City of Grand Island

Tuesday, April 21, 2009
Study Session

Item -2

Transmission Line and Substation Engineering Study; Northern Interconnection Route Analysis

Staff Contact: Gary R. Mader

Council Agenda Memo

From: Gary R. Mader, Utilities Director

Meeting: April 21, 2009

Subject: Presentation of Transmission Line Route Study

Item #'s:

Presenter(s): Gary R. Mader, Utilities Director

Background

The Electric Department has electric distribution substations connected at various distances along a 115 kV transmission loop. The loop generally runs along the outer edge of the urban area, providing power to the substations and providing power supply redundancy by use of the looped configuration. A map of the transmission system is attached for reference. Substations reduce voltage from the 115,000 volt level to 13,800 volts for distribution to individual customers across the City. Substations "E," located north of Swift on the east side of the loop, and "F," located north of Menards on the west side of the loop, are the newest substations. They were placed in initial service in 2001, and completed in 2007.

Power Generation and regional interconnections to NPPD are concentrated on the south and east side of the transmission system loop. The northern portion of the transmission loop has no interconnections. And while it can sustain a single line segment loss contingency, any additional failure could result in loss of several major substations, resulting in power loss to major portions of the City. With power plant and regional grid interconnections, the southern portion of the transmission loop has more redundancy.

Recognizing that the City is continuing to grow, that future transmission line construction will occur and that reliability improvement is always important, Substations "E" and "F" were constructed with provisions to accept additional 115 kV transmission interconnections. In the long range plan of the Electric Department, these substations are designed for new transmission interconnections as future load growth may require.

Advantage Engineering (AE) was contracted in 2006 to perform a Transmission and Substation System Study for the City of Grand Island Utilities Department (GIUD). Various alternatives and solutions were analyzed for the logical and economic expansion of the GIUD's 115 kV transmission loop, power interconnections with Nebraska Public

Power District (NPPD), substations, distribution, and communications. The system study period was ten (10) years (2006-2016) taking into account projected City expansion and load growth. When fully implemented, the major substation and transmission requirements should be satisfied through 2027.

The Transmission and Substation System Study was completed in 2007 and contained a detailed analysis of previous studies and reports; surrounding area power provider plans; State wide planned improvements; Contractual obligations; the City's comprehensive development plans; system capabilities and capacities; land use issues; and schedule related items. The study resulted in recommendations to expand the GIUD's transmission system to serve load growth and assure reliability. The results of the Transmission and Substation System Study were presented to the Grand Island City Council on January 8, 2008.

Discussion

One of the system improvements identified in the Transmission and Substation System Study was the need for providing a second 115 kV power supply to GIUD's Substation F. In the study it was recommended that a new 115 kV line be constructed to connect the open 115 kV transmission bay at GIUD's Substation F to the Nebraska Public Power District (NPPD) St. Libory Junction northwest of the City. The new 115 kV line would be approximately 7 miles in length and would require that GIUD select a route for the new line and obtain new transmission line easements necessary to construct the line. This new transmission line would improve the reliability of the entire GUID transmission system by providing an additional connection to the regional electric grid, to the north.

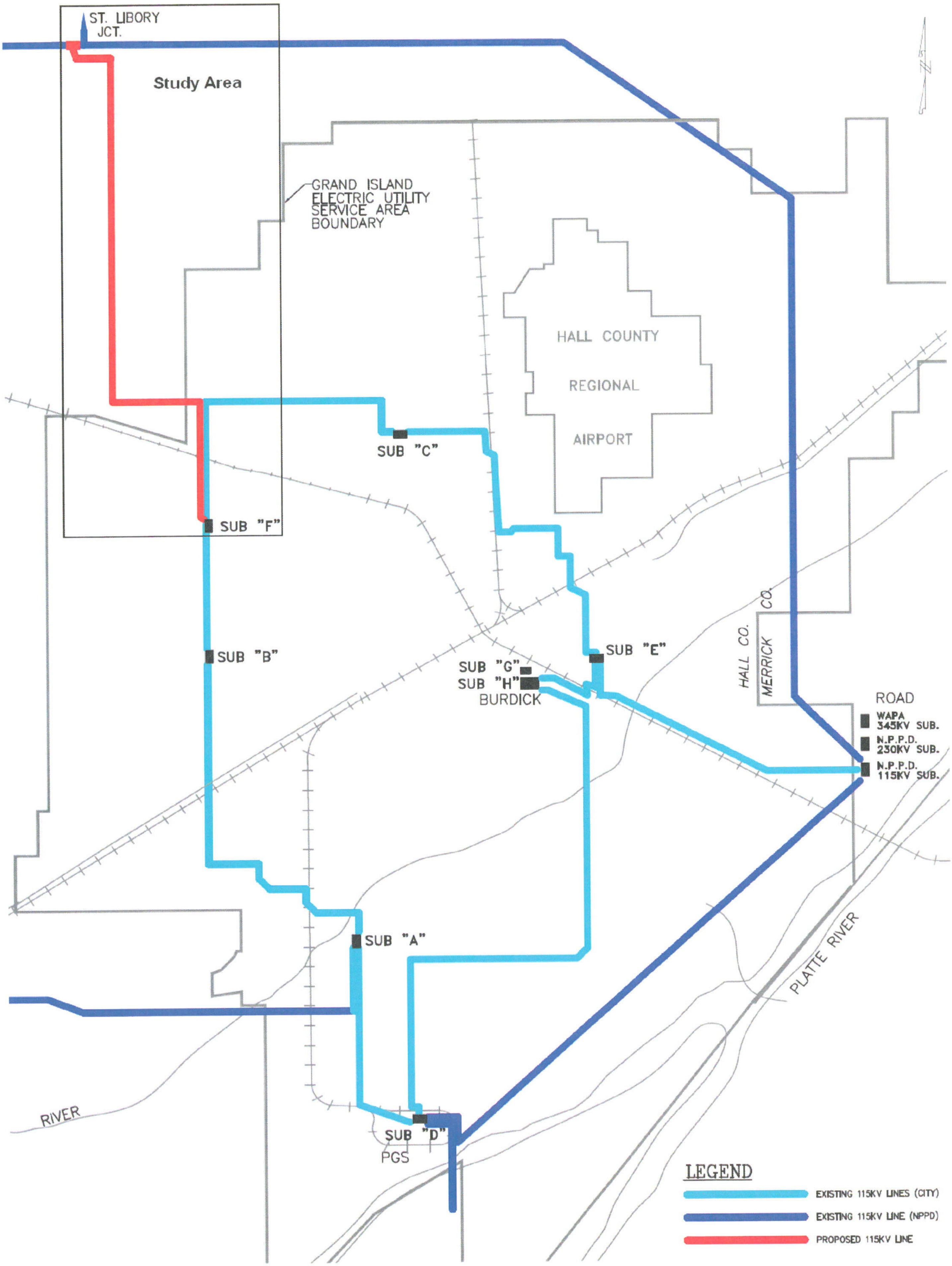
The purpose of this routing report is to assist GIUD in determining the most advantageous route for the GIUD Substation F to NPPD St. Libory Junction 115 kV transmission line.

A comprehensive field study was conducted of the area between the existing GIUD Substation F and the NPPD St. Libory Junction Substation Site. As a result of the field analysis, five alternate routes were selected and evaluated for the project. The evaluation of each route included a technical evaluation, a land use evaluation, an environmental evaluation, and an economic evaluation.

This presentation will cover the five alternate routes that were studied as well as the various design criteria used.

Conclusion

This item is presented to the City Council in a Study Session to allow for any questions to be answered and to create a greater understanding of the issue at hand.



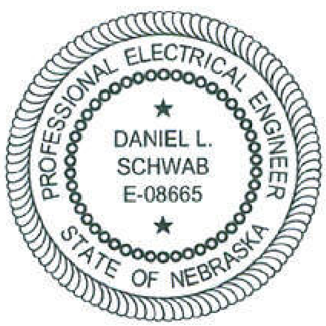
ST. LIBORY JCT.
Study Area
GRAND ISLAND ELECTRIC UTILITY SERVICE AREA BOUNDARY
HALL COUNTY REGIONAL AIRPORT
SUB "C"
SUB "F"
SUB "B"
SUB "E"
SUB "G"
SUB "H"
BURDICK
HALL CO.
MERRICK CO.
ROAD
WAPA 345KV SUB.
N.P.P.D. 230KV SUB.
N.P.P.D. 115KV SUB.
SUB "A"
PLATTE RIVER
RIVER
SUB "D"
PGS
LEGEND
EXISTING 115KV LINES (CITY)
EXISTING 115KV LINE (NPPD)
PROPOSED 115KV LINE

CITY OF GRAND ISLAND, NEBRASKA

New 115 kV Line - Substation F to St. Libory Junction

ROUTE STUDY REPORT

April 2009



ADVANTAGE ENGINEERING, INC.
769 SPIRIT OF ST. LOUIS BLVD.
CHESTERFIELD, MO 63005
Tel: 636-530-0470 Fax: 636-530-0670

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1.0 INTRODUCTION

The City of Grand Island Utilities Department (GIUD) proposes to construct and operate a new 115 kV transmission line northwest of the City in Hall County. The line will begin at the existing GIUD Substation F, located on Capital Avenue, and terminate at a new Nebraska Public Power District (NPPD) Substation to be constructed at the existing St. Libory Junction site on Engleman Road between Chapman Road and Prairie Road. The new line is needed to provide a second power supply at Substation F, and the northern portion of the GIUD 115 kV transmission loop.

A map of the Grand Island area showing the location of the existing 115 kV substations, 115 kV transmision lines, and the recommended line route for the proposed new line between the GIUD Substation F and NPPD St. Libory Junction is shown on Figure 1-1.

A system one-line diagram of the existing GIUD 115 kV system showing the proposed line addition between the GIUD Substation F and NPPD's St. Libory Junction is shown on Figure 1-2.

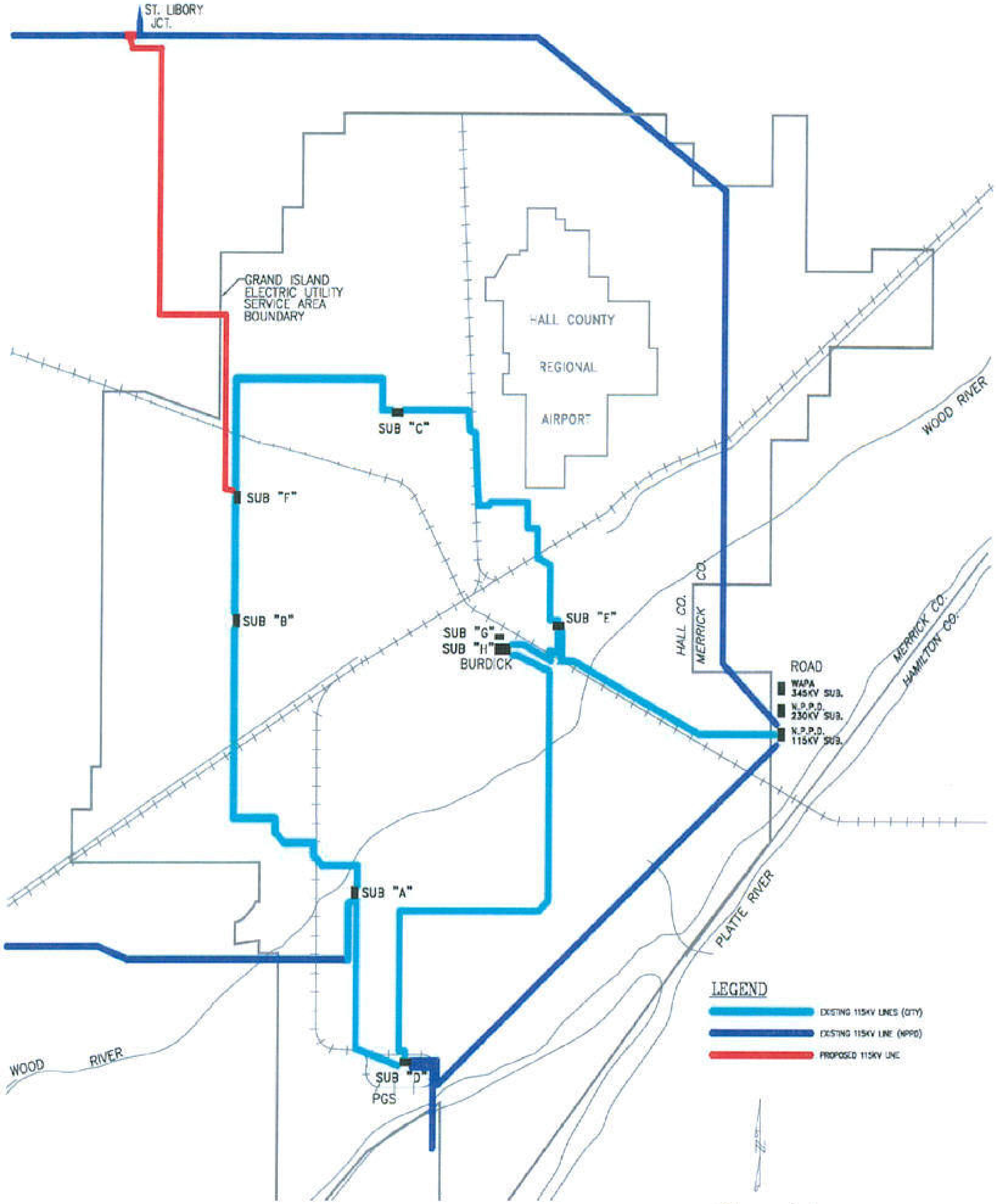


Figure 1-1
GIUD 115 kV System
Line & Substation
Location Map

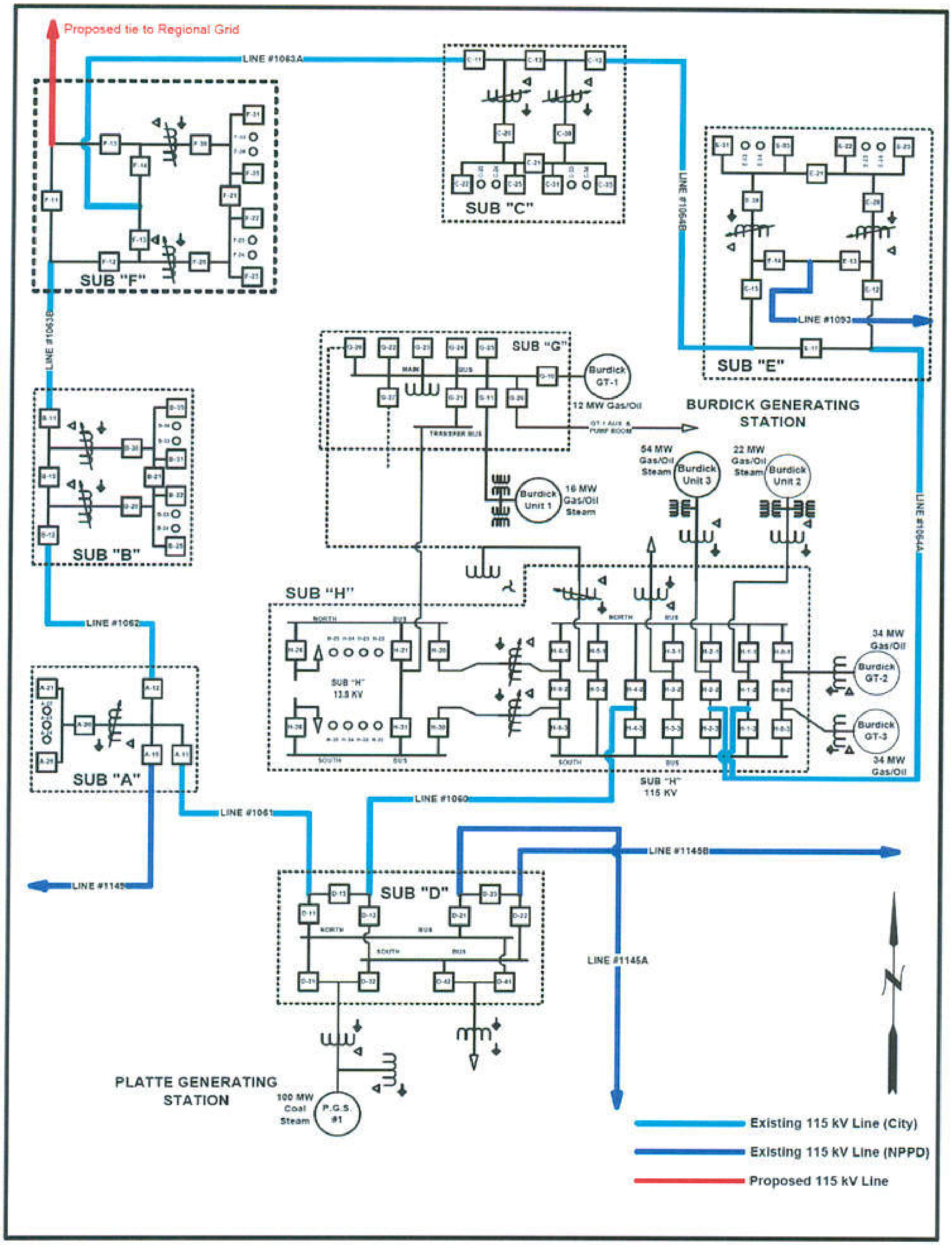


Figure 1-2
GIUD 115 kV System
One-Line Drawing

2.0 SUMMARY OF IMPORTANT INFORMATION

Advantage Engineering (AE) was contracted in 2006 to perform a Transmission and Substation System Study for the City of Grand Island Utilities Department (GIUD). Various alternatives and solutions were analyzed for the logical and economic expansion of the GIUD's 115 kV transmission loop, power interconnections with Nebraska Public Power District (NPPD), substations, distribution, and communications. The system study period was ten (10) years (2006-2016) taking into account projected City expansion and load growth. When fully implemented, the major substation and transmission requirements should be satisfied through 2027.

The Transmission and Substation System Study was completed in 2007 and contained a detailed analysis of previous studies and reports; surrounding area power provider plans; State wide planned improvements; Contractual obligations; the City's comprehensive development plans; system capabilities and capacities; land use issues; and schedule related items. The study resulted in recommendations to expand the GIUD's transmission system to serve load growth and assure reliability. The results of the Transmission and Substation System Study were presented to the Grand Island City Council on January 8, 2008.

One of the system improvements identified in the Transmission and Substation System Study was the need for providing a second 115 kV power supply to GIUD's Substation F. In the study it was recommended that a new 115 kV line be constructed to connect the open 115 kV transmission bay at GIUD's Substation F to the Nebraska Public Power District (NPPD) St. Libory Junction northwest of the City. The new 115 kV line would be approximately 7 miles in length and would require that GIUD select a route for the new line and obtain new transmission line easements necessary to construct the line. This new transmission line would improve the reliability of the entire GUID transmission system by providing an additional connection to the regional electric grid, to the north.

The purpose of this routing report is to assist GIUD in determining the most advantageous route for the GIUD Substation F to NPPD St. Libory Junction 115 kV transmission line.

A comprehensive field study was conducted of the area between the existing GIUD Substation F and the NPPD St. Libory Junction Substation Site. As a result of the field analysis, five alternate routes were selected and evaluated for the project. The alternate routes are shown on Figure A-1, which is located in Appendix A of this report. The evaluation of each route included a technical evaluation, a land use evaluation, an environmental evaluation, and an economic evaluation.

All five alternate routes were so close in all aspects of the evaluation that any one of the routes would be satisfactory for the line. However, it is recommended that the new 115 kV line from Substation F to St. Libory Junction be constructed along Alternate Route 5 for the following reasons.

(1) This route is slightly shorter and more direct than the other alternate routes.
(2) This route requires the least number of angle structures.
(3) This route passes near the least number of homes of any other route.
(4) This route is estimated to cost less than the other four routes evaluated.

3.0 ANALYSIS

3.1 OBJECTIVE OF ANALYSIS

The objective of this analysis is to identify economical, technically feasible, and environmentally compatible route alternatives for a GIUD Substation F to NPPD St. Libory Junction 115 kV regional transmission line interconnection.

3.2 METHODOLOGY OF ANALYSIS

Many independent and interrelated factors must be considered in the identification of a preferred route for an electric power transmission line. These factors include economics, technical and engineering criteria, land use and environmental concerns. This analysis integrates the study of these factors and results in a comparative evaluation of the five alternate routes.

To select the most suitable transmission line route for the proposed GIUD Substation F to St. Libory Junction 115 kV transmission line, appropriate technical and environmental requirements were established and applied to the project study area. This selection process involves four distinct phases with specific objectives.

1. Phase 1 - Identification of the study area and exclusion areas within the study area, and a general characterization of the major land uses within the study area.
2. Phase 2 - Identification of the project technical requirements including the safety requirements, line configuration, right-of-way requirements, radio and TV interference, audible noise, and electric and magnetic field information.
3. Phase 3 - Development of alternate transmission line routes in accordance with project requirements, considering the exclusion areas and routing criteria.
4. Phase 4 - Evaluation of alternate routes leading to the identification of a preferred line route.

3.3 PHASE 1 - STUDY AREA AND EXCLUSION AREAS

The following study areas, exclusion areas and other land requirements have been considered for this analysis and include the following.

3.3.1 Study Area

The line terminals for the GIUD Substation F to St. Libory Junction 115 kV transmission line are the existing GIUD Substation F located on Capital Avenue and the proposed new NPPD St. Libory Junction Substation to be constructed at the site of the existing switch station location on Engleman Road between Chapman Road and Prairie Road. Figure 3-1 shows the locations of these two substations and the line route study area.

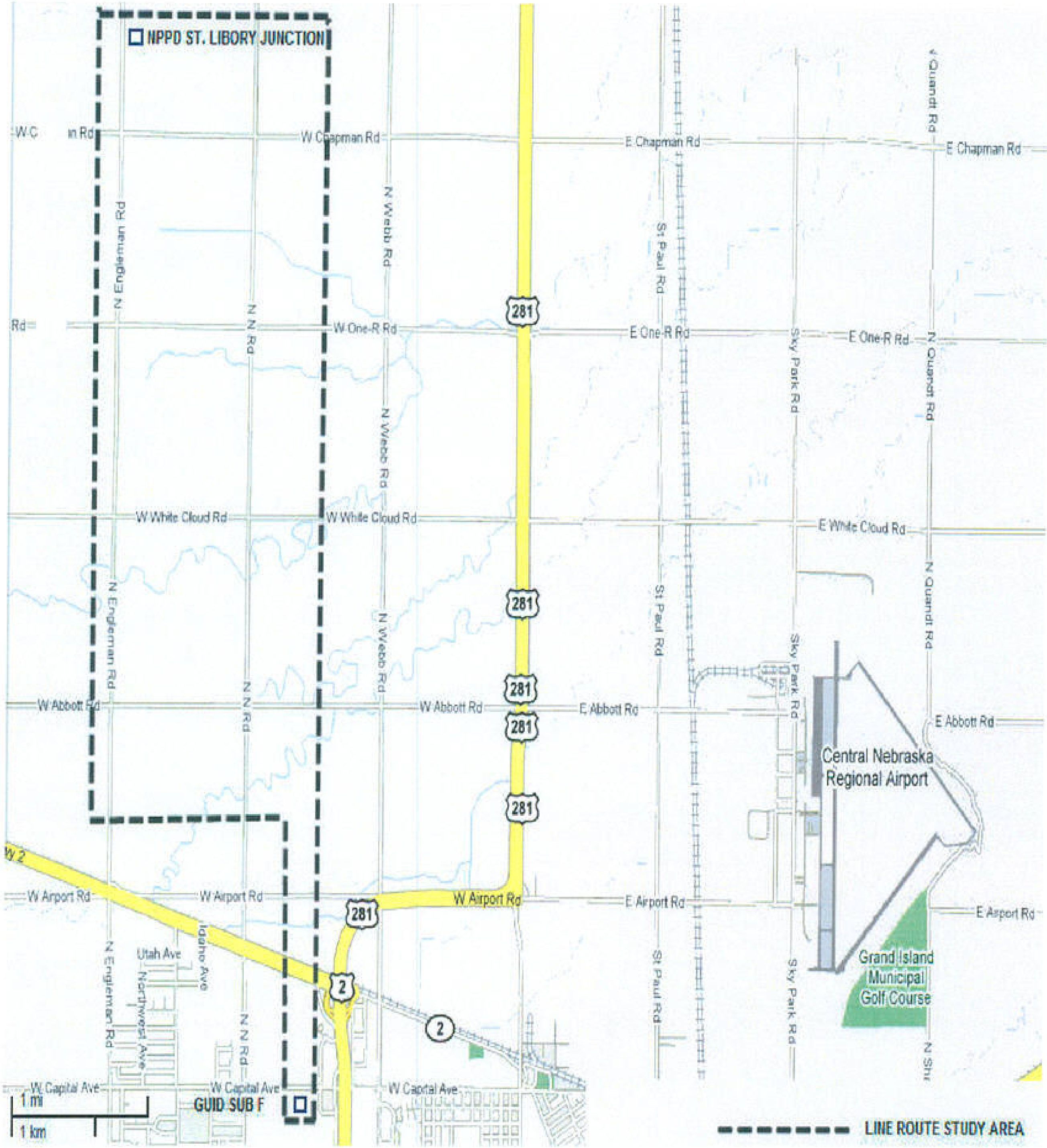


Figure 3-1
LINE ROUTE STUDY AREA
AND SUBSTATION LOCATIONS

3.3.2 Exclusion Areas

Exclusion areas are defined as areas which are to be avoided wherever practical. Such areas include cemeteries, windbreaks, occupied farmsteads, mechanically irrigated land, and airport clear zones. A farmstead in this report refers to that portion of a farm which includes the home and adjacent outbuildings. Center pivot irrigation system's path will define an exclusion area as the line cannot cross the path of the irrigation system.

Other exclusion considerations such as oil, gas, and water wells and known archaeological sites are defined as "exclusion points". Exclusion points may cause slight deflections in the alignment of the final route, but generally will not affect the selection of the overall route. The exclusion points are evaluated by a detailed survey of the proposed routes. The primary design consideration with archaeological sites would be the need to locate structures outside such sites.

If exclusion areas are unavoidable, routes within these areas are selected to minimize disturbances to the surrounding environment as much as possible

The primary land use in the route study area is agricultural crop land. Due to the pivot irrigation systems in the area, possible line route segments were selected that were either along roads or along center section lines to eliminate conflicts . Line routes that are along roads also reduce or minimize the possibility for conflicts with any historical or archaeological sites. There are no know historical or archaeological sites along any of the route segments.

3.4 PHASE 2 - PROJECT TECHINICAL REQUIREMENTS

The following technical requirements for the proposed transmission line construction have been considered for this analysis and include the following.

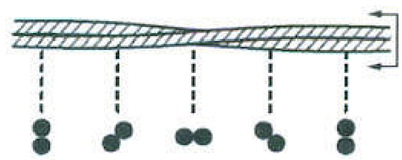
3.4.1 Safety

The National Electric Safety Code (NESC C2) and the laws of Nebraska govern the basic requirements for safeguarding persons from hazards arising from the installation, operation, and maintenance of conductors and equipment of overhead electric transmission lines. The proposed construction would meet or exceed the requirements of the NESC and those of the State of Nebraska.

3.4.2 Line Configuration

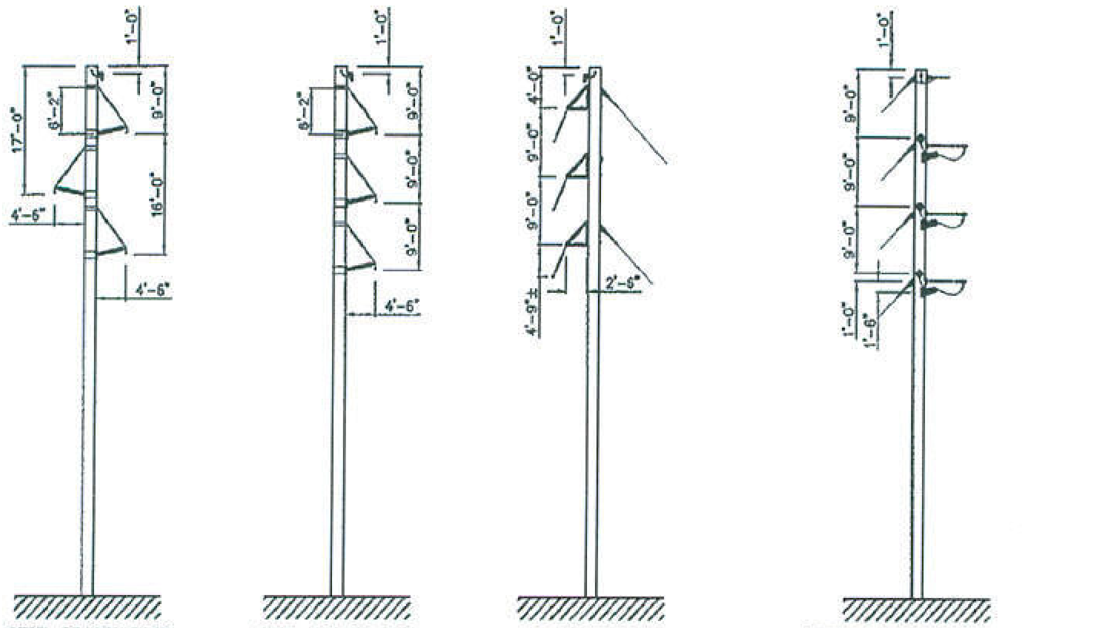
The proposed GIUD Substation F to St. Libory Junction Substation 115 kV transmission line would utilize single pole steel structures. Figure 3-2 illustrates the various single pole structure types that would be used in the design of this line. The single pole configuration was chosen in order to allow the line to be constructed along road right-of-ways and minimize the impact on the adjacent land use. It is proposed that all angle and corner dead end structures be self-supported without down guys or anchors to further minimize the impact on adjacent land use. It is anticipated that the spacing between structures will be approximately 225 to 300 feet.

The conductors will be supported on braced horizontal post insulators. The conductors will be T-2 336.4 kcmil 26/7 ACSR "T-2 Linnet" and the overhead shield wire will be an optical ground wire containing 48 single mode fibers for relay and control between the two substations. The T-2 conductor that is to be used for the line consists of two cables that are twisted together that will prevent the conductor from "galloping" during ice storm events.



3.4.3 Right-of-Way Requirements

A 50 foot wide right-of-way will be required where the line crosses private property and a 27 foot wide right-of-way will be required where the line is adjacent to existing road right-of-way. This right-of-way width meets the safety requirements of the National Electric Safety Code (NESC) and is sufficiently wide to assure that the conductors will not swing outside the right-of-way under the extreme wind design condition of 90 MPH.



STEEL BRACED POST
TANGENT
(SBPT)

STEEL BRACED POST
ANGLE
(SBPA)

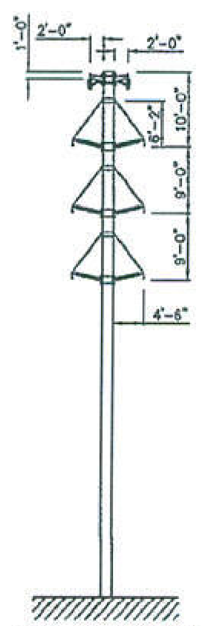
STEEL VERTICAL
FLYING ANGLE
(POLYMER)
(SVF)

STEEL VERTICAL DEAD END &
STEEL VERTICAL DEAD END W/ JUMPER POST
(POLYMER)
(SVD & SVDP)

CITY OF GRAND ISLAND
115KV TRANSMISSION STRUCTURE
SINGLE CIRCUIT STEEL POLE

STEEL VERTICAL DEAD END
NO ANGLE
(POLYMER)
(SVDN)

CITY OF GRAND ISLAND
115KV TRANSMISSION STRUCTURE
SINGLE CIRCUIT STEEL POLE



STEEL DOUBLE CIRCUIT
BRACED POST TANGENT &
BRACED POST TANGENT ANGLE
(SDBPT & SDBPTA)

CITY OF GRAND ISLAND
115KV TRANSMISSION STRUCTURE
DOUBLE CIRCUIT STEEL POLE

FIGURE 3-2
LINE CONFIGURATION
PROPOSED 115KV
STRUCTURES

3.4.4 Radio and TV Interference

Transmission line conductors can result in radio noise that may interfere with AM broadcast band reception. FM broadcast band reception is rarely affected by transmission line generated radio noise. Calculations for the line configuration that is proposed for the new line construction, show that the anticipated level of AM radio Interference is much less than the level that would be needed to cause interference problems, therefore, no AM radio interference is expected from the proposed transmission line.

Transmission line conductors can result in interference with the video portion of analog television reception. The audio portion of analog television reception is a FM signal and is not affected. The FCC has mandated that all full power analog TV broadcasts, with the exception of Low Power TV, will cease on June 12, 2009. After June 12, 2009, all TV broadcasts are to be in high definition digital format. Digital broadcasting will allow stations to offer improved picture and sound quality. Digital TV broadcasting is not affected by the transmission line conductors. The proposed construction of this line will be after the conversion to digital TV, therefore, no interference from the proposed line with television reception is expected.

The proposed line construction is similar to the existing line construction used on GIUD's 115 kV transmission line system around the City of Grand Island. No problems or complaints have been received from the public with regards to radio and TV interference from the existing 115 kV lines and none is expected from the proposed line.

3.4.5 Audible Noise

No audible noise will be heard from a 115 kV transmission line under most weather conditions. However, during wet conditions, the line may emit a moderate level of noise, usually a hiss or hum, that may be heard directly under the line. During heavy rain conditions, the storm noise will usually make the line noise undetectable. Consequently, the 115 kV transmission line will not cause significant noise impacts.

3.4.6 Electric and Magnetic Fields (EMF)

Whenever electricity is used or transmitted, electric and magetic fields (EMFs) are created. The term EMF refers to electric and magnetic fields that are coupled together such as in high frequency radiating fields. For lower frequencies such as for power lines, EMF should be seperated into electric fields and magnetic fields. Transmission lines operate at a frequency of 60 hertz (cycles per second), which is in the non-ionizing portion of the electromagnetic frequency spectrum.

Over the past several years, millions of research dollars have been spent studying this issue in an effort to determine whether EMF can cause adverse health effects. To date, a credible scientific consensus has not determined that such connection exists. These fields are basic forces of nature and are found almost everywhere. An electric field exists wherever there is a difference in voltage. For instance, they are present whenever electric charges build up in the atmosphere in a thunderstorm. The earth's magnetic field causes a compass neddle to point north-south direction and is used by birds and fish for navigation.

On the manmade side, these fields are present in any appliance that uses electricity, whether it is a battery-powered flashlight, the clock radio by your bed, or a power line.

3.4.6.1 Magnetic Fields

Magnetic fields result from the flow of electricity (current) in the transmission line. The intensity of the magnetic field is related to the current flow through the conductors and is not dependent on the line's voltage. The magnetic field associated with the transmission line surrounds the conductor and rapidly decreases with the distance from the conductor. The value of the magnetic field density is expressed in the unit of gauss (G) or milligauss (mG). Recent studies of the health effects from power frequency fields conclude that the evidence that suggests that there may be a health risk is weak.

Magnetic field profiles for the single circuit tangent structure and the double circuit tangent structure configurations proposed for the line during moderate and at maximum operating conditions with the system intact are provide in Appendix B. The magnetic field profile for the proposed single circuit structure configuration are shown on Figures B-1 and B-2. The magnetic field profile for the proposed double circuit structure configuration are shown on Figures B-3 and B-4. On these figures, the structure is centered at 0 feet and distances are measured in feet along the bottom of the graph with the distance to the left being a negative distance and to the right being the positive distance. The proposed right-of-way width (ROW) for both the single circuit and the double circuit structures is 50 feet (25 feet on each side of the centerline). The figures also show the magnetic field strength (bell shaped curve) measured in mG along the vertical axis. The magnetic field graph shows that the strength of the field increases the closer you are to the center of the transmission line and decreases as you move away.

As shown on Figures B-1 through B-4, the magnetic field strength values for the proposed new line are as follows:

	At the Edge of ROW	Maximum Inside the ROW
Single Circuit - Moderate Loading	4.35 mG	5.44 mG
Single Circuit - Maximum Loading	37.0 mG	46.2 mG
Double Circuit - Moderate Loading	7.2 mG	9.2 mG
Double Circuit - Maximum Loading	61.2 mG	78.3 mG

As shown in the table above, maximum magnetic field strength value for the proposed new GUID 115 kV transmission line will be less than 79.0 mG.

3.4.6.2 Electric Fields

The voltage in a transmission line also generates an electric field, but the magnitude of the electric field rapidly decreases with distance from the conductor. The electric field is expressed in a unit of volts per meter or kilovolts per meter (kV/m). The electric field magnitude does not vary or depend on the current in the line. The electric field profile for the single circuit structure is shown on Figure B-5 and for the double circuit structure on Figure B-6 in Appendix B.

As shown on Figures B-5 through B-6, the electric field strength values are as follows:

	At the Edge of ROW	Maximum Inside the ROW
Single Circuit Structure	0.44 kV/m	0.57 kV/m
Double Circuit Structure	0.61 kV/m	1.07 kV/m

3.4.6.3 Established Regulatory and Exposure Levels

Two organizations have developed voluntary occupational exposure guidelines for EMF exposure. These guidelines are intended to prevent effects, such as induced currents in cells or nerve stimulation, which are known to occur at high magnitudes, much higher (more than 1,000 times higher) than EMF levels found typically in occupational and residential environments.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) concluded that available data regarding potential longterm effects, such as increased risk of cancer, are insufficient to provide a basis for setting exposure restrictions. The ICNIRP has recommended guidelines for EMF exposure has shown in Table 3.4-1 below.

TABLE 3.4-1

ICNIRP Guidelines for EMF Exposure

Exposure (60 Hz)	Electric field	Magnetic field
Occupational	8.3 kV/m	4.2 G (4,200 mG)
General Public	4.2 kV/m	0.833 G (833 mG)

International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an organization of 15,000 scientists from 40 nations who specialize in radiation protection.

Source: ICNIRP, 1998.

The American Conference of Governmental Industrial Hygienists (ACGIH) publishes "Threshold Limit Values" (TLVs) for various physical agents. The TLVs for 60-Hz EMF shown in the table below are identified as guides to control exposure; they are not intended to establish what safe and dangerous levels may be.

TABLE 3.4-2

ACGIH Occupational Threshold Limit Values for 60-Hz EMF

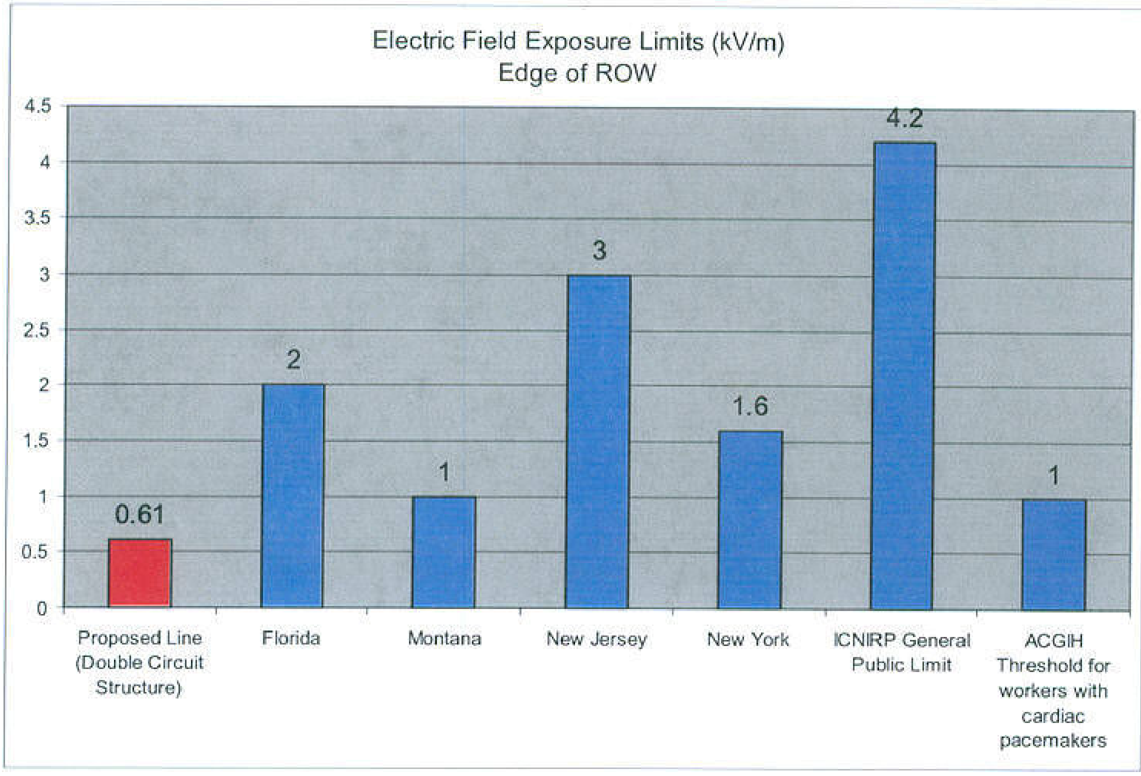
	Electric field	Magnetic field
Occupational exposure should not exceed	25 kV/m	10 G (10,000 mG)
Prudence dictates the use of protective clothing above	15 kV/m	–
Exposure of workers with cardiac pacemakers should not exceed	1 kV/m	1 G (1,000 mG)

American Conference of Governmental Industrial Hygienists (ACGIH) is a professional organization that facilitates the exchange of technical information about worker health protection. It is not a government regulatory agency.
Source: ACGIH, 2001.

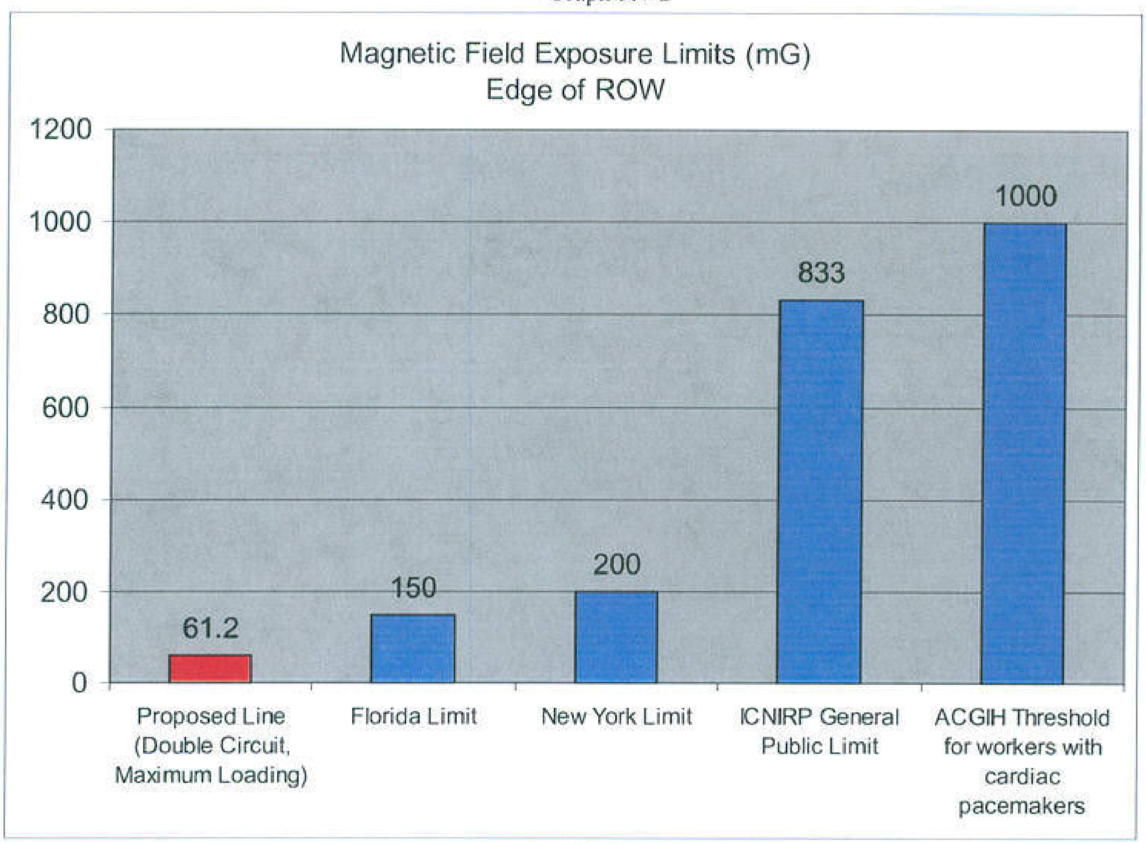
The electric field and magnetic field values generated by the proposed new GUID 115 kV transmission line will be well below any of the above recommended maximum levels.

While Nebraska does not have a regulatory levels for magnetic and electric fields, the EMF levels associated with this project are well below levels established by those states that do have regulatory limits. At least six states have set standards for transmission line electric fields; two of these states also have standards for magnetic fields. States with regulations have ranges from 150 mG to 250 mG at the edge of the ROW, depending on line voltage. In most cases, the maximum fields permitted by each state are the maximum fields that existing lines produce at maximum load carrying conditions. Some states further limit electric field strength at road crossings to ensure that electric current induced into large metal objects such as trucks and buses does not represent an electric shock hazard. Graphs 3.4-1 and 3.4-2 show the proposed transmission line's calculated electric and magnetic field values as compared to established state and organizational limits.

Graph 3.4-1



Graph 3.4-2



3.5 PHASE 3 - DEVELOPMENT OF ALTERNATE ROUTES

3.5.1 Alternate Line Route Selection Criteria

Criteria used in the selection of alternate routes for the transmission line include the following.

(1) Study area, exclusion area, and land use as outlined in Phase 1 - Section 3.3.
(2) Project technical requirements as outlined in Phase 2 - Section 3.4.

3.5.2 Selection of Alternate Routes

A comprehensive field study was conducted of the area between the GIUD sustation "F" and the proposed NPPD St. Libory Junction Substation. As a result of that investigation, twelve Line Segments A through L, as shown on Figure A-1 in Appendix A, were identified. The Line Segments are then combined in various configurations to develop Alternative Routes to achieve the Substation F to St. Libory Junction connection. Using these Line Segments, five possible Alternate Routes were identified. The locations of the Alternate Routes are shown on Figure A-1. Alternate Routes 1, 2, 3, and 4 are all routes that for the most part are along the existing roads. Alternate Route 5, for the most part, avoids existing roads and runs along the half-section line between North Road and Engleman Road. The Alternate Routes are described in the following paragraphs. All Alternate Routes are shown on Figure A-1 in Appendix A.

3.5.3 Alternate Routes 1, 2, 3, and 4 - Routes Along Existing Roads

All of the Alternate Routes include Line Segment A, the rebuilding with double circuit steel poles of 1.31 miles of existing single circuit 115 kV Line 1063A from Substation F north to the first corner structure. Alternate Routes 1, 2, 3, and 4 also include Line Segment B, new single circuit 115 kV steel pole construction from the corner structure at the end of Segment A west to North Road. At North Road at the end of Segment B, Alternate Routes 1, 2, 3, and 4 all turn north where there are two options - Line Segments C and D. There is an existing Southern Public Power District (Southern) three phase distribution line that is located on the east side of North Road for a short distance then switches to the west side of the road. Proposed line Segment C involves placing the transmission line on the west side of North Road for a short distance to avoid the existing Southern three phase distribution line. Proposed Line Segment D involves placing the transmission line on the east side of the road, on the same side of the road as the existing Southern distribution line and transferring the existing nine spans of the Southern three phase distribution line to the new transmission line poles as distribution undercircuit on the proposed 115 kV line.

At the north end of Line Segments C or D, Alternate Routes 1, 2, 3, and 4 continue north as Line Segment E on the east side of North Road past Abbott Road to the intersection of White Cloud Road. Line Segment E was selected to be on the opposite side of the road from the existing Southern three phase distribution line to avoid the added cost of having to rebuild that line as undercircuit on the proposed 115 kV Line.

At the intersection of White Cloud Road and North Road, two alternative Line Segments were considered to get from that intersection to the intersection of Engleman Road and One R Road. One alternate is to turn west on White Cloud Road and construct the proposed line on the north side of White Cloud Road and the west side of Engleman Road on the opposite side of the road from the existing Southern three phase distribution line to avoid the added cost of having to rebuild that distribution line as undercircuit on the proposed 115 kV Line. This would include Line Segments F and H. Due to the home and trees located along the north side of Segment F at the northwest corner of North and White Cloud Roads, an alternate segment was selected, Line Segment G, on the south side of the road to avoid these. Line Segment G involves placing the line on the south side of the road, on the same side of the road as the existing distribution line and transferring the existing five spans of the Southern three phase distribution line as distribution undercircuit on the proposed 115 kV line. The second alternate segment is to continue the line route north along the east side of North Road to One R Road then along the north side of One R Road to the intersection with Engleman Road. This second alternate segment would be Line Segment I which would all be on the opposite side of the road from the existing Southern Cooperative three phase distribution line to avoid the added cost of having to rebuild that line as undercircuit on the proposed 115 kV Line.

From the intersection of Engleman Road and One R Road, Alternate Routes 1, 2, 3, and 4 all continue north as Line Segment J on the west side of Engleman Road past Chapman Road to the NPPD St. Libory Substation Site. The west side of the road is on the opposite side of the road from the existing Southern three phase distribution line and avoids the added cost of having to rebuild that line as undercircuit on the proposed 115 kV Line.

3.5.4 Alternate Route 5 - Route Along the Center of The Section Line

Alternate Route 5 also includes Line Segment A, the rebuilding with double circuit steel poles of 1.31 miles of existing single circuit 115 kV Line 1063A from Substation F north to the first corner structure. From the existing corner structure in Line 1063A, Alternate Route 5 continues north with Line Segment K, for approximately 0.75 miles along the half-section line to the north side of Abbott Road. Alternate Route 5 then turns west and continues as Line Segment L for 1.0 miles along the north side of Abbott Road, crossing North Road to the center one-half section line between North Road and Engleman Roads. From this point, Alternate Route 5 turns north and continues as Line Segment M, for 3.50 miles along the center one-half section line between North Road and Engleman Roads. At this point, Alternate Route 5 and Line Segment L, turns west and parallels the existing NPPD 115 kV line for approximately one-quarter mile to the NPPD St. Libory Substation Site.

3.6 PHASE 4 - EVALUATION OF ALTERNATE ROUTES

3.6.1 Technical Comparison

Major technical data for each alternate route is given in Table 3.6-1 and summarized in the following paragraphs.

3.6.1.1 Route Length. There is little difference in length among the four alternate routes. All of the alternate routes are 7.03 to 7.06 miles in length.

3.6.1.2 Angle Structures. The number of angle structures required for each alternate route is shown in Table 3.6-1. Each additional angle structure required by an alternate route increases the total cost of the construction.

Table 3.6-1. TECHNICAL COMPARISON OF ALTERNATE ROUTES

Alternate Routes	Route Segments	Length miles	Total Angle Structures 6°-10°	30° - 60°	60° - 90°
1	A,B,C,E,F,H,J	7.05	2	2	6
2	A,B,D,E,G,H,J	7.06	2	2	6
3	A,B,C,E,I,J	7.05	2	2	6
4	A,B,D,E,I,J	7.04	2	0	6
5	A,K,L,M	7.03	2	0	4

3.6.2 Environmental Impact

The environmental comparison of each alternate route must be considered including the aesthetic impact on the public. Table 3.6-2 shows the number of homes within close proximity to each alternate route. The criteria used to evaluate the aesthetic impact of each alternate route was the number of homes within 500 feet of the alternate route. As shown in Table 3.6-2, Alternate Route 5 passes near the fewest number of homes with 1 home near the route, Alternate Routes 1 and 2 pass near one fewer home than do Alternate Routes 3 and 4. Alternate Route 5 would be judged to have less impact on homes near the right-of-way than any of the other alternate routes.

TABLE 3.6-2. HOMES IN CLOSE PROXIMITY TO ALTERNATE ROUTES

Alternate Route	Number of Homes Within 500 feet of Alternate Route*
1	10
2	10
3	11
4	11
5	1

* Does not include homes near segment A where there is an existing transmission line.

Table 3.6-3 lists the areas where trees would need to be removed. Alternate Route 5 would require slightly less tree removal than the other four alternate routes.

TABLE 3.6-3. TREE REMOVAL AREAS

Alternate Route	Areas That Require Tree Removal
1	A few trees along North Road near White Cloud Road. A few trees near the house at the corner of White Cloud and North Roads A few trees at the corner of White Cloud and Engleman Roads A few trees at the corner of Engleman and Chapman Roads
2	A few trees along North Road near White Cloud Road. A few trees at the corner of White Cloud and Engleman Roads A few trees at the corner of Engleman and Chapman Roads
3	A few trees along North Road near White Cloud Road. Several trees along North Road near One R Road A few trees at the corner of Engleman and Chapman Roads
4	A few trees along North Road near White Cloud Road. Several trees along North Road near One R Road A few trees at the corner of Engleman and Chapman Roads
5	A few trees along the half-section line north of the L1063A corner A few trees along the half-section line south of White Cloud Road A few trees along the half-section line north of One R Road

3.6.3 Economic Comparison

The economic comparison of the alternate routes is based on the following costs.

3.6.3.1 Cost of Right-of-Way. The method used for the cost of right-of-way is based on the area in acres that would be required for the easement strip times the cost of right-of-way per acre. The amount paid to each land owner would be based on the length of line and the width of the easement. For the line segments that crosses a property, a 50 feet wide easement is needed. For line segments that are along a road, a 27 feet wide easement is needed. It is estimated that based on land prices in the area and past history with obtaining easements in this area, that the average estimated cost per acre for easements will be $4,000. The estimated right-of-way costs for each alternate route is shown in Table 3.6-4.

The estimated right-of-way costs and the number of new easements required for Alternate Routes 1, 2, 3, and 4 , which are routes primarily along roads were approximately the same. The estimated right-of-way costs and the number of new easements required for Alternate Route 5, the route primarily along the center section line, was more than any of the other alternate routes.

TABLE 3.6-4. Estimated Easement Costs For Alternate Routes

Alternate Route	No. of New Easements Required	Total Acres Required	Average Cost Per Acre	Estimated Total Easement Costs
1	16	20.15	$4,000	$ 80,593
2	14	20.19	$4,000	$ 80,754
3	18	20.15	$4,000	$ 80,593
4	16	20.12	$4,000	$ 80,481
5	26	31.89	$4,000	$127,554

3.6.3.2 Cost of Construction. The following structure costs were used in the analysis. All structures were assumed to be tubular steel pole structures with all angle structures being self-supported without down guys and anchors. It was assumed that the structures would be spaced approximately every 300 feet for the single circuit section and every 235 feet for the double circuit section.

Structure Type	Structure Cost $
Single Circuit Tangent	35,000
Single Circuit Small Angle With Foundation	70,000
Single Circuit Dead End With Foundation	95,000
Double Circuit Tangent	55,000
Double Small Angle With Foundation	95,000

3.6.3.3 Comparison of Costs For Alternate Routes. Table 3.6-5 shows a comparison including costs of the five alternate routes in 2009 dollars

TABLE 3.6-5 COMPARISON OF COSTS FOR ALTERNATE ROUTES
NEW 115 KV LINE - SUBSTATION "F" to ST. LIBORY JUNCTION

Route Segments	Approximate Segement Length - Feet	Estimated Tree Removal Costs	Estimated No. of New Easements	No. of Homes Line Passes Within 500 Ft
A	6,910	$0	0	0
B	2,560	$0	2	0
C	2,110	$0	2	1
D	2,065	$2,000	0	1
E	7,175	$2,000	3	2
F	760	$2,000	1	1
G	870	$0	1	1
H	9,800	$2,000	4	3
I	10,560	$5,000	7	5
J	7,920	$2,000	4	3
K	3,960	$1,500	3	0
L	5,280	$0	2	0
M	20,970	$5,000	21	1

Route	Route Segments	Route Length - Miles	Total Number of Structures Required	No. of Single Circuit Tangent Structures	No. of Single Circuit Running Angle Structures	No. of Single Circuit Dead End Structures	No. of Double Circuit Tangent Structures	No. of Double Circuit Small Angle	No. of New Easements	No. of Homes Line Passes Within 500 Ft
Route #1	A,B,C,E,F,H,J	7.05	138	101	2	6	27	2	16	10
Route #2	A,B,D,E,G,H,J	7.06	138	101	2	6	27	2	14	10
Route #3	A,B,C,E,I,J	7.05	138	101	2	6	27	2	18	11
Route #4	A,B,D,E,I,J	7.04	136	101	0	6	27	2	16	11
Route #5	A,K,L,M	7.03	136	101	2	4	27	2	26	1

TABLE 3.6-5
COMPARISON OF COSTS FOR ALTERNATE ROUTES
NEW 115 KV LINE - SUBSTATION "F" to ST. LIBORY JUNCTION

Route	Route Segments	Single Circuit Tangent Structures Costs	Single Circuit Running Angle Structures Costs	Single Circuit Dead End Structures Costs	Double Circuit Tangent Structure Costs	Double Circuit Small Angle Structure Costs	Distribution Undercircuit Costs	Estimated Tree Removal Costs	Conductor Installed Costs	OPGW Fiber Installed Costs	Remove Existing Structures - Segment A	Total Construction Costs	TOTAL EASEMENT COSTS	TOTAL ROUTE COSTS
Route #1	A,B,C,E,F,H,J	$3,535,000	$140,000	$570,000	$1,485,000	$190,000	$0	$8,000	$781,935	$260,645	$72,500	$7,043,080	$80,592.75	$7,123,673
Route #2	A,B,D,E,G,H,J	$3,535,000	$140,000	$570,000	$1,485,000	$190,000	$24,000	$8,000	$783,300	$261,100	$72,500	$7,068,900	$80,753.90	$7,149,654
Route #3	A,B,C,E,I,J	$3,535,000	$140,000	$570,000	$1,485,000	$190,000	$0	$9,000	$781,935	$260,645	$72,500	$7,044,080	$80,592.75	$7,124,673
Route #4	A,B,D,E,I,J	$3,535,000	$0	$570,000	$1,485,000	$190,000	$16,000	$11,000	$780,990	$260,330	$72,500	$6,920,820	$80,481.18	$7,001,301
Route #5	A,K,L,M	$3,535,000	$140,000	$380,000	$1,485,000	$190,000	$0	$6,500	$779,520	$259,840	$72,500	$6,848,360	$127,553.72	$6,975,914

4.0 RECOMMENDED LINE ROUTE

All of the five alternate routes were so close in all aspects of the evaluation that any one of the routes could be used as the route for the line. However, it is recommended that the new 115 kV line from the GIUD Substation F to St. Libory Junction be constructed along Alternate Route 5 for the following reasons.

(1) This route is slightly shorter and more direct than the other alternate routes.

(2) This route requires the least number of angle structures.

(3) This route passes near the least number of homes of any other route..

(4) This alternate route is estimated to cost less than the other four routes evaluated.

APPENDIX A

ALTERNATE ROUTES FOR
NEW 115 KV LINE - GIUD SUBSTATION F TO NPPD ST. LIBORY JUNCTION

APPENDIX B

ESTIMATED ELECTRIC AND MAGNETIC FIELD PROFILES FOR NEW 115 KV LINE - GIUD SUBSTATION F TO NPPD ST. LIBORY JUNCTION

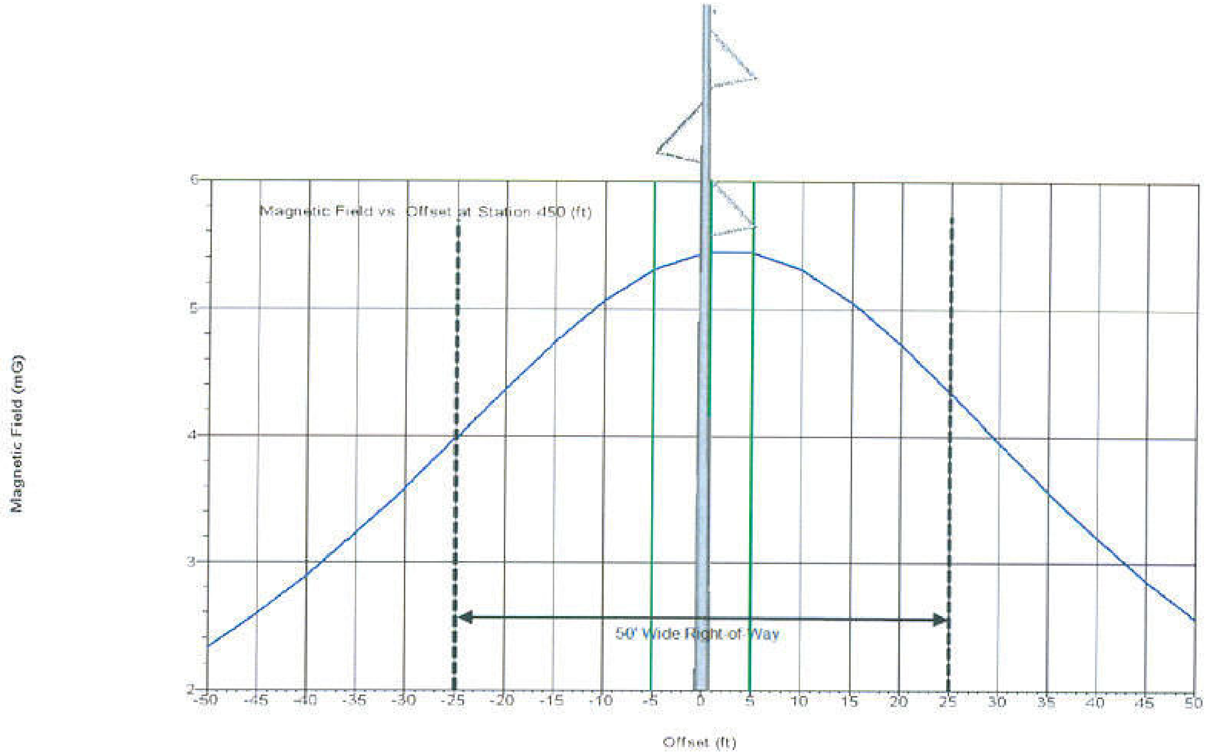


Figure B-1
Single Circuit Tangent Structure
Magnetic Field Profile - Moderate Loading - 100 Amps Per Phase

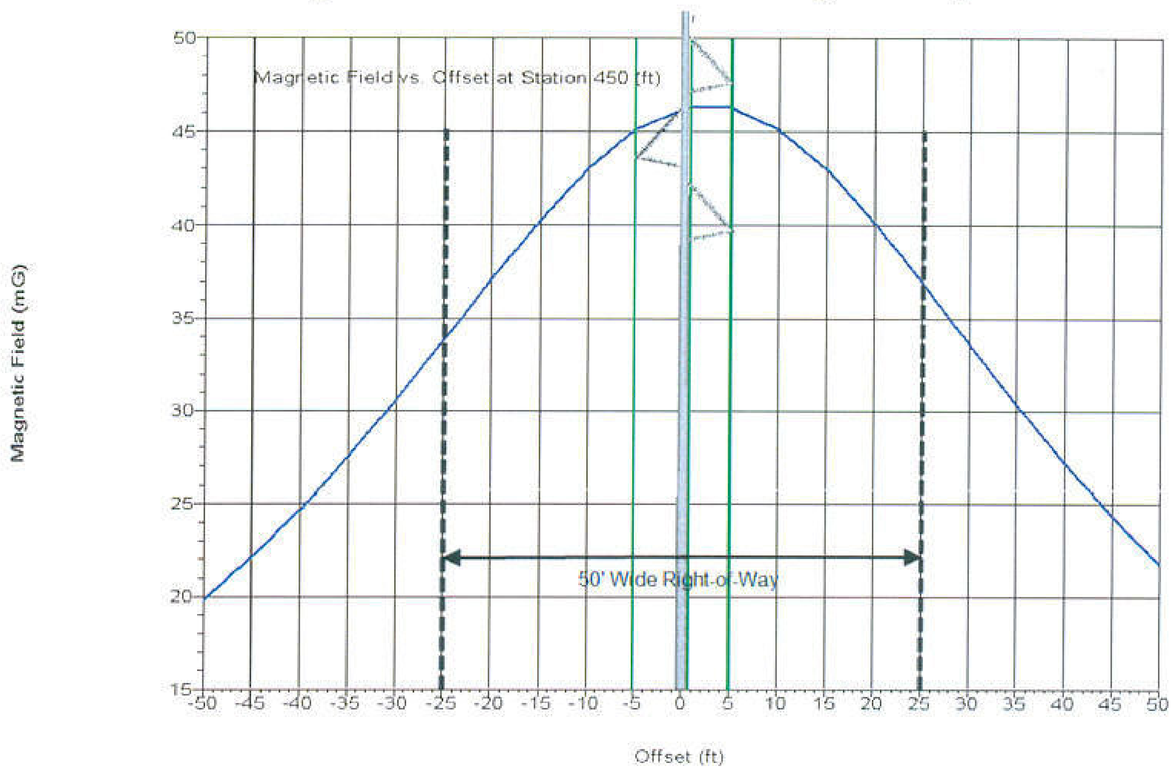


Figure B-2
Single Circuit Tangent Structure
Magnetic Field Profile - Maximum Loading - 850 Amps Per Phase

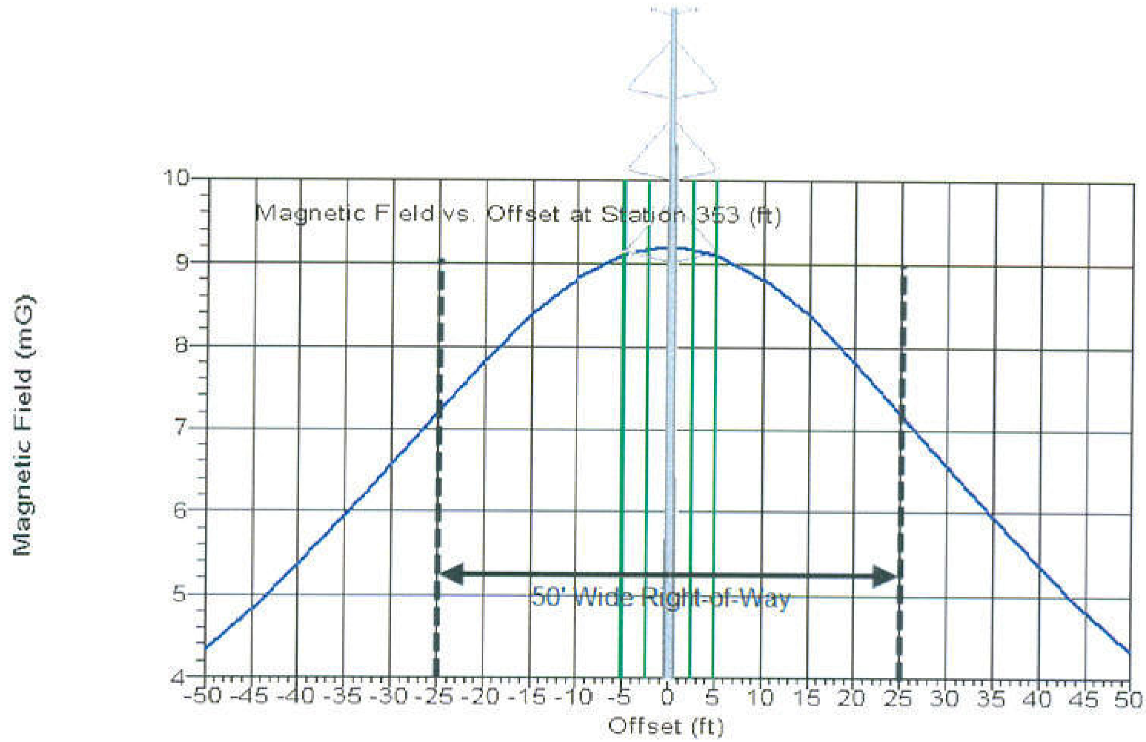


Figure B-3
Double Circuit Tangent Structure
Magnetic Field Profile - Moderate Loading - 100 Amps Per Phase

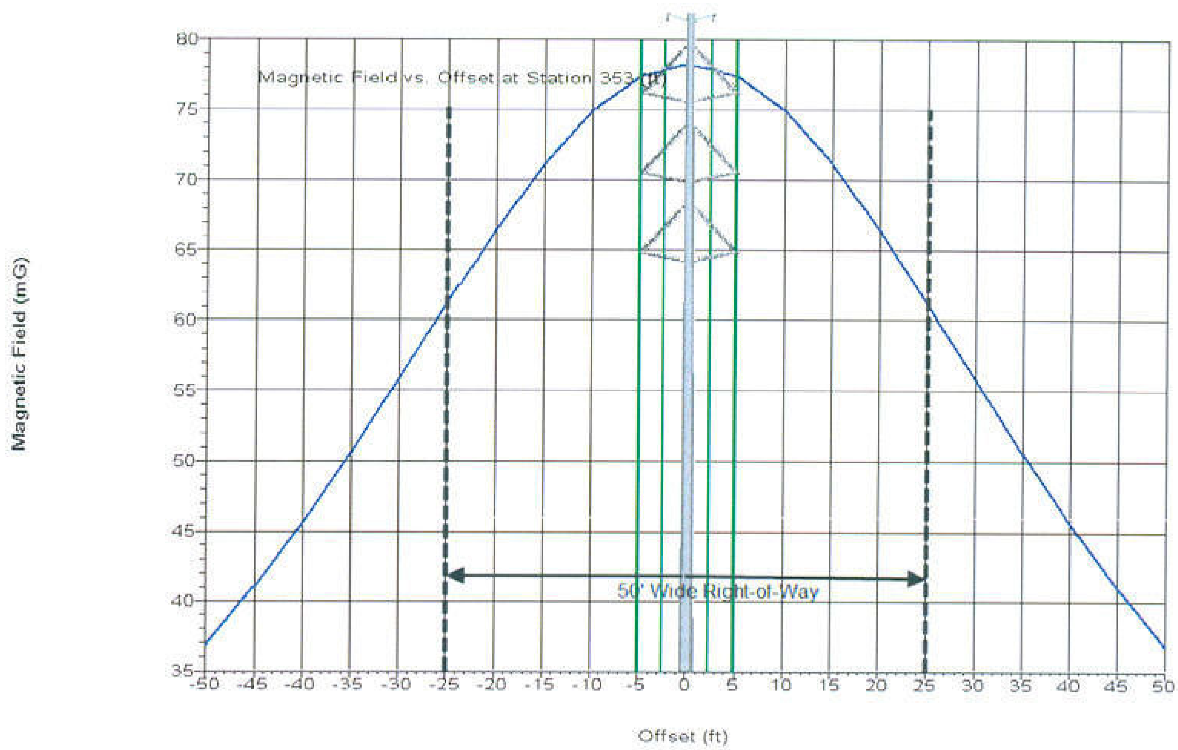


Figure B-4
Double Circuit Tangent Structure
Magnetic Field Profile - Maximum Loading - 850 Amps Per Phase

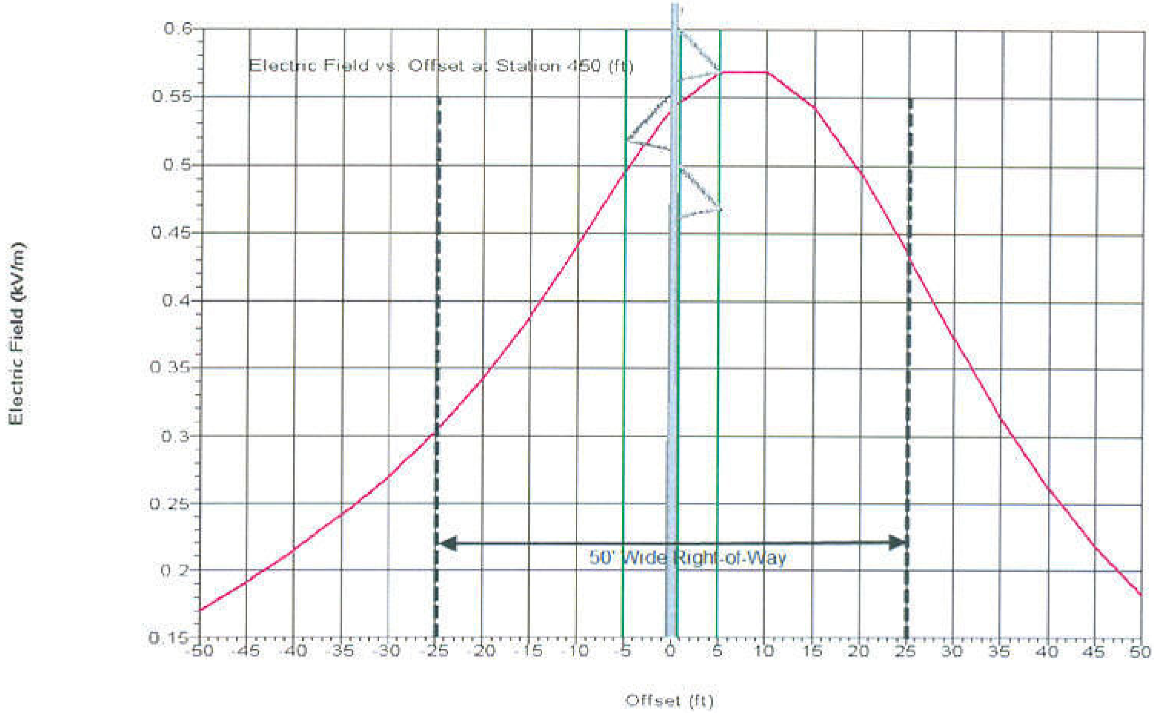


Figure B-5
Single Circuit Tangent Structure
Electric Field Profile

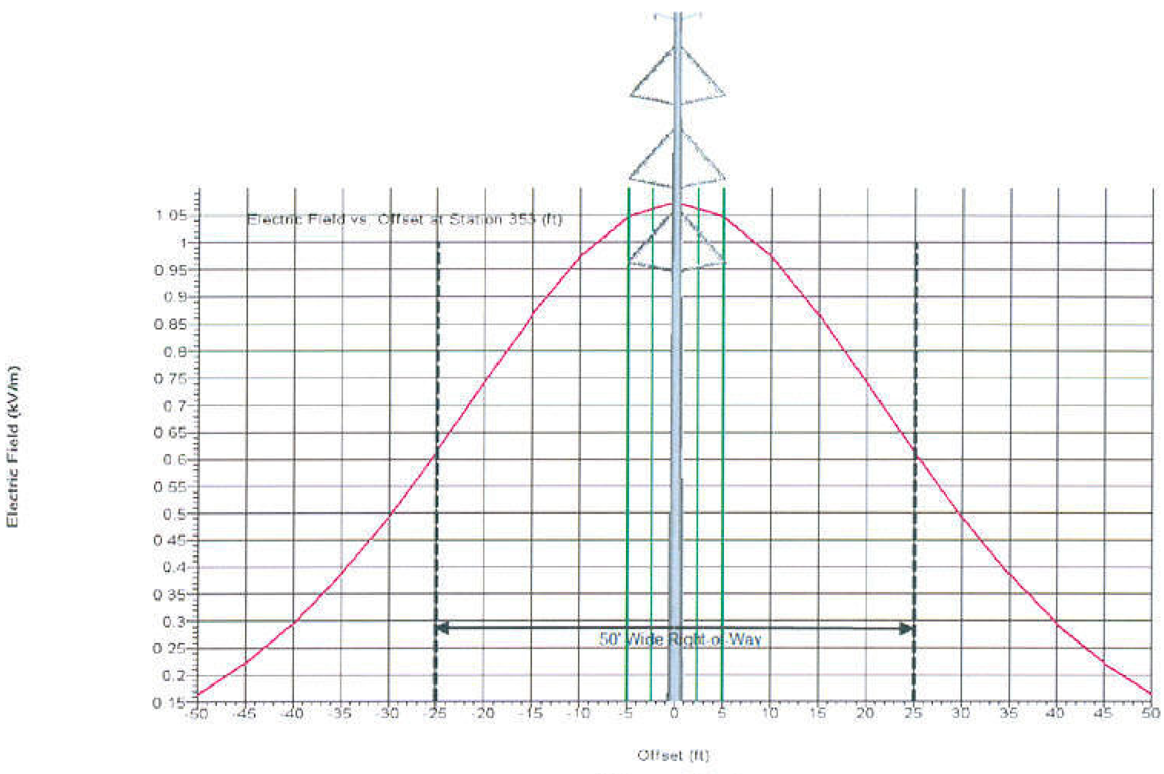


Figure B-6
Double Circuit Tangent Structure
Electric Field Profile