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POSITION PAPER ON ELECTRIC AND MAGNETIC POWER FREQUENCY FIELDS AND THE VELCO NORTHWEST VERMONT RELIABILITY PROJECT

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SUMMARY

Currently, there are no federal standards for occupational and residential exposure to electric and magnetic power frequency fields ("EMF") nor are there standards or guidelines limiting EMF fields for appliance manufacturers at this time. Electric and magnetic power frequency fields refer to those fields produced by 60 hertz power lines in this paper. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) established guidelines for exposure of the public to magnetic and electric power frequency fields of 833 milligauss (mG) and 4.2 kilovolts per meter (kV/m), respectively [11].[1] The Institute of Electrical and Electronics Engineers' ("IEEE") magnetic power frequency field guideline for exposure to the public is 9,040 mG [14]. New York has established guidelines for a 345 kV power line of 200 mG and 1.6 kV/m at the edge of the right-of-way when the power line is operating at its highest continuous current rating [30]. Florida has established guidelines for power lines less than 230 kV of 150 mG and 2.0 kV/m at the edge of the right-of-way when the power line is operating at its highest continuous current rating [7]. The New York and Florida guidelines are designed so that the maximum electric and magnetic power frequency fields will not exceed those fields produced by power lines now in operation and are not based on health effects. Germany (1997) adopted a national rule on EMF exposure for the general public limiting the electric power frequency field to 5 kV/m and the magnetic power frequency field to 1000 mG [18]. These fields are unlikely to be encountered in daily life. Typical magnetic power frequency fields in the home average 0.6 mG [24] and range from 0.1 to 4 mG [30] over a period of a day. Average electric power frequency fields in the home range from 0 to 0.01 kV/m [21].

For the purpose of the Vermont Department of Health's ("VDH") review of the Vermont Electric Power Company ("VELCO") Northwest Vermont Reliability Project ("NRP"), the New York and Florida guidelines were chosen for comparison because they provide the strictest guidelines presently available, even though they are not health-based. When the New York and Florida guidelines were exceeded, the ICNIRP guidelines, which are health-based, were compared with the projected magnetic or electric power frequency fields.

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[1] All bracketed numbers throughout this Paper refer to the corresponding report in the References section.

Projected average loads with maximum line sag, maximum line voltage, and maximum line to ground voltage were used for calculations of the electric and magnetic power frequency fields at the edge of the right of way for the proposed NRP. In summary, for average loading at the edge of the right of way, the NRP is expected to result in a decrease in the magnetic power frequency field for the West Rutland to Florence corridor from 8 mG in 2003 to 5 mG in 2012; the Florence to Middlebury corridor decreases from 6 mG in 2003 to 5 mG in 2012; the Middlebury to New Haven corridor increases from 3.4 mG in 2003 to 4.9 mG in 2012; the New Haven to Vergennes corridor increases from 3 mG in 2003 to 6 mG in 2012; the Vergennes to North Ferrisburg corridor increases from 11 mG in 2003 to 20 mG in 2012; the North Ferrisburg to Charlotte corridor increases from 6 mG in 2003 to 19 mG in 2012; the Charlotte to Shelburne corridor increases from 2 mG in 2003 to 16 mG in 2012; the Shelburne to Queen City-Pole 51 corridor decreases from 14 mG in 2003 to 12 mG in 2012; the Queen City-Pole 51 to Pole 58 decreases from 45 mG in 2003 to 39 mG in 2012; the Queen City-Pole 58 to Pole 67 decreases from 38 mG in 2003 to 33 mG in 2012; and the Queen City-Pole 67 to the Queen City Substation decreases from 37 mG in 2003 to 32 mG in 2012. The average projected magnetic power frequency field along the West Rutland to New Haven corridor is approximately 5 mG in 2012. The projected magnetic power frequency field along the New Haven to Queen City Pole 51 corridor ranges from 6 to 20 mG and the average is approximately 15 mG in 2012. The projected magnetic power frequency along the Queen City Pole 51 to the Queen City Substation ranges from 32 to 39 mG and the average is approximately 35 mG in 2012. (Refer to Appendix B Table 2 Columns "Existing Power Line-2003", "Proposed Power Line-2012" and "Proposed Power Line <30-ft ROW-2012".) All of the projected magnetic power frequency fields along the entire proposed NRP corridor, as indicated above, are well below the New York, Florida and ICNIRP guidelines.

Projected maximum continuous loading with maximum line sag, maximum line voltage, and maximum line to ground voltage were used to compare the present and proposed NRP power line magnetic and electric power frequency fields to the New York and Florida guidelines. In summary, for maximum continuous loading at the edge of the right of way, the magnetic power frequency field for the West Rutland to New Haven corridor increases from an existing level of

31 mG to a projected level of 76 mG with the NRP; the New Haven to Vergennes corridor increases from an existing level of 12 mG to a projected level of 36 mG; the Vergennes to Charlotte corridor increases from an existing level of 96 mG to a projected level of 139 mG; the Charlotte to Queen City Pole 51 corridor increases from an existing level of 75 mG to a projected level of 139 mG; the Queen City Pole 51 to Pole 58 decreases slightly from an existing level of 176 mG to a projected level of 171 mG; the Queen City Pole 58 to Pole 67 increases slightly from an existing level of 208 mG to a projected level of 228 mG; the Queen City Pole 67 to the Queen City Substation increases slightly from an existing level of 204 mG to a projected level of 213 mG. (Refer to Appendix B Table 3 Columns "Existing Power Line-ROW Edge", "Proposed Power Line-ROW Edge", and Proposed Power Line <30ft ROW-ROW Edge".)

The magnetic power frequency fields for a maximum continuous load at the edge of the ROW for both existing and proposed power lines for the West Rutland to New Haven and New Haven to Queen City Pole 51 corridors are less than the guidelines set by New York and Florida.

The existing and proposed magnetic power frequency fields for a maximum continuous load at the edge of the ROW along the Queen City Pole 51 to the Queen City Substation corridor are greater than the guideline set by Florida of 150 mG. It must be emphasized that the New York and Florida guidelines are not health-based but are used by them to maintain the status quo. The magnetic power frequency fields we have calculated for the present and proposed NRP lines, in our judgment, maintain the status quo. The highest magnetic power frequency field on the edge of the right of way is approximately 4 times less than the guideline of 833 mG set by ICNIRP. This demonstrates that the projected maximum magnetic power frequency fields for the NRP are well below the health based ICNIRP guideline.

The projected magnetic frequency fields at the edge of the right of way and in the right of way are less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, respectively.

The existing electric power frequency field maximum and at the ROW edge, and the projected electric power frequency fields at the edge of the right of way for the NRP are less than the ICNIRP guideline of 4.2 kV/m (refer to Appendix B Table 4 Columns "Existing Power Line-ROW Edge", "Proposed Power Line-ROW Edge", and Proposed Power Line <30ft ROW-ROW Edge"). This demonstrates that the existing and projected maximum electric power frequency fields along the right of way for the NRP are well below the health based ICNIRP guideline.

The projected maximum electric power frequency field directly under the power line in the West Rutland to Middlebury corridor is 6.68 kV/m, and in the Middlebury to New Haven corridor is 6.81 kV/m (refer to Appendix B, Table 4, Column "Proposed Power Line-Maximum"). These electric power frequency fields are greater than the ICNIRP guideline of 4.2 kV/m, but are less than the New York guideline of 7 kV/m for highway crossings directly under power lines. Based on the orthophotos provided by VELCO there are only three residences near the proposed power line along these corridors and they are at sufficient distance such that the proposed electric power frequency fields will be less than 4.2 kV/m. This demonstrates that the projected maximum electric power frequency fields for known residences near or in the right of way for the NRP are well below the health based ICNIRP guideline**.**

The projected maximum electric power frequency fields directly under the power line from New Haven to the Queen City Substation are approximately 1 ½ times less than the ICNIRP guideline of 4.2 kV/m (refer to Appendix B, Table 4, Column "Proposed Power Line-Maximum" and "Proposed Power Line <30 ft ROW – Maximum"). This demonstrates that the projected maximum electric power frequency fields in the right of way for the NRP are well below the health based ICNIRP guideline.

The Vermont Department of Health:

1) Concludes that the data in the current body of literature is insufficient to establish a direct cause and effect relationship between EMF exposure and adverse health effects;

2) Concludes that the average and maximum electric and magnetic power frequency field strength for the proposed NRP does not appear to be a public health hazard based on a review of the literature and on calculations with existing and proposed electric current loads; and

3) Concludes that Vermont should continue to follow the policy of prudent avoidance outlined in the Vermont Twenty Year Electric Plan (1994) in order to mitigate EMF exposures.

The Vermont Department of Health concludes that there are no compelling health concerns or reasons requiring modification to the NRP.

CURRENT SCIENTIFIC VIEW OF HUMAN HEALTH EFFECTS RELATED TO ELECTRIC AND MAGNETIC POWER FREQUENCY FIELDS

Electric and magnetic power frequency fields ("EMF") refer to those fields produced by 60 hertz power lines in this paper. EMFs are produced by the earth, static electricity, lightning, and man-made devices. The static magnetic field around the earth is around 500 mG and is produced by electric currents flowing in the earth's core. These static magnetic fields do not induce currents in stationary objects. However, currents may be induced in moving and rotating objects.

EMFs are also produced by high voltage transmission lines, distribution lines, wiring in buildings, and many commonly used appliances. Magnetic power frequency fields close to electrical appliances are often much stronger than those from other sources, including power lines. Exposures vary widely from clothes washers (up to 3 mG at 4 inches) to can openers (up to 4000 mG at 4 inches) [30].

Currently, there are no federal standards for occupational and residential exposure to EMF, nor standards or guidelines limiting EMF fields for appliance manufacturers at this time. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) established guidelines for exposure of the public to magnetic and electric power frequency fields of 833 milligauss (mG) and 4.2 kilovolts per meter (kV/m), respectively [11]. The Institute of Electrical and Electronics Engineers' (IEEE) magnetic power frequency field guideline for exposure to the public is 9,040 mG [14]. New York has established guidelines for a 345 kV power line of 200 mG and 1.6 kV at the edge of the right-of-way when the power line is operating at its highest continuous current rating. Florida has established guidelines for power lines less than 230 kV of 150 mG and 2.0 kV at the edge of the right-of-way when the power line is operating at its highest continuous current rating. The New York and Florida guidelines are designed so that the maximum electric and magnetic power frequency fields will not exceed those fields produced by power lines now in operation. Their guidelines are not based on health effects. Germany (1997) adopted a national rule on EMF exposure for the general public limiting the electric power frequency field to 5 kV/m and the magnetic power frequency field to 1000 mG. These fields are unlikely to be encountered in daily life. Typical magnetic power frequency fields in the home average 0.6 mG [24] and range from 0.1 to 4 mG [30] over a period of a day. Average electric power frequency fields in the home range from 0 to 0.01 kV/m [21].

The relationship between EMF and health effects has been studied extensively since the late 1970's when there appeared to be a weak association between increased rates of childhood leukemia and proximity to transmission lines [19].

Current research is qualitatively superior to those early studies, though a uniform exposure metric has not been determined because there is no biological data that can be attributed to a specific measure of the magnetic power frequency field (e.g., time-averaged mG, cumulative mG, peak mG, time spent in a field above a certain strength).

The criteria scientists use to evaluate laboratory and epidemiologic studies of EMF and health effects are [19, 24]:

1) How strong is the association between EMF and a health effect? A strong association is defined as one with a relative risk (RR) of equal to or greater than 5 (e.g. smoking RR = 10 to 30). A relative risk of less than 3 is a weak association. An RR of less than 1.5 is essentially meaningless unless it is supported by other data. The RR for most electric and magnetic power frequency fields is less than 2, and is therefore classified as a weak association (the RR's have not increased as the quality of the studies has increased).
2) How consistent are the studies of associations between exposure to EMF and a health effect? Studies show decreases, no increases and some increases in the incidence of some types of cancers and some types of exposure metrics. Many studies are

internally inconsistent (e.g. there is a positive association with calculated retrospective fields and negative association with measured EMFs).

3) Is there a dose response relationship between EMF and health effects? There are no published studies indicating a dose relationship between measured EMFs and cancer rates. The lack of a clear relationship between an exposure metric and increased health effect incidence is a major reason scientists are skeptical about the significance of much of the EMF epidemiology. Meta-analyses (combination of many epidemiological studies to attempt to calculate a summary risk estimate) have shown that there is a lack of adequate exposure information and clear dose response patterns to conclusively state that EMF causes cancer.
4) Is there laboratory evidence of an association between EMF and health effects? There is little evidence of the effect of EMF on cells, tissues or animals that point toward their being a cause of cancer. Existing laboratory studies have not yet been able to establish a biological mechanism for how EMF may cause cancer. There is evidence that normal daily exposure to EMF is not carcinogenic.
5) Are there plausible biological mechanisms suggesting an association between exposure to EMF and health effects? Laboratory studies do not suggest an association between EMF and cancer. However, biological effects have been observed and reproduced in experiments using very high magnetic power frequency fields above 5,000 mG. Convincing evidence for EMF causing health effects is only available for magnetic field densities greater than approximately 1,000 mG [22].

Validation of studies of positive associations between EMF and health effects suffer from: 1) no attempt to replicate single positive studies; 2) lack of publication of studies; 3) replication of a positive study failed; 4) variation in exposure metrics and the lack of adequate detail to make an attempt at replication impossible to reproduce; and 5) the use of a wide variety of biological systems, endpoints, and exposure conditions [19].

The energy of the electric and magnetic power frequency fields from high voltage power lines (60 Hz) is insufficient to damage DNA (genetic material) in cells directly and to cause thermal effects in biological systems [18, 19]. Electrical currents generated in the human body by changes in an electric and magnetic power frequency field of less than 1 kV/m or 500 mG (AC current in the power lines) are much smaller than those produced naturally by the brain, nerves and heart [19, 24]. Electric power frequency fields may produce biological effects without damaging DNA by exerting forces on charged and uncharged molecules or cellular structures, however, the field strength applied to the biological system in order to produce these effects generally far exceeds those in typical environmental exposure conditions [19]. Magnetic power frequency fields can exert forces on cellular structures, but since biological materials are mostly nonmagnetic these forces are usually very weak [19].

Most evidence suggests that there is no consistent evidence that EMFs are genotoxins (agents capable of initiating damage to DNA), nor epigenetic agents (agents contributing to development of cancer or promoters) [19]. There are several factors that result in false associations between EMF and health effects in some studies: 1) inappropriate controls (e.g. laboratory studies were not performed under controlled conditions, difficulty of obtaining a control group identical to the exposed group); 2) inadequate dose assessment (e.g. reliability of the exposure information and what exposure metric of the EMF is involved); 3) confounders (e.g. traffic density and socioeconomic class); 4) publication bias (e.g. unrepresentative subsets of the actual study are reported, positive studies are more likely to be published); and 5) multiple comparison artifacts (e.g. studies using multiple exposure metrics and/or multiple health effect endpoints) [19]. Studies that have initially shown a positive association between EMF and health effects have not been successfully replicated in many cases.

Electric power frequency fields are sensed as mild shocks when touching a conducting material while standing directly under a high voltage power line. Electric power frequency fields, from high voltage power lines, are easily shielded by conducting objects (houses, trees, and human skin) [19]. Electric power frequency fields do not change with increasing load demand around the power lines. Many studies show that the electric power frequency fields around power lines do not affect human health [19].

The easiest method of reducing exposure to either the magnetic or electric power frequency field is by increasing your distance away from the power lines. The magnetic and electric power frequency field strength decreases as the inverse of the square of the distance. In other words, if a person moves from 2 feet to 4 feet away from a source then the field strength decreases by a factor of 4. Spending less time near the source also will decrease the cumulative exposure.

However, exposure to EMFs has not been proven to be absolutely safe due to the small proportion of studies that have shown a small increase in health effects. This increase in health effects may be restricted to very small subgroups and for those occupationally exposed to high EMF fields.

Some laboratory studies suggest that there may be "windows" for health effects, which may be observed at some frequencies and intensities but not at others. Also, it is not known if continuous exposure to or repeated entrance and exiting a given field intensity causes a biological effect. Many laboratory studies (*in vivo* and *in vitro*) test at magnetic power frequency field strengths far above that which is normally encountered in the daily environment (e.g. up to 20,000 mG [19]). Because of all this uncertainty, it is difficult to determine a "safe" distance from any magnetic power frequency field source or a "safe" exposure. At this point in time only comparisons can be made from one set of field conditions to another. For example, the average magnetic power frequency field common in households and offices (primarily from the wiring and outside power lines) is 0.6 mG [24] varying from 0.1 to 4 mG [30]. Average electric power frequency fields in the home range from 0 to 0.01 kV/m [21].

There are no known definitive studies indicating that EMFs cause adverse health effects. However, with advances in science and technology, it could be possible that EMFs may in the future be shown to cause health concerns. Related issues that are brought up are: 1) what type of scientific studies should be done, and 2) what priority should these studies should be given.

Based on the current level of science and technology for electric and magnetic power frequency fields projected from the NRP, adverse health effects are not an issue. A new project with higher voltage power lines, the addition of power lines in the same corridor, or new technologies would require the reanalysis of the health effects from the power lines.

Excerpts from a number of scientific reviews of the literature and research on electrical and magnetic power frequency fields from the national, state and international levels, upon which we relied in the development of this position paper regarding electrical and magnetic power frequency fields and the NRP, are listed below. Most scientific reviews conclude that there is insufficient evidence to prove that EMFs from high voltage power lines cause human health effects, though some show a very weak association.

National Agencies

Institute of Electrical and Electronics Engineers (IEEE), Committee on Man and Radiation (COMAR) (2002) [14]:

"Protection is to be afforded to individuals in the general population by limiting maximum permissible exposure (MPD) to magnetic field levels of 9,040 mG at 60-Hz power-line frequencies."

American Cancer Society (ACS) (2002) [1]:

"There is conflicting evidence about electromagnetic field (EMF) exposure (such as that occurring near very high-voltage power lines) as a potential risk factor for developing leukemia. The NCI [National Cancer Institute] has several large studies going on now to look into this question. Most studies published so far suggest either no increased risk or a very slightly increase risk. Clearly, most cases of leukemia are not related to EMF exposure."

American Conference of Governmental Industrial Hygienists (ACGIH) (2002)[2]:

"It is recommended that lacking specific information on electromagnetic interference from the manufacturer, the exposure of persons wearing cardiac pacemakers or similar medical electronic devices be maintained at or below 1,000 mG at power-line frequencies (60 Hz)."

Institute of Electrical and Electronics Engineers (IEEE), Committee on Man and Radiation (COMAR) (2000) [15]:

"After examination of relevant research reports published during the last ten years, COMAR [Committee on Man and Radiation] concludes that it is highly unlikely that health problems can be associated with average 24-hour field exposure to power frequency magnetic fields of less than 1 microT (10 mG)."

National Institute of Environmental Health Sciences (NIEHS) (1999)[22] :

"The scientific evidence suggesting that ELF-EMF [Extremely Low Frequency Electric and Magnetic Fields] exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies although sporadic findings of biological effects (including increased cancers in animals) have been reported. No indication of increased leukemias in experimental animals has been observed….

The NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposure. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern."

"The association between exposure to magnetic fields and a variety of other cancers has also been considered in occupational settings. Included are brain cancers, breast cancers (in both males and females), testicular cancers, cancers in offspring of workers, lymphoma, multiple myeloma, melanoma, non-Hodgkin's lymphoma, thyroid cancers and many other. Some evidence exists for an association between brain cancers and exposure to ELF-EMF and between female breast cancers and ELF-EMF exposure; however, the studies evaluating these associations are inconsistent and have limits to their interpretation making them inadequate for supporting or refuting an effect. In the remaining cases, the evidence supporting an association is negative or too weak to warrant concern**….**

Limited data are available on risks of male and female breast cancer associated with residential exposure to ELF-EMF. A small, non-significant association between use of electric blankets and the risk for breast cancer was observed in one, large U.S. study but not in another. Both found no evidence for an association with duration of exposure. Three studies, using exposure measured by calculated fields, identified an association between exposure to magnetic fields and the risk of breast cancer. These same scientists also looked at exposure to ELF-EMF and cancers of the central nervous system (such as brain cancers); no associations were found."

"The association between occupational exposure to ELF-EMF (Extremely Low Frequency – Electromagnetic Fields) and Alzheimer's disease was considered in five studies**.** All five studies showed increases in one or more exposure groups with four studies showing statistically significant increase and one showing non-statistically significant increases. All of these studies suffer from design limitations that make it inappropriate to use them for addressing a causal association between ELF-EMF exposure and Alzheimer's disease**.** Two of these are based on diagnoses from death certificates (Alzheimer's disease is not consistently noted on death certificates). Two studies used different groups of cases and controls; some of the control groups included persons with other types of dementia, and proxy information was used to define the exposure of cases. The one remaining study was evaluated using data for twins and also suffered many limitations. These data are inadequate for interpreting the possibility of an association.

The association between exposure to magnetic fields and amyotrophic lateral sclerosis was assessed in three studies**.** One study showed an increase risk in the highest exposure group and the other two studies were negative**.** Adequate adjustment could not be made for known risk factors (electric shocks or a family history of amyotrophic lateral sclerosis) making these studies difficult to interpret**…"**

"Two occupational studies assessed possible adverse cardiovascular outcomes that may result from exposure to magnetic fields. In the first study, a significant decrease in risk using a broadly defined cardiovascular grouping was observed. In the second, data from five utilities were examined. This study was motivated ***a priori*** by a biological hypothesis based on the results of human clinical studies on heart rate variability for increase numbers of deaths due to arrhythmia and acute myocardial infarct**.** Significant exposure-dependent associations were reported. Lacking additional epidemiological studies to collaborate these results, these data are inconclusive regarding an association between cardiovascular disease and exposure to ELF-EMF."

"The NIEHS suggests that the level and strength of evidence supporting ELF-EMF exposure as a human health hazard are insufficient to warrant aggressive regulatory actions; thus, we do not recommend actions such as stringent standards on electric appliances and a national program to bury all transmission and distribution lines. Instead, the evidence suggests passive measures such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. NIEHS suggests that the power industry continue its current practice of siting power lines to reduce exposure and continue to explore ways to reduce the creation of magnetic fields around transmission and distribution lines without creating new hazards. We also encourage technologies that lower exposure from neighborhood distribution lines provided that they do not increase other risks, such as those from accidental electrocution or fire….

In summary, the NIEHS believes that there is weak evidence for possible health effects from ELF-EMF exposures, and until stronger evidence changes this opinion, inexpensive and safe reduction in exposure should be encouraged."

U. S. National Academy of Science (NAS) (1996) [28]:

"Based on a comprehensive evaluation of published studies relating to the effects of power-frequency electric and magnetic fields on cells, tissues, and organisms (including humans), the conclusion of the committee is that the current body of evidence does not show that exposure to these fields presents a human-health hazard. Specifically, no conclusive and consistent evidence shows that exposure to residential electric and magnetic fields produce cancer, adverse neurobehavioral effects, or reproductive and developmental effects."

Oak Ridge Associated Universities (ORAU)
Panel for the Committee on Interagency Radiation Research and Policy Coordination (CIRRPC)
Health Effects of Low-Frequency Electric and Magnetic Fields (1992) [31]:

"This review indicates that there is no convincing evidence in the published literature to support the contention that exposures to extremely low-frequency electric and magnetic fields (ELF-EMF) generated by sources such as household appliances, video display terminals, and local power lines are demonstrable health hazards. Epidemiologic findings of an association between electric and magnetic fields and childhood leukemia or other childhood or adult cancers are inconsistent and inconclusive. No plausible biological mechanism is presented that would explain causality. Neither is there conclusive evidence that these fields initiate cancer, promote cancer or influence tumor progression. Likewise, there is no convincing evidence to support suggestions that electric and magnetic fields result in birth defects or other reproductive problems. Furthermore, any neurobehavioral effects are likely to be temporary and do not appear to have health consequences."

U.S. Environmental Protection Agency (EPA)

Evaluation of the Potential Carcinogenicity of Electromagnetic Fields, External Review Draft, October 1990 [34]:

"In evaluating the potential for carcinogenicity of chemical agents, the U.S. EPA has developed an approach that attempts to integrate all of the available information into a summary classification of the weight of evidence that the agent is carcinogenic in humans. At this time, such a characterization regarding the link between cancer and exposure to EMF fields is not appropriate because the basic nature of the interaction between EM fields and biological processes leading to cancer is not understood. … With our current understanding, we can identify 60 Hz magnetic fields from power lines and perhaps other sources in the home as a possible, but not proven, cause of cancer in humans."

International Agencies

International Agency for Research on Cancer (IARC) (2002) [9]:

"The association between childhood leukaemia and high levels of magnetic fields is unlikely to be due to chance, but it may be affected by bias. In particular, selection bias may account for part of the association."

"…there is limited evidence in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to childhood leukaemia. There is inadequate evidence in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to all other cancers."

International Agency for Research on Cancer (IARC) (2001) [10]:

"In June 2001, an expert scientific working group of IARC reviewed studies related to the carcinogenicity of static and ELF electric and magnetic fields. Using the standard IARC classification that weighs human, animal and laboratory evidence, ELF magnetic fields were classified as possibly carcinogenic to humans based on epidemiological studies of childhood leukaemia. Evidence for all other cancers in children and adults, as well as other types of exposures (i.e. static fields and ELF electric fields) was considered not classifiable either due to insufficient or inconsistent scientific information.

'Possibly carcinogenic to humans' is a classification used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals.

This classification is the weakest of three categories ('is carcinogenic to humans', 'probably carcinogenic to humans' and 'possibly carcinogenic to humans') used by IARC to classify potential carcinogens based on published scientific evidence."

"Group 2B: The agent (mixture) is possibly carcinogenic to humans.
The exposure circumstance entails exposures that are possibly carcinogenic to humans.
This category is used for agents, mixtures and exposure circumstances for which there is *limited evidence* of carcinogenicity in humans and less than *sufficient evidence* of carcinogenicity in experimental animals. It may also be used when there is *inadequate evidence* of carcinogenicity in humans but there is *sufficient evidence* of carcinogenicity in experimental animals. In some instances, an agent, mixture or exposure circumstance for which there is *inadequate evidence* of carcinogenicity in humans but *limited evidence* of carcinogenicity in experimental animals together with supporting evidence from other relevant data may be placed in this group."

*Please note the IARC lists 236 different materials classified as "possible carcinogens". Also included are coffee, pickled vegetables, gasoline engine exhaust, welding fumes, and chloroform.

World Health Organization (WHO Fact Sheet 263, 2001) [39]:

"It is especially difficult to suggest protective measures for ELF fields because we do not know what field characteristic might be involved in the development of childhood leukaemia and therefore need to be reduced, or even if it is the ELF magnetic fields that are responsible for this effect. One approach is to have voluntary policies that aim to cost-effectively reduce exposure to ELF fields."

International Commission on Non-Ionizing Radiation Protection (ICNIRP) (2001) [12]:

"In the absence of evidence from cellular or animal studies, and given the methodological uncertainties and in many cases inconsistencies of the existing epidemiologic literature, there is no chronic disease outcome for which an etiological relation to EMF exposure can be regarded as established."

U.K. National Radiation Protection Board (NRPB) (2001) [27]:

"Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiologic evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. … In the absence of clear evidence of a carcinogenic effect in adults, or of plausible explanation from experiments on animals or isolated cells, the epidemiological evidence is currently not strong enough to justify a firm conclusion that such fields cause leukaemia in children. Unless however, further research indicates that the finding is due to chance or some currently unrecognized artifact, the possibility remains that intense and prolonged exposures to magnetic fields can increase the risk of leukaemia in children."

World Health Organization (WHO Fact Sheet 205, 1998) [38]:

"Consultation with local authorities and the public in siting new power lines: Obviously power lines must be sited to provide power to consumers. Despite the fact that ELF field levels around transmission and distribution lines are not considered a health risk, siting decisions are often required to take into account aesthetics and public sensibilities. Open communication and discussion between the electric power utility and the public during the planning stages can help create public understanding and greater acceptance of a new facility."

State Agencies

Minnesota Department of Health (2002) [18]:

"The Minnesota Department of Health concludes that the current body of evidence is insufficient to establish a cause and effect relationship between EMF and adverse health effects. However, as with many other environmental health issues, the possibility of a health risk from EMF cannot be dismissed. Construction of new generation and transmission facilities to meet increasing electrical needs in the State is likely to increase public exposure to EMF. Based on these considerations, the Work Group considers it prudent public health policy to take a prudent avoidance approach to mitigating EMF exposures."

Florida Department of Environmental Protection (2001) [6]:

"We seem to be approaching a time when some aspects of EMF exposure may be deemed a slight risk, but we are still lacking knowledge of EMF impact mechanisms and adequate scientific proof to allow a valid estimate of risk to the public and the knowledge to set a regulatory standard to manage the risk."

California Department of Health Services (draft 2001) [3]:

"To one degree or another all three of the DHS scientists are inclined to believe that EMFs can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage. They strongly believe that EMFs do not increase the risk of birth defects, or low birth weight. They strongly believe that EMFs are not universal carcinogens, since there are a number of cancer types that are not associated with EMF exposure. To one degree or another they are inclined to believe that EMFs do not cause an increased risk of breast cancer heart disease, Alzheimer's Disease, depression, or symptoms attributed by some to a sensitivity to EMFs. However, all three scientists had judgments that were close to the dividing line between believing and not believing that EMFs cause some degree of increased risk of suicide, or for adult leukemia, two of the scientists are close to the dividing line between believing or not believing and one was prone to believe that EMFs cause some degree of increased risk."

Virginia Department of Health (2000) [37]:

"Based on the review and analysis of the exhaustive literature review and other research projects completed under the EMF-RAPID program, the Virginia Department of Health is of the opinion that there is no conclusive and convincing evidence that exposure to extremely low frequency EMF emanated from nearby high voltage transmission lines is causally associated with an increased incidence of cancer or other detrimental health effects in humans."

Connecticut Department of Environmental Protection and Department of Health Services (1994) [5]:

"No definitive cause and effect relationship between exposure to EMF and an increase in health risk has been established."

Maryland Department of Natural Resources (1994) [17]:

"It is impossible to predict effects (or lack of effects) with any certainty, and it is not clear which biological effects observed in cellular or animal studies (if any) could have significant human health implications. … There is no definitive indication that EMF exposure does or does not cause adverse health effects."

Oregon Department of Energy (1993) [32]:

"Some early epidemiological studies have suggested an association between EMF exposure and increased risk for diseases such as leukemia in children, brain cancer, male breast cancer, lymphoma, miscarriages and birth defects. However, research to date has not shown that EMF exposure causes these diseases."

Texas Public Utility Commission
Health Effects of Exposure to Power-Frequency Electric and Magnetic Fields (1992) [33]:

"The Committee believes that, based on its evaluation of the existing EMF research, the evidence at this time is insufficient to conclude that exposure to EMF from electric power transmission lines poses an imminent or significant public health risk. … The Committee concludes that at present there is insufficient evidence regarding human health effects of EMF to provide the basis for a health-based standard."

Illinois Department of Public Health and Environmental Protection Agency
Possible Health Effects of Extremely Low Frequency Electric and Magnetic Field Exposure: A Review (1992) [8]:

"Whether these observed ELF bioeffects cause adverse health effects in humans and animals is not yet clear. No scientific consensus has been reached on this issue. Without sufficient information, health risks from exposure to these fields cannot be properly determined. … Because some studies have identified positive associations between ELF field exposure and certain adverse health effects, while other studies have not, the data obtained to date are far from conclusive."

GUIDELINES FROM SAFETY ORGANIZATIONS

International Commission on Non-Ionizing Radiation Protection (ICNIRP) (60 Hz General Public, 1998) [11]:

Magnetic Power Frequency Field:	833 mG
Electric Power Frequency Field:	4.2 kV/m

"Induction of cancer from long-term EMF exposure was not considered to be established, and so these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EMF."

Institute of Electrical and Electronics Engineers (IEEE) (Standard C95.6 General Public)[14]:

Magnetic Power Frequency Field: 9040 mG

Electric Power Frequency Field: 5.0 kV/m

World Health Organization (WHO Fact Sheet N182, 1998) [40]:

"Safety Standards: In order to ensure that human exposure to EMF should not have adverse health effects, that man-made EMF generating devices are safe and their use does not electrically interfere with other devices, various international guidelines and standards are adopted. Such standards are developed following reviews of all the scientific literature by groups of scientists who look for evidence of consistently reproduced effects with adverse health consequences. These groups then recommend guidelines for standards for action by the appropriate national and international bodies. A non-governmental organization, formally recognised by WHO in the field of NIR [non-ionizing radiation] protection, is the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP has established international guidelines on human exposure limits for all electromagnetic fields, including ultraviolet (UV) radiation, visible light and infrared radiation, as well as RF fields and microwaves… Even high intensity NIR cannot cause ionization in the biological system. NIR, however, have been shown to produce other biological effects, for instance, by heating, altering normal chemical reactions or inducing electrical currents in tissues."

STATE GUIDELINES

Please note that the bolded text in this section was added for ease of reference.

New York (2002) [30]:

"The Public Service Commission requires that new high voltage transmission lines in New York be designed so that the maximum magnetic fields at the edge of the right-of-way will not exceed the maximum magnetic field levels produced by the average of **345 kV** lines now in operation. This interim magnetic field standard of **200 milligauss at one meter above the ground at the edge of the right-of-way** applies when the line is operating at its highest continuous current rating. This happens infrequently. Routine operations create lower fields.

An interim electric field standard limits new high voltage transmission lines to **1.6 kilovolts per meter (kV/m) at the edge of the right-of-way**."

The maximum electric field allowed on the right of way is 11.8 kV/m. The maximum electric field for private road crossings is 11.0 kV/m. The maximum electric field for **highway crossings is 7.0 kV/m** [24].

Florida 62-814.450 (2001) [6]:

"(3) New transmission lines and substations.

(a) The maximum electric field **at the edge of the transmission line ROW** or at the property boundary of a new substation shall not exceed **2.00 kV/m**.

(b) The maximum electric field on the ROW of a 230 kV or smaller transmission line shall not exceed 8 kV/m.

(c) The maximum electric field on the ROW of a 500 kV transmission line shall not exceed 10 kV/m.

(d) The **maximum magnetic field at the edge of a 230 kV or smaller** transmission line ROW or at the property boundary of a new substation serving such lines **shall not exceed 150 milliGauss.**

(e) The **maximum magnetic field at the edge of the transmission line ROW for a 500 kV line** or at the property boundary of a new substation serving a 500 kV line **shall not exceed 200 milliGauss**, except for double circuit 500 kV lines to be constructed on ROWs existing on March 21, 1989, as identified below where the limit will be 250 milliGauss."

California (1999) [4]:

"The California Department of Education enacted regulations that require minimum distances between a new school and the edge of a transmission "right-of-way," or the area immediately surrounding lines that utility companies need to access the lines for maintenance and repairs. The setback distances are 100 feet for 50-133 kV lines, 150 feet for 220-230 kV lines, and 350 feet for 500-550 kV lines. These distances were not based on specific biological evidence, but on the known fact that the strength of electric fields from powerlines drops to near background levels at the specified distances, given that no there major sources are present."

WILL THE PROJECTED ELECTRIC AND MAGNETIC POWER FREQUENCY FIELDS INCREASE, DECREASE OR STAY THE SAME WITH THE NRP?

The VDH performed many calculations using an EXCEL format of the Bonneville Power Authority program provided by VELCO to derive existing and projected estimates of the electric and magnetic power frequency fields. Data was provided by VELCO and is listed in Appendix A. Data required for the calculations (Appendix A) include: 1) continuous load ratings, 2) distance of the power line from the center of the right of way (ROW), 3) sag height of the power line, 4) number of conductors, 5) diameter of the conductor, 6) bundle diameter, 7) line to ground voltage, 8) phase angle, 9) existing and proposed average loading, and 10) existing and proposed maximum loading. The calculations use the maximum power line kV, maximum sag (minimum height above the ground) and maximum line to ground voltage. The transmission line is modeled as a horizontal line at the actual or estimated sag height. The estimated existing and projected results are maximum possible values for the magnetic and electric power frequency fields. The results of these calculations are very conservative estimates and are not “real” or measured fields.

The right of way (“ROW”) from West Rutland to New Haven is either 250 or 350 feet. Calculations were performed using the 250-foot ROW.

The ROW from New Haven to Vergennes is either 100 or 150 feet. Calculations were performed using the 100-foot ROW.

The ROW from Vergennes to Queen City is along the railroad (20 feet) to 100 feet. Calculations were performed using a 20-foot ROW. Houses are located close to the proposed power line along this corridor.

ELECTRIC AND MAGNETIC POWER FREQUENCY FIELDS AT AVERAGE LOADING AT THE EDGE OF THE RIGHT OF WAY (APPENDIX B, TABLES 2 & 4)

Along the West Rutland to Florence corridor the magnetic power frequency field is projected to decrease from an annual average of **8.2** mG to **3.3** mG in the first year after installation of the NRP at the edge of the ROW at average loading. Over time the magnetic power frequency field is projected to increase slowly due to increasing load demand to **4.5** mG in

2012. This is approximately 2 times less than the projected magnetic power frequency field of **13** mG if the existing line continues to be used through 2012. The electric power frequency field is projected to increase from 0.20 kV/m in 2003 to 0.83 kV/m in 2006 and will not change as the current changes nor with time.

Along the Florence to Middlebury corridor the magnetic power frequency field is projected to decrease from an annual average of **6.1** mG to **3.7** mG in the first year after installation of the NRP at the edge of the ROW at average loading. Over time the magnetic power frequency field is projected to increase slowly due to increasing load demand to **5** mG in 2012. This is approximately 2 times less than the projected magnetic power frequency field of **10** mG if the existing line continues to be used through 2012. The electric power frequency field is projected to increase from 0.20 kV/m in 2003 to 0.83 kV/m in 2006 and will not change as the current changes nor with time.

Along the Middlebury to New Haven corridor the magnetic power frequency field is projected to remain the same at an annual average of **3.4** mG in the first year after installation of the NRP at the edge of the ROW at average loading. Over time the magnetic power frequency field is projected to increase slowly due to increasing load demand to **4.9** mG in 2012. This is less than the projected magnetic power frequency field of **7** mG if the existing lines continue to be used up through 2012. The electric power frequency field is projected to increase from 0.21 kV/m in 2003 to 0.83 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the New Haven to Vergennes corridor is projected to increase with the NRP along the ROW for average loading from **3** mG to **4.3** mG in 2006 and **6** mG in 2012. The proposed replacement of the 46 kV power line by a 115 kV power line will allow more current to flow therefore, increasing the magnetic power frequency field. The electric power frequency field is projected to increase from 0.07 kV/m in 2003 to 0.24 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the Vergennes to North Ferrisburg corridor is projected to increase with the NRP along the ROW for average loading from **11** mG to **14** mG in

2006 and **20** mG in 2012. It is projected that a very similar increase will occur if the existing lines are used up through 2012 (**18** mG). The proposed replacement of the 34.5 kV power line from Vergennes to Queen City by a 115 kV power line will allow more current to flow through it increasing the magnetic power frequency field. The electric power frequency field is projected to increase from 0.29 kV/m in 2003 to 1.15 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the North Ferrisburg to Charlotte corridor is projected to increase with the NRP along the ROW for average loading from **6.1** mG to **13** mG in 2006 and **19** mG in 2012. It is projected that if the existing 34.5 kV power line continues to be used the magnetic power frequency field will be **12** mG in 2012. The electric power frequency field is projected to increase from 0.29 kV/m in 2003 to 1.15 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the Charlotte to Shelburne corridor is projected to increase with the NRP along the ROW for average loading from **1.9** mG to **10** mG in 2006 and **16** mG in 2012. It is projected that if the existing 34.5 kV power line continues to be used the magnetic power frequency field will remain the same in 2012 (**1.8** mG). The proposed replacement of the 34.5 kV power line from Vergennes to Queen City by a 115 kV power line will allow more current to flow through increasing the magnetic power frequency field. The electric power frequency field is projected to increase from 0.28 kV/m in 2003 to 1.15 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the Shelburne to Queen City-Pole 51 corridor is projected to decrease with the NRP along the ROW for average loading from **14** mG to **7.1** mG in 2006 and increase to **12** mG in 2012. It is projected the magnetic power frequency field will be higher if the existing 34.5 kV power line continues to be used up through 2012 (**16** mG). The electric power frequency field is projected to increase from 0.28 kV/min in 2003 to 1.15 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the Queen City-Pole 51 to Pole 58 corridor is projected to decrease with the NRP along the ROW for average loading from **45** mG to **32** mG in 2006 and increase to **39** mG in 2012. It is projected the magnetic power frequency field will be higher if the existing 34.5 kV power line continues to be used up through 2012 (**62** mG). The electric power frequency field is projected to increase from 2.05 kV/min in 2003 to 2.63 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the Queen City-Pole 58 to Pole 67 corridor is projected to decrease with the NRP along the ROW for average loading from **38** mG to **28** mG in 2006 and increase to **33** mG in 2012. It is projected the magnetic power frequency field will be higher if the existing 34.5 kV power line continues to be used up through 2012 (**54** mG). The electric power frequency field is projected to increase from 1.17 kV/min in 2003 to 1.77 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency field along the Queen City-Pole 67 to the Queen City Substation corridor is projected to decrease with the NRP along the ROW for average loading from **37** mG to **28** mG in 2006 and increase to **32** mG in 2012. It is projected the magnetic power frequency field will be higher if the existing 34.5 kV power line continues to be used up through 2012 (**53** mG). The electric power frequency field is projected to increase from 1.16 kV/min in 2003 to 1.25 kV/m in 2006 and will not change as the current changes nor with time.

The magnetic power frequency fields at the edge of the right of way for average loading with the NRP are expected to be on the order of 20 to 200 times less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, respectively. The electric power frequency fields at the edge of the right of way for average loading with the NRP are expected to be approximately 1.5 to 15 times less than the ICNIRP guideline of 4.2 kV/m.

MAGNETIC POWER FREQUENCY FIELDS AT AVERAGE LOADING DIRECTLY UNDER THE POWER LINES (APPENDIX B, TABLES 1 & 4)

The magnetic power frequency field along the West Rutland to Florence corridor is projected to decrease with the NRP from an annual average of **56** mG to **31** mG in the first year after installation for average loading directly under the power lines. Over time it will increase slowly due to increasing load demand to **41** mG in 2012. This is approximately ½ of the projected magnetic power frequency field of **89** mG if the existing line continues to be used up through 2012.

The magnetic power frequency field along the Florence to Middlebury corridor is projected to decrease with the NRP from an annual average of **42** mG to **28** mG in the first year after installation for average loading directly under the power lines. Over time it will increase slowly due to increasing load demand to **37** mG in 2012. This is approximately ½ of the projected magnetic power frequency field of **71** mG if the existing line continues to be used up through 2012.

The magnetic power frequency field along the Middlebury to New Haven corridor is expected to increase with the NRP from an annual average of **19** mG to **29** mG in the first year after installation for average loading directly under the power lines. Over time it will increase slowly due to increasing load demand to **38** mG in 2012. It is projected the magnetic power frequency field will be **39** mG if the existing power line continues to be used up through 2012, and is at approximately the same projected level of magnetic power frequency field for the West Rutland to Florence and Florence to Middlebury corridors (37 mG to 41 mG).

The magnetic power frequency field along the New Haven to Vergennes corridor is projected to increase with the NRP from **10** mG to **18** mG in 2006 and to **25** mG in 2012 for average loading directly under the power lines. The proposed replacement of the 46 kV power line by a 115 kV power line will allow more current to flow through and therefore increase the magnetic power frequency field.

The magnetic power frequency field along the Vergennes to North Ferrisburg corridor is projected to increase with the NRP from **14** mG to **15** mG in 2006 and to **22** mG in 2012 for average loading directly under the power lines. A very similar increase is projected for the existing line if it continues to be used up through 2012 (**23** mG).

The magnetic power frequency field along the North Ferrisburg to Charlotte corridor is projected to increase with the NRP from **7.6** mG to **14** mG in 2006 and to **20** mG in 2012 for average loading directly under the power lines. It is projected that if the existing 34.5 kV power line continues to be used the magnetic power frequency field will be **15** mG in 2012. The proposed replacement of the 34.5 kV power line by a 115 kV power line will allow more current to flow through and therefore increase the magnetic power frequency field.

The magnetic power frequency field along the Charlotte to Shelburne corridor is projected to increase with the NRP from **2.4** mG to **11** mG in 2006 and to **17** mG in 2012 for average loading directly under the power lines. It is projected that if the existing 34.5 kV power line continues to be used the magnetic power frequency field will remain the same in 2012 (**2.2** mG). The proposed replacement of the 34.5 kV power line by a 115 kV power line will allow more current to flow through and therefore increase the magnetic power frequency field.

The magnetic power frequency field along the Shelburne to Queen City-Pole 51 corridor is projected to decrease with the NRP from **18** mG to **7.7** mG in 2006 and increase to **13** mG in 2012 for average loading directly under the power lines. It is projected the magnetic power frequency field will increase if the existing 34.5 kV power line continues to be used up through 2012 (**19** mG).

The magnetic power frequency field along the Queen City-Pole 51 to Pole 58 corridor is projected to decrease with the NRP from **45** mG to **32** mG in 2006 and increase to **39** mG in 2012 for average loading directly under the power lines. This is approximately 1.5 times less than the projected magnetic power frequency field of **62** mG if the existing line continues to be used up through 2012.

The magnetic power frequency field along the Queen City-Pole 58 to Pole 67 corridor is projected to decrease with the NRP from **40** mG to **31** mG in 2006 and increase to **35** mG in

2012 for average loading directly under the power lines. This is approximately 1.5 times less than the projected magnetic power frequency field of **57** mG if the existing line continues to be used up through 2012.

The magnetic power frequency field along the Queen City-Pole 67 to the Queen City Substation corridor is projected to decrease with the NRP from **39** mG to **30** mG in 2006 and increase to **34** mG in 2012 for average loading directly under the power lines. This is approximately 1.5 times less than the projected magnetic power frequency field of **57** mG if the existing line continues to be used up through 2012.

The magnetic power frequency fields with the NRP for average loading directly under the power lines are expected to be on the order of 20 to 200 times less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, respectively.

MAGNETIC POWER FREQUENCY FIELDS AT MAXIMUM CONTINUOUS LOADING AT THE EDGE OF THE ROW (APPENDIX B, TABLE 3)

The maximum existing and proposed magnetic power frequency fields are **31** and **76** mG, respectively for the West Rutland to New Haven 345 kV power line for maximum continuous loading a the edge of the ROW. These magnetic power frequency fields are less than New York's guideline of 200 mG for 345 kV power lines.

The maximum existing and proposed magnetic power frequency fields along the New Haven to Vergennes corridor are **12** and **36** mG, respectively for the 115 kV power line for maximum continuous loading at the edge of the ROW. The maximum existing and proposed magnetic power frequency fields along the Vergennes to Charlotte corridor are **96** and **139** mG, respectively for the 115 kV power line for maximum continuous loading at the edge of the ROW. The maximum existing and proposed magnetic power frequency fields along the Charlotte to Queen City **–** Pole 51 corridor are **75** and **139** mG, respectively for the 115 kV power line for maximum continuous loading a the edge of the ROW. These magnetic power frequency fields are less than Florida's guideline of 150 mG for power lines less than 230 kV.

The maximum existing and proposed magnetic power frequency fields along the Queen City-Pole 51 to Queen City-Pole 58 corridor are **176** mG and **171** mG, respectively, for maximum continuous loading at the edge of the ROW. The maximum existing and proposed magnetic power frequency fields along the Queen City-Pole 58 to the Queen City – Pole 67 corridor are **208** and **228** mG, respectively for maximum continuous loading at the edge of the ROW. The maximum existing and proposed magnetic power frequency fields along the Queen City-Pole 67 to the Queen City Substation corridor are **204** and **213** mG, respectively for maximum continuous loading at the edge of the ROW. These are small changes in the magnetic power frequency fields, especially when it is noted that the width of the magnetic power frequency fields are projected to decrease with the proposed replacement of the 34.5 kV with a 115 kV line at a greater height. It should also be noted that there will be two 115 kV lines paralleling each other along this corridor. The second 115 kV line is part of the Williston to Queen City corridor. Florida does not address the situation where more than one transmission line is present and these magnetic power frequency fields are greater than the guideline set by Florida of 150 mG for power lines less than 230 kV. It must be emphasized that the Florida guidelines are not health-based but are used by them to maintain the status quo. The magnetic power frequency fields we have calculated for the present and proposed NRP lines, in our judgment, maintain the status quo. The highest magnetic power frequency field on the edge of the right of way is approximately 4 times less than the ICNIRP guideline of 833 mG.

The magnetic power frequency fields at the edge of the right of way with the NRP for maximum continuous loading are expected to be approximately 4 times less than the ICNIRP (833 mG) and approximately 40 times less than the IEEE (9,040 mG) guidelines for public exposure. Florida does not address the situation where more than one transmission line is present. The existing and proposed magnetic power frequency fields along the Queen City-Pole 51 to the Queen City Substation corridor are greater than the guideline set by Florida of 150 mG for power lines less than 230 kV. It must be emphasized that the Florida guidelines are not health-based but are used by them to maintain the status

quo. The magnetic power frequency fields we have calculated for the present and proposed NRP lines, in our judgment, maintain the status quo. This demonstrates that the projected maximum magnetic power frequency fields for known residences near or in the right of way for the NRP are well below the health based ICNIRP guideline of 833 mG.

ELECTRIC POWER FREQUENCY FIELDS DIRECTLY UNDER THE POWER LINES FOR AVERAGE AND MAXIMUM CONTINUOUS LOADING (APPENDIX B, TABLES 3 & 4)

The maximum existing electric power frequency fields directly under the power lines are **1.15** kV/m and **0.89** kV/m, respectively, for the West Rutland to Middlebury and Middlebury to New Haven corridors. These electric power frequency fields are less than the ICNIRP guideline of 4.2 kV/m. The maximum proposed electric power frequency fields with the NRP directly under the power lines are **6.68** kV/m and **6.81** kV/m, respectively, for the West Rutland to Middlebury and Middlebury to New Haven corridors. These electric power frequency fields are greater than the ICNIRP guideline of 4.2 kV/m, but are less than the New York guideline of 7 kV/m for highway crossings directly under power lines. Based on the orthophotos provided by VELCO there are only three residences near the proposed power line along these corridors and they are at sufficient distance such that the proposed electric power frequency fields will be less than the ICNIRP guideline of 4.2 kV/m. This demonstrates that the projected maximum electric power frequency fields for known residences near or in the right of way for the NRP are well below the health based ICNIRP guideline**.**

The maximum existing and proposed electric power frequency fields directly under the power line along the New Haven to Vergennes corridor are **0.16** kV/m and **1.15** kV/m, respectively. The maximum existing and proposed electric power frequency fields directly under the power lines along the Vergennes to Charlotte corridor are **0.29** kV/m and **1.15** kV/m, respectively. The maximum existing and proposed electric power frequency fields directly under the power lines along the Charlotte to Queen City-Pole 51 corridor are **0.28** kV/m and **1.15** kV/m, respectively. The maximum existing and proposed electric power frequency fields directly under the power line along the Queen City-Pole 51 to Queen City-Pole 58 115 kV power line are **2.05** and **2.63** kV/m, respectively. The maximum existing and proposed electric power frequency fields directly under the power lines from Queen City-Pole 58 to the Queen City Substation are **1.17** and **1.77** kV/m, respectively. These electric power frequency fields are less than the ICNIRP guideline of 4.2 kV/m.

It should be noted that two 115 kV lines are proposed to parallel each other along the Queen City-Pole 51 to the Queen City Substation corridor. It should also be noted: 1) there are no nearby residences along this corridor; 2) the power lines operate at their highest continuous load only infrequently, and 3) the width of the electric and magnetic power frequency fields will decrease with the proposed removal of the 34.5 kV line and installation of a new 115 kV line at a greater height.

The projected electric power frequency fields directly under the power line for average or maximum continuous loading are approximately 1.5 times less than the ICNIRP guideline of 4.2 kV/m, except along the West Rutland to New Haven corridor. The proposed electric power frequency fields directly under the power line along the West Rutland to New Haven corridor are greater than the ICNIRP guideline of 4.2 kV/m, but are less than the New York guideline of 7 kV/m for highway crossings directly under power lines. Based on the orthophotos provided by VELCO there are only three residences near the proposed power line along these corridors and they are at sufficient distance such that the proposed electric power frequency fields will be less than 4.2 kV/m. This demonstrates that the projected maximum electric power frequency fields for known residences near or in the right of way for the NRP are well below the health based ICNIRP guideline.

SUMMARY

There is a projected decrease with the NRP in the magnetic power frequency field for average loading at the edge of the ROW for the West Rutland to New Haven and the Queen City-Pole 51 to Queen City Substation corridors between 2003 and 2012. There is a projected increase in the magnetic power frequency field for the New Haven to Queen City-Pole 51 corridor. The projected increase in the New Haven to Queen City-Pole 51 corridor (projected average of 14.6 mG) is between the projected average of the West Rutland to New Haven corridor (4.8 mG) and the projected average of the Queen City-Pole 51 to the Queen City Substation corridor (34.7 mG). The projected magnetic power frequency fields at the edge of the ROW are 20 and 200 times less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG, respectively, for public exposure.

There is a projected decrease with the NRP in the magnetic power frequency field for average loading directly under the power line for the West Rutland to Middlebury and the Queen City-Pole 51 to Queen City Substation corridors between 2003 and 2012. There is a projected increase in the magnetic power frequency field for the Middlebury to New Haven and New Haven to Queen City-Pole 51 corridors. The projected increases in the Middlebury to New Haven and New Haven to Queen City-Pole 51 corridor (projected averages of 38 mG and 19.4 mG) are less than the projected average of the West Rutland to Middlebury corridor (39 mG). The projected magnetic power frequency fields for average loading directly under the power lines are on the order of 20 to 200 times less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, respectively.

There is a projected increase with the NRP in the magnetic power frequency field for maximum continuous loading at the edge of the ROW for essentially the whole West Rutland to Queen City Substation corridor. The average projected increase in the magnetic power frequency field for the West Rutland to New Haven corridor is approximately 2.5 times the existing magnetic power frequency field. The average projected increase in the magnetic power frequency field for the New Haven to Queen City Substation corridor is approximately 1.3 times the existing magnetic power frequency field. The projected magnetic power frequency fields at the edge of the right of way for maximum continuous loading are approximately 4 times less than the ICNIRP (833 mG) and approximately 40 times less than the IEEE (9,040 mG) guidelines for public exposure. Florida does not address the situation where more than one transmission line is present. The existing and projected magnetic power frequency fields along the Queen City-Pole 51 to the Queen City Substation corridor (171 to 228 mG) are greater than the guideline set by Florida of 150 mG for power lines less than 230 kV. It must be emphasized that the Florida guidelines are not health-based but are used by them to maintain the status quo. The magnetic power frequency fields we have calculated for the present and proposed NRP lines, in our judgment, maintain the status quo. This demonstrates that the projected maximum magnetic power frequency fields at the edge of the ROW for the NRP are well below the health based ICNIRP guideline of 833 mG.

There is a projected increase with the NRP in the magnetic power frequency field for maximum continuous loading directly under the power line for essentially the whole West Rutland to Queen City Substation corridor. The average projected increase in the magnetic power frequency field for the West Rutland to New Haven corridor is 3.13 times the existing magnetic power frequency field. The average projected increase in the magnetic power frequency field for the New Haven to Queen City Pole 51 corridor is 2.14 times the existing magnetic power frequency field. The average projected increase in the magnetic power frequency field for the Queen City Pole 51 to Queen City Substation corridor is 1.04 times the existing magnetic power frequency field. The highest magnetic power frequency field is approximately 600 mG along the West Rutland to New Haven corridor. Based on the orthophotos provided by VELCO there are only three residences near the proposed power line along the Rutland to New Haven corridor and they are at sufficient distance such that the proposed magnetic power frequency fields (less than 4 mG, Appendix B, Table 6) are projected to be much less than the ICNIRP guideline of 833 mG. The projected magnetic power frequency fields directly under the proposed power line for maximum continuous loading are less than the ICNIRP (833 mG) and the IEEE (9,040 mG) guidelines for public exposure.

The electric power frequency fields are projected to increase with the NRP along the entire West Rutland to Queen City Substation corridor at the edge of the ROW. The electric power frequency fields are projected to be approximately1.5 to 15 times less than the ICNIRP guideline of 4.2 kV/m at the edge of the ROW. The projected electric power frequency field at the edge of the ROW along the Queen City-Pole 51 to Pole 58 corridor exceeds the guideline set by Florida of 2 kV/m for power lines less than 230 kV. Florida does not address the situation where more than one transmission line is present. It must be emphasized that the Florida guidelines are not health-based, but are used by them to maintain the status quo. The electric power frequency fields we have calculated for the present and proposed NRP lines, in our judgment, maintain the status quo.

The projected electric power frequency fields with the NRP directly under the power line for average or maximum continuous loading are approximately 1.5 times less than the ICNIRP guideline of 4.2 kV/m, except along the West Rutland to New Haven corridor. The proposed electric power frequency fields directly under the power line along the West Rutland to New Haven corridor are greater than the ICNIRP guideline of 4.2 kV/m, but are less than the New York guideline of 7 kV/m for highway crossings directly under power lines. Based on the orthophotos provided by VELCO there are only three residences near the proposed power line along these corridors and they are at sufficient distance such that the proposed electric power frequency fields will be less than 4.2 kV/m. This demonstrates that the projected maximum electric power frequency fields for known residences near or in the right of way for the NRP are well below the health based ICNIRP guideline.

In summary, the projected magnetic power frequency fields with the NRP at the edge and in the ROW are less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, and the projected electric power frequency fields with the NRP are less than the ICNIRP guideline of 4.2 kV/m at the edge of the ROW. This demonstrates that the projected electric and magnetic power frequency fields for the NRP are well below the health based ICNIRP guidelines at the edge of the ROW.

DOES THE VELCO TESTIMONY OF PETER A.VALBERG, PH.D. CORRESPOND WITH THE CURRENT SCIENTIFIC VIEW OF HUMAN EXPOSURE TO ELECTRIC AND MAGNETIC POWER FREQUENCY FIELDS?

The testimony provided by VELCO on the NRP and the response to question 56 of “VELCO Response to First Set of Information Requests by DPS” Docket No. 6860, October 3, 2003, page 85 of 139, corresponds with the current scientific view of human exposure to EMF.

Specifics that should be mentioned:

1. The magnetic power frequency field guidelines for Florida do not cover the range of power lines between 230 and 500 kV, nor above 500 kV. The regulations simply state the maximum magnetic power frequency fields at the edges of 230 kV or smaller lines (150 mG) and 500 kV lines (200 mG), separately. For double circuit 500 kV lines and specified existing ROWs the magnetic power frequency field guideline is 250 mG. [7]
2. We used a 20-foot ROW for the Vergennes to Queen City corridor based on the width of the railway. There are many residences within 50 feet of the center of the ROW along this corridor. Projected calculations indicate there will be no adverse health effects using a 20-foot ROW for residences identified on the orthophotos provided by VELCO

POLICY OF PRUDENT AVOIDANCE

The Vermont Department of Health concludes that we should continue to employ the policy of prudent avoidance as described in the Vermont Department of Public Services's Vermont Twenty Year Electric Plan (1994). The policy of prudent avoidance is described in that document as follows:

"In developing an EMF policy, a number of considerations should be weighed. On one hand, there is no scientific consensus on magnetic fields and human health at this time. Also, the best evidence to date indicates that, at worst, the relative risk of magnetic fields compared to the myriad of other risks faced by society is most likely small. On the other hand, evidence does exist which points toward the possibility of some risk associated with magnetic fields and human health. Given the present uncertainties about EMF and human health, Vermont's policy should strike a reasonable balance between avoiding potential harm and the attendant costs and risks. To take absolutely no action at this time is not commensurate with the evidence that some risk may exist. Similarly, adopting aggressive measures would most likely be costly and disruptive, and may ultimately turn out to be ineffective. Aggressive measures taken at this time could be ineffective for two key reasons. First, research could ultimately show that the risks to human health from magnetic fields are nonexistent or very small. Second, knowledge gained on the dose-response of magnetic fields could show that the measures that were taken to limit exposure were inappropriate or ineffective."

"If an EMF policy of prudent avoidance is determined to best strike a reasonable balance between avoiding potential harm and the associated costs and risks, Vermont utilities should take steps to lower magnetic field exposure in cases when this can be done at a modest cost. In most cases, this would apply only to new facilities since modifying old facilities would likely be very costly. Actions that could be considered under the prudent avoidance strategy include the use of low EMF design structures when constructing or rebuilding lines, and siting new or rebuilt lines away from populated areas. Utilities should monitor and might consider participating in research on EMF effects and on construction and design alternatives that would reduce EMF exposure. Several Vermont utilities are participating in an ad hoc working group on EMF, an effort that should help them deal with EMF issues. Finally, utilities could provide information on EMF for their customers and the public, including information that would allow concerned individuals to reduce possible risks from EMF exposure on their own. The utility industry in Vermont should rely on the state's Department of Health to determine if this policy needs modification."

DISCUSSION OF PUBLIC COMMENTS

The discussion below is based on questions and concerns of citizens provided to the Public Service Board at the public hearings held in Barre (September 4, 2003), Brandon (September 29, 2003), and Charlotte (September 30, 2003), and minutes of meetings between VELCO representatives and several towns involved with the NRP.

Will EMF increase from substations with the increased step down voltage?

No, please refer to the information below.

NIEHS (2002) [21]:

"In general, the strongest EMF around the outside of a substation comes from the power lines entering and leaving the substation. The strength of the EMF from the equipment within the substations, such as transformers, reactor, and capacitor banks, decreases rapidly with increasing distance. Beyond the substation fence or wall, the EMF produced by the substation equipment is typically indistinguishable from background levels."

New Jersey (1996-2003) [29]:

"SUBSTATIONS

Electrical substations serve many functions in controlling and transferring power on an electrical system. Substations may utilize transmission lines, distribution lines or a combination of both. In general, the strongest magnetic fields around the outside of the substation comes from the power lines entering and leaving the station. While transformers inside the substation can produce high magnetic fields, the fields remain localized around the transformer. Beyond the substation fence, the magnetic fields produced by the equipment within the station are typically indistinguishable from background levels.

TRANSFORMERS

Transformers are electrical devices used to adjust the voltage-current relationship of an electrical power circuit for best efficiency during transmission and distribution use. There are electric and magnetic fields near a transformer and around the lines that connect to them. But the fields tend to drop off rapidly as ones moves away from the transformer. Utilities use a variety of transformers throughout their system. Step-up transformers are used at the power generating station to raise the voltage so the power can be economically delivered over transmission lines. The magnetic fields from these types of transformers are high but localized and do not travel beyond the bounds of the substation. Step-down transformers are used to reduce line voltages.

Overhead (pole-mounted) transformers are used where distribution lines are overhead and surface (pad-mounted) transformers are used where distribution lines are underground. Frequently in urban situations, transformers can be located within buildings. If the transformer is what is referred to as a network transformer, which can supply power to an entire block, magnetic fields on the floor directly above the transformer can be as high as 700 milligauss. Since magnetic fields remain localized around the transformer itself, a pole-mounted transformer will have very little impact on ground level magnetic fields, which will be dominated by the overhead distribution lines coming in and going out of the transformer.

Pad mounted transformers have magnetic fields similar in intensity to kitchen appliances. The magnetic fields near this type of transformer are elevated close to the surface of the transformer. A few feet away, the levels drop off to background."

U.K. *National Radiation Protection Board (July 1996) [27]:*

"Electric field strength measurements close to local area substations indicate that electric field strengths are often below 1 volt per metre and this is attributed to the shielding provided by the metallic casing on components and cables, and to the enclosure walls. Only where overhead feeder lines occur, are electric fields likely to exceed a few volts per metre. Up to a few tens of volts per metre have been measured beneath associated high voltage supply lines; circuit configurations which are generally rare."

What have research and studies on electrical fields, corona discharge, ionization of molecules and stray voltage indicated about the health effects on people? [36]

The earth's static electric field is about 0.13 kV/m and can be as high as 3 kV/m under thunderclouds, even in the absence of local lightning.

Electric power frequency fields from transmission power lines exist whenever voltage is present and whether a current is flowing or not. Electric power frequency fields have very little ability to penetrate through the skin into the human body and are not strong enough to heat tissue or stimulate nerves. At very high field strengths, electric power frequency fields can induce currents in the body. Strong electric power frequency fields can also result in perceptual effects due to the alternating electric charge induced on the surface of the body causing, for example, body hair to vibrate. Indirect effects such as micro-shocks can occur in strong electric power frequency fields through contact between a person and a conducting object. There are no permanent health effects known to exist from prompt, acute nor long-term exposure to electric power frequency fields.

Corona discharge occurs when the electric power frequency field strength of a conductor reaches values when the surrounding air can no longer act as an insulator and is sufficient to cause air ionization. Transmission lines are designed not to go into corona under normal operating conditions. However, nicks, scrapes, insects, raindrops, etc. on the conductor surface can increase local field strength sufficiently to produce corona. Phenomena associated with corona discharge includes audible noise, radio, television and telephone interference, and production of ozone, nitrous oxides and air ions which decrease with increasing distance away from the power line. These phenomena are intermittent and for a well-constructed line they occur only during and immediately after periods of rain, snow, or fog. There are no permanent health effects known to exist from corona discharge.

Ionization of particles from corona discharges tends to make the particles more likely to adhere to any nearby surface. This process can cause changes in the concentration and deposition of particles (radon decay products and other environmental pollutants) in the vicinity of power lines. The U.K. Advisory Group on Non-Ionizing Radiation concluded that whether any such enhanced deposition will increase human exposure in a way that will result in adverse health effects to the general public has not been demonstrated. There are no permanent health effects known to exist from ionization of particles from corona discharges.

In nature, the ratio of positive and negative ions is approximately equal. Negative ions predominate in areas that are traditionally regarded as therapeutic in nature—spas, springs, waterfalls, mountaintops and the seashore. Human activity rarely creates negative ions. Negative ions are used to control pain with burn patients, favorably alter circadian rhythms, improve psychomotor performance, and give a general sense of well being and energy. Some reasons for this are thought to be that negative ions limit serotonin levels in the brain and increase activity in the endocrine system, circulation and metabolism. There are no adverse health effects from negative ions.

Positive ions have adverse effects on humans, ranging from respiratory difficulties, to migraine, irritability, depression and reduced psychomotor performance. Positive ions produce increased serotonin levels. Most authorities agree that ions affect our capacity to absorb and utilize oxygen. Positive ions can produce symptoms similar to anoxia. The production of positive ions is negligible for power frequency transmission lines and their concentration decreases with increasing distance away from the power line. This phenomenon is intermittent and for a well-constructed line they occur only during and immediately after periods of rain, snow, or fog. There are no permanent health effects known to exist from positive ions.

Ozone, singlet oxygen, nitric oxide, nitrogen dioxide, nitrous acid and peroxyacycle nitrates are among the electrochemical oxidants formed from oxygen and nitrogen in the vicinity of the high voltage power line. Electrochemical oxidants are unstable and highly reactive. Their destructive capabilities range from decreasing plant growth and combining with water to form acid rain, to causing respiratory problems and having carcinogenic properties. Their concentrations decrease with increasing distance away from the power line and for a well-constructed line they occur only during and immediately after periods of rain, snow, or fog. Studies to date indicate that contributions to environmental ozone levels are negligible. There are no permanent health effects known to exist from these electrochemical oxidants.

Stray voltage is not commonly a problem for humans.

Has a health survey of the people living near the present power lines been conducted and is there any planned research?

No, and the VDH does not intend to conduct a health survey. As discussed above, many epidemiological studies have been performed in the United States and other countries. The results of these studies show that no adverse health effects from EMF are expected from the proposed NRP.

What are the health effects of power line electric and magnetic radiation?

Refer to the section above entitled "CURRENT SCIENTIFIC VIEW OF HUMAN HEALTH EFFECTS RELATED TO ELECTRIC AND MAGNETIC POWER FREQUENCY FIELDS".

The Vermont Department of Health:

1) Concludes that the data in the current body of literature is insufficient to establish a direct cause and effect relationship between EMF exposure and adverse health effects,

2) Concludes that the average and maximum electric and magnetic power frequency field strength for the proposed NRP does not appear to be a public health hazard based on a review of the literature and on calculations with existing and proposed electric current loads, and

3) Concludes that Vermont should continue to follow the policy of prudent avoidance outlined in the Vermont Twenty Year Electric Plan (1994) in order to mitigate EMF exposures.

The Vermont Department of Health concludes there are no compelling health concerns or reasons requiring modification to the NRP.

Why do I feel the EMFs?

Strong electric power frequency fields may result in perceptual effects due to the alternating electric charge induced on the surface of the body causing, for example, body hair to vibrate. A person standing directly under a transmission line may feel a slight shock when touching something that conducts electricity. These sensations only occur at close range to the transmission line because electric power frequency fields decrease quickly with distance and are easily shielded or weakened by buildings, trees and other objects that conduct electricity. There are no permanent adverse health effects known to exist from acute exposure to strong electric power frequency fields.

What is the EMF field like if the line is buried?

Generally, the EMF from a buried power line is less than that from an overhead power line. However, directly over the buried power line the electric and magnetic power frequency field is higher than that from the overhead power line, because it is so much closer to the measurement point (one meter above the ground). The EMF from a buried power line decreases more rapidly away from it than from an overhead power line. The EMF at the edge of the ROW for buried lines is less than that from overhead lines. One study has shown that the magnetic power frequency field for a buried 69 kV power line is 55 mG directly over it. The magnetic power frequency field decreases to 1 mG at 50 feet away. Another study indicates the magnetic power frequency field directly over a buried 400 kV power line is 1000 mG. At 60 feet away the magnetic power frequency field decreases to 10 to 20 mG. If for example, the proposed 115 kV power lines in the New Haven to Queen City corridor, were to be buried, then based on the above studies it would appear that the magnetic power frequency field directly above the buried power line may be on the order of 200 mG, which is less than the ICNIRP guideline of 833 mG.

How do the expected EMF fields compare with the guidelines in other states?

Refer to the section above entitled “WILL THE PROJECTED EMF INCREASE, DECREASE OR STAY THE SAME FOR THE NRP? - Magnetic Power Frequency Fields at Maximum Continuous Loading at the Edge of the ROW”.

Does the EMF increase when there are two side-by-side lines?

No, in fact EMF may decrease because the conductor phases are oriented so that the magnetic power frequency fields will cancel each other out. The phases are oriented at 0, 120 and 240 degrees for three lines. The width of the EMF field will increase, but as one moves away from the power lines the EMF will decrease rapidly to background.

How does the Vermont Department of Health 2002 cancer study compare to the position of the power lines on the western side of Vermont?

There is no clear data at this point in correlating the individual cancer cases with the position of the present transmission power lines. Generally, VDH data indicates the cancer cases do not follow the transmission power line corridor.

Did we take into consideration that power lines may droop depending on weather conditions?

Yes, refer to the section above entitled “WILL THE PROJECTED EMF INCREASE, DECREASE OR STAY THE SAME FOR THE NRP?”

CONCLUSIONS

The Vermont Department of Health concludes that the electric and magnetic power frequency field strength for the proposed NRP does not appear to be a public health hazard based on a review of the literature and on calculations with existing and proposed current loads. In the absence of federal and state standards, the Vermont Department of Health applied the ICNIRP and IEEE guidelines for electric and magnetic power frequency fields to its analysis of the NRP. The magnetic power frequency fields at the edge of the ROW are on the order of 20 to 200 times less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, respectively. The electric power frequency fields at the edge of the ROW are less than the ICNIRP guideline of 4.2 kV/m.

The magnetic power frequency field for average loading at the edge of the ROW is projected to decrease with the NRP along the West Rutland to New Haven and the Queen City-Pole 51 to Queen City Substation corridors between 2003 and 2012. There is a projected increase with the NRP in the magnetic power frequency field for the New Haven to Queen City-Pole 51 corridor. The projected magnetic power frequency fields at the edge of the ROW are 20 and 200 times less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG, respectively, for public exposure.

The magnetic power frequency field for average loading directly under the power line is projected to decrease with the NRP along the West Rutland to Middlebury and the Queen City-Pole 51 to Queen City Substation corridors between 2003 and 2012. There is a projected increase with the NRP in the magnetic power frequency field for the Middlebury to New Haven and New Haven to Queen City-Pole 51 corridors. The projected magnetic power frequency fields for average loading directly under the power lines are on the order of 20 to 200 times less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, respectively.

The magnetic power frequency field for maximum continuous loading at the edge of the ROW is projected to increase with the NRP along essentially the whole West Rutland to Queen City Substation corridor. The projected magnetic power frequency fields at the edge of the right of way for maximum continuous loading are approximately 4 times less than the ICNIRP (833 mG) and approximately 40 times less than the IEEE (9,040 mG) guidelines for public exposure. The existing and projected magnetic power frequency fields along the Queen City-Pole 51 to the Queen City Substation corridor are greater than the guideline set by Florida of 150 mG for power lines less than 230 kV. It must be emphasized that the Florida guidelines are not health-based but are used by them to maintain the status quo. The magnetic power frequency fields we have calculated for the present and proposed NRP lines, in our judgment, maintain the status quo. This demonstrates that the projected maximum magnetic power frequency fields at the edge of the ROW for the NRP are well below the health based ICNIRP guideline of 833 mG.

The magnetic power frequency field for maximum continuous loading directly under the power line is projected to increase with the NRP along essentially the whole West Rutland to Queen City Substation corridor. The highest magnetic power frequency field is approximately 600 mG along the West Rutland to New Haven corridor. Based on the orthophotos provided by VELCO there are only three residences near the proposed power line along the Rutland to New Haven corridor and they are at sufficient distance such that the proposed magnetic power frequency fields (Appendix B, Table 6) are projected to be much less than the ICNIRP guideline of 833 mG. The projected magnetic power frequency fields directly under the proposed power line for maximum continuous loading are less than the ICNIRP (833 mG) and the IEEE (9,040 mG) guidelines for public exposure.

The electric power frequency fields are projected to increase with the NRP along the entire West Rutland to Queen City Substation corridor at the edge of the ROW. The electric power frequency fields are projected to be less than the ICNIRP guideline of 4.2 kV/m at the edge of the ROW. The projected electric power frequency field at the edge of the ROW along the Queen City-Pole 51 to Pole 58 corridor exceeds the guideline set by Florida of 2 kV/m for power lines less than 230 kV. It must be emphasized that the Florida guidelines are not health-based, but are used by them to maintain the status quo. The electric power frequency fields we have calculated for the present and proposed NRP lines, in our judgment, maintain the status quo.

The projected electric power frequency fields directly under the power line for average or maximum continuous loading with the NRP are less than the ICNIRP guideline of 4.2 kV/m, except along the West Rutland to New Haven corridor. The proposed electric power frequency fields directly under the power line along the West Rutland to New Haven corridor are greater than the ICNIRP guideline of 4.2 kV/m, but are less than the New York guideline of 7 kV/m for highway crossings directly under power lines. Based on the orthophotos provided by VELCO there are only three residences near the proposed power line along these corridors and they are at sufficient distance such that the proposed electric power frequency fields will be less than 4.2 kV/m. This demonstrates that the projected maximum electric power frequency fields for known residences near or in the right of way for the NRP are well below the health based ICNIRP guideline.

In summary, the projected magnetic power frequency fields at the edge and in the ROW with the NRP are less than the ICNIRP guideline of 833 mG and the IEEE guideline of 9,040 mG for public exposure, and the projected electric power frequency fields are less than the ICNIRP guideline of 4.2 kV/m at the edge of the ROW. This demonstrates that the projected electric and magnetic power frequency fields for the NRP are well below the health based ICNIRP guidelines at the edge of the ROW.

The Vermont Department of Health concludes that the data in the current body of literature is insufficient to establish a direct cause and effect relationship between EMF exposure and adverse health effects. Health risks from exposure to EMF cannot be properly determined without sufficient information relating a specific measure of the magnetic power frequency field (e.g., time-averaged mG, cumulative mG, peak mG, time spent above a certain field strength) to a specific health effect. However, the possibility of a health risk from EMF cannot be dismissed entirely because some studies have identified slight but positive associations between EMF exposure and certain adverse health effects, while other studies have not.

Based on these considerations, the Vermont Department of Health concludes that modifications to the NRP are not required for health reasons, but Vermont's policy of prudent avoidance to mitigate EMF exposure as identified in the Vermont Twenty Year Electric Plan (1994) should be continued. Principles for decreasing EMF from transmission lines include:

- Increasing the distance to the transmission line by increasing the width of the ROW.
- Phase cancellation by changing the proximity of the conductors.
- Reducing current levels on the transmission line. The power carried by the transmission line is equal to the voltage of the line times the current in the line. Therefore, a 345 kV

line replacing a 115 kV line will require less current in order to pass the same amount of power. Reducing the current will reduce the magnetic power frequency field.

- Burying the transmission line. This will generally decrease the magnetic power frequency field more quickly as one moves away from the line, but the magnetic power frequency field over the line is higher than for an overhead line. If VELCO decides to bury the transmission power lines, then the Vermont Department of Health recommends that the issue of EMFs be revisited, especially for dwellings within the ROW, to make sure the magnetic power frequency field remains below the ICNIRP guideline of 833 mG.

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APPENDIX A

DATA FROM VELCO

Table 1. Line Ampacity Ratings for NRP Project					
Jeff Carrara 8/11/2003					
Line Name	*Where to Where*	*Conductor*	*Cont. Rating*	*Emer. Preload*	*15min Emer.*
Line Sections: West Rutland - New Haven					
K30	West Rutland - Florence - Middlebury	927 ACAR	1195	1024	1246
K63	Middlebury - New Haven	954 ACSR	1245	1066	1442
380	West Rutland - New Haven	2-954 ACSR	2490	2132	2884
Line Sections: New Haven - Queen City					
CV/GMP 4465	New Haven - Vergennes	447 ACSR	799	688	901
GMP 3322	Vergennes - N. Ferrisburg - Charlotte	556 AAAC	827	710	832
GMP 3322	Charlotte - Shelburne - Queen City	336 ACSR	647	558	732
K18	New Haven - Vergennes	1272 ACSR	1492	1274	1745
K12	Vergennes - N. Fer. - Char. - Shel. - QC	1272 ACSR	1492	1274	1745
K33	Williston - Queen City	927 ACAR	1195	1024	1246
To achieve the 15 minute emergency rating the line must have been loaded to less than or equal to the emergency preload rating.					

Table 2. Electric & Magnetic Field Input Data

Jeff Carrara 8/13/2003

New Haven - Queen City

This is the field input data for proposed 115kV line from New Haven - Queen City for all the structures you asked about. Details below.

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase
1	-5.00	37.98	1	1.345	18	120.75	0.00
2	5.00	31.98	1	1.345	18	120.75	240.00
3	-5.00	25.98	1	1.345	18	120.75	120.00
4	1.00	56.59	1	0.375	18	0	0.00

These Structures are not near the railroad

GMP structure #63 @ 5.2 miles on Cross-Section 6
GMP structure #68 @ 5.5 miles on Cross-Section 10
GMP structure #167 @ 21.75 miles on Cross-Section 12
GMP structure near school on Cross-Section 15

These Structures are near the railroad

GMP structure #264 @ 16.7 miles on Cross-Section 18A.
Existing 125' from railroad to Proposed 350' from edge of Waldorf School
GMP structure #238 @ 18.4 miles on Cross-Section 18A. Existing 45' from railroad
GMP structure #138 @ 23.36 miles on Cross-Section CS16.
Existing not near railroad(but in Neighborhood) to Proposed 40' - 60' from Railroad
GMP structure #112 @ 24.15 miles on Cross-Section CS21A.
Existing 40'-55' from Railroad to Proposed 35' from Railroad
GMP structure #93 @ 24.7 miles on Cross-Section CS21A. "
GMP structure #80 @ 25.03 miles on Cross-Section CS21A. "

West Rutland - New Haven

This is the field input data for proposed 115kV & 345kV line from West Rutland - Middlebury

Velco #233 @ 20.6 miles

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase
1	64.00	29.60	1	1.108	18	120.75	0.00
2	50.00	29.60	1	1.108	18	120.75	240.00
3	36.00	29.60	1	1.108	18	120.75	120.00
4	58.00	48.22	1	0.375	18	0	0.00
5	42.00	48.22	1	0.375	18	0	0.00
6	-56.00	29.03	2	1.165	18	362.25	0.00
7	-30.00	29.03	2	1.165	18	362.25	240.00
8	-4.00	29.03	2	1.165	18	362.25	120.00
9	-44.25	69.97	1	0.375	18	0	0.00
10	-15.75	69.97	1	0.375	18	0	0.00

This is the field input data for proposed 115kV & 345kV line from Middlebury - New Haven only difference being the 115kV conductor type and sag

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase
1	64.00	34.03	1	1.165	18	120.75	0.00
2	50.00	34.03	1	1.165	18	120.75	240.00
3	36.00	34.03	1	1.165	18	120.75	120.00
4	58.00	48.22	1	0.375	18	0	0.00
5	42.00	48.22	1	0.375	18	0	0.00
6	-56.00	29.03	2	1.165	18	362.25	0.00
7	-30.00	29.03	2	1.165	18	362.25	240.00
8	-4.00	29.03	2	1.165	18	362.25	120.00
9	-44.25	69.97	1	0.375	18	0	0.00
10	-15.75	69.97	1	0.375	18	0	0.00

Velco #376 @ 29.08 miles

Velco #338 & #339 @ 32.4 miles

Table 3. Average Loading for NRP Project								
Jeff Carrara 8/15/2003								
		Existing				Proposed		
Line Name	*Where to Where*	*2003*	*2006*	*2009*	*2012*	*2006*	*2009*	*2012*
Line sections: West Rutland - New Haven								
K30	West Rutland - Florence	315.23	407.91	452.61	497.46	120.41	138.69	153.17
K30	Florence - Middlebury	233.32	320.78	359.94	396.77	33.94	47.32	56.28
K63	Middlebury - New Haven	136.73	217.99	251.27	282.09	88.43	77.01	70.15
380	West Rutland - New Haven					116.82	142.39	159.41
Line sections: New Haven - Queen City								
CV/GMP 4465	New Haven - Vergennes	199.06	217.82	234.14	252.14			
GMP 3322	Vergennes - N. Ferrisburg	94.63	129.44	141.41	158.30			
GMP 3322	N. Ferrisburg - Charlotte	52.21	84.85	95.72	105.51			
GMP 3322	Charlotte - Shelburne	16.32	6.76	9.79	15.15			
GMP 3322	Shelburne - Queen City	122.92	115.30	118.57	132.81			
K18	New Haven - Vergennes					180.05	220.92	248.87
K12	Vergennes - N. Ferrisburg					148.48	187.97	214.40
K12	N. Ferrisburg - Charlotte					135.10	174.26	200.37
K12	Charlotte - Shelburne					111.61	148.80	172.46
K12	Shelburne - Queen City					76.36	110.95	131.94
K33	Williston - Queen City	216.68	252.25	288.25	314.22	162.19	168.06	183.64
Peak loadings figured by load flow cases based on DPS forecast								
Average loading is figured as 65% of peak as per DPS forecast comparison of peak and energy usage								

Table 4. Electric & Magnetic Field Input Data

Jeff Carrara 8/22/2003

New Haven - Queen City

This is the field input data for existing 46kV line from **New Haven - Vergennes**

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase
1	-4.67	35.19	1	0.849	18	48.3	0.00
2	0.00	36.99	1	0.849	18	48.3	240.00
3	4.67	35.19	1	0.849	18	48.3	120.00

This is the field input data for existing 34.5kV line from **Vergennes to Charlotte**

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase
1	-4.58	21.61	1	0.858	18	36.225	0.00
2	0.00	22.44	1	0.858	18	36.225	240.00
3	4.58	21.61	1	0.858	18	36.225	120.00

This is the field input data for existing 34.5kV line from **Charlotte - Queen City**

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase
1	-4.58	21.61	1	0.720	18	36.225	0.00
2	0.00	22.44	1	0.720	18	36.225	240.00
3	4.58	21.61	1	0.720	18	36.225	120.00

Electric & Magnetic Field Input Data							
Jeff Carrara 9/5/2003							
Note: using K33 structure center as reference, K33 Line will not be changed, other lines in same ROW will change.							
K33 Williston Switching Station to Pole 51 (single circuit)							
Williston - Pole 6 (0.43182mi) 70' modified H-Frame							
Bundle	**x-feet**	**y-feet**	**n cond**	**Cond D**	**Bund D**	**l-n volt**	**phase**
1	-14.00	29.60	1	1.108	18	120.75	0.00
2	0.00	29.60	1	1.108	18	120.75	240.00
3	14.00	29.60	1	1.108	18	120.75	120.00
4	-7.00	53.95	1	0.375	18	0	0.00
5	7.00	53.95	1	0.375	18	0	0.00
Pole 6 - Pole 48 (3.81780mi) 60' H-Frame							
Bundle	**x-feet**	**y-feet**	**n cond**	**Cond D**	**Bund D**	**l-n volt**	**phase**
1	-14.00	29.60	1	1.108	18	120.75	0.00
2	0.00	29.60	1	1.108	18	120.75	240.00
3	14.00	29.60	1	1.108	18	120.75	120.00
4	-7.00	62.95	1	0.375	18	0	0.00
5	7.00	62.95	1	0.375	18	0	0.00
Pole 48 - Pole 51 (0.29356mi) Steel Pole Vertical Construction							
Bundle	**x-feet**	**y-feet**	**n cond**	**Cond D**	**Bund D**	**l-n volt**	**phase**
1	-1.00	53.60	1	1.108	18	120.75	0.00
2	0.00	41.60	1	1.108	18	120.75	240.00
3	1.00	29.60	1	1.108	18	120.75	120.00
4	0.00	77.23	1	0.375	18	0	0.00

K33 Pole 51 to Pole 58 (double circuit) This is the point where its in the same ROW as the 34.5kV line the proposed 115kV line will replace

Pole 51 - Pole 58 (0.63201mi) Steel Pole Double Davit-Arm Construction

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase	
1	8.17	49.18	1	1.108	18	120.75	0.00	K33
2	11.25	36.18	1	1.108	18	120.75	240.00	
3	8.42	23.18	1	1.108	18	120.75	120.00	
4	-4.00	74.03	1	0.375	18	0	0.00	
5	-8.17	23.18	1	0.720	18	36.225	120.00	GMP 3322
6	-11.25	36.18	1	0.720	18	36.225	240.00	
7	-8.42	49.18	1	0.720	18	36.225	0.00	
8	4.00	74.03	1	0.375	18	0	0.00	

Pole 58 - Pole 67 (.76521mi) 65' H-Frame, 34.5kV line 79' away on center

Bundle	x-feet	y-feet	n cond	Cond D	Bund D	l-n volt	phase	
1	-14.00	29.60	1	1.108	18	120.75	0.00	K33
2	0.00	29.60	1	1.108	18	120.75	240.00	
3	14.00	29.60	1	1.108	18	120.75	120.00	
4	-7.00	48.37	1	0.375	18	0	0.00	
5	7.00	48.37	1	0.375	18	0	0.00	
6	74.42	25	1	0.720	18	36.225	120.00	K12
7	79.00	25.83	1	0.720	18	36.225	240.00	
8	83.58	25	1	0.720	18	36.225	0.00	

Proposed >	**Bundle**	**x-feet**	**y-feet**	**n cond**	**Cond D**	**Bund D**	**l-n volt**	**phase**	
	1	8.17	49.18	1	1.108	18	120.75	0.00	K33
	2	11.25	36.18	1	1.108	18	120.75	240.00	
	3	8.42	23.18	1	1.108	18	120.75	120.00	
	4	-4.00	74.03	1	0.375	18	0	0.00	
	5	-8.17	28.86	1	1.345	18	120.75	120.00	K12
	6	-11.25	41.86	1	1.345	18	120.75	240.00	
	7	-8.42	54.86	1	1.345	18	120.75	0.00	
	8	4.00	74.03	1	0.375	18	0	0.00	
	Pole 58 - Pole 67 <u>Where Proposed ROW is available</u>, 115kV line 72.5' away on center								
Proposed >	**Bundle**	**x-feet**	**y-feet**	**n cond**	**Cond D**	**Bund D**	**l-n volt**	**phase**	
	1	-14.00	29.60	1	1.108	18	120.75	0.00	K33
	2	0.00	29.60	1	1.108	18	120.75	240.00	
	3	14.00	29.60	1	1.108	18	120.75	120.00	
	4	-7.00	48.37	1	0.375	18	0	0.00	
	5	7.00	48.37	1	0.375	18	0	0.00	
	6	77.50	37.98	1	1.345	18	120.75	0.00	K12
	7	67.50	31.98	1	1.345	18	120.75	240.00	
	8	77.50	25.98	1	1.345	18	120.75	120.00	
	9	71.50	56.59	1	0.375	18	0	0.00	

Pole 58 - Pole 67 <u>Where ROW is limited to < 30'</u>, 115kV line 72.5' away on center								
Proposed >	**x-feet**	**y-feet**	**n cond**	**Cond D**	**Bund D**	**l-n volt**	**phase**	
1	-14.00	29.60	1	1.108	18	120.75	0.00	K33
2	0.00	29.60	1	1.108	18	120.75	240.00	
3	14.00	29.60	1	1.108	18	120.75	120.00	
4	-7.00	48.37	1	0.375	18	0	0.00	
5	7.00	48.37	1	0.375	18	0	0.00	
6	65.00	46.98	1	1.345	18	120.75	0.00	K12
7	64.00	35.98	1	1.345	18	120.75	240.00	
8	65.00	24.98	1	1.345	18	120.75	120.00	
9	71.50	56.59	1	0.375	18	0	0.00	

Table 5. Voltage: Line-to-Line vs. Line-to-Neutral

Jeff Carrara 10/4/2003

Spurred by a mistake I made when giving data to Carla White of Vermont Dept. of Health, I decided to have a short description of a few terms
Often when we discuss voltage on lines we use the voltage between 2 phases (or line-to-line voltage, abbrev Vll).
This line-to-line voltage is greater than line-to-ground(Vlg) or line-to-neutral(Vln) voltage (to be exact the square root of 3 times greater)
Since we try to be conservative and make sure we don't understate the EMF we use a voltage that is 5% higher than nominal

Examples:

nominal Vll (kV)	maximum Vll (kV)	maximum Vln (kV)
345	362.25	209.15
115	120.75	69.72
46	48.30	27.89
34.5	36.23	20.91

APPENDIX B

Table 1.
MAGNETIC POWER FREQUENCY FIELD STRENGTH AT AVERAGE LOADING DIRECTLY UNDER THE POWER LINE

(milligauss)

Corridor*	Existing Power Line				Proposed Power Line			Proposed Power Line <30 ft ROW		
	2003	**2006**	**2009**	**2012**	**2006**	**2009**	**2012**	**2006**	**2009**	**2012**
WR - F	56	73	81	89	31	37	41	NA	NA	NA
F - M	42	57	64	71	28	34	37	NA	NA	NA
M - NH	19	30	35	39	29	34	38	NA	NA	NA
NH - V	10	11	12	13	18	22	25	NA	NA	NA
V - NF	14	19	21	23	15	19	22	NA	NA	NA
NF - C	7.6	12	14	15	14	18	20	NA	NA	NA
C - S	2.4	1	1.4	2.2	11	15	17	NA	NA	NA
S - QC	18	17	17	19	7.7	11	13	NA	NA	NA
QC51 - 58	45	50	56	62	32	35	39	NA	NA	NA
QC58 - 67	40	46	52	57	30	31	34	31	32	35
QC67 - QC	39	45	52	57	30	31	34	NA	NA	NA

* WR = West Rutland substation
F = Florence substation
M = Middlebury substation
NH = New Haven substation
V = Vergennes substation
NF = North Ferrisburg substation
C = Charlotte substation
QC = Queen City substation
QC51-58 = Queen City from poles 51 to 58
QC58-67 = Queen City from poles 58 to 67
QC67-QC = Queen City from pole 67 to substation

Table 2.
MAGNETIC POWER FREQUENCY FIELD STRENGTH AT AVERAGE LOADING ON THE EDGE OF THE RIGHT OF WAY
(milligauss)

	Existing Power Line				Proposed Power Line			Proposed Power Line <30 ft ROW		
Corridor*	**2003**	**2006**	**2009**	**2012**	**2006**	**2009**	**2012**	**2006**	**2009**	**2012**
WR - F	8.2	11	12	13	3.3	4	4.5	NA	NA	NA
F - M	6.1	8.3	9.3	10	3.7	4.4	5	NA	NA	NA
M - NH	3.4	5.4	6.2	7	3.4	4.3	4.9	NA	NA	NA
NH - V	3	3.3	3.5	3.8	4.3	5.3	6	NA	NA	NA
V - NF	11	15	17	18	14	18	20	NA	NA	NA
NF - C	6.1	10	11	12	13	16	19	NA	NA	NA
C - S	1.9	0.8	1.1	1.8	10	14	16	NA	NA	NA
S - QC	14	13	14	16	7.1	10	12	NA	NA	NA
QC51 - 58	45	50	56	62	32	35	39	NA	NA	NA
QC58 - 67	38	44	50	54	28	29	32	29	30	33
QC67 - QC	37	43	49	53	28	29	32	NA	NA	NA

* WR = West Rutland substation
F = Florence substation
M = Middlebury substation
NH = New Haven substation
V = Vergennes substation
NF = North Ferrisburg substation
C = Charlotte substation
QC = Queen City substation
QC51-58 = Queen City from poles 51 to 58
QC58-67 = Queen City from poles 58 to 67
QC67-QC = Queen City from pole 67 to substation

Table 3.
MAGNETIC POWER FREQUENCY FIELD STRENGTH AT MAXIMUM CONTINUOUS RATED LOAD DIRECTLY UNDER THE POWER LINE AND AT THE EDGE OF THE RIGHT OF WAY
(milligauss)

	Existing Power Line		Proposed Power Line		Proposed Power Line <30 ft ROW	
Corridor*	**Maximum**	**ROW Edge**	**Maximum**	**ROW Edge**	**Maximum**	**ROW Edge**
WR - M	214	31	601	76	NA	NA
M - NH	173	31	599	76	NA	NA
NH - V	41	12	149	36	NA	NA
V - C	121	96	149	139	NA	NA
C - QC	94	75	149	139	NA	NA
QC51 - 58	176	176	171	171	NA	NA
QC58 - 67	218	208	224	213	242	228
QC67 - QC	215	204	224	213	NA	NA

* WR = West Rutland substation
M = Middlebury substation
NH = New Haven substation
V = Vergennes substation
C = Charlotte substation
QC = Queen City substation
QC51-58 = Queen City from poles 51 to 58
QC58-67 = Queen City from poles 58 to 67
QC67-QC = Queen City from pole 67 to substation

Table 4.
ELECTRIC FIELD STRENGTH AT MAXIMUM OR AVERAGE CONTINUOUS RATED LOAD DIRECTLY UNDER THE POWER LINE AND AT THE EDGE OF THE RIGHT OF WAY
(kilovolt/meter)

Corridor*	Existing Power Line		Proposed Power Line		Proposed Power Line <30 ft ROW	
	Maximum	ROW Edge	Maximum	ROW Edge	Maximum	ROW Edge
WR - M	1.15	0.20	6.68	0.83	NA	NA
M - NH	0.89	0.21	6.81	0.83	NA	NA
NH - V	0.16	0.07	1.15	0.24	NA	NA
V - C	0.29	0.29	1.15	1.15	NA	NA
C - QC	0.28	0.28	1.15	1.15	NA	NA
QC51 - 58	2.05	2.05	2.63	2.63	NA	NA
QC58 - 67	1.17	1.17	1.25	1.25	1.77	1.77
QC67 - QC	1.16	1.16	1.25	1.25	NA	NA

* WR = West Rutland substation
M = Middlebury substation
NH = New Haven substation
V = Vergennes substation
C = Charlotte substation
QC = Queen City substation
QC51-58 = Queen City from poles 51 to 58
QC58-67 = Queen City from poles 58 to 67
QC67-QC = Queen City from pole 67 to substation

Table 5.
DISTANCE FROM CENTER OF RIGHT OF WAY AT WHICH MAGNETIC POWER FREQUENCY FIELD HAS DROPPED TO 4 MILLIGAUSS

(feet)

Corridor*	Existing Power Line				Proposed Power Line				Proposed Power Line <30 ft ROW			
	2003		2012		2006		2012		2006		2012	
	West	East	West	East	West	East	West	East	West	East	West	East
WR - F	60	160	95	195	120	105	130	110	NA	NA	NA	NA
F - M	45	145	75	175	120	78	135	85	NA	NA	NA	NA
M - NH	20	120	55	155	120	95	135	90	NA	NA	NA	NA
NH - V	40	40	50	50	52	47	63	57	NA	NA	NA	NA
V - NF	30	30	42	42	47	43	58	53	NA	NA	NA	NA
NF - C	19	19	32	32	43	40	55	52	NA	NA	NA	NA
C - S	all < 4 mG		all < 4 mG		38	33	52	47	NA	NA	NA	NA
S - QC	36	36	37	37	27	23	43	38	NA	NA	NA	NA
QC51 - 58	32	58	50	81	26	50	27	45	NA	NA	NA	NA
QC58 - 67	87	106	106	109	77	115	81	127	77	115	85	131
QC67 - QC	87	163	106	165	77	115	81	127	NA	NA	NA	NA

* WR = West Rutland substation
F = Florence substation
M = Middlebury substation
NH = New Haven substation
V = Vergennes substation
NF = North Ferrisburg substation
C = Charlotte substation
QC = Queen City substation
QC51-58 = Queen City from poles 51 to 58
QC58-67 = Queen City from poles 58 to 67
QC67-QC = Queen City from pole 67 to substation

Table 6.
MAGNETIC POWER FREQUENCY FIELD STRENGTH AT IDENTIFIED HOMES NEAR THE RIGHT OF WAY AT AVERAGE LOADING

(milliGauss)

Corridor*	Near Pole #	Distance feet	Existing Power Line 2003	Existing Power Line 2012	Proposed Power Line 2006	Proposed Power Line 2012
F - M						
	233	135	4.5	7.5	< 4	< 4
M - NH						
	376	-175	< 4	< 4	< 4	< 4
	338	115	4.3	8.9	< 4	< 4
NH - V						
	63	50	< 4	< 4	< 4	5.2
	68	-50	< 4	< 4	4.3	6.0
NF - C						
	264	-50	< 4	< 4	< 4	4.8
		-30	< 4	4.5	6.6	9.8
		-500	< 4	< 4	< 4	< 4
C - S						
	238	-25	< 4	< 4	6.6	10.2
	167	10	< 4	< 4	9.4	14.5
		75	< 4	< 4	< 4	< 4
		-75	< 4	< 4	< 4	< 4
		25	< 4	< 4	5.6	8.7
S - QC						
	138	175	< 4	< 4	< 4	< 4
	112	-50	< 4	< 4	< 4	< 4
		50	< 4	< 4	< 4	< 4
		40	< 4	< 4	< 4	< 4
	93	25	6.7	7.3	< 4	6.7
		50	< 4	< 4	< 4	< 4
	80	40	< 4	< 4	< 4	< 4
		20	8.7	9.4	4.6	8.0
		-30	5.2	5.7	< 4	6.4
		50	< 4	< 4	< 4	< 4

		500	< 4	< 4	< 4	< 4

Corridor*	Pole #	Distance feet	Existing Power Line 2003	Existing Power Line 2012	Proposed Power Line 2006	Proposed Power Line 2012	Proposed Power Line <30 ft ROW 2006	Proposed Power Line <30 ft ROW 2012
QC 51 - 58	65	65	< 4	< 4	< 4	< 4	NA	NA
	52	-160	< 4	< 4	< 4	< 4	NA	NA
	54	-160	< 4	< 4	< 4	< 4	NA	NA
	57	-150	< 4	< 4	< 4	< 4	NA	NA
		40	4.9	8.1	4.0	< 4	NA	NA
	58	100	< 4	< 4	< 4	< 4	NA	NA
QC 58 - 67	39	455	< 4	< 4	< 4	< 4	< 4	< 4
	36	130	< 4	< 4	< 4	4.9	4.1	6.1
	33	230	< 4	< 4	< 4	< 4	< 4	< 4
	31	155	< 4	< 4	< 4	< 4	< 4	< 4
	25	280	< 4	< 4	< 4	< 4	< 4	< 4
	23	305	< 4	< 4	< 4	< 4	< 4	< 4
	20	280	< 4	< 4	< 4	< 4	< 4	< 4
QC 67 - QC	10	635	< 4	< 4	< 4	< 4	NA	NA
	2	265	< 4	< 4	< 4	< 4	NA	NA

F = Florence substation
M = Middlebury substation
NH = New Haven substation
V = Vergennes substation
NF = North Ferrisburg substation
C = Charlotte substation
QC = Queen City substation
QC51-58 = Queen City from poles 51 to 58
QC58-67 = Queen City from poles 58 to 67
QC67-QC = Queen City from pole 67 to substation