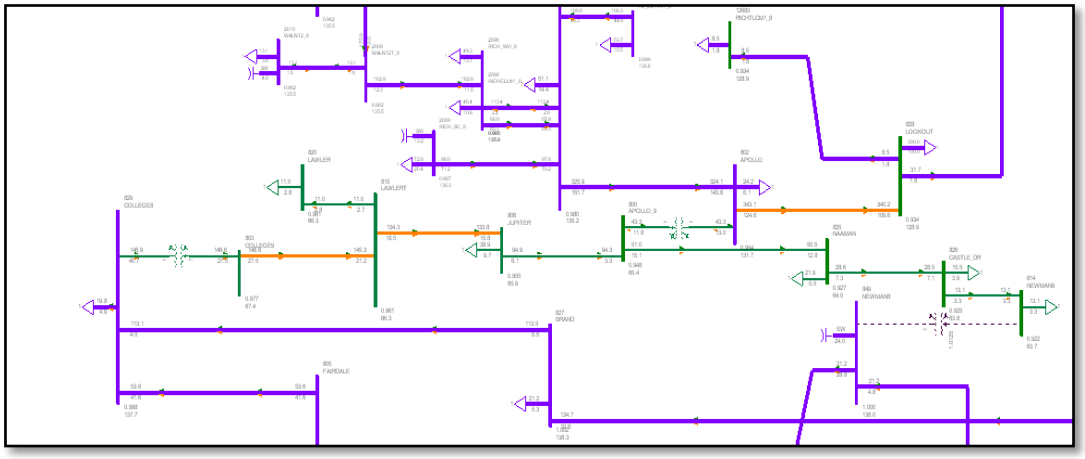
1.2 System Concerns Due to One New Data Center (1/3)

With the increase of one new data center at Lookout, the Apollo – Lookout – Fire Wheel 138 kV line overloads for the outage of the Royse Switch Station – Rockwall – Wylie 138 kV line. Overload is related to load growth in the Richardson area. This 138 kV transmission line starts to show overloads in 2020 at 100% and grows to 105% in 2025. Light load case shows high loading in 2021 similar to the summer peak load case. Adding the new data center, shows the local area system to have thermal limit. With one new data center modeled at 150 MW @ 0.95 pf, this same outage loads the Lookout – Fire Wheel line to 122.4%. (Growth estimate provided by developer.) That is with only one data center and before adding the two additional data centers this line is already strained beyond its thermal rating.

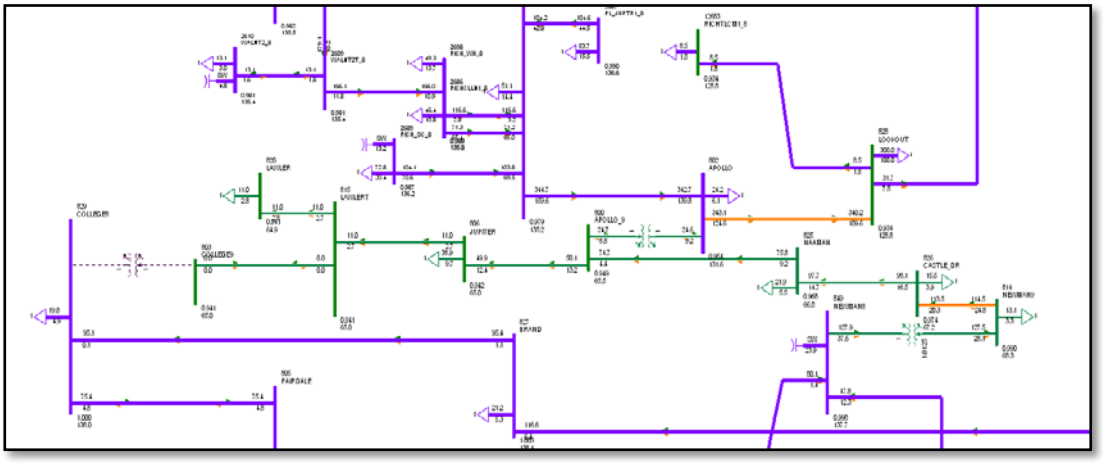
In addition to the 138 kV concerns, there are additional system concerns on the underlying 69 kV system. Adding one of the expected three new data centers in this area increases the thermal loading in this area significantly. As shown in the diagram below, for the 138 kV transmission line outage of the Fire Wheel to Wylie switching station and the estimated load grow at the new Lookout substation, the 69 kV system becomes heavily loaded (orange). The 69 kV College – Lawler line to 102% and the Jupiter – Lawler loads to 90%. If the Newman transformer is outage for this condition (N-1-1) the College – Lawler line is severely overloaded to 132% and the Lawler – Jupiter line loads to 120%. With one of the three new data centers on line, there is a need to convert the exiting 69 kV system to 138 kV.



FY 2020 with N-1, Outage of Fire Wheel – Wylie SS with new Data Center, Orange lines represents overloads.



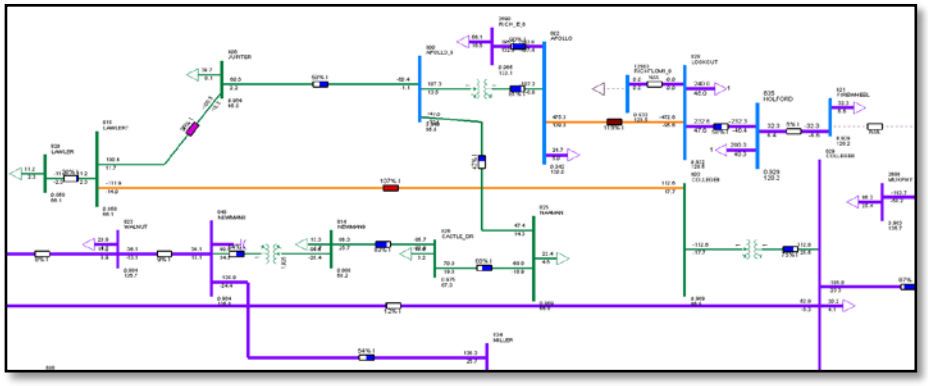
FY 2020 with N-1-1 Outage of Fire Wheel – Wylie SS & outage of 69 kV Newman transformer with new Data center – Orange line represent overloads.



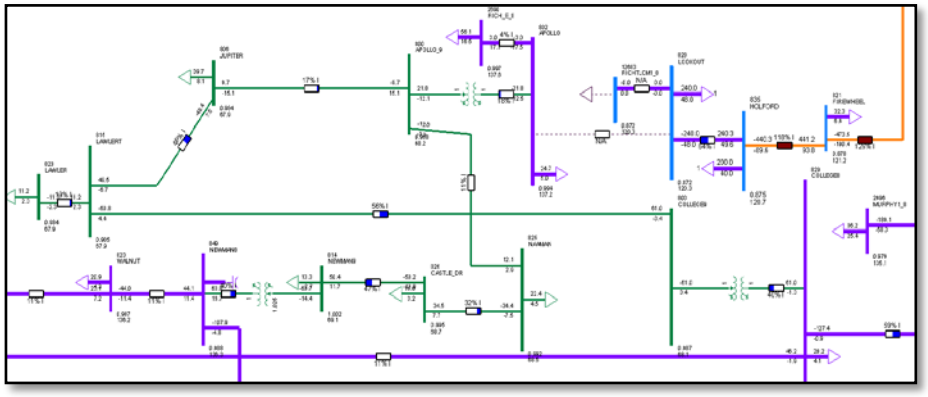
FY 2020 with N-1-1, Outage of Fire Wheel – Wylie SS & outage of 69 kV College transformer - Orange line represent overloads.

1.3 System Concerns Due to Adding Three Data Centers (3/3)

In total there are an expected three new data centers planned for this area. The ultimate system load in this area is expected to peak near 540 MW. With the added new load the system will require significant upgrades. For the 2020 case, load at the Lookout and Holford substation is expected to be approximately 290 MW. For this condition, two outages are of concern for the North Garland area. Outage of the Fire Wheel to Wylie switch 138 kV line loads the Apollo to Lookout line to 118% and cause low voltage in this area. Also outage of the Apollo to Lookout Line loads the Wylie to Fire Wheel line to 126% and the Fire Wheel to Holford line to 117%.



Outage of Fire Wheel – Wylie 138 kV line with increased load – orange represents overloads.



Outage of Lookout – Apollo with increased load orange represents overloads.

1.4 Base Case Assumptions

Because of the numerous system concerns found in the base case with the added load, GP&L assumed that the two upgrades will be required indifferent to the other long-term options need to address this load growth.

As a starting point for future studies the following two upgrades were assumed as part of all scenarios screened.

1) Convert 69 kV transmission lines interconnecting Apollo to College and Apollo to Newman to 138 kV.

2) Upgrade 138 kV conductor on existing transmission line from East Richardson to Apollo to Wylie using Cumberland 1926 ACSS/TW conductor with a thermal rating of 495 MVA.

2. POTENTIAL 138 KV OPTIONS

For this study a series of 138 kV options were reviewed for providing support to the Lookout substation. This series of studies were performed with the proposed 69 kV to 138 kV conversion. That is, converting the 69 kV system that interconnects to the Apollo system to 138 kV. Conversion includes the following 69 kV substations: College, Lawler, Jupiter, Apollo, Naaman, Castle and Newman. The base case was created adding the loads at Lookout=240 MW and Holford=200 MW in 2022 as estimated, and upgrading of the 138 kV line segments Apollo to Lookout to Holford to Fire Wheel to bundled Drake ACSS-795 conductor (ratings of 436 MVA) as originally proposed.

1. **C0a_BASEa** case = No system upgrades
2. **(C0a_BASEa)_ODH1-138 kV** case = new 138 kV - 218 MVA line Lookout to Ben Davis
3. **(C0a_BASEa)_ODH2-138 kV** case = new 138 kV - 218 MVA line Lookout to Brand
4. **(C0a_BASEa)_ODH3-138 kV** case = new 138 kV - 218 MVA line Lookout to Crist
5. **(C0a_BASEa)_ODH4-138 kV** case = new 138 kV - 218 MVA line Lookout to Walnut
6. **(C0a_BASEa)_ODH5-138 kV** case = new 138 kV - 218 MVA line Lookout to Fairdale
7. **(C0a_BASEa)_ODH6-138 kV** case = new 138 kV - 218 MVA line Lookout to College

None of the single line 138 kV alternatives studied were able to mitigate the overloads in the system and as such were not selected as viable solutions.

Listed below is a summary of the single-line outage (N-1) results. For this section of the study, single-element, double-element, bus and critical outages were performed for each of the options. These results can be found in appendix B.

Option 1A.C0a_BASEa (FY2020) -138 kV	Lookout=240 MW and Holford=200 MW 138 kV line segments Apollo to Lookout to Holford to Fire Wheel built with bundled Drake ACSS-795 conductor at 436 MVA

Results Summary: • Outage of Fire Wheel to Wylie Sw caused overloading on Apollo to Lookout at 118%, College to Lawler at 113% and Jupiter to Lawler at 126%. • Outage of Apollo to Lookout caused overloads on the Fire Wheel – Wylie Sw at 126% and Fire Wheel – Holford at 117%.	
Option 2A.(C0a_BASEa)_ODH1-138 kV	C0a_BASEa case plus adding a new 138 kV - 218 MVA line Lookout to Ben Davis
Results Summary : • Base case overload Lookout – Ben Davis at 191%	
Option 3A.(C0a_BASEa)_ODH2-138 kV	C0a_BASEa case plus adding a new 138 kV 218 MVA line Lookout to Brand
Results Summary : • Base case overload Brand – Lookout at 177% • Outage of Fire Wheel – Wylie Sw overloads Brand – Ben Davis at 117% • Outage of Brand – Ben Davis overloads Shiloh– McCree at 101%	
Option 4A.(C0a_BASEa)_ODH3-138 kV	C0a_BASEa case plus adding a new 138 kV - 218 MVA line Lookout to Crist
Results Summary: • Base case overload Lookout– Crist 156% • Base case overload Crist – Ben Davis 130% • McCree– Crist 138 kV overload for outage of Crist – Ben Davis	
Option 5A.(C0a_BASEa)_ODH4-138 kV	C0a_BASEa case plus adding a new 138 kV - 218 MVA line Lookout to Fairdale
Results Summary: • Base case overloads Walnut – Lookout 138 kV at 119% • Fairdale – Walnut 138 kV overloads at 135% for outage of Walnut – Newman • Miller – Newman 138 kV line overloads at 119% for Fairdale –Walnut outage • Brand – College 138 kV line overloads at 101% for Shiloh – McCree outage	
Option 6A.(C0a_BASEa)_ODH5-138 kV	C0a_BASEa case plus adding a new 138 kV - 218 MVA line Lookout to Fairdale
Results Summary: • Base case overload Fairdale – Lookout 138 kV at 127% • Brand – College 138 kV line overloads at 112% for outage of Shiloh – McCree • Shiloh – McCree 138 kV line overloads at 106% for outage of Brand – College	

Option 7A.(C0a_BASEa)_ODH6-138 kV	C0a_BASEa case plus adding a new 138 kV - 218 MVA line Lookout to College

Results Summary:

- Base case overload Fairdale – Lookout 138 kV at 127%
- Brand – College 138 kV line overloads at 112% for outage of Shiloh – McCree
- Shiloh – McCree 138 kV line overloads at 106% for outage of Brand – College

3. POTENTIAL 345 KV OPTIONS

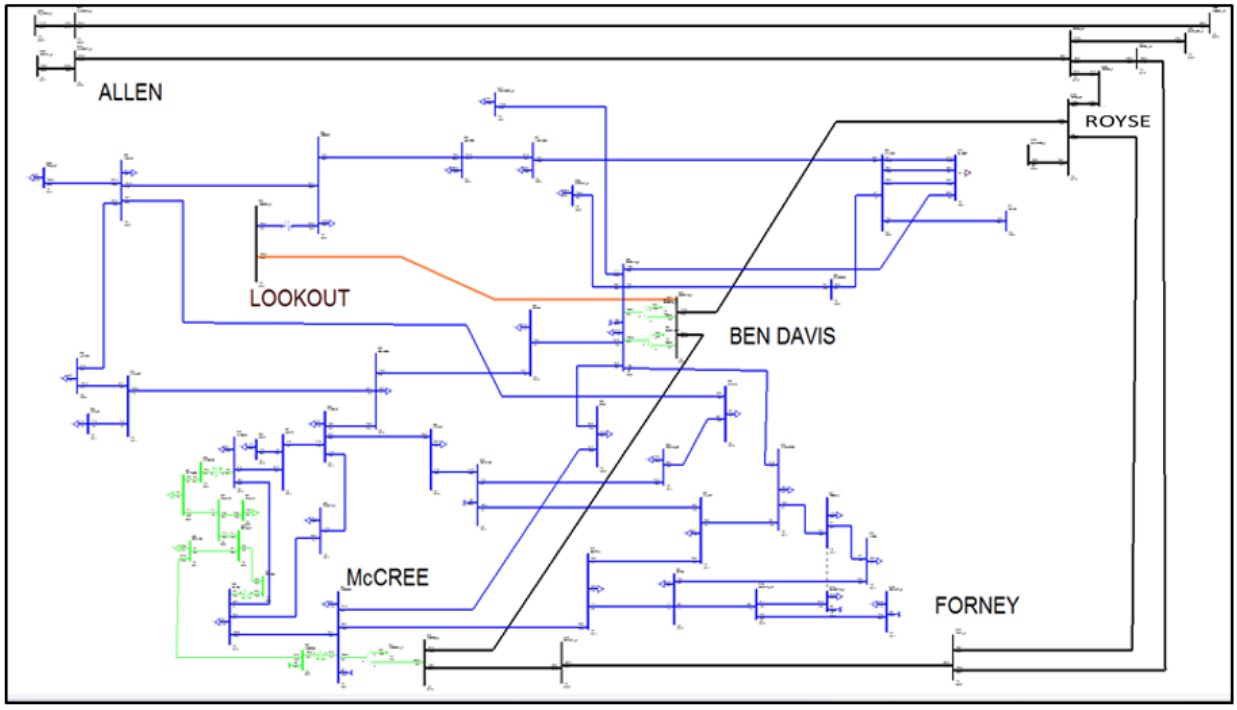
Because of the limitations of the 138 kV system in this area, there is a need to examine possible 345 kV alternatives. For this area, three alternatives were compared for performance.

The base case used for this section of the studies was developed in 2015 and load and topologies were modeled for the future year 2020. In this base case two lumped loads were added to Lookout at 240 MW and Holford at 200 MW. Also for this base case the 138 kV line segments from East Richardson to Apollo to Lookout to Holford to Fire Wheel were upgraded with Cumberland ACSS/TW, 1926.9 conductor with a thermal rating of 495 MVA. (This is case C0_BASE). Results from this section of the study can be found in the Appendix B with summaries of the results in the following text.

C0_BASE	Load added to Lookout @ 240 MW and Holford @ 200 MW. Reconductored the 138kV line from East Richardson to Apollo to Lookout to Holford to Fire Wheel to Cumberland ACSS/TW - 1926.9 conductor with a thermal ratings of 495 MVA.
Option 1:C0_01	C0_BASE case plus adding of a single 345 kV-1420 MVA line Lookout to Ben Davis and a new 345/138 kV – 600 MVA transformer at Lookout
Option 2: C0_02	C0_BASE case plus adding of building Lookout – Ben Davis line as loop circuit IN-OUT (additional line 345 kV – 1420 MVA line) and a new 345/138 kV – 600 MVA transformer at Lookout
Option 3:C0_03	C0_BASE At Lookout Substation add two 600 MVA 345/138 kV transformers and four breaker ring bus. Build a single 345 kV circuit from the Lookout substation to Lavon Sw. Sta. From the Lavon Sw. Sta. add an additional 345 kV circuit along the existing corridor to Royse Sw. Sta. This circuit will added to existing towers. Add a single 345 kV circuit from Lookout Substation to McCree Substation. From the McCree substation add an additional circuit to the existing towers to the Forney substation. This circuit will use existing towers.

3.1 Option 1

Description: Build a single 345 kV circuit from Ben Davis to Lookout substation. Install a 600 MVA 345/138 kV autotransformer.



Map of Option 1: Orange indicates
new 345 kV transmission circuit

3.2 Results for Option 1

Under single-contingency outage of the new Lookout autotransformer or the new 345 kV line from Ben Davis to Lookout substations results in overloads of the Jupiter to Lawler and Lawler to College line to 115% and 119%, respectfully.

For this portion of the study the Lookout autotransformer was modeled at 500 MVA, and for the outage of the McCree autotransformer this autotransformer loads to near 100%. This device overloads if the Fire Wheel to Wylie line is tripped. From this result it is recommended that the autotransformers rating match other

autotransformers at 600 MVA. Moreover, since outage of this single device shows overloads in the system an additional transformer should be added.

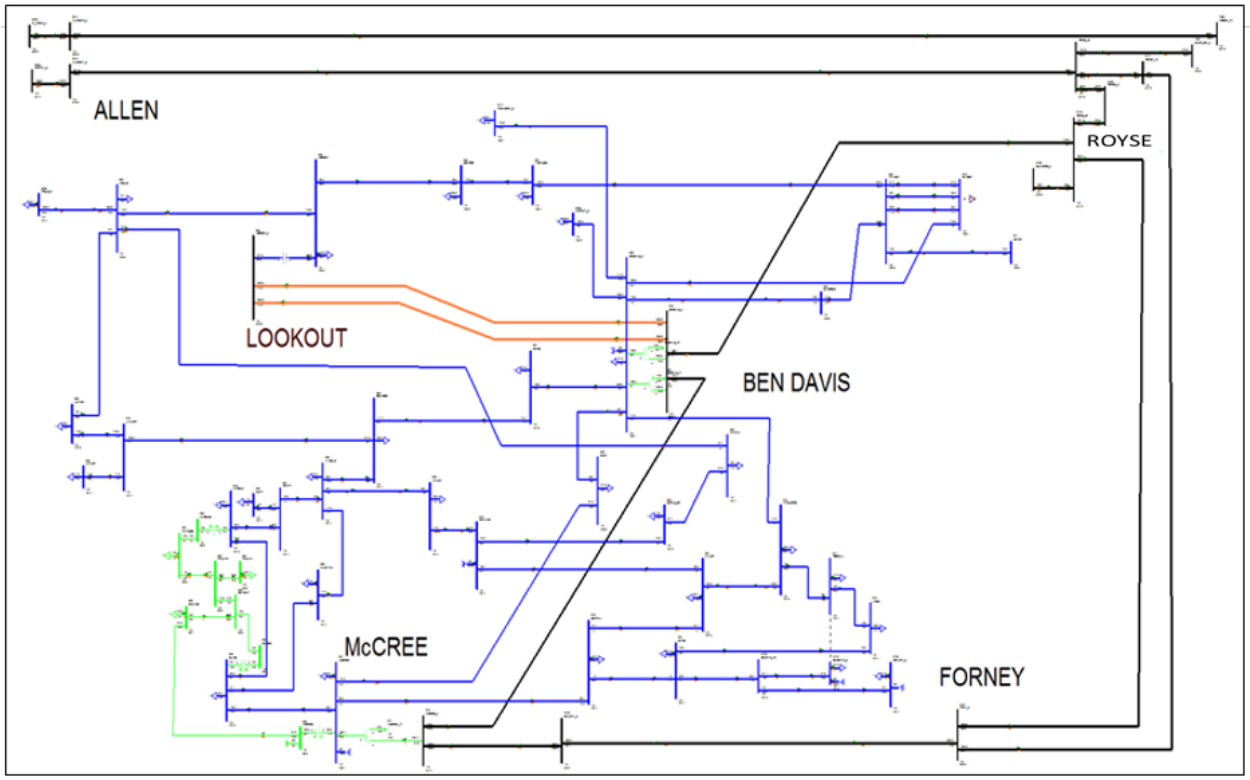
The following table shows the improvement for local N-1-1 (Doubles) outages in the Garland area.

BRANCH							CONTINGENCY	MVAFLOW	AMPFLOW	RATE A/B	% FLOW	Paired
	C0_O1											
802	APOLLO	138	806	JUPITER	138	1	DOUBLE 2467(821-833(1):828-856(1))	312.67	324.22	218.00	148.73	A
802	APOLLO	138	828	LOOKOUT	138	1	DOUBLE 2479(821-833(1):856-970(1))	-482.44	509.11	495.00	102.85	B
806	JUPITER	138	815	LAWLERT	138	1	DOUBLE 2467(821-833(1):828-856(1))	354.52	365.65	218.00	167.73	C
815	LAWLERT	138	829	COLLEGE8	138	1	DOUBLE 2467(821-833(1):828-856(1))	367.08	377.36	218.00	173.10	D
821	FIREWHEEL	138	833	WYLIESW	138	1	DOUBLE 456(802-828(1):856-970(1))	485.36	555.36	436.00	127.38	E
821	FIREWHEEL	138	835	HOLFORD	138	1	DOUBLE 456(802-828(1):856-970(1))	-449.73	517.69	495.00	104.58	F
825	NAAMAN	138	826	CASTLE_DR	138	1	DOUBLE 1885(815-829(1):828-856(1))	229.59	233.68	218.00	107.19	G
826	CASTLE_DR	138	849	NEWMAN8	138	1	DOUBLE 1885(815-829(1):828-856(1))	246.23	249.92	218.00	114.64	H
827	BRAND	138	829	COLLEGE8	138	1	DOUBLE 2843(828-856(1):830-834(1))	-238.42	242.32	218.00	111.16	I
828	LOOKOUT	138	856	LOOKOUT_5	345	1	DOUBLE 2474(821-833(1):834-973-974(1))	-628.95	628.95	500.00	125.79	
830	SHILOH	138	834	MCCREE8	138	1	DOUBLE 2775(827-968(1):828-856(1))	314.71	318.70	306.00	104.15	J
912	N_DENT69	69	985	N_DENT_8	138	2	DOUBLE 3231(912-985(1):981-982(1))	-69.78	69.78	60.00	116.30	K
	C0_BASE											
801	KRAFTT	138	848	MARQUIS	138	1	DOUBLE 996(808-830(1):827-968(1))	240.67	244.20	218.00	112.02	
801	KRAFTT	138	805	FAIRDALE	138	1	DOUBLE 996(808-830(1):827-968(1))	-235.66	239.61	218.00	109.91	
802	APOLLO	138	806	JUPITER	138	1	DOUBLE 2385(821-833(1):826-849(1))	436.54	455.80	218.00	209.08	A
802	APOLLO	138	825	NAAMAN	138	1	DOUBLE 1821(815-829(1):821-833(1))	327.71	345.48	218.00	158.48	
802	APOLLO	138	828	LOOKOUT	138	1	DOUBLE 1821(815-829(1):821-833(1))	-482.47	517.95	495.00	104.64	B
805	FAIRDALE	138	823	WALNUT	138	1	DOUBLE 1825(815-829(1):824-849(1))	-241.98	244.69	218.00	112.25	
805	FAIRDALE	138	808	PLASTIPAK	138	1	DOUBLE 2682(827-968(1):830-848(1))	235.59	239.57	218.00	109.90	
806	JUPITER	138	815	LAWLERT	138	1	BASE CASE	245.34	249.66	218.00	114.52	C
808	PLASTIPAK	138	830	SHILOH	138	1	DOUBLE 2682(827-968(1):830-848(1))	249.81	253.36	218.00	116.22	
810	CENTRVIL	138	834	MCCREE8	138	1	DOUBLE 2681(827-968(1):830-834(1))	243.27	245.52	218.00	112.62	
815	LAWLERT	138	829	COLLEGE8	138	1	BASE CASE	257.21	261.21	218.00	119.82	D
821	FIREWHEEL	138	833	WYLIESW	138	1	DOUBLE 404(802-828(1):811-833(1))	485.61	572.91	436.00	131.40	E
821	FIREWHEEL	138	835	HOLFORD	138	1	DOUBLE 404(802-828(1):811-833(1))	-449.80	534.06	495.00	107.89	F
824	MILLER	138	849	NEWMAN8	138	1	DOUBLE 2681(827-968(1):830-834(1))	-333.98	341.72	218.00	156.75	
825	NAAMAN	138	826	CASTLE_DR	138	1	DOUBLE 1821(815-829(1):821-833(1))	356.58	368.95	218.00	169.24	G
826	CASTLE_DR	138	849	NEWMAN8	138	1	DOUBLE 1821(815-829(1):821-833(1))	374.37	385.46	218.00	176.82	H
827	BRAND	138	829	COLLEGE8	138	1	DOUBLE 2543(824-849(1):830-834(1))	-336.79	344.29	218.00	157.93	I
830	SHILOH	138	834	MCCREE8	138	1	DOUBLE 2541(824-849(1):827-968(1))	420.14	426.66	306.00	139.43	J
830	SHILOH	138	848	MARQUIS	138	1	DOUBLE 650(805-808(1):827-829(1))	-248.12	251.14	218.00	115.20	
831	OATES	138	###	MSQTN1T_8	138	1	DOUBLE 2934(834-973-974(1):968-970-994(1))	235.35	238.94	214.00	111.65	
850	CRIST	138	968	BENDAVIS_	138	1	DOUBLE 2687(827-968(1):834-973-974(1))	243.38	245.60	220.00	111.64	
912	N_DENT69	69	985	N_DENT_8	138	2	DOUBLE 3068(912-985(1):981-982(1))	-70.11	70.11	60.00	116.85	K
968	BENDAVIS_	138	3WNI	BNDVSX2	WND	2	DOUBLE 2934(834-973-974(1):968-970-994(1))	506.59	506.59	448.00	113.08	
970	BENDAVIS_	345	3WNI	BNDVSX2	WND	2	DOUBLE 2934(834-973-974(1):968-970-994(1))	517.94	517.94	448.00	115.61	

Because of the number and type of overloads this option was not considered viable.

3.3 Option 2

Build two circuits from Ben Davis to Lookout such that they are independent towers. Install a 600 MVA 345/138kV autotransformer at Lookout substation.



Map of Option 2: Orange indicates
New 345 kV transmission circuit

3.4 Results for Option 2

Outage of the new Lookout 345/138 kV transformer results in overloading of the Lawler – Jupiter and Lawler – College 138 kV lines at 115% and 120% of their thermal limit, respectively. Also outage of the Fire Wheel – Wylie line resulted in overloading of the new Lookout autotransformer to 108% of it thermal limit. This condition shows that there is a need for a second autotransformer or an autotransformer with a higher rating.

Outage of the Ben Davis to Royse Sw. Sta. and McCree to Centerville 345 kV lines (N-1-1) results in overloading of the Centerville to Oates line at 112% and Wylie to Nevada line at 105%. Also for this condition, the voltage across North Garland drops below acceptable limits at Lookout, Holford, Fire Wheel and Murphy.

BRANCH							CONTINGENCY	MVAFLOW	AMPFLOW	RATE A/B	% FLOW
802	APOLLO	138	806	JUPITER	138	1	DOUBLE 2428(821-833(1):828-856(1))	312.60	324.14	218.00	148.69
802	APOLLO	138	828	LOOKOUT	138	1	DOUBLE 2428(821-833(1):828-856(1))	-482.44	509.05	495.00	102.84
806	JUPITER	138	815	LAWLERT	138	1	DOUBLE 2428(821-833(1):828-856(1))	354.45	365.55	218.00	167.69
815	LAWLERT	138	829	COLLEGE8	138	1	DOUBLE 2428(821-833(1):828-856(1))	367.01	377.26	218.00	173.06
821	FIREWHEEL	138	833	WYLIESW	138	1	DOUBLE 439(802-828(1):828-856(1))	485.36	555.32	436.00	127.37
821	FIREWHEEL	138	835	HOLFORD	138	1	DOUBLE 439(802-828(1):828-856(1))	-449.73	517.65	495.00	104.58
824	MILLER	138	849	NEWMAN8	138	1	DOUBLE 2729(827-968(1):830-834(1))	254.77	255.38	218.00	117.15
825	NAAMAN	138	826	CASTLE_DR	138	1	DOUBLE 1858(815-829(1):828-856(1))	229.53	233.61	218.00	107.16
826	CASTLE_DR	138	849	NEWMAN8	138	1	DOUBLE 1858(815-829(1):828-856(1))	246.17	249.85	218.00	114.61
827	BRAND	138	829	COLLEGE8	138	1	DOUBLE 2587(824-849(1):830-834(1))	265.92	265.46	218.00	121.77
828	LOOKOUT	138	856	LOOKOUT_5	345	1	DOUBLE 1848(815-829(1):821-833(1))	-500.69	500.69	500.00	100.14
830	SHILOH	138	834	MCCREE8	138	1	DOUBLE 2584(824-849(1):827-968(1))	-334.73	333.52	306.00	108.99
912	N_DENT69	69	985	N_DENT_8	138	2	DOUBLE 3149(912-985(1):981-982(1))	-70.17	70.17	60.00	116.95
968	BENDAVIS_8	138	3WNDTR	BNDVSX2	WND 2	2	DOUBLE 3015(834-973-974(1):968-970-994(1))	451.89	451.89	448.00	100.87
970	BENDAVIS_5	345	3WNDTR	BNDVSX2	WND 1	2	DOUBLE 3015(834-973-974(1):968-970-994(1))	455.93	455.93	448.00	101.77

3.5 Additional consideration

Additional consideration beyond servicing load is that the Ben Davis substation is currently built in a Federal Emergency Management Agency (FEMA) designated floodway, and recently has been flooded. Because of the flood way, there is a concern that expanding this substation to accommodate two additional 345 kV lines would take a considerable amount of time and money. Additional time will be required to obtain FEMA permits and cost due to obstruction of the flood water way requirements. Expanding the substation two allow two additional 345 kV lines from this critical substation would affect the flow of water in the flood way and require additional permits. (FEMA Flood map for the Ben Davis substation is attached in appendix).

During the flood, the Ben Davis Substation sustained damage to fencing and gravel surfacing from a recent Rowlett Creek flood event. Garland has plans to rebuild the Ben Davis substation and build key elements such as the control house and transformer on stilts.

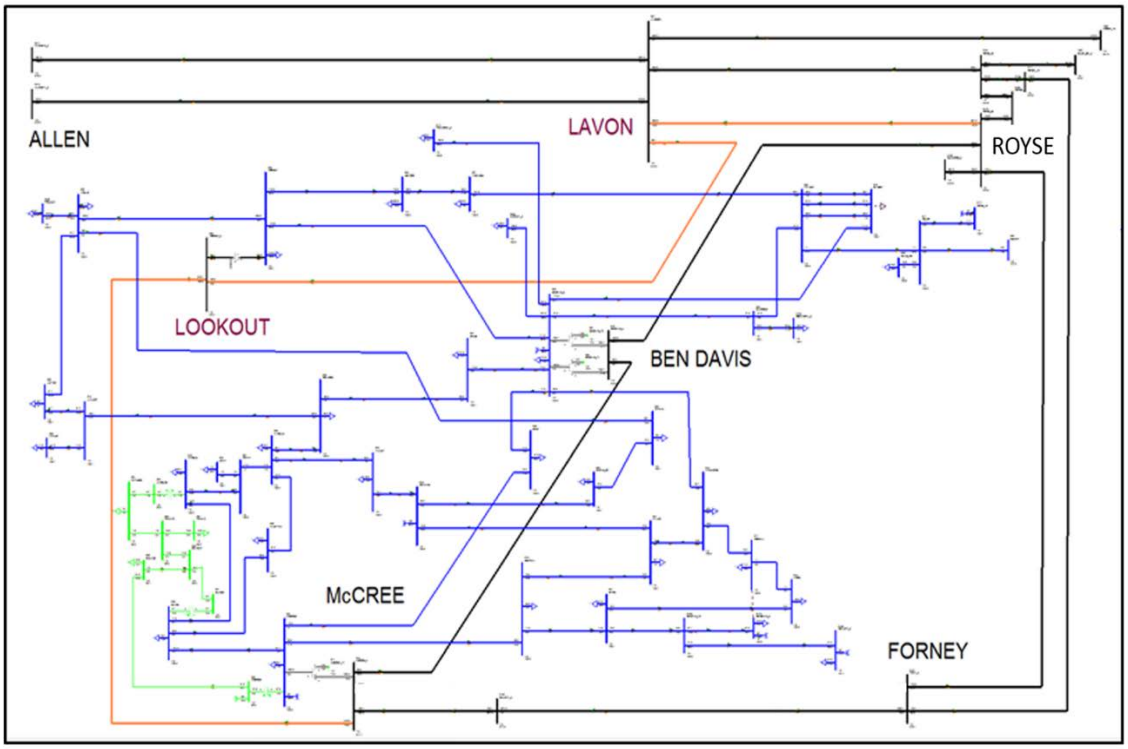
Moreover, the City of Garland is concerned that expanding the Ben Davis substation beyond its current footprint adds unnecessary reliability risk. Currently, there are already two autotransformers to support two 345 kV and seven 138 kV transmission lines. This is one of the key critical substations for the Garland system. This added risk highlights the over dependence of Garland on the Ben Davis substation. It is useful and practical that Garland limits the new growth at Ben Davis and focus growth to the new Lookout substation.

Ben Davis Substation located in Flood Way

Ben Davis Substation during 2015 Flood

3.6 Option 3:

Construct Lavon Sw. Sta. with 9-breaker 345 kV breaker-and-a-half bus arrangement. Construct the Lavon Sw. Sta. – Lookout Substation 345 kV circuit and Lavon Sw. Sta. – Royse Sw. Sta. 345 kV circuit. Parts of these circuits will be added to the existing Royse Sw. Sta. – Ben Davis 345 kV line. The Lookout substation should accommodate two 345/138 kV 600 MVA transformers and a four breaker 345 kV ring-bus configuration. Initially, only one transformer needs to be installed and second transformer installing is dependent on load growth. Build a 345 kV transmission line from Lookout to McCree substation. Furthermore, as load grows in this area an additional distribution substation will be required three miles south of Lookout substation. The tentative name of this substation is Holford. To serve this substation a new 138 kV, 495MVA (Cumberland) circuit between Holford and Ben Davis will be required. The following one-line diagram shows the 345 kV upgrades required for this project. Solid orange lines are new 345 kV constructions.



Map of Option 3: Orange indicates new 345 kV transmission circuit

3.7 Results for Option 3

The following table shows results for Option 3 with the under single-contingency outages. Two outages (N-1-1) showed the need for additional upgrades, namely that a second transformer should be installed at the Lookout substation for the outage of McCree autotransformer. Also, for the outage of one of the Lavon Sw. Sta. to Allen Sw. Sta. lines, there is a need to increase the rating of the existing 345 kV line from 1076 MVA to match the rating of the parallel line of 1631 MVA.

BRANCH							CONTINGENCY (n-1)	MVAFLOW	AMPFLOW	RATE A/B	% FLOW
	Option 3										
828	LOOKOUT	138	856	LOOKOUT_5	345	1	SINGLE 834-973-974(1)	-539.81	539.81	500.00	107.96
857	LAVONGPL	345	2514	ALLENSW2_5	345	1	SINGLE 857-2513(1)	-1223.90	1243.70	1076.00	115.59
	C0_BASE										
802	APOLLO	138	806	JUPITER	138	1	SINGLE 821-833(1)	312.65	324.22	218.00	148.72
802	APOLLO	138	828	LOOKOUT	138	1	SINGLE 821-833(1)	-482.44	509.11	495.00	102.85
806	JUPITER	138	815	LAWLERT	138	1	BASE CASE	245.34	249.66	218.00	114.52
815	LAWLERT	138	829	COLLEGE8	138	1	BASE CASE	257.21	261.21	218.00	119.82
821	FIREWHEEL	138	833	WYLIESW	138	1	SINGLE 802-828(1)	485.36	555.39	436.00	127.38
821	FIREWHEEL	138	835	HOLFORD	138	1	SINGLE 802-828(1)	-449.73	517.72	495.00	104.59
825	NAAMAN	138	826	CASTLE_DR	138	1	SINGLE 815-829(1)	229.57	233.67	218.00	107.19
826	CASTLE_DR	138	849	NEWMAN8	138	1	SINGLE 815-829(1)	246.21	249.92	218.00	114.64
827	BRAND	138	829	COLLEGE8	138	1	SINGLE 830-834(1)	-238.40	242.31	218.00	111.15
830	SHILOH	138	834	MCCREE8	138	1	SINGLE 827-968(1)	314.69	318.70	306.00	104.15

The following table shows the performance of the Option 3 under N-1-1 conditions.

Double-contingency outage 2941 is the outage of the autotransformer at Lookout and the Ben Davis to Lookout 138 kV line. With the addition of a second Lookout autotransformer this concern is removed. Similarly, outage Double 3550 is the outage of the two Ben Davis autotransformers, this outage causes the Lookout autotransformer to overload to 122%. This overload is also removed with the adding of a second autotransformer at Lookout substation.

BRANCH							CONTINGENCY (n-1-1)	MVAFLOW	AMPFLOW	RATE A/B	% FLOW
	Option 3										
806	JUPITER	138	815	LAWLERT	138	1	DOUBLE 2941(828-856(1):828-968(1))	240.35	243.99	218.00	111.92
815	LAWLERT	138	829	COLLEGE8	138	1	DOUBLE 2941(828-856(1):828-968(1))	252.15	255.49	218.00	117.20
828	LOOKOUT	138	856	LOOKOUT_5	345	1	DOUBLE 3550(968-970-994(1):968-970-993(2))	-611.21	611.21	500.00	122.24
912	N_DENT69	69	985	N_DENT_8	138	2	DOUBLE 3398(912-985(1):981-982(1))	-69.27	69.27	60.00	115.44

RECOMMENDATION

This report reviewed a series of options to service the new load growth in the Northern Garland area. Currently, the North Garland area is supported by a single 138 kV transmission line. The 138 kV line interconnects to the east at Ben Davis and to the west at Apollo. This transmission line was originally built using 795 ACSR with a thermal conductor rating of 218 MVA.

This study demonstrates that adding several 138 kV lines to meet the high load growth was impractical and did not meet the ERCOT reliability criteria and the NERC Planning Standard, and a 345 kV solution is required. Moreover, using a joint planning approach a solution was found that provides both support to the load and additional support to the overall system. Garland Power & Light and Oncor strongly recommend Option 3 solution to support the load growth in North Garland.

The following list is the highlights of this project:

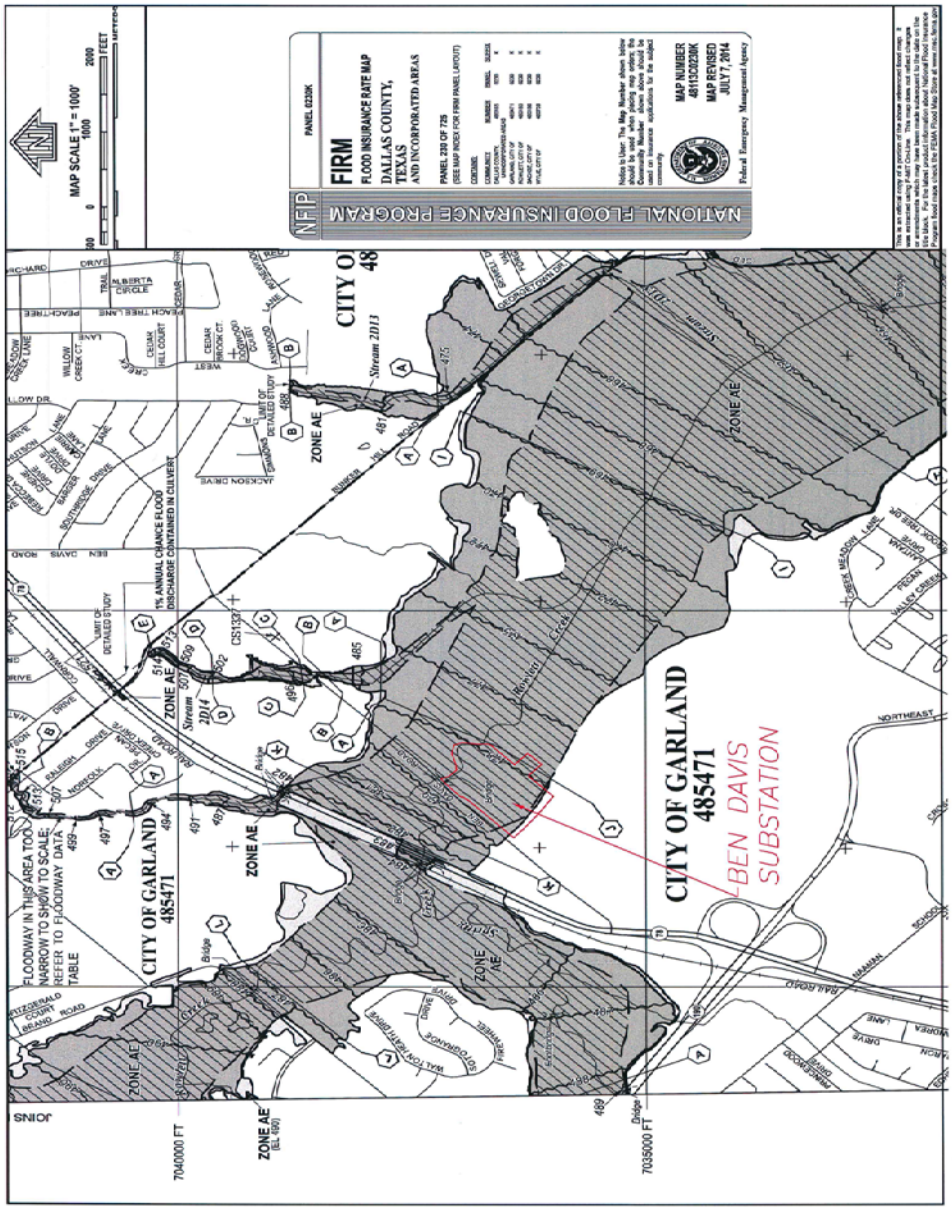
1. Meets load growth for the Garland area now and into the future.

2. This solution as outlined, provides for a more robust 345 kV loop around the Garland system and increases the overall reliability for this area.

3. Ben Davis is a major transmission hub for the Garland area, and due to the recent flooding there is concern with the overall reliability of this substation and Garland overdependence on this substation. Adding the N-GRIP transmission projects reduces this dependency and adds a new transmission feed into the Garland system.

4. APPENDIX

Diagram of Ben Davis substation showing FEMA flood way



Lookout Substation One-line