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## **XCEL ENERGY**

### **Colorado's Power Pathway Project** *Substation Magnetic Field and Audible Noise Study*

*Final*

**PROJECT NUMBER:**

167902

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## SUBSTATION MAGNETIC FIELD AND AUDIBLE NOISE STUDY

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- “Prelim” means this document is issued for preliminary review, not for implementation
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## EXECUTIVE SUMMARY

Public Service Company of Colorado (Public Service or the Company) contracted POWER Engineers, Inc. (POWER) to investigate magnetic field and audible noise effects for the expansion or construction of seven substations (including single voltage switching stations) as part of Colorado's Power Pathway Project (Pathway Project), which includes 560 miles of new, double circuit 345 kV transmission infrastructure in eastern Colorado. The purpose of this report is to set forth the expected maximum level of magnetic fields that could be experienced at substation boundaries and the projected level of audible noise at 25 feet beyond substation property lines. This is consistent with Colorado Public Utilities Commission (PUC) Rule 3206 – Construction or Extension of Transmission Facilities (4 CCR 723-3-3206), in support of Public Service's application for a Certificate of Public Convenience and Necessity (CPCN) for these substation expansions, new substation construction, and the related transmission line. This report will be submitted to the PUC with the CPCN application. All analysis provided in this report is presented for the substation build-out to support the Pathway Project.

Table 1 shows the maximum magnetic field strengths calculated at substation boundaries and the maximum audible noise levels calculated at 25 feet from substation property lines. For magnetic field strengths, the maximum value at the fence line or property line of each substation is shown. As detailed in the report, the calculated magnetic field strengths at the fence line of all substations in the Pathway Project are expected to be below the 150 mG level deemed reasonable by PUC Rule 3206(e), with the exception of Pawnee and Harvest Mile Substations. For the substations where magnetic field levels were calculated above 150 mG at the fence line, magnetic field levels were also calculated at the substation property line. For Pawnee Substation, although the magnetic field strength at one fence line is projected to be above the level deemed reasonable by Rule 3206(e), Public Service owns the land adjacent to and surrounding the substation, and the magnetic field strength at the property line is below the level deemed reasonable by Rule 3206(e). Similarly, for Harvest Mile Substation, although the magnetic field strength at one fence line is projected to be above the level deemed reasonable by Rule 3206(e), the magnetic field strength at that property line is below the level deemed reasonable by Rule 3206(e).

For audible noise levels, the maximum value 25 feet from the property line is shown in accordance with PUC Rule 3206(f). As detailed in the report, the audible noise levels for Fort St. Vrain Substation, Pawnee Substation, and Canal Crossing Substation are expected to be below the applicable zoning-dependent level deemed reasonable by PUC Rule 3206(f). The other substations are not, or will not be, located on land for which there is a zoning-dependent noise level limit deemed reasonable by PUC Rule 3206(f).

**TABLE 1 – MAGNETIC FIELD AND AUDIBLE NOISE RESULTS SUMMARY**

CASE	LOCATION OF APPLICABLE MAXIMUM VALUE	DEEMED REASONABLE LEVEL (PUC RULE 3206)	RESULTS
<b>Magnetic Field</b>	<b>Substation Boundary</b>	<b>150 mG</b>	—
Fort St. Vrain	Maximum at northern fence line	150 mG	112 mG
Canal Crossing	Maximum at southern fence line	150 mG	69 mG
Pawnee	Maximum at southern property line	150 mG	0.2 mG <sup>a</sup>
Goose Creek	Maximum at western fence line	150 mG	89 mG
May Valley	Maximum at western fence line	150 mG	82 mG
Tundra	Maximum at southwestern fence line	150 mG	105 mG
Harvest Mile	Maximum at southern property line	150 mG	32 mG <sup>a</sup>
<b>Audible Noise</b>	<b>25 feet from Substation Property Line</b>	<b>Deemed reasonable level (Zoning- dependent per Rule 3206)</b>	—
Fort St. Vrain	Maximum 25 feet from northern property line	75 dB(A) (Industrial)	62 dB(A)
Canal Crossing	Maximum 25 feet from northern property line	75 dB(A) (Industrial)	61 dB(A)
Pawnee	Maximum 25 feet from northern property line	75 dB(A) (Industrial)	62 dB(A)
Goose Creek	Maximum 25 feet from eastern property line	None established by Rule 3206(f) <sup>b</sup>	62dB(A)
May Valley	Maximum 25 feet from eastern property line	None established by Rule 3206(f) <sup>b</sup>	60 dB(A)
Tundra	Maximum 25 feet from northeastern property line	None established by Rule 3206(f) <sup>b</sup>	61 dB(A)
Harvest Mile	Maximum 25 feet from southern property line	None established by Rule 3206(f) <sup>b</sup>	57 dB(A)

(a) For Pawnee Substation, although the magnetic field strength results at one substation fence line are above the level deemed reasonable by Rule 3206(e), Public Service owns the land adjacent to and surrounding the substation, and the magnetic field strength at the property line is below the level deemed reasonable by PUC Rule 3206(e).

For Harvest Mile Substation, although the magnetic field strength results at one substation fence line are above the level deemed reasonable by Rule 3206(e), the magnetic field strength at the property line is below the level deemed reasonable by PUC Rule 3206(e).

(b) For some of the Power Pathway substations, the substation parcels and surrounding land are zoned agricultural and/or a mix of other zoning designations. Rule 3206(f) does not identify an audible noise level that is deemed reasonable for land zoned agricultural, and POWER does not draw any conclusions about the zoning-dependent audible noise levels that would be deemed reasonable by PUC Rule 3206(f). Additional information about zoning and land use can be found in the "Zoning Designations and Land Use" section below.

## PROJECT NEED

In 2018, Public Service announced the Company’s vision to reduce carbon dioxide emissions 80 percent company-wide from 2005 levels by 2030 and to provide 100 percent carbon-free electricity by 2050. In order to achieve an 80 percent reduction by 2030, extra high voltage transmission infrastructure will need to be constructed to assist bringing renewable generation from northeastern, eastern and/or southern parts of Colorado to the Denver Metro area and the Company’s existing transmission system.

## PROJECT DESCRIPTION

The Pathway Project will consist of a double circuit 345 kV transmission line that will connect with seven existing and new substations: Fort St. Vrain, Canal Crossing, Pawnee, Goose Creek, May Valley, Tundra, and Harvest Mile. Figure 1 shows the larger project area with the double circuit 345 kV transmission line.

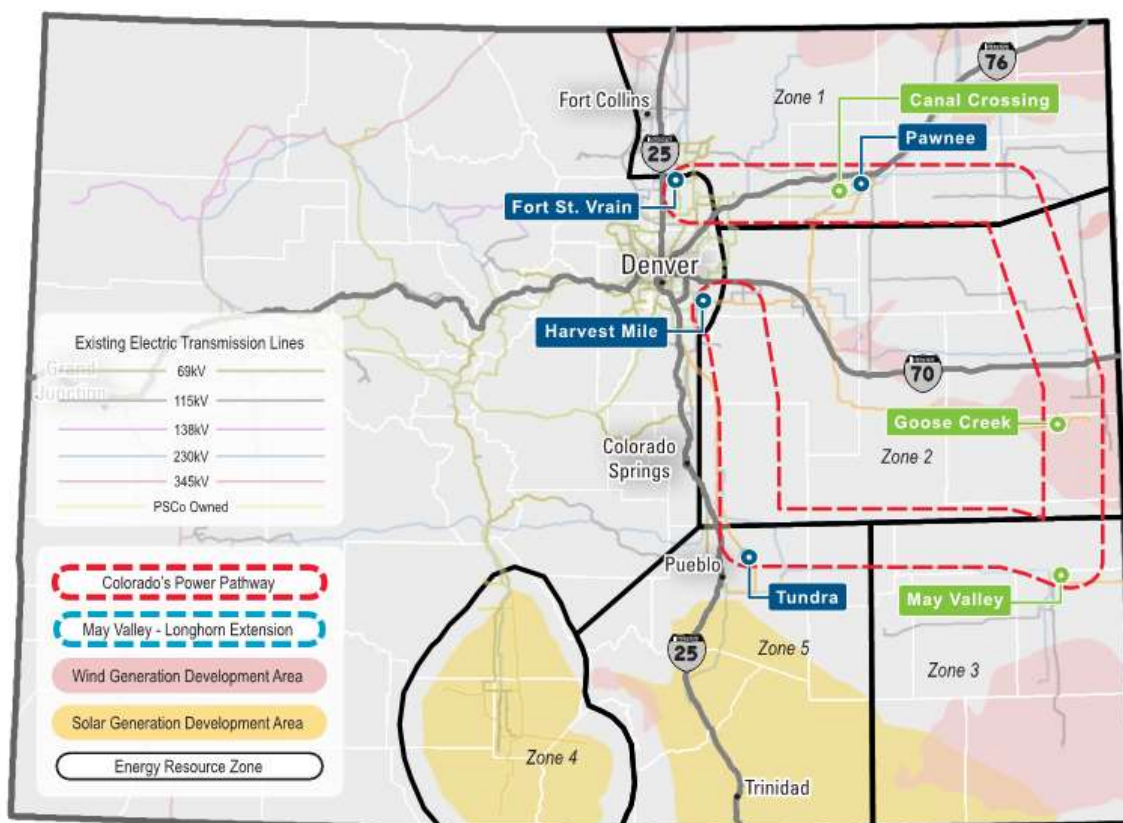


Figure 1: Pathway Project General Area Overview

## PUC RULES AND STUDY METHODOLOGY

### Applicable Rules for Magnetic Fields and Audible Noise

PUC Rule 3206 – Construction or Extension of Transmission Facilities (4 CCR 723-3-3206) requires new transmission facilities comply with Rule 3206(e) for magnetic field strengths and 3206(f) for audible noise.

Magnetic field levels are detailed in section 3206(e), which states the following:

The filing shall include the expected maximum level of magnetic fields that could be experienced under design conditions at the edge of the transmission line right-of-way or substation boundary, at a location of one meter above ground.

In addition, Rule 3206(e)(III) provides that “[p]roposed magnetic field levels of 150 mG (milliGauss) and below are deemed reasonable by rule and need not be mitigated to a lower level.”

Audible noise levels are detailed in section 3206(f), which states the following:

The filing shall include the projected level of noise radiating beyond the property line or right-of-way (as applicable) at a distance of 25 feet.

Rule 3206(f)(II) provides that proposed levels of noise at or below the values listed in Figure 2, by land use zoning designation, are deemed reasonable by rule and need not be mitigated to a lower level:

(A)	Residential	50 db(A)
(B)	Commercial	55 db(A)
(C)	Light industrial	65 db(A)
(D)	Industrial	75 db(A)

**Figure 2: Audible Noise Levels Deemed Reasonable by Rule 3206(f) by Zoning Designation**

Rule 3206(f)(III) further provides that for land that has a zoning designation other than one of the four designations enumerated above, proposed noise levels will not be subject to further review if the proposed noise threshold is 50 dB(A) or below regardless of use of land.

### Zoning Designations and Land Use

Table 2 summarizes the zoning designations of the Pathway Project substation parcels and details zoning and uses of the surrounding land.



**TABLE 2 – SUBSTATION ZONING AND SURROUNDING LAND USES**

SUBSTATION	SUBSTATION ZONING <sup>a</sup>	ZONING OF SURROUNDING LAND	SURROUNDING LAND USES
Fort St. Vrain	Heavy Industrial (I-3)	<ul style="list-style-type: none"> <li>• Agricultural (A)</li> </ul>	<ul style="list-style-type: none"> <li>• Agriculture and livestock operations</li> <li>• Oil and gas infrastructure</li> <li>• Power plant</li> <li>• South Platte River and associated floodplains</li> </ul>
Pawnee and Canal Crossing	Heavy Industrial (HI)	<ul style="list-style-type: none"> <li>• Split Zoning (SZ)</li> <li>• Agriculture Production Zone (A)</li> </ul>	<ul style="list-style-type: none"> <li>• Agriculture</li> <li>• Oil and gas infrastructure</li> <li>• Power plants and substations</li> <li>• State wildlife area</li> <li>• Water reservoirs and evaporation ponds</li> </ul>
Goose Creek	Agricultural (A)	<ul style="list-style-type: none"> <li>• Agricultural (A)</li> </ul>	<ul style="list-style-type: none"> <li>• Agriculture</li> <li>• Existing wind facility</li> </ul>
May Valley	Non-irrigated Agriculture (A-2)	<ul style="list-style-type: none"> <li>• Non-irrigated Agriculture (A-2)</li> </ul>	<ul style="list-style-type: none"> <li>• Agriculture</li> <li>• Oil and gas infrastructure</li> </ul>
Tundra	Agricultural (A-1)	<ul style="list-style-type: none"> <li>• Agricultural (A-1), except Pueblo Chemical Depot</li> </ul>	<ul style="list-style-type: none"> <li>• Grassland</li> <li>• Pueblo Chemical Depot</li> <li>• Pueblo Memorial Airport</li> </ul>
Harvest Mile	Agricultural (A-1)	<ul style="list-style-type: none"> <li>• Agricultural (A-1)</li> <li>• Mixed Use (MU)</li> <li>• Residential (R-2)</li> </ul>	<ul style="list-style-type: none"> <li>• Agriculture</li> <li>• Mixed use (Arapahoe County Fairgrounds Event Center)</li> <li>• Residential</li> </ul>

(a) Zoning information in this table was provided by Public Service.

## Substation Magnetic Field and Audible Noise Analysis Methodology and Assumptions

### ***Magnetic Fields***

The magnetic field effects were modeled using SES (Safe Engineering Services and technologies ltd.) CDEGS (Current Distribution, Electromagnetic fields, Grounding and Soil structure analysis) software, version 16.2. The CDEGS software allows for modeling of the bus work (typically horizontal conductors and vertical conductors) in three dimensions, which allows the physical system to be accurately represented within the model and field effects to be analyzed.

The analysis was performed by energizing the buses to the maximum rating. To this end, vertical and horizontal buses were energized to carry the maximum steady state current rating of 3,000 amperes in

the same directions. It is worth mentioning that this energization scheme may not be physically feasible given that currents will split at bus nodes. Therefore, this energization represents the worst-case magnetic field strengths (i.e. the highest EMF values) that can be produced outside of the bus zone if all the bus conductors carry their maximum current rating. Consistent with PUC Rule 3206(e), the magnetic field is analyzed and reported at a height of one meter above the ground.

The values of these effects were calculated at the substation fence line. In certain instances, the magnetic field levels were calculated for reference at the property line and beyond. Results include, for reference, plots of the values for the entire substation.

### ***Audible Noise***

The audible noise effects were analyzed through acoustic modeling of the substation using the DataKustik GmbH, CadnaA (Computer Aided Noise Abatement) software package (version 4.5.151 or version 2021 MR 1), which is a utility standard program. Noise propagation characteristics in this software package are based upon *ISO 9613 “Acoustics – Attenuation of sound during propagation outdoors –Part 1: Calculation of the absorption of sound by the atmosphere and Part 2: General method of calculation.”*

The audible noise effects for this project are driven by the maximum sound pressure of the transformers and reactors. The values of these effects were calculated at points 25 feet from the substation property line. The receptor height placement is modeled at 1.5 meters (4.9 feet) to approximate the height of an individual’s ear. Results include, for reference, plots of the values for the entire substation and at least 25 feet beyond the substation property line.

## STUDY DETAILS

Magnetic field and audible noise performance are based on the electrical and physical characteristics of the substation. Specifically, these factors are driven by the voltage and current loading of the bus, the heights of the conductors and buses from the ground, and transformer and reactor ratings. As a result, there are a number of variable factors that will affect results. The data listed in Table 3 was used for the analysis. Should any of this data change, the results will also change.

<b>TABLE 3 – SUMMARY OF INPUT DATA</b>	
<b>MEASUREMENT CATEGORY</b>	<b>DATA</b>
345 kV Bus Rating <sup>a</sup>	3,000 A
230 kV Bus Rating <sup>a</sup>	3,000 A
15 kV Bus Current Maximum <sup>b</sup>	1,540 A
345 kV Low Bus Height <sup>c</sup>	19.0 feet
345 kV High Bus Height <sup>c</sup>	33.5 feet
230 kV Low Bus Height <sup>c</sup>	17 feet
230 kV High Bus Height <sup>c</sup>	28 feet
15 kV Low Bus Height <sup>c</sup>	12 feet
15 kV High Bus Height <sup>c</sup>	19 feet
60 MVAR Reactor Maximum Sound Pressure Level <sup>d</sup>	83 dB(A)
40 MVAR Reactor Maximum Sound Pressure Level <sup>d</sup>	65 dB(A)
345 kV/230 kV 560 MVA Transformer Maximum Sound Pressure Level <sup>e</sup>	77 dB(A)

(a) Bus ratings are per Public Service design standards.

(b) Bus current maximum assumed using 15 kV and ideal 40 MVAR reactor.

(c) Bus heights listed in Table 3 are per Public Service design standards. For Harvest Mile and Goose Creek, the following bus heights were used in place of the design standards: 18 feet/28 feet for low/high bus at 230 kV, and 21 feet/37 feet for low/high bus at 345 kV, respectively.

(d) Measurement locations per IEEE Std C57.21-2008. 40 MVAR reactor level per NEMA.

(e) Measurement locations per IEEE Std C57.12.90-2010.

Appendix A includes substation general arrangement drawings from which dimensions were obtained. Note that for all new and expanding substations, buses shown horizontally on the drawings were assumed to be low buses, and buses shown vertically were assumed to be high buses. For the existing 230 kV sections at Fort St. Vrain, the buses shown horizontally were assumed to be high buses, and buses shown vertically were assumed to be low buses.

## RESULTS

### Magnetic Field

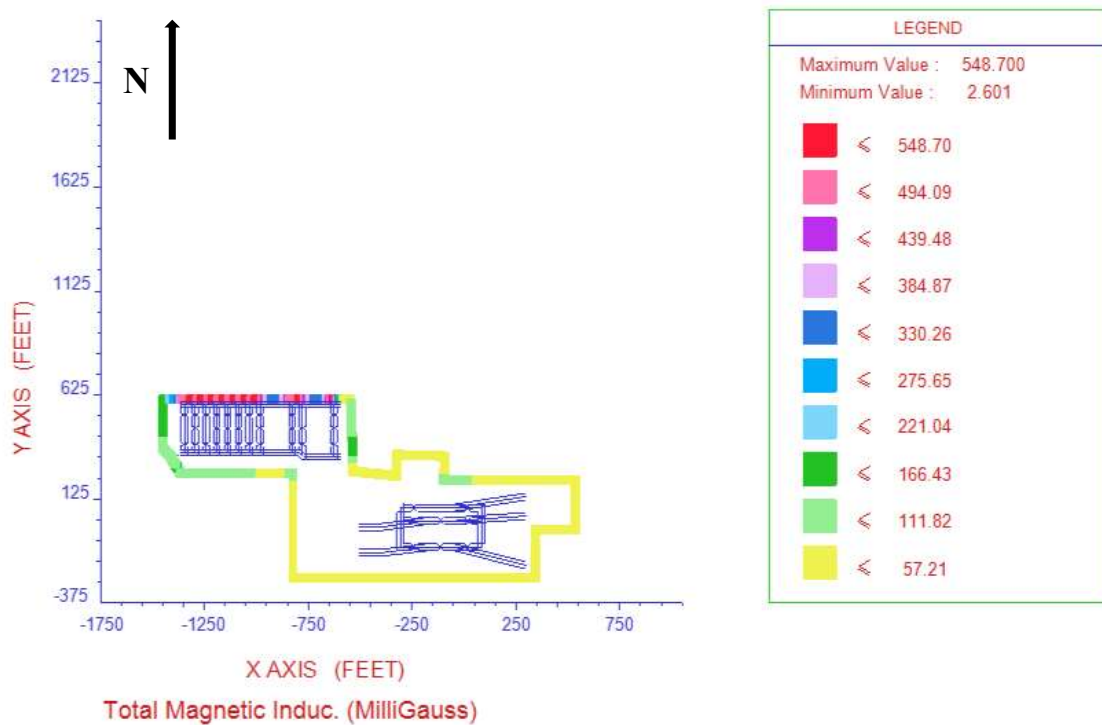
The reported magnetic field strength values are the magnetic flux densities at given points in space. Magnetic flux density is calculated in gauss or milligauss (mG). For these studies, magnetic field strengths were calculated with the maximum ampacity flowing in the substation based upon the bus rating.

#### **Fort St. Vrain**

Table 4 shows a summary of the magnetic field strength values at the fence line, within the existing property line, for the expanded Fort St. Vrain Substation. Values are calculated at a height of one meter above the ground per IEEE Std 644-2019 and consistent with PUC Rule 3206(e). The magnetic field strength levels at each of the proposed fence lines for the expansion portion of the substation are below the 150 mG magnetic field level deemed reasonable by PUC Rule 3206(e).

TABLE 4 – FORT ST. VRAIN MAGNETIC FIELD STRENGTH	
STATION FENCE LINE LOCATION	MAGNETIC FIELD AT EDGE OF FENCE LINE [mG]
<i>Magnetic Field Deemed Reasonable Level (PUC Rule 3206)</i>	150
Maximum Northern Fence Line	112
Maximum Eastern Fence Line	57
Maximum Southern Fence Line	57
Maximum Western Fence Line	57

Figure 3 shows magnetic field strengths along the entire substation fence line, while Figure 4 shows magnetic field strength values throughout the substation that exceed 150 mG. Figure 3 shows magnetic field strength values higher than the 150 mG deemed reasonable at certain points along the edge of the existing 230 kV yard, within the Public Service property line. The highest magnetic field levels are at the north end of the existing substation immediately adjacent to the Fort St. Vrain generating station. Access to this area is restricted, and the public is not permitted entry. Public Service also owns additional property adjacent to the identified parcel, extending north of the substation more than half a mile and to the west by 350 feet.



**Figure 3: Fort St. Vrain Magnetic Field Strength Values at the Fence Line**



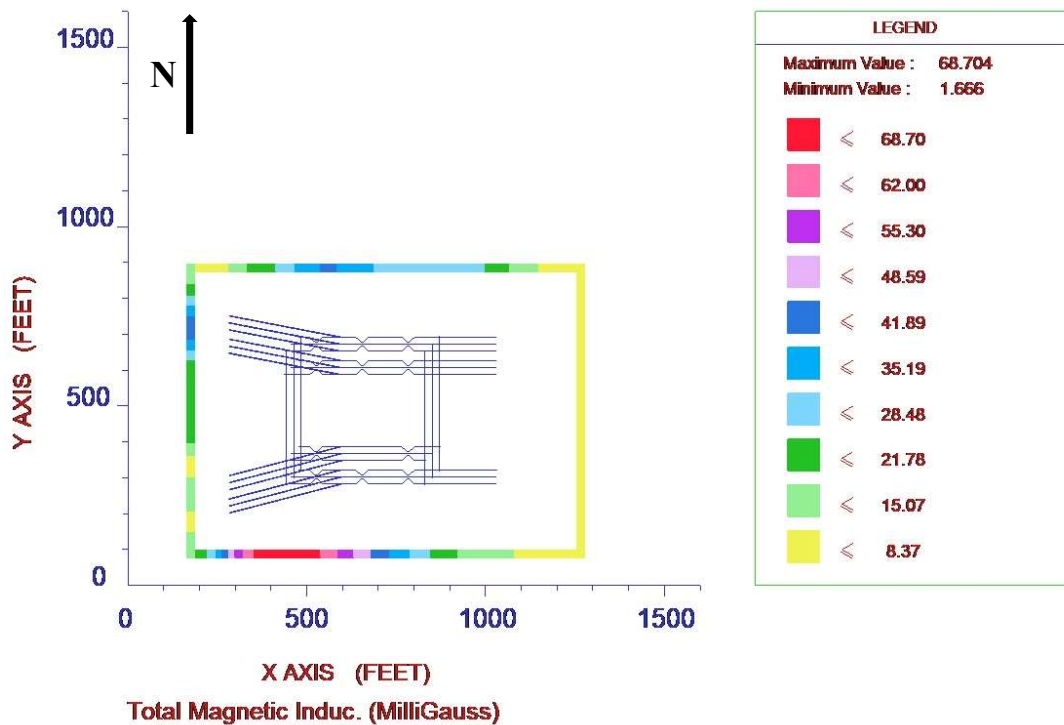
Figure 4: Fort St. Vrain Magnetic Field Strength Values Exceeding 150 mG

**Canal Crossing**

Table 5 shows a summary of the magnetic field strength values at the proposed fence line for the new Canal Crossing Substation based on a conceptual substation general arrangement provided by the Company. Values are calculated at a height of one meter above the ground per IEEE Std 644-2019 and consistent with PUC Rule 3206(e). The magnetic field strength levels at each of the proposed fence lines for the new substation are below the 150 mG magnetic field strength levels deemed reasonable by PUC Rule 3206(e).

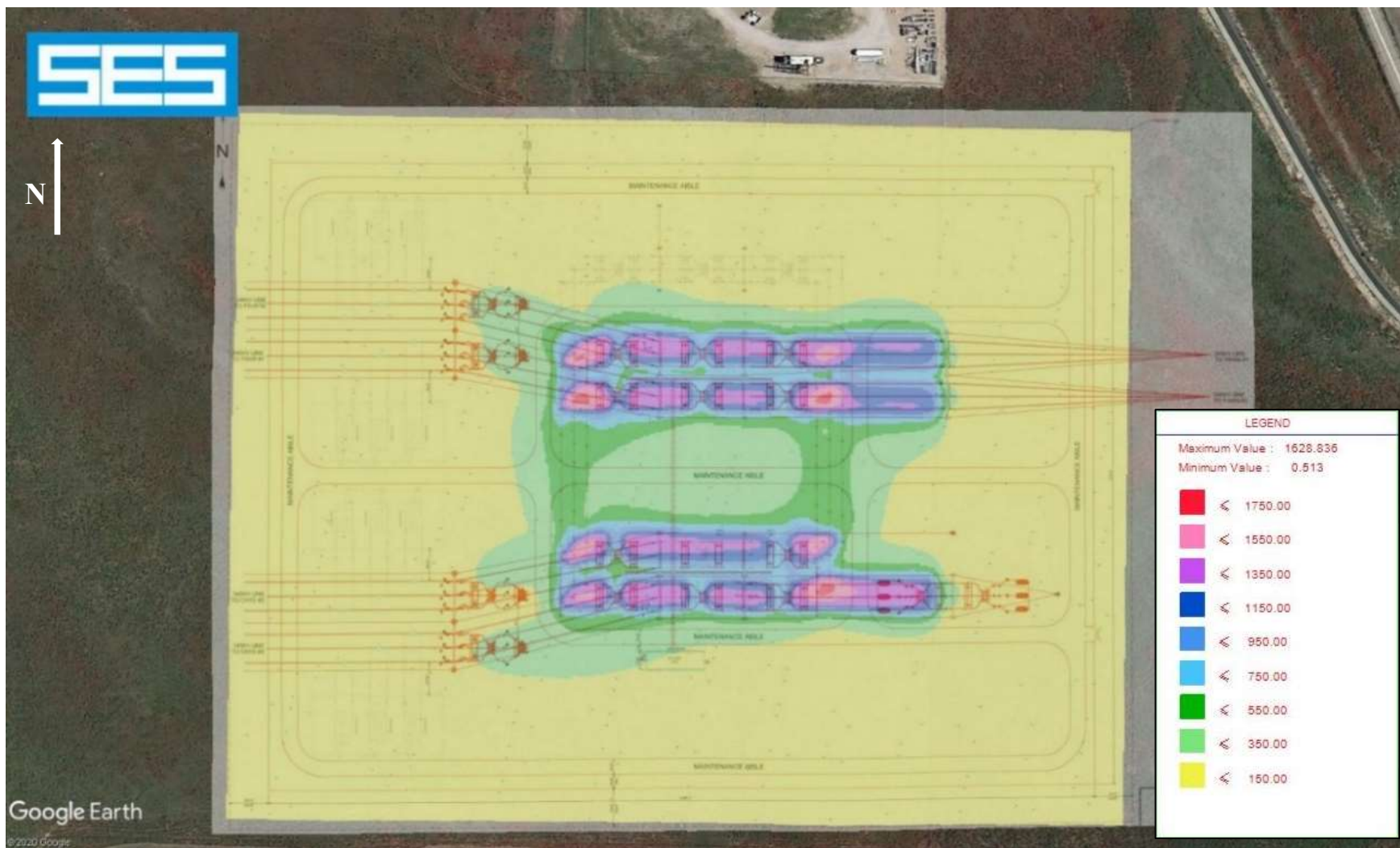
<b>TABLE 5 – CANAL CROSSING MAGNETIC FIELD STRENGTH</b>	
<b>SUBSTATION FENCE LINE LOCATION</b>	<b>MAGNETIC FIELD AT EDGE OF FENCE LINE [mG]</b>
<i>Magnetic Field Deemed Reasonable Level (PUC Rule 3206)</i>	150
Maximum Northern Fence Line	36
Maximum Eastern Fence Line	7
Maximum Southern Fence Line	69
Maximum Western Fence Line	38

Figure 5 shows magnetic field strengths along the fence line. Figure 6 shows magnetic field strength values throughout the substation that exceed 150 mG.



**Figure 5: Canal Crossing Magnetic Field Strength Values at the Fence Line**





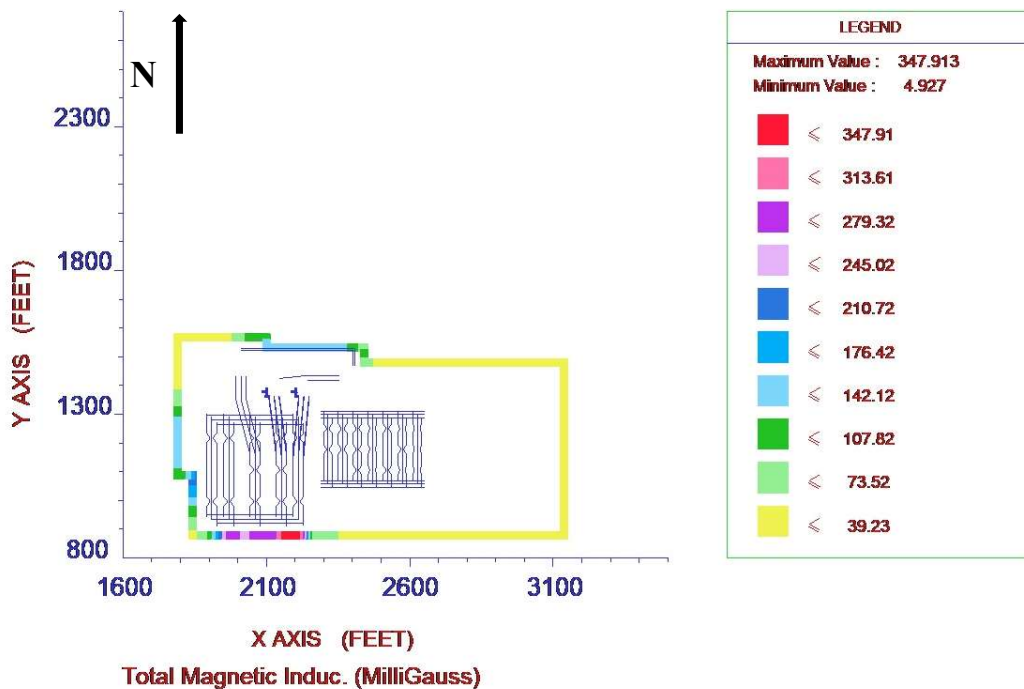
**Figure 6: Canal Crossing Magnetic Field Strength Values Exceeding 150 mG**

**Pawnee**

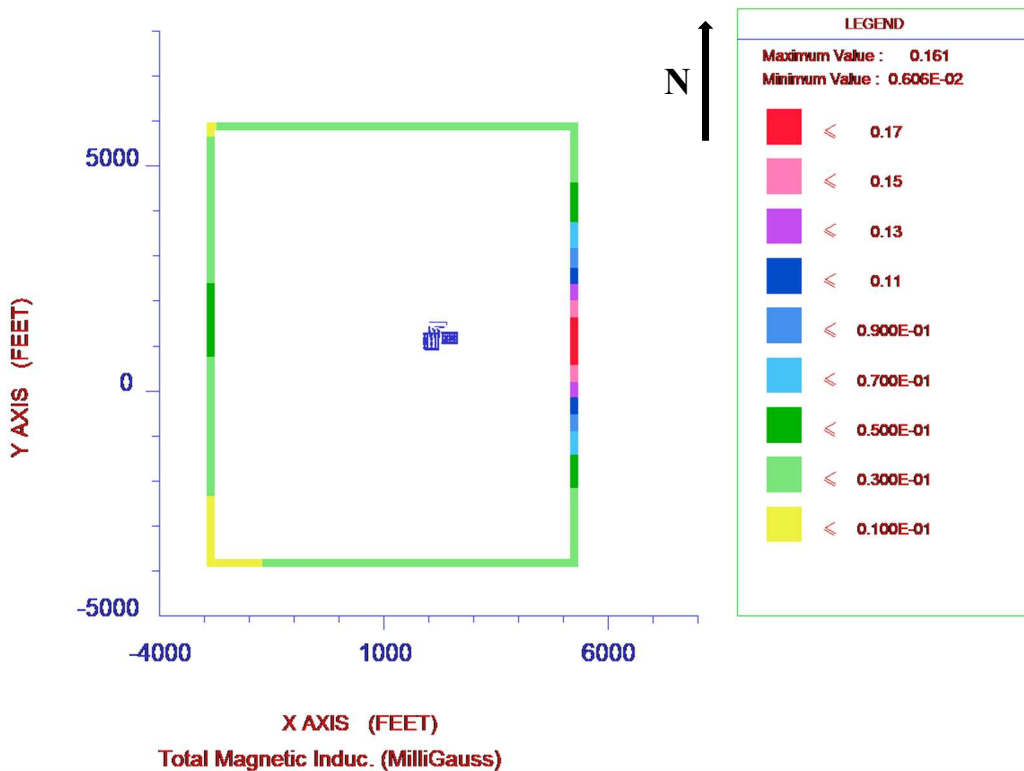
Table 6 shows a summary of the magnetic field strength values at the fence line and property line for the expanded Pawnee Substation. Values are calculated at a height of one meter above the ground per IEEE Std 644-2019 and consistent with PUC Rule 3206(e). Because the magnetic field strength level along one of the substation fence lines is above the 150 mG magnetic field level deemed reasonable by rule, magnetic field strength was calculated at the edge of the property line. The property line analyzed encompasses parcels owned by Public Service that are adjacent to the substation parcel. The magnetic field strength levels along the entire property line are below the 150 mG magnetic field level deemed reasonable by PUC Rule 3206(e).

TABLE 6 – PAWNEE MAGNETIC FIELD STRENGTH		
SUBSTATION FENCE LINE LOCATION	MAGNETIC FIELD AT EDGE OF FENCE LINE [mG]	MAGNETIC FIELD AT EDGE OF PROPERTY LINE [mG]
<i>Magnetic Field Deemed Reasonable Level (PUC Rule 3206)</i>	150	150
Maximum Northern Fence Line	142	0.0
Maximum Eastern Fence Line	39	0.2
Maximum Southern Fence Line	348	0.0
Maximum Western Fence Line	210	0.1

Figure 7 and Figure 8 show plots of the magnetic field strength values along the fence line and property line, respectively. Figure 9 shows magnetic field strengths that exceed 150 mG. The plots at the fence line show values higher than the 150 mG deemed reasonable at certain points along the edge of the southern edge of the substation fence line, well within the existing Public Service property line. Public Service owns the land surrounding the Pawnee Substation (including all the land shown on Figure 8), including for several thousand feet to the south of the substation’s southern fence line. Moreover, members of the public are not invited or expected at the substation site. Figure 8 shows that magnetic field strengths fall below 150 mG level deemed reasonable by PUC Rule 3206(e) within the Public Service property line.



**Figure 7: Pawnee Magnetic Field Strength Values at the Fence Line**



**Figure 8: Pawnee Magnetic Field Strength Values at the Property Line**

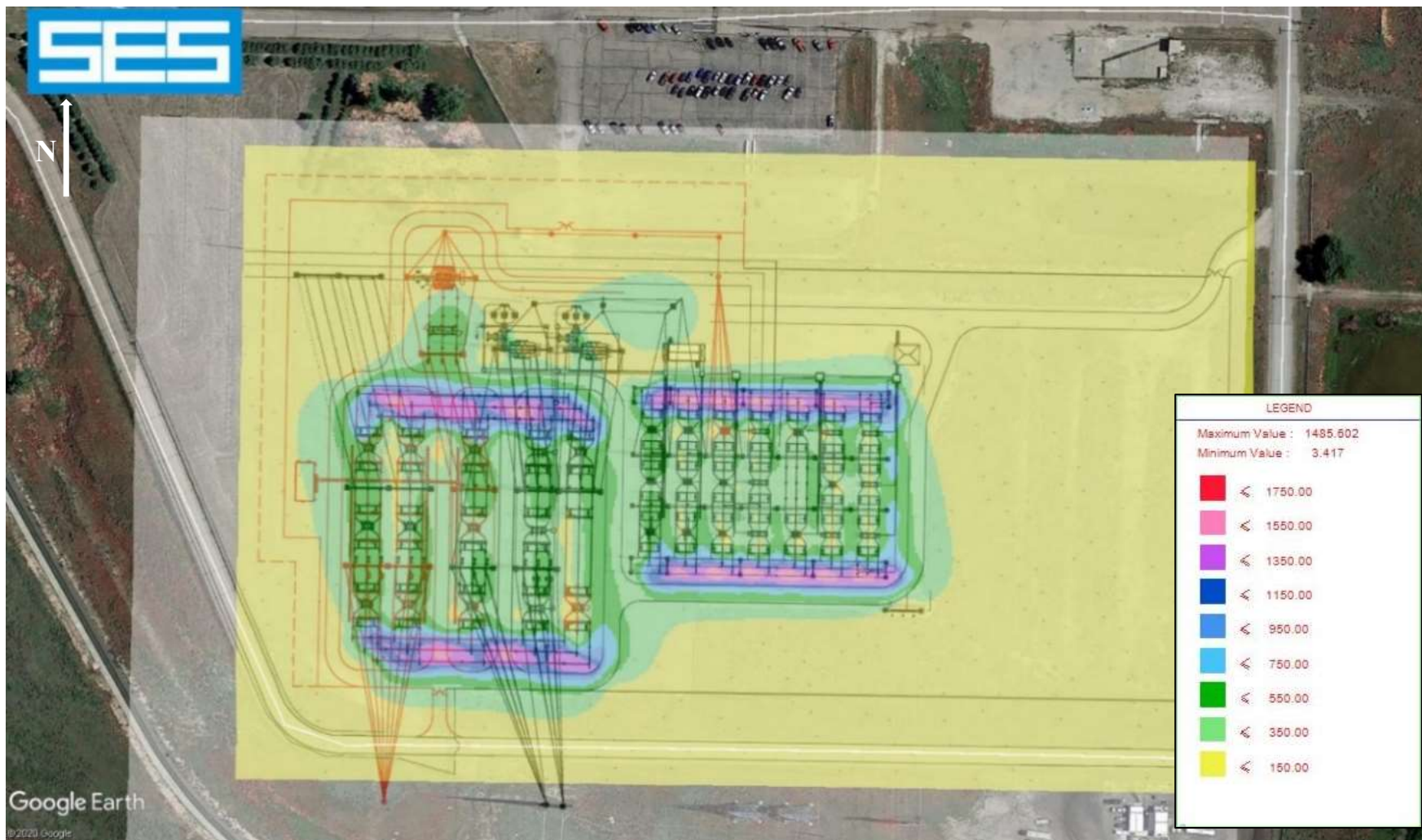


Figure 9: Pawnee Magnetic Field Strength Values Exceeding 150 mG

**Goose Creek**

Table 7 shows a summary of the magnetic field strength values at a hypothetical fence line for the new Goose Creek Substation based on a conceptual substation general arrangement provided by the Company and the assumed land acquisition for the substation. Values are calculated at a height of one meter above the ground per IEEE Std 644-2019 and consistent with PUC Rule 3206(e). The magnetic field strength levels at each of the hypothetical fence lines for the substation are below the 150 mG magnetic field strength levels deemed reasonable by PUC Rule 3206(e).

TABLE 7 – GOOSE CREEK MAGNETIC FIELD STRENGTH	
SUBSTATION FENCE LINE LOCATION	MAGNETIC FIELD AT EDGE OF FENCE LINE [mG]
<i>Magnetic Field Deemed Reasonable Level (PUC Rule 3206)</i>	150
Maximum Northern Fence Line	30
Maximum Eastern Fence Line	72
Maximum Southern Fence Line	13
Maximum Western Fence Line	89

Figure 10 shows magnetic field strengths along the fence line. Figure 11 shows magnetic field strength values throughout the substation that exceed 150 mG.



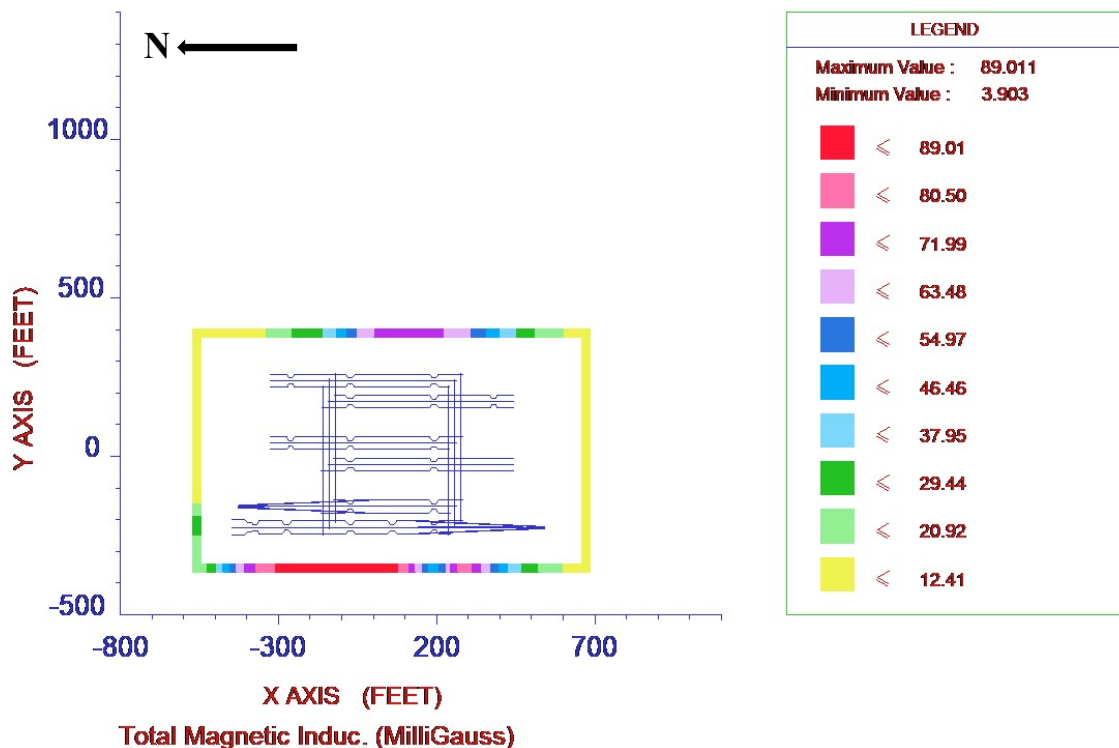


Figure 10: Goose Creek Magnetic Field Strength Values at the Fence Line

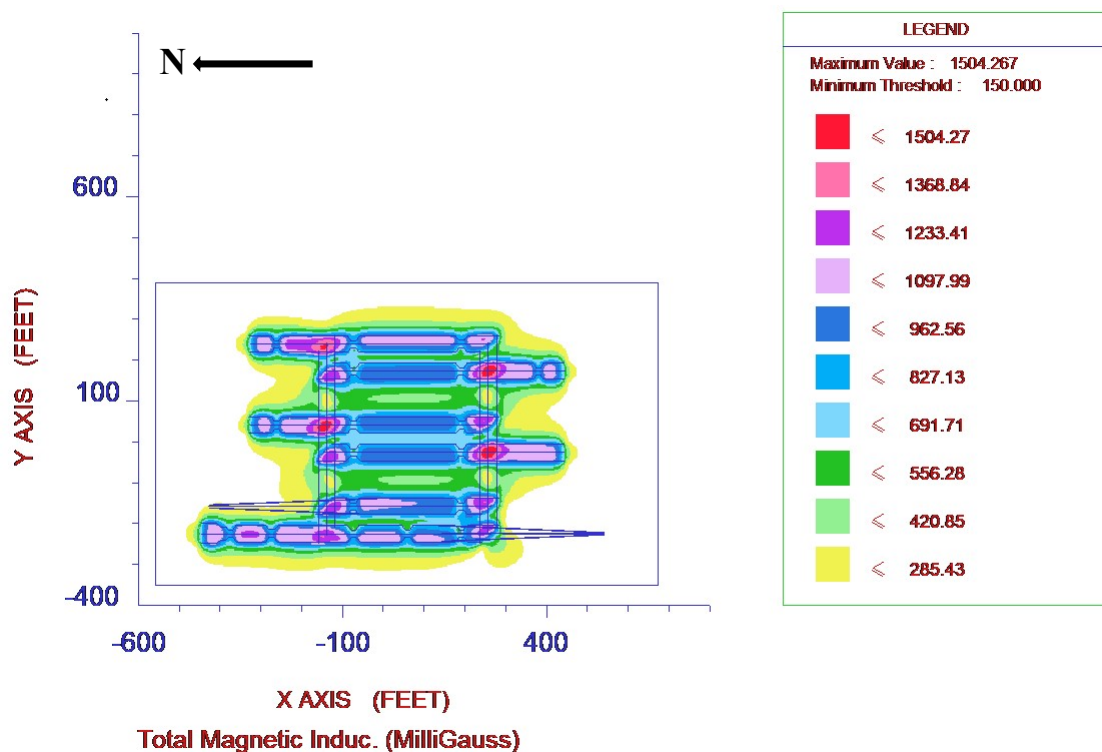


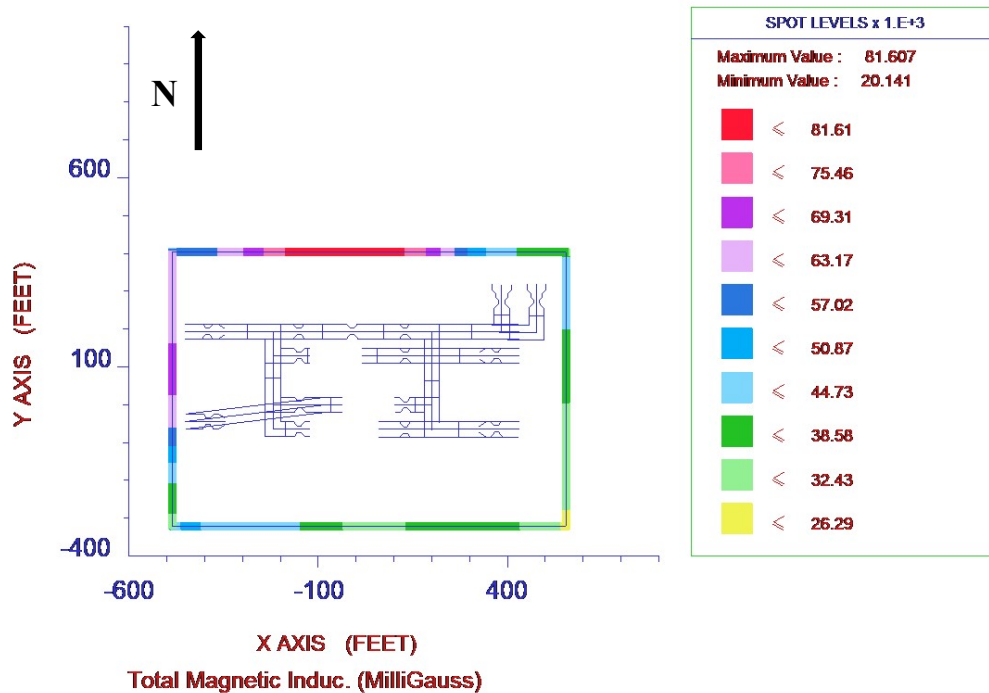
Figure 11: Goose Creek Magnetic Field Strength Values Exceeding 150 mG

**May Valley**

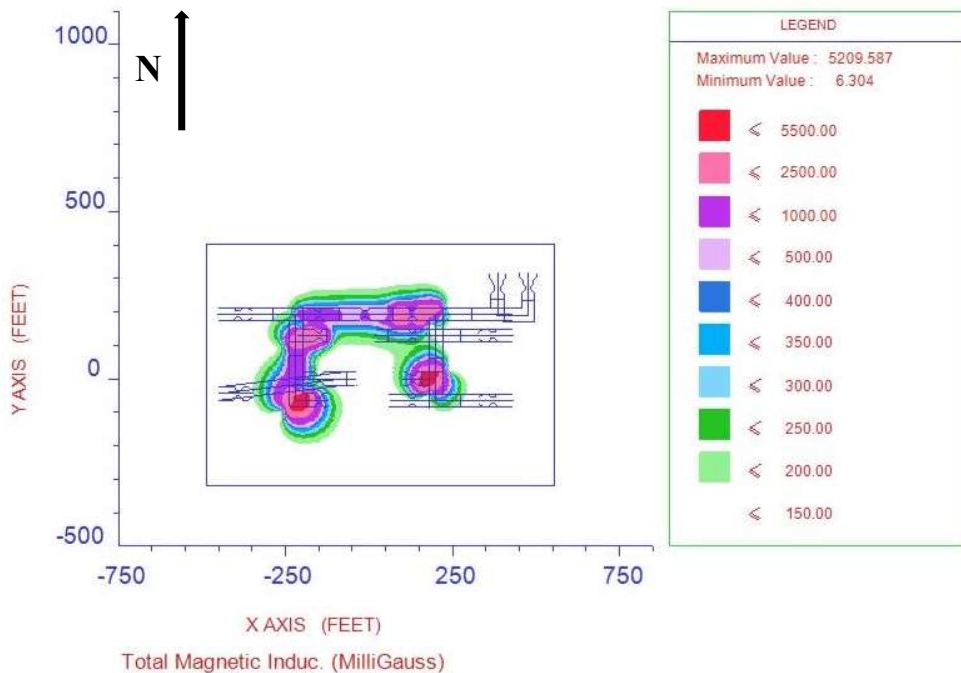
Table 8 shows a summary of the magnetic field strength values at a hypothetical fence line for the new May Valley Substation based on a conceptual substation general arrangement provided by the Company and the assumed land acquisition for the substation. Values are calculated at a height of one meter above the ground per IEEE Std 644-2019 and consistent with PUC Rule 3206(e). The magnetic field strength levels at each of the hypothetical fence lines for the new substation are below the 150 mG magnetic field strength levels deemed reasonable by PUC Rule 3206(e).

TABLE 8 – MAY VALLEY MAGNETIC FIELD STRENGTH	
SUBSTATION FENCE LINE LOCATION	MAGNETIC FIELD AT EDGE OF FENCE LINE [mG]
<i>Magnetic Field Deemed Reasonable Level (PUC Rule 3206)</i>	150
Maximum Northern Fence Line	45
Maximum Eastern Fence Line	39
Maximum Southern Fence Line	70
Maximum Western Fence Line	82

Figure 12 shows magnetic field strengths along the fence line. Figure 13 shows magnetic field strength values throughout the substation that exceed 150 mG.



**Figure 12: May Valley Magnetic Field Strength Values at the Fence Line**



**Figure 13: May Valley Magnetic Field Strength Values Exceeding 150 mG**

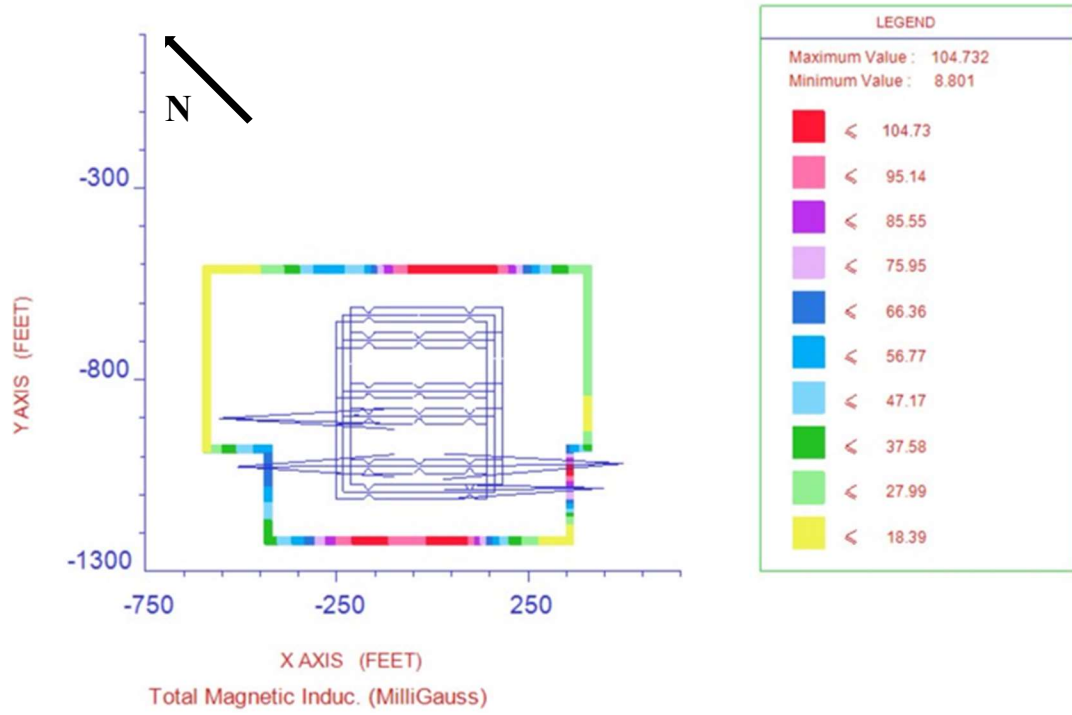


**Tundra**

Table 9 shows a summary of the magnetic field strength values at the proposed fence line for the expanded Tundra Substation based on a conceptual substation general arrangement provided by the Company. Values are calculated at a height of one meter above the ground per IEEE Std 644-2019 and consistent with PUC Rule 3206(e). The magnetic field strength levels at each of the proposed fence lines for the substation are below the 150 mG magnetic field strength levels deemed reasonable by PUC Rule 3206(e).

TABLE 9 – TUNDRA MAGNETIC FIELD STRENGTH	
SUBSTATION FENCE LINE LOCATION	MAGNETIC FIELD AT EDGE OF FENCE LINE [mG]
<i>Magnetic Field Deemed Reasonable Level (PUC Rule 3206)</i>	150
Maximum Northeastern Fence Line	104
Maximum Northwestern Fence Line	64
Maximum Southeastern Fence Line	103
Maximum Southwestern Fence Line	105

Figure 14 shows magnetic field strengths along the fence line. Figure 15 shows magnetic field strength values throughout the substation that exceed 150 mG.



**Figure 14: Tundra Magnetic Field Strength Values at the Fence Line**



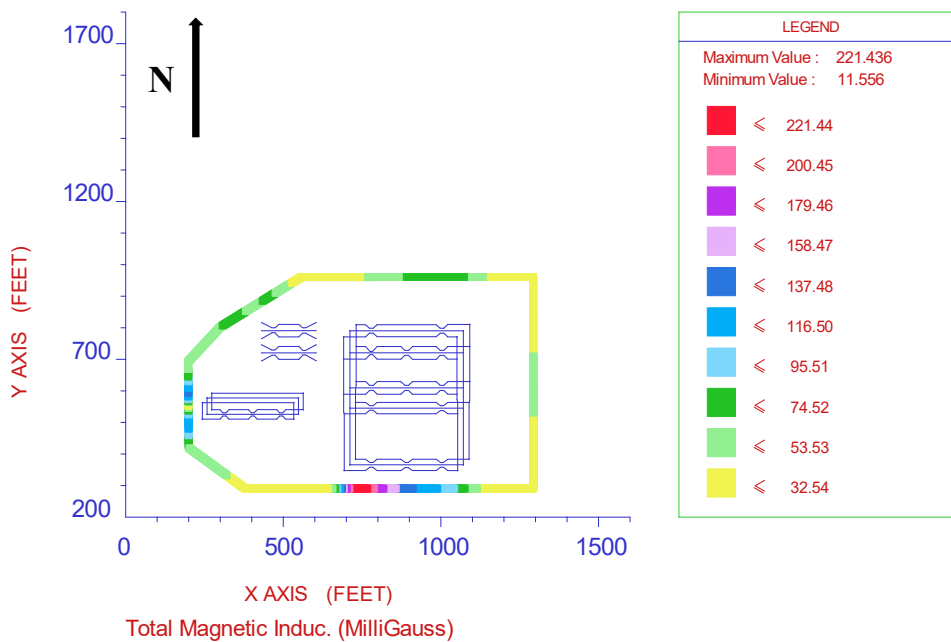
**Figure 15: Tundra Magnetic Field Strength Values Exceeding 150 mG**

**Harvest Mile**

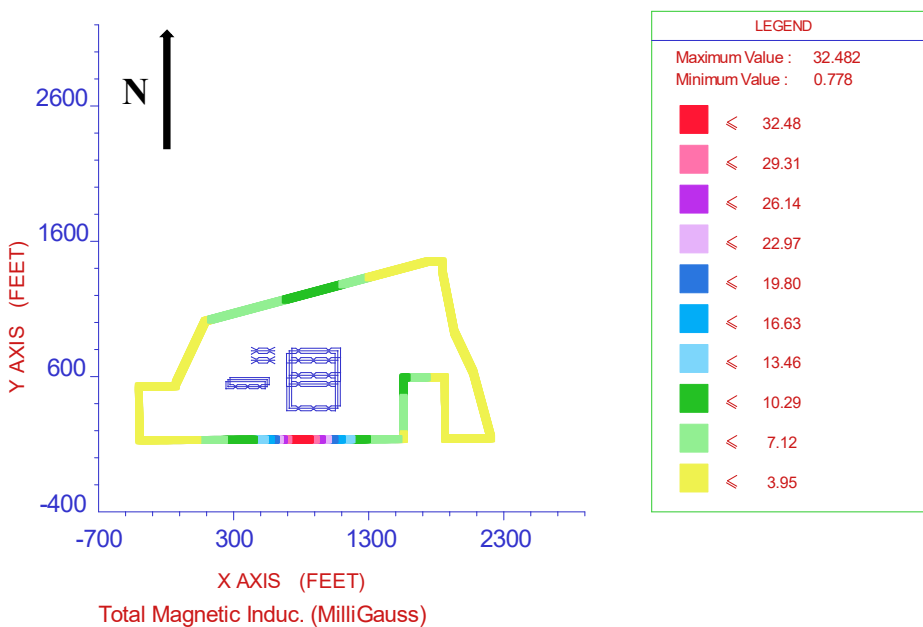
Table 10 shows a summary of the magnetic field strength values at the fence line and property line for the expanded Harvest Mile Substation. Values are calculated at a height of one meter above the ground per IEEE Std 644-2019 and consistent with PUC Rule 3206(e). Because the magnetic field strength level along one of the substation fence lines is above the 150 mG magnetic field level deemed reasonable by rule, magnetic field strength was calculated at the edge of the property line. The magnetic field strength levels along the entire property line of the substation are below the 150 mG magnetic field level deemed reasonable by PUC Rule 3206(e).

TABLE 10 – HARVEST MILE MAGNETIC FIELD STRENGTH		
SUBSTATION FENCE LINE LOCATION	MAGNETIC FIELD AT EDGE OF FENCE LINE [mG]	MAGNETIC FIELD AT EDGE OF PROPERTY LINE [mG]
<i>Magnetic Field Deemed Reasonable Level (PUC Rule 3206)</i>	150	150
Maximum Northern Fence Line	69	10
Maximum Eastern Fence Line	36	2
Maximum Southern Fence Line	224	32
Maximum Western Fence Line	121	3

Figure 16 and Figure 17 show plots of the magnetic field strengths along the fence line and property line, respectively. Figure 18 shows magnetic field strengths that exceed 150 mG.



**Figure 16: Harvest Mile Magnetic Field Strength Values at the Fence Line**



**Figure 17: Harvest Mile Magnetic Field Strength Values at the Property Line**





Figure 18: Harvest Mile Magnetic Field Strength Values Exceeding 150 mG

## **Audible Noise**

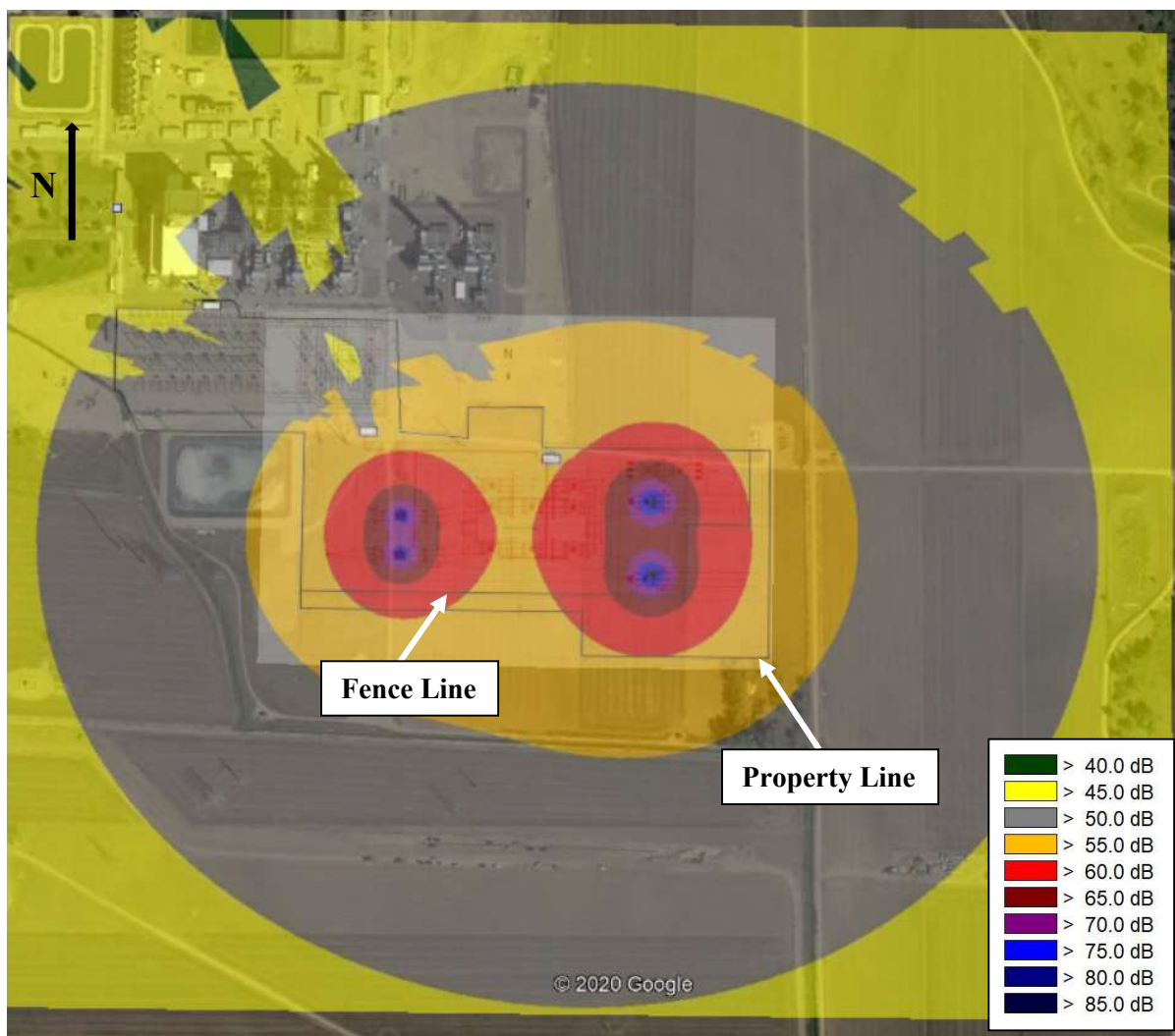
Within the scope of the Pathway Project, the new and expanded substations will contain reactors and transformers that are considered as continuous noise generating equipment. Each noise source was modeled as a point source. Additionally, the models included walls or barriers that might block sound, such as control houses, for their impact at mitigating noise outside the substations.

Audible noise is measured and calculated as an equivalent A-weighted sound pressure level in decibels (dB(A)). Values are calculated at a height of 1.5 meters (~4.9 feet) to approximate the height of an individual's ear.

This preliminary study assumes a flat surface at the site and does not account for possible elevation changes. Additionally, the analysis does not consider possible attenuation due to the properties of ground surfaces. No structures outside of substation fence lines, including buildings that would be expected to absorb, reflect, or shield audible noise, were modeled for these studies.

**Fort St. Vrain**

The expanded Fort St. Vrain Substation will contain two transformers (rating of 560 MVA) and two reactors (assumed rating of 60 MVAR) that are considered as continuous noise generating equipment on the site. Figure 19 shows the color-shaded plot of the sound pressure levels produced by the reactors and transformers around the substation.



**Figure 19: Fort St. Vrain Audible Noise Levels**

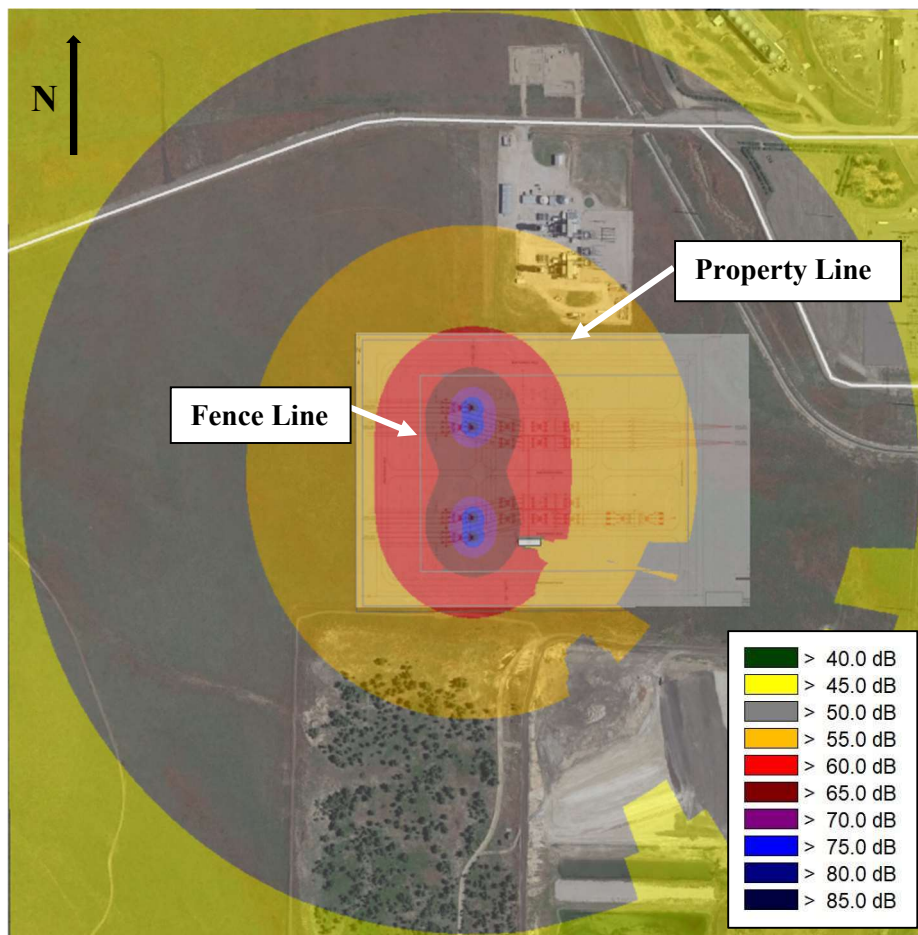
Table 11 shows the projected audible noise levels 25 feet from the substation’s property lines. The audible noise produced by the substation is expected to be 62 dB(A) or less at a distance of 25 feet from the property lines. This is below the noise level deemed reasonable by PUC Rule 3206(f) for property zoned as Industrial (75 dB(A)). Public Service also owns additional property adjacent to the identified parcel, and audible noise levels at those boundaries would be expected to be lower.



<b>TABLE 11 – FORT ST. VRAIN AUDIBLE NOISE VALUES</b>	
<b>SUBSTATION PROPERTY LINE LOCATION</b>	<b>AUDIBLE NOISE 25 FEET FROM PROPERTY LINE [DB(A)]</b>
<i>Audible Noise Deemed Reasonable Level (PUC Rule 3206)</i>	<i>75 dB(A) (Industrial)</i>
25 feet from Northern Property Line	62
25 feet from Eastern Property Line	58
25 feet from Southern Property Line	60
25 feet from Western Property Line	58

### Canal Crossing

The new Canal Crossing Substation will contain four reactors (assumed rating of 60 MVAR) that are considered as continuous noise generating equipment on the site. Figure 20 shows the color-shaded plot of the sound pressure levels produced by the reactors around the substation.



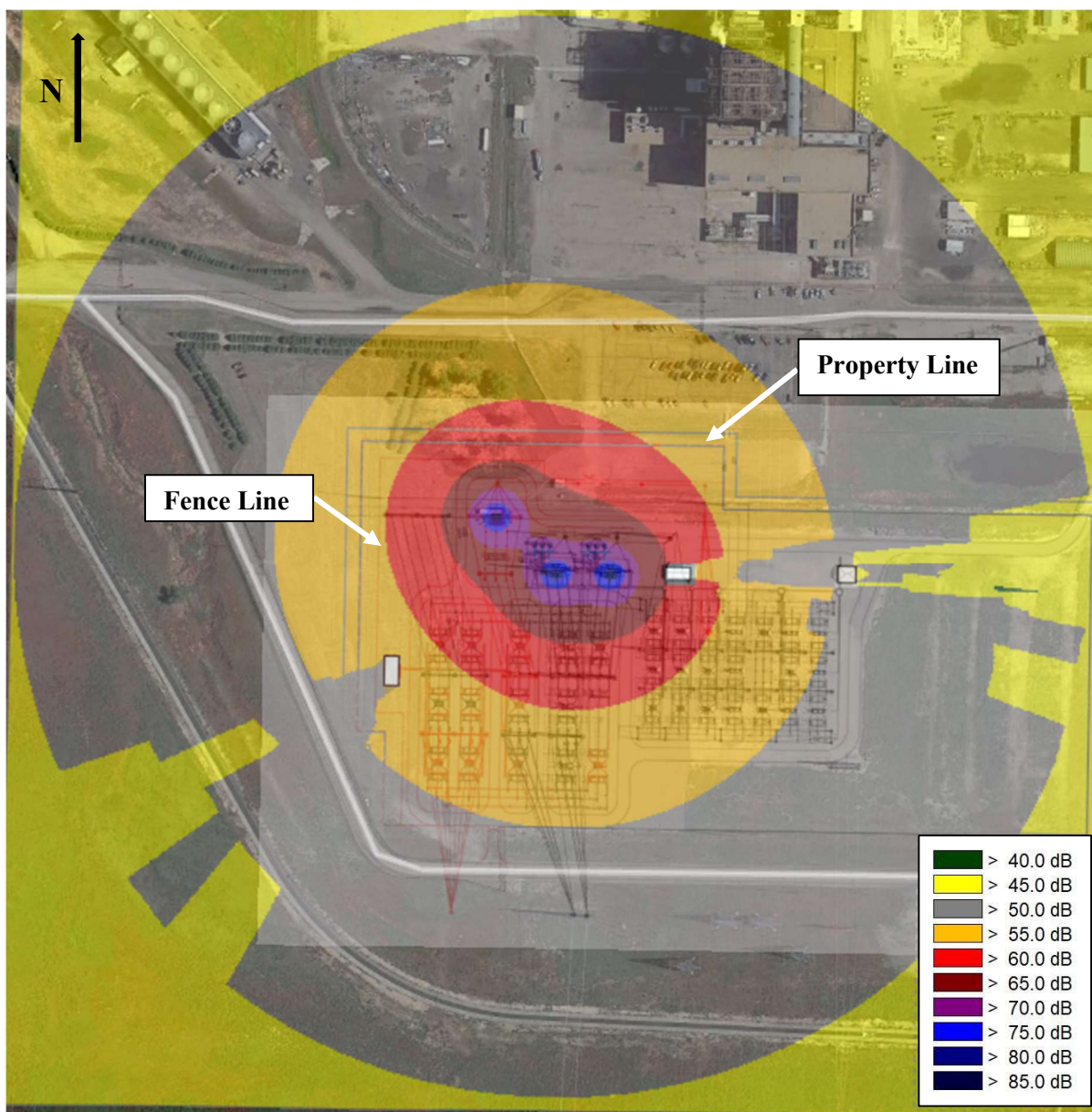
**Figure 20: Canal Crossing Audible Noise Levels**

Table 12 shows the projected audible noise levels 25 feet from the substation’s property lines. The audible noise produced by the substation is expected to be 61 dB(A) or less at a distance of 25 feet from the property lines. This is below the noise level deemed reasonable by PUC Rule 3206(f) for property zoned as Industrial (75 dB(A)). Public Service also owns additional property adjacent to the identified parcel, and audible noise levels at those boundaries would be expected to be lower.

<b>TABLE 12 – CANAL CROSSING AUDIBLE NOISE VALUES</b>	
<b>SUBSTATION PROPERTY LINE LOCATION</b>	<b>AUDIBLE NOISE 25 FEET FROM PROPERTY LINE [DB(A)]</b>
<i>Audible Noise Deemed Reasonable Level (PUC Rule 3206)</i>	<i>75 dB(A) (Industrial)</i>
25 feet from Northern Property Line	61
25 feet from Eastern Property Line	55
25 feet from Southern Property Line	61
25 feet from Western Property Line	59

**Pawnee**

The expanded Pawnee Substation will contain two 15 kV air core reactors (assumed rating of 40 MVAR) and three transformers (rating of 560 MVA) that are considered as continuous noise generating equipment on the site. Figure 21 shows the color-shaded plot of the sound pressure levels produced by the reactors and transformers around the substation.



**Figure 21: Pawnee Audible Noise Levels**

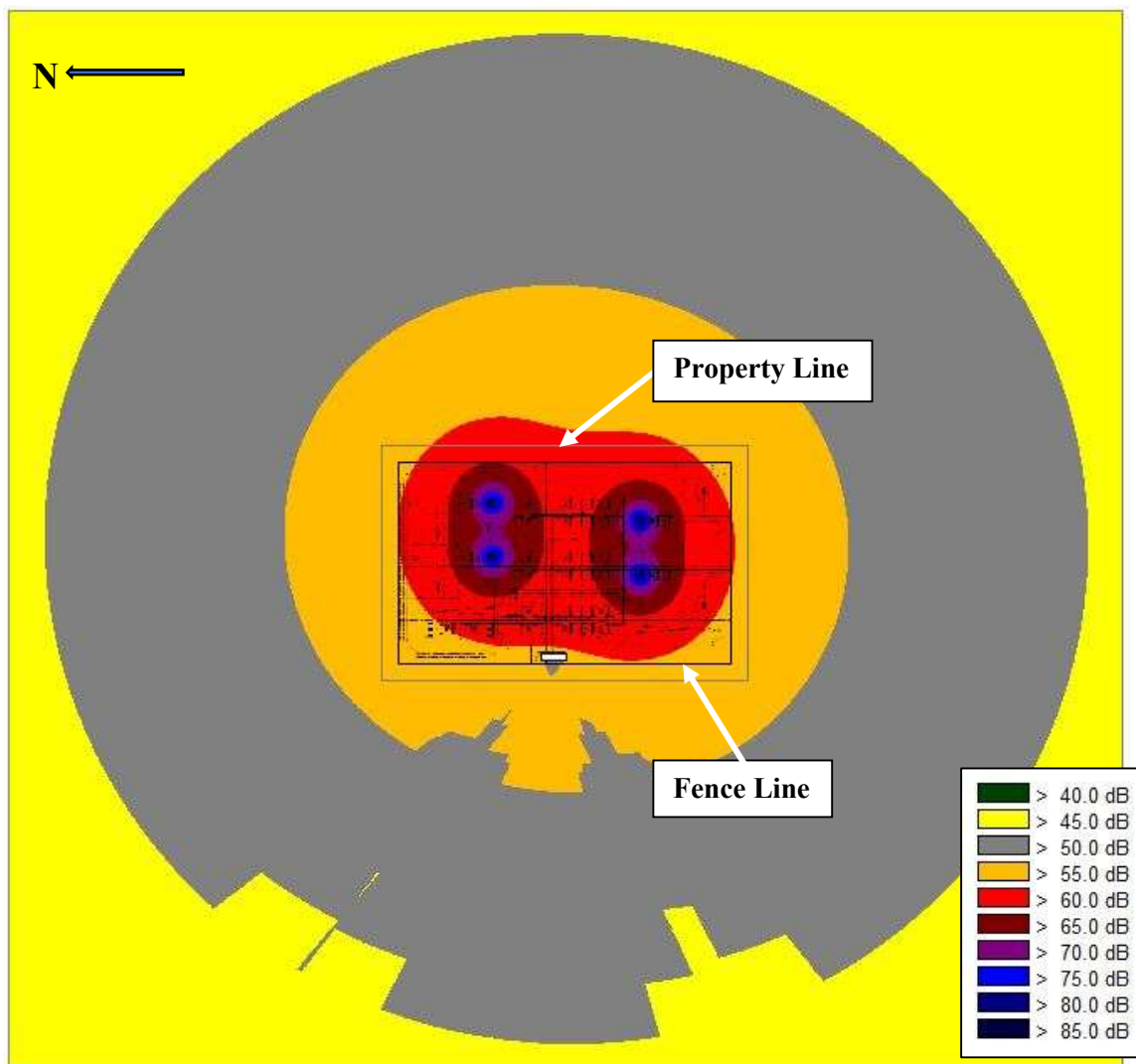
Table 13 shows the projected audible noise levels 25 feet from the substation’s property lines. The audible noise produced by the substation is expected to be 62 dB(A) or less at a distance of 25 feet

from the property lines. This is below the noise level deemed reasonable by PUC Rule 3206(f) for property zoned as Industrial (75 dB(A)). Public Service also owns additional property adjacent to the identified parcel, and audible noise levels at those boundaries would be expected to be lower.

<b>TABLE 13 – PAWNEE AUDIBLE NOISE VALUES</b>	
<b>SUBSTATION PROPERTY LINE LOCATION</b>	<b>AUDIBLE NOISE 25 FEET FROM PROPERTY LINE [DB(A)]</b>
<i>Audible Noise Deemed Reasonable Level (PUC Rule 3206)</i>	<i>75 dB(A) (Industrial)</i>
25 feet from Northern Property Line	62
25 feet from Eastern Property Line	50
25 feet from Southern Property Line	55
25 feet from Western Property Line	58

### Goose Creek

The new Goose Creek Substation will contain four reactors (assumed rating of 60 MVAR) that are considered as continuous noise generating equipment on the site. Figure 22 shows the color-shaded plot of the sound pressure levels produced by the reactors around the substation.



**Figure 22: Goose Creek Audible Noise Levels**

Table 14 shows the projected audible noise levels 25 feet from hypothetical substation property lines based on a conceptual substation general arrangement provided by the Company and the assumed land acquisition for the substation. A location for the substation has not been finalized at this point, so the actual property lines are unknown. The audible noise produced by the substation is expected to be 62 dB(A) or less at a distance of 25 feet from the property lines.

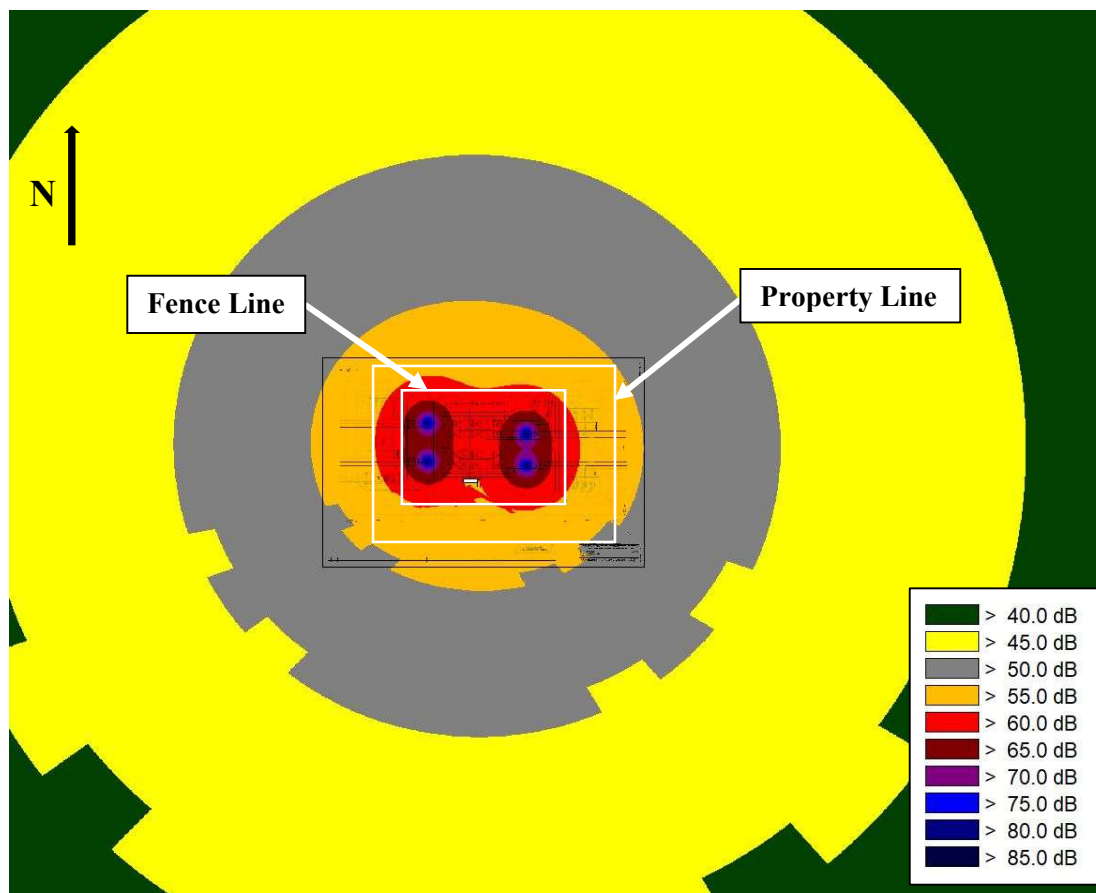
<b>TABLE 14 – GOOSE CREEK AUDIBLE NOISE VALUES</b>	
<b>SUBSTATION PROPERTY LINE LOCATION</b>	<b>AUDIBLE NOISE 25 FEET FROM PROPERTY LINE [DB(A)]</b>
<i>Audible Noise Deemed Reasonable Level (PUC Rule 3206)</i>	<i>No 3206(f) defined ruling limit<sup>a</sup></i>
25 feet from Northern Fence Line	59
25 feet from Eastern Fence Line	62
25 feet from Southern Fence Line	59
25 feet from Western Fence Line	58

(a) For some of the Power Pathway substations, the substation parcels and surrounding land are zoned agricultural and/or a mix of other zoning designations. Rule 3206(f) does not identify an audible noise level that is deemed reasonable for land zoned agricultural, and POWER does not draw any conclusions about the zoning-dependent audible noise levels that would be deemed reasonable by PUC Rule 3206(f). Additional information about zoning and land use can be found in the "Zoning Designations and Land Use" section.



**May Valley**

The new May Valley Substation will contain four reactors (assumed rating of 60 MVAR) that are considered as continuous noise generating equipment on the site. Figure 23 shows the color-shaded plot of the sound pressure levels produced by the reactors around the substation.



**Figure 23: May Valley Audible Noise Levels**

Table 15 shows the projected audible noise levels 25 feet from hypothetical substation property lines based on a conceptual substation general arrangement provided by the Company and the assumed land acquisition for the substation. A location for the substation has not been finalized at this point, so the actual property lines are unknown. The audible noise produced by the substation is expected to be 60 dB(A) or less at a distance of 25 feet from the property lines.

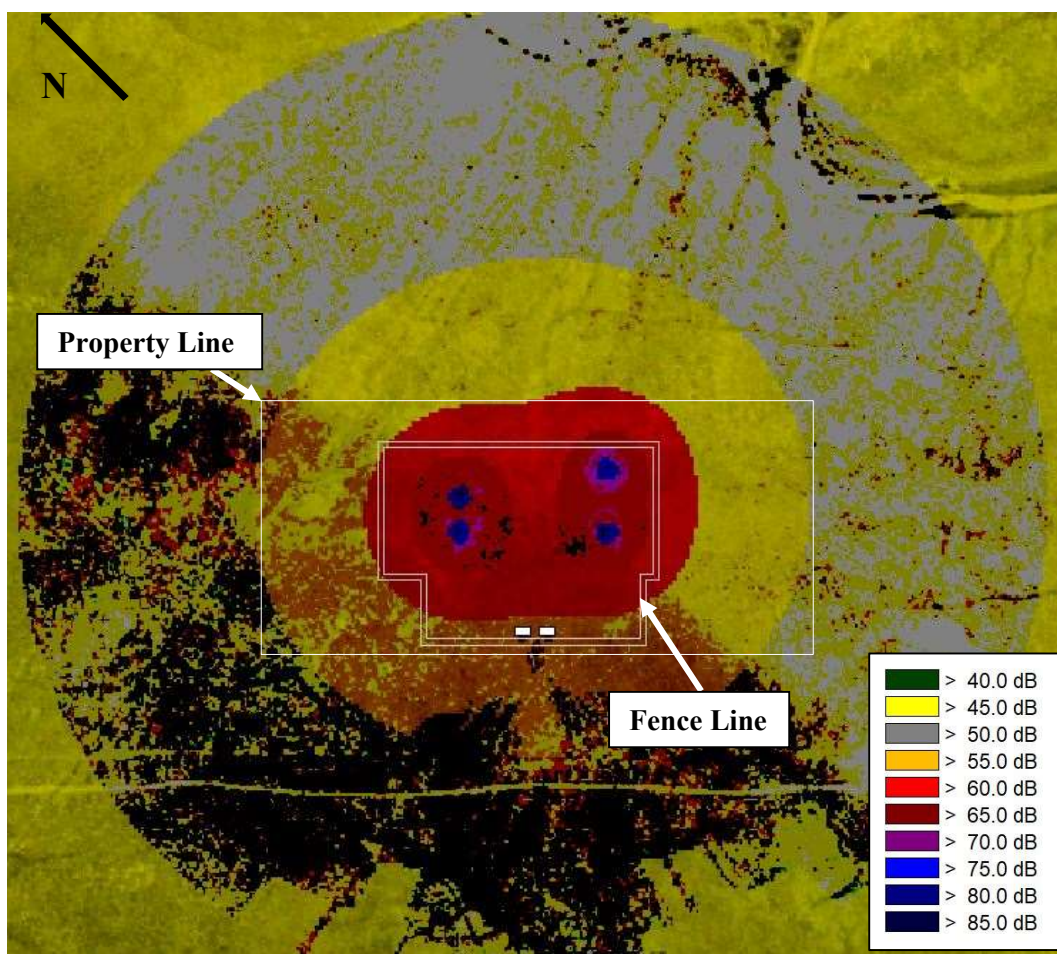


TABLE 15 – MAY VALLEY AUDIBLE NOISE VALUES	
SUBSTATION PROPERTY LINE LOCATION	AUDIBLE NOISE 25 FEET FROM PROPERTY LINE [DB(A)]
<i>Audible Noise Deemed Reasonable Level (PUC Rule 3206)</i>	<i>No 3206(f) defined ruling limit<sup>a</sup></i>
25 feet from Northern Property Line	56
25 feet from Eastern Property Line	60
25 feet from Southern Property Line	57
25 feet from Western Property Line	60

(a) For some of the Power Pathway substations, the substation parcels and surrounding land are zoned agricultural and/or a mix of other zoning designations. Rule 3206(f) does not identify an audible noise level that is deemed reasonable for land zoned agricultural, and POWER does not draw any conclusions about the zoning-dependent audible noise levels that would be deemed reasonable by PUC Rule 3206(f). Additional information about zoning and land use can be found in the "Zoning Designations and Land Use" section.

### **Tundra**

The expanded Tundra Substation will contain four reactors (assumed rating of 60 MVAR) that are considered as continuous noise generating equipment on the site. Figure 24 shows the color-shaded plot of the sound pressure levels produced by the reactors around the substation.



**Figure 24: Tundra Audible Noise Levels**

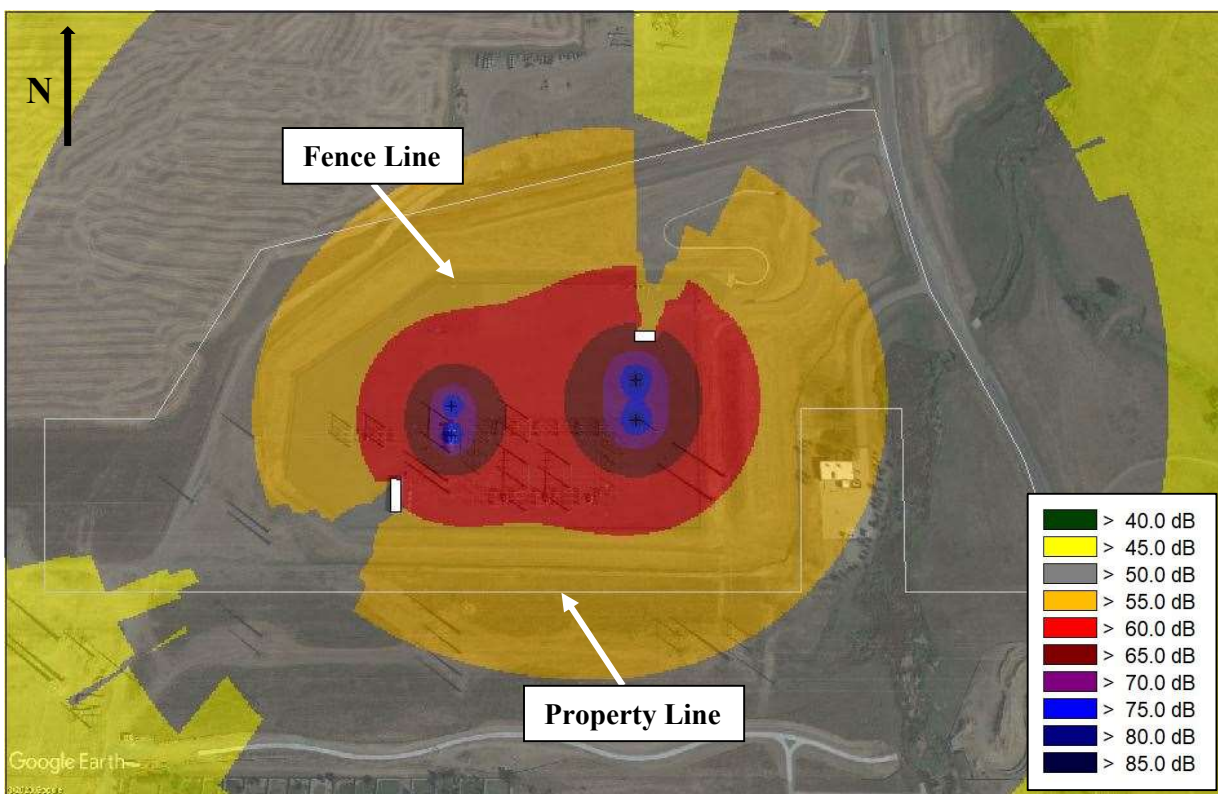
Table 16 shows the projected audible noise levels 25 feet from the substation's property lines. The audible noise produced by the substation is expected to be 61 dB(A) or less at a distance of 25 feet from the property lines.

TABLE 16 – TUNDRA AUDIBLE NOISE VALUES	
SUBSTATION PROPERTY LINE LOCATION	AUDIBLE NOISE 25 FEET FROM PROPERTY LINE [DB(A)]
<i>Audible Noise Deemed Reasonable Level (PUC Rule 3206)</i>	<i>No 3206(f) defined ruling limit<sup>a</sup></i>
25 feet from Northeastern Property Line	61
25 feet from Northwestern Property Line	55
25 feet from Southeastern Property Line	55
25 feet from Southwestern Property Line	58

(a) For some of the Power Pathway substations, the substation parcels and surrounding land are zoned agricultural and/or a mix of other zoning designations. Rule 3206(f) does not identify an audible noise level that is deemed reasonable for land zoned agricultural, and POWER does not draw any conclusions about the zoning-dependent audible noise levels that would be deemed reasonable by PUC Rule 3206(f). Additional information about zoning and land use can be found in the "Zoning Designations and Land Use" section.

**Harvest Mile**

The expanded Harvest Mile Substation will contain two transformers (rating of 560 MVA) and two reactors (assumed rating of 60 MVAR) that are considered as continuous noise generating equipment on the site. Figure 25 shows the color-shaded plot of the sound pressure levels produced by the reactors and transformers around the substation.



**Figure 25: Harvest Mile Audible Noise Levels**

Table 17 shows the projected audible noise levels 25 feet from the substation’s property lines. The audible noise produced by the substation is expected to be 57 dB(A) or less at a distance of 25 feet from the property lines.

<b>TABLE 17 – HARVEST MILE AUDIBLE NOISE VALUES</b>	
<b>SUBSTATION PROPERTY LINE LOCATION</b>	<b>AUDIBLE NOISE 25 FEET FROM PROPERTY LINE [DB(A)]</b>
<i>Audible Noise Deemed Reasonable Level (PUC Rule 3206)</i>	<i>No 3206(f) defined ruling limit<sup>a</sup></i>
25 feet from Northern Property Line	56
25 feet from Eastern Property Line	54
25 feet from Southern Property Line	57
25 feet from Western Property Line	54

(a) For some of the Power Pathway substations, the substation parcels and surrounding land are zoned agricultural and/or a mix of other zoning designations. Rule 3206(f) does not identify an audible noise level that is deemed reasonable for land zoned agricultural, and POWER does not draw any conclusions about the zoning-dependent audible noise levels that would be deemed reasonable by PUC Rule 3206(f). Additional information about zoning and land use can be found in the "Zoning Designations and Land Use" section.

## CONCLUSION

Public Service contracted POWER to investigate magnetic field and audible noise effects for the expansion or construction of seven substations (including single voltage switching stations) as part of the Pathway Project for the purpose of determining the expected maximum level of magnetic fields that could be experienced at substation boundaries and the projected level of audible noise at 25 feet beyond substation property lines, consistent with PUC Rule 3206 – Construction or Extension of Transmission Facilities (4 CCR 723-3-3206) requirements.

For magnetic field strengths, the maximum value at the fence line was provided if the calculated maximum was below the 150 mG level deemed reasonable by PUC Rule 3206(e). POWER calculated magnetic field strengths at the substation fence lines. If the maximum magnetic field strength at the substation fence line was not below 150 mG, the maximum field strength value was calculated at the property line. As detailed in the report, the calculated magnetic field strengths for the substations in the Pathway Project are expected to be below the 150 mG level deemed reasonable by PUC Rule 3206(e), with the exception of Pawnee and Harvest Mile Substations. For Pawnee Substation, although magnetic field strength at one fence line is projected to be above the level deemed reasonable by Rule 3206(e), Public Service owns the land adjacent to and surrounding the substation, and the magnetic field strength at the property line is below the level deemed reasonable by Rule 3206(e). Similarly, for Harvest Mile Substation, although the magnetic field strength at one fence line is projected to be above the level deemed reasonable by Rule 3206(e), the magnetic field strength at that property line is below the level deemed reasonable by Rule 3206(e).

For audible noise levels, the maximum value 25 feet from the property line was calculated in accordance with PUC Rule 3206(f). As detailed in the report, the audible noise levels for Fort St. Vrain Substation, Pawnee Substation, and Canal Crossing Substation are expected to be below the applicable zoning-dependent level deemed reasonable by PUC Rule 3206(f). The other substations are not, or will not be, located on land for which there is a zoning-dependent noise level limit deemed reasonable by PUC Rule 3206(f).

## **APPENDIX A – REFERENCE DRAWINGS**



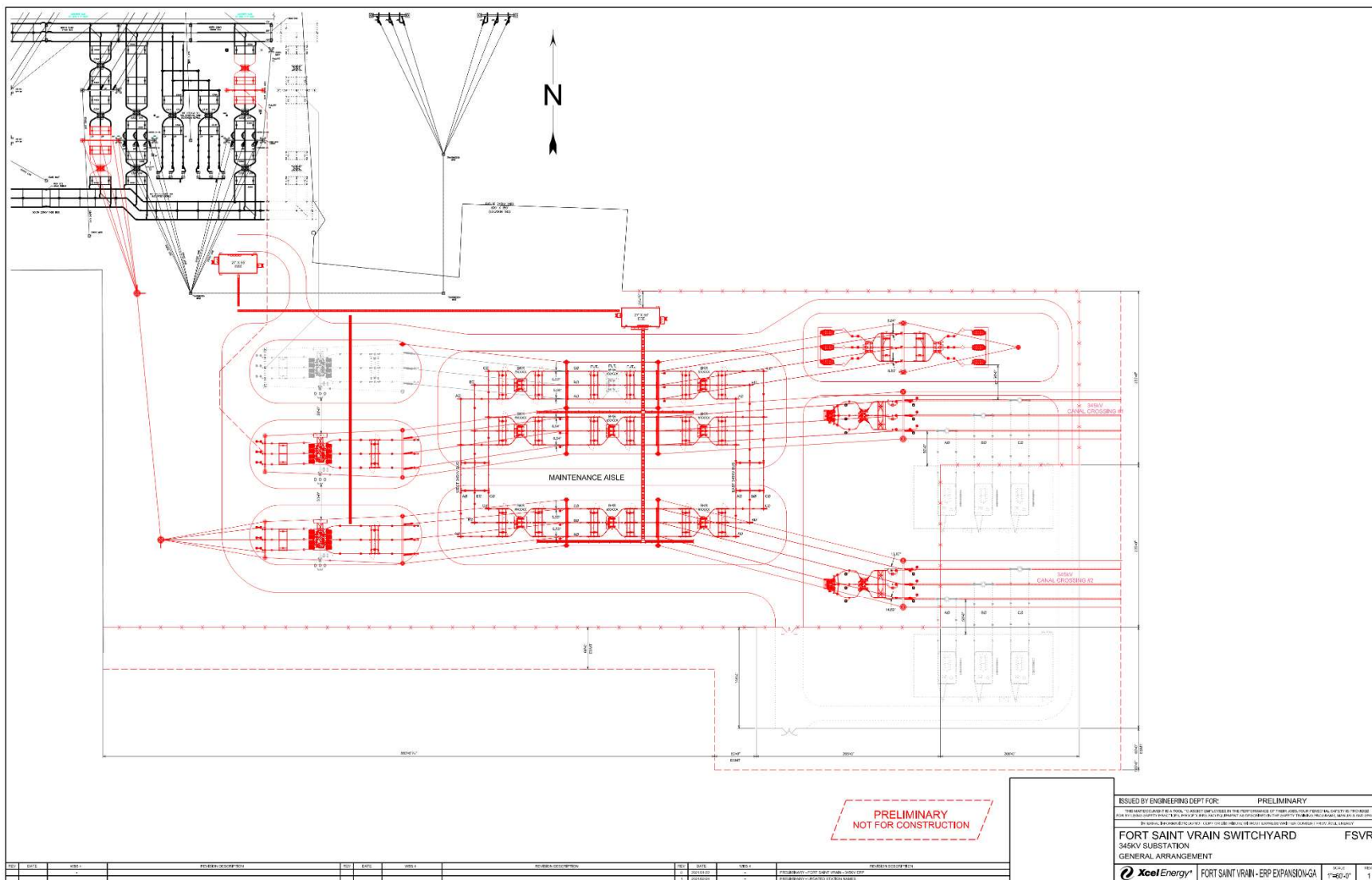


Figure 26: Fort St. Vrain General Arrangement Drawing

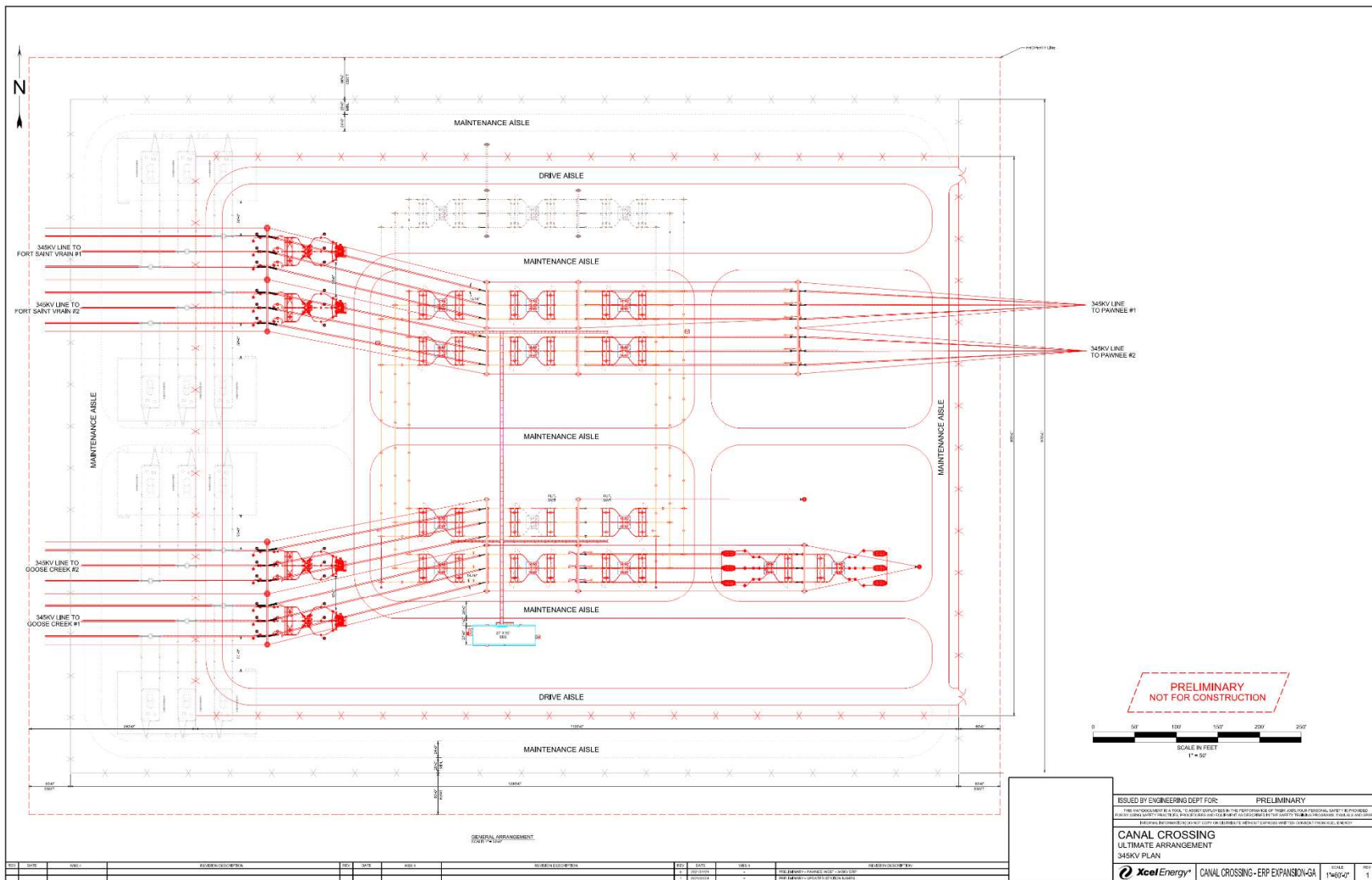


Figure 27: Canal Crossing General Arrangement Drawing

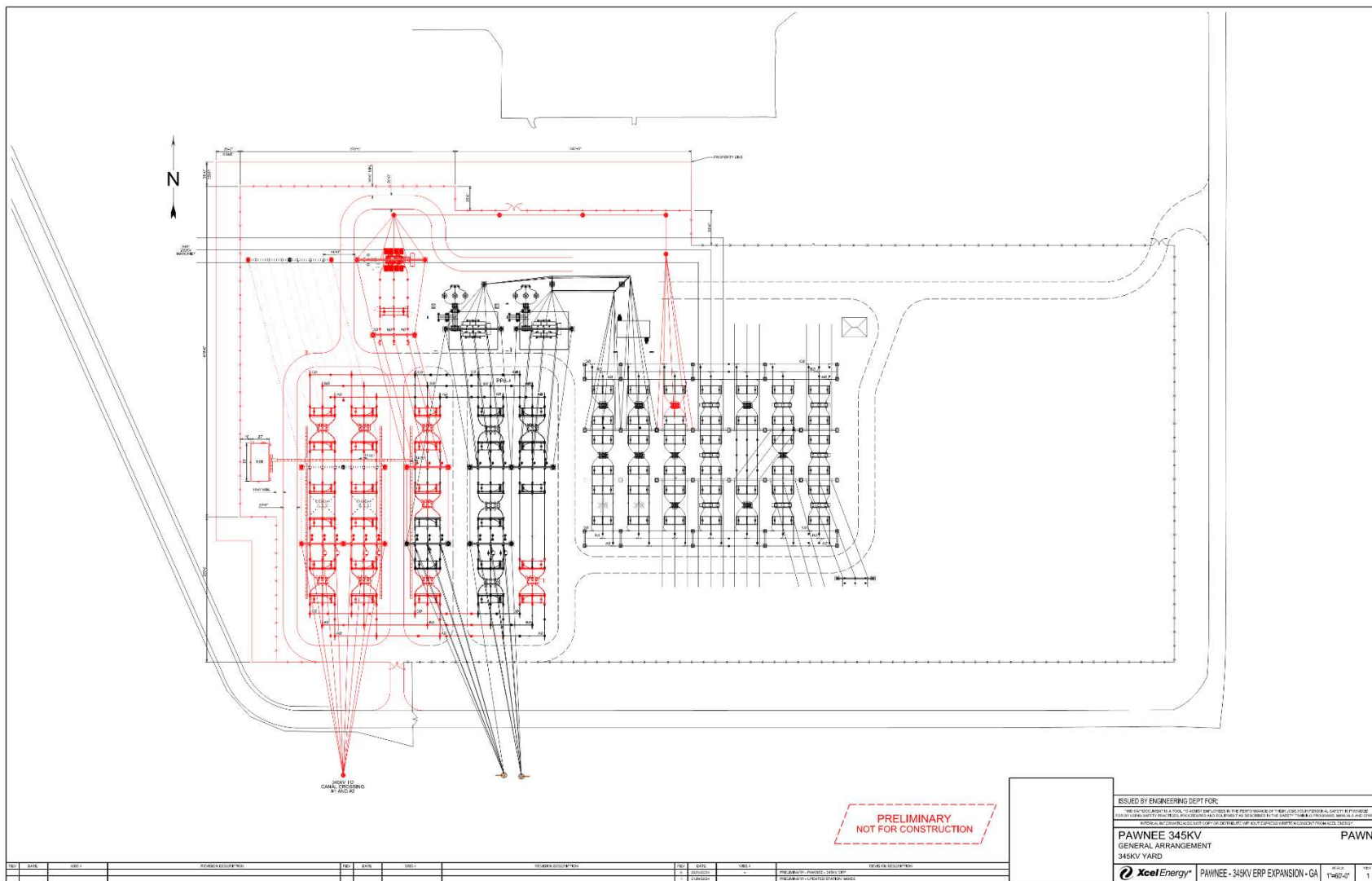


Figure 28: Pawnee General Arrangement Drawing

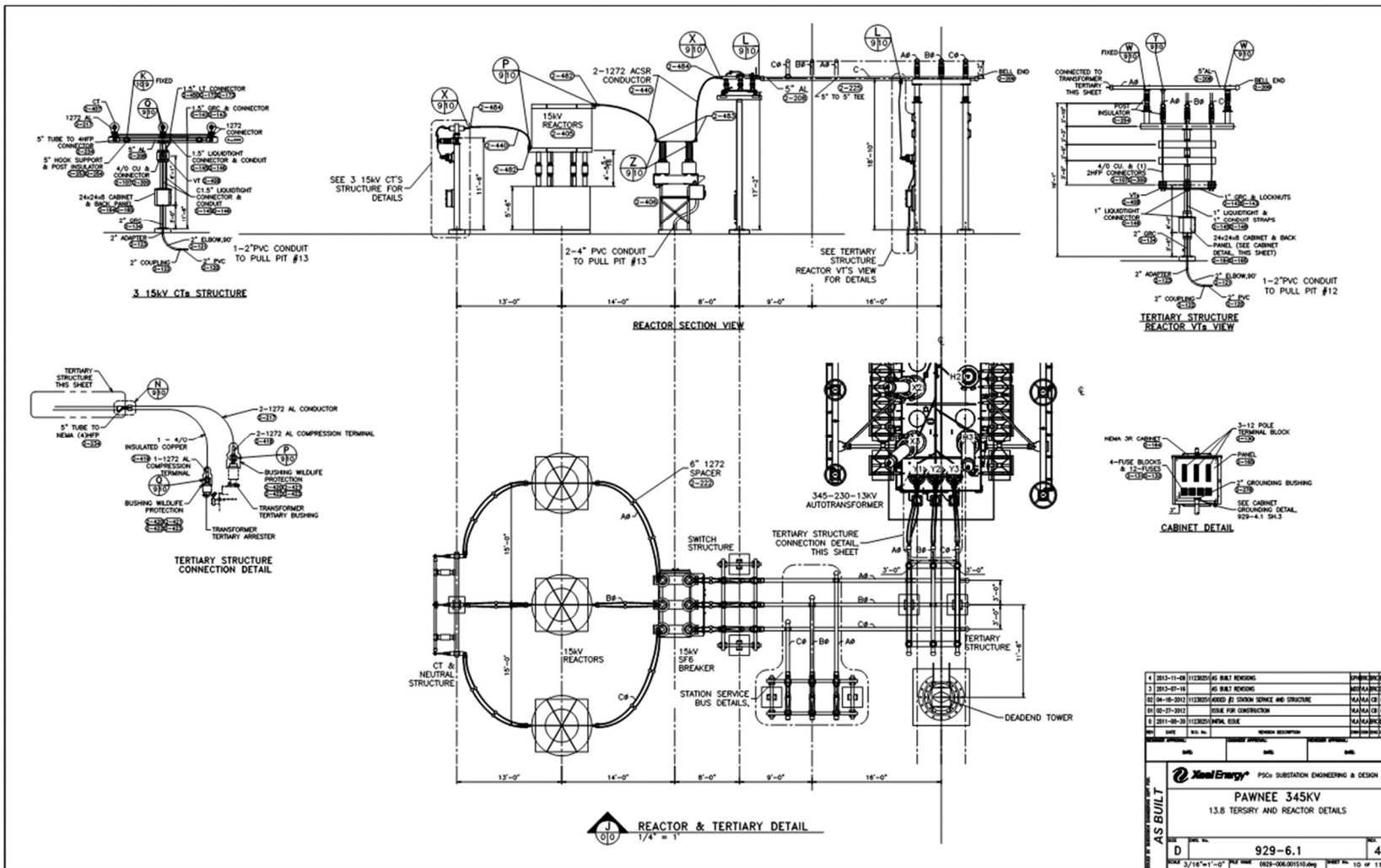


Figure 29: Pawnee Reactor Details



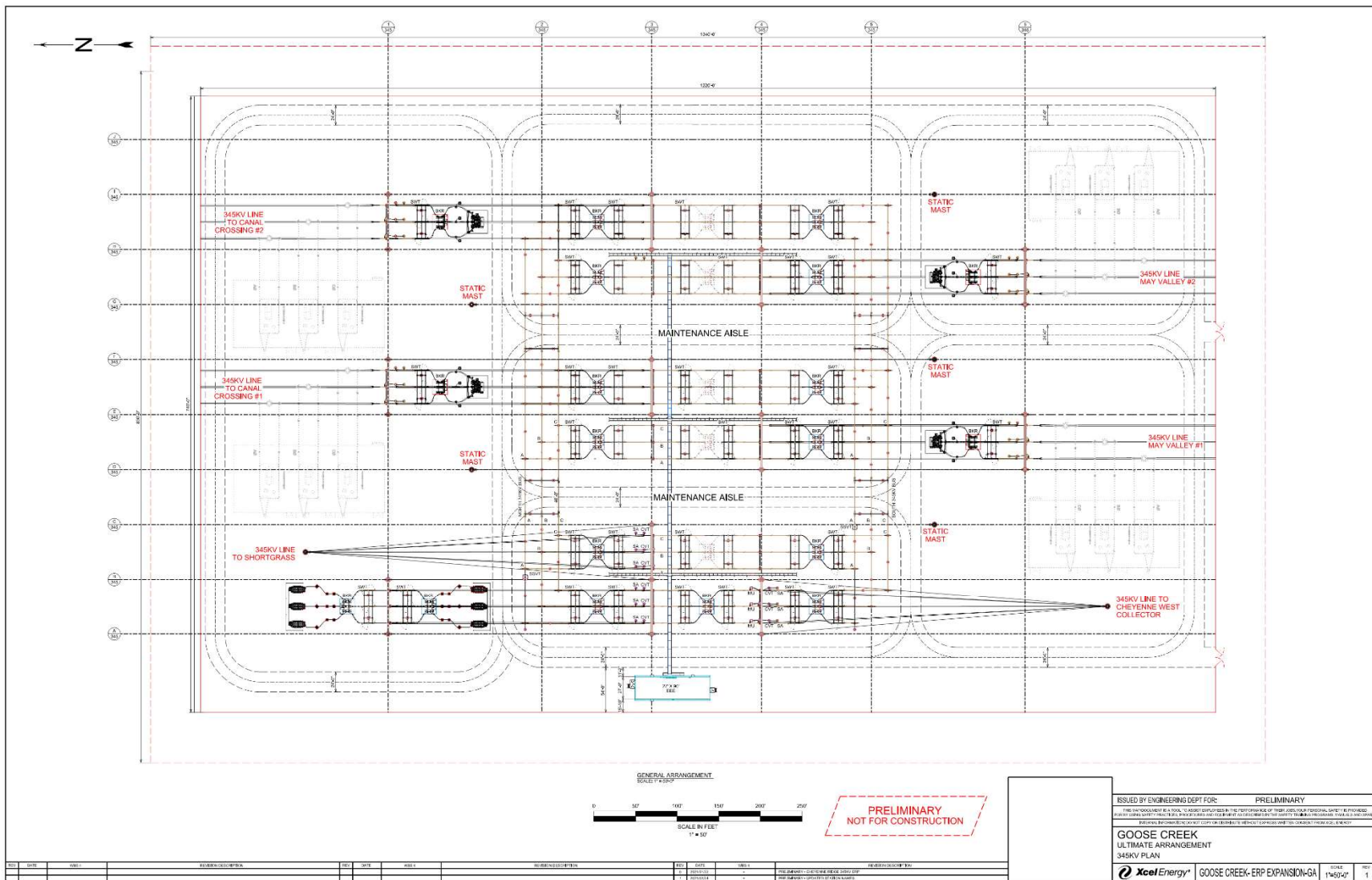


Figure 30: Goose Creek General Arrangement Drawing

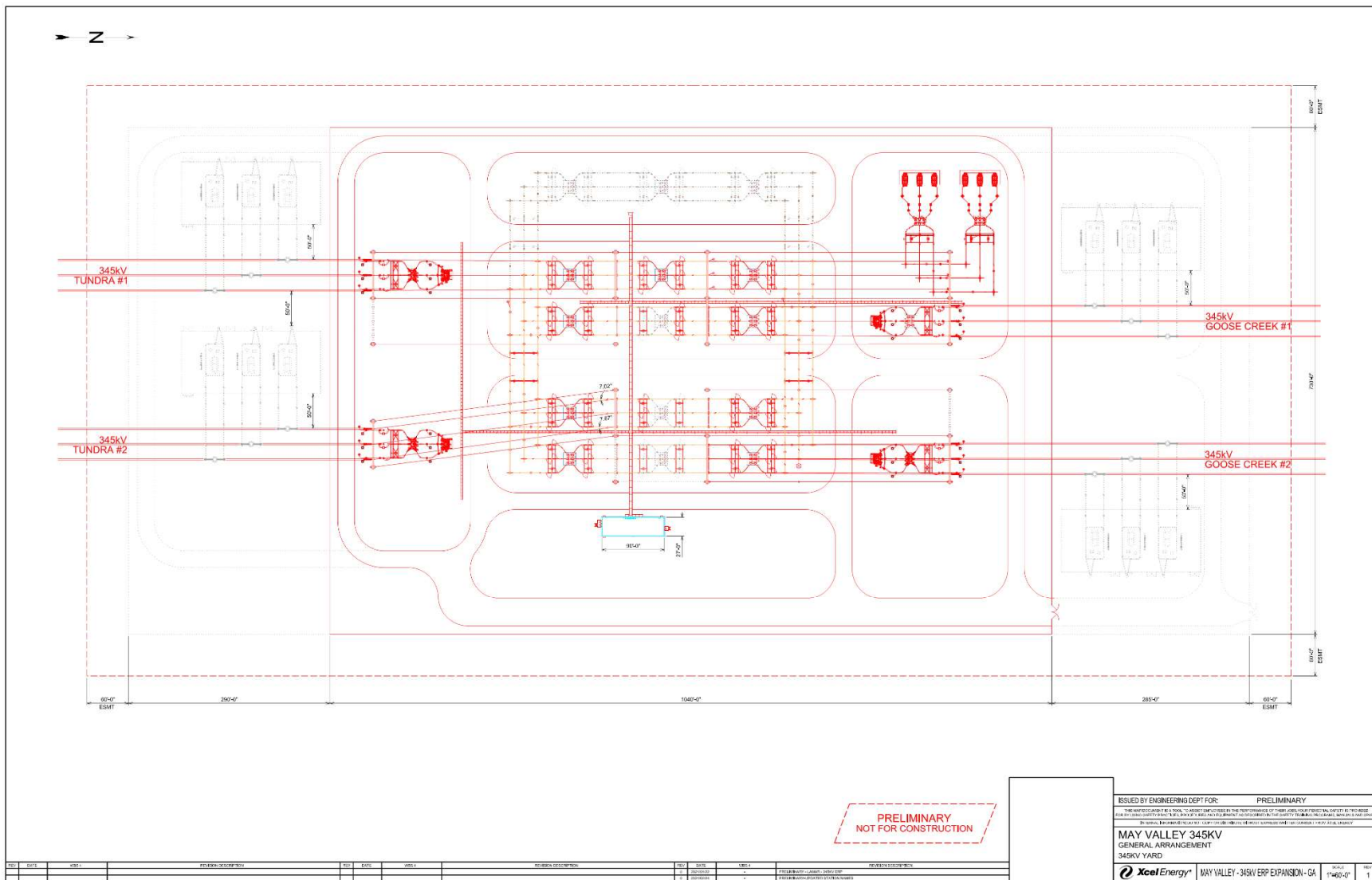


Figure 31: May Valley General Arrangement Drawing

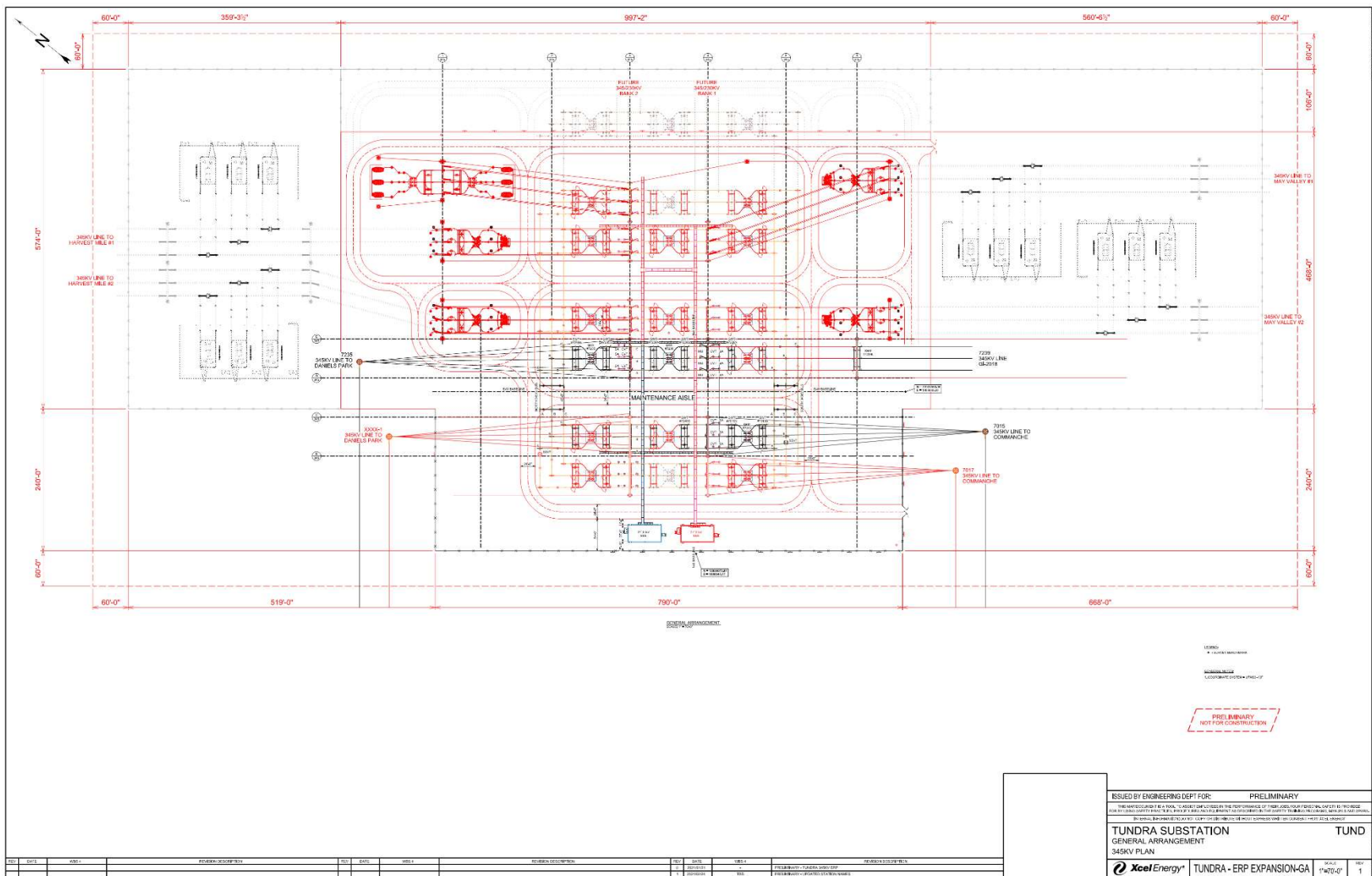


Figure 32: Tundra General Arrangement Drawing



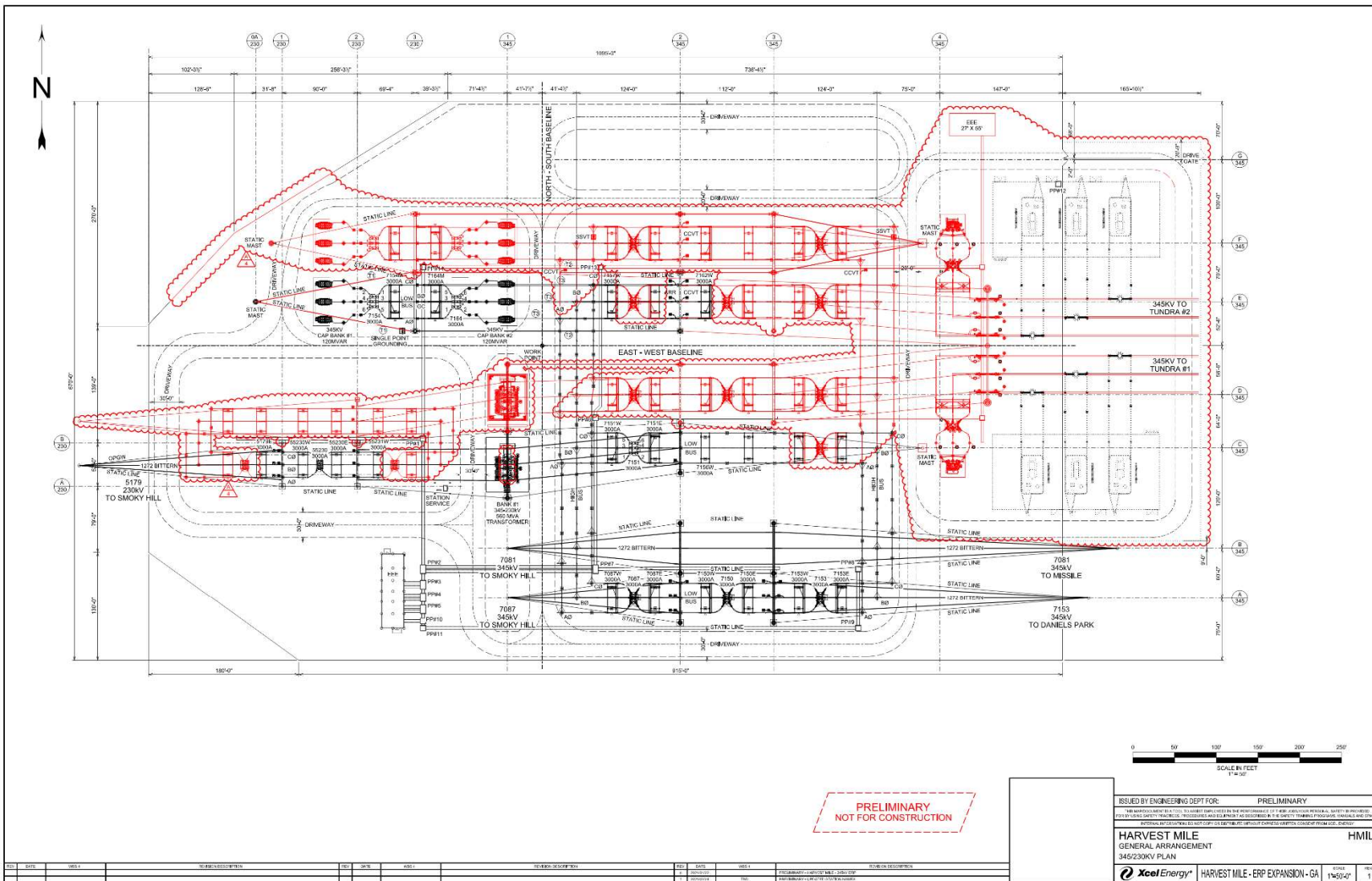


Figure 33: Harvest Mile General Arrangement Drawing