Electric Transmission Line Project

Presentation Outline

Basics of Electric Systems

Background & Historical Information

Route Selection Matrix Overview

System Improvements & Comparison of Options

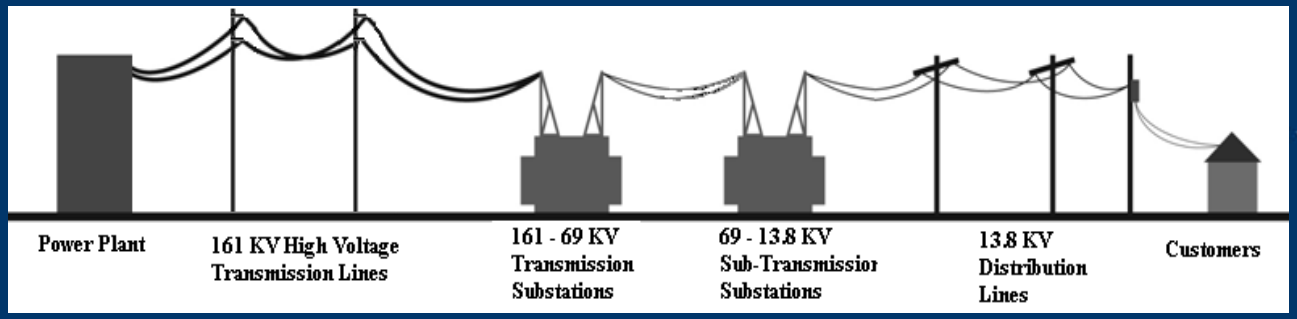
Finances & Planning

Electric & Magnetic Fields

Transmission Line Structures

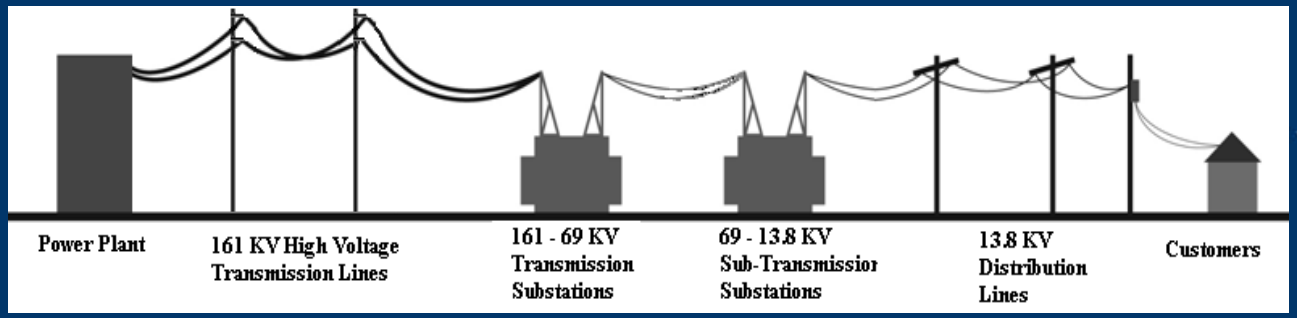
Recommendations

Basics of Electric Systems



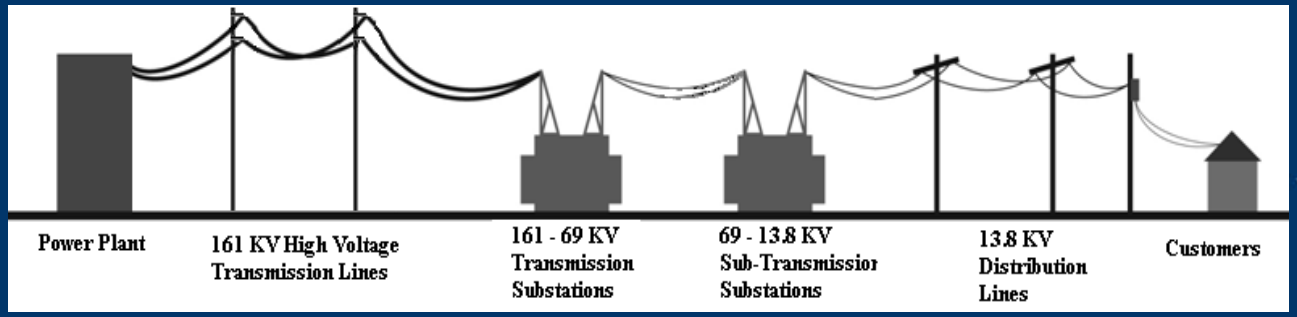
Electric systems: Electricity can't be stored on utility scale. Extra capacity is needed on systems so electricity can be switched to another line when problems occur

Transmission: After electricity is generated, voltage is increased to move large amounts of electricity to where it is needed



Transmission Systems

- Voltages of transmission lines in U.S. range from 765 kV to 115 kV
- Transmission lines are generally not buried due to high costs
- North American Electric Reliability Corporation (NERC) sets reliability standards
  - Fines can be up to $1 million/day/violation for noncompliance
- Columbia imports 90% of power

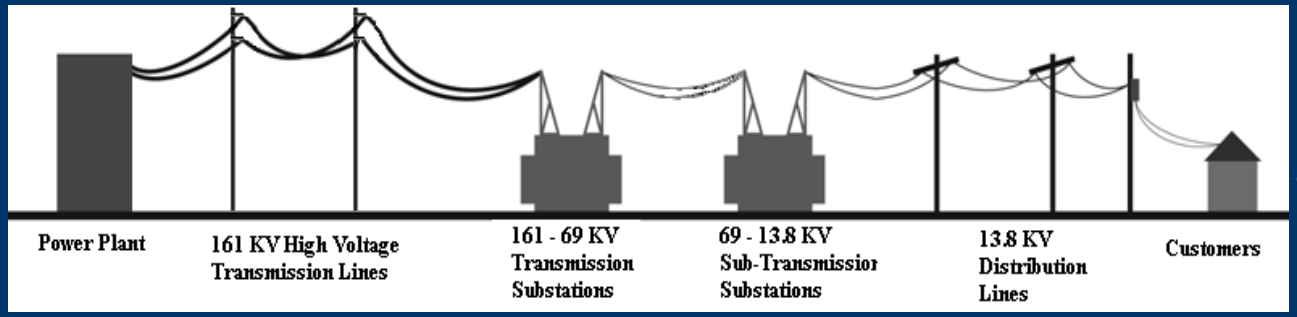


Sub-Transmission

- Voltages in U.S. is 69 kV & 34.5 kV
  - City of Fulton & MU have interconnections at the 69 kV level

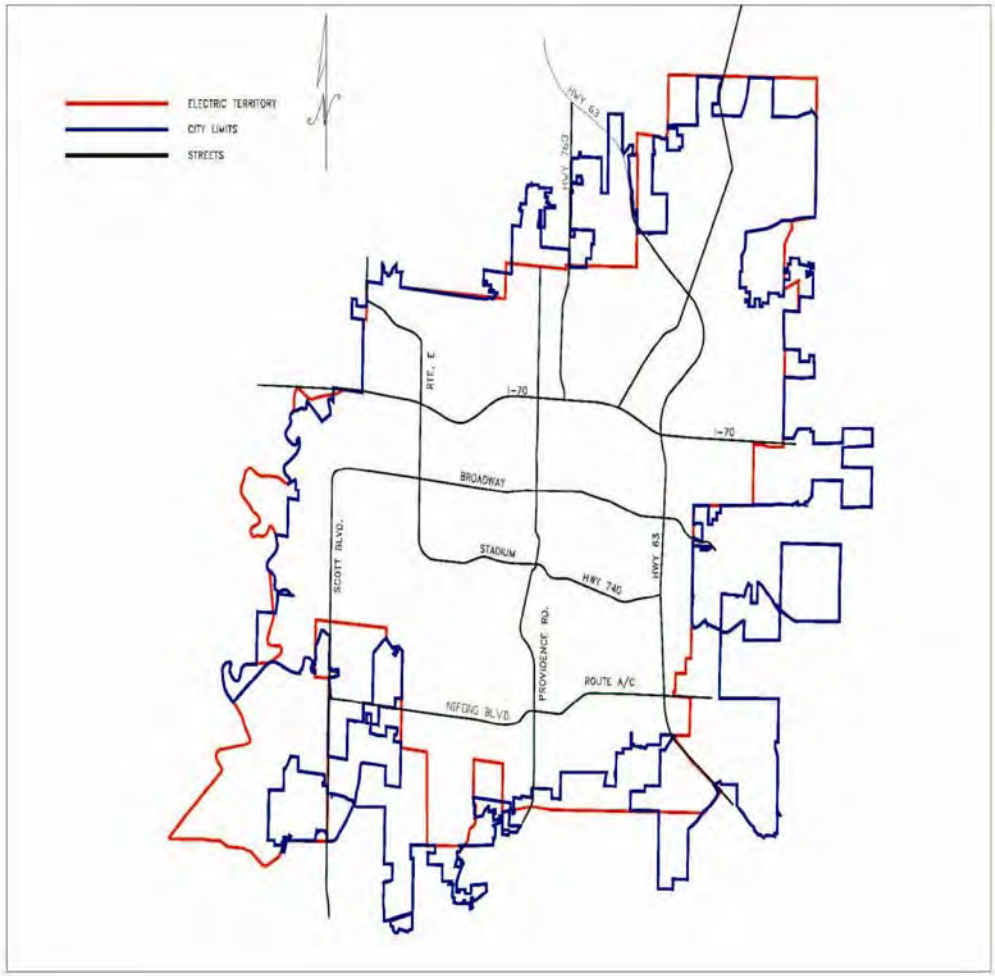
Substations

- Step up or step down the voltage



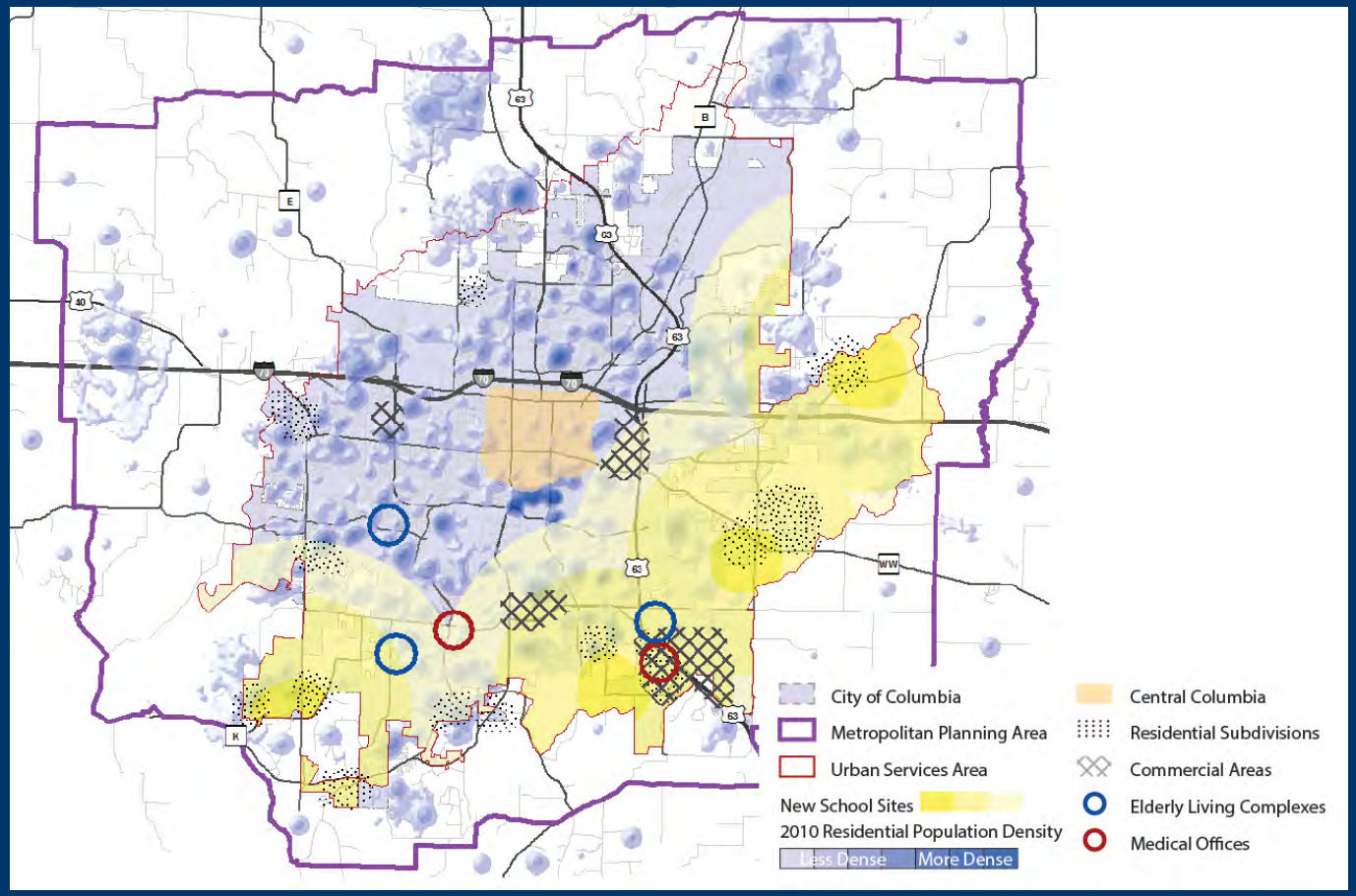
Distribution

- Columbia delivers electricity to customers at 13.8 kV
- Most of Columbia's distribution system lines are underground
- Plan to bury distribution lines along transmission route



Columbia's Electric System

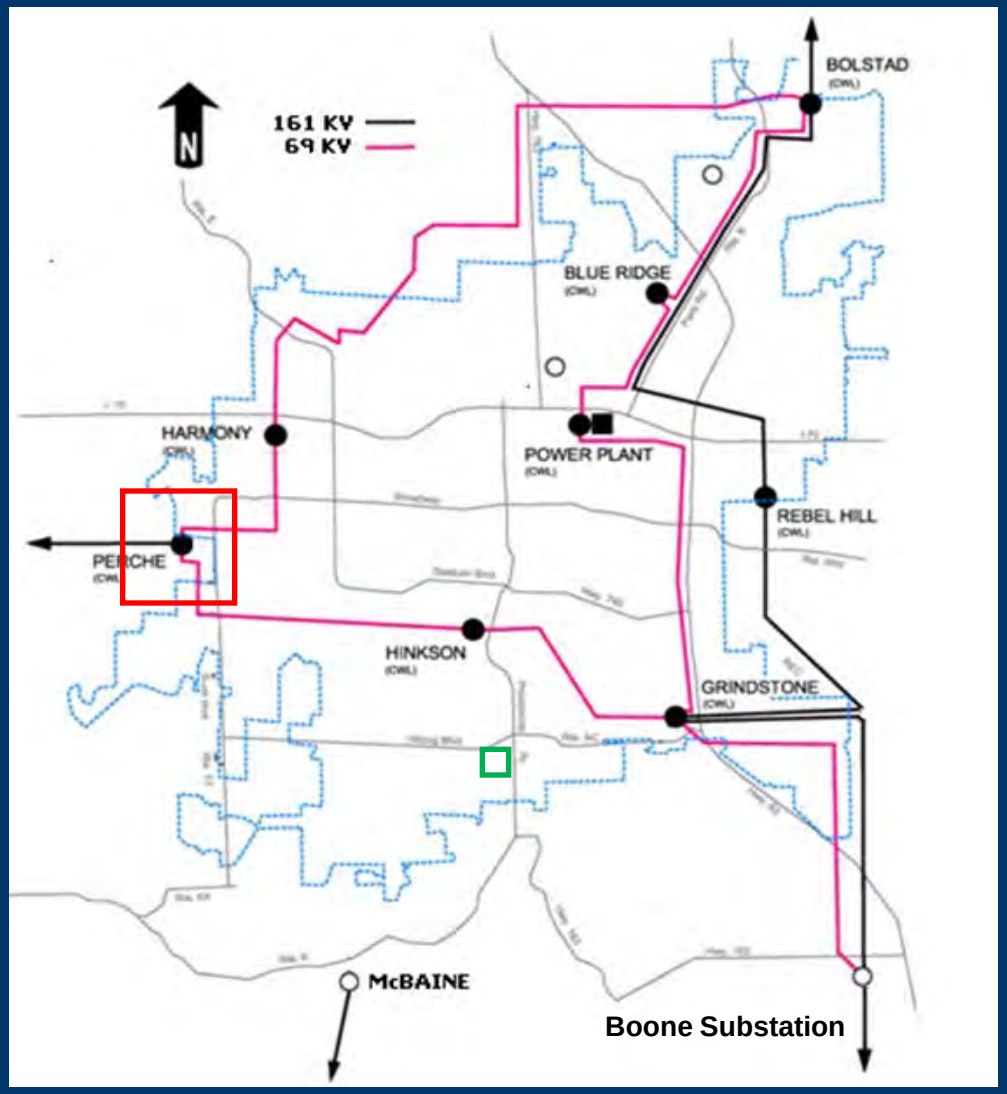
- Service territory with Boone Electric established in 1980s
- It is not uncommon for transmission and distribution electric lines from one utility to be in another's territory



Areas of Projected Growth

- Electric load growth is down from 2% to 1.25% after the recession but it could move up again
- Continued build out of subdivisions, new development plus redevelopment expected on south side of Columbia

Background & Historical Information

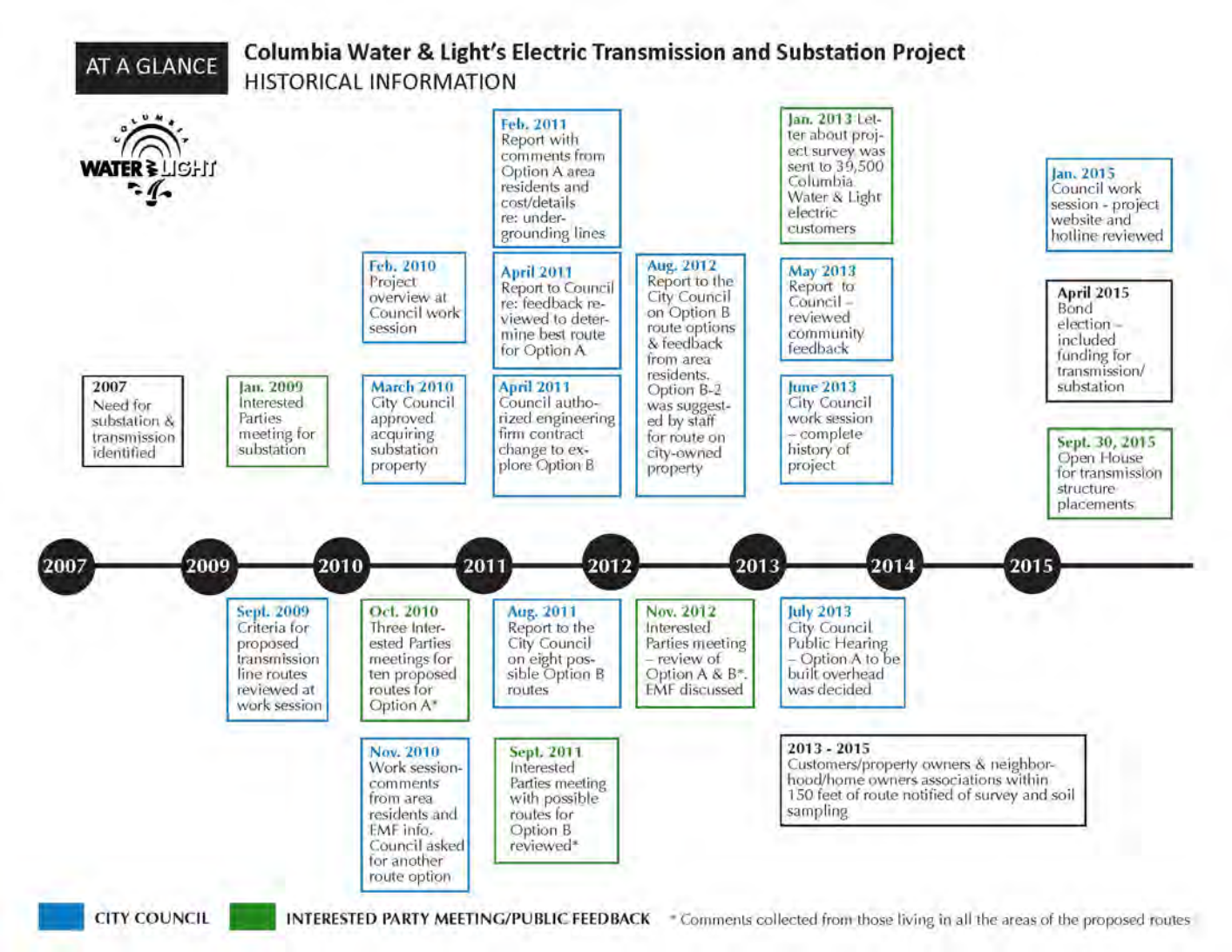


Improvements Needed:

1. Second 161 kV transmission line into Perche Creek for system redundancy (red)
2. Substation in southern part of electric service territory to reduce load at others (green)
3. Limit reliability exposure

Planning Order for New Substation & Transmission Lines

- **Substation:** Identify where substation will be located so possible transmission line routes can be determined
- **Route Selection:** Identify criteria and submit several options, gather feedback to determine least objectionable route
- **Line Design:** Survey, soil sampling, determine existing easements and plan for any road expansion to determine pole type & location
  - At 30% of this phase
  - Presented preliminary structure locations/types to collect feedback
  - This portion of project stopped in November 2015
- Can't easily move back & forth in this process without costing additional time & money

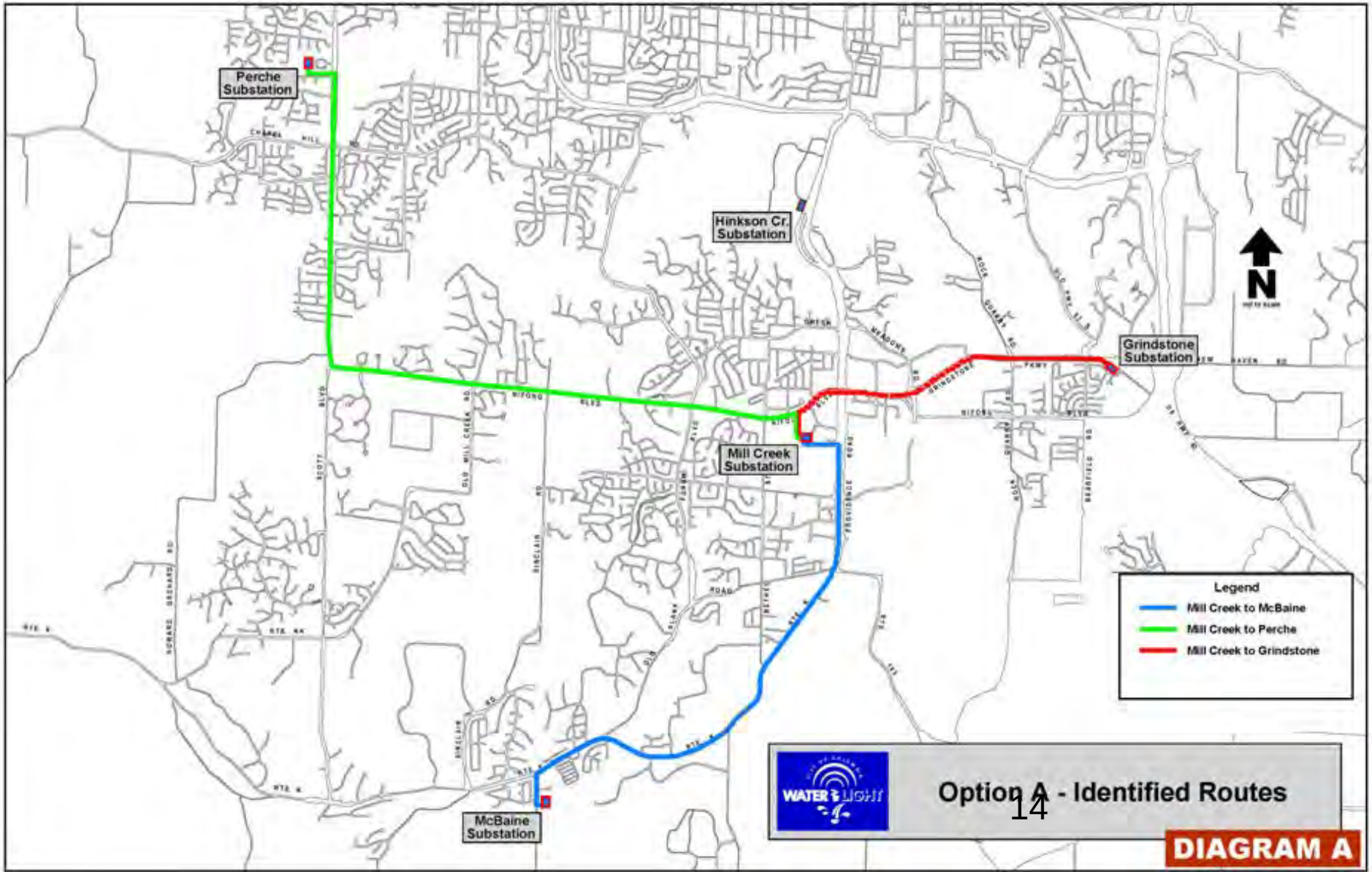


Property owners near 18 suggested route options were invited, by mail, to FIVE public meetings to provide comment about route selection

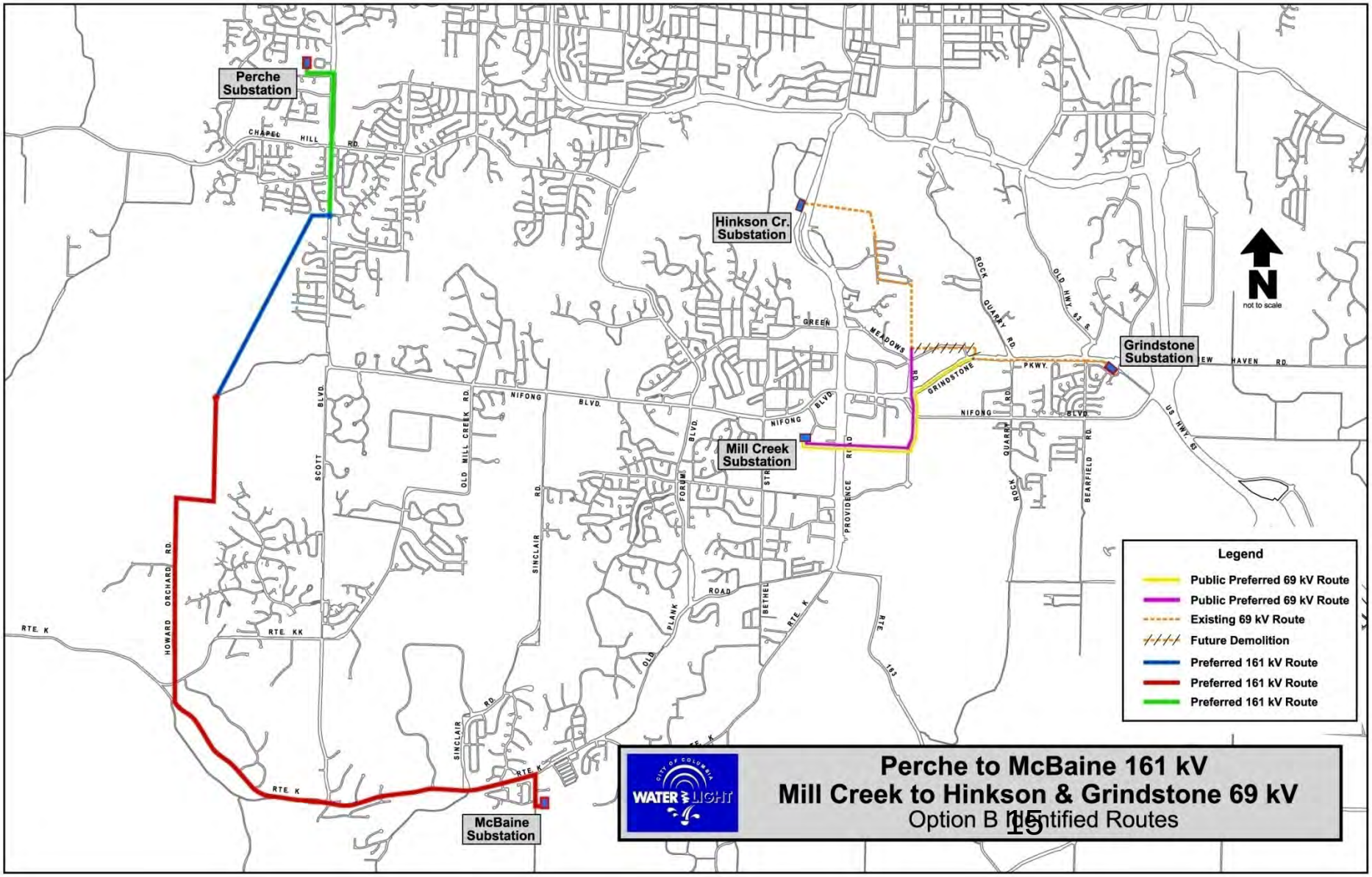
There was one meeting to gather feedback about pole structure types and locations (at 30% completion of design phase)

The project has been subject to City Council review FOURTEEN times

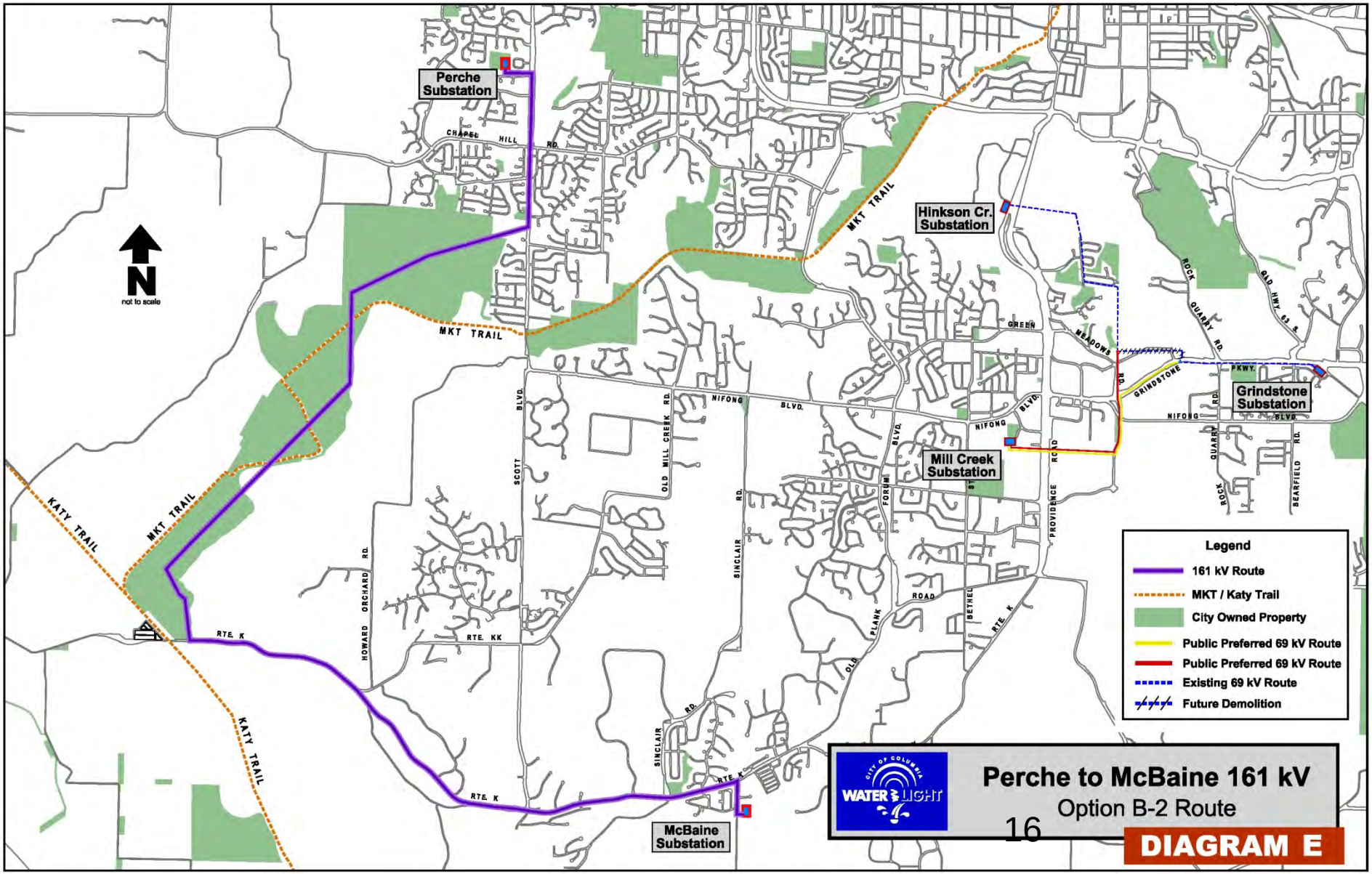
Option A


Perche Substation
Hinkson Cr. Substation
Grindstone Substation
Mill Creek Substation
McBaine Substation
N
Legend
Mill Creek to McBaine
Mill Creek to Perche
Mill Creek to Grindstone
WATER & LIGHT
Option A - Identified Routes
DIAGRAM A

Option B


Perche Substation
Hinkson Cr. Substation
Mill Creek Substation
Grindstone Substation
McBaine Substation
CHAPEL HILL RD.
NIFONG BLVD.
GREEN MEADOWS RD.
GRINDSTONE PKWY.
ROCK QUARRY RD.
OLD HWY. 63 S.
US HWY. 63
NEW HAVEN RD.
SCOTT BLVD.
OLD MILL CREEK RD.
SINCLAIR RD.
FORUM BLVD.
PROVIDENCE RD.
BEARFIELD RD.
HOWARD ORCHARD RD.
RTE. K
RTE. KK
OLD PLANK ROAD
BETHEL
N
not to scale
Legend
Public Preferred 69 kV Route
Public Preferred 69 kV Route
Existing 69 kV Route
Future Demolition
Preferred 161 kV Route
Preferred 161 kV Route
Preferred 161 kV Route
CITY OF COLUMBIA WATER & LIGHT
Perche to McBaine 161 kV
Mill Creek to Hinkson & Grindstone 69 kV
Option B Identified Routes

Option B-2


Perche Substation
Hinkson Cr. Substation
Mill Creek Substation
Grindstone Substation
McBaine Substation
N
not to scale
MKT TRAIL
KATY TRAIL
CHAPEL HILL RD.
SCOTT BLVD.
OLD MILL CREEK RD.
NIFONG BLVD.
SINCLAIR RD.
HOWARD ORCHARD RD.
RTE. K
RTE. KK
FORUM BLVD.
PLANK ROAD
BETHEL RD.
PROVIDENCE ROAD
GREEN MEADOWS RD.
GRINDSTONE PKWY.
ROCK QUARRY RD.
OLD HWY 63 S.
BEARFIELD RD.
Legend
161 kV Route
MKT / Katy Trail
City Owned Property
Public Preferred 69 kV Route
Public Preferred 69 kV Route
Existing 69 kV Route
Future Demolition
CITY OF COLUMBIA WATER & LIGHT
Perche to McBaine 161 kV
Option B-2 Route
DIAGRAM E

Route Selection Matrix Overview

Route Selection Matrix

Overview

Options A, B and B-2 are engineering solutions to meet the reliability and load growth of Columbia

Routes WITHIN each option were compared to determine the least objectionable route

Routes were selected using general criteria

- Streets preferred over backyards and cross-country
- Main roads preferred over side streets
- Commercial corridors preferred over residential
- Most direct route preferred to minimize cost

Route Selection Matrix

Overview

Once general criteria was applied and multiple routes chosen, further evaluation was completed using a matrix

Matrix evaluation criteria categories

- Transmission line characteristics
- Buildings and other facilities near line (distance)
- Crossings
- Right-of-way characteristics (existing utility easements)
- Costs

Route Selection Matrix

Selection Matrix "Factors"

Importance Factors

- Values from +10 to -10
  - +10 gives the attribute high positive influence
  - -10 gives the attribute high negative influence
    - E.g. homes within 100-ft have an importance factor of -10

Weighting Factors

- Percentages assigned to evaluation criteria (sum all to 100%) categories
- Weighting factors adjusted to reflect public responses

Route Selection Matrix

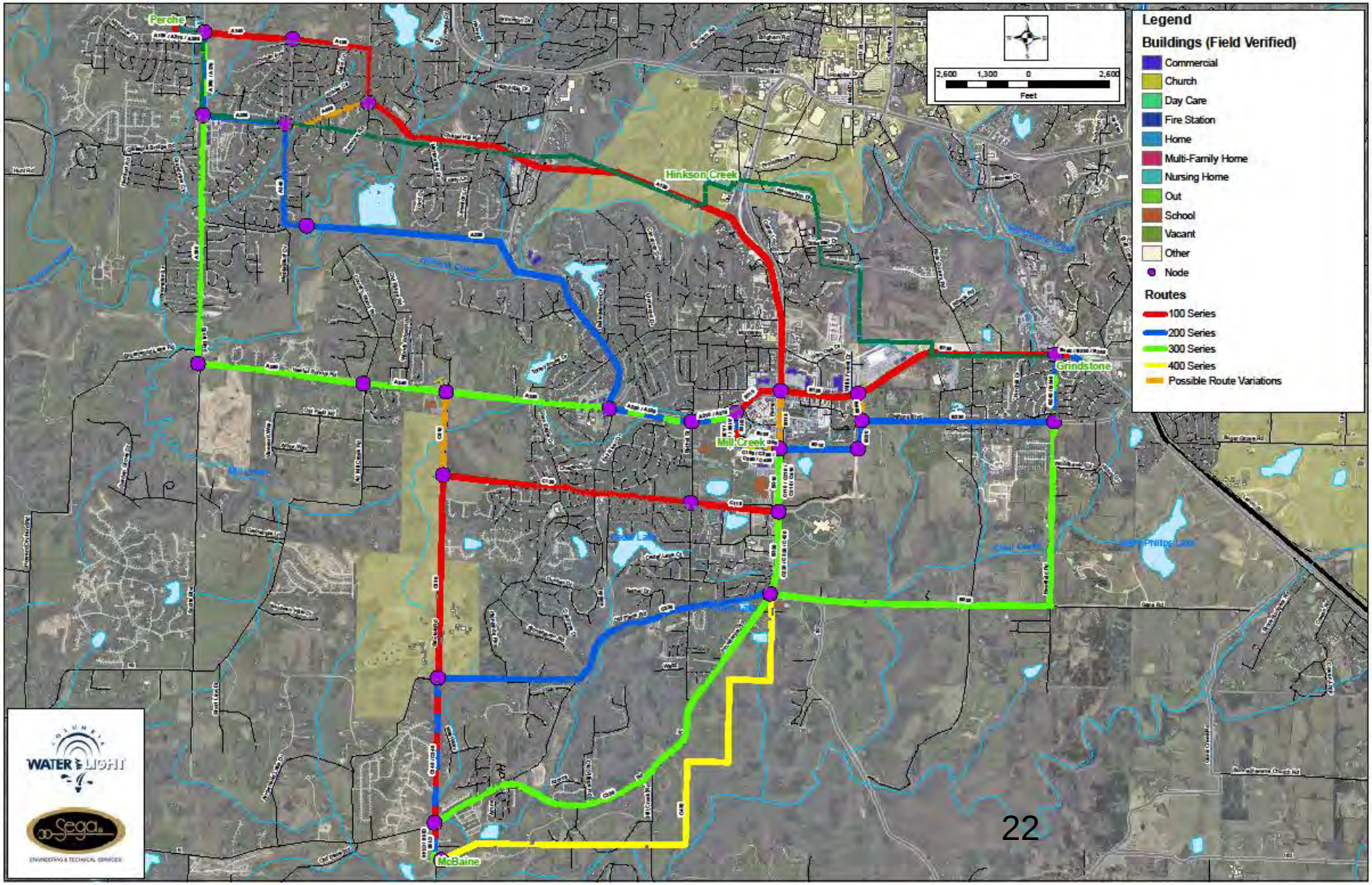
Option A Route Selection Matrix

Three line segments created for Option A

- Mill Creek Substation to Perche Creek Substation
- Mill Creek Substation to Grindstone Substation
- Mill Creek Substation to McBaine Substation

Ten routes were presented, three to four routes for each segment

Route Selection Matrix – Option A



Route Selection Matrix

Option A Route Selection Matrix

Comments collected at public meetings

Most common public concerns

- Potential loss of property value
- Health and safety concerns
- Environmental impacts

Matrix factors adjusted to reflect public comments

- Importance factors
- Weighting factors

Route Selection Matrix

Option B Route Selection Matrix

Eight routes presented for Option B

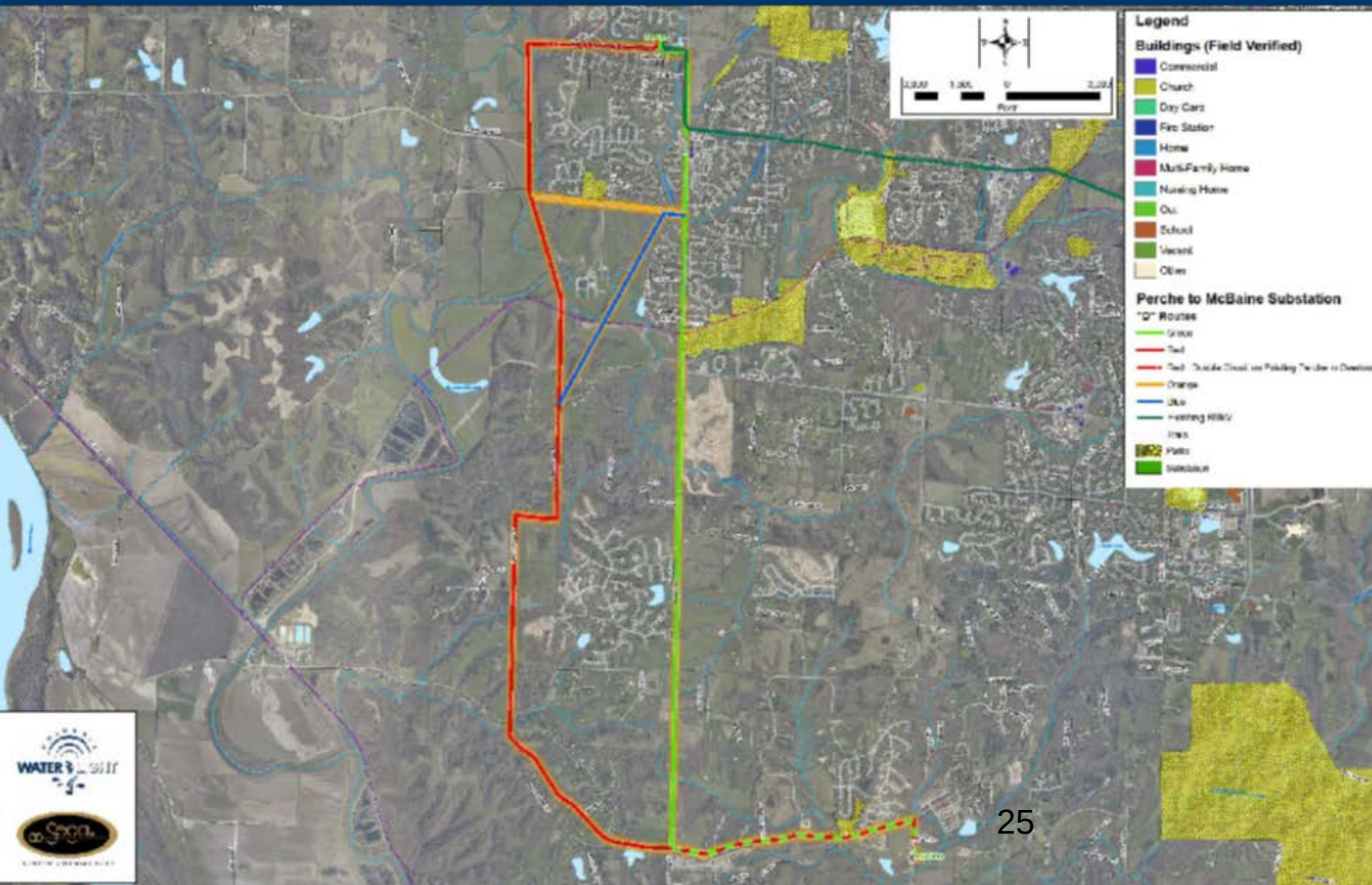
Evaluation criteria categories revised based on public feedback from nearby residents

- Proximity to residences
- Proximity to schools
- Costs
- Environmental concerns
- Proximity to businesses
- Proximity to recreation areas

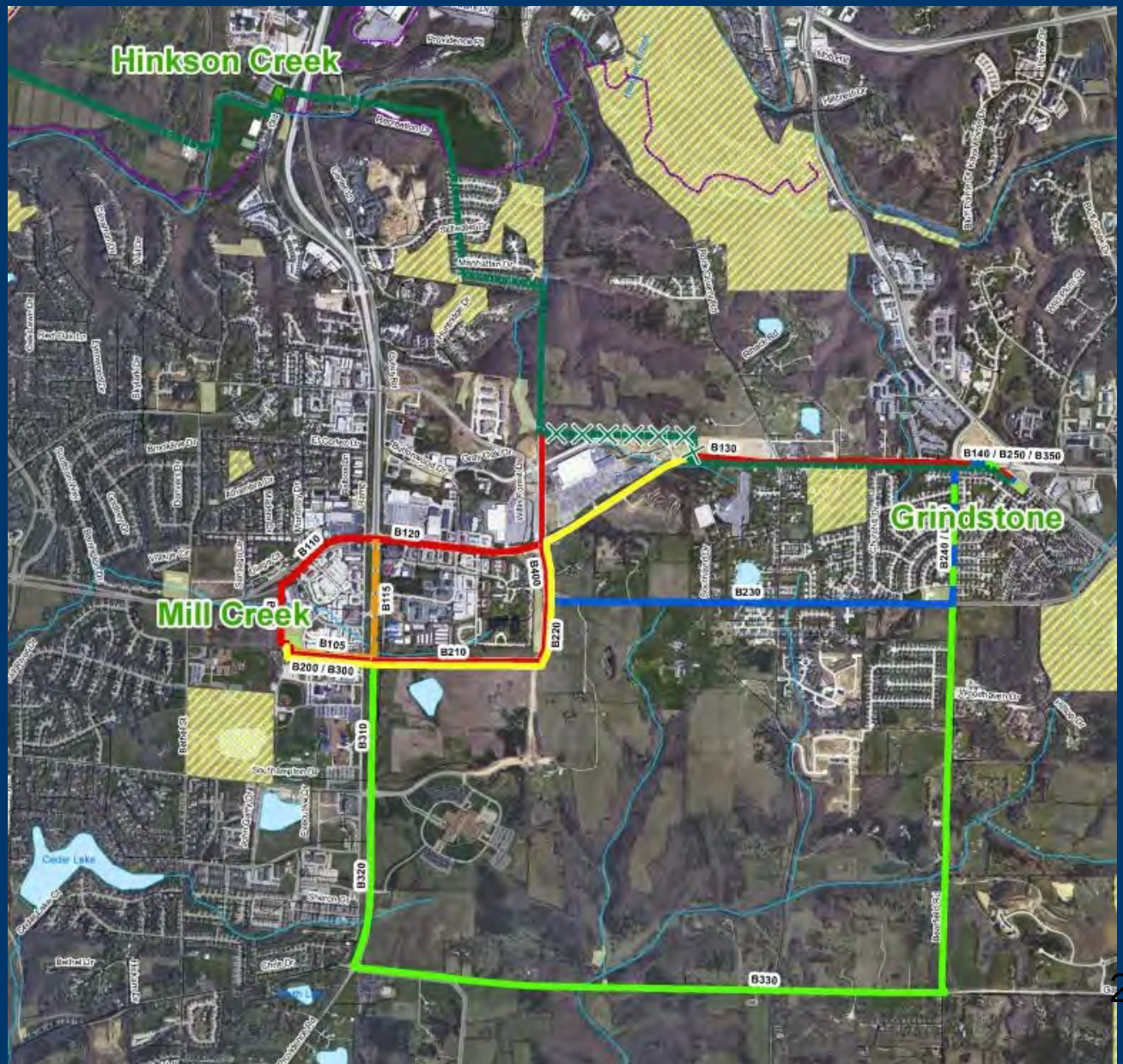
Weighting factors adjusted to reflect public feedback

(renamed to Public Feedback Rankings)

Route Selection Matrix – Option B



Route Selection Matrix – Option B (Cont.)



Route Selection Matrix

Normalizing Factor

Used to equally weight large estate homes with more standard sized single-family homes along the proposed routes

Each home is counted within the given setback and then that number is multiplied by 200, which is an average linear home property frontage along the route

Route Selection Matrix

Normalizing Factor (NF) - Example

Example X

10 homes within 100 ft. of the line, frontage of 200 ft. each

- Without NF = 2,000 ft. (linear) of single family home property frontage
- NF = 2,000 ft. (10 homes x 200 ft./home)

Example Y

3 estate homes within 100 ft. of the line, frontage of 1,000 ft. each

- Without NF = 3,000 ft. (linear) of single family home property frontage
- NF = 600 ft. (3 homes x 200 ft./home)

If the NF is NOT used, 3 homes (example Y) have a greater effect on the route decision than 10 homes example X)

Route Selection Matrix

Engineering Solution Comparisons

Matrix intended to compare routes for each Engineering solution

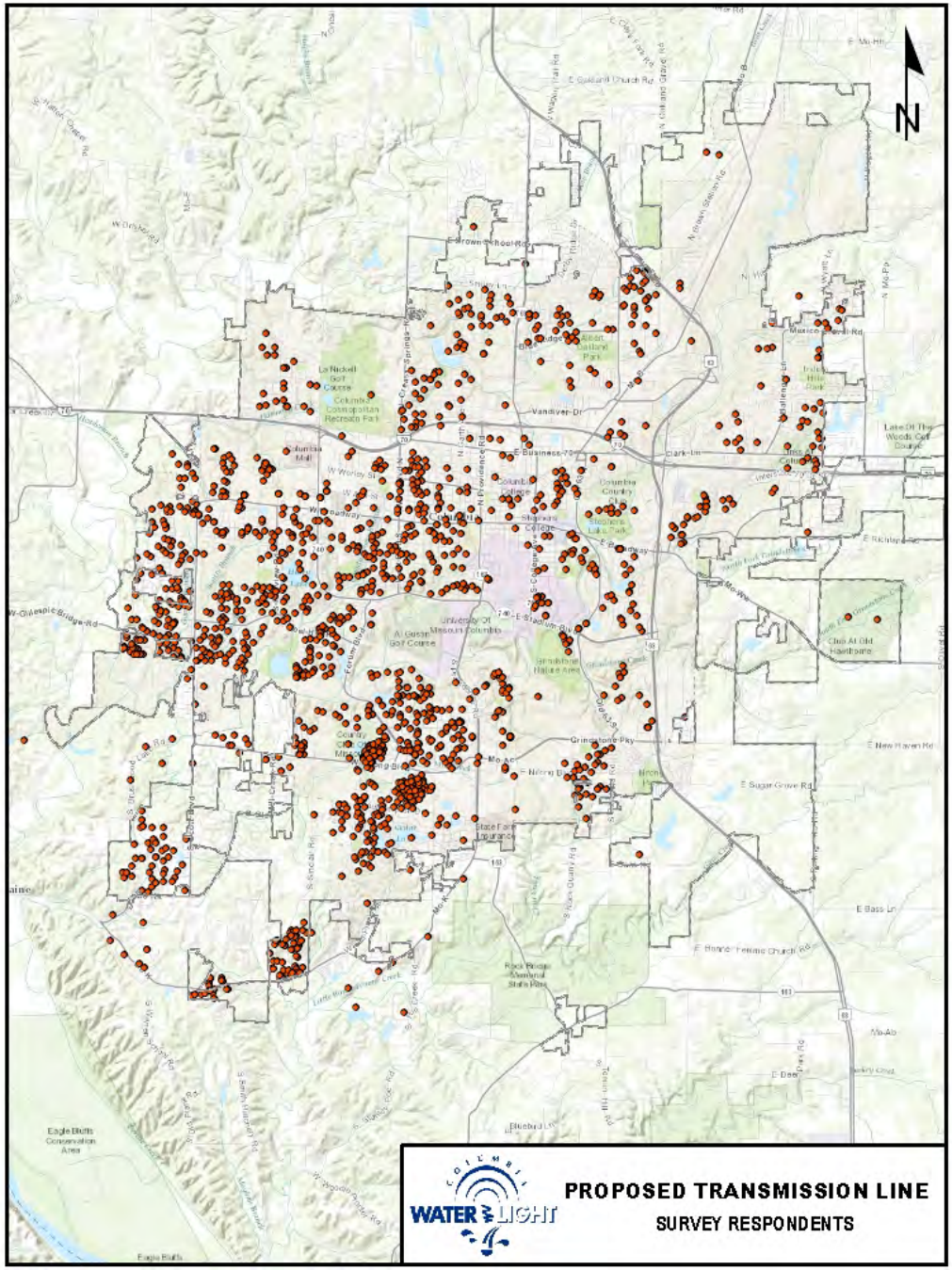
Matrix NOT intended to compare engineering solutions to each other

Engineering Solutions provided different results for:

- System capacity
- System upgradability
- Required future improvements timeline
- Costs

2013 Survey Results

- There was an online survey before route selection public hearing
- Purpose of survey was to gather input before public hearing
- A letter was mailed to 4,246 property owners within 250 feet of any of the 18 proposed routes for Options A, B/B-2 to invite them to a meeting and take the survey
- A letter was mailed to 39,500 Columbia electric customers about the project and the survey
- Survey results: 1,210 preferred Option A, 271 preferred Option B, 104 preferred Option B-2



Survey Route Preference by Ward

	Option A	Option B	Option B-2
Ward 1	89%	10%	1%
Ward 2	77%	19%	4%
Ward 3	83%	13%	3%
Ward 4	85%	11%	4%
Ward 5	59%	27%	14%
Ward 6	87%	9%	4%
Outside City Limit	75%	17%	8%

System Improvements & Comparison of Options

NERC Requirements

- Regulatory authority to assure reliability of nationwide grid
- No single contingency problems
  - Examples: loss of a single transmission element due to storms, accidents, sabotage, etc. that could lead to overloading of other transmission elements on the grid

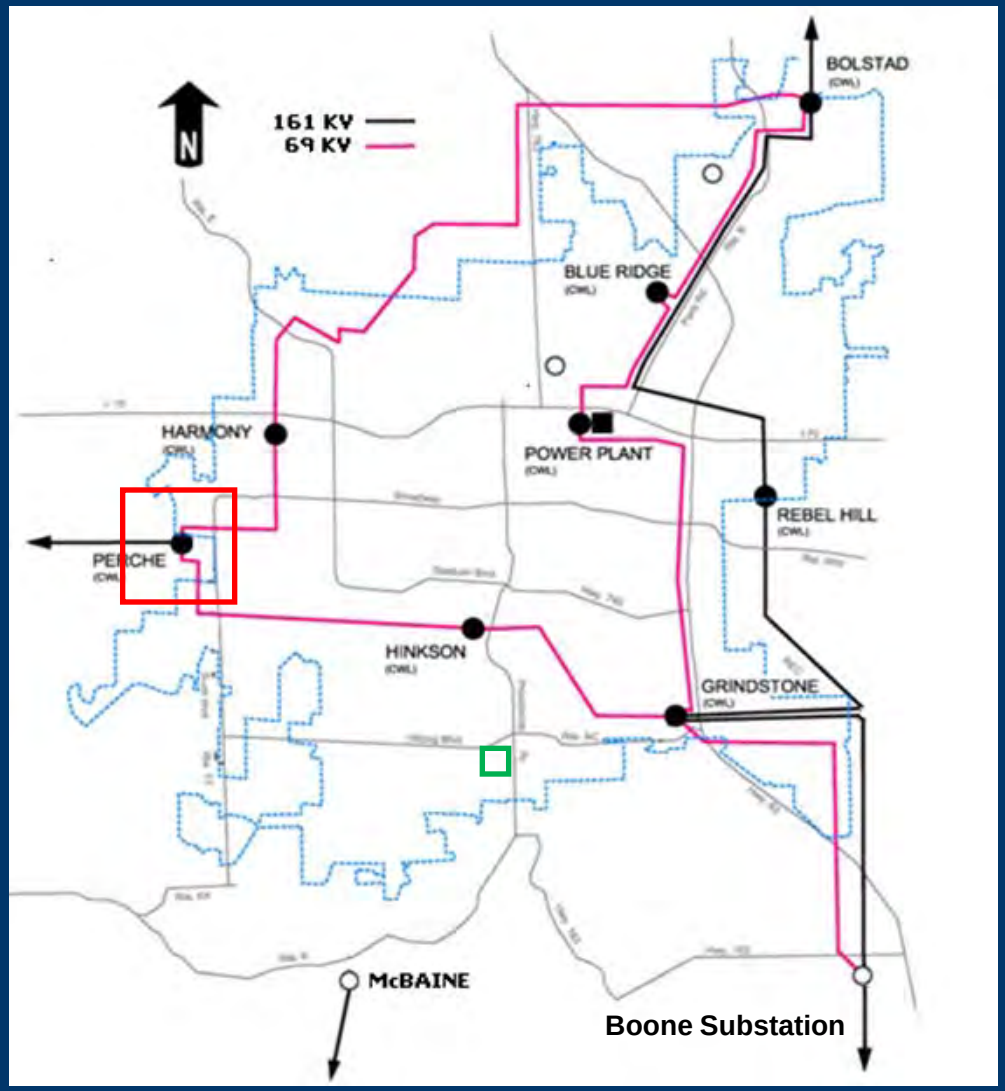
Reliability Issues

What happens when two problems (contingencies) happen at the same time?

- NERC allows shedding load to escape national grid problems
- Council decision for the community
  - What risk is acceptable when 2 things go wrong with system?
  - Either build system to eliminate as many 2nd contingencies as possible or accept rolling blackouts

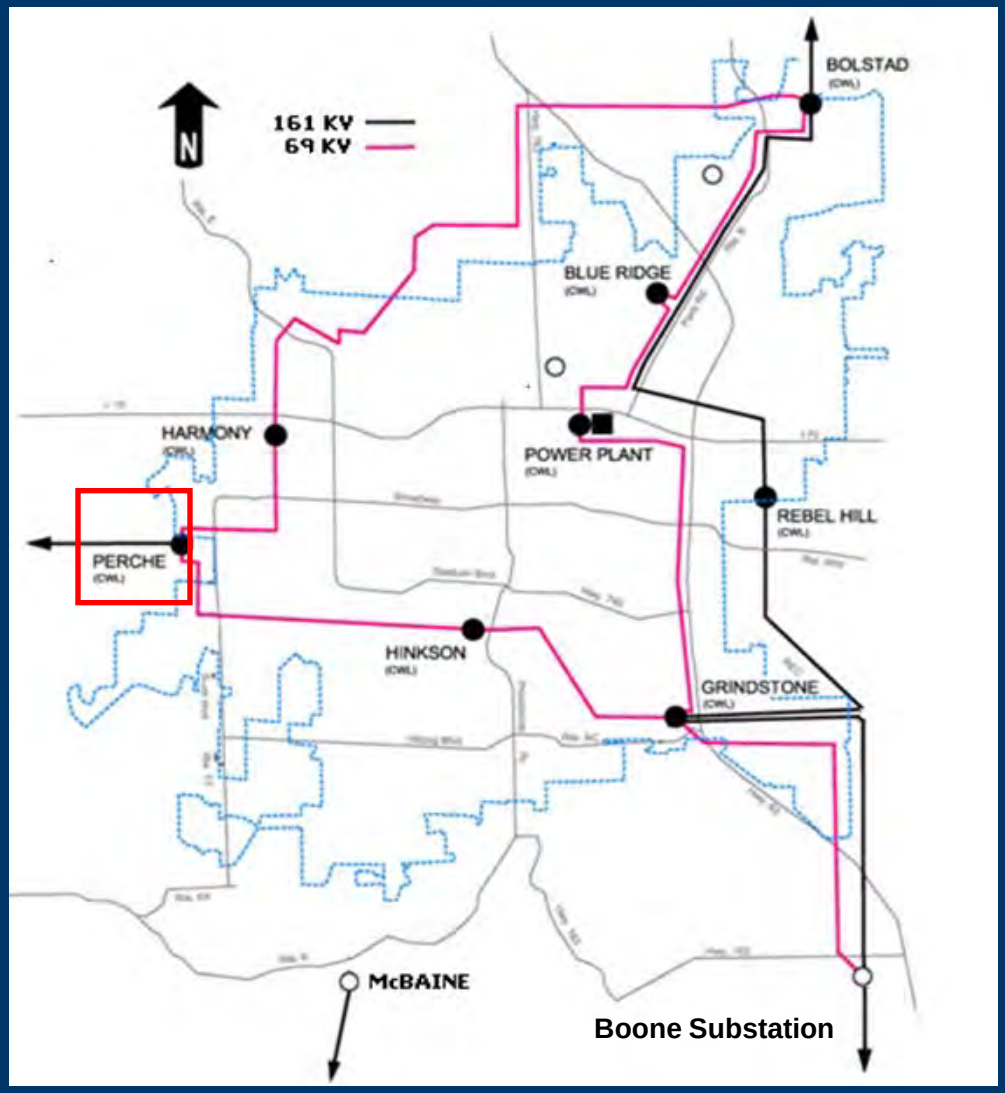
Electric Load Projections

- Updated electric load modeling since growth in 2007 was 2% and is now around 1.25%
  - Could increase up to 2% or more in the future
- Base for model: summer of 2020
- City of Fulton & MU electric loads
  - Fulton is not impacted by this project
  - University of Missouri
    - Current agreement for up to 40 MW of non-firm capacity
    - MU requesting 60 MW or more of firm capacity starting in 2021



This leads us back to the improvements needed:

1. Second 161 kV transmission line into Perche Creek for system redundancy (red)
2. Substation in southern part of electric service territory to reduce load at others (green)
3. Limit reliability exposure



Improvement 1: Transmission

- To comply with NERC requirements, need another 161 kV transmission line into Perche substation for system redundancy & reliability (red)
- Option A solves this problem until 2045
- Option B/B-2 solves this problem until 2036

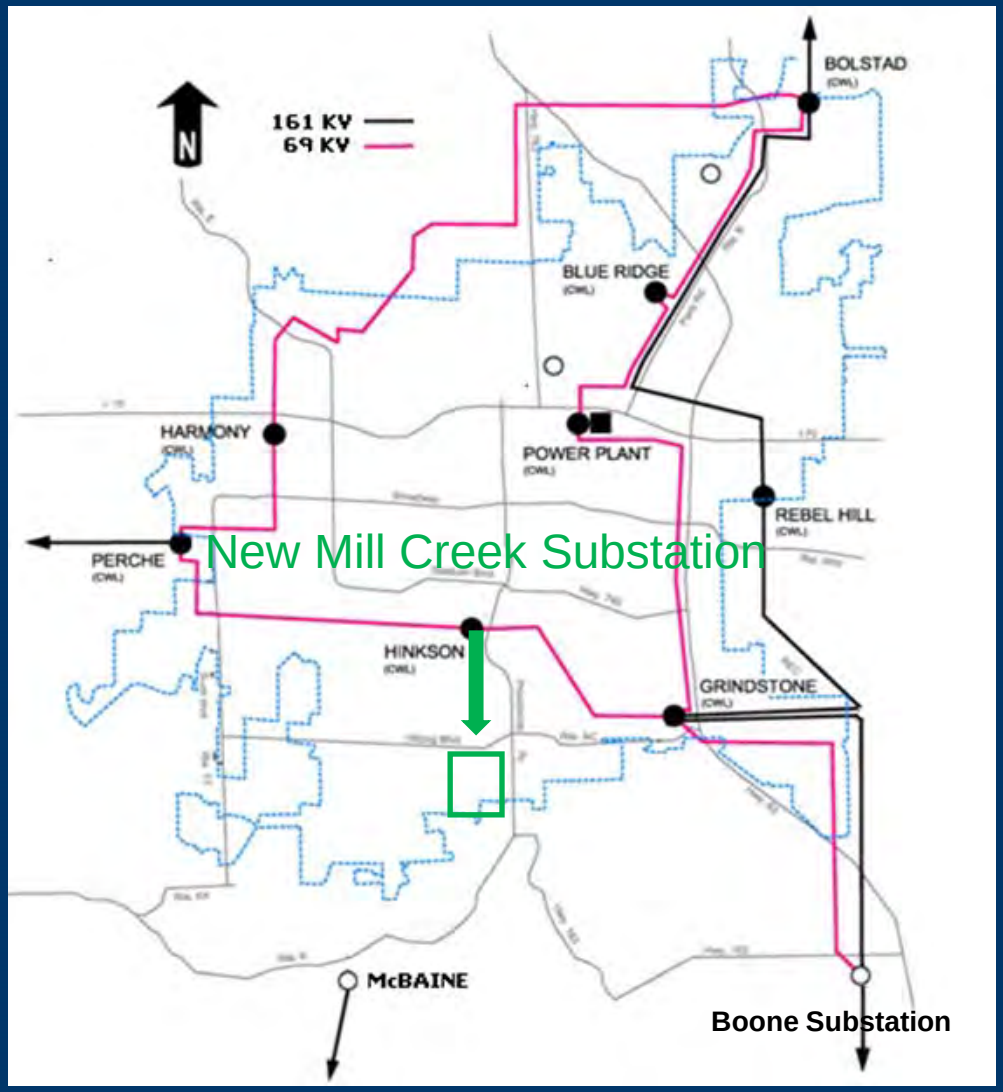
Improvement 2: Substation

- Electric systems must have reserved capacity for time of high loads and/or problems with system
- Substation loading goal: two transformers at 50%, three transformers at 66.6%
  - Hinkson & Perche at or over capacity

Year	Grindstone (3*)	Hinkson (3*)	Perche (2*)
2007	41.5%	67.6%	61.8%
2010	44.7%	68.6%	64.4%
2015	48.6%	64.2%	72.0%

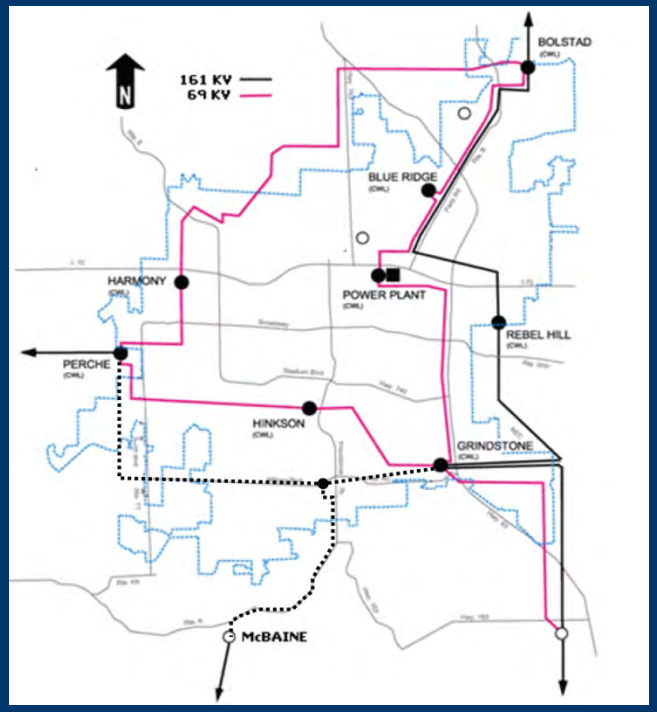
*number of transformers

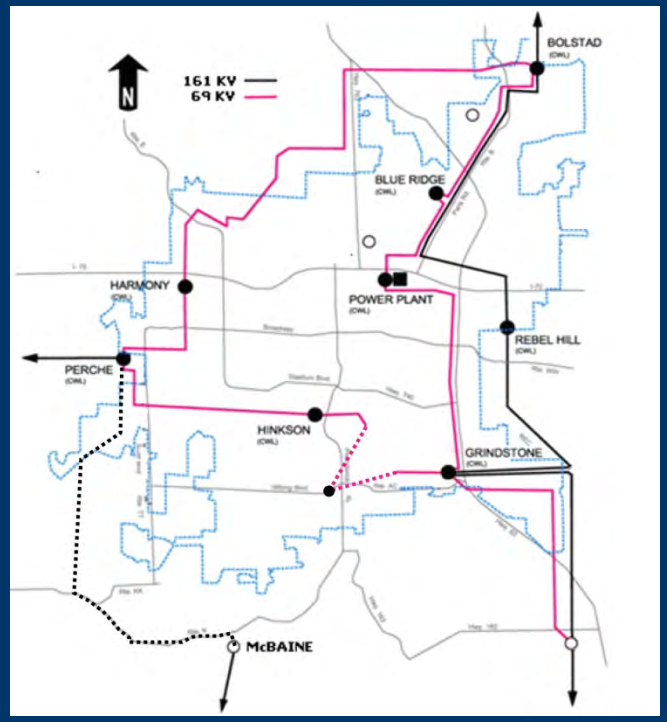
Improvement 2: Substation



- 161 kV substation with Option A: long-term solution (past 2045)
- 69 kV substation with Option B: would require additional 69 kV upgrades be built in south for electric loads by 2021
    - Considering duration of approval process, need to start planning for 69 kV upgrades now

Improvement 3: Reliability Exposure





<u>Second Contingency Issues</u>

- Option A: 22 issues
- Option A: works until 2045

<u>Second Contingency Issues</u>

- Option B: 93 issues
- Option B: potential to overload 69 kV system

Improvement 3: Reliability Exposure

Option A

- Preserves 69 kV system for future growth & reliability
- Supports 75 MW planned distribution capacity and expandable to 249 MW
- Supports MU's needs for future firm capacity

Option B

- Requires transmission upgrades to address reliability & load growth
- Supports 60 MW distribution capacity needs
- Needs additional transmission lines to support MU's future electric transmission needs

Finances & Planning

Funding & Planning

- Staff updated numbers since November 2015 meeting
- As of December 2015, $7.3 million encumbered, spent $3.5 million
- If Option A were abandoned & Option B/B-2 was selected, $3 million would be lost
- Starting over with pole location structure engineering work for Option B would add two to three years before improvements could be made
- April 2015 bond language would allow changes to this project, but voters were presented information based on the Option A route
- Columbia electric customers would be responsible for $3 million lost by changing to Option B/B-2

Real Estate Impact*

<u>Option A</u>
Grindstone/Mill Creek/Perche
Agricultural – 17,600
Commercial – 23,760
Residential – 36,160

Millcreek/McBaine
Agricultural - 9,500
Commercial - 8,300
Residential - 23,650

<u>Option B</u>
Perche/McBaine161 kV Line:
Agricultural – 56,000
Commercial – 2,600
Residential – 24,000

Insert Mill Creek into 69 kV Line:
(modeled as extension from existing infrastructure path)
Agricultural – 2,200
Commercial – 10,500
Residential – 2,000

*Values in linear feet
This includes property on both sides of the line

Electric & Magnetic Fields

Electric & Magnetic Fields (EMF)

EMF Units

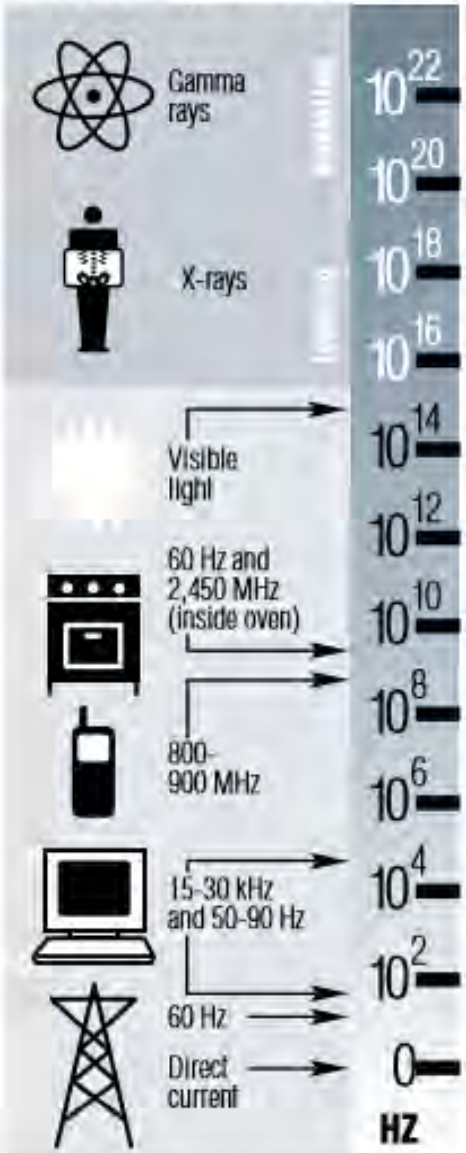
Electric Fields

Usually measured in volts per meter (V/m)
For large fields the units usually used are:
1 kilovolt per meter (kV/m) = 1,000 volts per meter

Magnetic Fields

Usually measured in milliGauss (mG)
Other units sometimes used:
1 microTesla = 10 milliGauss
1 Amp/meter = 0.1257 milliGauss

Electromagnetic Spectrum



Magnetic Fields *(milligauss)*		
Product	**At The Head****	**4 inches From The Body***
Cellular Phone	1.2 to 2	N/A
Coffee Maker	N/A	2.3 to 3
Alarm Clock	N/A	5 to 15
Toaster	N/A	10 to 60
Iron	N/A	12 to 45
Vacuum Cleaner	N/A	230 to 1300
Hair Dryer	N/A	3 to 1400
Television	N/A	4.8 to 100

* Source: Gauger, Jr., Household Appliance Magnetic Field Survey. IEEE transactions on power apparatus and systems. PA-104
** Source: Medical College of Wisconsin

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Power Lines, Electrical Devices and Extremely Low Frequency Radiation

How are people exposed to ELF radiation?

Generating, transmitting, distributing, and using electricity all expose people to ELF radiation. Some sources include power lines, household wiring, and anything using electricity. This can include anything from refrigerators and vacuum cleaners to television sets and computer monitors (when they are on). Even electric blankets expose people to ELF radiation.

How much electromagnetic radiation someone is exposed to depends on the strength of the field, the distance from the source of the field, and the length of time the person is exposed. The highest exposure occurs when the person is very close to a source putting out a strong field and stays there for a long period.

Does ELF radiation cause cancer?

In children

In the studies that have looked at a possible link between ELF radiation from magnetic fields in the home and **childhood leukemia**, the results have been mixed. Still, when the findings from these studies are combined, a small increase in risk is seen for children at the highest exposure levels compared to those with the lowest exposure levels.

Studies that looked at the effect of ELF electric fields on childhood leukemia did not find a link.

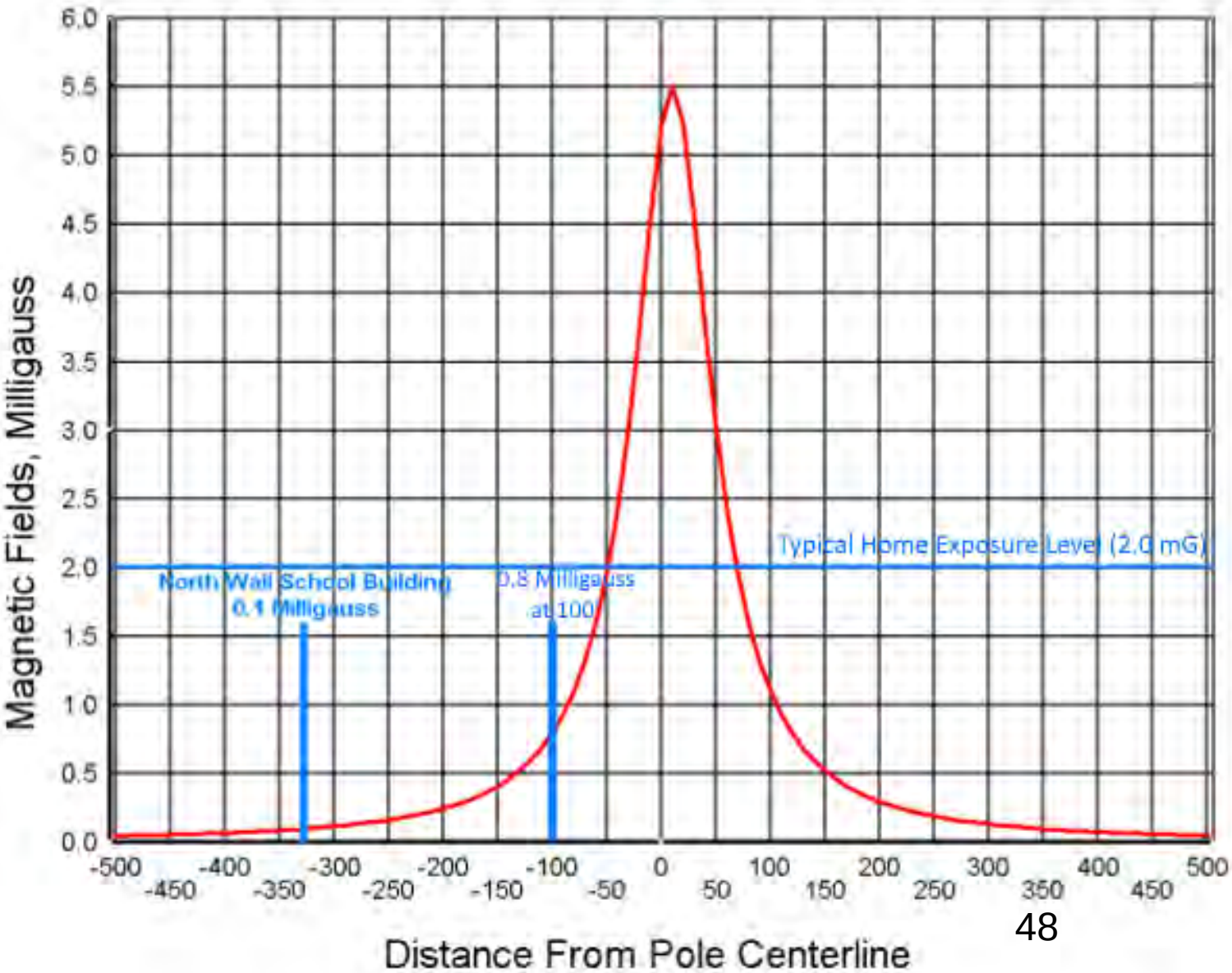
Studies of other childhood cancers have generally not found any strong links to ELF electric or magnetic fields.

In adults

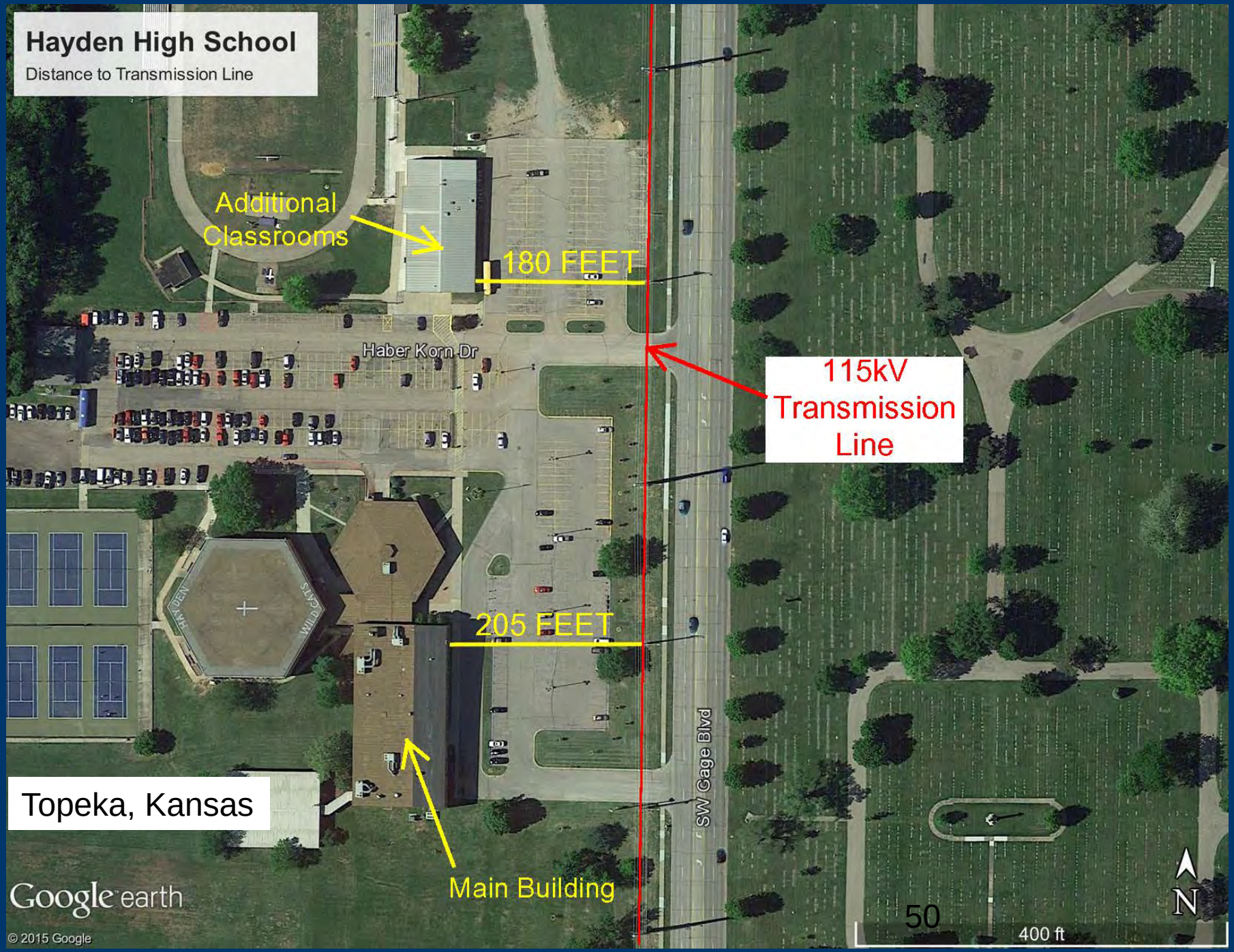
Most studies in adults have not found links between ELF magnetic fields and cancer.

Magnetic Fields

Mill Creek - Perche 161-kV Transmission Line



two 161 kV circuits
161 kV transformers at substation
two 345 kV circuits
Transmission corridor in Chesterfield, MO
On Clarkson Road by Marquette High School
Clarkson Woods Dr
Clarkson Woods Dr
Meadow Oak Dr
Sarah's Cake Shop
Pizza Hut
Fuji Sushi & Teriyaki
St Louis County
Municipal Court - West...
Federal Way
Sterling Pointe Dr
Pointe Ct
Willow Forest Ct
Country Ridge Dr
Marquette High School
Kehrs Mill Rd
Barons Way Dr
Joyceridge Dr
Clarkson Rd
Picardy Hill Dr
Jennycliffe
Stonebriar Ridge Dr
Rycroft Ct
Kehrs Mill Elementary School

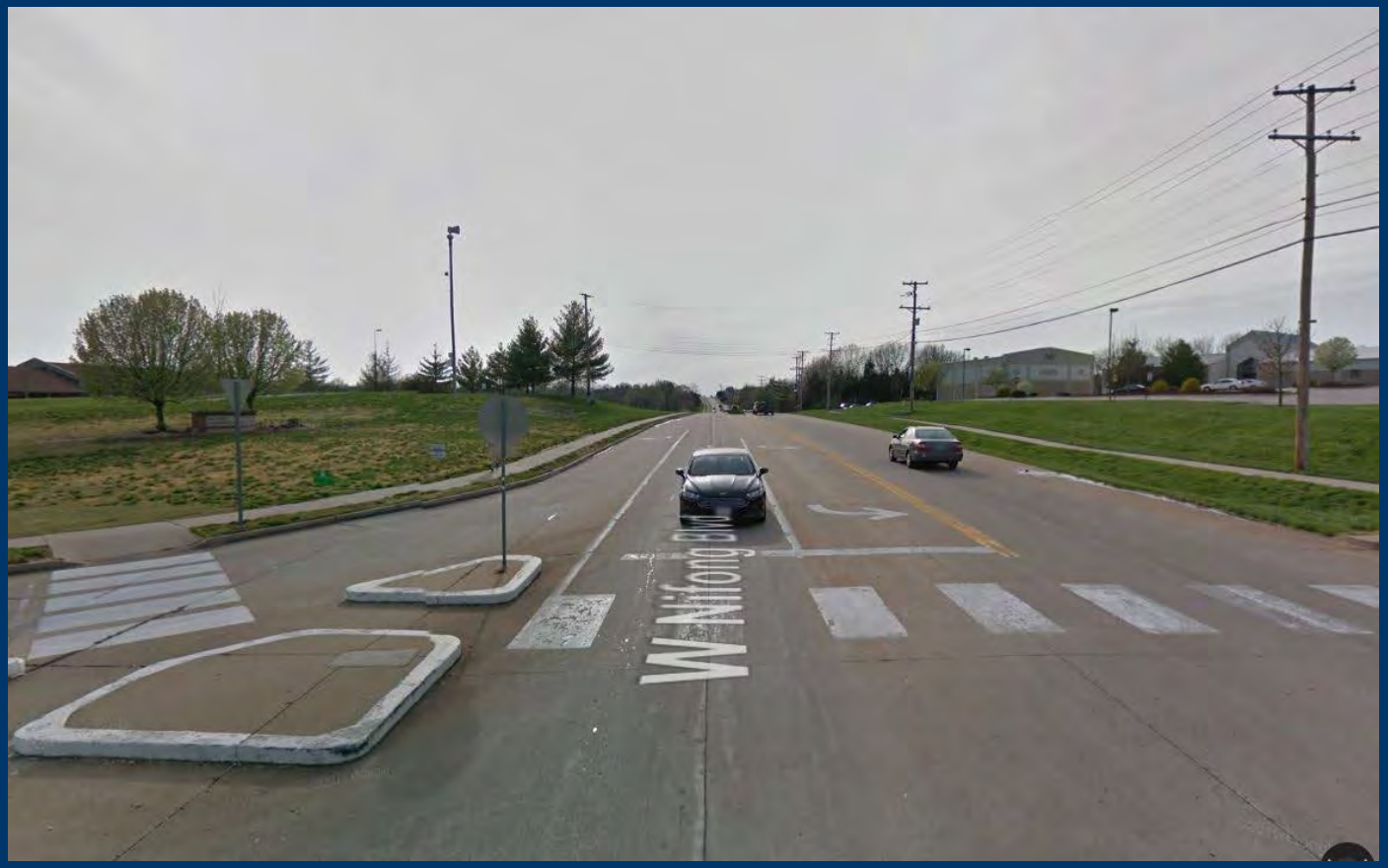

Hayden High School
Distance to Transmission Line
Additional Classrooms
180 FEET
Haber Korn Dr
115kV Transmission Line
205 FEET
SW Gage Blvd
Topeka, Kansas
Main Building
Google earth
© 2015 Google
50
400 ft
N

Transmission Line Structures

2009: Rendering of Proposed Structure Type single circuit structure

2009: Rendering of Proposed Structure Type double single circuit structure

Photo: Nifong/Sinclair



Following images are from LIDAR scans

Existing Lines Along Nifong: looking west

Transmission Lines Along Nifong: looking west

Existing Lines Along Nifong: looking east

Transmission Lines Along Nifong: looking east

Existing Lines Along Grindstone

Transmission Lines Along Grindstone

Steel vs. Wood Overview

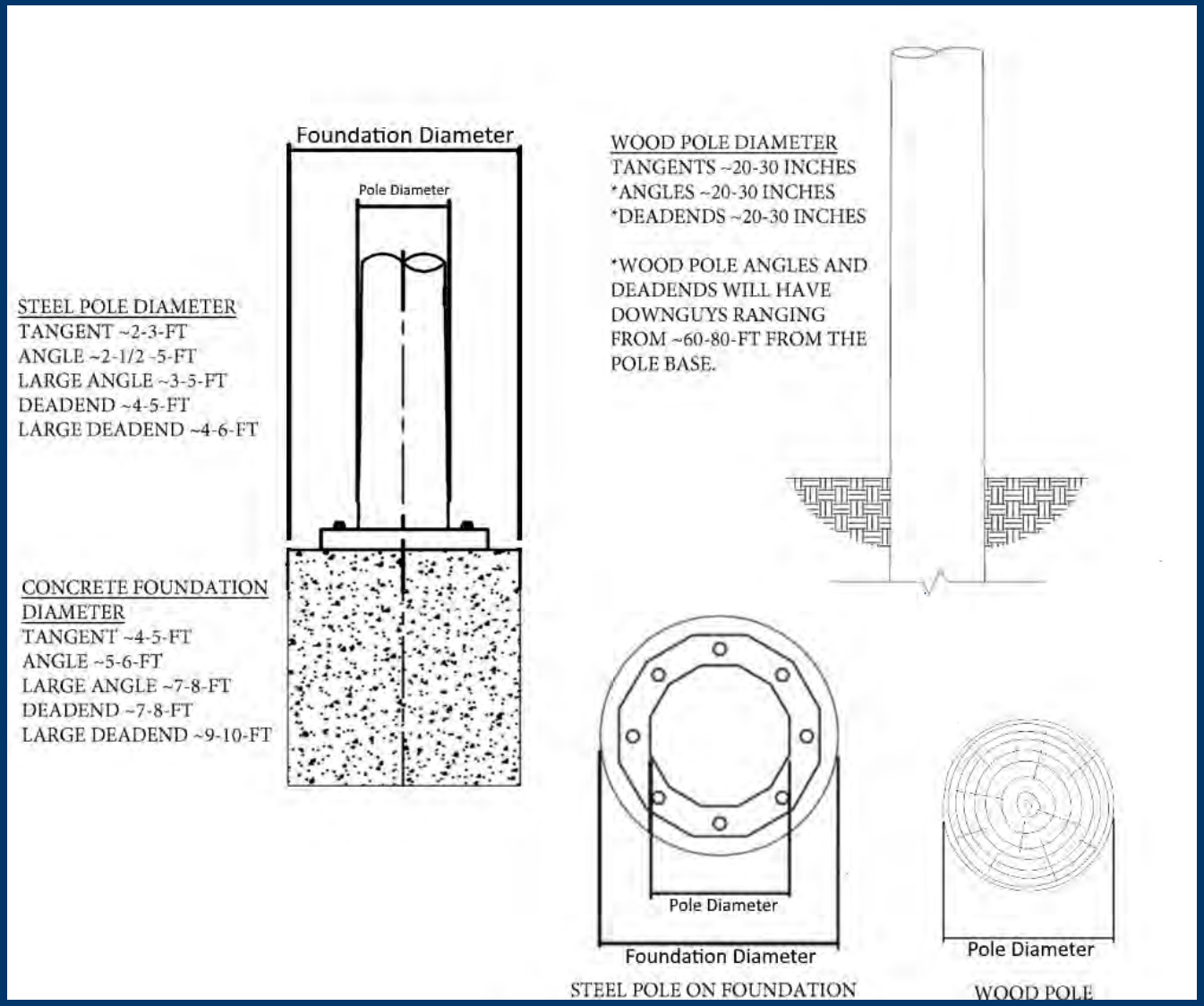
Steel Pole Construction

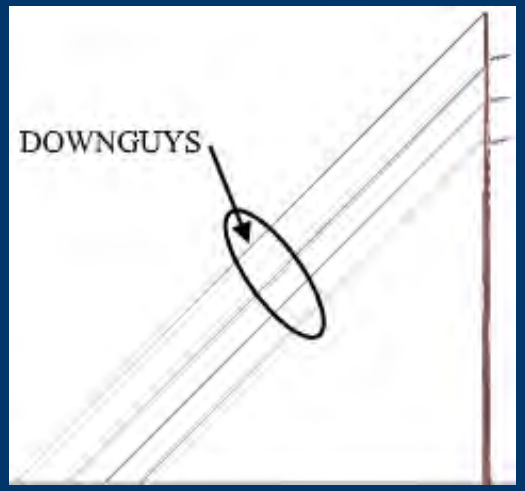
- Engineered material; consistent, controlled properties
- Reduced safety factors required
- No height or span limitations
- Self supporting angles and deadends
- More flexibility during design
- More flexibility during construction

Wood Pole Construction

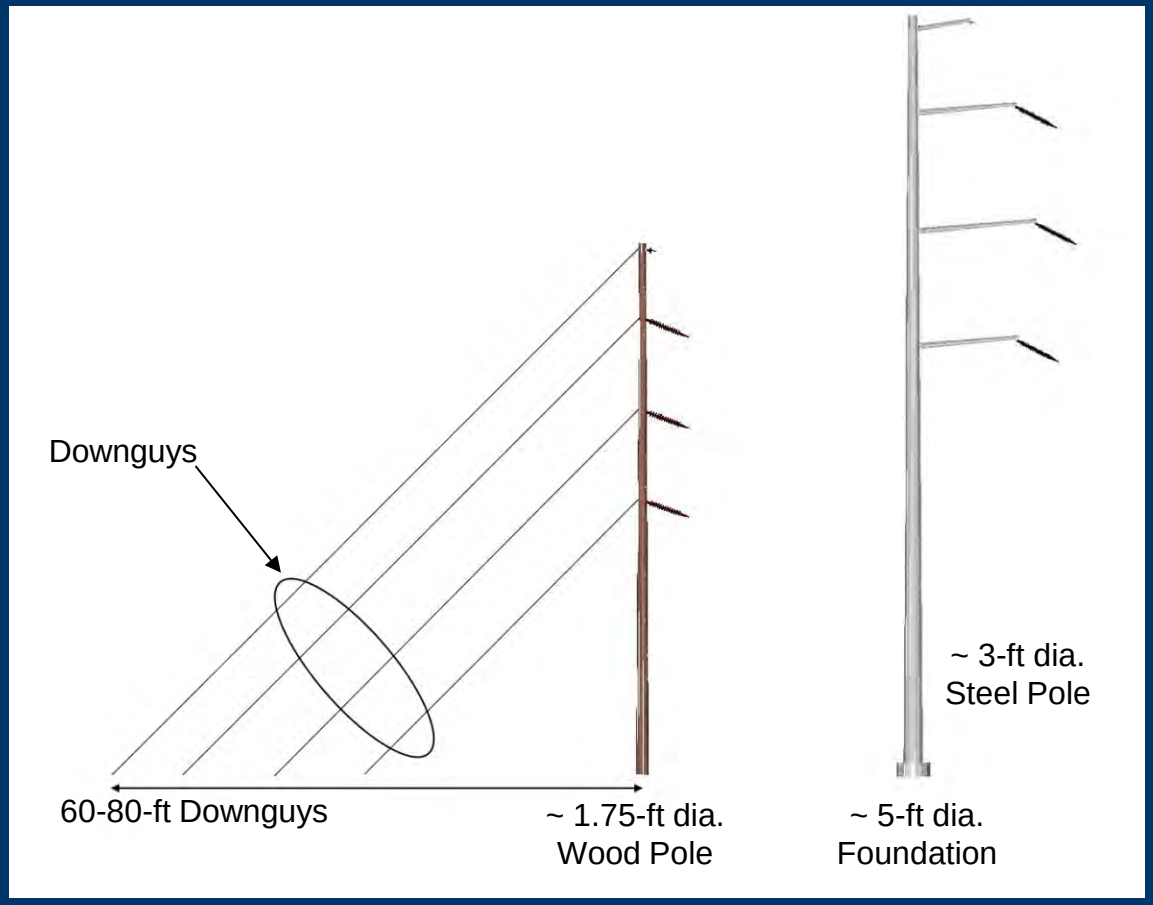
- Natural material; varying properties
- Height & span limitations – more poles required
- Angles & dead ends are not self-supporting; require down guys – more intrusion on properties/easements
- Limited design adjustments during construction

Steel vs. Wood – Size Comparison





Steel vs. Wood – Structure View



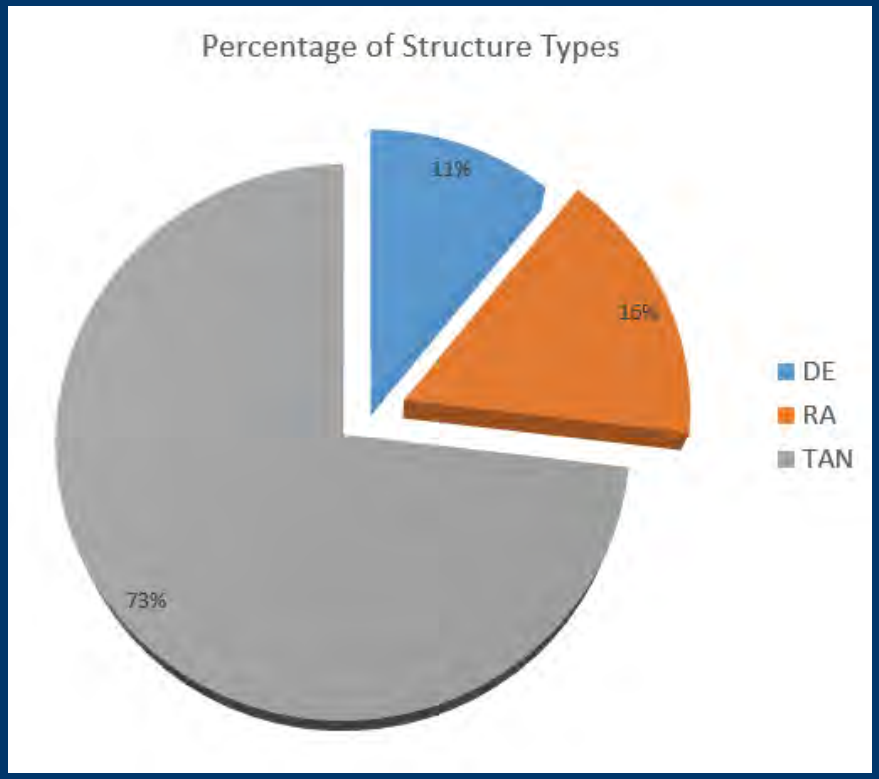
<u>Steel Structures</u>

- Davit arms hang wires away from property
- Majority of structures will have ~4-5 ft. foundations with pole diameter of ~2.5-3 ft.
- Wires higher above ground

<u>Wood Structures</u>

- Angles and dead ends require down guys
- Wires closer to ground

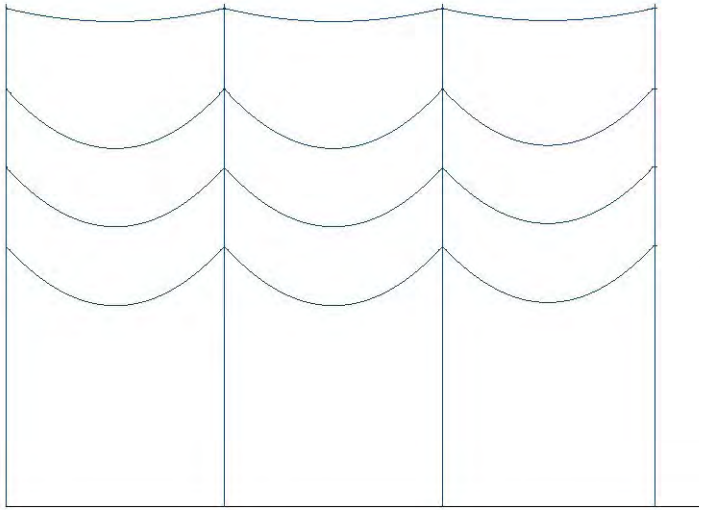
Steel vs. Wood – Structure Quantity



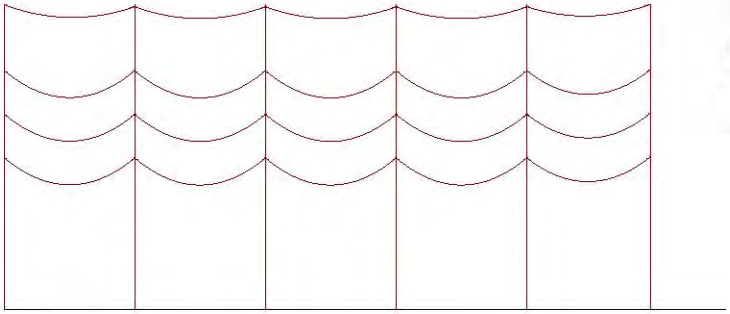
- Steel poles would require 93 structures
- Wood poles would require 145 structures
    - The number of additional structures needed is 52 or an increase of 55.9%

Steel vs. Wood – Span Profile

Steel Structures
Typical Span = 500-ft
~11 Structures Per Mile



1500-ft



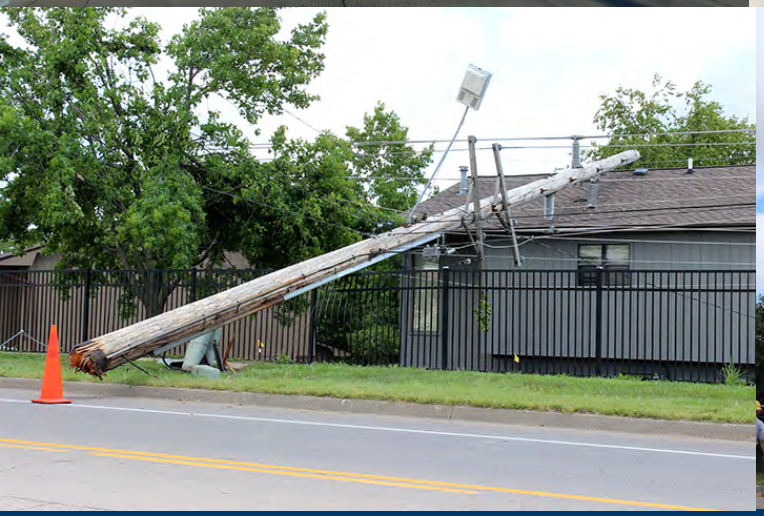
Wood Structures
Typical Span = 300-ft
~ 18 Structures per Mile

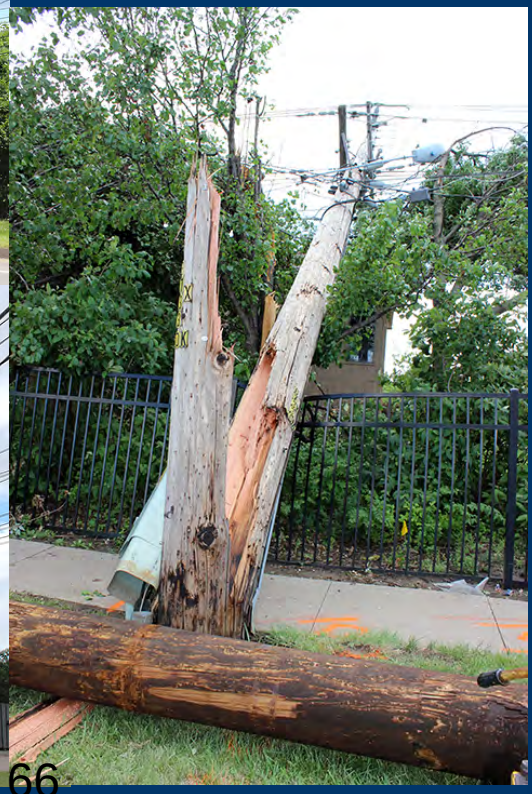
Higher wire clearances attainable using steel structures

Option A - Wood vs. Steel Comparison	Steel Str's	Wood Str's
Typical Span Length	500	300
Structures per mile	11	18
Structure Quantity	127	212
Clearance above ground	45-ft	25-ft

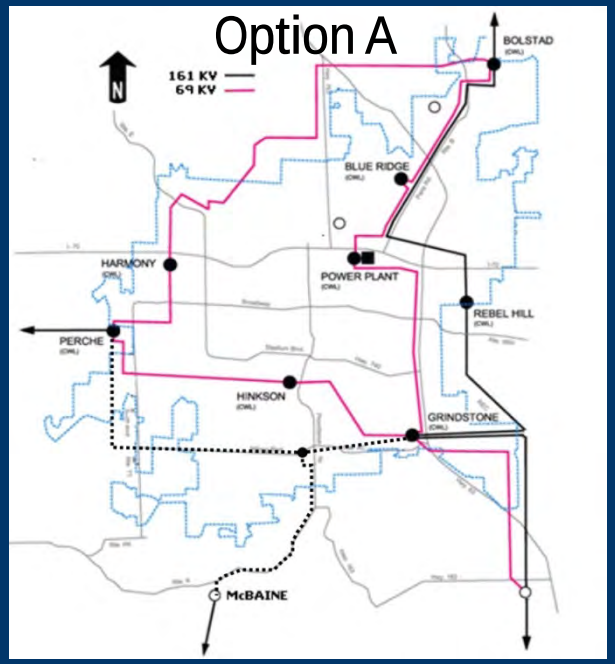
1. Preliminary values
2. Wood poles limited on height due to availability and strength.

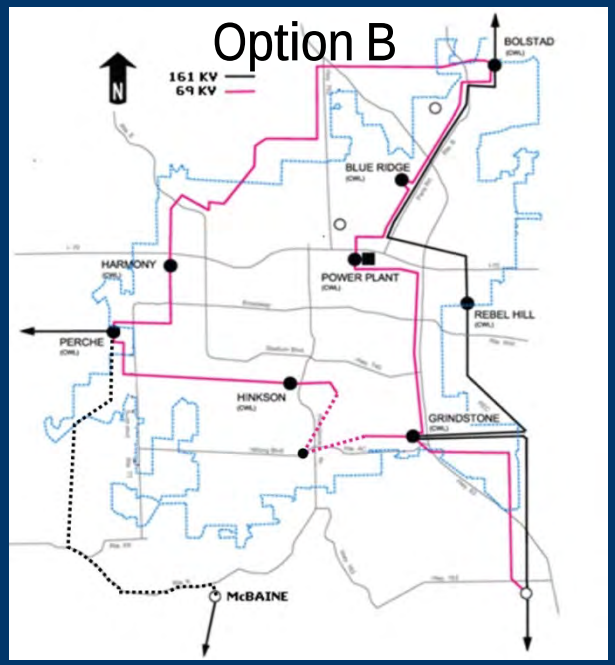
2014 Storm Damage to 69 kV Line wooden poles on Fairview





Recommendations





	Option A Phase I	Option A Phase II	Option B	Option B-2
Transmission (161KV)	$ 15,600,123	$ 8,103,960	$ 16,410,519	$ 20,057,301
SubTransmission (69KV)	$ 0	$ 0	$ 2,425,500	$ 2,425,500
Projected Easement	$ 610,000	$ 1,503,610	$ 3,055,080	$ 3,072,285
Undergrounding of Distribution (Columbia W&L)	$ 3,463,400	$ 250,000	$ 1,229,200	$ 1,229,200
Undergrounding of Distribution (Boone Electric)	$ 1,536,600	$ 2,790,600	$ 4,327,200	$ 3,762,400
SubTotal	$ 21,210,123	$ 12,648,170		
Total	**$33,858,293**		**$ 27,447,499**	**$ 30,546,686**
Load Serving Capacity MW (Upon Completion)	**270**		**27**	**27**

Staff Recommendation of Option A

- Increasing both the transmission and distribution capacity for the longest term with a single cost-effective solution
- Transfers load to the 161 kV system and preserves current 69 kV capacity
- 161 kV option more than doubles the power transmission capacity
- Does not require rebuild of existing 69 kV system
- Provides connections between three different import substations which is a more reliable & longer-term solution
- Water & Light Advisory Board endorsed Option A without undergrounding options (before 2013 hearing & again in January 2016)

Discussion