A. ELECTRIC AND MAGNETIC FIELDS (EMF)

Electric and magnetic fields (EMF) are invisible lines of force that surround any electrical device. EMF are naturally occurring (i.e., lightning, the earth's magnetic field, etc.) and is also a byproduct of a technical society. EMFs from electric power frequencies (60 cycles per second) are also referred to as extremely low frequency (ELF) and have very low energy levels. Since ELF EMF has so little energy, the fields weaken rapidly as they move away from the source. Radio, television, and cellular and microwave communications are also invisible fields of force, as are invisible light, X-rays, and cosmic rays. All these fields are part of the "electromagnetic spectrum" that describes the frequency and energy of both visible and invisible fields. Cellular communications, for example, operate are frequencies almost a billion times higher that ELF EMF, which means that they are much more powerful and can transmit signals over long distances. The frequency of visible light is a trillion times higher that ELF EMF, while X-reays and cosmic rays are millions of times higher still.

Electric fields are produced by voltage, which is the presence of an electric charge. In general, the higher the voltage of the power supply, the greater the electric field. An electric field is produced when any device or wire is connected to a source of electricity. Electric fields are also natural phenomena and occur in the form of lightning from a thunderstorm or the static charge you sometimes feel on a dry day. Typically, electric fields are easily shielded by common objects such as trees, fences, and buildings. More important, scientific studies have not found any association between typical exposure levels for electric fields and human disease.

Magnetic fields are produced by current, which is the flow of electric charges. As the current increases, the strength of the magnetic field also increases. Magnetic fields are created only when there is a flow of current. Any device that uses electric current produces a magnetic field. This includes common household appliances and lights, industrial machinery, as well as electric supply and distribution equipment, including transmission lines, distribution lines, and substations.

The following section discusses potential EMF impacts of the proposed new 69 kilovolt (kV) transmission line between the Southampton and Bridgehampton Substations and the expansion of the Bridgehampton Substation. It focuses on potential effects due to magnetic fields created by the transmission line, because normal construction materials provide virtually total shielding from electric fields[1] and would not be expected to result in exposure levels above existing guidelines.

[1] "Electric and Magnetic Field Management Reference Book," 1st Edition, Report TR-114200, Electric Power Research Institute, December 1999.

B. GENERAL DESCRIPTION OF MAGNETIC FIELDS

As mentioned above, any object with an electric charge on it has a voltage (potential) at its surface and can create an electric field. When electric charges move together (an electric current), they create a magnetic field. Magnetic fields are one of the basic forces of nature. The strength of a magnetic field depends on the current (higher currents create stronger magnetic fields), the configuration/size of the source, spacing between conductors, and distance from the source (magnetic fields decrease as the distance from the source increases).

Magnetic flux densities are reported using units of gauss (G). However, it is usually more convenient to report magnetic field using the unit milligauss (mG), which is equal to one-thousandth of a gauss (i.e., 1 mG = 0.001 G). Some technical reports also report magnetic flux densities in the unit of tesla (T) or microtesla (µT; 1 µT = 0.000001 T). The conversion between these units is 1 mG = 0.1 µT and 1 µT = 10 mG.

Magnetic fields can be static/unchanging in direction (caused by direct current [DC]) or changing/alternating in direction (alternating current [AC]). As an example, static magnetic fields occur in nature. The earth has a natural static magnetic field of about 550 mG (0.550 Gauss) in the project area.[1] Some electrical devices operate on a DC system while others operate on an AC system. The magnetic field from AC sources (such as most electrical power lines, electrical equipment, residential wiring, and appliances) differ from DC fields (like the earth) because the field is due to alternating currents (AC) and changes direction at a rate of 60 cycles per second or 60 Hertz.

The characteristics of magnetic fields can differ depending on the field source. A magnetic field near an appliance decreases rapidly with distance away from the device. A magnetic field also decreases with distance away from line sources, such as power lines, but not as rapidly as it does with appliances. Since the magnetic field is caused by the flow of an electric current, a device must be operated for it to create a magnetic field. The magnetic fields for a large number of typical AC household appliances were measured by the Illinois Institute of Technology Research (IITRI) for the U.S. Navy[2] and by Enertech Consultants[3] for the Electric Power Research Institute (EPRI). Typical values for appliances are presented in Table 14-1. The Enertech Consultants study[4] for EPRI also found that the mean resultant AC magnetic field in residential U.S. homes was approximately 0.9 mG (at approximately 1 meter above ground level).

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[1] The Earth's Magnetic Field, International Geophysics Series, Vol. 32, New York: R.T. Merrill and M.W. McElhinny, Academic Press, 1983.

[2] "Household Appliance Magnetic Field Survey," U.S. Naval Electronic Systems Technical Report No. EO6549-3, Illinois Institute of Technology Research Institute, Chicago, March 1984.

[3] Silva, J.M., Hummon, N.P., Rutter, D.A., Hooper, H.C., "Power Frequency Magnetic Fields in the Home," IEEE Transactions on Power Delivery, Vol. PWRD-4, No. 1, pp. 465-478, January, 1989.

[4] Survey of Residential Magnetic Field Sources," L.E. Zaffanella, Final Report TR-102759 (2 Volumes), prepared by the High Voltage Transmission Research Center for the Electric Power Research Institute, 1993.

Table 14-1
Magnetic Field (mG) from Household Appliances

Appliance	12 Inches Away	Maximum
Electric Range	3 to 30	100 to 1,200
Electric Oven	2 to 5	10 to 50
Garbage Disposal	10 to 20	850 to 1,250
Refrigerator	0.3 to 3	4 to 15
Clothes Washer	2 to 30	10 to 400
Clothes Dryer	1 to 3	3 to 80
Coffee Maker	0.8 to 1	15 to 250
Toaster	0.6 to 8	70 to 150
Crock Pot	0.8 to 1	15 to 80
Iron	1 to 3	90 to 300
Can Opener	35 to 250	10,000 to 20,000
Mixer	6 to 100	500 to 7,000
Blender, Popper, Processor	6 to 20	250 to 1,050
Vacuum Cleaner	20 to 200	2,000 to 8,000
Portable Heater	1 to 40	100 to 1,100
Fans/blowers	0.4 to 40	20 to 300
Hair Dryer	1 to 70	60 to 20,000
Electric Shaver	1 to 100	150 to 15,000
Color TV	9 to 20	150 to 500
Fluorescent Fixture	2 to 40	140 to 2,000
Fluorescent Desk Lamp	6 to 20	400 to 3,500
Circular Saws	10 to 250	2,000 to 10,000
Electric Drill	25 to 35	4,000 to 8,000
Source: "Household Appliance Magnetic Field Survey," US Naval Electronic Systems Technical Report Number EO6549-3, Illinois Institute of Technology Research Institute, Chicago, March 1984		

Typical levels of magnetic fields were also measured by Enertech Consultants during two studies performed in New York City in 1989 and in 1999. For these studies a magnetic field meter was worn at the waist and continuously recorded exposure levels while several people went about their typical daily activities--walking along streets, using public transit, shopping in stores, and eating in restaurants. Measured magnetic fields for these activities varied from approximately 1 mG to over 100 mG. This is well within the range (and well below the maximum fields) produced by a number of household appliances.

In general, factors affecting EMF exposure include distance, time, field strength, and wiring configuration. Exposure is greater the nearer to the source, and deceases with distance from the source. The more time spend near a source, the greater the exposure. The stronger the source strength (i.e., voltage levels for electric fields and current levels for magnetic fields), the greater the exposure. Wiring configuration (i.e., how wires are placed relative to one another) affect field strength and drop-off with distance.

Burying electric power lines does not necessarily reduce magnetic fields at ground level. Measurements taken at ground level over underground distribution lines show magnetic fields comparable to those beneath overhead distribution and transmission lines. The determining factors for these field levels are the current in the wires, depth of wire burial, geometry of the wires (i.e., the configuration of the conductors may increase cancellation effects), and whether shielding practices are employed.

STANDARDS AND CRITERIA

At least two states have adopted engineering-based exposure guidelines or standards ("status quo" standards) for magnetic fields. The purpose of most of these exposure standards is to make the field levels from new power lines similar to the field levels from existing lines. Table 14-2 presents a summary of these standards.[1]

Table 14-2
State Regulations that Limit Magnetic Field Strengths on New Transmission Line Rights-of-Way (ROW)

State	Magnetic Field Limit
New York	200 mG at edge of ROW (Max Load)[1]
Florida	200 mG for 500 kV lines at edge of ROW (Maximum Load)
	250 mG for double circuit 500 kV lines at edge of ROW (Maximum Load)
	150 mG for 230 kV and smaller lines at edge of ROW (Maximum Load)

Note: [1]The 200 mG standard applies to the edges of defined ROWs for Article VII transmission facilities (transmission lines 100 kV and greater) and where there is no defined ROW, the 200 mG standard is measured at 75 feet from the centerline of the structures supporting the transmission line operating at 345 kV, 60 feet from the centerline of the structures supporting transmission lines operating at 230, kV and 50 feet from the centerline of structures supporting Article VII circuits operating at a lower voltage.

(New York State regulations limit electric fields to 1.6 kilovolts per meter [kV/m] at the edge of the right-of-way [ROW], and 11.8 kV/m on the ROW, with further limitation of 11 kV/m and 7 kV/M for maximum levels for private road crossings, and highway crossings, respectively. Typically a 69 kV transmission line would have less than 0.8 kV/m electric field on the ROW.)

Although there are no federal standards in the United States specifically to limit exposure to 60 Hertz magnetic fields, two organizations have developed exposure guidelines: the International Commission on Non-Ionizing Radiation Protection (ICNIRP), 1998, and the American Conference of Governmental Industrial Hygienists (ACGIH), 1994. Tables 14-3 and 14-4 present a summary of the magnetic field levels of these guidelines, respectively.

Table 14-3
Summary of ICNIRP 60 Hz Magnetic Field Exposure Guidelines

Exposure (60 Hz)	Magnetic Field
Occupational	
Reference Levels for Time-Varying Fields	4.167 G (4,167 mG)
General Public	
Reference Levels for Time-Varying Fields	0.833 G (833 mG)

Source: International Commission on Non-Ionizing Radiation Protection Guideline, 1998

[1] "Proceedings: Substation Magnetic Field Management Workshop," Report TR-101852, Electric Research and Management for the Electric Power Research Institute, April 1993.

Table 14-4
Summary of ACGIH 60 Hz Magnetic Field Exposure Guidelines

Exposure (60 Hz)	Magnetic Field
Occupational exposures should not exceed	10 G (10,000 mG)
For workers with cardiac pacemakers, the field should not exceed	1 G (1,000 mG)

Source: American Conference of Governmental Industrial Hygienists (ACGIH) Occupational Threshold Limit Values for 60-Hz EMF, 1994

ELECTRIC AND MAGNETIC FIELDS AND HEALTH

Many studies have been conducted about health effects from EMFs. These studies have focused primarily on magnetic rather than electric fields. Early epidemiological studies (statistical analyses of exposed human populations) did not actually measure magnetic field exposures but rather relied on proximity to power lines as an assumption of exposure. Some of these early studies appeared to show a weak association between exposure to power-frequency magnetic fields and the incidence of certain cancers, particularly childhood leukemia. This statistical association, however, was not strong enough to say whether it reflects any real effect or not. Laboratory studies have shown little evidence of a link between power-frequency magnetic fields and cancer. Still other studies have shown that life-time exposure of animals to power-frequency magnetic fields does not cause cancer. Acute effects, such as induced currents in the body, are know to occur at very high magnetic field levels, well above levels associated with power-line and home exposures, overall, most scientists believe that the evidence that power line fields cause or contribute to cancer is weak to nonexistent.

Since 1977, over 130 reviews of EMF science have been conducted by scientific panels, public health organizations, or governmental bodies. Based on the weight of evidence from statistical and laboratory studies, the following conclusions have been published by recognized scientific organizations.

- In 1999 the US National Institute of Health concluded that scientific evidence suggesting that EMFs due to electric power exposures pose any health risk is weak."
- In 2001, the International Agency for Research on Cancer (IARC), an agency of the World Health Organization, classified EMFs due to power generation as "possibly carcinogenic" on the basis of "limited" evidence from humans concerning childhood leukemia. Others of the over 250 agents in this category included coffee, aflotoxin (found in peanut butter), caffeic acid (naturally occurring in fruits, vegetables, seasonings, and beverages), pickled vegetables, gasoline, gasoline engine exhaust, and fuel oils.
- A 2001 review by the International Commission on Non-Ionizing Radiation Protection concluded that "In the absence of evidence from cellular or animal studies and given the methodological uncertainties and in many cases inconsistencies of the existing epidemiological literature, there is no chronic disease for which an etiological (causal) relation to EMFs due to [power-frequency fields] can be established".
- In 2004, a U.K. National Radiation Protection Board (NRPB) review stated that "…the epidemiological evidence that …exposure to power frequency magnetic fields above 0.4 uT [equal to 4 mG] is associated with a small absolute raised risk of leukemia in children is, at present, an observation for which there is no sound scientific explanation. There is no clear evidence of carcinogenic effect of ELF EMFs in adults and no plausible biological

explanation of the association that can be obtained from experiments with animals or from cellular and molecular studies….Thus any judgments developed on the assumption that the association is causal would be subject to a very high level of uncertainty." The NRPB went on to conclude that the results of epidemiological studies could not be used as a basis for restrictions on exposure to EMFs.

- In March 2007, the Scientific Committee on Emerging and Newly Identified Health Risks of the European Union stated that "The previous conclusion that ELF fields are possibly carcinogenic, chiefly based upon childhood leukemia results, is still valid" (see 2001 IARC cite above), but went on to say that "There is no known mechanism to explain how electromagnetic field exposure may induce leukemia. The effects have not been replicated in animal studies."
- In June 2007, the World Health Organization (WHO) issued an Environmental Health Criteria for EMFs. The WHO had established an International EMP Project in 1996 to access the scientific evidence of possible health effects of EMFs. The Environmental Health Criteria concludes that: there is no new evidence to change IARC classifications; ICNIRP guidelines are adequate to protect people from known acute effects of magnetic fields; no proposed biophysical mechanism whereby magnetic fields could cause cancer seem plausible; evidence not strong enough for childhood leukemia to be considered causal; and it recommended against lower numerical limits in exposure guidelines to some arbitrary level (i.e., less than the ICNIRP limit) in the name of precaution. In its recommendations to member states and other policy makers, the Environmental Health Criteria states that precaution should be applied to EMF based on the "limited evidence" for a link between magnetic fields and childhood leukemia. It also states that based on the weakness of the evidence and the limited impact on public health, if there is a link, the benefits of exposure reduction on health are unclear. Thus the costs of precautionary measures should be very low and should not compromise the benefits of a public electricity supply.

With regard to EMF exposure and breast cancer, while a number of smaller studies showed no association between EMFs and breast cancer, the results of two large multiyear epidemiological studies were announced in 2003. The first, a study of over 1,100 women on Long Island was conducted by researchers at SUNY Stony Brook as part of the Long Island Breast Cancer Study Project, was the largest and most thorough to-date. The study found no association between breast cancer and residential EMF exposures. The second study, led by the U.S. National Institute of Environmental Health, involved over 1,400 women in Los Angeles and Hawaii. The study was careful to use a multiethnic population to control bias and also resulted in what the authors termed "a pertinent negative finding." The results of this study were in concurrence with previous studies and in the words of the authors "provide some reasonable reassurance to the public regarding this ubiquitous low-level exposure." The 2007 World Health Organization Environmental Health Criteria for EMF confirms that evidence is sufficient to say that breast cancer is not caused by magnetic fields.

C. EXISTING CONDITIONS

Currently, portions of the proposed transmission line route for the Direct Route Alternative have above-grade 13 kV distribution lines and above-grade 69 kV transmission lines, and some portion of the route along David Whites Lane has neither distribution nor transmission lines. In general, for transmission lines a number of variables affect magnetic field strength—the amount of current, the distance from the wires, the line configuration, (i.e., how wires are placed in relation to one another), etc. While no measurements have been made of existing magnetic fields in the study area, it would be expected that magnetic fields would be in the range of approximately 1-35 mG, depending upon the current in the lines, the distance form the ROW, the line clearance, the phasing of the circuits, etc.

Currently, the proposed site of the expansion of the Bridgehampton Substation is undeveloped land. Based upon measurements at other substations, maximum magnetic fields at locations immediately adjacent to the existing Bridgehampton Substation would be expected to be in the range of 1 to 25 mG, and maximum fields would be expected to be within 1 to 2 mG at distances of 100 feet or more from the substation.

Existing magnetic fields at locations along the proposed transmission line route and at locations adjacent to the proposed site of the substation route are well below applicable standards and well within the range (and well below the maximum fields) produced by a number of household appliances.

D. POTENTIAL IMPACTS OF THE PROPOSED PROJECT

MAGNETIC FIELDS ASSOCIATED WITH THE PROPOSED PROJECT

For a 69 kV transmission line operating at 167 amps, at the transmission line center the strength of the magnetic field would typically be approximately 23-27 mG. At a distance of 40 feet from the transmission line centerline, the strength of the magnetic field would typically drop to approximately 4 to 7 mG, and at a distance of 100 feet from the transmission line centerline, the strength of the magnetic field would typically drop to less than 2 mG. Field strength decays with distance, and consequently at distances beyond 100 feet, the magnetic field would be expected to be 0-1 mG. Regardless of whether the line is above or below grade, magnetic fields of the magnitudes cited above would be expected.

Magnetic field levels in nearby buildings would vary depending upon the contribution from other indoor sources, e.g., appliances and wiring. However, at all locations adjacent to the proposed transmission line route for the Direct Route Alternative, regardless of whether the transmission line is on poles or underground, the strength of the magnetic field would be significantly below the guideline exposure value established for the general population by the International Commission on Non-Ionizing Radiation Protection.

Maximum magnetic fields at locations immediately adjacent to the site of the expanded Bridgehampton Substation would be expected to be in the range of 1 to 25 mG, and maximum fields would be expected to be within 0 to 2 mG at distances of 100 feet or more from the substation. At all locations near the proposed site of the expanded substation, off LIPA property, the maximum strength of any magnetic field would be significantly below the guideline exposure value established for the general population by the International Commission on Non-Ionizing Radiation Protection.

CONCLUSIONS

Installation of the proposed 69 kV transmission line, with the Direct Route Alternative, would result in magnetic fields significantly below the New York State 200 milligauss level at the edge of the right-of-way. In addition, magnetic fields would also be significantly below the guideline exposure value established for the general population by the International Commission on Non-Ionizing Radiation Protection at or in the vicinity of the proposed line, including nearby building and residences. ✷