TRANSMISSION MAGNETIC FIELD MANAGEMENT PLAN
MISSOURI FLAT-GOLD HILL 115 KV LINES RECONDUCTORING PROJECT

I. General Description of Project

Project Lead: Project Manager, Electric Transmission Maintenance and Construction

Transmission Lines: Missouri Flat-Gold Hill 115 kV line #1
Missouri Flat-Gold Hill 115 kV line #2

Distribution line Underbuild: 21 kV.

Scope of Work:

The current scope of work is to reconductor Missouri Flat-Gold Hill 115 kV lines No. 1 and 2 (~ 25 miles long each) with 3M ACCR 636 T16 (Grosbeak) conductor. These 2 lines are on a Double Circuit Pole Line (DCPL) and Double Circuit Tower Line (DCTL) the scope starts from 2 spans northeast of Shingle Spring Substation (pole 22/174) to Shingle Spring Substation, then to Clarksville Substation and ends @ Gold hill Substation. The Gold Hill-Clarksville 115 kV line and the Gold Hill 60 kV No. 1 lines (also a DCTL) run parallel with the Missouri Flat-Gold Hill 115 kV No. 1 & 2 lines from Clarksville Substation to Gold Hill Substation.

Base Cost of Project: Approximately $25,000,000

II. BACKGROUND: CPUC DECISION 93-11-013 AND EMF POLICY

On January 15, 1991, the CPUC initiated an investigation to consider its role in mitigating the health effects, if any, of electric and magnetic fields from utility facilities and power lines. A working group of interested parties, called the California EMF Consensus Group, was created by the CPUC to advise it on this issue. It consisted of 17 stakeholders representing citizens groups, consumer groups, environmental groups, state agencies, unions, and utilities. The Consensus Group's fact-finding process was open to the public, and its report incorporated concerns expressed by the public. Its recommendations were filed with the Commission in March 1992.

In August 2004 the CPUC began a proceeding known as a “rulemaking” (R.04-08-020) to explore whether changes should be made to existing CPUC policies and rules concerning EMF from electric transmission lines and other utility facilities.

Through a series of hearings and conferences, the Commission evaluated the results of its existing EMF mitigation policies and addressed possible improvements in implementation of these policies. The CPUC also explored whether new policies are warranted in light of recent scientific findings on the possible health effects of EMF exposure.

The CPUC completed the EMF rulemaking in January 2006 and presented these conclusions in Decision D.06-01-042:

- The CPUC affirmed its existing policy of requiring no-cost and low-cost mitigation measures to reduce EMF levels from new utility transmission lines and substation projects.

- The CPUC adopted rules and policies to improve utility design guidelines for reducing EMF, and provides for a utility workshop to implement these policies and standardize design guidelines.

- Despite numerous studies, including one ordered by the Commission and conducted by the California Department of Health Services, the CPUC stated “we are unable to determine whether there is a significant scientifically verifiable relationship between EMF exposure and negative health consequences.”

- The CPUC said it will “remain vigilant” regarding new scientific studies on EMF, and if these studies indicate negative EMF health impacts, the Commission will reconsider its EMF policies and open a new rulemaking if necessary.

In response to a situation of scientific uncertainty and public concern, the decision specifically requires PG&E to consider “no-cost” and “low-cost” measures, where feasible, to reduce exposure from new or upgraded utility facilities. It directs that no-cost mitigation measures be undertaken, and that low-cost options, when they meet certain guidelines for field reduction and cost, be adopted through the project certification process. PG&E was directed to develop, submit and follow EMF guidelines to implement the CPUC decision. Four percent of total project budgeted cost is the benchmark in implementing EMF mitigation, and mitigation measures should achieve incremental magnetic field reductions of at least 15%.

III. ELECTRIC AND MAGNETIC FIELDS (EMF)

EMF is a term used to describe electric and magnetic fields that are created by electric voltage (electric field) and electric current (magnetic field). Power frequency EMF is a natural consequence of electrical circuits, and can be either directly measured using the appropriate measuring instruments or calculated using appropriate information.

Electric fields are present whenever voltage exists on a wire, and are not dependent on current. The magnitude of the electric field is primarily a function of the configuration and operating voltage of the line and decreases with the distance from the source (line). The electric field can be shielded (i.e., the strength can be reduced) by any conducting surface, such as trees, fences, walls, buildings, and most types of structures. The strength of an electric field is measured in volts per meter (V/m) or kilovolts per meter (kV/m).

Magnetic fields are present whenever current flows in a conductor, and are not dependent on the voltage of the conductor. The strength of these fields also decreases with distance from the source. However, unlike electric fields, most common materials have little shielding effect on magnetic fields.

The magnetic field strength is a function of both the current on the conductor and the design of the system. Magnetic fields are measured in units called Gauss. However, for the low levels normally encountered near electric utility facilities, the field strength is expressed in a much smaller unit, the milliGauss (mG), which is one thousandth of a Gauss.

Power frequency EMF are present wherever electricity is used. This includes not only utility transmission lines, distribution lines, and substations, but also the building wiring in homes, offices, and schools, and in the appliances and machinery used in these locations. Magnetic field intensities from these sources can range from below 1 mG to above 1,000 mG (1 Gauss).

Magnetic field strengths diminish with distance. Fields from compact sources (i.e., those containing coils such as small appliances and transformers) drop off with distance “r” from the source by a factor of $1/r^3$. For three-phase power lines with balanced currents, the magnetic field strength drops off at a rate of $1/r^2$. Fields from unbalanced currents, which flow in paths such as neutral or ground conductors, fall off inversely proportional to the distance from the source, 1/r. Conductor spacing and configuration also affect the rate at which the magnetic field strength decreases, as well as the presence of other sources of electricity. The magnetic field levels of PG&E’s power lines will vary with customer demand.

Magnetic field strengths for typical transmission power line loads at the edge of rights-of-way are approximately 10 to 90 mG.

IV. No-Cost and Low-Cost Magnetic Field Mitigation

Base Case Phasing:

Missouri Flat-Gold Hill 115 kV #1: Vertical: **CBA** (Top, Middle, Bottom), circuit one.

Missouri Flat-Gold Hill 115 kV #2: Vertical: **BAC** (Top, Middle, Bottom), circuit two.

Base Case Load Flow:

Missouri Flat-Gold Hill #1: The summer peak load current (system peak, all lines in service) used for the base case calculation of the magnetic field is 200 Amps, flowing from Gold Hill Substation to Silver Springs Substation. The load currents are assumed to be balanced at 120 electrical degrees separation between the three phases.

Missouri Flat-Gold Hill #2: The summer peak load current (system peak, all lines in service) used for the base case calculation of the magnetic field is 450 Amps, flowing from Gold Hill Substation to Silver Springs Substation. The load currents are assumed to be balanced at 120 electrical degrees separation between the three phases.

No Cost Field Reduction

Optimally Phase Circuits:

The phases of the Missouri Flat-Gold Hill 115 kV line #2 will be arranged for minimum magnetic field level at the edge of the right of way. The phasing will be changed to the following:

From Gold Hill Sub to Clarksville Sub to Shingle Spring Sub –

Missouri Flat-Gold Hill 115 kV #1: Vertical: CBA (Top, Middle, Bottom), circuit one.

Missouri Flat-Gold Hill 115 kV #2: Vertical: **ABC** (Top, Middle, Bottom), circuit two.

Base Case Field Level at the Edge of the Right of Way: 20.8 mG

Field Level at the Edge of the ROW with Reduction Measure of cross phasing: 17.3 mG

Reduction: 16.9%, using base case load flows. (See Table 1 and Graph 1)

V. General Description of Surrounding Land Uses

Schools or Daycare: Two poles.
Residential (rural): Eleven poles & thirteen towers.
Commercial/Industrial: Twenty-four poles.
Recreational: None.
Agricultural, Rural, and Undeveloped Land: Twenty-two poles & four towers.

Priority Areas where Low Cost Measures are to be Applied

The thirteen poles and thirteen towers in the school and residential land use areas are considered for magnetic field reduction.

The FMP does not proposed to raise the thirteen lattice steel towers on the Missouri Flat-Gold Hill 115 kV line (structure nos. 31/231 to 33/247) for EMF mitigation due to structural reasons. We are installing a larger conductor at a higher tension than these towers were originally designed for, the existing towers without any raises are capable of supporting the new conductor with mostly minor modifications, the tower supporting the cell antennas is the exception.

Following is a summary of the three options evaluated for raising these towers:

- Cage top extensions – due to the conductor loading of the new wire typical cage top extension cannot be installed on the towers without significant modifications to the towers; this raise type of extension is not recommended by engineering for this project.

- Waist cage extensions – these extensions are a feasible alternative but would still require significant structural modifications. Another drawback with the waist cage extensions is access for large cranes for lifting, access to the towers in the residential areas is not very good and would cause significant ground disturbance and impose on the residence.

- Vertical extensions – these extensions are placed at the base of the tower, this requires the existing tower to have level/even leg extensions and none of the towers in the residential area has level/even legs so this option to raise the towers is not feasible.

Description: Raise conductor height above ground by ten feet. The strength of the magnetic field decreases as the distance from the conductors increases. Therefore, one method of reducing the magnetic field strength at a particular location is to increase the distance of the conductors from the location of interest. The primary method in which this may be accomplished is to raise the height of the transmission structures used and increase the height of the conductor at midspan. This low cost option proposes to install poles ten feet taller.

Percent Reduction: At the edge of the right of way:

Cross Phase Case:	17.3 mG
10’ higher:	11.5 mG
Reduction:	33.4 %

Cost: Approximately $ 195,000.

This FMP proposes to raise the height of thirteen poles in the school and residential land use areas by 10 feet taller than required for meeting General Order 95. No other low-cost mitigation is available for this project.

VI. Conclusion - Field Reduction Options Selected

This FMP proposes to raise the height of thirteen poles in the school and residential land use areas by 10 feet taller than required for meeting General Order 95. No other low-cost mitigation is available for this project.

The phases of the Missouri Flat-Gold Hill 115 kV line #2 will be arranged for minimum magnetic field level at the edge of the right of way. The phasing will be changed to the following:

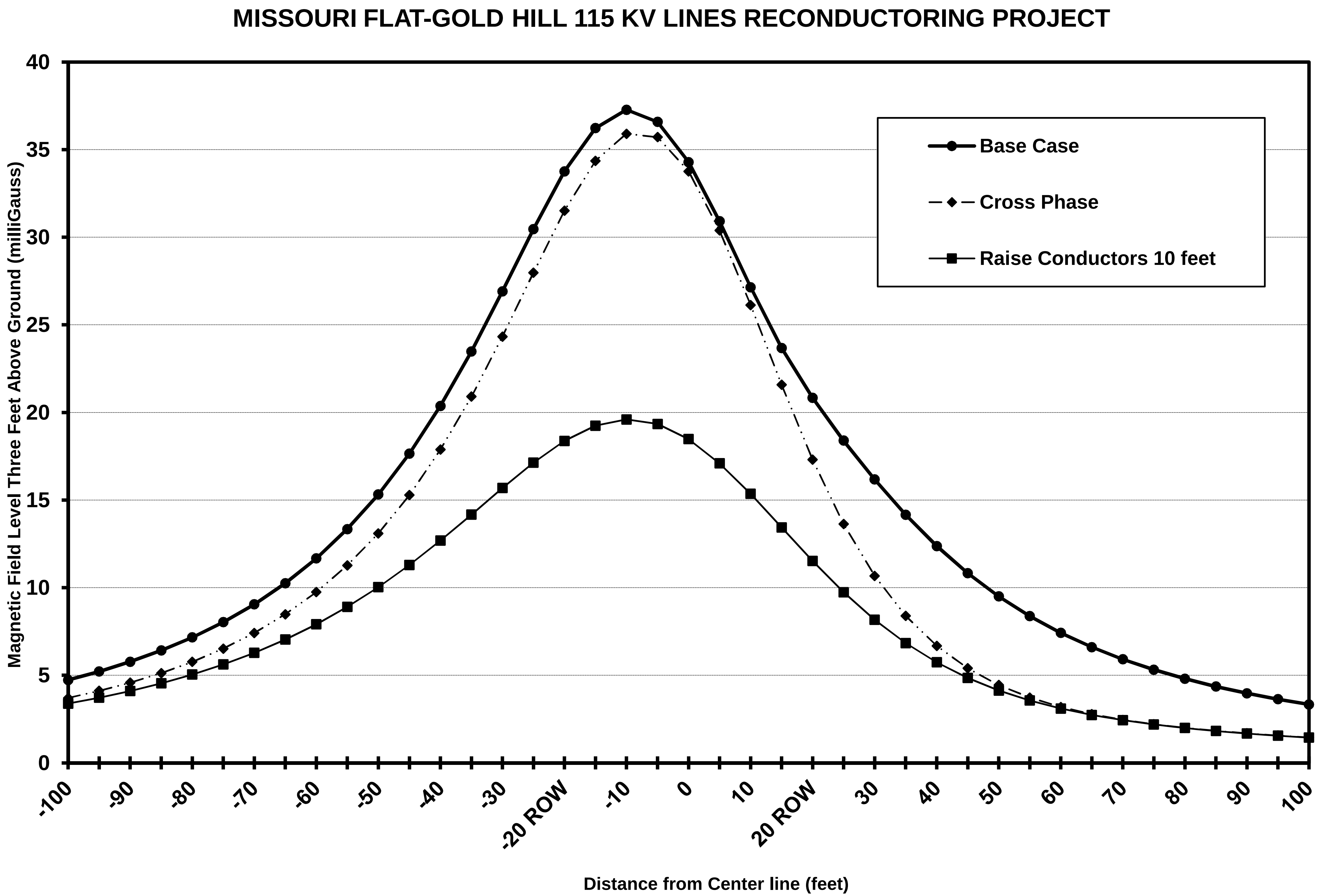
From Gold Hill Sub to Clarksville Sub to Shingle Spring Sub –

Missouri Flat-Gold Hill 115 kV line #1 Phasing	Top-C, Mid-B, Bot-A
Missouri Flat-Gold Hill 115 kV line #2 Phasing	**Top A, Mid-B, Bot-C**

TABLE 1

	Magnetic Field Level Three Feet Above Ground (milliGauss)		
Distance from Center line (feet)	**Base Case**	**Cross Phase**	**Raise Conductors 10 feet**
-100	4.7	3.7	3.4
-95	5.2	4.1	3.7
-90	5.8	4.6	4.1
-85	6.4	5.1	4.5
-80	7.2	5.8	5.0
-75	8.0	6.5	5.6
-70	9.1	7.4	6.3
-65	10.3	8.5	7.0
-60	11.7	9.7	7.9
-55	13.3	11.3	8.9
-50	15.3	13.1	10.0
-45	17.7	15.3	11.3
-40	20.4	17.9	12.7
-35	23.5	20.9	14.2
-30	26.9	24.3	15.7
-25	30.5	28.0	17.1
-20 ROW	33.8	31.5	18.4
-15	36.2	34.4	19.2
-10	37.3	35.9	19.6
-5	36.6	35.7	19.3
0	34.3	33.8	18.5
5	30.9	30.4	17.1
10	27.1	26.1	15.4
15	23.7	21.6	13.4
20 ROW	20.8	17.3	11.5
25	18.4	13.6	9.7
30	16.2	10.7	8.2
35	14.2	8.4	6.8
40	12.4	6.7	5.7
45	10.8	5.4	4.8
50	9.5	4.4	4.1
55	8.4	3.7	3.6
60	7.4	3.2	3.1
65	6.6	2.8	2.7
70	5.9	2.5	2.4
75	5.3	2.2	2.2
80	4.8	2.0	2.0
85	4.4	1.8	1.8
90	4.0	1.7	1.7
95	3.6	1.6	1.6
100	3.3	1.5	1.4

Graph 1


MISSOURI FLAT-GOLD HILL 115 KV LINES RECONDUCTORING PROJECT
Magnetic Field Level Three Feet Above Ground (milliGauss)
0
5
10
15
20
25
30
35
40
Base Case
Cross Phase
Raise Conductors 10 feet
-100
-90
-80
-70
-60
-50
-40
-30
-20 ROW
-10
0
10
20 ROW
30
40
50
60
70
80
90
100
Distance from Center line (feet)

TRANSMISSION MAGNETIC FIELD MANAGEMENT PLAN
GOLD HILL #1 60 KV LINE RECONDUCTOR

I. General Description of Project

Project Lead: Project Manager, Electric Transmission Maintenance and Construction

Transmission Line: Gold Hill #1 60 kV line.

Distribution line Underbuild: 21 kV.

Scope of Work:

This job is a Shoofly Upgrade to 115kv from Gold Hill Sub to a few poles past Shingle Springs Sub. Transmission Conductor will be upgraded to 715A from Clarksville Sub to a few poles past Shingle Springs (approximately 7 miles) which will require reframing and/or replacing of existing poles. Most poles are accessible when dry with a few exceptions. Most all poles have distribution under-build.

Base Cost of Project: Approximately $8,500,000

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- The CPUC adopted rules and policies to improve utility design guidelines for reducing EMF, and provides for a utility workshop to implement these policies and standardize design guidelines.

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Magnetic field strengths for typical transmission power line loads at the edge of rights-of-way are approximately 10 to 90 mG.

TRANSMISSION MAGNETIC FIELD MANAGEMENT PLAN
GOLD HILL #1 60 KV LINE RECONDUCTOR

IV. General Description of Surrounding Land Uses

Schools or Daycare: None.

Residential: One hundred-four poles.

High Density Residential	29
Low Density Residential	62
Multi-Family Residential	13

Commercial/Industrial: Thirty-three poles.

Recreational: None.

Agricultural, Rural, and Undeveloped Land: Fifty-three poles.

V. No Cost and Low Cost Magnetic Field Mitigation

No Cost Field Reduction

The operating voltage of the 60 kV line will be increased to 115 kV. This voltage increase will reduce magnetic field levels by 47%.

Priority Areas where Low Cost Measures are to be Applied

The twenty-nine poles are in the high density residential land use area for consideration of magnetic field reduction.

Low Cost Magnetic Field Reduction Options

Description: Raise conductor height above ground by ten feet. The strength of the magnetic field decreases as the distance from the conductors increases. Therefore, one method of reducing the magnetic field strength at a particular location is to increase the distance of the conductors from the location of interest. The primary method in which this may be accomplished is to raise the height of the transmission structures used and increase the height of the conductor at midspan. This low cost option proposes to install poles ten feet taller. Using maximum normal loading for the conductor of 631 amps. (See Table 1 and Graph 1)

Percent Reduction: At the edge of the right of way:

Cross Phase Case:	26.6 mG
10’ higher:	17.5 mG
Reduction:	34.2 %

TRANSMISSION MAGNETIC FIELD MANAGEMENT PLAN
GOLD HILL #1 60 KV LINE RECONDUCTOR

Cost: Approximately $ 263,000.

This FMP proposes to raise the height of twenty-nine poles in the high density residential land use areas ten feet taller than required for meeting General Order 95. No other low cost mitigation is available for this project.

VI. Conclusion - Field Reduction Options Selected

The operating voltage of the 60 kV line will be increased to 115 kV. This voltage increase will reduce magnetic field levels by 47%.

This FMP proposes to raise the height of twenty-nine poles in the high density residential land use areas ten feet taller than required for meeting General Order 95. No other low cost mitigation is available for this project.

GOLD HILL #1 60 KV LINE RECONDUCTOR

TABLE 1

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-100	3.5	3.2
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-90	4.2	3.9
-85	4.6	4.3
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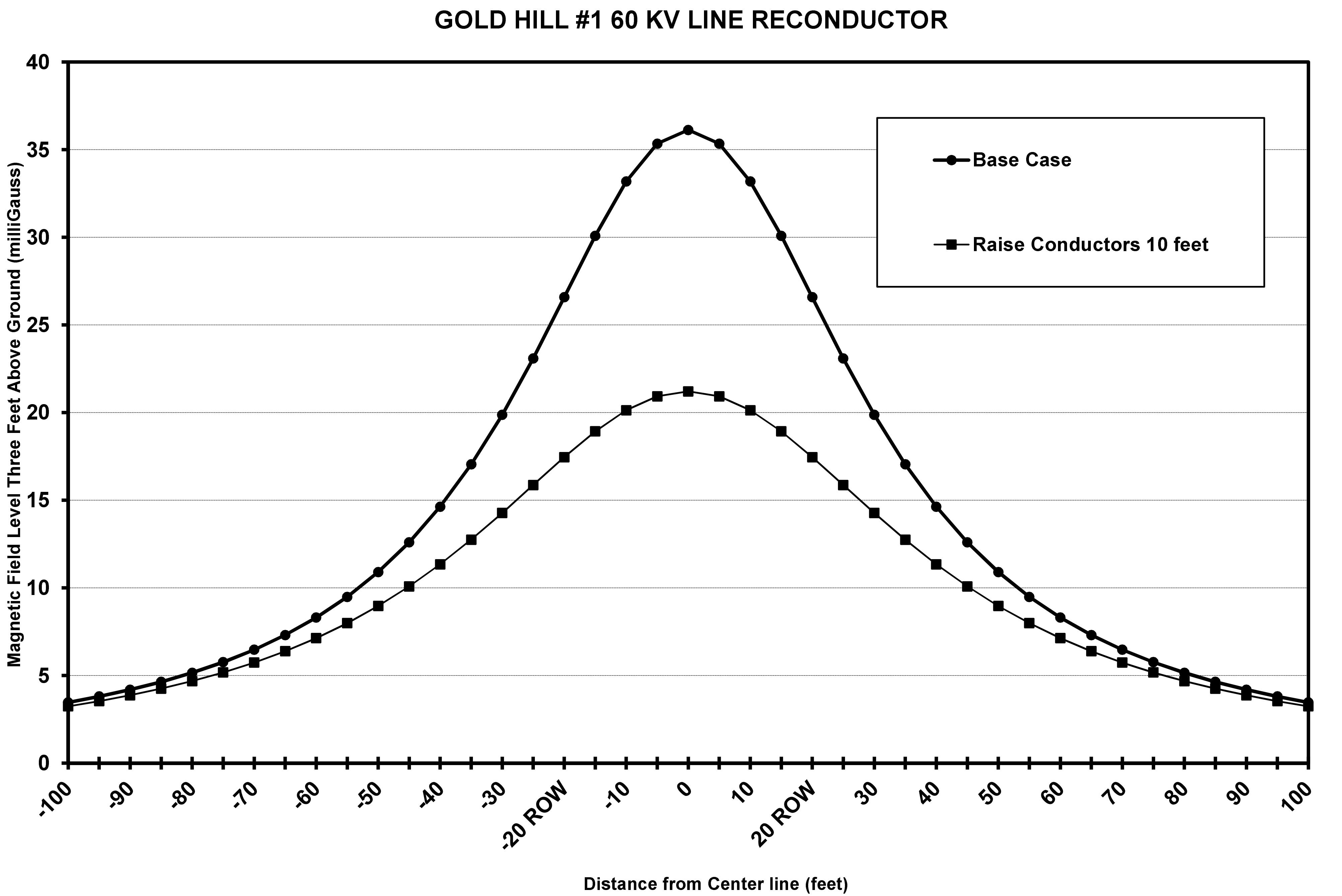
30	19.9	14.3
35	17.0	12.8
40	14.6	11.3
45	12.6	10.1
50	10.9	9.0
55	9.5	8.0
60	8.3	7.1
65	7.3	6.4
70	6.5	5.7
75	5.8	5.2
80	5.2	4.7
85	4.6	4.3
90	4.2	3.9
95	3.8	3.5
100	3.5	3.2

Graph 1



GOLD HILL #1 60 KV LINE RECONDUCTOR
Magnetic Field Level Three Feet Above Ground (milliGauss)
0
5
10
15
20
25
30
35
40
Base Case
Raise Conductors 10 feet
-100
-90
-80
-70
-60
-50
-40
-30
-20 ROW
-10
0
10
20 ROW
30
40
50
60
70
80
90
100
Distance from Center line (feet)